BC hydro

Integrated Resource Plan

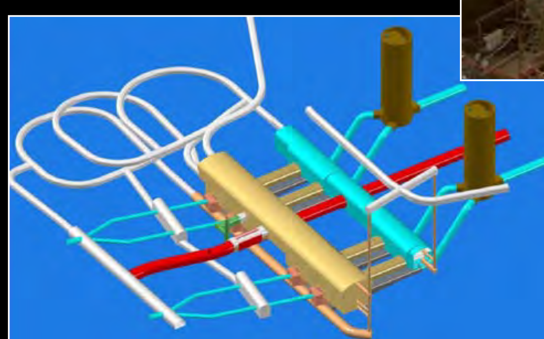
Appendix 3A-30

2013 Resource Options Report Update

Lower Mainland / Vancouver Island Pumped Storage Report and North Coast Pumped Storage Report

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SCREENING ASSESSMENT REPORT



PREPARED FOR

BC Hydro
333 Dunsmuir Street
Vancouver, BC V6B 5R3

PREPARED BY

Knight Piésold Ltd.
Suite 1400 – 750 West Pender Street
Vancouver, BC V6C 2T8

VA103-313/1-1
Rev 0
November 30, 2010

Knight Piésold
CONSULTING

ISO 9001, ISO 14001
OHSAS 18001

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SCREENING ASSESSMENT REPORT
(REF. NO. VA103-313/1-1)

Rev	Description	Date	Approved
0	Issued in Final	November 30, 2010	SRM

Knight Piésold Ltd.
Suite 1400
750 West Pender Street
Vancouver, British Columbia Canada V6C 2T8
Telephone: (604) 685-0543
Facsimile: (604) 685-0147
www.knightpiesold.com

Knight Piésold
CONSULTING

Knight Piésold CONSULTING

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SCREENING ASSESSMENT REPORT
(REF. NO. VA103-313/1-1)

EXECUTIVE SUMMARY

BC Hydro requested the services of Knight Piésold Ltd. (KPL) to conduct a screening assessment of the pumped storage potential in the Lower Mainland and Vancouver Island region of southwest British Columbia.

The focusing question of this study is: "Are there potentially viable greenfield pumped storage hydroelectric sites in the Lower Mainland and Vancouver Island region of southwest British Columbia that are economically viable?"

The answer to this question is YES, there are numerous potential pumped storage sites that meet the basic criteria established for this study. The results of this study are summarized below, with each numbered paragraph below being a summary of the corresponding section of this report:

1. BC Hydro has conducted three previous assessments of pumped storage hydro potential in the Lower Mainland and Vancouver Island dating back to 1977. These studies have included site identification, costing and environmental consideration.

2. Freshwater pumped storage is the most prevalent form of pumped storage that has been developed worldwide to date, with approximately 127,000 MW in operation as of 2009. Only one conventional saltwater pumped storage facility is in operation worldwide (the 30 MW Okinawa Pumped Storage Facility in Japan), and there are no known operating underground pumped storage plants (i.e. with an underground reservoir). Each type of pumped storage facility is subject to permitting, financial and schedule risks, however saltwater and underground pumped storage have additional technical, environmental, permitting and schedule risks due to the lack of worldwide experience.

3. The screening assessment was limited to the area south of latitude 51°N and west of longitude 121°W. The following screening constraints were also applied:
    a. Terrestrial parks were excluded from the assessment, but all other land use types were considered, such as marine parks, private land, and Indian reserves
    b. Known salmon bearing rivers were excluded from the study (Chinook, Sockeye, Chum, Coho, Pink and/or Steelhead); however, salmon bearing lakes were considered in the assessment
    c. Drinking water reservoirs and BC Hydro reservoirs were also considered in the assessment
    d. The capacity threshold for the assessment was limited to 1,000 MW in the Lower Mainland and 500 MW on Vancouver Island
    e. A minimum storage requirement was set at 6,000 MWh for 1,000 MW sites, and 3,000 MWh for 500 MW sites, equivalent to the water required for full plant generation output for 6 hrs; and

Knight Piésold
CONSULTING

f. A loaded capital cost threshold at plant gate (no site access, transmission or interconnection costs were assessed in this study) of $200/kW-yr was set for the assessment, based on a design life of 70 years and a discount rate of 6%.

194 sites in the Lower Mainland and Vancouver were identified using a combination of a GIS-based assessment tool and visual assessment. As anticipated, freshwater pumped storage was generally the most economical form of pumped storage, followed by saltwater and underground pumped storage. Compared to the most attractive freshwater and saltwater alternatives identified in this study, underground pumped storage is not cost competitive in BC. The identified sites fit into the following levelized cost ranges:

- Freshwater Pumped Storage
  - 45 projects were identified less than $100 /kW-yr
  - 54 projects were identified between $100 – $125 /kW-yr
  - 9 projects were identified between $125 – $150 /kW-yr
  - 9 projects were identified between $150 – $175 /kW-yr, and
  - 4 projects were identified greater than $175 /kW-yr.
- Saltwater Pumped Storage
  - 6 projects were identified less than $100 /kW-yr
  - 31 projects were identified between $100 – $125 /kW-yr
  - 27 projects were identified between $125 – $150 /kW-yr
  - 7 projects were identified between $150 – $175 /kW-yr, and
  - 2 projects were identified greater than $175 /kW-yr.
- Underground Pumped Storage
  - A 'typical' underground pumped storage project is anticipated to cost in the range of $230/kW-yr.

This study was limited in its scope based on the tight timeline associated with the deliverables, with the entire study being completed in less than 6 weeks. The level of detail and screening criteria used for this assessment can easily be updated, as the key components of the GIS assessment tool have now been developed. If this study is to be expanded upon, the following items are recommended. KPL is aware that some of these items are already underway as a follow-up to this study.

- Estimate the costs of transmission, interconnection and access to each alternative identified above in order to meaningfully be able to compare each identified site
- Conduct a system-wide study of the BC Hydro grid to determine the benefits/impacts of integrating pumped storage
- Determine the 'ideal' characteristics of a pumped storage facility, in terms of providing the maximum benefits to the BC Hydro system, improving export opportunities and firming of renewable (especially wind power) sources
- Conduct a screening assessment for the remaining portions of the province, especially where there is a high resource potential of intermittent renewable energy sources such as wind, run-of-river hydro, tidal and/or wave energy, and
- Conduct a more detailed assessment of the most favourable sites identified in this assessment.

Knight Piésold CONSULTING

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SCREENING ASSESSMENT REPORT
(REF. NO. VA103-313/1-1)

TABLE OF CONTENTS

Knight Piésold CONSULTING

TABLES

FIGURES

PHOTOS

Knight Piésold
CONSULTING

Knight Piésold
CONSULTING

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SCREENING ASSESSMENT REPORT
(REF. NO. VA103-313/1-1)

SECTION 1.0 - INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

BC Hydro requested the services of Knight Piésold Ltd. (KPL) to conduct a screening assessment of the pumped storage potential in the Lower Mainland and Vancouver Island region of southwest British Columbia. This report discusses the results of the assessment.

1.2 PREVIOUS STUDIES

BC Hydro has commissioned three screening level studies of pumped storage hydroelectric potential in southwest British Columbia since 1977. A brief discussion of the findings of each study is presented in the following subsections.

1.2.1 Pumped Storage in British Columbia – Preliminary Engineering Assessment, 1977

In December 1977, BC Hydro and Power Authority completed a preliminary assessment of pumped storage hydroelectric potential in the Lower Mainland and Vancouver Island. The study was bound by the following constraints:

1. The lower Mainland area was limited to approximately 150 km from Vancouver
2. Only sites capable of generating 500 MW or higher were considered, and
3. Both lower and upper reservoirs were required to have sufficient storage to operate on a weekly cycle.

The report identified approximately 80 sites that were deemed suitable for pumped storage development. Of these 80 sites, eight sites were selected (four on Vancouver Island and four in the Lower Mainland) based on their ability to generate 500 MW for 10 hours of continuous operation, the conduit length to head ratio and other considerations, such as interfering with park boundaries.

Overall design concepts were prepared on 1:50,000 scale mapping of the eight shortlisted sites. A helicopter reconnaissance and overview geological assessment was conducted for each site in order to identify the top two preferred sites on each of Vancouver Island and the Lower Mainland. The most attractive pumped storage sites were identified to be:

1. Lower Mainland – Stave River – Thomas Lake 1000 MW Development
2. Lower Mainland – Harrison lake – Slollicum Lake 1000 MW Development
3. Vancouver Island – Buttle Lake – Beadnell Lake 1000 MW Development, and
4. Vancouver island – Great Central Lake – Doran Lake 1000 MW Development.

Knight Piésold
CONSULTING

Cost estimates of each development were generated, and ranged from $249 million to $326 million dollars (1977). This corresponds to an approximate development cost ranging from $249/kW to $324/kW.

It was noted in the study that "When it became apparent that there were a large number of good sites, the potential in the more remote areas of the Lower Mainland and north-western part of Vancouver Island was not pursued in detail."

1.2.2 Resource Smart - Pumped Storage in British Columbia, 1993

In March 1993, the Hydroelectric Engineering Division of BC Hydro re-evaluated the economics associated with the pumped storage alternatives that were identified in the 1977 study. The main objectives of the study were to:

1. Update the costs of the 1977 study
2. Obtain equipment costs from manufactures
3. Determine any significant change to pumped storage technology and costs, and
4. Conduct environmental assessments of the four sites identified in the 1977 study.

The results of the study indicated the following main findings:

1. Development costs had increased from a range of $249/kW - $324/kW to a range of $635/kW - $773/kW.
2. The updated costs were similar to inflated 1977 costs.
3. Sites located in areas where increased peak capacity is required, would be most beneficial.
4. Advances in technology between 1977 and 1993 increased single unit capacities to approximately 300-330 MW. For single-stage reversible pump turbines, the maximum allowable head increased from 600 m in 1977 to approximately 900 m in 1993.
5. Pumped storage could be incorporated into existing BC Hydro facilities, such as Ash River, Wahleach, Bridge River and Cheakamus.
6. Peak vs. off-peak energy pricing should be included in future analyses.

1.2.3 Vancouver Island Green Energy Study – Review of Pumped Storage and Tidal Barrage Energy Generation, 2001

In September 2001, Klohn Crippen Consultants Ltd. completed a review of the pumped storage sites identified in the 1977 study. The purpose of the assessment was to identify the most cost effective development that would add a combined capacity of 200 MW to Vancouver Island. Sites in the Lower Mainland were not considered in the study.

Potential pumped storage sites identified in the 1977 study that were situated in parks were not considered in the assessment. An initial screening was completed, resulting in the selection of the seven most attractive sites for development. From these seven alternatives, the two best sites were chosen for a more detailed assessment and costing. The redevelopment of the Strathcona generating site was also considered in the detailed assessment and costing. The results of the study indicate the following main findings:

1. Shawnigan Site – 200 MW – Development cost of $1200 /kW

Knight Piésold
CONSULTING

2. Comox Site – 200 MW – Development cost of $1270 /kW, and
3. Strathcona Redevelopment – 200 MW – Development cost of $1230 / kW.

Environmental considerations were also described for each development alternative listed above.

SECTION 2.0 - TECHNOLOGY REVIEW

2.1 BACKGROUND

The concept of pumped storage is the generation of electricity by capturing the energy of water being transferred from a higher elevation upper reservoir, through turbine/generator units, into a lower elevation reservoir. The system is then reversed and the water from the lower reservoir is pumped back to the upper reservoir. Though the system is a net consumer of energy, it can be advantageous to developers/utilities by:

- Providing additional capacity during high-load hours when the cost of energy is greatest
- Increasing profitability by using low-value base load energy to pump water to the upper reservoir during low-load hours
- Providing grid stability by reducing the generation differential between high-load and low-load periods,
- Relieving constrained transmission components
- Providing voltage regulation, especially at the end of long transmission systems (i.e. the Peace River to Lower Mainland transmission network)
- Providing storage for intermittent renewable energy sources that cannot be dispatched on demand
- Providing backup capacity in the event of a planned or unplanned outage of another significant generation source connected to the grid, and/or
- Providing capacity for export.

The following subsections discuss some of the types of pumped storage, including their general concepts, development status and development risks. Comments on the state of pump-turbine technology are discussed as well as closed vs. open systems.

2.2 FRESHWATER PUMPED STORAGE

2.2.1 General Concept

Freshwater pumped storage simply refers to a pumped storage hydroelectric project where the upper and lower reservoirs impound only fresh water. Nearly all pumped storage development to date worldwide has primarily consisted of freshwater pumped storage.

2.2.2 Worldwide Development Status

Freshwater pumped storage is by far the most prevalent form of pumped storage that has been developed to date worldwide. Construction of freshwater pumped storage dates back to the early 1900s, when the first pumped storage plants came into operation in Italy and Switzerland. Since then, pumped storage development has increased with rising energy demand, and the increased need for peaking capacity.

The last thirty years has seen the largest growth of pumped storage development. Table 2.1 shows a list of operating projects greater than 1,000 MW in capacity that are known to be operating to date.

Knight Piésold CONSULTING

As of 2009, it was estimated that more than 127,000 MW of pumped storage capacity was operating worldwide, with some experts predicting future growth to be up to 60 percent over the next four years.

2.2.3 Development Risks

There are very few technical risks unique to freshwater pumped storage development that cannot be addressed through diligent planning and design. Freshwater pumped storage is a proven technology with projects operating worldwide, and as such, the predominant risks in development are similar to those of conventional hydropower development, or any large infrastructure project. Some of these risks include:

- Permitting risks – Social acceptance and environmental impact
- Geotechnical risks
- Financial risks, and
- Schedule risks.

2.3 SALTWATER PUMPED STORAGE

2.3.1 General Concept

The concept of saltwater pumped storage is the same to that of freshwater pumped storage, with the exception that seawater is exchanged between the ocean and an upper reservoir instead of freshwater. The advantage of saltwater pumped storage over freshwater pumped storage is that construction of only one reservoir is needed. This allows for potential development of sites closer to load centres, where freshwater pumped storage may not be feasible due to unsuitable terrain or other constraints.

2.3.2 Worldwide Development Status

Only one “conventional” saltwater pumped storage plant exists worldwide: the Okinawa Pumped Storage Plant on the coast of Japan. The 30 MW plant was constructed as a demonstration project and consists of a lined upper reservoir that transfers water via a tunnel and fibre-reinforced plastic penstock through an underground powerhouse to the Pacific Ocean. The project, which commenced operation in 1999, has a net head of approximately 136 m, and consists of a single 30 MW reversible pump-turbine.

2.3.3 Development Risks

Due to the unique high corrosion environment of saltwater pumped storage projects, as well as the lack of worldwide experience in saltwater pumped storage, there are higher development risks than conventional freshwater pumped storage.

Some of these risks include:

- Corrosion protection of components exposed to sea water that are susceptible to rust
- Potential saltwater contamination of groundwater

Knight Piésold CONSULTING

- Prevention of marine growth in project waterways
- Potential requirement to line upper reservoir and install costly drainage collection system to prevent saltwater seepage into groundwater
- Potentially longer permitting timeline
- Higher operating costs, and
- Higher equipment costs.

Initial feedback from some pump/turbine manufacturers indicates that corrosion protection of high head projects (gross head > 400 m) represents a much higher risk than low head projects (gross head < 400 m) due to the current technology of corrosion resistant austenitic stainless steel having a lower strength than traditional martensitic stainless steel. Further, these manufacturers believe that currently available coatings (including ceramic coatings traditionally used for abrasion protection) are not suitable for use in saltwater pump-turbines due to their brittle nature as well as low resistance to cavitation.

2.4 UNDERGROUND PUMPED STORAGE

2.4.1 General Concept

The concept of underground pumped storage is the same as conventional pumped storage, with the exception that one or both of the reservoirs are located underground in either natural or man-made caverns.

The concept of underground pumped storage has advanced in recent decades as the number of viable surface configurations have been reduced with development, as well as the increased environmental and social sensitivity associated with the disturbance caused by the construction of a conventional pumped storage scheme above ground.

2.4.2 Worldwide Development Status

To date there are no known operating “Underground Pumped Storage” projects (i.e. with the lower reservoir located underground). Concepts for such developments have been presented in both Canada and the USA, but none have proceeded to the construction phase to date.

Studies to date have considered the use of abandoned mines for reservoir storage, and others have considered excavation of a cavity large enough to meet reservoir requirements. In order to make the alternative more cost effective, abandoned mines or natural cavities could be used to meet the reservoir requirements.

Though conceptually feasible, the increased cost and higher technical risk of underground pumped storage development is much higher than other more economical energy alternatives. Prohibitive costs and underground geotechnical risks are the primary detractors from advancing underground pumped storage beyond feasibility study and into construction and operation.

Knight Piésold
CONSULTING

2.4.3 Development Risks

Sources of technical risk for underground pumped storage development include:

- Higher volume and cost of excavation of underground reservoirs.
- Longer (more expensive) access tunnels and shafts.
- Longer (more expensive) and more complex ventilation requirements.
- Higher geotechnical risks, including:
  - Structural adequacy of the rock mass
  - Permeability of the rock mass
  - Mineral content and contamination of the water supply, and
  - Groundwater contamination.
- Disposal of large amount of excavated material (large spoil areas required).

2.5 PUMPED STORAGE IN BRITISH COLUMBIA

To date, there are no operating pump-storage generation stations in the province of British Columbia, or are there any under construction. Recently, some private companies have applied for water licenses in support of future pumped storage developments.

2.6 DEVELOPMENT SCHEDULE

Conceptual development schedules were prepared for each pumped storage type, and are shown on Figure 2.1. It should be noted that the development schedule for each particular pumped-storage alternative can be expected to vary significantly. The schedules shown on Figure 2.1 aim to show the differences in development timelines between the different pumped-storage types, and are not applicable to any particular site.

Some of the key differences in development schedules between the three pumped storage types are:

- Saltwater pumped storage may have longer lead time on equipment and materials due to anti-corrosion requirements, permitting period extended since no projects have been completed to date in Canada or the USA; and
- Underground pumped storage has a longer timeline due to increased geotechnical investigations, longer construction timeline, potential challenges in permitting, and longer technical studies due to lack of worldwide experience (i.e. no reference projects built to date, and therefore likely extended due diligence requirements by financiers).

2.7 CLOSED VERSUS OPEN SYSTEMS

A “closed” pumped storage project refers to a design where the water used for generation and pumping is in a hydraulically closed loop. There are no (or minimal) inflows or discharges from either the upper or lower reservoir beyond seepage, evaporation, sublimation and direct rainfall.

An “open” pumped storage project refers to a design where a portion of the water used in generation or pumping comes from either natural runoff, or sources beyond the storage of the upper and lower reservoirs. Some of the following scenarios can be considered “open” systems:

- A pumped-storage plant that is integrated into an existing traditional hydroelectric plant
- A pumped-storage plant where either reservoir receives a significant portion of inflow from natural basin runoff, and
- A pumped-storage plant where either reservoir draws from or discharges to a natural lake or an existing river system.

Some "open" pumped storage projects can be converted to "closed" systems by constructing diversions around both the upper and lower reservoirs, similar to those used in tailings ponds in the mining industry. This hydraulically isolates each reservoir, and thus "closes" the system by eliminating external inflows.

Knight Piésold
CONSULTING

SECTION 3.0 - SCREENING ASSESSMENT

3.1 SCREENING CONSTRAINTS

3.1.1 Spatial Limitations

The study area was limited to the Lower Mainland and Vancouver Island, defined as the area south of latitude 51°N and west of longitude 121°W. Within this study area, the following spatial limitations apply:

- Terrestrial parks and reserve areas will be EXCLUDED from the study area
- Marine parks will be INCLUDED in the study area
- Private land will be INCLUDED in the study area, and
- Indian Reserves will be INCLUDED in the study area.

A summary of the study area is shown on Figure 3.1.

3.1.2 Limitations on Generation Capacity

The original project terms of reference called for the identification of projects capable of generating a peak capacity of at least 100 MW. Due to the suspected large number of potential sites, this generating capacity threshold was increased to 1,000 MW for the Lower Mainland, and 500 MW for Vancouver Island, with the idea that should inadequate sites be found, the generation capacity threshold criteria would be lowered.

3.1.3 Minimum Storage Requirements

The minimum storage requirements for each pumped-storage facility was set at 6,000 MWh (the amount of water required for 6 hours of generation at 1000 MW capacity) for the Lower Mainland, and 3,000 MWh (the equivalent storage of 6 hours of generation at 500 MW capacity) for the 500 MW sites on Vancouver Island. The volume of water required to store this amount of energy varies by project, depending on the available head.

3.1.4 Environmental Limitations

Salmon bearing rivers were excluded from the study. The Fish Information Summary System (FISS) from the BC Ministry of Environment was used as the basis for known fish distribution data. Rivers with historical observances of Chinook, Sockeye, Chum, Coho, Pink and/or Steelhead were not considered in the screening assessment.

It should be noted that lakes and rivers with historical observations of Kokanee Salmon were not excluded from the study area, as several existing BC Hydro reservoirs contain this salmon species. Historical observances of any other fish species other than those listed above were ignored in the assessment.

Existing lakes with historical observances of Salmon were included in the assessment. However, these lakes were labelled as being salmon bearing in the assessment results. A summary of the fish distribution data for the salmon species mentioned above are shown on Figure 3.2.

For the saltwater pumped storage screening assessment this constraint was ignored.

3.1.5 Technical Constraints

As per the terms of reference, projects with a maximum real levelized cost greater than $200/kW-year were to be excluded from the assessment. Since a cost estimate could not be completed until a potential site had been identified, additional constraints were necessary to eliminate un-attractive sites prior to completing project capital cost estimates.

In order to determine the real levelized cost ($/kW-year), the following was assumed:

- Design Life = 70 years, and
- Discount Rate = 6%.

Freshwater Lake-to-Lake Sites

The abundance of small lakes in combination with the steep topography, give south-western British Columbia a high potential for freshwater pumped-storage development. Due to this large potential, sites with the most attractive characteristics were targeted. These characteristics included:

- Existing lakes within a 5 km horizontal distance that could be used as an upper and lower reservoir respectively (i.e. waterway length is limited to approximately 5 km or less). In some instances, lakes with horizontal distances greater than 5 km were considered.
- Existing lakes with the capability of storing 6,000 MWh (or 3,000 MWh for the 500 MW sites on Vancouver Island) by constructing a maximum dam height of 20 m. In some instances, maximum dam heights exceeding 20 m were considered. Since no bathymetry data was obtained for the lakes in the study area, the depth-area-capacity curve for each lake could not be determined. As such, all storage was assumed to be constructed above the natural lake water level, with the following exceptions:
    - For BC Hydro reservoirs, lake drawdown was accepted, since existing operations draw down most reservoirs
    - For drinking water reservoirs, lake drawdown was accepted, since existing operations draw down most reservoirs, and
    - For large existing lakes, where the draw down would be minimal, draw down was accepted.

Freshwater "Crow's Nest" Sites

As historical developments have shown, existing lakes or reservoirs are not a pre-requisite for a successful pumped-storage development. Some reservoirs are created through the construction of a dam in an incised valley, or even by constructing perimeter dams on flat ground or around

Knight Piésold
CONSULTING

natural depressions (i.e. “Crow’s nest” sites). Since the combinations of dam locations and geometries are limitless, it was necessary to apply some screening constraints.

The same constraints were used for the identification of freshwater “Crow’s nest” sites, including the 5 km maximum waterway length, the ability to store either 6,000 MWh (1000 MW sites) or 3,000 MWh (500 MW sites) by constructing a maximum embankment height of 20 m. In some instances, these constraints were exceeded. The same drawdown constraints were also applied.

Saltwater Pumped Storage Sites

The same constraints for the freshwater “Crow’s nest” sites were applied to the screening assessment of saltwater pumped storage sites. Additionally, freshwater lakes were not considered as upstream reservoirs, due to the high environmental impact of pumping saltwater into a freshwater ecosystem. In some instances, upstream reservoirs were proposed in areas that contained either wetland or small ponds. Since it is difficult to determine at what size threshold this may not be permissible, a certain amount of judgement was required to satisfy this constraint.

Underground Pumped-Storage Sites

Due to the potentially smaller surface footprint of an underground pumped storage project, potential sites could potentially be located anywhere (though proximity to load centres, geological conditions and available spoil areas may drive site selection). To make the sites economically competitive however, they would potentially need to utilize existing underground caverns (such as those in abandoned underground mines) to save the costly expense of excavating a large cavern. Site identification was therefore limited to searches of active and abandoned underground mines in the study area.

3.1.6 Other Limitations and Constraints

- Existing BC Hydro reservoirs were INCLUDED in the study area, and
- Drinking water reservoirs were INCLUDED in the study area.

The potential impact of a potential pumped storage project on existing BC Hydro reservoirs and drinking water reservoirs was considered beyond the scope of this study.

3.2 SCREENING ASSESSMENT RESULTS

3.2.1 Freshwater Site Identification

Freshwater pumped-storage sites were identified using a combination of an automated GIS search, and a visual assessment. For the automated GIS search, KPL developed a pumped-storage assessment tool, which identified existing lakes that could be developed into pumped storage projects while meeting the constraints listed in Section 3.1. These constraints could be varied in order to identify projects of different characteristics. The tool analyzes a pair of existing lakes by extracting their elevation, area and proximity. It then calculated whether their head differential and surface area were sufficient to meet the characteristics of the constraints mentioned in Section 3.1.

As mentioned in Section 3.1, sites were also identified by visual assessment of the areas in the vicinity of the largest existing lakes and BC Hydro reservoirs. The visual assessment was conducted by examining digital TRIM and NTS mapping for incised valleys or plateaus surrounding largest freshwater lakes in the study area. Sites were flagged and then characterised in the same manner as the sites identified using the automated GIS search (discussed in Section 3.2.4). A summary of the results are shown in Table 3.1. Similarly, the identified sites can be seen on Figure 3.3.

The sites listed in the above tables are considered the most attractive sites in the study area, and range in gross head from 42 m to 1590 m. Many of the identified sites in the Lower Mainland area are clustered around existing lakes and BC Hydro reservoirs, as the larger lower reservoir in many cases eliminated the need for construction of a lower impoundment, thus making the projects more economically viable. Further, the large lower reservoir provides adequate storage for projects of ranging gross head.

3.2.2 Saltwater Site Identification

Saltwater pumped-storage sites were identified through a visual assessment of the coastline for high-elevation depressions, incised valleys and/or plateaus. Utilizing existing lakes as upper reservoirs was not deemed suitable for site identification, since the environmental impacts of pumping saltwater into an existing freshwater lake were deemed too great.

The potential saltwater sites identified ranges in gross head from 180 m to 1670 m. The majority of the saltwater pumped storage sites are located in the Lower Mainland, since coastal Vancouver Island contains numerous coastal parks on the west coast, and lacks steep topography near the coastline on a large portion of the east coast.

The identified saltwater pumped storage sites are shown in Table 3.2 and Figure 3.4.

3.2.3 Underground Site Identification

Table 3.3 shows a list of current and historical underground mines in the project area. These sites are shown on Figure 3.5. The assessment of the feasibility of underground pumped storage at these active/abandoned underground mines is considered beyond the scope of this assessment.

In order to determine the cost competitiveness of a greenfield underground pumped storage project, KPL completed a cost estimate of a "generic" underground pumped storage plant with the following characteristics:

- The upper reservoir would consist of an existing lake with adequate storage (6,000 MWh), therefore eliminating the requirement to construct a reservoir

- New underground lower reservoir (no existing underground cavern or abandoned underground mine considered) corresponding to a volume of 6,000 MWh of storage, and
- Gross head = 750 m. This gross head was selected because it is approximately equal to the highest achievable gross head of single-stage reversible pump turbines.

The estimated cost of such a "generic" development, which was considered to have very favourable characteristics, was approximately 230 $/kW-yr. Compared to the most attractive freshwater and saltwater alternatives identified in this study, underground pumped storage is not cost competitive in BC.

3.2.4 Site Characterisation and Costing

Each site was characterised in order to determine the project properties, which were then used as the basis of the cost estimate for each alternative. The main parameters of the characterisation include overall project parameters (gross head, design flow, capacity) reservoir parameters (required storage volume, reservoir area, embankment height and length, embankment volume), and waterway parameters (length, diameter, lining requirements). A summary of the parameters for each site is shown in Tables 3.1 and 3.2.

Cost estimates were prepared for each identified pumped storage alternative by developing a cost template of unit rates for project components. The unit rates used in the costing were based on experience from other recent projects, as well as budget quote information from pump/turbine suppliers. All costs are in 2010 dollars. The capital cost esimates do not include transmission, interconnection or access to the site. BC Hydro indicated to KPL that these costs would be determined by others, and should not be considered in this assessment.

The costs for each site are presented as loaded capital costs (based on the schedules presented in Figure 2.1, a discount rate of 6%, and a cost distribution as presented in Table 3.4). Cost per MW installed, cost per MWh stored, and levelized capital cost ($/kW-yr) were also determined. The costs for each site are summarized in Tables 3.1 and 3.2. As indicated, costs range from $77/kW-yr ($1.3 billion loaded capital cost) to $213/kW-yr ($3.3 billion loaded capital cost) for 1000 MW facilities. This is in the range of $1,300 to $3,300 per kW installed. A breakdown of the cost ranges is shown below:

- Freshwater Pumped Storage
  - 45 projects were identified less than $100 /kW-yr
  - 54 projects were identified between $100 – $125 /kW-yr
  - 9 projects were identified between $125 – $150 /kW-yr
  - 9 projects were identified between $150 – $175 /kW-yr, and
  - 4 projects were identified greater than $175 /kW-yr.
- Saltwater Pumped Storage
  - 6 projects were identified less than $100 /kW-yr
  - 31 projects were identified between $100 – $125 /kW-yr
  - 27 projects were identified between $125 – $150 /kW-yr
  - 7 projects were identified between $150 – $175 /kW-yr, and

Knight Piésold
CONSULTING

    - 2 projects were identified greater than $175 /kW-yr.
- Underground Pumped Storage
    - A favourable pumped storage project is anticipated to cost in the range of $230/kW-yr.

As mentioned previously, the costs above do not include transmission, interconnection or access to the site. As such, it would not be prudent to compare the above sites purely on a cost basis until these additional costs have been determined. Ultimately, the cost of transmission, interconnection and access will favour those sites closer to the load centres or major transmission lines in the Lower Mainland and Vancouver Island.

The cost breakdown varied by each project, but is summarized below as average percentages of the total estimated capital cost.

- Freshwater pumped storage
    - 17% - Mob, Demob, Insurance, Bonds, Overhead, Contractor's Profits
    - 6% - Permitting and Design
    - 24% - Generation equipment and switchyard (this ranged from 14%-30%, depending on the project)
    - 31% - Construction costs (this ranged from 25%-41%, depending on the project), and
    - 22% - Contingency.
- Saltwater Sites:
    - 17% - Mob, Demob, Insurance, Bonds, Overhead, Contractor's Profits
    - 6% - Permitting and Design
    - 27% - Generation equipment and switchyard (this ranged from 15%-32%, depending on the project)
    - 28% - Construction costs (this ranged from 23%-40%, depending on the project), and
    - 22% - Contingency.

Operation and maintenance costs were also estimated for each site. These costs were described as a percentage of the total estimated capital cost (2010 dollars) as follows:

- Freshwater pumped storage sites, 1000 MW – 1.0%
- Freshwater pumped storage sites, 500 MW – 1.5%, and
- Saltwater pumped storage sites, 1000 MW – 2.0 %.

3.3 PHOTOS AND SCHEMATICS OF TYPICAL PUMP STORAGE PROJECTS

Attached with this report are several schematics and photos of ‘typical’ developments as well as photos from recent KPL experience. A description of the photos/schematics and the applicability to this study are below.

Photo 1 is a schematic of a typical pumped storage scheme. The schematic could apply to both freshwater and saltwater pumped storage projects.

Photo 2 is a schematic of single-stage and multistage pump turbines. The single-stage pump turbine is applicable to the sites identified in this study that have a gross head approximately less than or equal to 750 m. The multistage pump turbine is applicable to sites with a gross head greater than 750 m.

Photo 3 is a schematic of a powerhouse where the pelton turbine is combined with a submersible pump. They are connected such that the two can be run simultaneously in order to be dispatched nearly instantaneously, such as for spinning reserve. Though not applicable to any particular project identified in this study, pumped storage facilities can be designed with this concept.

Photo 4 is a rendition of a three dimensional computer model of the underground works of a pumped-storage powerhouse. The schematic includes the powerhouse cavern, inlet valve hall, waterway tunnels, transformer gallery, surge chambers (pump mode) and access tunnels. This schematic is applicable to all sites identified in this study.

Photos 5 and 6 are applicable to all saltwater pumped storage projects. Photo 5 is an artistic rendition of the Spirit of Ireland Project, which KPL has been recently involved. Photo 6 is a photo of a physical model of the Okinawa Pumped Storage Plant in Japan. The cutaway shows the reservoir, tunnel, underground powerhouse and access shaft.

Photos 7 – 10 are from the Ingula Pumped Storage Scheme in South Africa, which KPL has been a part of the design team. The photos show the upper dam, intake tower, underground works and outlet structure during construction. This 1,334 MW project is similar in scale to a potential 1000 MW development in south western BC.

Photos 11 – 14 show different “Crow’s Nest” reservoirs from various projects around the world (USA, Japan and Czech Republic). These are applicable to the “Crow’s Nest” reservoirs that have been identified in this study.

SECTION 4.0 - CONCLUSIONS AND RECOMMENDATIONS

South-western British Columbia has a high technical potential for freshwater and saltwater pumped storage development, due to the steep topography and existence of hundreds of large natural lakes and man-made reservoirs. The vast coastline also yields a high potential for numerous saltwater pumped storage sites, especially near the Lower Mainland.

Approximately 194 sites were identified in the Lower Mainland and Vancouver Island, ranging from 500 MW to 1,000 MW in installed capacity as shown on Figure 3.6. Each site has the capability of storing the equivalent of 6 hrs at full output (3,000 MWh for a 500 MW site, and 6,000 MWh for a 1,000 MW site). Cost estimates were prepared for sites (at the plant gate, not including transmission, interconnection or access to the site), which ranged from $77/kW-year to $213/kW-yr. Within that range, projects were divided into the following levelized capital cost brackets:

Freshwater Pumped Storage
- 45 projects were identified less than $100 /kW-yr
- 54 projects were identified between $100 – $125 /kW-yr
- 9 projects were identified between $125 – $150 /kW-yr
- 9 projects were identified between $150 – $175 /kW-yr, and
- 4 projects were identified greater than $175 /kW-yr.

