2008 Long Term Acquisition Plan

BC hydro

APPENDIX F4a

BC Hydro Engineering Report Concerning Jordan River Pumped Storage

BC hydro

ENGINEERING

Inter-office memo

TO: File **DATE:** 8 November 2007

FROM: Engineering **FILE:** GENMIS08 – NRGPLN

SUBJECT: **Jordan River Pumped Storage**

1.0 Introduction

The British Columbia Utility Commission has directed BC Hydro to include a pumped storage hydro project on the Jordan River in its next Resource Options Report (Directive 21, BCUC, 2007). Consequently, the Resource Planning group requested that Engineering provide an assessment of pumped storage potential within the Jordan River watershed.

This memo provides an overview level assessment of pumped storage opportunities using BC Hydro's existing reservoir system, and comments on the potential for greenfield sites in the Jordan River watershed.

2.0 Jordan River Watershed

The Jordan River watershed is located on the southwest portion of Vancouver Island approximately 50 km from Victoria. A map of the watershed is presented in Figure 1. The river drains into the Pacific Ocean at the community of Jordan River, and elevations in the watershed range from sea level up to approximately 1000 m.

In order from upstream to downstream, the BC Hydro reservoir facilities include Bear Creek Reservoir and Dam, Diversion Reservoir and Dam, and Elliot Headpond and Dam. Most of the flow in the river at Elliot Dam is directed through a 7 km tunnel and surface penstock to the Jordan Generating Station. The tailrace of the Generating Station is located just above the Jordan River estuary.

Table 1: BC Hydro Reservoirs in the Jordan River Basin

	Bear Creek Reservoir	Diversion Reservoir	Elliot Headpond	Jordan Generating Tailrace
Maximum Normal Elevation (m)	411.7	386.2	335.9	~ 2.1
Minimum Normal Elevation (m)	410.0	367.9	325.2	~ 2.1
Available Storage (Mm3)	1.26	17.4	1.28	-
Storage (cms-days)	14.5	200	14.8	-

Early development of the watershed included a forebay dam and reservoir located in the mountains on the east side of the river about 2 km from the Jordan Generating Station. The Forebay Dam was decommissioned in 2005 and the flume and penstock leading to and from this reservoir were dismantled earlier.

A memo on the subject of the Jorvic sewage reclaim pipeline (Powertech, 2007) mentioned Boneyard Lake in the discussion about Jordan pumped storage proposals. The only Boneyard Lake evident in the region is located outside of the Jordan watershed in the mountains just a few kilometers to the west of the Sooke River.

3.0 Pumped Storage

The role of pumped storage is to use low cost, off-peak power and energy to pump water from a lower elevation storage reservoir to a higher elevation storage reservoir. The stored water is then used to generate power and energy during the peak load periods when demand is highest. The pumped storage plant is cycled daily between night time pumping and daytime and evening generation.

A pumped storage plant does not create new energy; rather it is a net consumer of energy. Approximately 25% of the energy used to pump water is not regained in the generation cycle. The economic incentive offered by pumped storage is in the difference in value between off peak energy and peak energy.

A typical installation includes an underground powerhouse with tailrace/intake tunnel to the lower reservoir, with Francis turbine generator units with reversible capability so the units can operate as pumps.

Attractive pumped storage opportunities exist where:

- ⇒ there is a large elevation difference between upper and lower reservoirs and the distance between the two is short;
- ⇒ daily water level fluctuations due to the generation/pumping cycle are within acceptable limits on both the upper and lower reservoirs; and
- ⇒ new transmission distances are short.

4.0 Previous BC Hydro Assessments of Pumped Storage Opportunities on Vancouver Island

BC Hydro report 888 (1977) identified 43 potential pumped storage sites on Vancouver Island. None of these sites were within the Jordan River catchment. Elevation differences between the upper and lower reservoirs (gross head) ranged from 130 m to 1105 m, with most being in the 300 – 500 m range.

The ratio of the horizontal distance between the reservoirs over the gross head provided one measure of the economic potential of the projects. Ratios ranged from 1.7 to 16.2, with most being less than 5. Lower ratios are more favourable since longer power conduit distances for a given head increase the cost of the project.

BC Hydro report H2645 (1993) evaluated the potential for adapting existing BC Hydro plants to pumped storage operation. Plants that might have suitable site configurations were noted to be Ash, Wahleach, Bridge and Cheakamus. Jordan River was not mentioned in the report.

BC Hydro Engineering report PSE379 (2001) included an appendix report by Klohn-Crippen Consultants that reviewed pumped storage sites on Vancouver Island. The review used the 43 sites identified in the 1977 study as a starting point, and then screened the list to 7 sites for more

detailed investigation. The most promising three sites were at Shawnigan Lake, Comox Lake, and Campbell River, which together could provide the total of 500 MW of capacity. These projects were included as the representative Pumped Storage projects in the 2005 Resource Options Report.

