SITE C CLEAN ENERGY PROJECT

RESERVOIR FILLING PLAN

Prepared by

Klohn Crippen Berger Ltd. and SNC-Lavalin Inc.

For

BC Hydro

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RESERVOIR FILLING PLAN

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1. Overview

The Site C reservoir would be filled during the construction phase, after the earthfill dam and spillways were completed to the stage that the reservoir could be safely filled. The purpose of this document is to describe the anticipated stages of the reservoir filling process and to outline estimated durations for each stage. Key transition points during the reservoir filling process are also described including approximations of the flow changes that would be observed downstream of the dam site. Commissioning of the generating units would commence after filling the reservoir to approximately elevation 452 m. The Site C generating station would enter into commercial operation, signifying the start of the operational phase for the Project, after commissioning of the first turbine/generator is completed.

The process of reservoir filling would increase the reservoir level up to elevation 461.8 m which is approximately 50 m higher than the current average level of the Peace River at the Site C dam site. The Site C minimum outflow requirement during reservoir filling would be 390 m^3/s, which would be the same as the minimum flow requirement during the operational phase of the Project. During reservoir filling, the outlet structures at the Site C dam would be capable of maintaining a minimum outflow of 390 m^3/s. To fill the reservoir, outflows from the Site C reservoir must be less than the inflows. With an inflow equal to the mean annual flow of 1,273 m^3/s and a minimum outflow of 390 m^3/s, it would take approximately 30 days to fill the 2,310 million m^3 volume of the reservoir.

However, as described herein, filling the Site C reservoir would take approximately three months depending on:

1) the time of year;
2) inflows to the Site C reservoir;
3) discharges from the Site C reservoir; and
4) the duration of reservoir hold points, which are periods of time when the reservoir is maintained at a constant elevation, during filling.

Table 1 shows the variability of mean monthly flows measured at Water Survey of Canada (WSC) gauge #07FA004 “Peace River above Pine River,” which is located approximately 6 km downstream of the proposed Site C dam site. This gauge provides an approximation of historic flows at the proposed dam site.

Reservoir filling is currently scheduled to commence in the late summer or fall; however, filling may occur at a different time of year depending on the actual construction progress. Reservoir filling would be scheduled to:

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- Avoid the local basin spring freshet period in order to ensure controlled reservoir filling
- Maintain Peace River flows greater than 1450 ± 100 m^3/s depending on local inflow conditions during the period of Peace River freeze-up at the Town of Peace River

Prior to reservoir filling, during the diversion phase of construction, the reservoir elevation would generally fluctuate between 411 m and 421 m due to changes in the inflows to Site C that are mainly due to the operation of the G.M. Shrum and Peace Canyon facilities. Additional details of the expected changes to the surface water regime during this phase of construction are described in Volume 2 Section 11.4 Surface Water Regime.

Table 1 - Variability of Mean Monthly Flows measured in the Peace River upstream of the Pine River

Peace River above Pine River (WSC Gauge #07FA004) data for 1980 to 2010													
Mean Monthly Flow (m^3/s)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
AVG	1470	1458	1335	1266	1035	1022	1237	1036	1108	1243	1425	1598	1273
MAX	1950	1860	1840	1940	1820	2770	5400	2820	1720	1660	1820	1930	1949
MIN	689	560	490	617	424	554	449	441	543	478	821	894	898

2. Tunnel Conversion Prior to Reservoir Filling

During river diversion the two diversion tunnels (Tunnels A and B) are designed to pass a maximum flow of 3000 m^3/s with the reservoir at a maximum elevation of 433 m. The design levels would only be reached in the event of a flood that occurs once every 120 years, on average, based on historical flow data. The discharge capacity of the tunnels increases with reservoir level and is greater than the maximum monthly inflows shown in Table 1 (the one exception is the maximum monthly flow for July which exceeds the discharge capacity of the tunnels, however, this flow was a result of a rare event in 1996 that caused unusually high outflow from the W.A.C Bennett Dam).

The capacity of Tunnels A and B would be too high to allow reservoir filling to occur with expected inflows from upstream. Therefore, the capacity of the tunnels would have to be restricted in order to fill the reservoir. This would be done by modifying one diversion tunnel (Tunnel A) to reduce its capacity and completely closing the other diversion tunnel (Tunnel B).

To perform the modification to Tunnel A, it must first be closed, temporarily passing the full river flow through Tunnel B. To safely shut off flow through Tunnel A, the Site C headpond would have to be at or below elevation 414 m.

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This would likely require one to two days, depending on inflows, of reduced releases from G.M. Shrum and Peace Canyon generating stations to reduce Site C headpond levels and the corresponding Site C diversion tunnel discharge to about 1000 m^3/s (500 m^3/s per tunnel).

With the headpond below elevation 414 m, the gate in Tunnel A would be closed to shut off flow (gate closure would take approximately 15 minutes) which would reduce the total downstream discharge from about 1000 m^3/s to about 500 m^3/s. Immediately after closure of Tunnel A, the reservoir elevation and the tunnel outflow would begin to rise until an elevation of about 420 m is reached (after 2 to 15 days depending on inflow). At a reservoir elevation of approximately 420 m the discharge from Tunnel B would match the inflow. The reservoir level would then generally fluctuate between elevations 412 m and 433 m (with Peace Canyon discharge restricted to 2 turbines) due to changes in the inflows to Site C, which are largely driven by the operation of G.M. Shrum and Peace Canyon generating stations.