Saltwater Pumped Storage
- 6 projects were identified less than $100 /kW-yr
- 31 projects were identified between $100 – $125 /kW-yr
- 27 projects were identified between $125 – $150 /kW-yr
- 7 projects were identified between $150 – $175 /kW-yr, and
- 2 projects were identified greater than $175 /kW-yr.

Underground Pumped Storage
- A ‘typical’ underground pumped storage project is anticipated to cost in the range of $230/kW-yr.

Should BC Hydro wish to pursue further pumped storage potential in BC, KPL recommends the items below. KPL is aware that some of these items are already underway as a follow-up to this study.
- Estimate the costs of transmission, interconnection and access to each alternative identified above in order to meaningfully be able to compare each identified site
- Conduct a system-wide study to determine the benefits/impacts of integrating pumped storage into the BC Hydro grid
- Determine the ‘ideal’ characteristics of a pumped storage facility, in terms of providing the maximum benefits to the BC Hydro system, improving export opportunities and firming of renewable (especially wind power)
- Conduct a screening assessment for the remaining portions of the province, especially where there is a high resource potential of intermittent renewable energy sources such as wind, run-of-river hydro, solar, tidal and/or wave energy, and
- Conduct a more detailed assessment of the most favourable sites identified in this assessment.

Knight Piésold CONSULTING

SECTION 5.0 - REFERENCES

American Society of Civil Engineers. 1989. *Civil engineering guidelines for planning and designing hydroelectric developments.* Volume 5, Pumped Storage and Tidal Power. New York, NY: American Society of Civil Engineers.

American Society of Civil Engineers. 1993. *Compendium of Pumped Storage Plants in the United States.* New York, NY: American Society of Civil Engineers.

BC Hydro and Power Authority. 1977. *Pumped storage in British Columbia preliminary engineering assessment.*

BC Hydro. 1993. *Pumped storage in British Columbia*.

Deane, J.P., Ó Gallachóir, B.P. & McKeogh, E.J. (2010). Techno-economic review of existing and new pumped hydro energy storage plant. *Renewable and Sustainable Energy Reviews*, 14, 1293-1302.

Elizabeth A. Ingram. 2010. *Worldwide pumped storage activity.* Retrieved September 21, 2010, from www.hydroworld.com.

Klohn Crippen Consultants Ltd. 2001. *Review of Pumped Storage and Tidal Barrage Energy Generation.*

Task Committee on Pumped Storage. *Hydroelectric pumped storage technology international experience.* New York, NY: American Society of Civil Engineers.

Knight Piésold
CONSULTING

SECTION 6.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

NOV 30, 2010

Prepared:

Tom Furst, P.Eng.
Project Engineer

Reviewed:

Sam Mottram, P.Eng.
Specialist Hydropower Engineer

Approved:

Jeremy Haile, P.Eng.
President

Knight Piésold
CONSULTING

TABLE 2.1

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SUMMARY OF FRESHWATER PUMPED STORAGE SITES > 1000 MW WORLDWIDE

Print: 11/30/2010 10:25

ID	Station	Country	Location	Capacity (MW)
	FRESHWATER PUMPED STORAGE			
	Operating Projects			
1	Tumut-3	Australia		1,500
2	Coo Hydroelectric Power Station(fr)	Belgium	50°23'12" N 5°51'26" E	1,164
3	Sir Adam Beck Hydroelectric Power Stations	Canada	43°08'51" N 79°02'42" W	1,600
4	Bailianhe Hydroelectric Station	China		1,224
5	Baoquan Pumped Hydroelectric Station	China		1,200
6	Guangdong Pumped Storage Power Station	China	23°45'52" N 113°57'12" E	2,400
7	Heimifeng Pumped Storage Power Station	China		1,200
8	Huhhot Dam	China		1,200
9	Liyang Hydroelectric Power Station	China		1,000
10	Pushihe Pumped Storage Power Station	China		1,200
11	Taian Pumped Storage Power Station	China		1,000
12	Tianhuangping Pumped Storage Power Station	China		1,800
13	Tongbai Pumped Storage Station	China		1,200
14	Xiangshuijian Pumped Storage Station	China		1,000
15	Xianyou Pumped-storage Power Station	China		1,200
16	Xilongchi Pumped Storage Power Station	China		1,200
17	Yixing Pumped Storage Power Station	China		1,000
18	Zhanghewan Pumped Storage Station	China		1,000
19	Zhuhai Pumped Storage Station	China		1,800
20	Grand Maison Dam	France		1,070
21	Goldisthal Hydroelectric Power Station	Germany		1,060
22	Markersbach Dam	Germany		1,050
23	Tehri Pumped Storage Power Station	India	30°22'40" N 78°28'50" E	1,000
24	Siah Bisheh Dam	Iran		1,140
25	Chiotas Dam	Italy		1,184
26	Lago Delio Hydroelectric Station	Italy		1,040
27	Piastra Edolo Pumped Storage Station	Italy		1,020
28	Presenzano Pumped Storage Power Station	Italy		1,000
29	Imaichi Dam	Japan		1,050
30	Kazunogawa Dam	Japan		1,600
31	Matanoagawa Pumped Storage Station	Japan		1,200
32	Ohkawachi Pumped Storage Power Station	Japan		1,280
33	Okukiyotsu Pumped Storage Power Station	Japan		1,040
34	Okumino Pumped Storage Power Station	Japan		1,036
35	Okutataragi Pumped Storage Power Station	Japan		1,932
36	Okuyoshino Pumped Storage Power Station	Japan		1,206
37	Shimogo Pumped Storage Power Station	Japan		1,040
38	Shin Takasegawa Pumped Storage Station	Japan		1,280
39	Shintoyone Dam	Japan	35°07'33" N 137°45'38" E	1,125
40	Tamahara Pumped Storage Power Station	Japan		1,200
41	Kruonis Pumped Storage Plant	Lithuania	54°47'56" N 24°14'51" E	1,600
42	Vianden Pumped Storage Plant	Luxembourg		1,100
43	Kaishador Pumped Storage Station	Russia		1,600
44	Zagorsk Pumped Storage Station	Russia		1,200/1,320
45	Drakensberg Pumped Storage Scheme	South Africa	28°34'23" S 29°05'13" E	1,000
46	Ingula Pumped Storage Scheme	South Africa		1,332
47	Yangyang Pumped Storage Power Station	South Korea		1,000
48	Grande Dixence Dam	Switzerland	46°04'50" N 07°24'14" E	2,069
49	Minghu Dam	Taiwan		1,000
50	Mingtan Dam	Taiwan		1,602
51	Tashlyk Hydro-Accumulating Power Station	Ukraine		1,494
52	Dinorwig Power Station	United Kingdom	53°07'07" N 04°06'50" W	1,728
53	Bad Creek Hydroelectric Station	United States	35°0'40" N 83°0'52" W	1,065
54	Bath County Pumped Storage Station	United States	38°12'32" N 79°48'00" W	2,772
55	Blenheim-Gilboa Hydroelectric Power Station	United States	42°27'18" N 74°27'29" W	1,057
56	Castaic Dam	United States	34°31'09" N 118°36'25" W	1,566
57	Helms Pumped Storage Project	United States		1,200
58	Ludington Pumped Storage Power Plant	United States	43°53'37" N 86°26'43" W	1,872
59	Mount Elbert	United States		1,412
60	Muddy Run Pumped Storage Facility	United States	39°48'29" N 76°17'54" W	1,071
61	Northfield Mountain	United States	42°36'36" N 72°26'50" W	1,080
62	Pyramid Lake	United States	34°38'39" N 118°45'51" W	1,495
63	Raccoon Mountain Pumped-Storage Plant	United States	35°02'55" N 85°23'48" W	1,530
64	Rocky Mountain Hydroelectric Plant	United States	34°20'41" N 85°18'14" W	1,046
	Projects Under Construction			
1	Lima	South Africa		1,470
2	Dniester Pumped Storage Power Station U/C	Ukraine		2,268
3	Huizhou Pumped Storage Power Station U/C	China	23°16'07" N 114°18'50" E	2,400
4	Kannagawa Hydropower Plant U/C	Japan	36°00'18" N 138°39'09" E	2,820
5	Limmern Pumped Storage Project U/C	Switzerland		1,000
6	Jixi Pumped Storage Project	China		1,800
	SALTWATER PUMPED STORAGE			
1	Okinawa Seawater Pumped Storage Power Station	Japan		30

M:\1\03\00313\01\A\Data\Task 100 - Technology Review\[Table 2.1_PumpedStorageSites_greater_1000MW.xlsx]Sheet1

0	25NOV'10	ISSUED WITH REPORT VA103-313/1-1	TMF	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold
CONSULTING

TABLE 3.1

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SUMMARY OF FRESHWATER PUMPED STORAGE SITES

11/30/2010 16:14

Name	Latitude (dd mm ss.s)	Longitude (dd mm ss.s)	Latitude (dd.dddd)	Longitude (dd.dddd)	Capacity (MW)	Location (LM/VI)	Salt/Fresh	Pure/Mixed	FISS - Salmon Bearing (Y/N)	Drinking Water Reservoir (Y/N)	Type	Upper Reservoir Area (ha)	Upper Reservoir Base Elevation (masl)	Upper Reservoir Crest Length (m)	Upper Reservoir Dam Height (m)	Upper Reservoir Catchment Area (km2)	Approx Unit Runoff (l/s/km2)	% Contribution of Natural Inflow (%)	Lower Reservoir Area (ha)	Lower Reservoir Base Elevation (masl)	Lower Reservoir Dam Crest Length (m)
Alouette-Stave	N49 22 55.1	W122 18 13.8	49.38196	122.30383	1000	LM	Fresh	Mixed	N	N	Lake to Lake	1650.0	126	0	6.2	202	97	0.6%	5640	84	0
Antimony - John George	N50 07 50.5	W121 50 56.9	50.1307	121.84914	1000	LM	Fresh	Mixed	N	N	Lake to Lake	20.4	1867	350	20.9	2.2	50	0.1%	23.5	1120	400
Appleton	N49 57 00.2	W124 32 56.8	49.95005	124.54912	1000	LM	Fresh	Pure	N	Y	Man Made	30.0	440	1700	27.0	0.3	33	0.0%	12445	56	0
Battle - Fraser	N50 41 30.6	W126 19 38.0	50.69183	126.32722	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	115.0	319	500	12.9	6.2	67	0.1%	94	89	400
Battle - Loose	N50 45 00.9	W126 22 45.9	50.75025	126.37943	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	115.0	319	500	11.1	6.2	67	0.1%	283	44	300
Beavertail - Campbell	N50 00 42.9	W125 31 14.7	50.01191	125.52074	500	VI	Fresh	Mixed	N	Y	Lake to Lake	105.4	274	2300	16	6.4	49	0.0%	2435.9	179	0
Berkeley - Heydon	N50 33 21.7	W125 38 29.7	50.55603	125.64157	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	93.9	798	200	6.0	3.3	33	0.1%	813	36	0
Berkely - Glendale	N50 36 57.4	W125 38 15.1	50.61594	125.63753	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	93.9	798	200	6.2	3.3	33	0.1%	122	73	1200
Blinch - Stave	N49 26 18.7	W122 13 36.5	49.43853	122.22681	1000	LM	Fresh	Mixed	N	N	Lake to Lake	58.8	770	750	9.1	3.5	97	0.2%	5640	84	0
Bookhout - Great Central	N49 19 48.4	W125 06 14.6	49.3301	125.10405	1000	VI	Fresh	Pure	Y	N	Lake to Man Made	20.0	960	1585	18.6	0.2	132	0.0%	5301	95	0
Bookhout 2	N49 19 36.2	W125 03 33.1	49.32673	125.05919	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	20.0	800	1585	22.4	0.2	132	0.0%	5301	95	0
Boomerang - Hibbard	N51 02 04.3	W127 01 51.0	51.03452	127.03084	1000	LM	Fresh	Mixed	N	N	Lake to Lake	124.1	131	325	25.2	6.6	79	0.0%	255	31	700
Bradburn - Forbes1	N50 15 31.3	W124 28 37.6	50.2587	124.47712	1000	LM	Fresh	Mixed	N	N	Lake to Lake	49.2	1125	550	16.4	2.9	86	0.1%	130.5	720	225
Bradburn - Forbes2	N50 15 36.3	W124 27 32.8	50.26008	124.45912	1000	LM	Fresh	Mixed	N	N	Lake to Lake	49.2	1125	550	20.3	2.9	86	0.1%	56.9	806	650
Bradburn - Powell	N50 12 10.4	W124 24 15.9	50.2029	124.40441	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	49.2	1125	550	7.5	2.9	86	0.2%	12445	56	0
Burwell - Seymour	N49 26 50.7	W122 58 08.1	49.44741	122.96892	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	46.0	837	534	15.2	3.6	98	0.1%	262.6	364	0
Butchart - Goldstream	N48 30 52.5	W123 37 58.4	48.51458	123.6329	500	VI	Fresh	Mixed	N	Y	Lake to Lake	68.7	570	3000	21	3.2	36	0.0%	71.5	457	600
Butchart - Sooke	N48 33 59.2	W123 40 37.9	48.56644	123.6772	1000	VI	Fresh	Mixed	N	Y	Lake to Lake	67.8	570	500	13.0	3.2	36	0.0%	593.6	183	0
Camp Cove	N49 22 11.3	W121 50 21.9	49.36981	121.83941	1000	LM	Fresh	Mixed	Y	Y	Lake to Man Made	50.0	380	250	17.6	2.3	57	0.0%	22263	11	0
Carpenter - Seton	N50 43 51.3	W122 14 17.8	50.73091	122.23829	1000	LM	Fresh	Mixed	Y	Y	Lake to Lake	4672.0	909	0	2.1	3703	24	44.4%	2504	243	0
Centre - Lower Eldrid	N50 09 37.2	W124 08 34.8	50.16033	124.14301	1000	LM	Fresh	Mixed	N	N	Lake to Lake	17.7	1495	335	19.7	0.9	86	0.1%	17.9	575	533
Chickwat - Lower Tzoonie	N49 52 44.3	W123 37 17.9	49.87897	123.62164	1000	LM	Fresh	Mixed	N	N	Lake to Lake	68.2	1588	600	5.5	2.3	105	0.2%	19.3	369	300
Chusan - Daniels	N50 24 38.7	W124 18 08.0	50.41074	124.30223	1000	LM	Fresh	Mixed	N	N	Lake to Lake	79.9	1473	575	16.8	2.2	86	0.0%	183	1229	700
Chusan - Upper Powell	N50 24 37.5	W124 15 23.8	50.41041	124.2566	1000	LM	Fresh	Mixed	N	N	Lake to Lake	79.9	1473	580	18.6	2.2	86	0.0%	80.3	1256	520
Clover - Powell	N50 04 33.0	W124 28 58.5	50.07583	124.48293	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	61.2	133	750	63.1	10	33	0.0%	12445	56	0
Clowhom 1	N49 42 59.9	W123 32 30.4	49.71663	123.54177	1000	LM	Fresh	Pure	N	N	Lake to Man Made	8.8	841	915	43.7	1	105	0.1%	748.1	57	0
Comox 1	N49 35 16.7	W125 10 24.1	49.58796	125.17337	1000	VI	Fresh	Mixed	Y	Y	Lake to Man Made	20.0	920	1585	20.3	9.2	85	0.5%	2118	133	0
Deserted - Un-named	N50 10 07.2	W123 40 08.8	50.16866	123.66911	1000	LM	Fresh	Mixed	N	N	Lake to Lake	45.3	1531	330	8.1	2.9	86	0.2%	14.5	487	225
Dodd - Powell	N50 01 15.1	W124 19 44.0	50.02086	124.3289	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	722.0	186	350	5.1	63.6	33	0.2%	554.3	56	230
Dodd-Goat	N50 01 28.8	W124 17 47.4	50.02465	124.2965	1000	LM	Fresh	Mixed	N	N	Lake to Lake	722.0	186	700	5.1	63.6	33	0.2%	12445	56	0
Doran - Great Central	N49 20 32.5	W125 17 20.4	49.34237	125.289	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	67.3	676	1400	9.4	2.7	132	0.2%	5301	95	0
Doran Neighbour	N49 20 42.0	W125 15 50.5	49.34501	125.26404	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	15.7	876	1000	25.5	4.4	132	0.3%	5301	95	0
Elephant - Lois	N49 50 08.3	W124 14 39.1	49.83565	124.24419	1000	LM	Fresh	Mixed	Y	N	Lake to Man Made	22.0	907	1663	18.9	0.22	33	0.0%	2410	133	0
Elsie - Ash	N49 25 28.1	W125 06 25.0	49.42448	125.10695	500	VI	Fresh	Mixed	N	N	Lake to Lake	645.1	337	1000	4	238	43	2.0%	59.7	206	1400
Florence - Stave	N49 21 28.6	W122 19 00.9	49.35793	122.31691	1000	LM	Fresh	Mixed	N	N	Lake to Lake	32.4	370	2030	33.1	1.1	97	0.0%	5640.8	84	0
Freda	N49 54 33.9	W124 17 04.0	49.90941	124.28444	1000	LM	Fresh	Pure	N	N	Man Made	100.0	360	2300	16.7	1	33	0.0%	403.8	164	600
Frogpond - Powell	N50 01 41.4	W124 24 45.6	50.02816	124.41268	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	120.8	506	432	7.3	7.8	33	0.1%	12445	56	0
Gibson	N49 16 45.0	W125 11 55.1	49.27915	125.19865	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	15.0	1040	1373	21.0	0.15	108	0.0%	4238	32	0
Goat	N50 00 03.5	W124 29 25.9	50.00097	124.49053	1000	LM	Fresh	Pure	N	Y	Lake	40.0	640	1500	14.3	0.4	33	0.0%	12445	56	0
Goldstream - Sooke	N48 31 14.4	W123 41 50.2	48.52066	123.69728	1000	VI	Fresh	Mixed	N	Y	Lake to Lake	71.5	457	730	16.7	12.7	36	0.1%	593.6	183	1400
Goldstream - Sooke	N48 32 10.7	W123 41 50.2	48.5363	123.69728	500	VI	Fresh	Mixed	N	Y	Lake to Lake	71.5	457	800	9	12.7	36	0.2%	593.6	183	500
Griffin - Glendale	N50 36 53.8	W125 37 18.9	50.61495	125.6219	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	45.6	666	230	12.6	3.5	33	0.1%	122	73	1200
Gun - Downton	N50 49 58.2	W122 52 25.6	50.83282	122.87378	1000	LM	Fresh	Mixed	N	N	Lake to Lake	578.2	883	950	5.7	43	28	0.1%	2242.3	747	0
Gun-Carpenter	N50 52 40.5	W122 49 37.6	50.87792	122.8271	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	578.2	883	950	4.3	43	28	0.2%	4672	671	0
Haynon - Chochiwa	N50 06 01.0	W121 51 29.1	50.10029	121.85808	1000	LM	Fresh	Mixed	N	N	Lake to Lake	22.6	1801	400	20.0	2.1	50	0.1%	64.1	1095	485
Heather - Cowichan	N48 55 26.3	W124 26 59.0	48.92397	124.44971	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	31.8	990	300	13.0	0.9	75	0.0%	6229	164	0
Heather - Kissinger	N48 55 16.5	W124 28 52.2	48.92124	124.48117	500	VI	Fresh	Mixed	N	N	Lake to Lake	31.8	990	350	8	0.9	75	0.1%	12.5	192	1000
Henderson	N49 06 29.2	W125 05 15.5	49.1081	125.08763	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	40.0	560	2242	15.7	0.4	133	0.0%	1549	35	0
High Falls - Powell	N50 09 43.3	W124 21 27.0	50.16204	124.3575	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	40.2	1125	570	8.7	4.4	86	0.3%	12445	56	0
Holyoak - Holland	N48 56 39.3	W123 51 47.3	48.94424	123.86314	500	VI	Fresh	Mixed	N	N	Lake to Lake	21.1	1055	1130	19	1.2	55	0.0%	43.5	657	840
Irving - Uun-named	N49 37 39.7	W126 19 18.6	49.6277	126.32182	1000	VI	Fresh	Mixed	N	N	Lake to Lake	66.1	626	200	9.3	2.7	133	0.2%	34.2	33	150
Isabel - Pitt	N49 29 36.6	W122 34 16.2	49.4935	122.57116	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	32.0	617	300	20.6	2.4	118	0.1%	5339	134	0
Kaipit - Zeballos	N50 05 06.9	W126 44 42.5	50.08524	126.74515	1000	VI	Fresh	Mixed	N	N	Lake to Lake	98.5	550	200	15.5	14.9	133	0.3%	198.5	333	300
Keary - Carpenter	N50 50 03.5	W122 28 16.5	50.83431	122.47125	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	87.3	1759	200	5.0	20.9	7	0.1%	4672	671	0
Kenyon - Stave	N49 24 09.0	W122 16 20.0	49.40249	122.27222	1000	LM	Fresh	Mixed	N	N	Lake to Lake	27.8	659	440	20.0	2.4	97	0.1%	5640.8	84	0
Knight - Fourth	N49 04 11.6	W124 25 00.5	49.06988	124.41682	500	VI	Fresh	Mixed	N	N	Lake to Lake	15	855	320	20	2.1	78	0.1%	200.9	323	260
Lake of the Mountains - Georgie	N50 45 35.4	W127 44 08.5	50.75982	127.73569	1000	VI	Fresh	Mixed	N	N	Lake to Lake	180.0	309	690	20.6	15.8	62	0.1%	465.1	223	550
Lewis - Dodd	N49 57 21.8	W124 19 00.4	49.95607	124.31679	1000	LM	Fresh	Mixed	N	N	Lake to Lake	90.3	414	500	16.0	18.9	33	0.1%	722	186	550
Lewis - Horseshoe	N49 55 16.1	W124 18 06.0	49.92114	124.30166	1000	LM	Fresh	Mixed	N	N	Lake to Lake	90.3	414	500	14.7	18.9	33	0.1%	403.8	164	600
Lewis - Nanton	N49 55 05.3	W124 19 49.7	49.91815	124.33046	1000	LM	Fresh	Mixed	N	N	Lake to Lake	90.3	414	500	15.0	18.9	33	0.1%	105.4	169	500
Lookout - Harrison	N49 24 49.7	W121 45 56.0	49.41381	121.76556	1000	LM	Fresh	Mixed	Y	Y	Lake to Lake	10.7	1377	1000	21.7	0.4	57	0.0%	22263	11	0
Loquilts - Un-named	N50 11 12.6	W123 40 58.6	50.18683	123.68295	1000	LM	Fresh	Mixed	N	N	Lake to Lake	47.1	1346	400	18.5	4	86	0.1%	58.2	975	230
Marshall - Carpenter	N50 53 24.3	W122 36 19.5	50.89009	122.60541	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	63.2	1146	275	11.6	21.1	28	0.2%	4672	671	0
McVey- Khartoum	N49 54 02.6	W124 05 28.0	49.90073	124.09111	1000	LM	Fresh	Mixed	N	N	Lake to Lake	91.0	920	370	6.0	3.3	86	0.2%	482.3	133	0
Mystery - Harrison	N49 31 41.8	W121 53 13.8	49.52829	121.88717	1000	LM	Fresh	Mixed	Y	Y	Lake to Man Made	19.5	380	400	42.0	18.3	57	0.3%	22263	11	0
Nimpkish 1	N50 30 10.4	W127 01 25.1	50.5029	127.02365	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	15.1	975	1380	22.0	0.15	67	0.0%	3814	25	0
Nimpkish 2	N50 21 16.8	W126 55 51.0	50.35467	126.93085	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	40.0	900	2242	10.2	0.4	67	0.0%	3814	25	0
North Bonanza	N50 22 50.8	W126 46 44.2	50.38078	126.77893	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	40.0	622	500	22.5	10.3	67	0.2%	915	271	0
North Harrison	N49 44 47.3	W122 07 00.8	49.74647	122.11689	1000	LM	Fresh	Mixed	Y	Y	Lake to Man Made	4.2	1601	530	45.1	1.1	57	0.1%	22263	11	0
North Henderson	N49 07 14.5	W125 05 24.4	49.1207	125.09012	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	45.7	460	400	16.8	4.1	133	0.2%	1549	35	0
Oliphant - Shawnigan	N48 36 00.4	W123 37 23.1	48.60012	123.62309	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	21.5	421	1600	46.2	2.8	44	0.0%	541	118	0
Palisade - Seymour	N49 26 43.3	W122 58 16.1	49.44537	122.97113	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	56.3	895	70	11.6	2.4	98	0.1%	262.6	364	0
Peneplain - Coquitlam	N49 26 06.2	W122 45 32.2	49.43505	122.75894	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	28.2	967	400	14.5	2.1	130	0.2%	1199.6	152	0
Pointer - Hornet	N50 46 30.0	W126 26 05.2	50.77501	126.43477	1000	LM	Fresh	Mixed	N	N	Lake to Lake	75.0	411	200	12.5	2.3	79	0.0%	44.7	46	160
Pointer - Loose	N50 45 30.9	W126 23 20.7	50.7586	126.38908	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	75.0	411	450	12.5	2.3	67	0.0%	283	44	300
Potato - Un-named	N50 09 05.5	W123 41 17.9	50.15154	123.68829	1000	LM	Fresh	Mixed	N	N	Lake to Lake	23.7	1038	1000	17.4	6	86	0.3%	103.9	248	600
Powell 1	N50 00 29.4	W124 33 48.6	50.00817	124.5635	1000	LM	Fresh	Pure	N	Y	Lake to Man Made	100.0	1000	980	5.0	1.7	86	0.1%	12445	56	0
Powell 2	N49 59 52.7	W124 33 49.5	49.99797	124.56374	1000	LM	Fresh	Pure	N	Y	Lake to Man Made	60.0	840	835	8.1	1.6	86	0.1%	12445	56	0
Powell 3	N50 03 04.1	W124 31 59.0	50.05115	124.53304	1000	LM	Fresh	Pure	N	Y	Lake to Man Made	21.7	720	1650	22.0	21.7	86	0.9%	12445	56	0
Powell 4	N50 06 32.6	W124 25 54.0	50.10906	124.43166	1000	LM	Fresh	Mixed	N	Y	Lake to Man Made	18.3	728	460	25.4	3.9	86	0.2%	12445	56	0
Powell 5	N50 00 36.0	W124 22 33.8	50.01001	124.37605	1000	LM	Fresh	Mixed	N	Y	Lake to Man Made	26.5	493	915	26.9	5.4	86	0.2%	12445	56	0
Pretty Girl - Ellen	N49 27 52.8	W126 13 09.2	49.46465	126.21922	1000	VI	Fresh	Mixed	N	N	Lake to Lake	141.2	317	250	10.4	17.4	133	0.4%	95.9	74	300
Quimper - Bulson	N49 18 41.0	W125 43 22.6	49.31139	125.72295	500	VI	Fresh	Mixed	N	N	Lake to Lake	18.6	739	800	18	1.3	121	0.1%	33.3	261	225
Salsbury - Stave	N49 21 34.0	W122 16 28.9	49.35944	122.2747	1000	LM	Fresh	Mixed	N	N	Lake to Lake	78.3	431	1200	12.6	3.9	97	0.1%	5640	84	0
Sechelt - Henriette	N49 40 24.8	W123 20 21.0	49.67354	123.33917	1000	LM	Fresh	Mixed	N	N	Lake to Lake	111.3	1183	1800	9.7	4	105	0.1%	56.9	847	400
Skwim - Freda	N50 00 25.8	W124 08 56.2	50.00716	124.14894	1000	LM	Fresh	Mixed	N	N	Lake to Lake	26.6	1275	700	18.7	1.8	86	0.1%	60.1	627	400
Sliammon - Powell	N49 56 16.3	W124 32 48.9	49.93787	124.54691	1000	LM	Fresh	Mixed	Y	Y	Lake to Lake	175.8	126	575	25.4	43.4	33	0.1%	12445	56	0
Slippery - Clowhom	N49 44 35.5	W123 28 15.5	49.74318	123.47097	1000	LM	Fresh	Mixed	N	N	Lake to Lake	11.3	1332	450	22.0	1	105	0.1%	748.1	57	0
Slollicum - Harrison	N49 24 08.6	W121 45 34.0	49.40238	121.75946	1000	LM	Fresh	Mixed	Y	Y	Lake to Lake	26.0	1258	200	10.9	1.6	57	0.1%	22263	11	0
Stukolait - Chochiwa	N50 06 05.1	W121 51 29.0	50.10141	121.85805	1000	LM	Fresh	Mixed	N	N	Lake to Lake	67.3	1435	850	14.6	13.8	50	0.2%	64.1	1095	425
Tsable - Comox	N49 34 04.8	W125 10 07.3	49.56801	125.16869	1000	VI	Fresh	Mixed	Y	Y	Lake to Man Made	65.0	1017	250	7.0	2.6	68	0.1%	2118	133	0
Tsable - Nimnim	N49 30 02.7	W125 09 16.3	49.50075	125.15452	1000	VI	Fresh	Mixed	N	N	Lake to Lake	65.0	1017	520	10.1	2.6	68	0.1%	44	469	900
Tsable - Willemar	N49 30 57.3	W125 10 34.5	49.51591	125.17625	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	65.0	1017	350	8.1	2.6	68	0.1%	86.1	291	420
Twin Lakes - Stave	N49 21 31.7	W122 16 24.9	49.35881	122.27358	1000	LM	Fresh	Mixed	N	N	Lake to Man Made	25.0	485	1772	30.7	0.25	84	0.0%	5640	84	0
Tyaughton - Carpenter	N50 54 24.6	W122 44 18.7	50.90683	122.73853	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	95.7	1006	250	11.0	14.2	28	0.1%	4672	671	0
Un-named - Effingham	N49 09 57.6	W125 16 32.6	49.16601	125.27571	1000	VI	Fresh	Mixed	N	N	Lake to Lake	23.2	1135	560	18.1	0.7	108	0.0%	31.5	366	522
Un-named - Goat	N50 04 44.8	W124 13 20.4	50.07911	124.22232	1000	LM	Fresh	Mixed	N	N	Lake to Lake	37.5	1127	500	9.2	4.2	86	0.3%	554.3	56	0
Un-named - Hesquiat	N49 30 57.2	W126 23 28.4	49.5159	126.39124	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	33.3	536	230	18.3	2.2	133	0.1%	477.8	7	0
Un-named - Huaskin	N50 58 45.5	W126 55 06.2	50.97931	126.9184	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	105.0	206	700	19.5	6.1	67	0.0%	2146	49	0
Un-Named - Powell	N50 14 35.8	W124 21 12.8	50.24329	124.35355	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	26.3	719	1700	18.5	1.8	86	0.1%	12445	56	0
Un-named - Stafford	N50 46 14.6	W125 26 14.1	50.77074	125.43726	1000	LM	Fresh	Mixed	N	N	Lake to Lake	14.2	1251	250	19.4	1.4	63	0.1%	249.4	85	300
Un-named - Tzoonie 1	N49 52 30.5	W123 37 17.1	49.87513	123.62141	1000	LM	Fresh	Mixed	N	N	Lake to Lake	24.1	1211	450	16.2	4.4	105	0.3%	19.3	369	220
Un-named - Tzoonie 2	N49 52 34.8	W123 37 05.0	49.87633	123.61804	1000	LM	Fresh	Mixed	N	N	Lake to Lake	22.0	1249	230	16.9	3.8	105	0.3%	19.3	369	250
Un-named - Uchuck	N49 02 09.6	W125 05 37.2	49.036	125.09366	500	VI	Fresh	Mixed	N	N	Lake to Lake	19.7	569	800	16	2.9	108	0.2%	115.1	44	310
Un-named - Zeballos	N50 04 57.7	W126 43 40.4	50.08269	126.72788	500	VI	Fresh	Mixed	N	N	Lake to Lake	25.7	727	600	16	2.5	133	0.2%	198.5	333	220
Upper Deserted - Un-named	N50 09 14.1	W123 41 08.3	50.15392	123.68565	1000	LM	Fresh	Mixed	N	N	Lake to Lake	58.5	975	225	8.8	12.2	86	0.6%	109.3	248	580
Upper Eldrid - Lower Eldrid	N50 09 20.4	W124 08 32.1	50.15566	124.14224	1000	LM	Fresh	Mixed	N	N	Lake to Lake	131.6	1347	700	4.8	3.7	86	0.2%	17.9	575	560
Upper Elsie	N49 26 29.5	W125 10 00.4	49.44152	125.16677	1000	VI	Fresh	Pure	Y	N	Lake to Man Made	20.0	720	1350	39.6	1.1	43	0.0%	645	337	0
Upper Great Central	N49 22 39.4	W125 13 34.4	49.37762	125.22621	1000	VI	Fresh	Pure	Y	N	Lake to Man Made	20.0	900	830	19.9	1	132	0.1%	5301	95	0
Upper Misery - Lower Misery	N49 45 20.9	W123 36 07.1	49.75581	123.60197	1000	LM	Fresh	Mixed	N	N	Lake to Lake	45.4	1273	280	12.8	2.5	105	0.1%	16.5	688	360
Upper Misery - Un-named	N49 48 35.2	W123 35 05.3	49.80977	123.58479	1000	LM	Fresh	Mixed	N	N	Lake to Lake	45.4	1273	360	17.8	2.5	105	0.1%	59	871	600
Upper Quinsam - Upper Campbell	N49 52 04.4	W125 38 01.7	49.8679	125.63381	1000	VI	Fresh	Mixed	N	N	Lake to Lake	504.6	369	350	7.5	69.2	35	0.2%	3046.7	266	0
Upper Tzoonie - Lower Tzoonie	N49 52 54.8	W123 36 52.1	49.8819	123.61448	1000	LM	Fresh	Mixed	N	N	Lake to Lake	23.3	1346	218	14.6	3.1	105	0.2%	19.3	369	250
Upper Vancouver - Lower Vancouver	N49 54 39.1	W123 44 08.4	49.91085	123.73566	1000	LM	Fresh	Mixed	N	N	Lake to Lake	34.4	1626	420	17.5	1.2	105	0.1%	39.9	1085	285
View - Great Central	N49 22 10.8	W125 21 42.4	49.36966	125.36177	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	101.0	310	825	15.3	8.3	132	0.2%	5301	95	0
Walt - Khartoum	N49 53 29.6	W124 05 57.6	49.89156	124.09933	1000	LM	Fresh	Mixed	N	N	Lake to Lake	38.2	971	290	11.0	3.9	86	0.2%	482.3	133	0
Wilson - Chehalis	N49 25 52.6	W122 02 18.7	49.43127	122.03853	1000	LM	Fresh	Mixed	Y	N	Lake to Lake	38.2	821	400	14.6	3.5	99	0.2%	629.6	221	0
Windsor - Goat	N50 01 35.5	W124 17 31.1	50.02653	124.29197	1000	LM	Fresh	Mixed	N	N	Lake to Lake	96.2	202	375	22.5	10.9	86	0.1%	554.3	56	120
Windsor - Powell	N50 01 23.9	W124 19 23.9	50.0233	124.32332	1000	LM	Fresh	Mixed	N	Y	Lake to Lake	96.2	202	375	22.5	10.9	86	0.1%	12445	56	0
Woss 1	N50 06 52.0	W126 35 58.7	50.11445	126.59965	1000	VI	Fresh	Mixed	Y	N	Lake to Man Made	25.0	763	1772	20.7	2	133	0.1%	1404	148	0
Woss 2	N50 08 37.4	W126 37 05.8	50.14372	126.61827	1000	VI	Fresh	Mixed	Y	N	Lake to Lake	14.5	969	460	26.2	1.4	133	0.1%	1404	148	0