5.0 Options for Pumped Storage at Jordan River

Potential pumped storage projects in the Jordan River watershed that would use the existing reservoir storage system are presented in Table 2 below.

Projects that would require construction of a lower reservoir situated downstream from the Jordan powerhouse are not included. This is because there is insufficient room for freshwater storage, and pumping of seawater or brackish water up into the existing Jordan project reservoirs would not be permitted. The Jordan River ecosystem contains several species of salmon (chum, coho, and pink) trout (rainbow and steelhead) and numerous plant, invertebrate reptile and mammal species. The resident species' and juvenile anadromous species' physiologies are adapted to freshwater environments. Pumped seawater would increase salinity in the upper reservoir and river and negatively impact these species and the ecology of the Jordan River system.

Table 2 : Potential Jordan River Pumped Storage Projects Using Existing Reservoirs

Upper Reservoir	Lower Reservoir	Horizontal Distance (m)	Maximum Gross Head (m)	Length/Head Ratio	Approximate Max. Capacity* (MW)
Bear Creek	Diversion	2500	44	57	< 20
Diversion	Elliot	2350	61	39	< 20

* generating capacities based on assumed efficiency of 0.9, assumed generation schedule of 10 hours per day, and flowrate constrained by maximum storage variation in the reservoirs.

As shown, these projects have very poor length to head ratios, and they offer very low installed capacities compared with other potential sites on Vancouver Island.

Projects that would require construction of a new upper reservoir impoundment may have more potential than using the current system of reservoirs. Diversion Reservoir would be a logical downstream reservoir for such developments since the available storage would allow for higher rates of flow recycling and therefore higher capacities. However, a powerhouse/ generating station on Diversion Reservoir would need to be set very deep into the ground to accommodate the wide range in reservoir levels. Consequently, construction costs would be much higher than for other sites where the lower reservoir would fluctuate within a narrow range of levels. The earlier BC Hydro studies identified many such sites.

Construction of any new upper or lower reservoir impoundments would have significant environmental and social implications. On this basis, greenfield projects in the Jordan River watershed would be expected to compare poorly against other potential pumped storage sites on Vancouver Island that would have only minor impacts on existing water bodies.

6.0 Conclusions

There is low potential for development of pumped storage hydroelectric projects using the existing reservoir system within the Jordan River watershed because:

⇒ the difference in head between existing reservoirs is low;

- ⇒ Bear Creek and Elliot have low storage capacities within reservoir operational constraints; and
- ⇒ severe environmental impacts would occur from pumping seawater into the river system.

The feasibility of new greenfield storage reservoirs for pumped storage schemes has not been investigated in detail. However, there are many other sites on Vancouver Island that could take advantage of existing upper and lower reservoirs, which would have lower social, environmental and construction costs.

7.0 References

BC Hydro, 1977. "Pumped Storage in British Columbia, Preliminary Engineering Assessment", Hydroelectric Design Division, Report No. 888. December 1977