A temporary removable gate would be installed in the outlet structure on Tunnel A which would then be dewatered. Tunnel A would be modified by installing an energy dissipation device(s) within the tunnel to reduce its capacity. After the modification is complete, Tunnel A would be flooded, the temporary gate removed, and the tunnel placed back into service. Modification of Tunnel A would take from one to three months. With the modified tunnel placed back in service, the reservoir level would then generally fluctuate between elevations 411 m and 430 m due to changes in the inflows to Site C, which are largely driven by the operation of G.M. Shrum and Peace Canyon generating stations.

3. Filling Stages

As shown in Figure 1, reservoir filling would take place in three stages with provision for a hold point at the end of Stage 2 when the reservoir is at elevation 452 m. The stages of filling are described in more detail below.

During reservoir filling, downstream flows would be discharged by:

1) the diversion tunnels during Stage 1;

2) the spillway undersluices during Stage 2; and

3) the spillway gates and/or the spillway undersluices during Stage 3.

During reservoir filling there would be a number of short term changes in Peace River flows as described in the following subsections.

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3.1 Stage 1 Filling

To commence filling, the reservoir would be brought down below elevation 414 m to safely shut off flow through the non-modified diversion tunnel (Tunnel B). This would likely require one to two days, depending on inflows, of reduced flows from G.M. Shrum and Peace Canyon generating stations. With the headpond below elevation 414 m, the gate in Tunnel B would be closed to shut off flow which would reduce the total downstream discharge to about 390 m^3/s through the modified tunnel (Tunnel A) only. The total downstream discharge would reduce from approximately 1000 m^3/s to the minimum downstream flow of 390 m^3/s as Tunnel B is closed (gate closure would take approximately 15 minutes). A flow of at least 390 m^3/s would then be maintained through Tunnel A for the duration of Stage 1 filling.

Following closure of the gate in Tunnel B, the reservoir level would begin to rise until an elevation of 440 m is reached (after one to two weeks depending on reservoir inflow). Once the reservoir reached elevation 440 m, the spillway undersluices would be opened to provide additional downstream flows. The spillway undersluices are ports through the spillway that allow the spillway to pass flows at reservoir levels that are below the normal spillway crest.

3.2 Stage 2 Filling

Stage 2 filling begins with the transfer of downstream flow from Tunnel A to the spillway undersluices with no planned reservoir hold point. The downstream discharge would increase from approximately 390 m^3/s to 780 m^3/s for a duration of less than 1 hour when both the spillway undersluices and Tunnel A are discharging. Once minimum flows are confirmed through the spillway undersluices, the gate in Tunnel A would be closed (gate closure would take approximately 15 minutes) reducing downstream flow back to approximately 390 m^3/s.

Stage 2 filling would increase the reservoir elevation from 440 m to 452 m and would take from one to two weeks depending on reservoir inflows. The minimum downstream flow of 390 m^3/s would be maintained by the spillway undersluices. When the reservoir reaches elevation 450 m, the main spillway gates would be commissioned and could then be used to control downstream flow releases.

3.3 Hold Point

The reservoir would be held at elevation 452 m for about four weeks with downstream flows of at least 390 m^3/s maintained by the main spillway gates. During this period, the penstocks would be filled with water and commissioning of the turbines/generators using flow from the Site C reservoir would begin.

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3.4 Stage 3 Filling

The third stage of reservoir filling from elevation 452 m to the maximum normal reservoir elevation of 461.8 m would take from two to six weeks depending on reservoir inflows and selected reservoir outflow. The minimum downstream flow of 390 m^3/s would be maintained by the main spillway gates. As the reservoir level nears the maximum normal reservoir level, the commissioning of the first turbine/generator would be completed and a transition to the operational phase for the Site C Clean Energy Project would begin. The duration of the hold point at elevation 452 m, or the duration of Stage 3 filling, may be increased depending on reservoir inflows to enable commissioning of the first turbine/generator to be completed prior to the reservoir reaching elevation 461.8 m.

3.5 Turbine/Generator Commissioning

After reservoir filling and commissioning of the first turbine/generator, commissioning of the second and subsequent turbine/generators would be completed in sequence with approximately 4 to 8 weeks in between the completion of each individual turbine/generator commissioning process. It is estimated that the commissioning process for all 6 turbine/generators would take between 6 and 8 months. Following commissioning of the first turbine/generator, the reservoir would be maintained within the normal operating range of elevation 460.0 m to 461.8 m for the duration of the commissioning process. As each additional turbine/generator is commissioned, the discharge through the spillway would be reduced until the capacity of the commissioned turbine/generators exceeds the inflows.

4. Monitoring

During reservoir filling, instrumentation in the dam and reservoir slopes would be monitored to compare observations of actual dam movement and groundwater pressure relative to expected values. Based on the monitoring results, the duration of the hold points may be extended or the rate of filling may be reduced.