Name	Lower Reservoir Drawdown (if no additional lower dam) (m)	Lower Reservoir Dam Height (m)	Storage Requirement (m3)	Storage Requirement (MWh)	2D Waterway Length (m)	Gross Head (m)	H/L Ratio (%)	Design Flow (Generation) (m3/s)	Design Flow (Pumping), 70% of Generation Flow (m3/s)	Pump/Turbine Type	Pumping Duration at Peak Output (hrs)	Generation Duration at Peak Output (hrs)	Development and Construction Time (years)	Total Estimated Capital Cost ($)	Loaded Capital Cost ($)	Unit Cost of Capacity (Loaded Capital Cost/Capacity) ($/MW)	Unit Cost of Stored Energy ($/MWh)	Levelized Cost ($/kW-yr)	Estimated Annual Operating Cost ($/yr)	Upper Reservoir Footprint (ha)	Upper Dam Footprint (ha)	Lower Reservoir Footprint (ha)	Lower Dam Footprint (ha)	Staging/Lay down Footprint (ha)	Spoil Footprint (ha)	Roads Footprint (ha)	Total Footprint (ha)
Alouette-Stave	1.22	0.0	68,528,941	6,000	1400	42	3%	3173	2221	Single-Stage	8.6	6	8	2,659,319,370	3,022,162,689	3,022,163	503,694	184.5	26,593,194	12.0	0.0	6.5	0.0	6.0	9.0	2.1	35.6
Antimony - John George		18.4	3,853,033	6,000	4400	747	17%	178	125	Multi-Stage	8.6	6	8	1,287,477,562	1,463,143,800	1,463,144	243,857	89.3	12,874,776	6.5	1.5	6.0	1.5	6.0	6.5	7.5	35.4
Appleton	0.06	0.0	7,495,353	6,000	500	384	77%	347	243	Single-Stage	8.6	6	8	1,708,452,145	1,941,557,071	1,941,557	323,593	118.5	17,084,521	10.5	9.1	0.5	0.0	6.0	4.6	3.8	34.5
Battle - Fraser		15.3	12,513,980	6,000	3600	230	6%	579	406	Single-Stage	8.6	6	8	1,669,431,377	1,897,212,225	1,897,212	316,202	115.8	16,694,314	8.4	1.4	9.4	1.3	6.0	6.5	5.4	38.5
Battle - Loose		5.7	10,466,238	6,000	2800	275	10%	485	339	Single-Stage	8.6	6	8	1,514,326,226	1,720,944,189	1,720,944	286,824	105.0	15,143,262	7.0	1.3	4.4	0.5	6.0	6.0	4.2	29.4
Beavertail - Campbell	0.62	3	15,148,503	3,000	3000	95	3%	701	491	Single-Stage	8.6	6	8	1,532,625,828	1,741,740,629	3,483,481	580,580	212.6	22,989,387	10.7	8.0	2.2	0.0	6.0	6.4	4.5	37.8
Berkeley - Heydon	0.46	0.0	3,777,186	6,000	4400	762	17%	175	122	Multi-Stage	8.6	6	8	1,530,735,876	1,739,592,808	1,739,593	289,932	106.2	15,307,359	2.8	0.3	0.9	0.0	6.0	6.5	7.6	24.1
Berkely - Glendale		5.3	3,969,952	6,000	4100	725	18%	184	129	Multi-Stage	8.6	6	8	1,241,851,041	1,411,291,898	1,411,292	235,215	86.1	12,418,510	2.9	0.3	2.6	1.9	6.0	6.3	7.3	27.2
Blinch - Stave	0.07	0.0	4,195,649	6,000	3900	686	18%	194	136	Single-Stage	8.6	6	8	1,172,117,948	1,332,044,270	1,332,044	222,007	81.3	11,721,179	3.9	1.7	0.4	0.0	6.0	6.2	6.9	25.1
Bookhout - Great Central	0.06	0.0	3,327,417	6,000	1900	865	46%	154	108	Multi-Stage	8.6	6	8	1,482,621,375	1,684,913,460	1,684,913	280,819	102.8	14,826,214	20.0	6.2	0.3	0.0	6.0	5.1	8.7	46.3
Bookhout 2	0.08	0.0	4,082,575	6,000	1300	705	54%	189	132	Multi-Stage	8.6	6	8	1,242,218,115	1,411,709,056	1,411,709	235,285	86.2	12,422,181	20.0	7.2	0.4	0.0	6.0	4.8	7.1	45.5
Boomerang - Hibbard		13.3	28,782,155	6,000	2700	100	4%	1333	933	Single-Stage	8.6	6	8	2,116,492,164	2,405,270,958	2,405,271	400,878	146.8	21,164,922	19.0	1.6	12.9	2.1	6.0	7.1	4.1	52.8
Bradburn - Forbes1		7.4	7,106,705	6,000	2400	405	17%	329	230	Single-Stage	8.6	6	8	1,308,310,674	1,486,819,428	1,486,819	247,803	90.7	13,083,107	7.4	1.9	4.4	0.4	6.0	5.6	4.1	29.9
Bradburn - Forbes2		17.9	9,022,619	6,000	3000	319	11%	418	292	Single-Stage	8.6	6	8	1,467,173,266	1,667,357,577	1,667,358	277,893	101.8	14,671,733	9.5	2.3	8.8	2.4	6.0	6.0	4.5	39.6
Bradburn - Powell	0.02	0.0	2,692,437	6,000	5900	1069	18%	125	87	Multi-Stage	8.6	6	8	1,443,854,009	1,640,856,590	1,640,857	273,476	100.1	14,438,540	2.8	1.1	0.2	0.0	6.0	7.2	10.7	27.9
Burwell - Seymour	2.32	0.0	6,085,022	6,000	2000	473	24%	282	197	Single-Stage	8.6	6	8	1,177,004,048	1,337,597,040	1,337,597	222,933	81.6	11,770,040	6.6	1.8	2.7	0.0	6.0	5.3	4.7	27.0
Butchart - Goldstream		20	12,735,467	3,000	2200	113	5%	590	413	Single-Stage	8.6	6	8	1,478,556,673	1,680,294,161	3,360,588	560,098	205.1	22,178,350	11.3	12.7	11.1	2.5	6.0	5.8	3.3	52.6
Butchart - Sooke	1.25	0.0	7,437,249	6,000	3100	387	12%	344	241	Single-Stage	8.6	6	8	1,387,278,584	1,576,561,892	1,576,562	262,760	96.2	13,872,786	6.6	1.4	2.2	0.0	6.0	5.9	4.7	26.8
Camp Cove	0.04	0.0	7,800,042	6,000	1100	369	34%	361	253	Single-Stage	8.6	6	8	1,256,556,724	1,428,004,056	1,428,004	238,001	87.2	12,565,567	50.0	0.9	0.4	0.0	6.0	4.9	3.7	65.9
Carpenter - Seton	0.17	0.0	4,321,645	6,000	4800	666	14%	200	140	Single-Stage	8.6	6	8	1,266,011,320	1,438,748,658	1,438,749	239,791	87.8	12,660,113	0.4	0.0	0.6	0.0	6.0	6.7	7.2	20.9
Centre - Lower Eldrid		19.5	3,128,495	6,000	2000	920	46%	145	101	Multi-Stage	8.6	6	8	1,391,533,757	1,581,397,649	1,581,398	263,566	96.5	13,915,338	5.7	1.4	5.6	2.1	6.0	5.2	9.2	35.2
Chickwat - Lower Tzoonie		14.2	2,361,128	6,000	3300	1219	37%	109	77	Multi-Stage	8.6	6	8	1,350,744,837	1,535,043,401	1,535,043	255,841	93.7	13,507,448	2.0	0.9	4.0	0.9	6.0	5.9	12.2	32.0
Chusan - Daniels		8.4	11,795,965	6,000	1300	244	19%	546	382	Single-Stage	8.6	6	8	1,359,238,252	1,544,695,675	1,544,696	257,449	94.3	13,592,383	9.6	2.0	6.2	1.5	6.0	5.3	2.4	33.1
Chusan - Upper Powell		18.5	13,263,666	6,000	3900	217	6%	614	430	Single-Stage	8.6	6	8	1,763,961,589	2,004,640,344	2,004,640	334,107	122.3	17,639,616	10.9	2.3	10.8	2.0	6.0	6.7	5.9	44.5
Clover - Powell	0.30	0.0	37,379,422	6,000	1400	77	6%	1731	1211	Single-Stage	8.6	6	8	2,315,865,787	2,631,847,552	2,631,848	438,641	160.6	23,158,658	38.6	8.7	2.4	0.0	6.0	7.0	2.1	64.8
Clowhom 1	0.49	0.0	3,671,193	6,000	2600	784	30%	170	119	Multi-Stage	8.6	6	8	1,629,436,549	1,851,760,415	1,851,760	308,627	113.0	16,294,365	8.8	7.6	1.0	0.0	6.0	5.5	7.8	36.7
Comox 1	0.17	0.0	3,657,199	6,000	2600	787	30%	169	119	Multi-Stage	8.6	6	8	1,838,362,374	2,089,192,534	2,089,193	348,199	127.5	18,383,624	20.0	6.6	0.6	0.0	6.0	5.5	7.9	46.6
Deserted - Un-named		21.0	2,756,911	6,000	5200	1044	20%	128	89	Multi-Stage	8.6	6	8	1,483,681,328	1,686,118,036	1,686,118	281,020	102.9	14,836,813	3.0	0.7	5.6	1.0	6.0	6.9	10.4	33.5
Dodd - Powell		6.0	22,140,119	6,000	4000	130	3%	1025	718	Single-Stage	8.6	6	8	2,059,005,858	2,339,941,095	2,339,941	389,990	142.8	20,590,059	5.9	0.5	6.7	0.4	6.0	7.3	6.0	32.8
Dodd-Goat	0.18	0.0	22,140,119	6,000	4000	130	3%	1025	718	Single-Stage	8.6	6	8	2,062,602,461	2,344,028,427	2,344,028	390,671	143.1	20,626,025	5.9	1.1	1.4	0.0	6.0	7.3	6.0	27.7
Doran - Great Central	0.09	0.0	4,953,899	6,000	2800	581	21%	229	161	Single-Stage	8.6	6	8	1,434,677,334	1,630,427,830	1,630,428	271,738	99.5	14,346,773	4.3	3.2	0.5	0.0	6.0	5.7	5.8	25.5
Doran Neighbour	0.07	0.0	3,685,295	6,000	2400	781	33%	171	119	Multi-Stage	8.6	6	8	1,532,982,746	1,742,146,246	1,742,146	290,358	106.3	15,329,827	15.7	5.1	0.4	0.0	6.0	5.4	7.8	40.4
Elephant - Lois	0.15	0.0	3,718,625	6,000	3600	774	22%	172	121	Multi-Stage	8.6	6	8	1,621,936,184	1,843,236,684	1,843,237	307,206	112.5	16,219,362	22.0	6.5	0.5	0.0	6.0	6.0	7.7	48.9
Elsie - Ash		20	10,985,555	3,000	3700	131	4%	509	356	Single-Stage	8.6	6	8	1,392,249,316	1,582,210,841	3,164,422	527,404	193.1	20,883,740	3.1	1.3	10.5	5.9	6.0	6.4	5.6	38.7
Florence - Stave	0.18	0.0	10,063,691	6,000	783	286	37%	466	326	Single-Stage	8.6	6	8	1,585,100,491	1,801,375,049	1,801,375	300,229	109.9	15,851,005	13.7	13.0	1.0	0.0	6.0	4.9	2.9	41.5
Freda		5.6	14,684,773	6,000	1000	196	20%	680	476	Single-Stage	8.6	6	8	1,618,132,689	1,838,914,232	1,838,914	306,486	112.2	16,181,327	10.7	8.2	5.2	1.0	6.0	5.3	2.0	38.3
Frogpond - Powell	0.05	0.0	6,396,034	6,000	2200	450	20%	296	207	Single-Stage	8.6	6	8	1,174,593,365	1,334,857,439	1,334,857	222,476	81.5	11,745,934	4.2	0.8	0.4	0.0	6.0	5.4	4.5	21.3
Gibson	0.07	0.0	2,855,373	6,000	5000	1008	20%	132	93	Multi-Stage	8.6	6	8	1,642,920,261	1,867,083,875	1,867,084	311,181	114.0	16,429,203	15.0	5.9	0.3	0.0	6.0	6.8	10.1	44.1
Goat	0.04	0.0	4,928,451	6,000	1500	584	39%	228	160	Single-Stage	8.6	6	8	1,540,626,770	1,750,833,237	1,750,833	291,806	106.9	15,406,268	5.7	4.7	0.3	0.0	6.0	5.0	5.8	27.5
Goldstream - Sooke		3.8	10,504,436	6,000	5000	274	5%	486	340	Single-Stage	8.6	6	8	1,687,352,588	1,917,578,645	1,917,579	319,596	117.0	16,873,526	9.1	2.6	3.1	1.8	6.0	7.1	7.5	37.2
Goldstream - Sooke		3	5,252,218	3,000	5900	274	5%	243	170	Single-Stage	8.6	6	8	1,171,784,965	1,331,665,855	2,663,332	443,889	162.6	17,576,774	4.5	1.8	1.5	0.6	6.0	7.3	8.9	30.5
Griffin - Glendale		6.0	4,853,652	6,000	3400	593	17%	225	157	Single-Stage	8.6	6	8	1,274,448,220	1,448,336,707	1,448,337	241,389	88.4	12,744,482	5.2	0.7	3.1	2.0	6.0	6.0	5.9	28.9
Gun - Downton	0.94	0.0	21,163,349	6,000	2500	136	5%	980	686	Single-Stage	8.6	6	8	1,789,345,069	2,033,487,202	2,033,487	338,915	124.1	17,893,451	6.3	1.5	3.2	0.0	6.0	6.5	3.8	27.2
Gun-Carpenter	0.29	0.0	13,576,488	6,000	1500	212	14%	629	440	Single-Stage	8.6	6	8	1,418,810,078	1,612,395,610	1,612,396	268,733	98.4	14,188,101	4.0	1.3	1.4	0.0	6.0	5.5	2.3	20.5
Haynon - Chochiwa		8.4	4,076,793	6,000	3400	706	21%	189	132	Multi-Stage	8.6	6	8	1,165,474,388	1,324,494,248	1,324,494	220,749	80.8	11,654,744	6.5	1.7	3.7	1.0	6.0	5.9	7.1	31.8
Heather - Cowichan	0.06	0.0	3,484,522	6,000	5500	826	15%	161	113	Multi-Stage	8.6	6	8	1,686,803,116	1,916,954,202	1,916,954	319,492	117.0	16,868,031	4.5	0.9	0.3	0.0	6.0	7.0	8.3	27.0
Heather - Kissinger		16	1,803,393	3,000	5300	798	15%	83	58	Multi-Stage	8.6	6	8	1,162,239,888	1,320,818,427	2,641,637	440,273	161.2	17,433,598	2.3	0.7	3.9	3.5	6.0	6.8	8.0	31.2
Henderson	0.35	0.0	5,482,315	6,000	1500	525	35%	254	178	Single-Stage	8.6	6	8	1,304,886,067	1,482,927,560	1,482,928	247,155	90.5	13,048,861	40.0	7.6	1.0	0.0	6.0	5.0	5.3	64.8
High Falls - Powell	0.02	0.0	2,692,437	6,000	3100	1069	34%	125	87	Multi-Stage	8.6	6	8	1,334,747,150	1,516,862,955	1,516,863	252,810	92.6	13,347,472	3.1	1.2	0.2	0.0	6.0	5.8	10.7	26.9
Holyoak - Holland		10	3,615,849	3,000	6100	398	7%	167	117	Single-Stage	8.6	6	8	1,187,997,225	1,350,090,151	2,700,180	450,030	164.8	17,819,958	5.9	4.5	4.0	2.0	6.0	7.3	9.2	38.9
Irving - Uun-named		16.2	4,853,652	6,000	3000	593	20%	225	157	Single-Stage	8.6	6	8	1,187,093,434	1,349,063,044	1,349,063	224,844	82.3	11,870,934	4.3	0.5	6.1	0.5	6.0	5.8	5.9	29.1
Isabel - Pitt	0.11	0.0	5,959,038	6,000	2200	483	22%	276	193	Single-Stage	8.6	6	8	1,270,704,182	1,444,081,824	1,444,082	240,680	88.1	12,707,042	7.9	1.3	0.6	0.0	6.0	5.4	4.8	26.0
Kaipit - Zeballos		8.7	13,263,666	6,000	5200	217	4%	614	430	Single-Stage	8.6	6	8	1,884,961,658	2,142,149,926	2,142,150	357,025	130.7	18,849,617	9.7	0.7	6.7	0.6	6.0	7.4	7.8	38.9
Keary - Carpenter	0.06	0.0	2,645,419	6,000	6800	1088	16%	122	86	Multi-Stage	8.6	6	8	1,568,330,180	1,782,316,560	1,782,317	297,053	108.8	15,683,302	2.0	0.3	0.3	0.0	6.0	7.7	10.9	27.2
Kenyon - Stave	0.09	0.0	5,005,592	6,000	2000	575	29%	232	162	Single-Stage	8.6	6	8	1,138,379,527	1,293,702,505	1,293,703	215,617	79.0	11,383,795	7.1	1.8	0.5	0.0	6.0	5.2	5.8	26.4
Knight - Fourth		3	2,705,090	3,000	5500	532	10%	125	88	Single-Stage	8.6	6	8	1,019,750,273	1,158,887,218	2,317,774	386,296	141.5	15,296,254	5.4	1.3	1.4	0.3	6.0	6.9	8.3	29.5
Lake of the Mountains - Georgie		9.2	33,467,622	6,000	3100	86	3%	1549	1085	Single-Stage	8.6	6	8	2,426,643,879	2,757,740,448	2,757,740	459,623	168.3	24,266,439	18.1	2.9	11.1	1.2	6.0	7.6	4.7	51.6
Lewis - Dodd		3.7	12,623,752	6,000	2500	228	9%	584	409	Single-Stage	8.6	6	8	1,477,806,676	1,679,441,833	1,679,442	279,907	102.5	14,778,067	9.7	1.7	3.3	0.7	6.0	5.9	3.8	31.1
Lewis - Horseshoe		4.9	11,512,862	6,000	5400	250	5%	533	373	Single-Stage	8.6	6	8	1,721,567,464	1,956,461,873	1,956,462	326,077	119.4	17,215,675	8.8	1.6	4.1	0.9	6.0	7.4	8.1	36.9
Lewis - Nanton		13.1	11,747,818	6,000	4600	245	5%	544	381	Single-Stage	8.6	6	8	1,667,889,464	1,895,459,930	1,895,460	315,910	115.7	16,678,895	9.0	1.6	8.3	1.5	6.0	7.0	6.9	40.2
Lookout - Harrison	0.01	0.0	2,107,039	6,000	3600	1366	38%	98	68	Multi-Stage	8.6	6	8	1,574,483,756	1,789,309,744	1,789,310	298,218	109.2	15,744,838	5.1	4.4	0.1	0.0	6.0	6.0	13.7	35.3
Loquilts - Un-named		15.3	7,757,993	6,000	4900	371	8%	359	251	Single-Stage	8.6	6	8	1,535,515,132	1,745,024,156	1,745,024	290,837	106.5	15,355,151	8.4	1.5	7.4	0.8	6.0	6.9	7.4	38.4
Marshall - Carpenter	0.13	0.0	6,059,401	6,000	3600	475	13%	281	196	Single-Stage	8.6	6	8	1,240,313,995	1,409,545,134	1,409,545	234,924	86.0	12,403,140	5.5	0.7	0.6	0.0	6.0	6.1	5.4	24.4
McVey- Khartoum	0.76	0.0	3,657,199	6,000	5700	787	14%	169	119	Multi-Stage	8.6	6	8	1,563,281,954	1,776,579,543	1,776,580	296,097	108.4	15,632,820	2.7	0.6	1.2	0.0	6.0	7.1	8.6	26.2
Mystery - Harrison	0.04	0.0	7,800,042	6,000	3200	369	12%	361	253	Single-Stage	8.6	6	8	1,511,499,910	1,717,732,244	1,717,732	286,289	104.8	15,114,999	19.5	3.2	0.4	0.0	6.0	6.0	4.8	39.9
Nimpkish 1	0.08	0.0	3,029,701	6,000	3200	950	30%	140	98	Multi-Stage	8.6	6	8	1,562,180,057	1,775,327,302	1,775,327	295,888	108.4	15,621,801	15.1	6.2	0.3	0.0	6.0	5.8	9.5	43.0
Nimpkish 2	0.09	0.0	3,289,389	6,000	3800	875	23%	152	107	Multi-Stage	8.6	6	8	1,549,163,926	1,760,535,221	1,760,535	293,423	107.5	15,491,639	40.0	5.4	0.4	0.0	6.0	6.1	8.8	66.7
North Bonanza	0.90	0.0	8,200,044	6,000	2000	351	18%	380	266	Single-Stage	8.6	6	8	1,382,905,754	1,571,592,423	1,571,592	261,932	95.9	13,829,058	40.0	2.3	1.9	0.0	6.0	5.4	3.5	59.1
North Harrison	0.01	0.0	1,810,198	6,000	4800	1590	33%	84	59	Multi-Stage	8.6	6	8	1,634,633,923	1,857,666,931	1,857,667	309,611	113.4	16,346,339	4.2	4.5	0.1	0.0	6.0	6.7	15.9	37.4
North Henderson	0.44	0.0	6,772,272	6,000	1800	425	24%	314	219	Single-Stage	8.6	6	8	1,386,933,177	1,576,169,356	1,576,169	262,695	96.2	13,869,332	7.4	1.4	1.2	0.0	6.0	5.2	4.3	25.5
Oliphant - Shawnigan	1.76	0.0	9,499,061	6,000	3400	303	9%	440	308	Single-Stage	8.6	6	8	2,139,202,085	2,431,079,470	2,431,079	405,180	148.4	21,392,021	17.0	13.9	2.9	0.0	6.0	6.2	5.1	51.1
Palisade - Seymour	2.06	0.0	5,420,368	6,000	3700	531	14%	251	176	Single-Stage	8.6	6	8	1,207,930,159	1,372,742,777	1,372,743	228,790	83.8	12,079,302	5.2	0.2	2.4	0.0	6.0	6.2	5.6	25.5
Peneplain - Coquitlam	0.29	0.0	3,531,553	6,000	3700	815	22%	163	114	Multi-Stage	8.6	6	8	1,375,305,577	1,562,955,261	1,562,955	260,493	95.4	13,753,056	4.9	1.3	0.7	0.0	6.0	6.1	8.2	27.1
Pointer - Hornet		19.6	7,885,522	6,000	2500	365	15%	365	256	Single-Stage	8.6	6	8	1,325,903,514	1,506,812,673	1,506,813	251,135	92.0	13,259,035	6.6	0.6	8.8	0.6	6.0	5.7	3.8	32.0
Pointer - Loose		4.8	7,842,549	6,000	830	367	44%	363	254	Single-Stage	8.6	6	8	1,273,631,078	1,447,408,072	1,447,408	241,235	88.3	12,736,311	6.6	1.3	3.3	0.4	6.0	4.8	3.7	26.0
Potato - Un-named		5.5	3,643,311	6,000	4900	790	16%	169	118	Multi-Stage	8.6	6	8	1,486,790,540	1,689,651,474	1,689,651	281,609	103.1	14,867,905	5.6	3.7	2.5	1.0	6.0	6.7	7.9	33.4
Powell 1	0.02	0.0	3,048,957	6,000	5900	944	16%	141	99	Multi-Stage	8.6	6	8	1,543,462,767	1,754,056,184	1,754,056	292,343	107.1	15,434,628	100.0	1.5	0.2	0.0	6.0	7.2	9.4	124.3
Powell 2	0.03	0.0	3,671,193	6,000	1700	784	46%	170	119	Multi-Stage	8.6	6	8	1,377,115,213	1,565,011,808	1,565,012	260,835	95.5	13,771,152	60.0	1.7	0.2	0.0	6.0	5.0	7.8	80.8
Powell 3	0.03	0.0	4,334,662	6,000	3500	664	19%	201	140	Single-Stage	8.6	6	8	1,333,701,423	1,515,674,546	1,515,675	252,612	92.5	13,337,014	21.7	7.4	0.3	0.0	6.0	6.0	6.6	48.0
Powell 4	0.03	0.0	4,283,059	6,000	3900	672	17%	198	139	Single-Stage	8.6	6	8	1,254,730,909	1,425,929,123	1,425,929	237,655	87.0	12,547,309	18.3	2.3	0.3	0.0	6.0	6.2	6.7	39.8
Powell 5	0.05	0.0	6,586,306	6,000	1800	437	24%	305	213	Single-Stage	8.6	6	8	1,362,304,981	1,548,180,836	1,548,181	258,030	94.5	13,623,050	26.5	4.9	0.4	0.0	6.0	5.2	4.4	47.4
Pretty Girl - Ellen		14.4	11,844,508	6,000	4200	243	6%	548	384	Single-Stage	8.6	6	8	1,626,049,767	1,847,911,533	1,847,912	307,985	112.8	16,260,498	7.2	0.6	8.8	0.9	6.0	6.8	6.3	36.6
Quimper - Bulson		11	3,010,686	3,000	2600	478	18%	139	98	Single-Stage	8.6	6	8	952,708,170	1,082,697,745	2,165,395	360,899	132.2	14,290,623	5.3	3.0	3.8	0.6	6.0	5.4	4.8	28.9
Salsbury - Stave	0.15	0.0	8,294,569	6,000	4100	347	8%	384	269	Single-Stage	8.6	6	8	1,503,373,858	1,708,497,457	1,708,497	284,750	104.3	15,033,739	6.8	3.4	0.8	0.0	6.0	6.5	6.2	29.6
Sechelt - Henriette		17.1	8,566,118	6,000	3800	336	9%	397	278	Single-Stage	8.6	6	8	1,521,882,363	1,729,531,303	1,729,531	288,255	105.6	15,218,824	5.8	4.2	8.3	1.4	6.0	6.4	5.7	37.9
Skwim - Freda		9.4	4,441,691	6,000	4000	648	16%	206	144	Single-Stage	8.6	6	8	1,234,819,253	1,403,300,677	1,403,301	233,883	85.6	12,348,193	6.5	2.7	4.1	0.9	6.0	6.3	6.5	33.0
Sliammon - Powell	0.33	0.0	41,117,364	6,000	1400	70	5%	1904	1333	Single-Stage	8.6	6	8	2,220,236,979	2,523,170,941	2,523,171	420,528	154.0	22,202,370	22.7	2.9	2.6	0.0	6.0	7.2	2.1	43.5
Slippery - Clowhom	0.30	0.0	2,257,424	6,000	3600	1275	35%	105	73	Multi-Stage	8.6	6	8	1,383,471,589	1,572,235,461	1,572,235	262,039	96.0	13,834,716	5.3	2.0	0.6	0.0	6.0	6.0	12.8	32.6
Slollicum - Harrison	0.01	0.0	2,308,112	6,000	3900	1247	32%	107	75	Multi-Stage	8.6	6	8	1,497,635,033	1,701,975,614	1,701,976	283,663	103.9	14,976,350	3.3	0.5	0.1	0.0	6.0	6.2	12.5	28.6
Stukolait - Chochiwa		15.2	8,465,340	6,000	5100	340	7%	392	274	Single-Stage	8.6	6	8	1,606,015,915	1,825,144,220	1,825,144	304,191	111.4	16,060,159	7.5	2.7	7.7	1.4	6.0	7.1	7.7	40.0
Tsable - Comox	0.15	0.0	3,255,900	6,000	6500	884	14%	151	106	Multi-Stage	8.6	6	8	1,733,447,222	1,969,962,532	1,969,963	328,327	120.2	17,334,472	2.9	0.5	0.5	0.0	6.0	7.6	9.8	27.2
Tsable - Nimnim		13.9	5,252,218	6,000	4700	548	12%	243	170	Single-Stage	8.6	6	8	1,314,466,892	1,493,815,614	1,493,816	248,969	91.2	13,144,669	4.7	1.2	5.8	2.8	6.0	6.7	7.1	34.2
Tsable - Willemar		6.6	3,964,484	6,000	5700	726	13%	184	128	Multi-Stage	8.6	6	8	1,541,344,032	1,751,648,363	1,751,648	291,941	106.9	15,413,440	3.5	0.7	3.1	0.7	6.0	7.1	8.6	29.7
Twin Lakes - Stave	0.13	0.0	7,177,595	6,000	1500	401	27%	332	233	Single-Stage	8.6	6	8	1,514,592,258	1,721,246,519	1,721,247	286,874	105.1	15,145,923	25.0	10.6	0.7	0.0	6.0	5.1	4.0	51.4
Tyaughton - Carpenter	0.18	0.0	8,591,688	6,000	4700	335	7%	398	278	Single-Stage	8.6	6	8	1,516,572,076	1,723,496,468	1,723,496	287,249	105.2	15,165,721	6.3	0.6	0.9	0.0	6.0	6.9	7.1	27.8
Un-named - Effingham		13.9	3,742,803	6,000	6300	769	12%	173	121	Multi-Stage	8.6	6	8	1,608,967,762	1,828,498,823	1,828,499	304,750	111.6	16,089,678	5.8	2.1	4.9	1.6	6.0	7.5	9.5	37.4
Un-named - Goat	0.48	0.0	2,687,409	6,000	5300	1071	20%	124	87	Multi-Stage	8.6	6	8	1,473,449,258	1,674,489,879	1,674,490	279,082	102.2	14,734,493	3.2	1.1	0.8	0.0	6.0	6.9	10.7	28.7
Un-named - Hesquiat	1.14	0.0	5,440,861	6,000	4700	529	11%	252	176	Single-Stage	8.6	6	8	1,607,921,235	1,827,309,505	1,827,310	304,552	111.5	16,079,212	7.0	0.9	1.8	0.0	6.0	6.7	7.1	29.4
Un-named - Huaskin	0.85	0.0	18,332,583	6,000	2000	157	8%	849	594	Single-Stage	8.6	6	8	1,722,973,145	1,958,059,348	1,958,059	326,343	119.5	17,229,731	13.1	2.8	2.8	0.0	6.0	6.1	3.0	33.7
Un-Named - Powell	0.03	0.0	4,341,200	6,000	3200	663	21%	201	141	Single-Stage	8.6	6	8	1,260,370,069	1,432,337,702	1,432,338	238,723	87.4	12,603,701	6.3	6.6	0.3	0.0	6.0	5.8	6.6	31.7
Un-named - Stafford		3.0	2,468,452	6,000	3500	1166	33%	114	80	Multi-Stage	8.6	6	8	1,359,074,099	1,544,509,124	1,544,509	257,418	94.3	13,590,741	5.0	1.0	1.1	0.3	6.0	6.0	11.7	31.1
Un-named - Tzoonie 1		19.7	3,418,308	6,000	5100	842	17%	158	111	Multi-Stage	8.6	6	8	1,512,904,635	1,719,328,634	1,719,329	286,555	104.9	15,129,046	5.2	1.6	5.9	0.9	6.0	6.8	8.4	34.8
Un-named - Tzoonie 2		18.9	3,270,699	6,000	3200	880	28%	151	106	Multi-Stage	8.6	6	8	1,415,805,177	1,608,980,715	1,608,981	268,163	98.2	14,158,052	5.2	0.8	5.6	1.0	6.0	5.8	8.8	33.3
Un-named - Uchuck		4	2,741,158	3,000	7300	525	7%	127	89	Single-Stage	8.6	6	8	1,120,314,456	1,273,172,597	2,546,345	424,391	155.4	16,804,717	4.6	2.7	1.8	0.4	6.0	7.9	11.0	34.4
Un-named - Zeballos		4	3,652,558	3,000	6400	394	6%	169	118	Single-Stage	8.6	6	8	1,128,647,950	1,282,643,131	2,565,286	427,548	156.6	16,929,719	5.4	2.1	1.8	0.3	6.0	7.4	9.6	32.6
Upper Deserted - Un-named		5.6	3,959,031	6,000	3100	727	23%	183	128	Multi-Stage	8.6	6	8	1,108,809,946	1,260,098,386	1,260,098	210,016	76.9	11,088,099	3.7	0.5	2.7	0.9	6.0	5.8	7.3	26.9
Upper Eldrid - Lower Eldrid		22.8	3,728,258	6,000	2600	772	30%	173	121	Multi-Stage	8.6	6	8	1,412,010,229	1,604,667,976	1,604,668	267,445	97.9	14,120,102	2.3	1.0	6.8	2.6	6.0	5.5	7.7	32.0
Upper Elsie	1.17	0.0	7,514,923	6,000	3300	383	12%	348	244	Single-Stage	8.6	6	8	1,710,030,719	1,943,351,030	1,943,351	323,892	118.6	17,100,307	20.0	10.2	2.1	0.0	6.0	6.1	5.0	49.3
Upper Great Central	0.07	0.0	3,575,423	6,000	2300	805	35%	166	116	Multi-Stage	8.6	6	8	1,478,762,177	1,680,527,705	1,680,528	280,088	102.6	14,787,622	20.0	3.4	0.3	0.0	6.0	5.4	8.1	43.2
Upper Misery - Lower Misery		31.8	4,920,027	6,000	1600	585	37%	228	159	Single-Stage	8.6	6	8	1,138,239,577	1,293,543,461	1,293,543	215,591	78.9	11,382,396	5.3	0.8	9.7	2.2	6.0	5.0	5.9	34.9
Upper Misery - Un-named		14.1	7,159,740	6,000	5400	402	7%	331	232	Single-Stage	8.6	6	8	1,552,433,642	1,764,251,064	1,764,251	294,042	107.7	15,524,336	7.8	1.3	6.8	1.9	6.0	7.1	8.1	39.1
Upper Quinsam - Upper Campbell	0.92	0.0	27,943,840	6,000	3200	103	3%	1294	906	Single-Stage	8.6	6	8	2,165,111,549	2,460,524,078	2,460,524	410,087	150.2	21,651,115	8.9	0.7	3.6	0.0	6.0	7.3	4.8	31.2
Upper Tzoonie - Lower Tzoonie		17.3	2,945,973	6,000	5200	977	19%	136	95	Multi-Stage	8.6	6	8	1,491,080,467	1,694,526,729	1,694,527	282,421	103.4	14,910,805	4.5	0.7	5.0	0.9	6.0	6.9	9.8	33.8
Upper Vancouver - Lower Vancouver		15.3	5,320,177	6,000	1400	541	39%	246	172	Single-Stage	8.6	6	8	1,129,806,520	1,283,959,779	1,283,960	213,993	78.4	11,298,065	6.7	1.5	6.2	0.9	6.0	4.9	5.4	31.8
View - Great Central	0.25	0.0	13,387,049	6,000	1600	215	13%	620	434	Single-Stage	8.6	6	8	1,691,240,455	1,921,996,981	1,921,997	320,333	117.3	16,912,405	9.7	2.7	1.3	0.0	6.0	5.5	2.4	27.6
Walt - Khartoum	0.71	0.0	3,434,625	6,000	5000	838	17%	159	111	Multi-Stage	8.6	6	8	1,473,552,851	1,674,607,607	1,674,608	279,101	102.2	14,735,529	4.0	0.7	1.1	0.0	6.0	6.8	8.4	27.0
Wilson - Chehalis	0.76	0.0	4,797,026	6,000	4500	600	13%	222	155	Single-Stage	8.6	6	8	1,328,232,054	1,509,458,924	1,509,459	251,576	92.1	13,282,321	5.7	1.3	1.4	0.0	6.0	6.5	6.8	27.6
Windsor - Goat		5.6	19,713,805	6,000	1600	146	9%	913	639	Single-Stage	8.6	6	8	1,638,025,076	1,861,520,780	1,861,521	310,253	113.6	16,380,251	14.8	1.7	6.0	0.2	6.0	5.9	2.4	37.0
Windsor - Powell	0.16	0.0	19,713,805	6,000	3600	146	4%	913	639	Single-Stage	8.6	6	8	1,963,870,353	2,231,825,095	2,231,825	371,971	136.2	19,638,704	14.8	1.7	1.3	0.0	6.0	7.0	5.4	36.1
Woss 1	0.33	0.0	4,680,025	6,000	3100	615	20%	217	152	Single-Stage	8.6	6	8	1,352,149,741	1,536,639,993	1,536,640	256,107	93.8	13,521,497	25.0	7.5	0.9	0.0	6.0	5.8	6.2	51.4
Woss 2	0.25	0.0	3,505,744	6,000	5800	821	14%	162	114	Multi-Stage	8.6	6	8	1,620,000,128	1,841,036,469	1,841,036	306,839	112.4	16,200,001	7.3	2.4	0.7	0.0	6.0	7.2	8.7	32.2