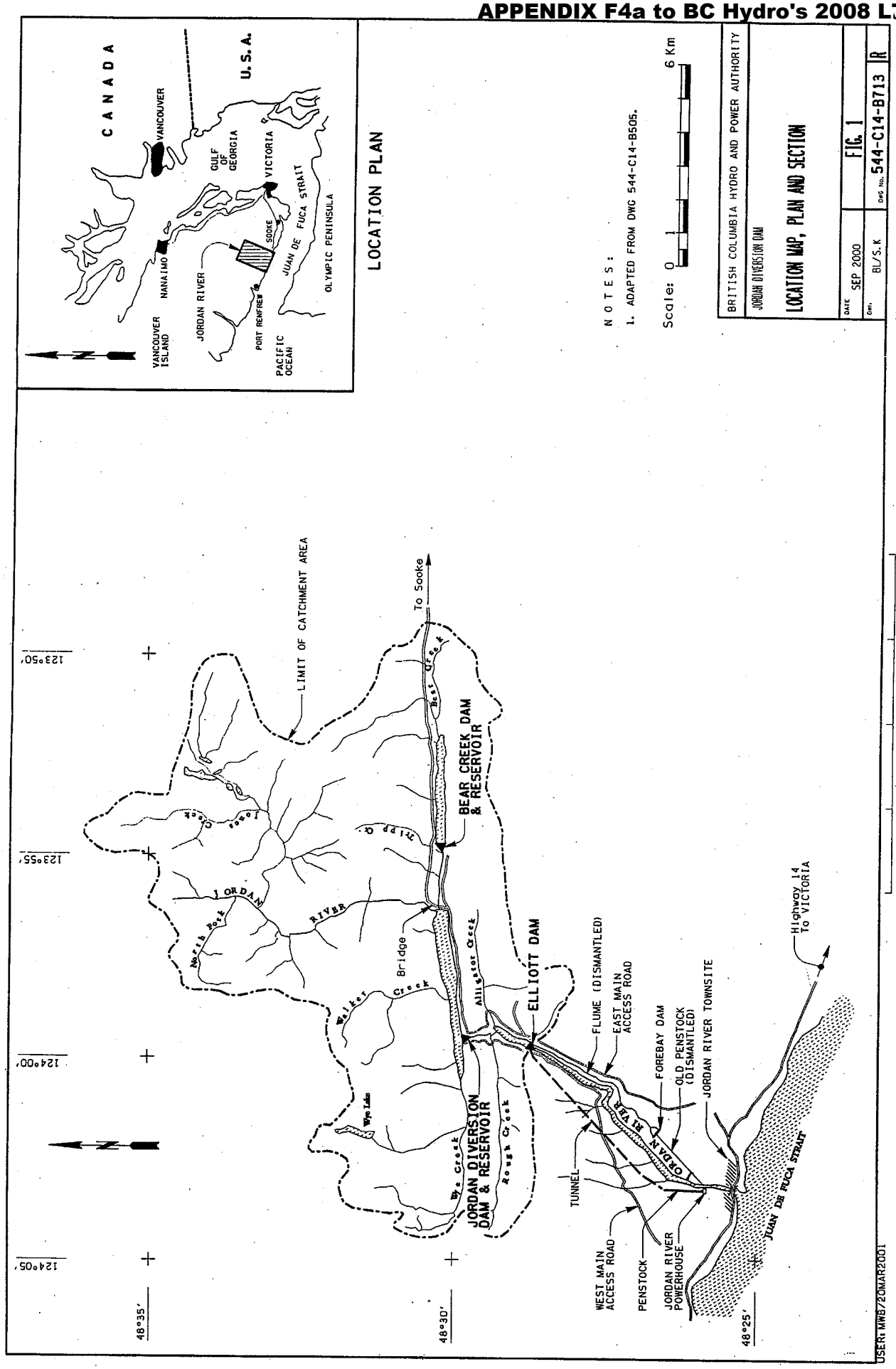
BC Hydro, 1993. "Pumped Storage in British Columbia", Hydroelectric Design Division, Report No. H2645. March 1993.

BC Hydro, 2001. "Green Energy Study for British Columbia, Phase 1: Vancouver Island", Green and Alternative Energy Division, Report No. PSE379. September 2001.

Powertech, 2007 (draft). "Evaluation of the Jorvic Sewage Reclaim Pipeline at the Jordan River Hydroelectric Project", undated draft memo.

BC Hydro, 2005. "BC Hydro 2005 Resource Options Report, Appendix B, Project and Program Database, Pumped Storage Opportunities for Vancouver Island".

British Columbia Utilities Commission, 2007. "On the Matter of BC Hydro and Power Authority, 2006 Integrated Electricity Plan and 2006 Long Term Acquisition Plan, Decision". May 2007.


LOCATION PLAN
CANADA
U.S.A.
VANCOUVER
NANAIMO
GULF OF GEORGIA
VICTORIA
SOOKE
JUAN DE FUCA STRAIT
OLYMPIC PENINSULA
YANCOUVER ISLAND
JORDAN RIVER
PORT RENFREW
PACIFIC OCEAN
N O T E S :
1. ADAPTED FROM DWG 544-C14-B505.
Scale: 0 1 6 Km
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
JORDAN DIVERSION DAM
LOCATION MAP, PLAN AND SECTION
DATE SEP 2000
FIG. 1
Des. BL/S.K
DWG No. 544-C14-B713 R
REPORT No. PSF330
LIMIT OF CATCHMENT AREA
To Sooke
Bear Creek
BEAR CREEK DAM & RESERVOIR
Tugwell Creek
Loss Ocean
JORDAN RIVER
North Rock
Bridge
Walker Creek
Alligator Creek
ELLIOTT DAM
FLUME (DISMANTLED)
EAST MAIN ACCESS ROAD
FOREBAY DAM
OLD PENSTOCK (DISMANTLED)
JORDAN RIVER TOWNSITE
Highway 14 To VICTORIA
Wye Lake
Wye Creek
JORDAN DIVERSION DAM & RESERVOIR
Rough Creek
TUNNEL
JORDAN RIVER
WEST MAIN ACCESS ROAD
PENSTOCK
JORDAN RIVER POWERHOUSE
JUAN DE FUCA STRAIT
123°50'
123°55'
124°00'
124°05'
48°35'
48°30'
48°25'
USER: MWB/20MAR2001