During the design of the dam, generating station and spillway the requirements for monitoring of parameters such as dam movement and groundwater pressures during reservoir filling and operations will be determined. The design drawings will include the type and locations of all instrumentation required for this monitoring. The instrumentation will be installed during construction and BC Hydro will verify that the instrumentation is performing properly. Deficient instrumentation will be replaced.

The Operation Maintenance and Surveillance Manuals described in Volume 1 Section 4 Project Description will include an appendix describing the monitoring required during reservoir filling. This appendix will identify:

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- The frequency of measurements during reservoir filling, recognizing that the frequency may change depending on the observations;
- Reporting requirements;
- Trigger or acceptance criteria; and
- Procedures required to control the filling rate and authorizations to extend the planned hold point(s).

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FIGURES

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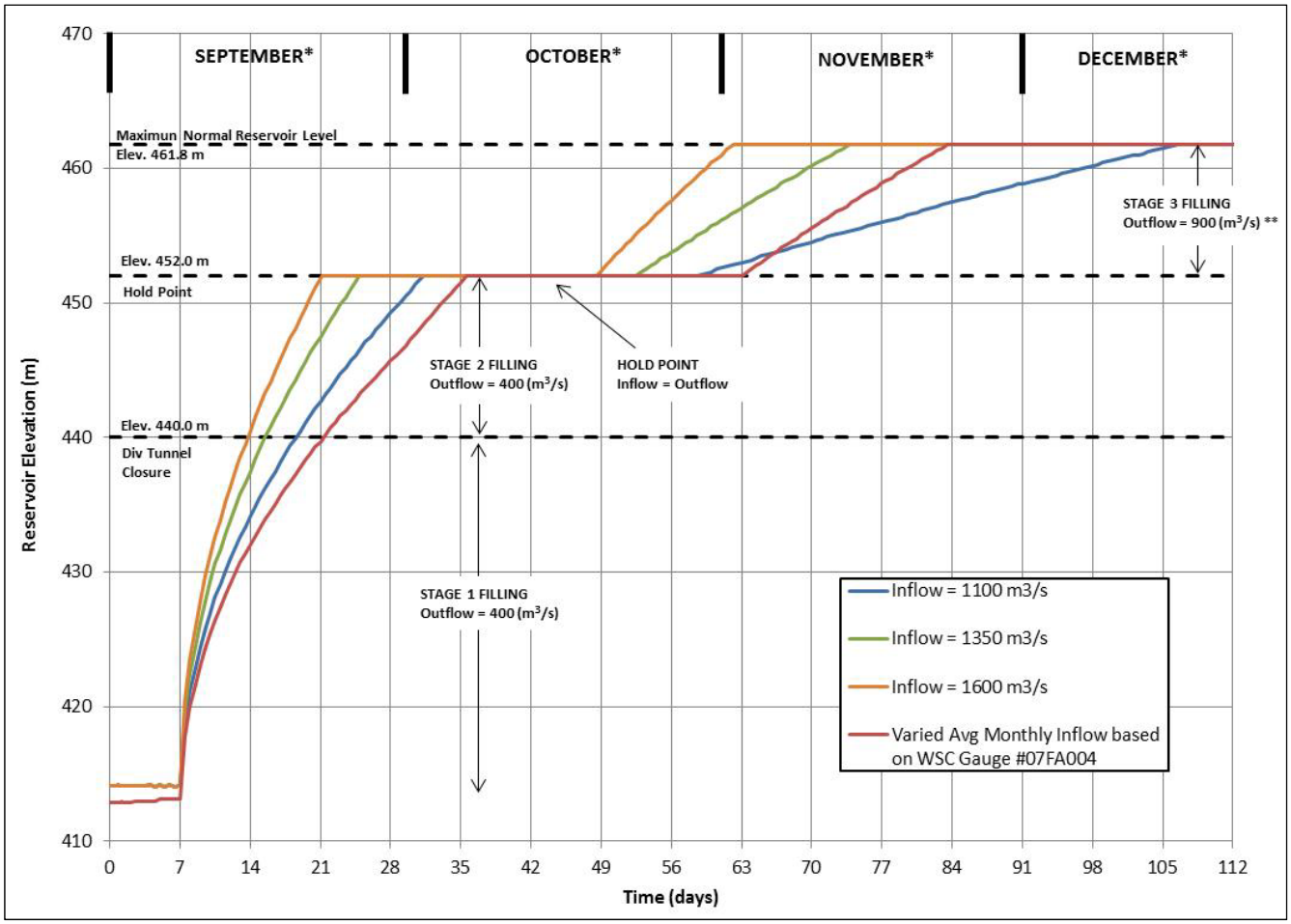
Figure 1 – Reservoir filling curves for various average inflows



NOTES:
* The timeline shown illustrates a potential schedule for reservoir filling that is subject to change based on actual construction progress.
**The hold duration and/or the outflow during filling from 452 to 461.8 can be varied to minimize the duration at El. 461.8 prior to the first generating unit being in operation to mitigate potential TGP issues.

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