M:\1\03\00313\01\A\Data\Task 200 - Screening Assessment\[Summary Pump Storage Sites 20101123.xlsx]Freshwater

0	25NOV'10	ISSUED WITH REPORT VA103-313/1-1	TMF	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.2

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SUMMARY OF SALTWATER PUMPED STORAGE SITES

11/30/2010 16:40

Name	Latitude (dd mm ss.s)	Longitude (dd mm ss.s)	Latitude (dd.dddd)	Longitude (dd.dddd)	Capacity (MW)	Location (LM/VI)	Salt/Fresh	Pure/Mixed	Type	Upper Reservoir Area (ha)	Upper Reservoir Base Elevation (masl)	Upper Reservoir Crest Length (m)	Upper Reservoir Dam Height (m)	Storage Requirement (m3)	Storage Requirement (MWh)	2D Waterway Length (m)	Gross Head (m)	H/L Ratio (%)	Design Flow (Generation) (m3/s)
McDonald	N50 36 13.8	W125 31 48.2	50.60383	125.53005	1000	LM	Salt	Pure	Lake	20	720	300	21	3,844,675	6,000	2200	720	33%	178
Upper Frell	N49 51 48.9	W123 54 46.9	49.86358	123.91303	1000	LM	Salt	Pure	Lake	20	620	200	24	4,464,784	6,000	1500	620	41%	207
Shamrock	N50 38 37.2	W125 31 17.6	50.64367	125.52155	1000	LM	Salt	Pure	Lake	20	620	300	24	4,464,784	6,000	1800	620	34%	207
Hulton	N50 43 11.5	W126 14 20.0	50.71986	126.23888	1000	LM	Salt	Pure	Man Made	20	670	900	23	4,131,591	6,000	1000	670	67%	191
Foster	N50 46 48.2	W126 01 32.4	50.78005	126.02567	1000	LM	Salt	Pure	Lake	20	520	240	29	5,323,396	6,000	1100	520	47%	246
Griffin	N50 36 24.5	W125 33 26.2	50.60682	125.55729	1000	LM	Salt	Pure	Lake	50	680	200	10	4,070,832	6,000	1400	680	49%	188
Tsakonu	N50 38 19.3	W126 10 06.9	50.6387	126.1686	1000	LM	Salt	Pure	Lake	30	520	300	20	5,323,396	6,000	1600	520	33%	246
Fawn	N50 28 56.4	W125 06 48.9	50.48234	125.11359	1000	LM	Salt	Pure	Lake	50	515	140	13	5,375,080	6,000	1300	515	40%	249
McNab	N49 34 00.7	W123 20 52.3	49.56686	123.34785	1000	LM	Salt	Pure	Man Made	40	490	500	16	5,649,319	6,000	1200	490	41%	262
Bobs	N49 37 14.2	W124 16 12.7	49.62061	124.2702	1000	LM	Salt	Pure	Lake	40	640	1600	13	4,325,260	6,000	2300	640	28%	200
Storm	N49 38 17.5	W123 46 41.7	49.63818	123.77826	1000	LM	Salt	Pure	Lake	60	580	800	10	4,772,700	6,000	1600	580	36%	221
Nelson Island	N49 45 34.6	W124 08 01.6	49.75961	124.13377	1000	LM	Salt	Pure	Man Made	20	520	1200	29	5,323,396	6,000	600	520	87%	246
Nepah	N51 00 29.4	W126 46 34.4	51.00816	126.77622	1000	LM	Salt	Pure	Lake	50	430	300	15	6,437,596	6,000	1200	430	36%	298
Walter	N50 13 16.8	W124 47 04.2	50.22132	124.7845	1000	LM	Salt	Pure	Lake	10	480	350	60	5,767,013	6,000	1500	480	32%	267
Cosby	N50 32 34.3	W125 33 52.0	50.54287	125.56443	1000	LM	Salt	Pure	Man Made	20	500	1100	30	5,536,332	6,000	1100	500	45%	256
Grant	N49 37 22.2	W124 16 25.4	49.62283	124.27372	1000	LM	Salt	Pure	Man Made	10	620	900	47	4,464,784	6,000	1800	620	34%	207
Burley	N50 54 00.9	W126 45 51.2	50.90024	126.76422	1000	LM	Salt	Pure	Lake	20	900	150	17	3,075,740	6,000	900	900	100%	142
Mouat	N49 39 29.1	W124 18 56.8	49.65809	124.31578	1000	LM	Salt	Pure	Man Made	50	440	1400	15	6,291,287	6,000	1500	440	29%	291
Downie	N50 26 53.3	W125 02 53.3	50.44814	125.04815	1000	LM	Salt	Pure	Lake	40	330	400	23	8,388,382	6,000	1400	330	24%	388
Lawrence	N50 25 46.9	W125 07 04.4	50.42969	125.11788	1000	LM	Salt	Pure	Man Made	30	370	1100	27	7,481,530	6,000	800	370	46%	346
Snout	N50 23 57.0	W124 37 53.5	50.39918	124.63153	1000	LM	Salt	Pure	Lake	100	440	400	8	6,291,287	6,000	1000	440	44%	291
Appolina	N50 54 46.2	W126 19 28.0	50.91285	126.32445	1000	LM	Salt	Pure	Lake	20	1060	1000	15	2,611,477	6,000	1100	1060	96%	121
Thors	N50 03 32.3	W124 42 00.3	50.05896	124.70009	1000	LM	Salt	Pure	Man Made	10	780	300	37	3,548,931	6,000	1800	780	43%	164
Haliday	N50 54 38.3	W126 16 46.2	50.91065	126.2795	1000	LM	Salt	Pure	Lake	30	900	120	12	3,075,740	6,000	2200	900	41%	142
Amor	N50 33 53.7	W124 59 31.6	50.56492	124.99211	1000	LM	Salt	Pure	Lake	30	1080	120	11	2,563,117	6,000	2400	1080	45%	119
Hkusam Mountain	N50 22 47.1	W125 51 13.4	50.37974	125.85372	1000	VI	Salt	Pure	Man Made	16	1220	360	16	2,268,989	6,000	3100	1220	39%	105
Jordan River South	N48 24 29.1	W123 59 52.1	48.40808	123.9978	1000	VI	Salt	Pure	Man Made	48	600	2450	12	4,613,610	6,000	4670	600	13%	214
Breg	N50 18 47.9	W124 49 10.7	50.3133	124.81964	1000	LM	Salt	Pure	Lake	30	840	800	13	3,295,436	6,000	1600	840	53%	153
Altwood	N50 19 00.8	W124 39 55.3	50.3169	124.66537	1000	LM	Salt	Pure	Man Made	10	440	600	65	6,291,287	6,000	1300	440	34%	291
Calder	N49 54 05.4	W123 57 12.8	49.9015	123.95355	1000	LM	Salt	Pure	Lake	30	790	900	14	3,504,008	6,000	1400	790	56%	162
Moh	N50 31 32.7	W125 01 11.8	50.52574	125.01994	1000	LM	Salt	Pure	Lake	10	1120	600	27	2,471,577	6,000	2600	1120	43%	114
Ramsay	N50 26 09.9	W124 58 20.4	50.4361	124.97233	1000	LM	Salt	Pure	Lake	40	1040	300	9	2,661,698	6,000	2500	1040	42%	123
Camp	N50 38 25.3	W125 57 42.5	50.64036	125.96181	1000	LM	Salt	Pure	Man Made	20	1000	1700	16	2,768,166	6,000	1200	1000	83%	128
Saumarez	N49 53 49.0	W123 56 17.7	49.89696	123.93826	1000	LM	Salt	Pure	Man Made	20	950	1400	17	2,913,859	6,000	1800	950	53%	135
Misery	N49 41 12.0	W123 33 25.5	49.68668	123.55707	1000	LM	Salt	Pure	Lake	30	790	750	14	3,504,008	6,000	2600	790	30%	162
Highland Point	N49 41 23.1	W123 49 22.3	49.68976	123.82286	1000	LM	Salt	Pure	Man Made	20	940	1400	17	2,944,858	6,000	2000	940	47%	136
Annis	N49 44 58.8	W124 02 36.1	49.74966	124.04337	1000	LM	Salt	Pure	Man Made	40	320	1800	24	8,650,519	6,000	500	320	64%	400
Gustafson	N49 39 36.8	W123 39 26.0	49.66023	123.65721	1000	LM	Salt	Pure	Lake	40	1400	300	7	1,977,261	6,000	3500	1400	40%	92
Stakawus	N50 03 16.3	W123 47 03.9	50.05452	123.78441	1000	LM	Salt	Pure	Man Made	30	280	1100	35	9,886,307	6,000	600	280	47%	458
Albert	N50 11 25.1	W123 56 18.0	50.1903	123.93834	1000	LM	Salt	Pure	Man Made	10	1670	1200	19	1,657,584	6,000	2300	1670	73%	77
Hays	N50 19 51.3	W124 57 00.0	50.33091	124.95	1000	LM	Salt	Pure	Man Made	10	800	1000	37	3,460,208	6,000	750	800	107%	160
Hat	N50 23 41.8	W124 32 41.1	50.39493	124.54474	1000	LM	Salt	Pure	Lake	60	1160	260	6	2,386,350	6,000	2600	1160	45%	110
Thornhill	N49 39 35.2	W123 35 46.0	49.65978	123.59612	1000	LM	Salt	Pure	Lake	70	1070	500	6	2,587,071	6,000	2300	1070	47%	120
Lyon	N49 39 18.1	W123 51 37.6	49.65503	123.86044	1000	LM	Salt	Pure	Lake	60	1060	850	6	2,611,477	6,000	2900	1060	37%	121
Purcell	N50 47 28.8	W124 54 41.8	50.79133	124.91161	1000	LM	Salt	Pure	Man Made	40	940	3300	9	2,944,858	6,000	1500	940	63%	136
Raza	N50 16 49.6	W125 00 46.3	50.28045	125.01286	1000	LM	Salt	Pure	Man Made	10	820	1200	36	3,375,812	6,000	1200	820	68%	156
Young	N50 45 41.9	W125 42 21.6	50.76165	125.70599	1000	LM	Salt	Pure	Lake	70	1040	400	6	2,661,698	6,000	2800	1040	37%	123
Mount Hallowell	N49 41 39.1	W123 53 07.2	49.6942	123.88534	1000	LM	Salt	Pure	Man Made	50	975	1800	8	2,839,145	6,000	3100	975	31%	131
Gastineau	N50 21 25.2	W124 44 35.6	50.357	124.74322	1000	LM	Salt	Pure	Lake	50	1120	2300	7	2,471,577	6,000	3200	1120	35%	114
Davie	N49 35 52.9	W124 22 48.1	49.59804	124.38002	1000	LM	Salt	Pure	Man Made	60	300	2000	17	9,227,220	6,000	1500	300	20%	427
Elk Bay South	N50 12 04.5	W125 23 04.7	50.20126	125.38463	1000	VI	Salt	Pure	Man Made	117	740	3830	5	3,740,765	6,000	5700	740	13%	173
Mid Point	N49 38 59.7	W123 42 42.8	49.64993	123.71189	1000	LM	Salt	Pure	Man Made	70	1160	2400	5	2,386,350	6,000	2800	1160	41%	110
Hkusam Mountain South	N50 21 40.3	W125 44 34.5	50.3612	125.74293	1000	VI	Salt	Pure	Man Made	113	550	3770	6	5,033,029	6,000	4000	550	14%	233
Mt Collison	N50 31 47.8	W126 44 31.4	50.52996	126.74205	1000	VI	Salt	Pure	Man Made	60	1050	3470	6	2,636,349	6,000	2760	1050	38%	122
Mount Troubridge	N49 46 44.3	W124 12 00.0	49.77898	124.20001	1000	LM	Salt	Pure	Man Made	60	960	3100	7	2,883,506	6,000	3700	960	26%	133
Halfway	N49 37 05.1	W123 50 26.4	49.61808	123.84067	1000	LM	Salt	Pure	Man Made	90	915	2800	5	3,025,318	6,000	1800	915	51%	140
Newcastle Peak	N50 26 19.3	W126 03 29.0	50.4387	126.05806	1000	VI	Salt	Pure	Man Made	67	1050	2700	6	2,636,349	6,000	3960	1050	27%	122
Cataract Lake	N48 59 18.2	W125 11 43.5	48.98838	125.19543	1000	VI	Salt	Pure	Man Made	154	540	4390	5	5,126,233	6,000	2440	540	22%	237
Homfray	N50 16 45.0	W124 37 26.1	50.27917	124.62392	1000	LM	Salt	Pure	Lake	130	1040	500	4	2,661,698	6,000	1600	1040	65%	123
McConnel	N50 08 46.2	W123 53 08.2	50.14617	123.88562	1000	LM	Salt	Pure	Lake	130	820	300	5	3,375,812	6,000	2100	820	39%	156
Mt Collison South	N50 30 51.7	W126 40 44.5	50.51437	126.67903	1000	VI	Salt	Pure	Man Made	88	1300	3330	4	2,129,359	6,000	4590	1300	28%	99
Mt Palmerston	N50 28 49.3	W126 20 50.7	50.48037	126.34741	1000	VI	Salt	Pure	Man Made	105	1050	3645	5	2,636,349	6,000	2910	1050	36%	122
Jordan River East	N48 25 14.8	W124 03 04.7	48.42077	124.0513	1000	VI	Salt	Pure	Man Made	32	300	2000	31	9,227,220	6,000	3000	300	10%	427
Syren	N49 52 55.1	W124 01 58.3	49.88196	124.03286	1000	LM	Salt	Pure	Man Made	30	240	2100	40	11,534,025	6,000	100	240	240%	534
Myers	N49 41 03.5	W123 52 32.1	49.68432	123.87558	1000	LM	Salt	Pure	Lake	140	1060	2400	4	2,611,477	6,000	2600	1060	41%	121
Picton	N50 27 34.2	W125 24 58.4	50.45949	125.41621	1000	LM	Salt	Pure	Man Made	40	180	1600	40	15,378,700	6,000	600	180	30%	712
Crucil	N49 32 44.9	W123 45 31.0	49.5458	123.7586	1000	LM	Salt	Pure	Lake	130	1060	2400	4	2,611,477	6,000	4700	1060	23%	121
Port Alberni	N49 13 56.7	W124 50 18.1	49.23241	124.83836	1000	VI	Salt	Pure	Man Made	148	410	5000	7	6,751,625	6,000	3130	410	13%	313
Dinner	N49 56 54.6	W124 43 09.0	49.9485	124.71917	1000	LM	Salt	Pure	Man Made	70	200	3000	22	13,840,830	6,000	1500	200	13%	641
Alberni Inlet	N48 59 59.4	W124 53 46.0	48.99984	124.8961	1000	VI	Salt	Pure	Man Made	254	500	5650	4	5,536,332	6,000	1890	500	26%	256
Colvin	N49 29 23.3	W123 54 26.2	49.48979	123.90727	1000	LM	Salt	Pure	Man Made	130	180	3700	14	15,378,700	6,000	1400	180	13%	712
Elk Bay	N50 16 43.1	W125 26 21.3	50.27863	125.43924	1000	VI	Salt	Pure	Man Made	154	250	4390	9	11,072,664	6,000	3870	250	6%	513
Caren	N49 37 16.3	W123 50 33.9	49.6212	123.84275	1000	LM	Salt	Pure	Lake	350	880	2500	3	3,145,643	6,000	2700	880	33%	146

Name	Design Flow (Pumping), 70% of Generation Flow (m3/s)	Pump/Turbine Type	Pumping Duration at Peak Output (hrs)	Generation Duration at Peak Output (hrs)	Development and Construction Time (years)	Total Estimated Capital Cost ($)	Loaded Capital Cost ($)	Unit Cost of Capacity (Loaded Capital Cost/Capatity) ($/MW)	Unit Cost of Stored Energy ($/MWh)	Levelized Cost ($/kW-yr)	Estimated Annual Operating Cost ($/yr)	Upper Reservoir Footprint (ha)	Tailwater Canal / Breakwater Footprint (ha)	Staging/ Laydown Footprint (ha)	Spoil Footprint (ha)	Roads Footprint (ha)	Total Footprint (ha)
McDonald	125	Multi-Stage	8.6	6	9	1,366,839,478	1,553,334,029	1,553,334	258,889	95	27,336,790	22	5	5	5	7.2	44
Upper Frell	145	Single-Stage	8.6	6	9	1,371,053,971	1,558,123,557	1,558,124	259,687	95	27,421,079	22	5	5	5	6.2	43
Shamrock	145	Single-Stage	8.6	6	9	1,399,269,762	1,590,189,172	1,590,189	265,032	97	27,985,395	22	5	5	5	6.2	43
Hulton	134	Single-Stage	8.6	6	9	1,410,533,553	1,602,989,819	1,602,990	267,165	98	28,210,671	22	5	5	5	6.7	44
Foster	173	Single-Stage	8.6	6	9	1,414,280,422	1,607,247,918	1,607,248	267,875	98	28,285,608	22	5	5	5	5.2	42
Griffin	132	Single-Stage	8.6	6	9	1,425,415,447	1,619,902,231	1,619,902	269,984	99	28,508,309	55	5	5	5	6.8	77
Tsakonu	173	Single-Stage	8.6	6	9	1,463,796,031	1,663,519,546	1,663,520	277,253	102	29,275,921	33	5	5	5	5.2	53
Fawn	174	Single-Stage	8.6	6	9	1,497,183,643	1,701,462,636	1,701,463	283,577	104	29,943,673	55	5	5	5	5.15	75
McNab	183	Single-Stage	8.6	6	9	1,503,839,437	1,709,026,560	1,709,027	284,838	104	30,076,789	44	5	5	5	4.9	64
Bobs	140	Single-Stage	8.6	6	9	1,545,471,159	1,756,338,606	1,756,339	292,723	107	30,909,423	44	5	5	5	6.4	65
Storm	155	Single-Stage	8.6	6	9	1,546,241,106	1,757,213,605	1,757,214	292,869	107	30,924,822	66	5	5	5	5.8	87
Nelson Island	173	Single-Stage	8.6	6	9	1,551,698,743	1,763,415,894	1,763,416	293,903	108	31,033,975	22	5	5	5	5.2	42
Nepah	209	Single-Stage	8.6	6	9	1,555,406,877	1,767,629,974	1,767,630	294,605	108	31,108,138	55	5	5	5	4.3	74
Walter	187	Single-Stage	8.6	6	9	1,567,873,808	1,781,797,920	1,781,798	296,966	109	31,357,476	11	5	5	5	4.8	31
Cosby	179	Single-Stage	8.6	6	9	1,580,948,256	1,796,656,274	1,796,656	299,443	110	31,618,965	22	5	5	5	5	42
Grant	145	Single-Stage	8.6	6	9	1,639,313,198	1,862,984,656	1,862,985	310,497	114	32,786,264	11	5	5	5	6.2	32
Burley	100	Multi-Stage	8.6	6	9	1,646,726,523	1,871,409,472	1,871,409	311,902	114	32,934,530	22	5	5	5	9	46
Mouat	204	Single-Stage	8.6	6	9	1,647,817,409	1,872,649,200	1,872,649	312,108	114	32,956,348	55	5	5	5	4.4	74
Downie	272	Single-Stage	8.6	6	9	1,679,644,287	1,908,818,606	1,908,819	318,136	117	33,592,886	44	5	5	5	3.3	62
Lawrence	242	Single-Stage	8.6	6	9	1,687,122,565	1,917,317,237	1,917,317	319,553	117	33,742,451	33	5	5	5	3.7	52
Snout	204	Single-Stage	8.6	6	9	1,708,340,360	1,941,430,035	1,941,430	323,572	118	34,166,807	110	5	5	5	4.4	129
Appolina	85	Multi-Stage	8.6	6	9	1,718,851,515	1,953,375,354	1,953,375	325,563	119	34,377,030	22	5	5	5	10.6	48
Thors	115	Multi-Stage	8.6	6	9	1,719,796,818	1,954,449,637	1,954,450	325,742	119	34,395,936	11	5	5	5	7.8	34
Haliday	100	Multi-Stage	8.6	6	9	1,729,359,348	1,965,316,898	1,965,317	327,553	120	34,587,187	33	5	5	5	9	57
Amor	83	Multi-Stage	8.6	6	9	1,733,348,356	1,969,850,176	1,969,850	328,308	120	34,666,967	33	5	5	5	10.8	59
Hkusam Mountain	74	Multi-Stage	8.6	6	9	1,735,830,885	1,972,671,426	1,972,671	328,779	120	34,716,618	17.6	5	5	5	12.2	45
Jordan River South	150	Single-Stage	8.6	6	9	1,750,082,368	1,988,867,412	1,988,867	331,478	121	35,001,647	52.8	5	5	5	7.005	75
Breg	107	Multi-Stage	8.6	6	9	1,751,241,978	1,990,185,242	1,990,185	331,698	121	35,024,840	33	5	5	5	8.4	56
Altwood	204	Single-Stage	8.6	6	9	1,753,671,479	1,992,946,229	1,992,946	332,158	122	35,073,430	11	5	5	5	4.4	30
Calder	114	Multi-Stage	8.6	6	9	1,754,092,337	1,993,424,510	1,993,425	332,237	122	35,081,847	33	5	5	5	7.9	56
Moh	80	Multi-Stage	8.6	6	9	1,761,506,352	2,001,850,109	2,001,850	333,642	122	35,230,127	11	5	5	5	11.2	37
Ramsay	86	Multi-Stage	8.6	6	9	1,779,800,133	2,022,639,934	2,022,640	337,107	123	35,596,003	44	5	5	5	10.4	69
Camp	90	Multi-Stage	8.6	6	9	1,784,718,978	2,028,229,917	2,028,230	338,038	124	35,694,380	22	5	5	5	10	47
Saumarez	94	Multi-Stage	8.6	6	9	1,791,012,107	2,035,381,694	2,035,382	339,230	124	35,820,242	22	5	5	5	9.5	47
Misery	114	Multi-Stage	8.6	6	9	1,796,587,232	2,041,717,501	2,041,718	340,286	125	35,931,745	33	5	5	5	7.9	56
Highland Point	95	Multi-Stage	8.6	6	9	1,800,774,597	2,046,476,199	2,046,476	341,079	125	36,015,492	22	5	5	5	9.4	46
Annis	280	Single-Stage	8.6	6	9	1,801,134,359	2,046,885,048	2,046,885	341,148	125	36,022,687	44	5	5	5	3.2	62
Gustafson	64	Multi-Stage	8.6	6	9	1,814,858,030	2,062,481,206	2,062,481	343,747	126	36,297,161	44	5	5	5	14	73
Stakawus	320	Single-Stage	8.6	6	9	1,822,354,125	2,071,000,085	2,071,000	345,167	126	36,447,082	33	5	5	5	2.8	51
Albert	54	Multi-Stage	8.6	6	9	1,837,676,183	2,088,412,718	2,088,413	348,069	127	36,753,524	11	5	5	5	16.7	43
Hays	112	Multi-Stage	8.6	6	9	1,837,891,860	2,088,657,822	2,088,658	348,110	127	36,757,837	11	5	5	5	8	34
Hat	77	Multi-Stage	8.6	6	9	1,848,555,960	2,100,776,955	2,100,777	350,129	128	36,971,119	66	5	5	5	11.6	93
Thornhill	84	Multi-Stage	8.6	6	9	1,880,263,414	2,136,810,644	2,136,811	356,135	130	37,605,268	77	5	5	5	10.7	103
Lyon	85	Multi-Stage	8.6	6	9	1,882,854,911	2,139,755,730	2,139,756	356,626	131	37,657,098	66	5	5	5	10.6	92
Purcell	95	Multi-Stage	8.6	6	9	1,888,139,893	2,145,761,806	2,145,762	357,627	131	37,762,798	44	5	5	5	9.4	68
Raza	109	Multi-Stage	8.6	6	9	1,895,441,174	2,154,059,290	2,154,059	359,010	131	37,908,823	11	5	5	5	8.2	34
Young	86	Multi-Stage	8.6	6	9	1,897,349,610	2,156,228,117	2,156,228	359,371	132	37,946,992	77	5	5	5	10.4	102
Mount Hallowell	92	Multi-Stage	8.6	6	9	1,901,742,534	2,161,220,421	2,161,220	360,203	132	38,034,851	55	5	5	5	9.75	80
Gastineau	80	Multi-Stage	8.6	6	9	1,916,488,125	2,177,977,933	2,177,978	362,996	133	38,329,762	55	5	5	5	11.2	81
Davie	299	Single-Stage	8.6	6	9	1,916,884,196	2,178,428,044	2,178,428	363,071	133	38,337,684	66	5	5	5	3	84
Elk Bay South	121	Multi-Stage	8.6	6	9	1,943,745,532	2,208,954,400	2,208,954	368,159	135	38,874,911	128.7	5	5	5	8.55	152
Mid Point	77	Multi-Stage	8.6	6	9	1,960,477,744	2,227,969,591	2,227,970	371,328	136	39,209,555	77	5	5	5	11.6	104
Hkusam Mountain South	163	Single-Stage	8.6	6	9	1,966,247,230	2,234,526,278	2,234,526	372,421	136	39,324,945	124.3	5	5	5	6	145
Mt Collison	85	Multi-Stage	8.6	6	9	1,972,674,282	2,241,830,252	2,241,830	373,638	137	39,453,486	66	5	5	5	10.5	92
Mount Troubridge	93	Multi-Stage	8.6	6	9	2,004,969,208	2,278,531,567	2,278,532	379,755	139	40,099,384	66	5	5	5	9.6	91
Halfway	98	Multi-Stage	8.6	6	9	2,005,968,194	2,279,666,857	2,279,667	379,944	139	40,119,364	99	5	5	5	9.15	123
Newcastle Peak	85	Multi-Stage	8.6	6	9	2,012,495,801	2,287,085,105	2,287,085	381,181	140	40,249,916	73.7	5	5	5	10.5	99
Cataract Lake	166	Single-Stage	8.6	6	9	2,041,196,521	2,319,701,814	2,319,702	386,617	142	40,823,930	169.4	5	5	5	5.4	190
Homfray	86	Multi-Stage	8.6	6	9	2,061,929,695	2,343,263,867	2,343,264	390,544	143	41,238,594	143	5	5	5	10.4	168
McConnel	109	Multi-Stage	8.6	6	9	2,081,711,864	2,365,745,158	2,365,745	394,291	144	41,634,237	143	5	5	5	8.2	166
Mt Collison South	69	Multi-Stage	8.6	6	9	2,108,875,779	2,396,615,376	2,396,615	399,436	146	42,177,516	96.8	5	5	5	13	125
Mt Palmerston	85	Multi-Stage	8.6	6	9	2,117,947,492	2,406,924,854	2,406,925	401,154	147	42,358,950	115.5	5	5	5	10.5	141
Jordan River East	299	Single-Stage	8.6	6	9	2,144,486,233	2,437,084,598	2,437,085	406,181	149	42,889,725	35.2	5	5	5	4.5	55
Syren	374	Single-Stage	8.6	6	9	2,156,399,238	2,450,623,040	2,450,623	408,437	150	43,127,985	33	5	5	5	2.4	50
Myers	85	Multi-Stage	8.6	6	9	2,187,785,522	2,486,291,737	2,486,292	414,382	152	43,755,710	154	5	5	5	10.6	180
Picton	498	Single-Stage	8.6	6	9	2,212,299,291	2,514,150,217	2,514,150	419,025	153	44,245,986	44	5	5	5	1.8	61
Crucil	85	Multi-Stage	8.6	6	9	2,237,200,201	2,542,448,662	2,542,449	423,741	155	44,744,004	143	5	5	5	10.6	169
Port Alberni	219	Single-Stage	8.6	6	9	2,259,360,007	2,567,632,000	2,567,632	427,939	157	45,187,200	162.8	5	5	5	4.695	182
Dinner	449	Single-Stage	8.6	6	9	2,301,988,481	2,616,076,796	2,616,077	436,013	160	46,039,770	77	5	5	5	2.25	94
Alberni Inlet	179	Single-Stage	8.6	6	9	2,406,426,318	2,734,764,359	2,734,764	455,794	167	48,128,526	279.4	5	5	5	5	299
Colvin	498	Single-Stage	8.6	6	9	2,444,431,198	2,777,954,707	2,777,955	462,992	170	48,888,624	143	5	5	5	2.1	160
Elk Bay	359	Single-Stage	8.6	6	9	2,554,160,461	2,902,655,669	2,902,656	483,776	177	51,083,209	169.4	5	5	5	5.805	190
Caren	102	Multi-Stage	8.6	6	9	2,935,913,377	3,336,495,784	3,336,496	556,083	204	58,718,268	385	5	5	5	8.8	409

M:\1\03\00313\01\A\Data\Task 200 - Screening Assessment\[Summary Pump Storage Sites 20101123.xlsx]Saltwater

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25NOV'10	ISSUED WITH REPORT VA103-313/1-1	TMF	SRM	JPH

Knight Piésold
CONSULTING

TABLE 3.3

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

UNDERGROUND MINES IN THE PROJECT AREA

Print: 11/30/2010 10:27

Site Name	Type of Operation	Products
Myra Falls Operations[1]	Operating Underground Mine	Copper, Gold, Silver, Zinc
Quinsam Mine[2]	Operating Underground Mine	Coal
Britannia Mine[2]	Historic Underground Mine	Copper
Pioneer Mine[2]	Historic Underground Mine	Gold
Bralorne Mine[2]	Historic Underground Mine	Gold
Minto Mine[2]	Historic Underground Mine	Gold

M:\1\03\00313\01\A\Data\Task 100 - Technology Review\[Table 3.3_Underground PSH.xlsx]Sheet1

NOTES:
1. SOURCE: http://mmsd.mms.nrcan.gc.ca/stat-stat/mine-mine/bcm-pcm-eng.aspx?CID=11
2. SOURCE: http://en.wikipedia.org/wiki/List_of_ghost_towns_in_British_Columbia

0	25NOV'10	ISSUED WITH REPORT VA103-313/1-1	TMF	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold
CONSULTING

TABLE 3.4

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

DEVELOPMENT COST DISTRIBUTION BY PUMPED STORATE TYPE

Print: 11/30/2010 10:29

	Development Cost Distribution		
Year	**Freshwater**	**Saltwater**	**Underground**
Year 1	0%	0%	0%
Year 2	0%	0%	0%
Year 3	5%	0%	0%
Year 4	10%	5%	0%
Year 5	20%	10%	0%
Year 6	30%	20%	5%
Year 7	30%	30%	10%
Year 8	5%	30%	20%
Year 9	--	5%	30%
Year 10	--	--	30%
Year 11	--	--	5%
Total	**100%**	**100%**	**100%**

M:\1\03\00313\01\A\Data\Task 200 - Screening Assessment\[Table 3.4_CostDistribution.xlsx]Sheet1

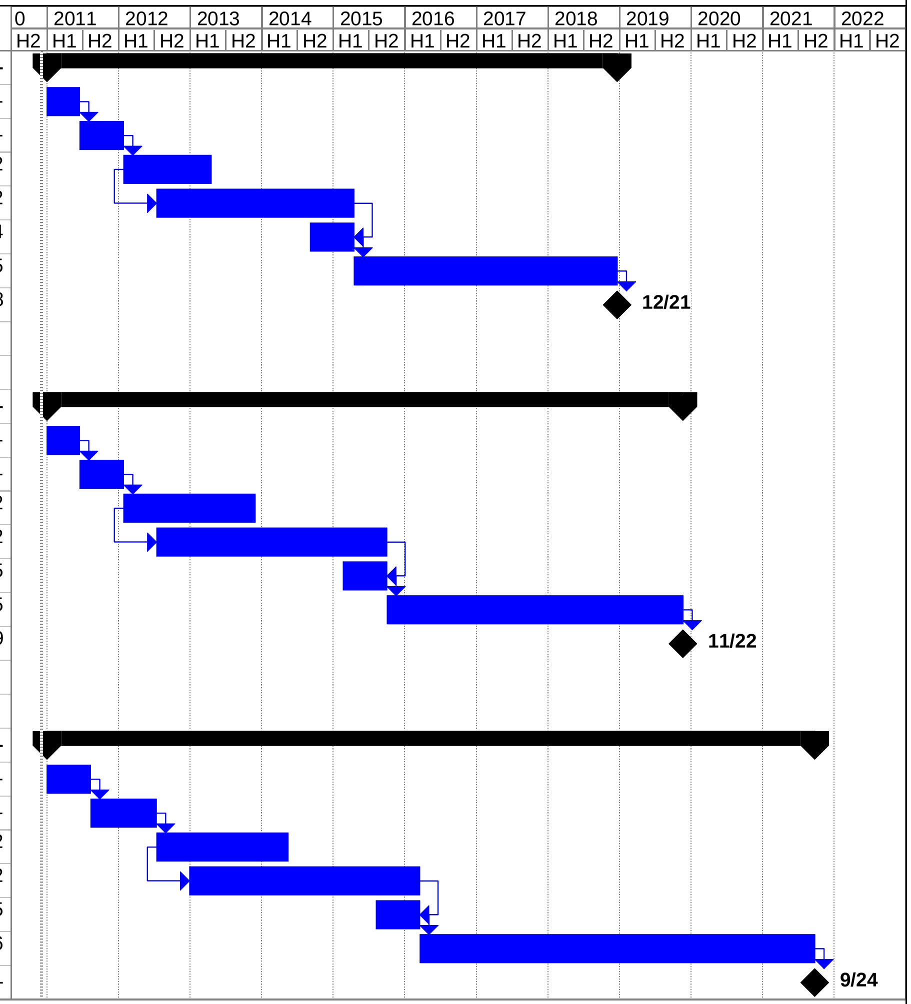
0	25NOV'10	ISSUED WITH REPORT VA103-313/1-1	TMF	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

FIGURE 2.1
BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL
CONCEPTUAL DEVELOPMENT SCHEDULE

Tue 11/30/10 11:25 AM

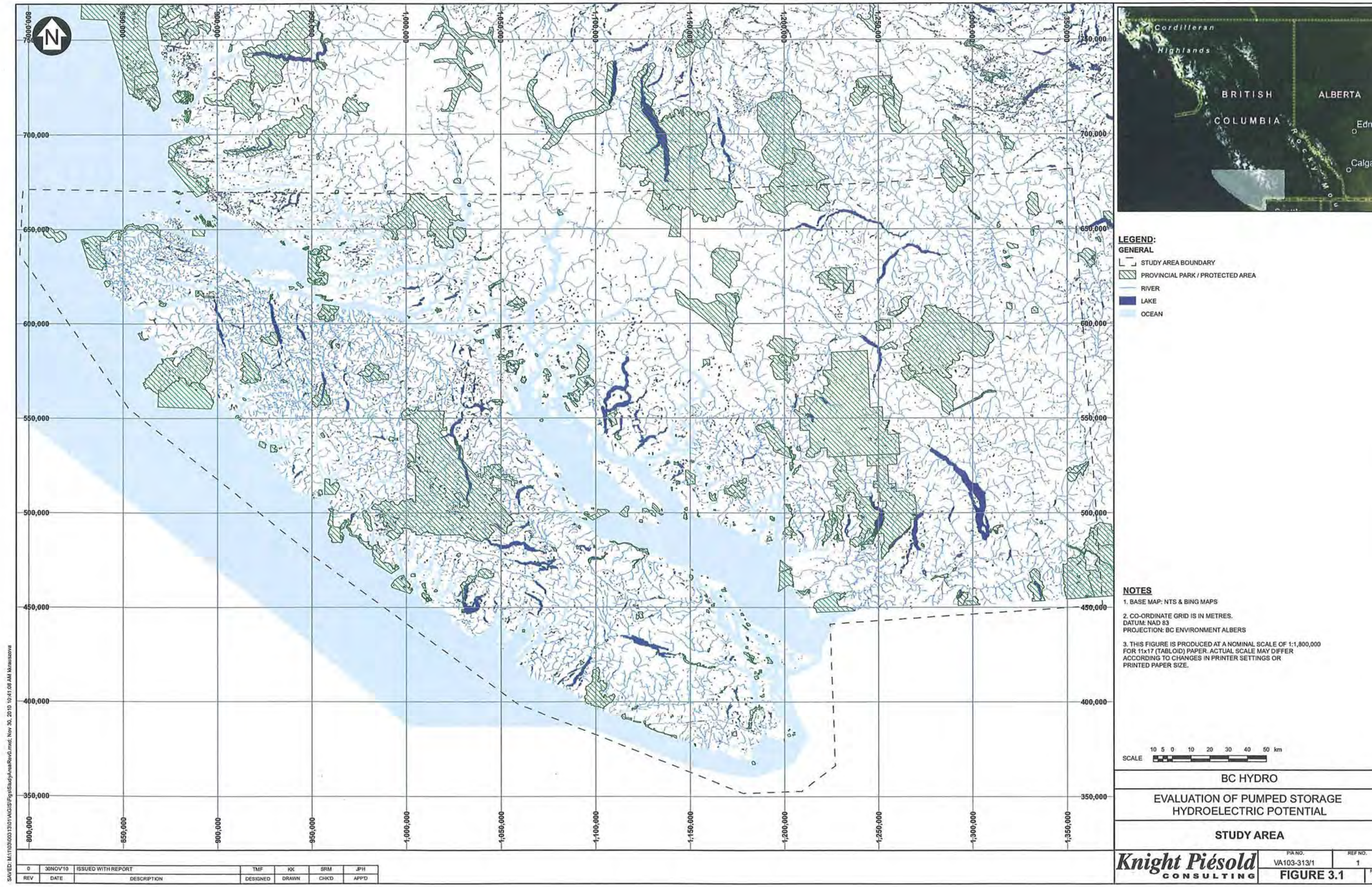
ID		Task Name	Duration	Start
1		**FRESHWATER PUMPED STORAGE**	**2080 days**	**Mon 1/3/11**
2		CONCEPTUAL STUDIES	6 mons	Mon 1/3/11
3		PRE-FEASIBILITY STUDIES	8 mons	Mon 6/20/11
4		FEASIBILITY STUDIES	16 mons	Mon 1/30/12
5		PERMITTING PROCESS	36 mons	Mon 7/16/12
6		FINANCING	8 mons	Mon 9/8/14
7		CONSTRUCTION	48 mons	Mon 4/20/15
8		COD	0 days	Fri 12/21/18
9				
10				
11		**SALTWATER PUMPED STORAGE**	**2320 days**	**Mon 1/3/11**
12		CONCEPTUAL STUDIES	6 mons	Mon 1/3/11
13		PRE-FEASIBILITY STUDIES	8 mons	Mon 6/20/11
14		FEASIBILITY STUDIES	24 mons	Mon 1/30/12
15		PERMITTING PROCESS	42 mons	Mon 7/16/12
16		FINANCING	8 mons	Mon 2/23/15
17		CONSTRUCTION	54 mons	Mon 10/5/15
18		COD	0 days	Fri 11/22/19
19				
20				
21		**UNDERGROUND PUMPED STORAGE**	**2800 days**	**Mon 1/3/11**
22		CONCEPTUAL STUDIES	8 mons	Mon 1/3/11
23		PRE-FEASIBILITY STUDIES	12 mons	Mon 8/15/11
24		FEASIBILITY STUDIES	24 mons	Mon 7/16/12
25		PERMITTING PROCESS	42 mons	Mon 12/31/12
26		FINANCING	8 mons	Mon 8/10/15
27		CONSTRUCTION	72 mons	Mon 3/21/16
28		COD	0 days	Fri 9/24/21

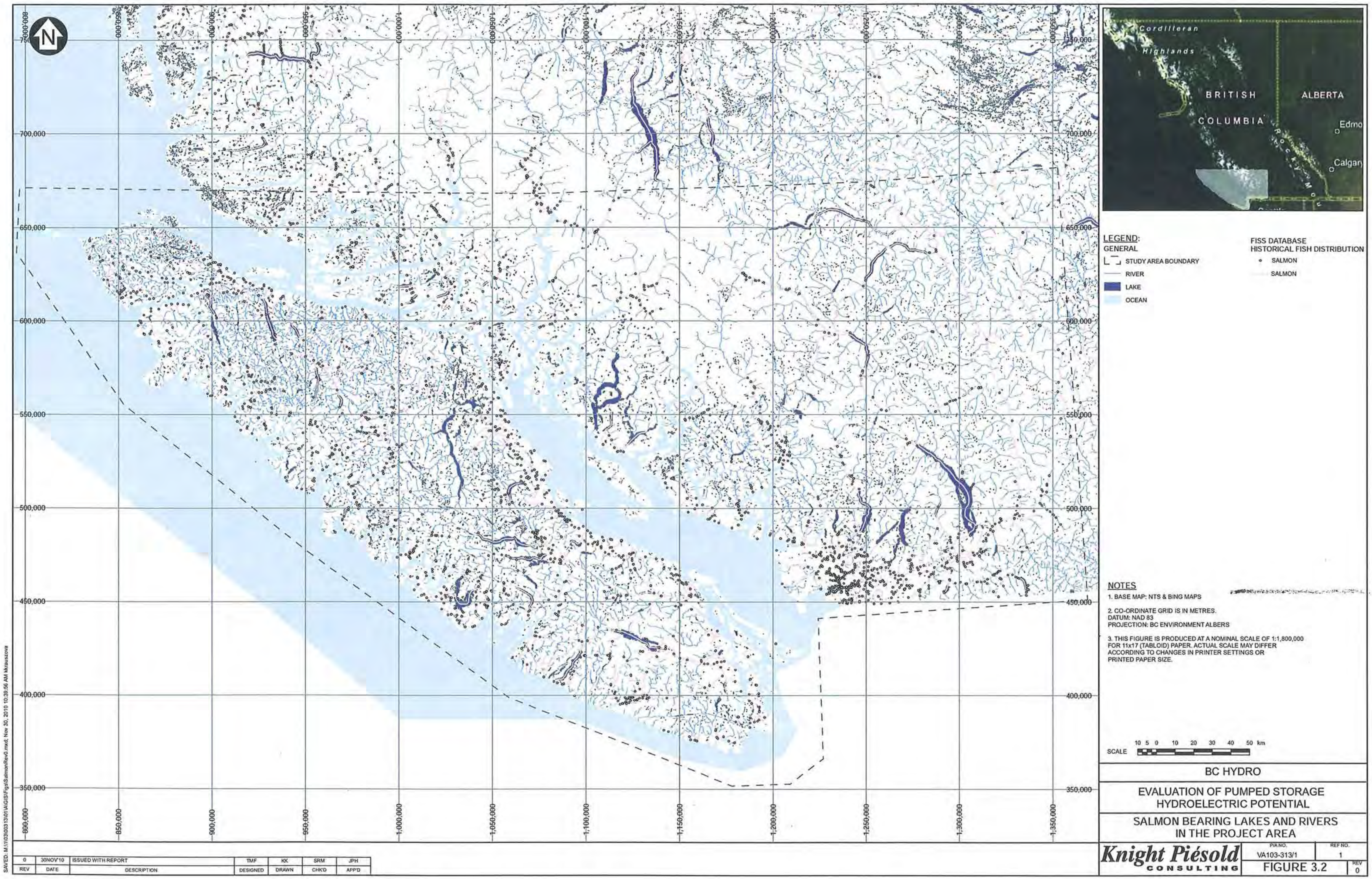


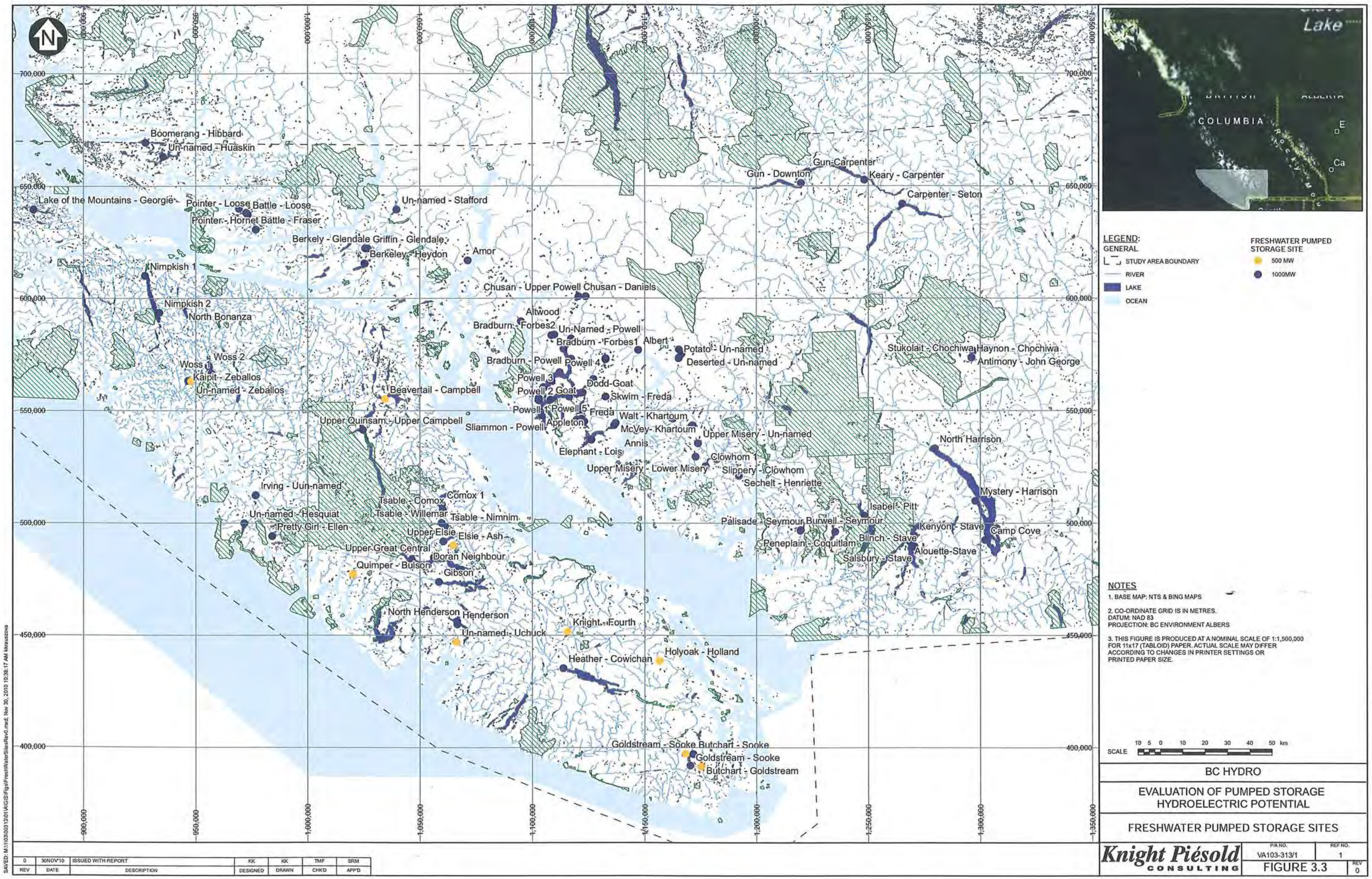
Project: ConceptualDevelopmentSchedule
Date: Tue 11/30/10

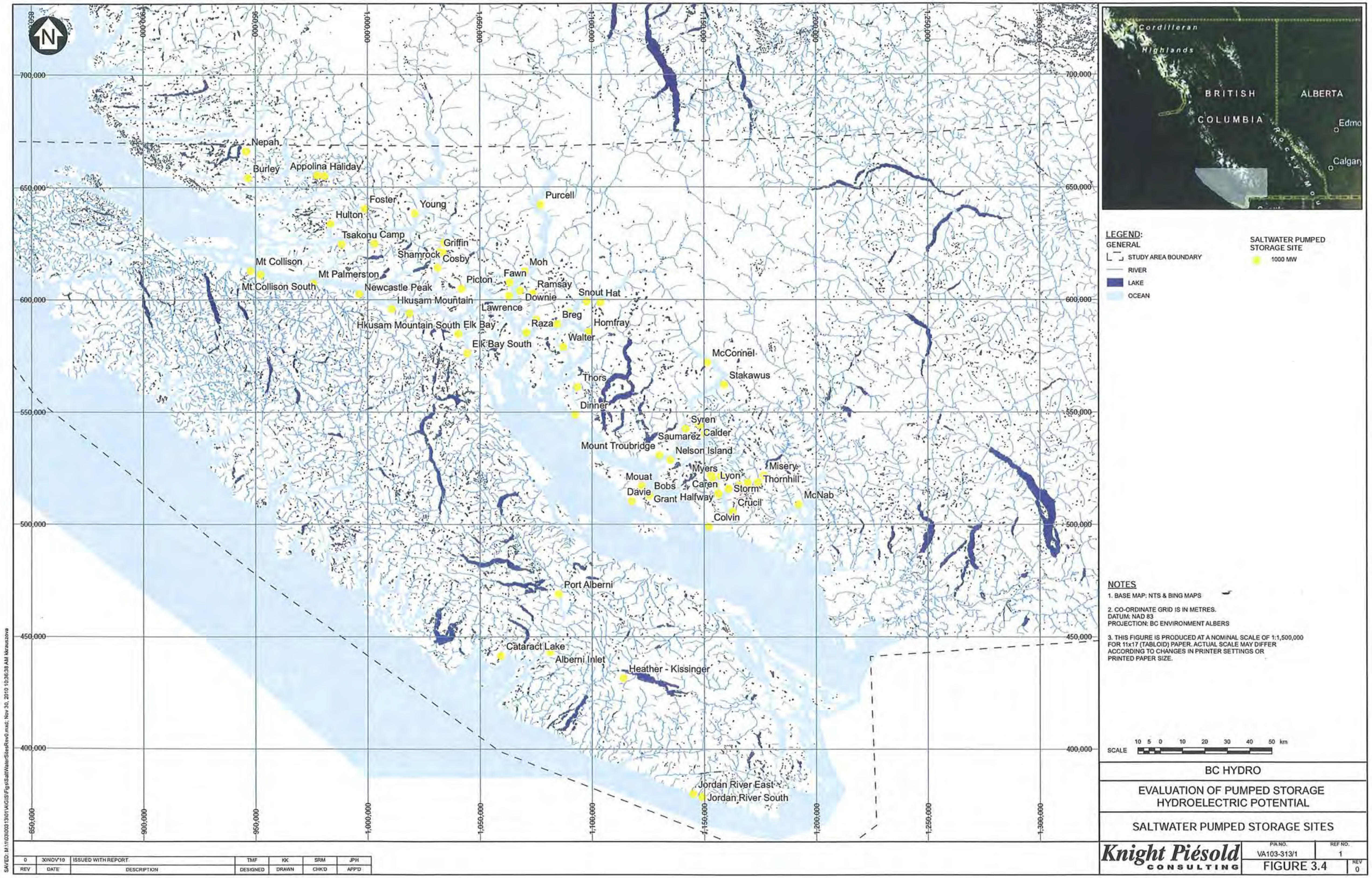
VA103-313/1-1
\\van11\prj_file\1\03\00313\01\A\Data\Task 100 - Technology Review\Schedules\ConceptualDevelopmentSchedule.mpp

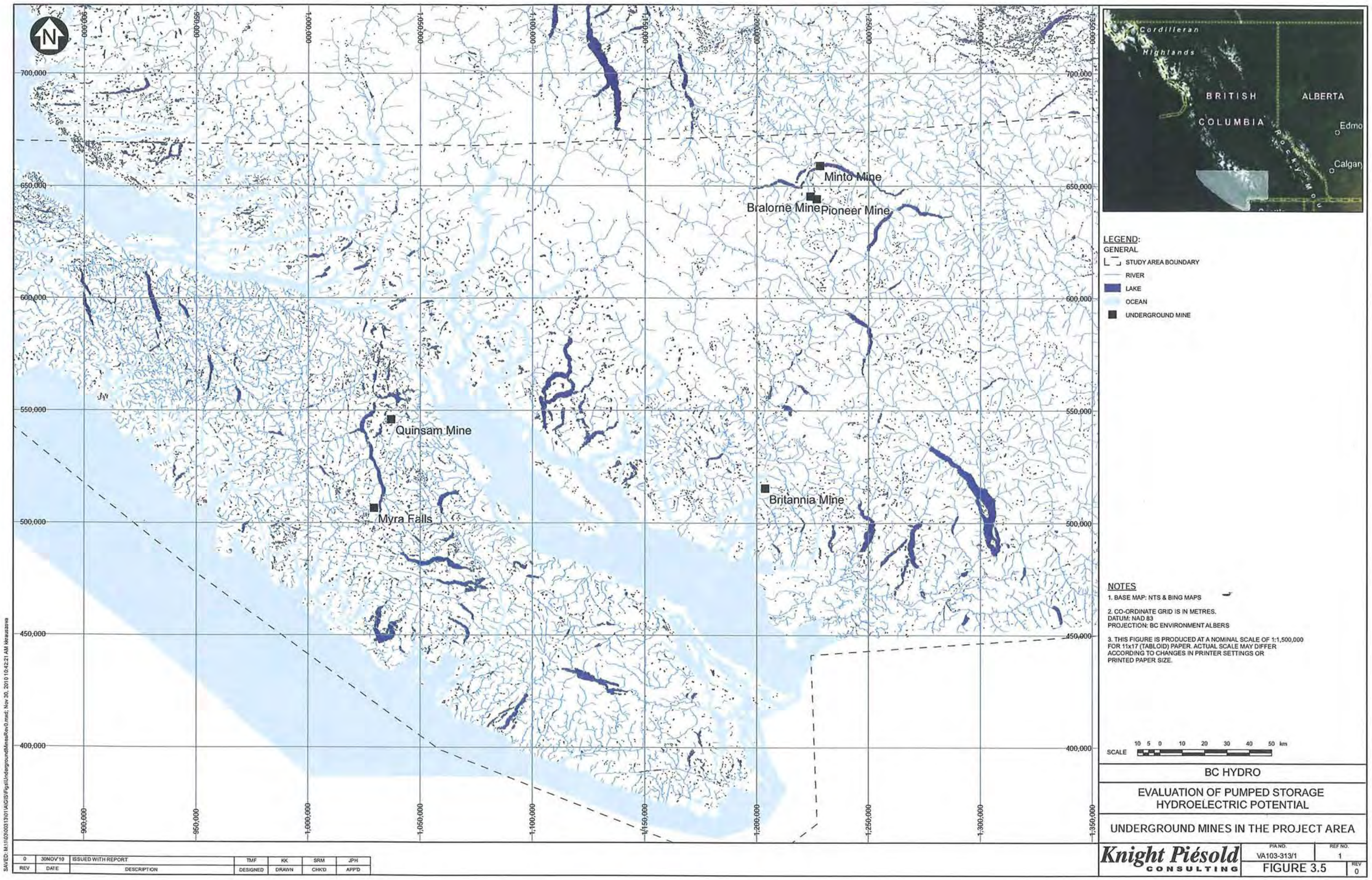
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	25NOV'10	ISSUED WITH REPORT	TMF	SRM	JPH

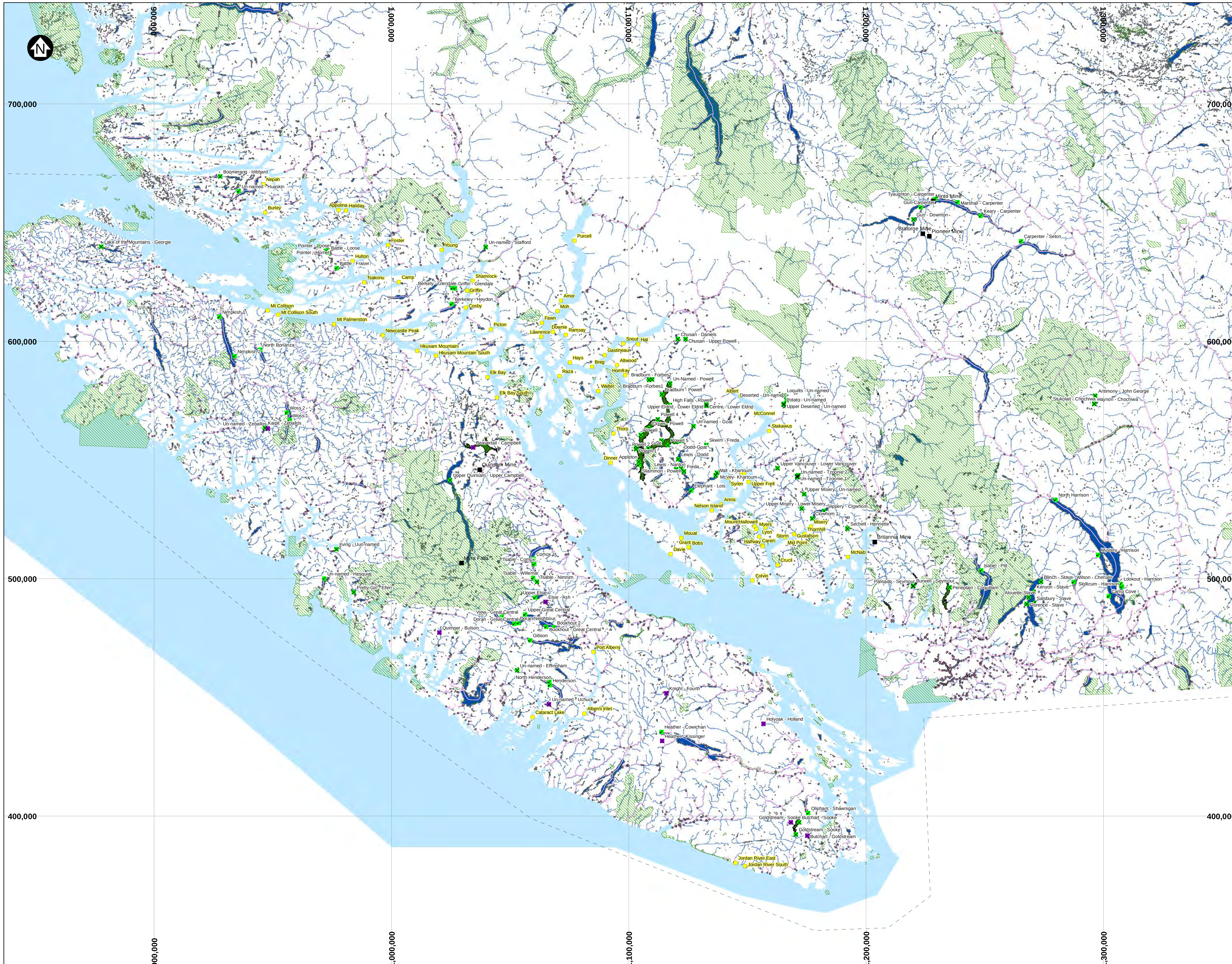

N
BRITISH
COLUMBIA
ALBERTA
Cordilleran
Highlands
Calgary
700,000
650,000
600,000
550,000
500,000
450,000
400,000
350,000
800,000
850,000
900,000
950,000
1,000,000
1,050,000
1,100,000
1,150,000
1,200,000
1,250,000
1,300,000
1,350,000
LEGEND:
GENERAL
STUDY AREA BOUNDARY
PROVINCIAL PARK / PROTECTED AREA
RIVER
LAKE
OCEAN
NOTES
1. BASE MAP: NTS & BING MAPS
2. CO-ORDINATE GRID IS IN METRES.
DATUM: NAD 83
PROJECTION: BC ENVIRONMENT ALBERS
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,800,000
FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER
ACCORDING TO CHANGES IN PRINTER SETTINGS OR
PRINTED PAPER SIZE.
SCALE
10 5 0 10 20 30 40 50 km
BC HYDRO
EVALUATION OF PUMPED STORAGE
HYDROELECTRIC POTENTIAL
STUDY AREA
Knight Piésold
CONSULTING
P/A NO.
VA103-313/1
REF NO.
1
FIGURE 3.1
REV
0
0 | 30NOV'10 | ISSUED WITH REPORT | TMF | KK | SRM | JPH
REV | DATE | DESCRIPTION | DESIGNED | DRAWN | CHK'D | APP'D


BRITISH COLUMBIA
ALBERTA
Cordilleran Highlands
LEGEND:
GENERAL
STUDY AREA BOUNDARY
RIVER
LAKE
OCEAN
FISS DATABASE
HISTORICAL FISH DISTRIBUTION
SALMON
SALMON
NOTES
1. BASE MAP: NTS & BING MAPS
2. CO-ORDINATE GRID IS IN METRES.
DATUM: NAD 83
PROJECTION: BC ENVIRONMENT ALBERS
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,800,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE 10 5 0 10 20 30 40 50 km
BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL
SALMON BEARING LAKES AND RIVERS IN THE PROJECT AREA
Knight Piésold CONSULTING
VA103-313/1
FIGURE 3.2
0 30NOV'10 ISSUED WITH REPORT TMF KK SRM JPH
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D


Boomerang - Hibbard
Un-named - Huaskin
Lake of the Mountains - Georgie
Pointer - Loose
Battle - Loose
Pointer - Hornet
Battle - Fraser
Un-named - Stafford
Berkely - Glendale
Griffin - Glendale
Berkeley - Heydon
Amor
Nimpkish 1
Nimpkish 2
North Bonanza
Woss 2
Woss 1
Kaipit - Zeballos
Un-named - Zeballos
Chusan - Upper Powell
Chusan - Daniels
Altwood
Bradburn - Forbes2
Un-Named - Powell
Bradburn - Forbes1
Albert
Potato - Un-named
Deserted - Un-named
Bradburn - Powell
Powell 4
Powell 3
Dodd-Goat
Powell 2
Goat
Skwim - Freda
Beavertail - Campbell
Powell 1
Powell 5
Freda
Walt - Khartoum
McVey - Khartoum
Appleton
Upper Quinsam - Upper Campbell
Sliammon - Powell
Annis
Elephant - Lois
Upper Misery - Un-named
Clowhom 1
Upper Misery - Lower Misery
Slippery - Clowhom
Sechelt - Henriette
Gun - Downton
Gun-Carpenter
Keary - Carpenter
Carpenter - Seton
Stukolait - Chochiwa
Haynon - Chochiwa
Antimony - John George
North Harrison
Mystery - Harrison
Isabel - Pitt
Palisade - Seymour
Burwell - Seymour
Kenyon - Stave
Camp Cove
Peneplain - Coquitlam
Blinch - Stave
Alouette-Stave
Salsbury - Stave
Irving - Uun-named
Comox 1
Tsable - Comox
Tsable - Willemar
Tsable - Nimnim
Un-named - Hesquiat
Pretty Girl - Ellen
Upper Elsie
Elsie - Ash
Upper Great Central
Doran Neighbour
Quimper - Bulson
Gibson
North Henderson
Henderson
Un-named - Uchuck
Knight - Fourth
Holyoak - Holland
Heather - Cowichan
Goldstream - Sooke
Butchart - Sooke
Goldstream - Sooke
Butchart - Goldstream
700,000
650,000
600,000
550,000
500,000
450,000
400,000
900,000
950,000
1,000,000
1,050,000
1,100,000
1,150,000
1,200,000
1,250,000
1,300,000
1,350,000
Lake
BRITISH
COLUMBIA
ALBERTA
LEGEND:
GENERAL
STUDY AREA BOUNDARY
RIVER
LAKE
OCEAN
FRESHWATER PUMPED STORAGE SITE
500 MW
1000MW
NOTES
1. BASE MAP: NTS & BING MAPS
2. CO-ORDINATE GRID IS IN METRES.
DATUM: NAD 83
PROJECTION: BC ENVIRONMENT ALBERS
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,500,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE
10 5 0 10 20 30 40 50 km
BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL
FRESHWATER PUMPED STORAGE SITES
Knight Piésold
CONSULTING
P/A NO.
VA103-313/1
REF NO.
1
FIGURE 3.3
REV
0
0 30NOV'10 ISSUED WITH REPORT KK KK TMF SRM
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D


Nepah
Burley
Appolina Haliday
Foster
Young
Purcell
Hulton
Tsakonu Camp
Griffin
Shamrock
Cosby
Mt Collison
Mt Palmerston
Moh
Fawn
Picton
Ramsay
Mt Collison South
Newcastle Peak
Downie
Snout Hat
Hkusam Mountain
Lawrence
Breg
Raza
Homfray
Hkusam Mountain South
Elk Bay
Walter
Elk Bay South
McConnel
Thors
Stakawus
Dinner
Syren
Calder
Saumarez
Mount Troubridge
Nelson Island
Myers
Misery
Mouat
Lyon
Thornhill
Bobs
Caren
Storm
Davie
Grant
Halfway
Crucil
McNab
Colvin
Port Alberni
Cataract Lake
Alberni Inlet
Heather - Kissinger
Jordan River East
Jordan River South
BRITISH
COLUMBIA
ALBERTA
LEGEND:
GENERAL
STUDY AREA BOUNDARY
RIVER
LAKE
OCEAN
SALTWATER PUMPED STORAGE SITE
1000 MW
NOTES
1. BASE MAP: NTS & BING MAPS
2. CO-ORDINATE GRID IS IN METRES. DATUM: NAD 83 PROJECTION: BC ENVIRONMENT ALBERS
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,500,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE
BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL
SALTWATER PUMPED STORAGE SITES
Knight Piésold CONSULTING
VA103-313/1
FIGURE 3.4
0 30NOV'10 ISSUED WITH REPORT TMF KK SRM JPH
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D


N
Cordilleran
Highlands
BRITISH
COLUMBIA
ALBERTA
Edmo
Calgar
Minto Mine
Bralorne Mine
Pioneer Mine
Quinsam Mine
Britannia Mine
Myra Falls
700,000
650,000
600,000
550,000
500,000
450,000
400,000
900,000
950,000
1,000,000
1,050,000
1,100,000
1,150,000
1,200,000
1,250,000
1,300,000
1,350,000
LEGEND:
GENERAL
STUDY AREA BOUNDARY
RIVER
LAKE
OCEAN
UNDERGROUND MINE
NOTES
1. BASE MAP: NTS & BING MAPS
2. CO-ORDINATE GRID IS IN METRES.
DATUM: NAD 83
PROJECTION: BC ENVIRONMENT ALBERS
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,500,000
FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER
ACCORDING TO CHANGES IN PRINTER SETTINGS OR
PRINTED PAPER SIZE.
SCALE 10 5 0 10 20 30 40 50 km
BC HYDRO
EVALUATION OF PUMPED STORAGE
HYDROELECTRIC POTENTIAL
UNDERGROUND MINES IN THE PROJECT AREA
Knight Piésold
CONSULTING
P/A NO. VA103-313/1
REF NO. 1
FIGURE 3.5
REV 0
0 30NOV'10 ISSUED WITH REPORT TMF KK SRM JPH
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D



LEGEND:

GENERAL
- FISS SALMON LOCATION POINT
- FISS SALMON LOCATION LINE
- STUDY AREA BOUNDARY
- RIVER
- DRINKING WATER
- PARKS
- LAKE
- OCEAN

PUMPED STORAGE SITES
- FRESH WATER 500 MW
- FRESH WATER 1000MW
- SALT WATER 1000MW
- NO SALMON
- WITH SALMON
- ACTIVE/ABANDONED UNDERGROUND MINE

NOTES:

1. BASE MAP: NTS AND BING MAP
2. CO-ORDINATE GRID IS IN METRES. DATUM: NAD 83 PROJECTION: BC ENVIRONMENT ALBERS
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:800,000 FOR 24x36 ("D" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. FISH DATA DERIVED FROM FISS DATABASE

SCALE 10 5 0 10 20 30 40 50 Kilometers

BC HYDRO

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL

SUMMARY OF PUMPED STORAGE POTENTIAL

Knight Piésold CONSULTING

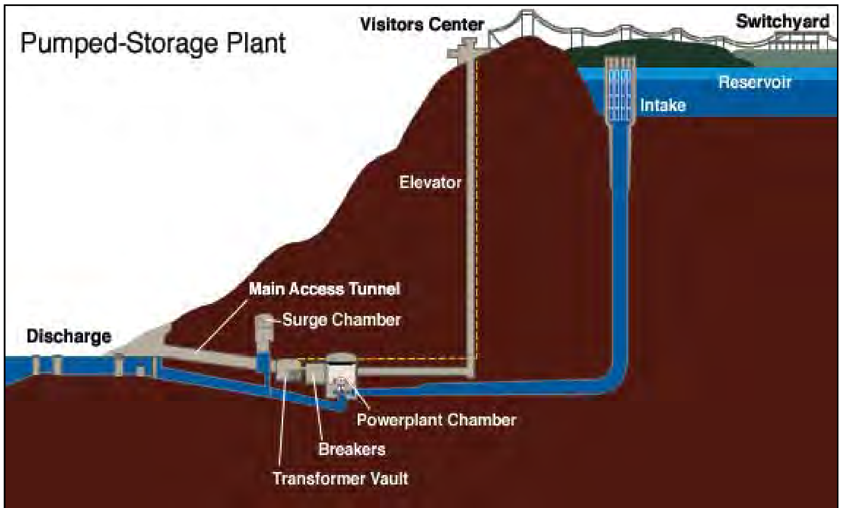
P/A NO.	REF NO.
VA103-313/1	1

FIGURE 3.6 REV 0

0	30NOV'10	ISSUED WITH REPORT	TMF	KK	SRM	JPH
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

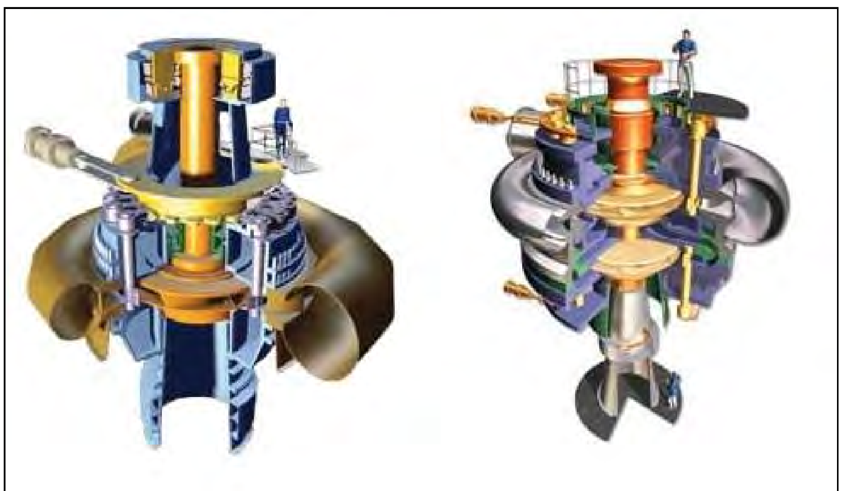
SAVED: M:\1\03\00313\01\A\GIS\Figs\BCHydroPumpedStorageRev0.mxd; Nov 30, 2010 10:45:12 AM kkrauszova

Knight Piésold
CONSULTING



Source: http://carbon-pros.com/image/tva-pumped-storage.jpg

PHOTO 1 – Schematic of Pumped Storage Scheme.



Source: Alstom

PHOTO 2 – Schematic of Single-Stage vs. Multistage Reversible Pump Turbines.

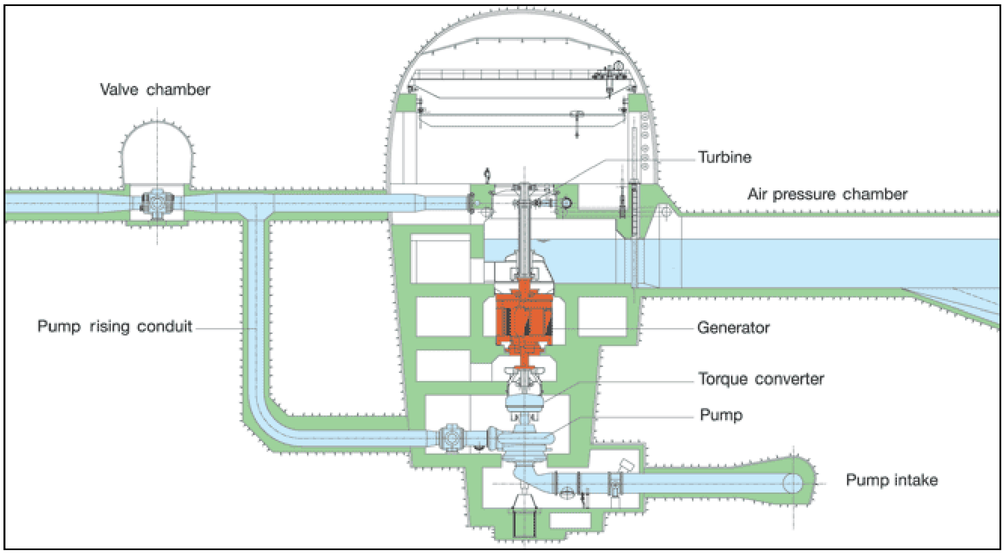


PHOTO 3 – Schematic of Pelton Unit Combined with Multistage Pump.

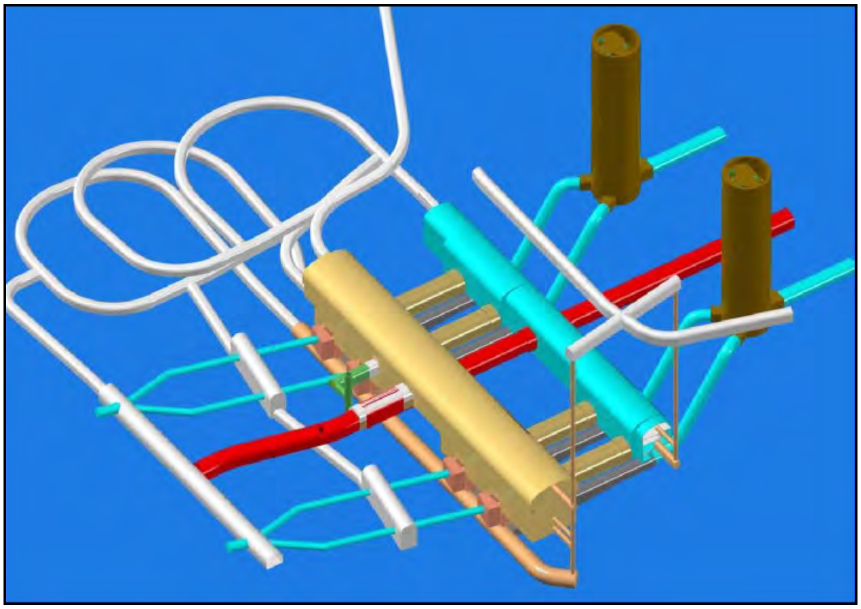


PHOTO 4 – Schematic of 3D Model of Underground Powerhouse.

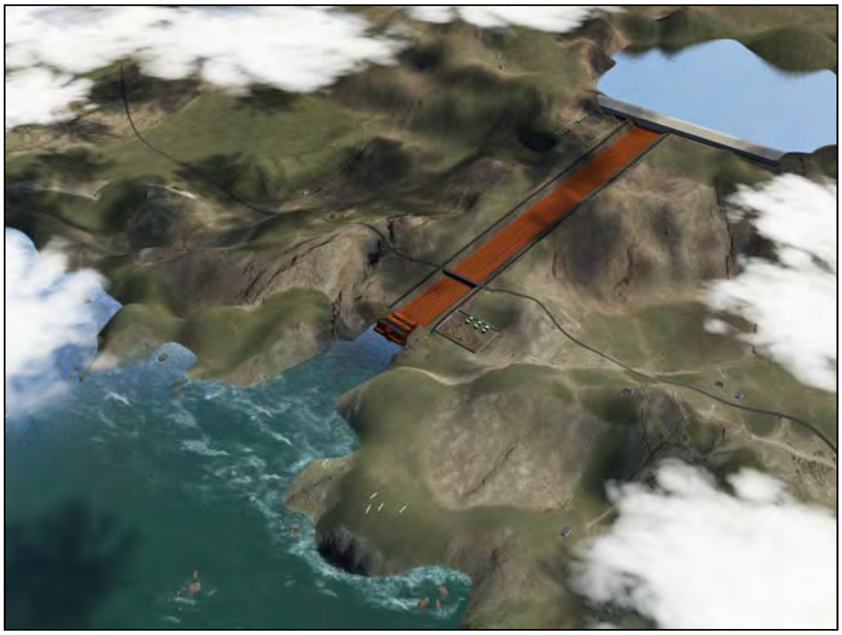


PHOTO 5 – Spirit of Ireland Project – Artistic Rendition of Saltwater Pumped Storage Scheme.

PHOTO 6 – Okinawa Saltwater Pumped Storage Plant – Cutaway Model of Plant.

Knight Piésold
CONSULTING

PHOTO 7 – Ingula Pumped Storage Scheme – CFRD Dam.

PHOTO 8 – Ingula Pumped Storage Scheme – Intake Tower Under Construction.

Knight Piésold
CONSULTING

PHOTO 9 – Ingula Pumped Storage Scheme – Machine Hall Under Construction.

PHOTO 10 – Ingula Pumped Storage Scheme – Outlet Structure Under Construction.

Knight Piésold
CONSULTING

Source: http://www.hydroworld.com/etc/medialib/HRW/Articles/Volume-18/issue-4.Par.90483.Image.450.319.1.gif

PHOTO 11 – Example of "Crow's Nest" Upper Reservoir – Taum Sauk Facility, USA.

Source: http://lostontheshore.typepad.com/photos/uncategorized/2008/02/20/usace_kinzua_dam_downriver.jpg

PHOTO 12 – Example of "Crow's Nest" Upper Reservoir – Seneca Facility, USA.

Knight Piésold
CONSULTING

Source: http://data.czechtourism.com/aktivity/foto/2008-09-01-0953-za-poznanim-pesi-turistika-loucna-nad-desnou/e474ebbb-77fa-11dd-addc-001a64a218ce.jpg

PHOTO 13 – Example of “Crow’s Nest” Upper Reservoir – Dlouhé Stráně Facility, Czech Republic.

Source: http://4.bp.blogspot.com/_WyIc2oXjvmc/SzqzWWU6j1I/AAAAAAAABfk/YH75vjWDXus/s400/Japan+hydro.jpg

PHOTO 14 – Aerial View of Okinawa Saltwater Pumped Storage Plant, Japan.

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL IN THE NORTH COAST REGION OF BRITISH COLUMBIA

SCREENING ASSESSMENT

PREPARED FOR:

BC Hydro
333 Dunsmuir Street
Vancouver BC, V6B 5R3

PREPARED BY:

Knight Piésold Ltd.
Suite 1400 – 750 West Pender Street
Vancouver, BC V6C 2T8 Canada
p. +1.604.685.0543 • f. +1.604.685.0147

Knight Piésold
CONSULTING
www.knightpiesold.com

VA103-313/2-1
Rev 0
March 15, 2012

ISO 9001, ISO 14001
OHSAS 18001

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL IN THE NORTH COAST REGION OF BRITISH COLUMBIA

SCREENING ASSESSMENT
(REF. NO. VA103-313/2-1)

Rev	Description	Date	Approved
0	Issued in Final	March 15, 2012	SRM

Knight Piésold Ltd.
Suite 1400
750 West Pender Street
Vancouver, British Columbia Canada V6C 2T8
Telephone: (604) 685-0543
Facsimile: (604) 685-0147
www.knightpiesold.com

Knight Piésold CONSULTING

Knight Piésold
CONSULTING

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL IN THE NORTH COAST REGION OF BRITISH COLUMBIA

SCREENING ASSESSMENT
(REF. NO. VA103-313/2-1)

EXECUTIVE SUMMARY

BC Hydro engaged Knight Piésold Ltd. (KPL) to conduct a screening assessment of the pumped storage potential in the North Coast Region of British Columbia. The purpose of this assessment was to determine whether there are potentially viable greenfield pumped storage hydroelectric sites in the North Coast Region of British Columbia. This report illustrates that there are a number of potentially viable sites, all of which are freshwater.

The assessment was limited to an area within 50 km of BC Hydro's two main transmission lines within the North Coast Region (2L101 and 2L99). Within the area surrounding 2L99, sites of up to 1000 MW capacity were assessed, while sites were limited to 500 MW in the region near 2L101. In addition, potential pumped storage sites were assessed along a likely transmission corridor from the West Coast of Banks Island to Douglas Channel, given the high potential for wind resources in the area.

Potential basins were identified using a combination of existing lakes and/or man-made reservoirs. Using these potential candidate basins, an in-house GIS screening tool identified sites that could provide storage for 16 or 48 hours of continuous generation with a minimum dam embankment construction volume. In addition, potential saltwater sites were identified. The 120 potential sites identified using Knight Piésold's in-house GIS screening tool were then ranked using a cost estimation spreadsheet in order of levelised capital cost ($/kW-year).

From the list of possible sites, a total of 33 were identified as having the potential to provide 16 hrs of continuous generation at either 500 MW or 1000 MW capacity below a threshold of $200/kW-yr. In addition, 29 sites were identified as having the ability to provide 48 hrs of continuous generation below a threshold of $500/kW-yr. The 25 best sites had estimated costs ranging from $83/kW-yr to $140/kW-yr for 16 hours of continuous generation, and $181/kW-yr to $430/kW-yr for 48 hours of continuous generation. While a number of potential saltwater sites were identified, it appears that development of freshwater pumped storage sites would be more cost effective. The saltwater pumped storage sites identified ranged in cost between $267 – 490/kW-yr. In addition, the development of freshwater pumped storage sites will likely have a reduced environmental impact in comparison to saltwater pumped storage.

The North Coast Region of British Columbia has a high technical potential for freshwater pumped storage development due to the steep topography and existence of many natural lakes and other suitable basins for constructing pumped storage reservoirs. The development costs appear to be similar to the Lower Mainland and Vancouver Island, but with fewer viable sites, due to the relative lack of existing hydropower reservoirs in the region. Based on the potential for pumped storage in the North Coast, and the projected increase in loads and renewable energy in the region, we recommend further assessment of these sites, commencing with estimation of transmission, access and interconnection costs.

Knight Piésold
CONSULTING

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL IN THE NORTH COAST REGION OF BRITISH COLUMBIA

SCREENING ASSESSMENT
(REF. NO. VA103-313/2-1)

TABLE OF CONTENTS

PAGE

Knight Piésold CONSULTING

TABLES

FIGURES

Knight Piésold
CONSULTING

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL IN THE NORTH COAST REGION OF BRITISH COLUMBIA

SCREENING ASSESSMENT
(REF. NO. VA103-313/2-1)

SECTION 1.0 - INTRODUCTION

1.1 INTRODUCTION

BC Hydro engaged Knight Piésold Ltd. (KPL) to conduct a screening assessment of the pumped storage potential in the North Coast Region of British Columbia. This report discusses the results of the assessment.

1.2 PREVIOUS STUDIES

KPL previously conducted a similar study for the Lower Mainland and Vancouver Island region of southwest British Columbia, in 2010. KPL have adopted a similar methodology in the current report, and have adapted the same screening and assessment tools that were developed for that study.

1.3 BACKGROUND TO PUMPED STORAGE

The concept of pumped storage is the generation of electricity by capturing the energy of water being transferred from a higher elevation upper reservoir, through turbine/generator units, into a lower elevation reservoir. The system is then reversed and the water from the lower reservoir is pumped back to the upper reservoir. Though the system is a net consumer of energy, it can be advantageous to developers/utilities by:

- Providing additional capacity during high-load hours when the cost of energy is greatest
- Increasing profitability by using low-value base load energy to pump water to the upper reservoir during low-load hours
- Providing grid stability by reducing the generation differential between high-load and low-load periods,
- Relieving constrained transmission components
- Providing voltage regulation, especially at the end of long transmission systems (relevant to the North Coast Region of BC)
- Providing storage for intermittent renewable energy sources that cannot be dispatched on demand
- Providing backup capacity in the event of a planned or unplanned outage of another significant generation source connected to the grid, and/or
- Providing capacity for export.

Pumped storage projects can be either freshwater or saltwater. Nearly all pumped storage projects worldwide to date are freshwater pumped storage projects. As of 2009, it was estimated that more than 127, 000 MW of pumped storage capacity was operating worldwide.

The concept of saltwater pumped storage is the same as that of freshwater pumped storage, with the exception that seawater is exchanged between the ocean and an upper reservoir instead of a freshwater lower reservoir. The advantage of saltwater pumped storage over freshwater pumped storage is that construction of only one reservoir is needed, which can significantly reduce the capital cost of the development. There is currently only one saltwater pumped storage project operating worldwide. This is located in Okinawa, Japan, and has been operating for more than 10 years. There are also numerous saltwater tidal power projects around the world. However, in BC there are numerous fresh water lakes that could also act as the lower reservoir, without the additional complications of salt water corrosion, marine growth issues and added environmental permitting risk of a saltwater development.

Knight Piésold CONSULTING

SECTION 2.0 - SCREENING METHODOLOGY

2.1 SPATIAL LIMITATIONS

The study area was limited to the North Coast Region of British Columbia, limited to a 50 km boundary on either side of the 2L99 and 2L101 transmission lines of BC Hydro's grid. Within the study area, the following spatial limitations apply:

- Terrestrial parks and reserve areas are excluded from the study area
- Marine parks are included in the study area
- Private land is included in the study area, and
- Indian Reserves are included in the study area.

A summary of the study area is shown on Figure 2.1.

In addition, potential pumped storage sites were assessed along a likely transmission corridor from the West Coast of Banks Island to Douglas Channel, given the high potential for wind resources in the area.

2.2 LIMITATIONS ON GENERATION CAPACITY

Only sites that have an installed capacity of 500 MW were considered along the 2L101 corridor. Sites with either 500 MW or 1000 MW of installed capacity were considered along the 2L99 corridor. In instances where the defined study areas along 2L99 and 2L101 intersect, the requirements for 2L99 applied.

It is assumed that the additional sites along potential transmission line routes from Banks Island to Kitimat would follow the same requirements for the 2L99 region.

2.3 MINIMUM STORAGE REQUIREMENTS

Two sets of sites were identified. The first set included sites that have storage for 16 continuous hours of generation. The second set included sites that have storage for 48 hours of continuous generation. These equate to an energy storage of 8,000 MWh and 24,000 MWh for the 500 MW sites, and 16,000 MWh and 48,000 MWh for the 1,000 MW sites respectively. The volume of water required to store this amount of energy varies by project, depending on the available head.

2.4 ENVIRONMENTAL LIMITATIONS

Salmon bearing rivers were excluded from the study. The Fish Information Summary System (FISS) from the BC Ministry of Environment was used as the basis for known fish distribution data. Rivers with historical observances of Chinook, Sockeye, Chum, Coho, Pink and/or Steelhead were not considered in the screening assessment.

Existing lakes with historical observances of Salmon were included in the assessment. Only one salmon bearing lakes was identified as a potential pumped storage site, and this was not one of the more cost effective sites. Another two salmon bearing lakes (Kitsumkalum Lake and Lakelse Lake) were identified in the study area as potentially good pumped storage reservoir locations. However, these were excluded as it would be likely that construction of a pumped storage facility at other of these locations would require the creation of a reservoir that would impact salmon habitat on the rivers upstream of the lake. A summary of the fish distribution data for the salmon species mentioned above are shown on Figure 2.2.

2.5 TECHNICAL CONSTRAINTS

For each of the two sets of sites (16 hours storage and 48 hours of storage), a maximum of 25 sites were identified. A preliminary cost estimate for each of the 120 potential sites identified by the screening was undertaken in order to rank the sites in order of levelised capital cost. Only the 25 highest ranked sites for each of the two sets of sites were included in the report. Where a potential site was ranked highly for both 500 MW or 1000 MW capacity, only the lower cost (levelised capital cost) configuration was included in the list of potential sites. In order to determine the real levelised cost ($/kW-year), the following was assumed;

- Design Life = 70 years, and
- Discount Rate = 6%

2.5.1 Freshwater Lake to Lake Sites

The North Coast Region of British Columbia has an abundance of small lakes in combination with the steep topography. Due to this high number of potential sites, lakes with the most attractive characteristics were targeted, and were included in the pool of candidate basins for further assessment. All existing lakes within the study area were screened as follows;

- Lakes > 2 ha were assessed as potential reservoir basins.
- Existing lakes within a 10 km horizontal distance that could be used as an upper and lower reservoir respectively (i.e. waterway length is limited to approximately 10 km or less).
- For existing lakes, all water storage was assumed to be constructed above the natural lake water level.

A total of approximately 100 “existing lake” basins were identified using an automated GIS searching tool.

2.5.2 Man-Made Reservoir Sites

Due to the relatively undisturbed nature of the North Coast Region, there are few existing reservoirs, and large existing lakes are concentrated towards the west coast. For this reason, it was necessary to assess the potential of new man-made reservoirs to serve as potential upper and/or lower reservoirs. A visual assessment was undertaken using TRIM mapping to manually identify potential reservoir basins. For each potential basin, a “nominal” reservoir size was calculated using GIS, including the dam height and crest length, reservoir storage volume, and reservoir elevation. A total of approximately 200 “man-made reservoir” basins were identified using a visual assessment of the entire study area.

2.5.3 Saltwater Pumped Storage Sites

The same constraints for the freshwater “man-made reservoir” sites were applied to the screening assessment of saltwater pumped storage sites. Additionally, freshwater lakes were not considered as upstream reservoirs, due to the high environmental impact of pumping saltwater into a freshwater ecosystem. In some instances, upstream reservoirs were proposed in areas that contained either wetland or small ponds. Since it is difficult to determine at what size threshold this may not be permissible, a certain amount of judgement was required to satisfy this constraint. Only sites whose watershed flows directly to the ocean were considered and any saltwater site that would flow into an existing lake or salmon bearing river was not considered. Using visual assessment, a total of approximately 20 potential saltwater basins were identified in the study area. These potential basins are shown on Figure 2.3.

2.5.4 Screening Assessment

From the above, a list of 320 potential basins for freshwater reservoirs was created as shown on Figure 2.4. A screening was undertaken using an automated GIS tool to choose the best combinations of freshwater basins that would lead to viable pumped storage sites. This tool identifies any two basins within approximately 10 km. In some cases, two basins slightly more than 10 km apart were assessed. Between any two basins, the GIS tool will assess the gross head between the two sites and will calculate the storage volume required to meet the project assessment requirements. The GIS tool then determines whether the two basins can be constructed as a potential pumped-storage facility with a dam embankment construction volume below a certain threshold. This threshold was chosen as dam embankment construction can potentially add up to 33% or more of project construction costs, and so minimising dam embankment volume appears to be a useful mechanism to screen some of the best sites from the pool of potentially infinite combinations of sites between the basins identified. The GIS assessment tool was used with the following two constraints;

- A total dam embankment construction volume of 1,000,000 m^3, with a reservoir storage capacity for 48 hrs of continuous generation.
- A total dam embankment construction volume of 500,000 m^3, with a reservoir storage capacity for 16 hrs of continuous generation.

Using these constraints, the GIS tool flagged a total of 120 potential pumped-storage sites.

2.5.5 Site Characterisation and Costing

Using the 120 potential sites flagged by the GIS tool, each site was characterised in order to determine the project properties, which were then used as the basis of the cost estimate for each alternative. The main parameters of the characterisation include overall project parameters (gross head, design flow, capacity), reservoir parameters (required storage volume, reservoir area, embankment height and length, embankment volume), and waterway parameters (length, diameter, lining requirements). Due to the coarse resolution of the data, and the automated nature of the calculations, some of the site parameters (such as dam height, crest length and reservoir area) may vary once each site is assessed in greater detail on an individual basis.

Cost estimates were prepared for each identified pumped-storage site by using a cost template of unit rates for project components. The unit rates used in the costing were based on experience from other pumped storage and hydroelectric projects that KPL has experience in. To provide comparison, these were the same costs as were adopted for the Assessment of Pumped Storage Potential in South-West BC, so all costs are in 2010 dollars. The capital cost estimates do not include transmission, interconnection or access to the site. As such, it would not be prudent to compare the sites based purely on a cost basis until these additional costs have been determined. The cost of transmission, interconnection and access will favour those sites closer to load centres or transmission lines.

The costs for each site are presented as loaded capital costs (based on the schedules presented in Figure 2.5, a discount rate of 6% and cost distributions as presented in Table 2.1). Cost per MW installed, cost per MWh stored, and levelized capital cost ($/kW-yr) were also determined.

Annual Operation and Maintenance costs were also estimated for each site. These costs are estimated as a percentage of the total estimated capital cost as follows;

- Freshwater pumped storage sites, 1000 MW – 1.0%
- Freshwater pumped storage sites, 500 MW – 1.5%, and
- Saltwater pumped storage sites, 500 MW – 2.0%.

Knight Piésold CONSULTING

SECTION 3.0 - SCREENING ASSESSMENT RESULTS

3.1 FRESHWATER SITE IDENTIFICATION

A total of 33 potential freshwater sites with storage for 16 hrs of continuous generation and levelised capital cost below $200/kW-yr were identified. These included;

- Four sites with costs less than $100/kW-yr
- Fourteen sites with costs between $100 – 125/kW-yr
- Eleven sites with costs between $125 – 150/kW-yr, and
- Ten sites with costs greater than $150/kW-yr.

The cost of cumulative installed capacity is indicated on Figure 3.1. The characteristics and costs of the 25 sites with the lowest estimated levelised cost are shown in Table 3.1 and Figure 3.4.

A total of 29 potential freshwater sites with storage for 48 hrs of continuous generation and levelised capital cost below $500/kW-yr were identified. These included;

- Three sites with costs less than $200/kW-yr
- Eleven sites with costs between $200 – 300/kW-yr
- Nine sites with costs between $300 – 400/kW-yr, and
- Six sites with costs greater than $400/kW-yr.

The cost of cumulative installed capacity is indicated on Figure 3.2. The characteristics and costs of the 25 sites with the lowest estimated levelised cost are shown in Table 3.2 and Figure 3.5

3.2 SALTWATER SITE IDENTIFICATION

A total of 12 potential saltwater sites with storage for 16 hrs of continuous generation and levelised capital cost below $500/kW-yr were identified. These included;

- Three sites with costs less than $300/kW-yr
- Four sites with costs between $300 – 400/kW-yr, and
- Five sites with greater than $400/kW-yr.

The cost of cumulative installed capacity is indicated on Figure 3.3. No saltwater sites with potential for storage for 48 hrs continuous generation were identified. The lists of the lowest estimated cost sites (Tables 3.1 and 3.2), did not include any saltwater sites.

Knight Piésold CONSULTING

SECTION 4.0 - CONCLUSIONS AND RECOMMENDATIONS

The North Coast Region of British Columbia has a high technical potential for freshwater pumped storage development due to the steep topography and existence of many natural lakes and other suitable basins for constructing pumped storage reservoirs. The potential appears to be slightly less than in the Lower Mainland and Vancouver Island, primarily due to the relatively undisturbed nature of the landscape and the lack of many existing hydropower and other man-made reservoirs suitable for use as part of a pumped storage facility. In addition, it appears that larger lakes are concentrated in the western portion of the region, where there are a large number of parks and few suitable high elevation basins for use as an upper reservoir. These factors appear to limit the total number of sites, however the most cost effective sites appear to be similar in terms of unit cost ($/kW-yr) to the best sites in the Lower Mainland.

A total of 33 sites were identified with the potential to provide 16 hrs of continuous generation at either 500 MW or 1000 MW capacity. In addition, 29 sites were identified having the ability to provide 48 hrs of continuous generation. The 25 best sites had estimated costs ranging from $83/kW-yr to $140/kW-yr for 16 hours of continuous generation, and $181/kW-yr to $430/kW-yr for 48 hours of continuous generation. Of the top 25 sites for 48 hours of continuous generation, all were of 500 MW capacity. While some sites can be developed to 1000 MW capacity, it appears to be more cost effective to constrain these larger sites to 500 MW. Still, it is likely that it would be more cost effective to develop some of the best sites to a capacity of 1000 MW than to develop two lower ranked sites to a capacity of 500 MW each.

While a number of potential saltwater sites were identified, it appears that development of freshwater pumped storage sites would be more cost effective. The saltwater pumped storage sites identified ranged in cost between $267 – 490/kW-yr. In addition, the development of freshwater pumped storage sites will likely be easier to permit, and pose fewer technical challenges in comparison to construction of saltwater pumped storage sites.

Should BC Hydro wish to further pursue pumped storage potential in BC, KPL recommends the items below. KPL is aware that some of these items are underway already;

- Estimate the costs of transmission, interconnection and access to each of the sites identified in order to meaningfully compare each potential project.
- Conduct a system-wide study to determine the benefits/impacts of integrating pumped storage into the BC Hydro grid.
- Determine the “ideal” characteristics of a pumped storage facility, in terms of providing the maximum benefits to the BC Hydro system, improving export opportunities and firming of renewable energy (especially wind power).
- Conduct a screening assessment for the remaining portions of the province where there is a high resource potential of intermittent loads or renewable energy sources such as wind, run-of-river hydro, solar, tidal and/or wave energy.
- Conduct a more detailed assessment of the most favourable sites identified in this assessment.

Knight Piésold CONSULTING

SECTION 5.0 - REFERENCES

American Society of Civil Engineers. 1989. *Civil engineering guidelines for planning and designing hydroelectric developments.* Volume 5, Pumped Storage and Tidal Power. New York, NY: American Society of Civil Engineers.

Knight Piésold Ltd. 2010. *Evaluation of Pumped Storage Hydroelectric Potential in South-West BC – Screening Assessment Report*. Ref: VA103-313/1-1.

Knight Piésold
CONSULTING

SECTION 6.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA M. G. PULLINGER # 162149

Mar 15, 2012.

Prepared:

Michael Pullinger, M.Sc., P.Eng.
Project Engineer

Reviewed:

Sam Mottram, P.Eng.
Power Services Manager

Approved:

for.

Jeremy Haile, P.Eng.
President

Knight Piésold CONSULTING

TABLE 2.1

BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT

DEVELOPMENT COST DISTRIBUTION BY PUMPED STORAGE TYPE

Print: 3/15/2012 10:38

	Development Cost Distribution	
Year	**Freshwater**	**Saltwater**
Year 1	0%	0%
Year 2	0%	0%
Year 3	5%	0%
Year 4	10%	5%
Year 5	20%	10%
Year 6	30%	20%
Year 7	30%	30%
Year 8	5%	30%
Year 9	--	5%
Total	**100%**	**100%**

M:\1\03\00313\02\A\Report\1 - North Coast Region Pumped Storage\Rev 0\Tables\[Table2-1.xlsx]Sheet1

0	6MAR'12	ISSUED WITH REPORT VA103-313/2-1	MGP	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.1

BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT

SUMMARY OF SITES WITH STORAGE FOR 16 HRS OF CONTINUOUS GENERATION

Print: 3/6/2012 9:35

Name	Latitude	Longitude	Latitude	Longitude	Capacity	Location	Upper Reservoir Area	Upper Reservoir Base Elevation	Upper Reservoir Crest Length	Upper Reservoir Dam Height	Lower Reservoir Area	Lower Reservoir Base Elevation	Lower Reservoir Dam Crest Length	Lower Reservoir Dam Height	Storage Requirement	Storage Requirement	2D Waterway Length	Gross Head	H/L Ratio	Design Flow (Generation)	Design Flow (Pumping), 70% of Generation Flow
	decimal degrees	decimal degrees	decimal degrees	decimal degrees	MW	Trans. Line	ha	masl	m	m	ha	masl	m	m	m3	MWh	m	m	%	m3/s	m3/s
Upper Clore	54.212	-127.933	54.184	-127.975	1000	2L99	101.6	1260	369	51	46.9	580	164.2	48.5	11,287,120	16,000	4150	680	16%	196	137
Sleeman	53.671	-128.675	53.697	-128.672	1000	2L99	105.1	900	555	54	115.1	300	598.7	49.9	12,792,069	16,000	2825	600	21%	222	155
Hirsch	54.027	-128.380	54.033	-128.334	1000	2L99	89.5	1340	636	64	36.7	400	223.8	22.4	8,165,150	16,000	3076	940	31%	142	99
Lower Falls	53.735	-128.498	53.702	-128.527	1000	2L99	71.5	700	481	83	119.1	120	102.2	7.8	13,233,175	16,000	4122	580	14%	230	161
Hugh	53.750	-128.774	53.697	-128.672	1000	2L99	85.3	900	397	39	82.2	60	110.3	25	9,137,192	16,000	8897	840	9%	159	111
Upper Falls	53.700	-128.488	53.702	-128.527	1000	2L99	74.0	700	499	86	123.4	140	611.0	37.4	13,705,788	16,000	2622	560	21%	238	167
Oliver	54.803	-128.193	54.820	-128.165	1000	2L99	74.3	1020	468	63	74.3	400	829.7	66.1	12,379,422	16,000	2580	620	24%	215	150
Kitimat 1	54.044	-128.120	54.049	-128.032	1000	2L99	67.2	1300	421	90	62.2	560	370.1	36.6	10,371,948	16,000	5798	740	13%	180	126
Lower Hirsch 2	54.088	-128.487	54.017	-128.446	1000	2L99	56.3	1140	711	54	90.1	220	165.5	4.6	8,342,654	16,000	8383	920	11%	145	101
Andesite	54.409	-129.268	54.384	-129.186	1000	2L99	114.7	900	829	72	59.2	200	62.9	18.5	10,964,631	16,000	5996	700	12%	190	133
Jesse Creek 1	53.929	-128.901	53.939	-128.929	1000	2L99	215.9	360	783	67	431.7	40	1177.8	25.1	23,985,129	16,000	2095	320	15%	416	291
Lower Hirsch 1	54.098	-128.484	54.033	-128.334	1000	2L99	77.7	1340	534	53	74.0	220	136.0	3.8	6,852,894	16,000	12186	1120	9%	119	83
Lower Clore 2	54.295	-127.924	54.341	-127.793	1000	2L99	287.8	980	901	45	50.8	500	108.4	13.8	15,990,086	16,000	9902	480	5%	278	194
Kitimat 2	54.070	-128.123	54.049	-128.032	1000	2L99	64.0	1300	399	86	106.3	520	545.4	35.0	9,840,053	16,000	6392	780	12%	171	120
Lower Clore 1	54.275	-127.940	54.184	-127.975	1000	2L99	90.9	1260	330	46	32.1	500	68.8	8.7	10,099,002	16,000	10424	760	7%	175	123
Jesse Lake	53.917	-128.898	53.935	-128.934	1000	2L99	203.2	360	737	63	1776.5	20	714.7	49	22,574,239	16,000	3094	340	11%	392	274
Chimdemash	54.615	-128.220	54.593	-128.195	1000	2L99	28.8	1300	587	93	53.1	700	567.7	63.6	12,792,069	16,000	2938	600	20%	222	155
North Hirsch	54.063	-128.253	54.034	-128.327	1000	2L99	109.3	1340	808	81	62.2	600	725.6	49.5	10,371,948	16,000	5813	740	13%	180	126
Upper Lukes	54.132	-128.845	54.196	-128.884	1000	2L99	90.2	980	719	86	76.2	300	394.8	38.1	11,287,120	16,000	7544	680	9%	196	137
Diana	54.206	-130.150	54.205	-130.168	500	2L101	107.9	400	104	30	699.5	80	328.7	11.0	11,992,565	8,000	1165	320	27%	208	146
Lower Lukes	54.147	-128.733	54.196	-128.884	1000	2L99	80.4	980	627	75	35.4	200	51.9	11.0	9,840,053	16,000	11270	780	7%	171	120
Sue-Bardon 1	53.675	-129.018	53.639	-129.100	1000	2L99	162.8	400	193	44	230.3	100	292.4	109.7	25,584,138	16,000	6667	300	4%	444	311
Sue-Bardon 2	53.668	-129.048	53.639	-129.100	1000	2L99	190.7	400	263	60	194.4	180	546.2	68.3	34,887,461	16,000	4658	220	5%	606	424
Jesse Creek 2	53.963	-128.948	53.940	-128.934	1000	2L99	246.7	360	895	77	296.0	80	572.4	60.9	27,411,576	16,000	2643	280	11%	476	333
Aveling	54.221	-128.883	54.196	-128.884	1000	2L99	92.5	980	741	88	89.7	320	890.8	81.0	11,629,154	16,000	2776	660	24%	202	141

Name	Pump/Turbine Type	Total Estimated Capital Cost	Loaded Capital Cost	Unit Cost of Capacity (Loaded Capital Cost/Capacity)	Unit Cost of Stored Energy	Levelized Cost	Upper Reservoir Footprint	Upper Dam Footprint	Lower Reservoir Footprint	Lower Dam Footprint	Staging/Laydown Footprint	Spoil Footprint	Roads Footprint	Total Footprint
		$	$	$/MW	$/MWh	$/kW-yr	ha	ha	ha	ha	ha	ha	ha	ha
Upper Clore	Single-Stage	1,199,967,306	1,363,693,455	1,199,967	74,998	83.2	38.4	3.5	25.3	1.5	6.0	6.3	6.8	87.7
Sleeman	Single-Stage	1,329,292,286	1,510,663,817	1,329,292	83,081	92.2	41.6	5.5	39.3	5.5	6.0	5.7	6.0	109.5
Hirsch	Multi-Stage	1,408,031,541	1,600,146,427	1,408,032	88,002	97.7	46.1	7.3	9.3	1.0	6.0	5.8	9.4	84.8
Lower Falls	Single-Stage	1,418,849,098	1,612,439,955	1,418,849	88,678	98.4	56.8	7.2	4.5	0.2	6.0	6.4	6.2	87.2
Hugh	Multi-Stage	1,450,922,536	1,648,889,562	1,450,923	90,683	100.6	25.9	2.8	15.8	0.5	6.0	8.8	13.3	73.2
Upper Falls	Single-Stage	1,481,452,194	1,683,584,754	1,481,452	92,591	102.8	60.1	7.7	29.5	4.2	6.0	5.6	5.6	118.6
Oliver	Single-Stage	1,484,079,322	1,686,570,332	1,484,079	92,755	102.9	41.9	5.3	44.3	9.9	6.0	5.5	6.2	119.2
Kitimat 1	Single-Stage	1,517,064,912	1,724,056,548	1,517,065	94,817	105.2	61.1	6.8	20.9	2.5	6.0	7.2	8.7	113.1
Lower Hirsch 2	Multi-Stage	1,564,032,935	1,777,432,991	1,564,033	97,752	108.5	30.8	6.9	1.8	0.2	6.0	8.5	12.6	66.9
Andesite	Single-Stage	1,581,949,905	1,797,794,590	1,581,950	98,872	109.7	59.4	10.8	9.3	0.2	6.0	7.3	9.0	102.0
Jesse Creek 1	Single-Stage	1,624,035,890	1,845,622,879	1,624,036	101,502	112.6	73.2	9.5	34.6	5.6	6.0	5.5	3.2	137.6
Lower Hirsch 1	Multi-Stage	1,638,581,601	1,862,153,238	1,638,582	102,411	113.7	35.4	5.2	1.1	0.1	6.0	10.5	18.3	76.6
Lower Clore 2	Single-Stage	1,649,729,649	1,874,822,351	1,649,730	103,108	114.4	54.1	7.4	6.1	0.3	6.0	9.4	14.9	98.2
Kitimat 2	Multi-Stage	1,652,999,182	1,878,537,986	1,652,999	103,312	114.7	56.2	6.1	25.5	3.5	6.0	7.5	9.6	114.4
Lower Clore 1	Multi-Stage	1,690,199,438	1,920,813,926	1,690,199	105,637	117.2	32.2	2.8	2.8	0.1	6.0	9.6	15.6	69.1
Jesse Lake	Single-Stage	1,707,693,616	1,940,695,047	1,707,694	106,731	118.4	66.5	8.4	144.1	6.4	6.0	6.0	4.6	242.1
Chimdemash	Single-Stage	1,713,917,122	1,947,767,702	1,713,917	107,120	118.9	44.8	9.7	36.6	6.5	6.0	5.7	6.0	115.4
North Hirsch	Single-Stage	1,810,944,527	2,058,033,737	1,810,945	113,184	125.6	66.2	11.7	29.4	6.6	6.0	7.2	8.7	135.8
Upper Lukes	Single-Stage	1,811,198,926	2,058,322,847	1,811,199	113,200	125.6	65.3	11.1	23.9	2.8	6.0	8.1	11.3	128.5
Diana	Single-Stage	912,036,809	1,036,477,095	1,824,074	114,005	126.5	21.4	0.6	17.0	0.8	6.0	4.7	3.2	53.7
Lower Lukes	Multi-Stage	1,859,125,119	2,112,788,194	1,859,125	116,195	129.0	53.0	8.4	3.9	0.1	6.0	10.1	16.9	98.4
Sue-Bardon 1	Single-Stage	1,876,885,771	2,132,972,147	1,876,886	117,305	130.2	40.1	1.6	130.4	5.7	6.0	7.9	10.0	201.7
Sue-Bardon 2	Single-Stage	1,924,007,175	2,186,522,898	1,924,007	120,250	133.5	60.9	2.9	71.0	6.7	6.0	7.1	7.0	161.6
Jesse Creek 2	Single-Stage	1,963,207,318	2,231,071,595	1,963,207	122,700	136.2	90.2	12.3	76.2	6.3	6.0	5.9	4.0	200.9
Aveling	Single-Stage	2,010,547,752	2,284,871,260	2,010,548	125,659	139.5	68.3	11.7	60.9	13.0	6.0	5.6	6.6	172.1

M:\1\03\00313\02\A\Report\1 - North Coast Region Pumped Storage\Tables\[Fig_Table_3-1.xlsx]Table3.1

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	6MAR'12	ISSUED WITH REPORT VA103-313/2-1	MGP	SRM	JPH

Knight Piésold CONSULTING

TABLE 3.2

BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT

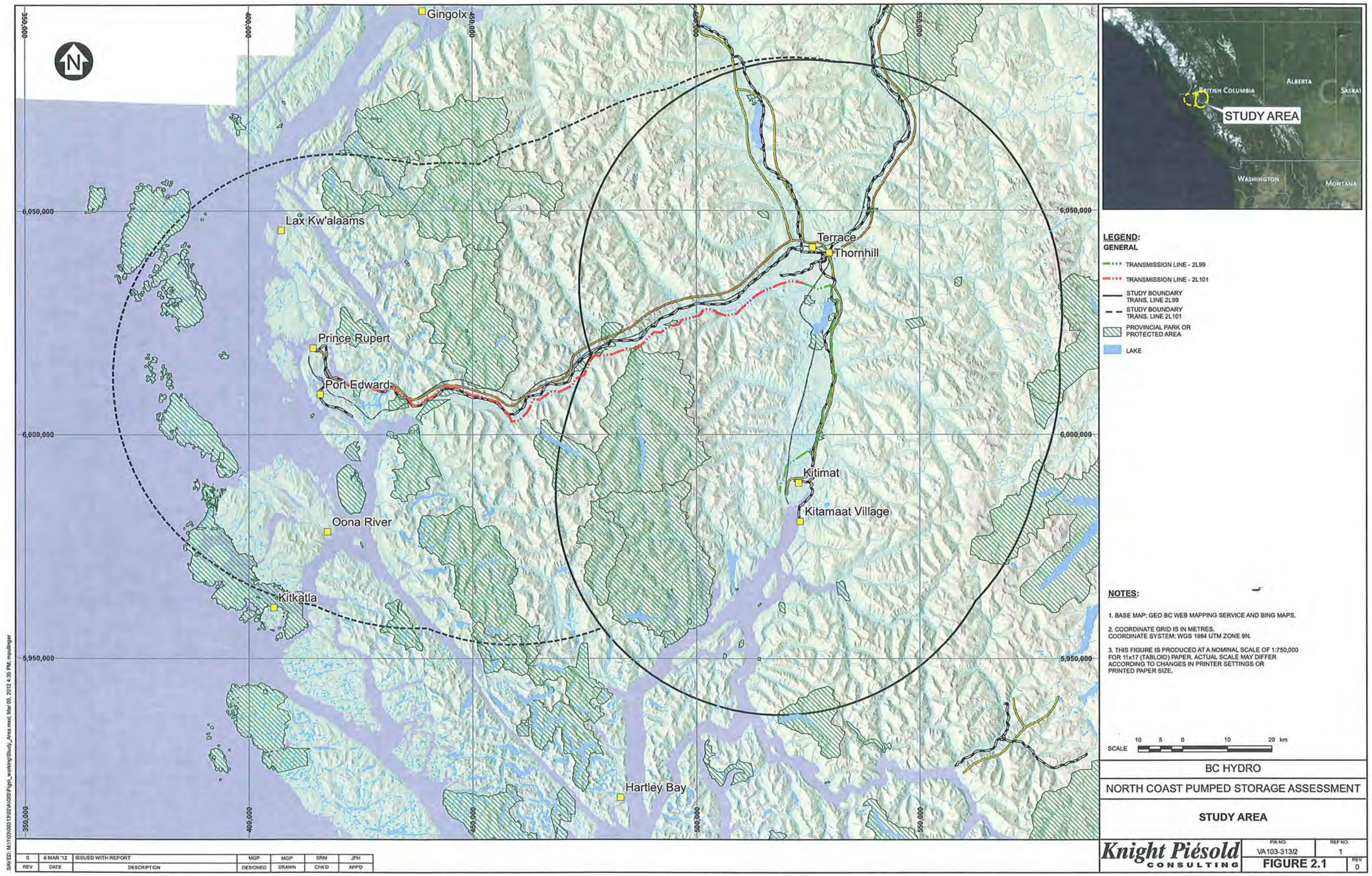
SUMMARY OF SITES WITH STORAGE FOR 48 HRS OF CONTINUOUS GENERATION

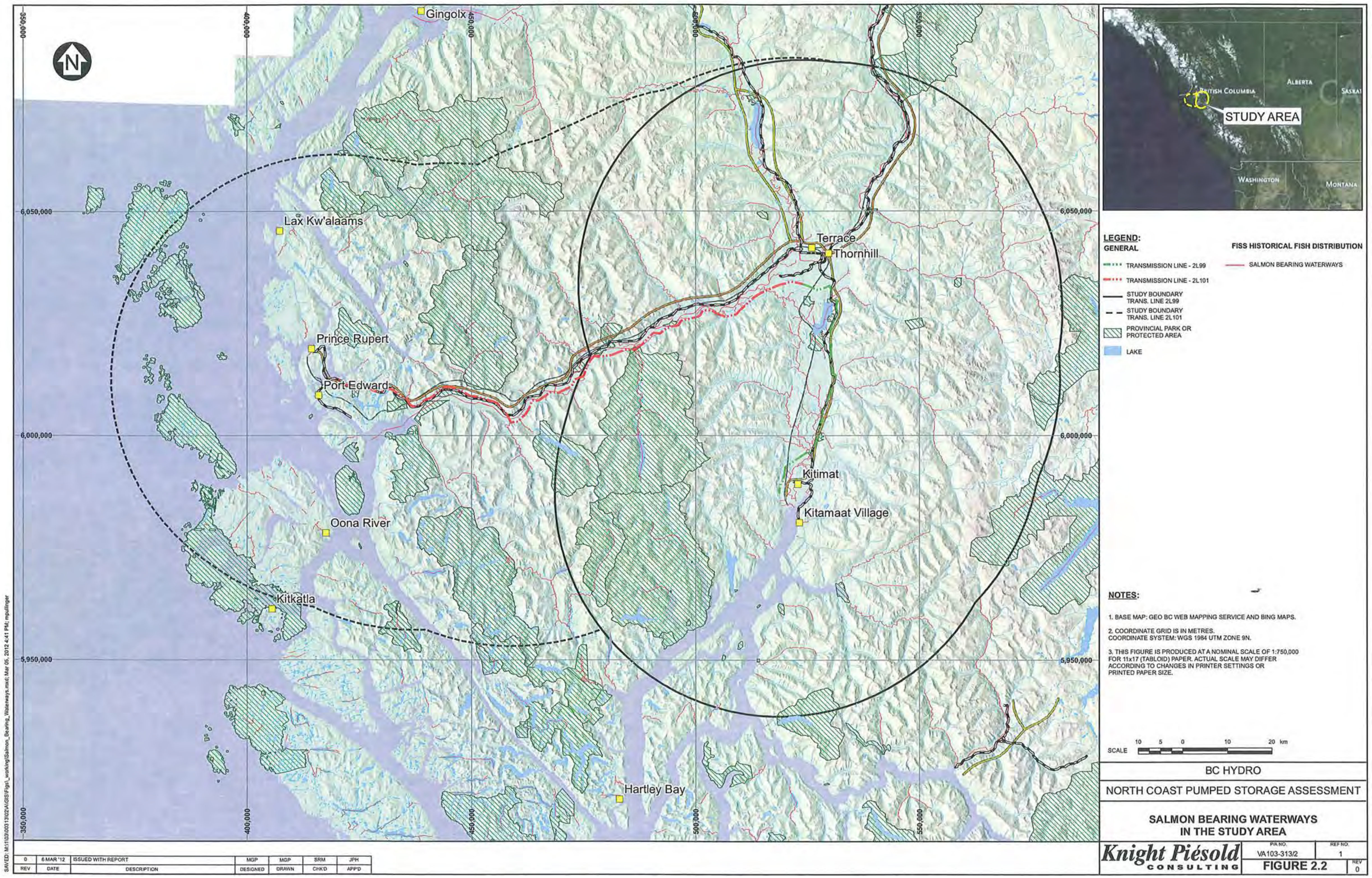
Print: 3/6/2012 9:36

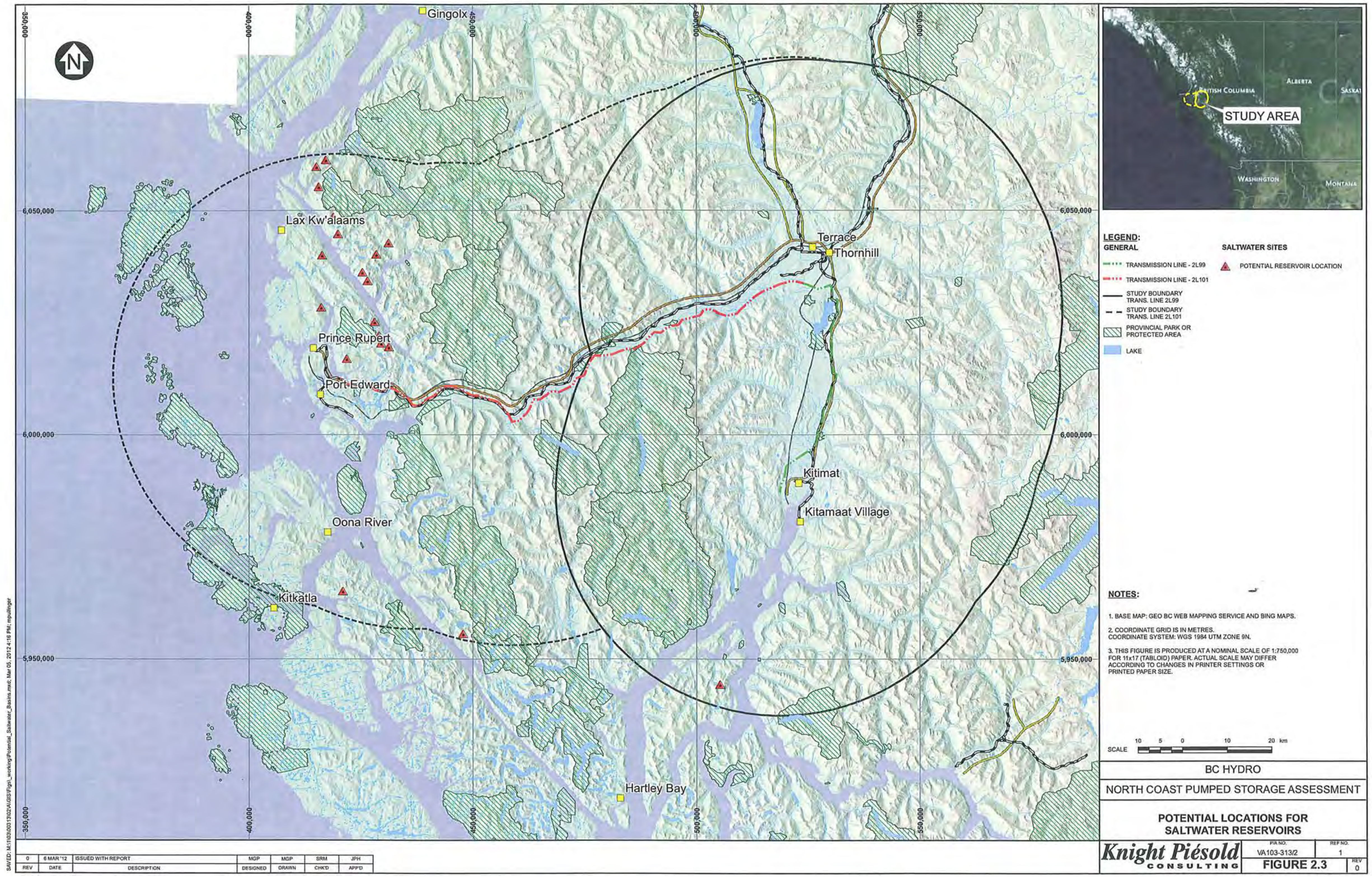
Name	Latitude	Longitude	Latitude	Longitude	Capacity	Location	Upper Reservoir Area	Upper Reservoir Base Elevation	Upper Reservoir Crest Length	Upper Reservoir Dam Height	Lower Reservoir Area	Lower Reservoir Base Elevation	Lower Reservoir Dam Crest Length	Lower Reservoir Dam Height	Storage Requirement	Storage Requirement	2D Waterway Length	Gross Head	H/L Ratio	Design Flow (Generation)	Design Flow (Pumping), 70% of Generation Flow	Pump/Turbine Type	Total Estimated Capital Cost	Loaded Capital Cost	Unit Cost of Capacity (Loaded Capital Cost/Capacity)	Unit Cost of Stored Energy	Levelized Cost	Upper Reservoir Footprint	Upper Dam Footprint	Lower Reservoir Footprint	Lower Dam Footprint	Staging/Laydown Footprint	Spoil Footprint	Roads Footprint	Total Footprint
	decimal degrees	decimal degrees	decimal degrees	decimal degrees	MW	Trans. Line	ha	masl	m	m	ha	masl	m	m	m3	MWh	m	m	%	m3/s	m3/s		$	$	$/MW	$/MWh	$/kW-yr	ha	ha	ha	ha	ha	ha	ha	ha
Diana	54.206	-130.150	54.205	-130.168	500	2L101	323.8	400	312	89	958.6	80	986.2	33.1	35,977,694	24,000	1165	320	27%	208	146	Single-Stage	1,304,491,993	1,482,479,718	2,608,984	54,354	181.0	120.8	5.0	69.5	6.1	6.0	4.7	3.2	215.2
Upper Clore	54.212	-127.933	54.184	-127.975	500	2L99	152.4	1260	553	77	70.3	580	246.3	72.8	16,930,679	24,000	4150	680	16%	98	69	Single-Stage	1,397,056,169	1,587,673,551	2,794,112	58,211	193.8	72.9	7.7	48.4	3.2	6.0	6.2	6.8	151.1
Hugh	53.750	-128.774	53.697	-128.672	500	2L99	110.0	900	595	58	123.4	60	165.4	38.2	13,705,788	24,000	8897	840	9%	79	56	Multi-Stage	1,478,930,471	1,680,718,961	2,957,861	61,622	205.2	45.9	6.3	30.1	1.2	6.0	8.7	13.3	111.5
Lower Clore 1	54.275	-127.940	54.184	-127.975	500	2L99	136.3	1260	495	69	48.1	500	103.2	13.1	15,148,503	24,000	10424	760	7%	88	61	Multi-Stage	1,541,842,715	1,752,215,088	3,083,685	64,243	213.9	61.1	6.2	5.6	0.3	6.0	9.5	15.6	104.3
Loretta-Bardon	53.689	-128.940	53.636	-129.088	500	2L99	201.1	400	289	66	148.0	100	308.4	100	38,376,207	24,000	11474	300	3%	222	155	Single-Stage	1,827,119,264	2,076,415,390	3,654,239	76,130	253.5	69.4	3.4	97.0	5.5	6.0	10.2	17.2	208.8
Lower Hirsch 1	54.098	-128.484	54.033	-128.334	500	2L99	108.5	1340	801	80	111.0	220	204.0	5.7	10,279,341	24,000	12186	1120	9%	59	42	Multi-Stage	1,836,259,420	2,086,802,648	3,672,519	76,511	254.7	65.3	11.5	2.8	0.3	6.0	10.5	18.3	114.6
Sleeman	53.671	-128.675	53.697	-128.672	500	2L99	139.6	900	833	82	172.7	300	898.0	74.8	19,188,103	24,000	2825	600	21%	111	78	Single-Stage	1,857,558,607	2,111,007,943	3,715,117	77,398	257.7	74.7	12.2	74.5	12.1	6.0	5.5	6.0	191.1
Lower Clore 2	54.295	-127.924	54.341	-127.793	500	2L99	431.7	980	1351	68	76.2	500	162.6	20.6	23,985,129	24,000	9902	480	5%	139	97	Single-Stage	1,895,746,349	2,154,406,104	3,791,493	78,989	263.0	102.0	16.5	12.0	0.6	6.0	9.2	14.9	161.1
Lower Hirsch 2	54.088	-128.487	54.017	-128.446	500	2L99	84.5	1140	1067	80	135.2	220	248.3	6.9	12,513,980	24,000	8383	920	11%	72	51	Multi-Stage	1,900,653,182	2,159,982,436	3,801,306	79,194	263.7	58.9	15.4	4.1	0.4	6.0	8.4	12.6	105.8
Hirsch	54.027	-128.380	54.033	-128.334	500	2L99	126.2	1340	954	95	55.1	400	335.6	33.6	12,247,726	24,000	3076	940	31%	71	50	Multi-Stage	1,920,277,472	2,182,284,307	3,840,555	80,012	266.4	85.4	16.3	17.9	2.1	6.0	5.6	9.4	142.6
Lower Falls	53.735	-128.498	53.702	-128.527	500	2L99	107.2	700	722	125	178.6	120	153.2	11.6	19,849,762	24,000	4122	580	14%	115	80	Single-Stage	2,017,465,362	2,292,732,723	4,034,931	84,061	279.9	108.8	16.0	9.3	0.4	6.0	6.2	6.2	152.8
Big Falls	53.995	-129.678	53.976	-129.557	500	2L101	431.7	200	392	51	1599.2	80	647.9	50.8	95,940,517	24,000	8201	120	1%	555	389	Single-Stage	2,062,223,752	2,343,598,046	4,124,448	85,926	286.1	75.3	3.6	141.4	6.0	6.0	8.9	12.3	253.5
Sue-Bardon 1	53.675	-129.018	53.639	-129.100	500	2L99	201.1	400	289	66	345.4	100	438.6	164.5	38,376,207	24,000	6667	300	4%	222	155	Single-Stage	2,128,012,525	2,418,363,182	4,256,025	88,667	295.2	69.4	3.4	247.3	12.8	6.0	7.6	10.0	356.5
Sue-Bardon 2	53.668	-129.048	53.639	-129.100	500	2L99	243.0	400	394	90	288.6	180	819.3	102.4	52,331,191	24,000	4658	220	5%	303	212	Single-Stage	2,199,503,331	2,499,608,349	4,399,007	91,646	305.1	106.8	6.3	133.6	15.0	6.0	6.7	7.0	281.4
Kitimat 1	54.044	-128.120	54.049	-128.032	500	2L99	98.3	1300	631	135	93.3	560	555.1	54.9	15,557,922	24,000	5798	740	13%	90	63	Single-Stage	2,218,247,521	2,520,910,038	4,436,495	92,427	307.7	116.1	15.2	39.8	5.5	6.0	7.1	8.7	198.3
Kitimat 2	54.070	-128.123	54.049	-128.032	500	2L99	93.6	1300	599	128	159.4	520	818.1	52	14,760,080	24,000	6392	780	12%	85	60	Multi-Stage	2,282,387,994	2,593,801,976	4,564,776	95,099	316.6	106.7	13.7	48.3	7.8	6.0	7.4	9.6	199.6
Upper Falls	53.700	-128.488	53.702	-128.527	500	2L99	111.0	700	748	129	185.0	140	916.5	56.1	20,558,682	24,000	2622	560	21%	119	83	Single-Stage	2,321,789,285	2,638,579,265	4,643,579	96,741	322.1	115.1	17.2	55.9	9.3	6.0	5.4	5.6	214.5
Oliver	54.803	-128.193	54.820	-128.165	500	2L99	111.4	1020	703	94	111.4	400	1244.6	99.1	18,569,132	24,000	2580	620	24%	107	75	Single-Stage	2,359,396,713	2,681,317,932	4,718,793	98,308	327.3	79.8	11.9	84.5	22.1	6.0	5.4	6.2	215.9
Jesse Creek 1	53.929	-128.901	53.939	-128.929	500	2L99	323.8	360	1175	101	647.6	40	1766.7	37.6	35,977,694	24,000	2095	320	15%	208	146	Single-Stage	2,368,897,655	2,692,115,204	4,737,795	98,704	328.6	138.1	21.1	65.8	12.3	6.0	5.2	3.2	251.8
Andesite	54.409	-129.268	54.384	-129.186	500	2L99	164.0	900	1244	108	88.8	200	94.3	27.7	16,446,946	24,000	5996	700	12%	95	67	Single-Stage	2,394,690,377	2,721,427,140	4,789,381	99,779	332.2	110.6	24.0	18.0	0.5	6.0	7.2	9.0	175.3
Jesse Lake	53.917	-128.898	53.935	-128.934	500	2L99	304.8	360	1105	95	2081.3	20	1072.1	73.9	33,861,359	24,000	3094	340	11%	196	137	Single-Stage	2,440,122,755	2,773,058,411	4,880,246	101,672	338.5	125.6	18.7	239.2	14.3	6.0	5.7	4.6	414.2
Lower Lukes	54.147	-128.733	54.196	-128.884	500	2L99	113.6	980	940	112	53.1	200	77.9	16.5	14,760,080	24,000	11270	780	7%	85	60	Multi-Stage	2,448,676,842	2,782,779,636	4,897,354	102,028	339.7	98.6	18.8	7.7	0.3	6.0	9.9	16.9	158.2
Upper Lukes	54.132	-128.845	54.196	-128.884	500	2L99	128.3	980	1078	129	114.3	300	592.2	57.1	16,930,679	24,000	7544	680	9%	98	69	Single-Stage	2,889,369,258	3,283,601,084	5,778,739	120,390	400.8	122.0	24.7	45.6	6.1	6.0	8.0	11.3	223.7
Chimdemash	54.615	-128.220	54.593	-128.195	500	2L99	43.2	1300	880	139	79.7	700	851.5	95.4	19,188,103	24,000	2938	600	20%	111	78	Single-Stage	3,023,828,919	3,436,406,713	6,047,658	125,993	419.5	87.4	21.7	70.1	14.5	6.0	5.6	6.0	211.3
North Hirsch	54.063	-128.253	54.034	-128.327	500	2L99	156.0	1340	1212	121	93.3	600	1088.4	74.2	15,557,922	24,000	5813	740	13%	90	63	Single-Stage	3,100,066,059	3,523,045,814	6,200,132	129,169	430.0	123.4	26.2	56.0	14.5	6.0	7.1	8.7	241.9

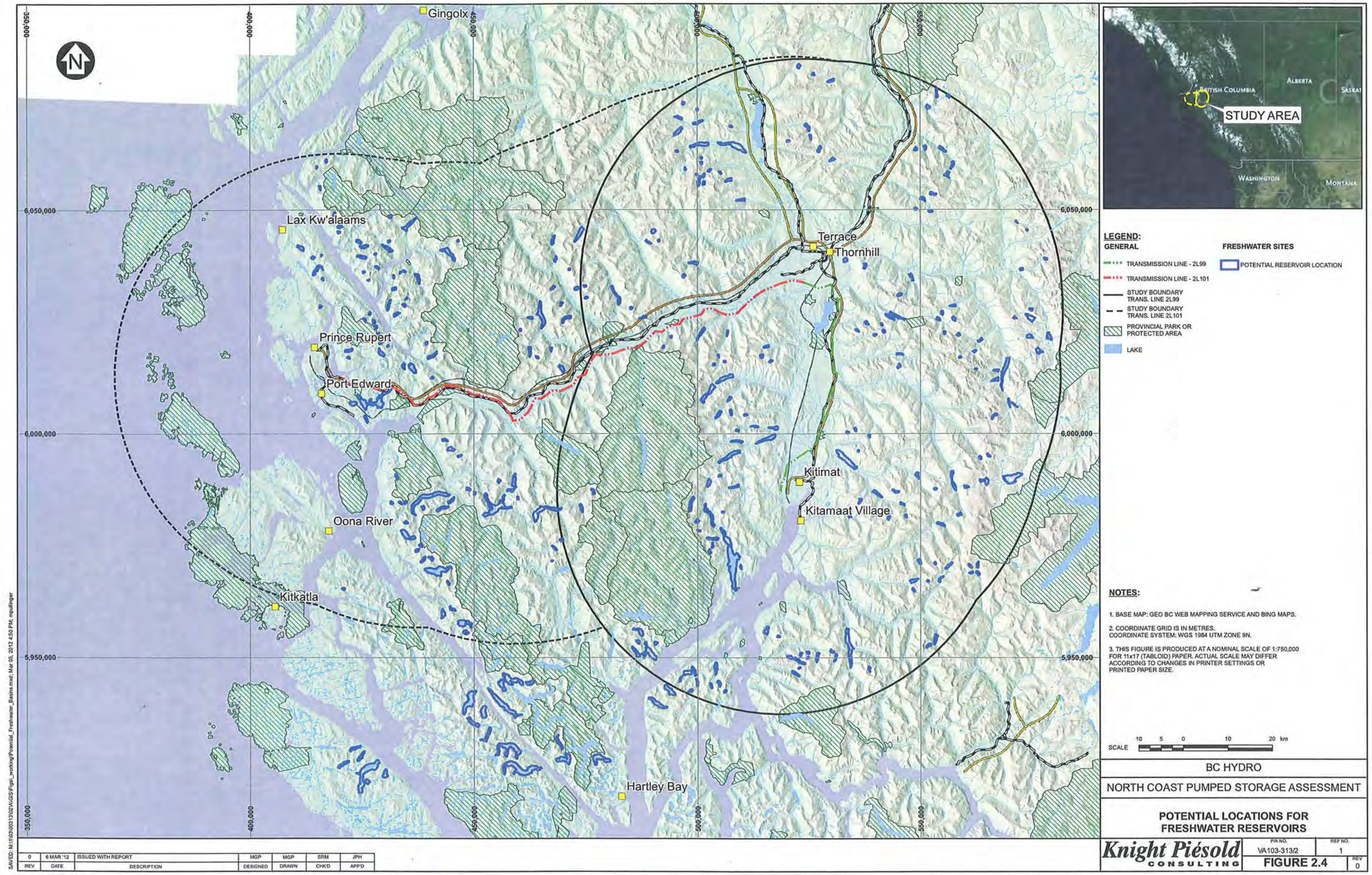
M:\1\03\00313\02\A\Report\1 - North Coast Region Pumped Storage\Tables\[Fig_Table_3-2.xlsx]Table3.2

0	6MAR'12	ISSUED WITH REPORT VA103-313/2-1	MGP	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D


Gingolx
Lax Kw'alaams
Terrace
Thornhill
Prince Rupert
Port Edward
Kitimat
Kitamaat Village
Oona River
Kitkatla
Hartley Bay
350,000
400,000
450,000
500,000
550,000
6,050,000
6,000,000
5,950,000
ALBERTA
WASHINGTON
MONTANA
STUDY AREA
LEGEND:
GENERAL
TRANSMISSION LINE - 2L99
TRANSMISSION LINE - 2L101
STUDY BOUNDARY TRANS. LINE 2L99
STUDY BOUNDARY TRANS. LINE 2L101
PROVINCIAL PARK OR PROTECTED AREA
LAKE
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE 10 5 0 10 20 km
BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
STUDY AREA
Knight Piésold CONSULTING
P/A NO. VA103-313/2
REF NO. 1
FIGURE 2.1
REV 0
0 | 6 MAR '12 | ISSUED WITH REPORT | MGP | MGP | SRM | JPH
REV | DATE | DESCRIPTION | DESIGNED | DRAWN | CHK'D | APP'D


N
Gingolx
Lax Kw'alaams
Prince Rupert
Port Edward
Terrace
Thornhill
Kitimat
Kitamaat Village
Oona River
Kitkatla
Hartley Bay
350,000
400,000
450,000
500,000
550,000
6,050,000
6,000,000
5,950,000
STUDY AREA
BRITISH COLUMBIA
ALBERTA
WASHINGTON
MONTANA
LEGEND:
GENERAL
TRANSMISSION LINE - 2L99
TRANSMISSION LINE - 2L101
STUDY BOUNDARY TRANS. LINE 2L99
STUDY BOUNDARY TRANS. LINE 2L101
PROVINCIAL PARK OR PROTECTED AREA
LAKE
FISS HISTORICAL FISH DISTRIBUTION
SALMON BEARING WATERWAYS
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE 10 5 0 10 20 km
BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
SALMON BEARING WATERWAYS IN THE STUDY AREA
Knight Piésold CONSULTING
P/A NO. VA103-313/2
REF NO. 1
FIGURE 2.2
REV 0
0 6 MAR '12 ISSUED WITH REPORT MGP MGP SRM JPH
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D

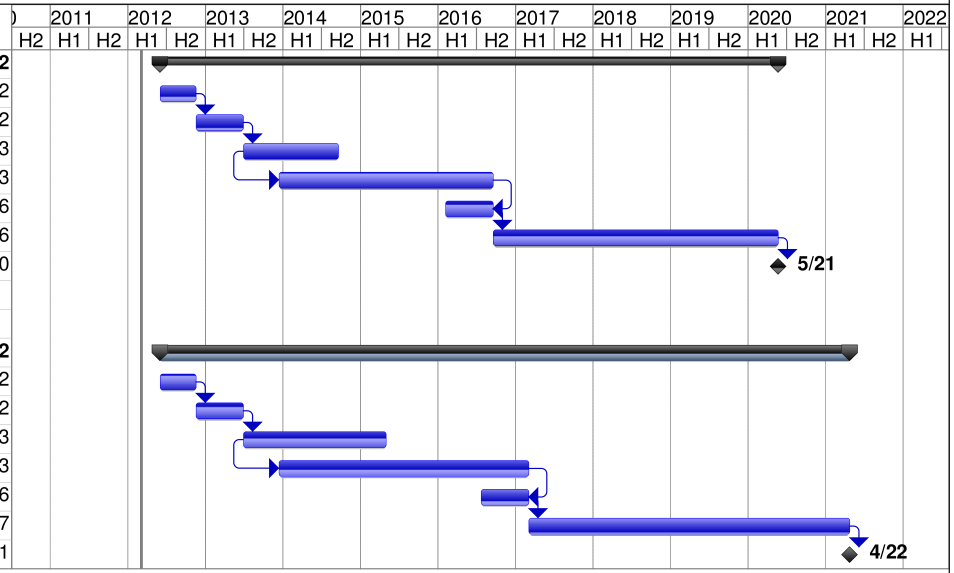

Gingolx
Lax Kw'alaams
Prince Rupert
Port Edward
Oona River
Kitkatla
Hartley Bay
Terrace
Thornhill
Kitimat
Kitamaat Village
6,050,000
6,000,000
5,950,000
350,000
400,000
450,000
500,000
550,000
STUDY AREA
LEGEND:
GENERAL
TRANSMISSION LINE - 2L99
TRANSMISSION LINE - 2L101
STUDY BOUNDARY TRANS. LINE 2L99
STUDY BOUNDARY TRANS. LINE 2L101
PROVINCIAL PARK OR PROTECTED AREA
LAKE
SALTWATER SITES
POTENTIAL RESERVOIR LOCATION
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE 10 5 0 10 20 km
BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
POTENTIAL LOCATIONS FOR SALTWATER RESERVOIRS
Knight Piésold CONSULTING
P/A NO. VA103-313/2
REF NO. 1
FIGURE 2.3
REV 0
0 6 MAR '12 ISSUED WITH REPORT MGP MGP SRM JPH
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D


N
Gingolx
Lax Kw'alaams
Prince Rupert
Port Edward
Oona River
Kitkatla
Hartley Bay
Terrace
Thornhill
Kitimat
Kitamaat Village
350,000
400,000
450,000
500,000
550,000
6,050,000
6,000,000
5,950,000
ALBERTA
WASHINGTON
MONTANA
STUDY AREA
LEGEND:
GENERAL
TRANSMISSION LINE - 2L99
TRANSMISSION LINE - 2L101
STUDY BOUNDARY TRANS. LINE 2L99
STUDY BOUNDARY TRANS. LINE 2L101
PROVINCIAL PARK OR PROTECTED AREA
LAKE
FRESHWATER SITES
POTENTIAL RESERVOIR LOCATION
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE 10 5 0 10 20 km
BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
POTENTIAL LOCATIONS FOR FRESHWATER RESERVOIRS
Knight Piésold CONSULTING
P/A NO. VA103-313/2
REF NO. 1
FIGURE 2.4
REV 0
0 | 6 MAR '12 | ISSUED WITH REPORT | MGP | MGP | SRM | JPH
REV | DATE | DESCRIPTION | DESIGNED | DRAWN | CHK'D | APP'D

Knight Piésold CONSULTING

BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL
CONCEPTUAL DEVELOPMENT SCHEDULE

ID	Task Name	Duration	Start
1	**FRESHWATER PUMPED STORAGE**	**2080 days**	**Fri 6/1/12**
2	CONCEPTUAL STUDIES	6 mons	Fri 6/1/12
3	PRE-FEASIBILITY STUDIES	8 mons	Fri 11/16/12
4	FEASIBILITY STUDIES	16 mons	Fri 6/28/13
5	PERMITTING PROCESS	36 mons	Fri 12/13/13
6	FINANCING	8 mons	Fri 2/5/16
7	CONSTRUCTION	48 mons	Fri 9/16/16
8	COD	0 days	Thu 5/21/20
9			
10			
11	**SALTWATER PUMPED STORAGE**	**2320 days**	**Fri 6/1/12**
12	CONCEPTUAL STUDIES	6 mons	Fri 6/1/12
13	PRE-FEASIBILITY STUDIES	8 mons	Fri 11/16/12
14	FEASIBILITY STUDIES	24 mons	Fri 6/28/13
15	PERMITTING PROCESS	42 mons	Fri 12/13/13
16	FINANCING	8 mons	Fri 7/22/16
17	CONSTRUCTION	54 mons	Fri 3/3/17
18	COD	0 days	Thu 4/22/21



REV 0 - ISSUED WITH REPORT VA103-313/2-1

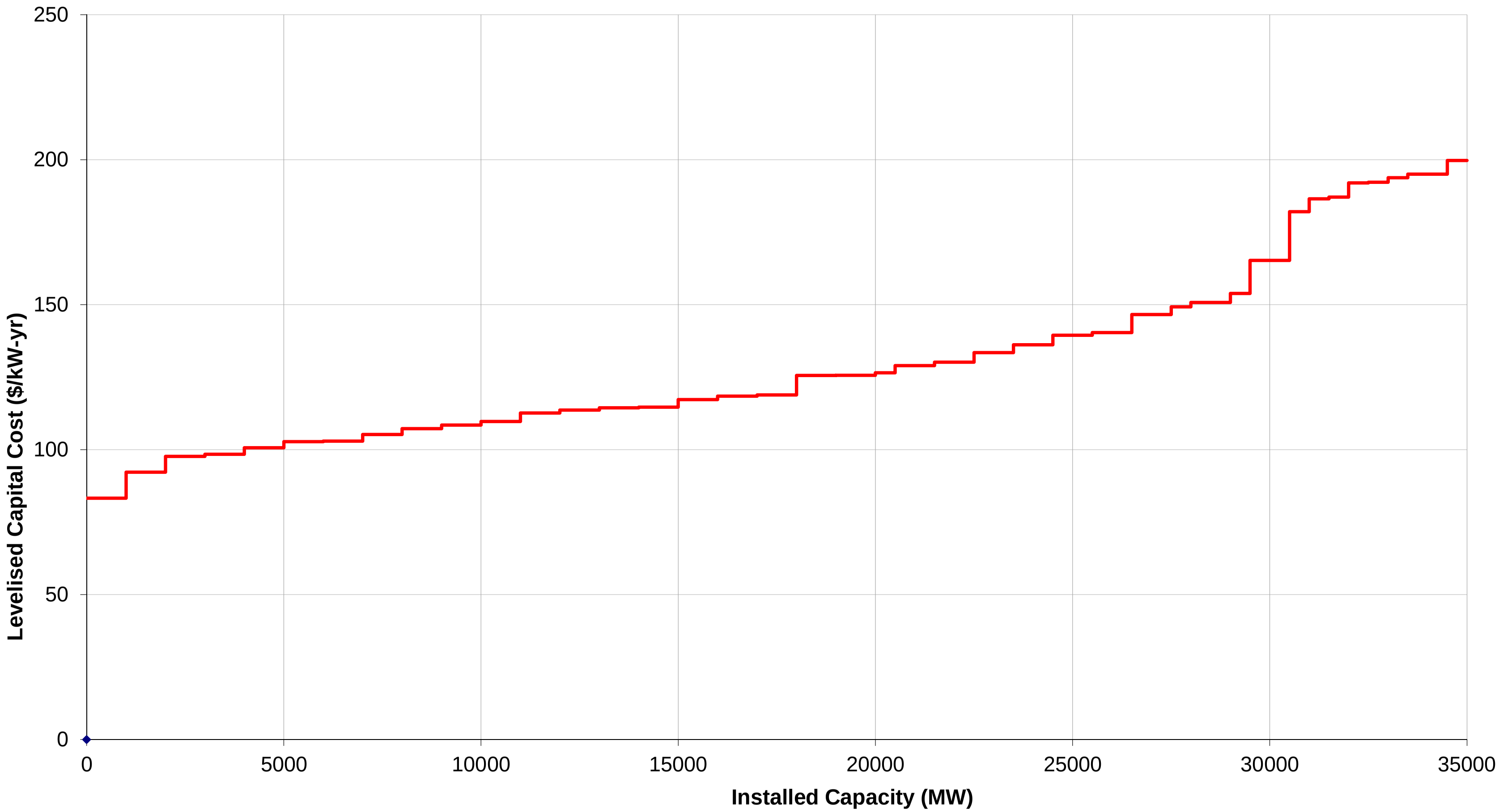
Page 1

\\van11\prj_file\1\03\00313\02\A\Data\Schedule\ConceptualDevelopmentSchedule.mpp

FIGURE 2.5

VA103-313/2-1

M:\1\03\00313\02\A\Report\1 - North Coast Region Pumped Storage\Tables\Fig_Table_3-1Figure3.1 06/03/20129:40 AM



NOTES:
1. COSTS DO NOT INCLUDE ACCESS TO SITE, OR TRANSMISSION AND INTERCONNECTION.
2. POTENTIAL SITES ARE OF EITHER 500 MW OR 1000 MW CAPACITY

0	6MAR'12	ISSUED WITH REPORT	MGP	SRM	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

BC HYDRO

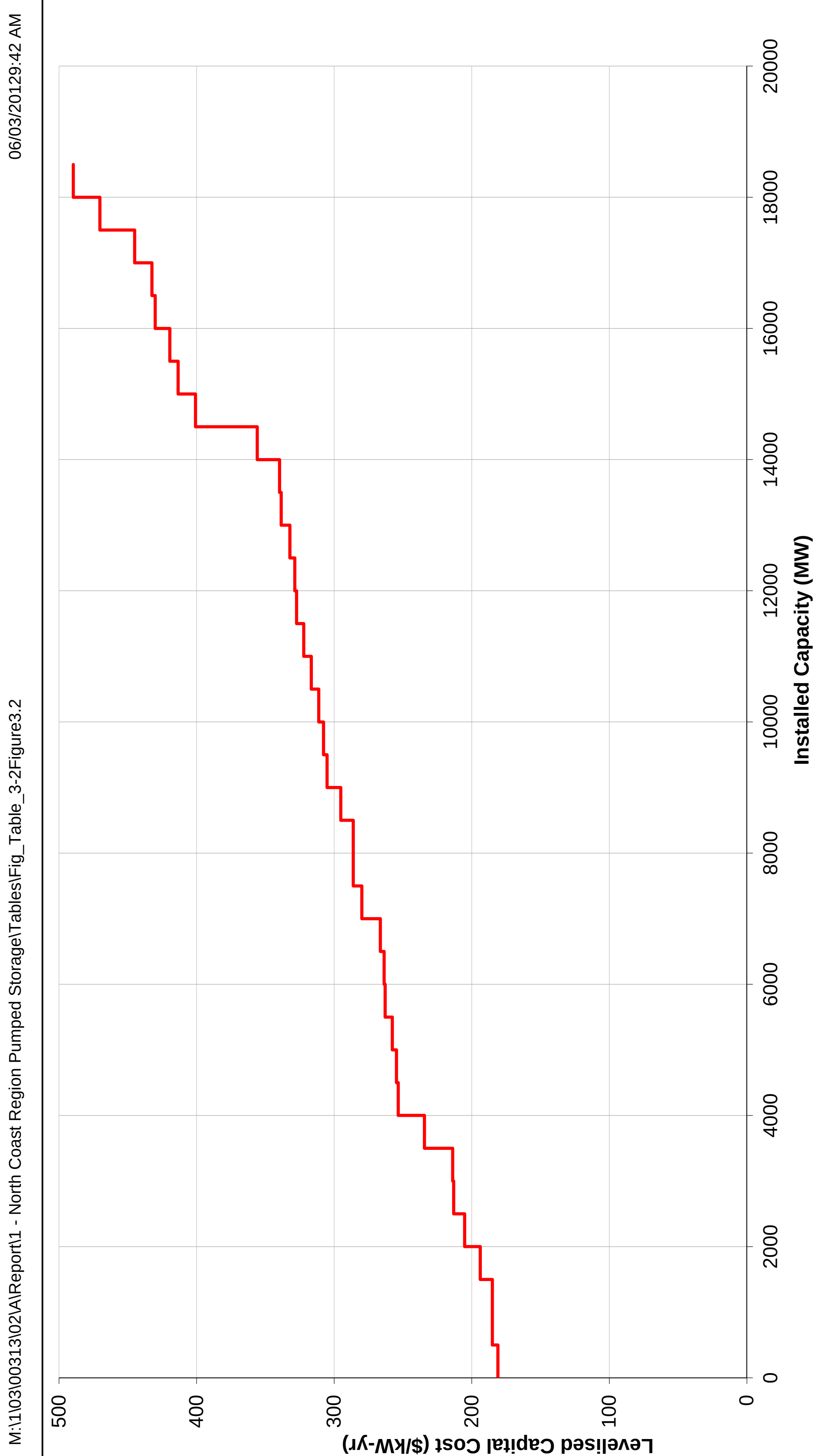
NORTH COAST PUMPED STORAGE ASSESSMENT

COST OF CUMULATIVE INSTALLED CAPACITY STORAGE FOR 16 hrs CONTINUOUS GENERATION

Knight Piésold CONSULTING

P/A NO. VA103-313/2 | REF. NO. 1

FIGURE 3.1 | REV 0



NOTES:

1. COSTS DO NOT INCLUDE ACCESS TO SITE, OR TRANSMISSION AND INTERCONNECTION.
2. POTENTIAL SITES ARE OF EITHER 500 MW OR 1000 MW CAPACITY

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	6MAR'12	ISSUED WITH REPORT	MGP	SRM	JPH

BC HYDRO

NORTH COAST PUMPED STORAGE ASSESSMENT

COST OF CUMULATIVE INSTALLED CAPACITY STORAGE FOR 48 hrs CONTINUOUS GENERATION

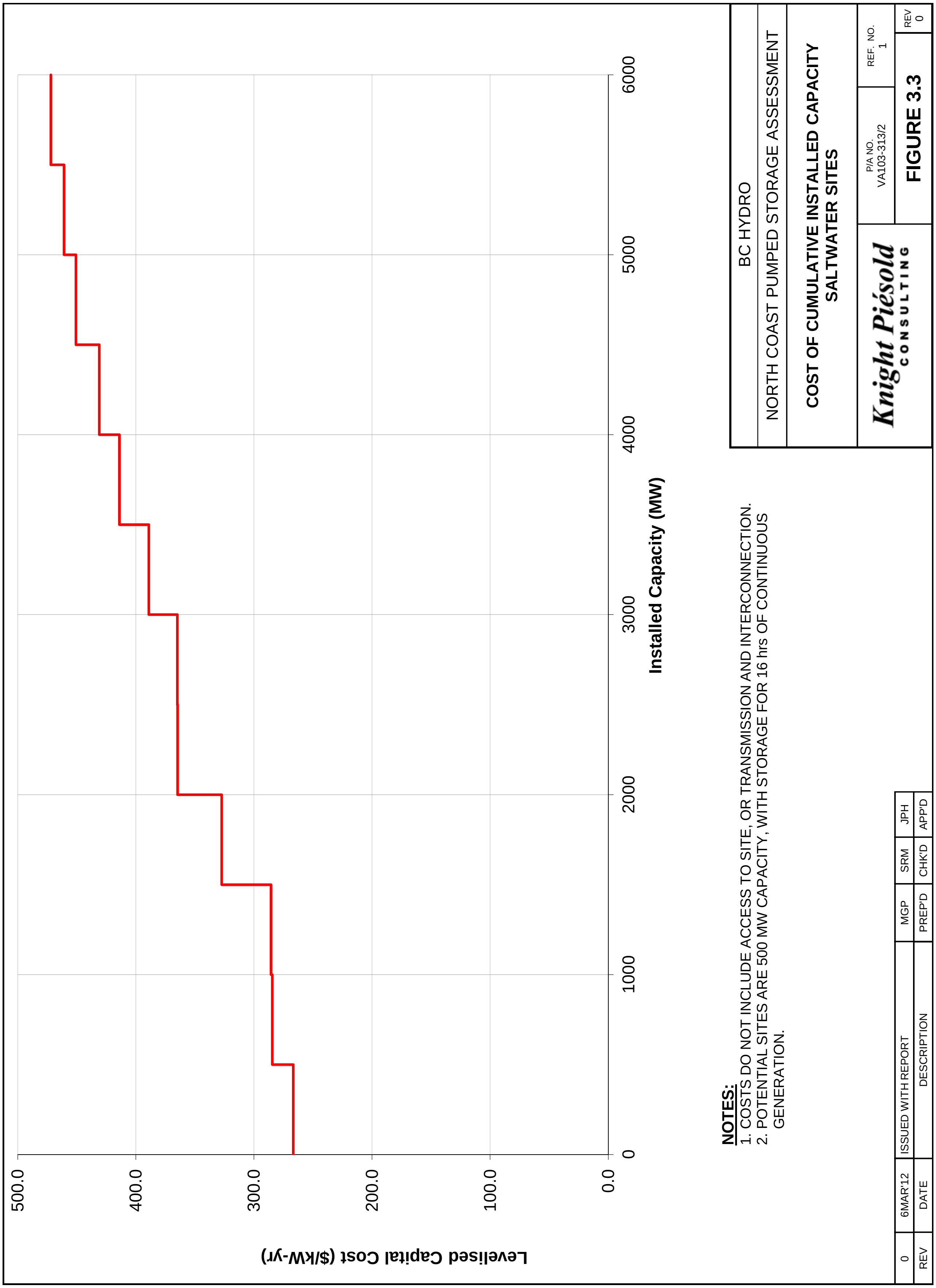
Knight Piésold CONSULTING

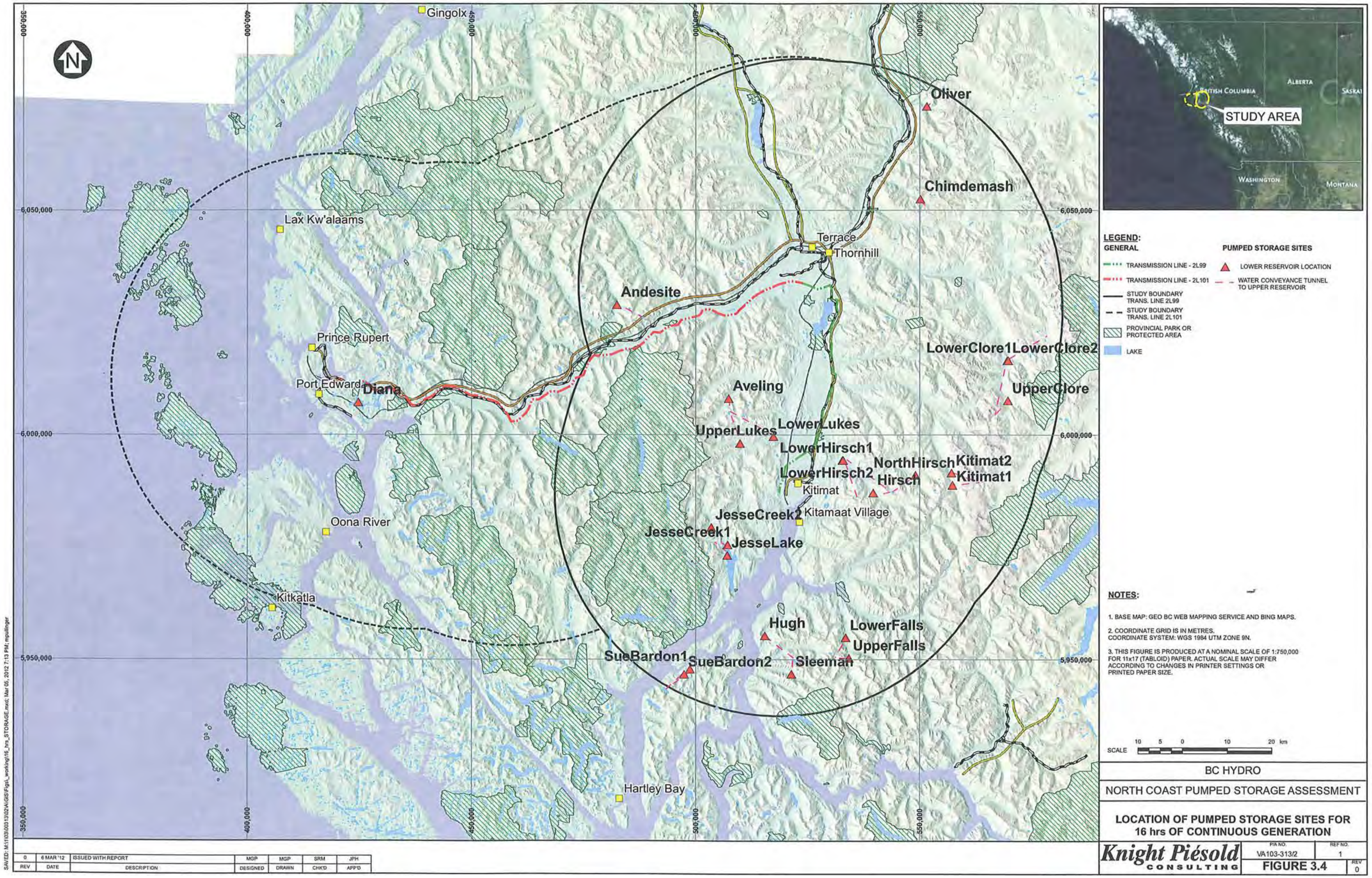
P/A NO. VA103-313/2

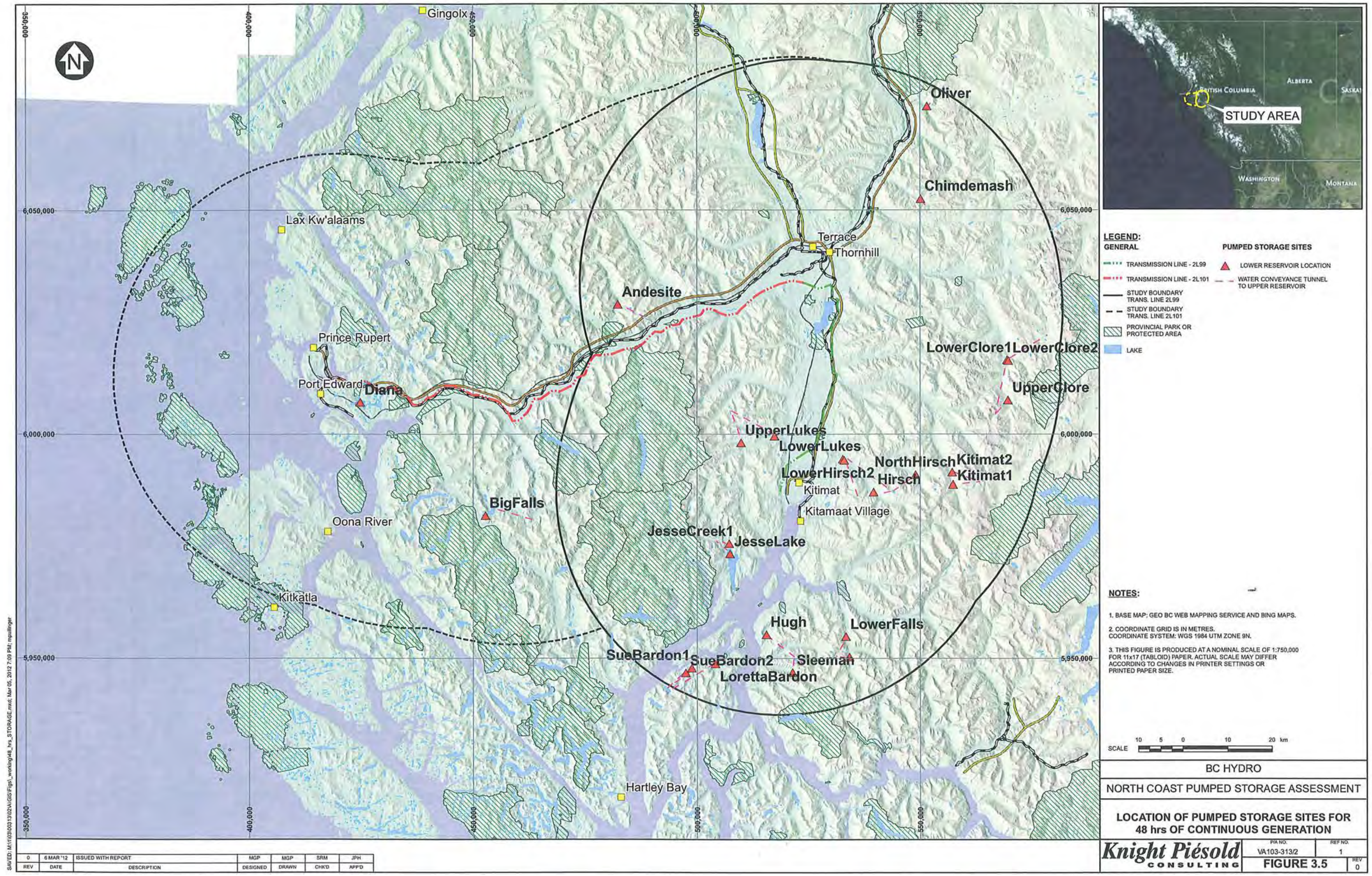
REF. NO. 1

FIGURE 3.2

REV 0


M:\1\03\00313\02\A\Report\1 - North Coast Region Pumped Storage\FIGURES\FIG3-3Figure3.3
06/03/20129:38 AM
Levelised Capital Cost ($/kW-yr)
500.0
400.0
300.0
200.0
100.0
0.0
0
1000
2000
3000
4000
5000
6000
Installed Capacity (MW)
NOTES:
1. COSTS DO NOT INCLUDE ACCESS TO SITE, OR TRANSMISSION AND INTERCONNECTION.
2. POTENTIAL SITES ARE 500 MW CAPACITY, WITH STORAGE FOR 16 hrs OF CONTINUOUS GENERATION.
BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
COST OF CUMULATIVE INSTALLED CAPACITY SALTWATER SITES
Knight Piésold CONSULTING
P/A NO. VA103-313/2
REF. NO. 1
FIGURE 3.3
REV 0
0
6MAR'12
ISSUED WITH REPORT
MGP
SRM
JPH
REV
DATE
DESCRIPTION
PREP'D
CHK'D
APP'D


Gingolx
Lax Kw'alaams
Prince Rupert
Port Edward
Diana
Oona River
Kitkatla
Hartley Bay
Andesite
Terrace
Thornhill
Oliver
Chimdemash
LowerClore1
LowerClore2
UpperClore
Aveling
UpperLukes
LowerLukes
LowerHirsch1
LowerHirsch2
NorthHirsch
Hirsch
Kitimat2
Kitimat1
Kitimat
Kitamaat Village
JesseCreek2
JesseCreek1
JesseLake
Hugh
LowerFalls
UpperFalls
Sleeman
SueBardon1
SueBardon2
6,050,000
6,000,000
5,950,000
350,000
400,000
450,000
500,000
550,000
STUDY AREA
BRITISH COLUMBIA
ALBERTA
WASHINGTON
MONTANA
LEGEND:
GENERAL
TRANSMISSION LINE - 2L99
TRANSMISSION LINE - 2L101
STUDY BOUNDARY TRANS. LINE 2L99
STUDY BOUNDARY TRANS. LINE 2L101
PROVINCIAL PARK OR PROTECTED AREA
LAKE
PUMPED STORAGE SITES
LOWER RESERVOIR LOCATION
WATER CONVEYANCE TUNNEL TO UPPER RESERVOIR
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE
10 5 0 10 20 km
BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
LOCATION OF PUMPED STORAGE SITES FOR 16 hrs OF CONTINUOUS GENERATION
Knight Piésold CONSULTING
VA103-313/2
1
FIGURE 3.4
0
0 6 MAR '12 ISSUED WITH REPORT MGP MGP SRM JPH
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D


Gingolx
Oliver
Chimdemash
Lax Kw'alaams
Terrace
Thornhill
Andesite
Prince Rupert
Port Edward
Diana
LowerClore1
LowerClore2
UpperClore
UpperLukes
LowerLukes
NorthHirsch
Kitimat2
Kitimat1
LowerHirsch2
Hirsch
Kitimat
Kitamaat Village
BigFalls
Oona River
JesseCreek1
JesseLake
Kitkatla
Hugh
LowerFalls
SueBardon1
SueBardon2
Sleemah
LorettaBardon
Hartley Bay
STUDY AREA
BRITISH COLUMBIA
ALBERTA
WASHINGTON
MONTANA
LEGEND:
GENERAL
TRANSMISSION LINE - 2L99
TRANSMISSION LINE - 2L101
STUDY BOUNDARY TRANS. LINE 2L99
STUDY BOUNDARY TRANS. LINE 2L101
PROVINCIAL PARK OR PROTECTED AREA
LAKE
PUMPED STORAGE SITES
LOWER RESERVOIR LOCATION
WATER CONVEYANCE TUNNEL TO UPPER RESERVOIR
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
SCALE 10 5 0 10 20 km
BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
LOCATION OF PUMPED STORAGE SITES FOR 48 hrs OF CONTINUOUS GENERATION
Knight Piésold CONSULTING
P/A NO. VA103-313/2
REF NO. 1
FIGURE 3.5
REV 0
0 6 MAR '12 ISSUED WITH REPORT MGP MGP SRM JPH
REV DATE DESCRIPTION DESIGNED DRAWN CHK'D APP'D