Addendum Report -DRAFT

Prepared by BC Hydro and Power Authority

October 30, 2013

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1.0 Introduction

This report is an addendum to the Columbia River Treaty Review Technical Studies Report, which was initially released in draft on March 11, 2013. After the release in March, the BC Treaty Review Team conducted a third round of consultations with stakeholders and basin residents as well as continuing government-to-government consultation with First Nations. As part of the consultation, a technical conference was held in Castlegar to discuss the Technical Studies Report and other topics. Feedback from the public consultation is summarized in the draft CRT Public Consultation Report[1].

During the consultation processes, the Treaty Review Team heard a strong desire from residents living in the Fauquier area to further investigate modelling a mid-elevation stable reservoir level in the Arrow Lakes Reservoir. In addition, many people from across the basin and First Nations expressed a desire to further investigate an ecosystem alternative (defined below). As a result, the project team has modelled two additional alternatives.

The purpose of this addendum report is to present the results of the two new alternatives that are modelled under the Treaty Terminate Scenario:

- Arrow Lakes Reservoir stabilized mid-elevation
- Ecosystem function

A new alternative for Okanagan Sockeye Salmon is also being developed in collaboration with the Okanagan Nation Alliance and once completed will be summarized in a separate report.

Other studies conducted in response to feedback from the consultation process are summarized in additional reports. For example, basin residents near Duncan Dam wanted to see a wider range of options such as decommissioning the dam and adding generation[2], while residents in Valemount and Golden were interested in new dams built across Canoe Reach and Columbia Reach in Kinbasket Reservoir to provide stable lakes for recreational purposes[3].

The reader is referred to the Technical Studies Report for additional information not covered in this addendum such as the scope of the Treaty Review, the modelling process, and descriptions of performance measures that are used to indicate impacts of alternatives on different interests.

2.0 Description of Alternatives

A short description of the two Treaty Terminate alternatives is provided in Table 1 with further information on the Ecosystem Function alternative provided in the following section. While this section provides the specific assumptions for the two additional Treaty Terminate alternatives, the study assumptions and models that are applied to all of the alternatives modelled in the Columbia River Treaty Review Technical Studies are summarized in Appendix D of that report.

[1] The CRT Public Consultation Report is available at: http://blog.gov.bc.ca/columbiarivertreaty/public-consultation-report/
[2] http://blog.gov.bc.ca/columbiarivertreaty/files/2013/04/Duncan-and-Arrow-Lakes-Reservoir-Options-Post-2024-Presentation-July-5-2013.pdf
[3] http://blog.gov.bc.ca/columbiarivertreaty/files/2012/07/CRT_KinbasketResevoir_ver01.pdf

Table 1: New Treaty Terminate (TT) Alternatives

Alternative	Description
Alt 7 TT	**Arrow Reservoir stabilized at mid-elevation (TT) –** This alternative stabilizes the reservoir at specified mid-elevations allowing fluctuations of ~5 ft. The intent of this alternative is to establish vegetation around the reservoir, provide wildlife habitat, and in general improve aesthetics of the reservoir. Two different elevations were simulated a)1425ft and b)1420 ft. The operations are similar to Alt Ref TT, except with a lower Arrow elevation which causes head loss for power production at Arrow Lakes Hydro.
Alt 8 TT	**Ecosystem Function (TT) –** The intent of this alternative is to specify a water regime that would theoretically benefit the ecosystem on the Columbia River in Canada including riparian/wetland function, vegetation, wildlife, riverine fish communities, and enhanced littoral and pelagic productivity. To accomplish this, the top 15 ft of reservoirs are only used in 20% of years with high volume runoff, limits on Mica drafts are added as constraints in average and low water years, and Arrow is operated at a stabilized elevation in most years. Further information on this alternative is provided below.

Notes:
1) TC = Treaty Continue; TT = Treaty Terminate

2.1 Alt 8 TT – Ecosystem Function alternative: additional specification details

The intent of the Treaty Terminate alternative is to potentially benefit the ecosystem on the Columbia River in Canada including:

- Benefit riparian/wetland function and vegetation, birds and other wildlife by reducing Mica and Arrow full pool elevation in 80% of years;
- Benefit riverine fish communities by providing fish friendly flow downstream of Arrow to the U.S. border;
- Reduce reservoir drawdown of Mica and Arrow to support enhanced reservoir littoral and pelagic productivity

Changes to Duncan on the Kootenay system have not been included in this model run of the Columbia River. A Kootenay Ecosystem Function alternative could potentially include Duncan, Libby and Kootenay Lake; however, only Duncan operations would be fully within Canadian control in a Treaty Terminate scenario. Although Duncan has not been modeled, the potential benefits and impacts to the reservoir of imposing similar operating constraints to Duncan as those on Mica/Arrow will be described.

The specific modelling constraints were proposed by the Canadian Columbia River Intertribal Fisheries Commission (CRIFIC) and then reviewed by the CRT Fish and Wildlife Technical Committee.

Modelling constraints are:

1. Mica and Arrow only use top 15ft of reservoir in 20% of years when the April to August flow is high (exceed 80% probability). The new upper operating level will be set 15ft below full pool (Full pool elevations Mica:2475ft, Arrow: 1444ft)
2. Fish hydrograph below Arrow targets white fish and trout spawning flows. For white fish, limit the flow reduction in February and March. Flow reduction levels are set as a percentage of the flows during the first three weeks of January. For trout, maintain non-decreasing flow from April to June.

3. Reduce reservoir drawdown and stabilize reservoirs:

   Mica: Reduce Mica fall/winter power draft to increase flow in the freshet. The table below provides April 1 draft limits based on a sliding scale of April to August runoff at The Dalles. Reservoir elevations on Apr 1 may be above these elevations but not below them. The table is based on sliding scales developed by the U.S. tribes, where the primary purpose appears to be increasing discharge from Canada in the spring. The tables developed by the tribes were for runoff forecasts (at the beginning of January, February and March) at The Dalles, Oregon. For the planning level study observed flows are substituted for the forecasted flow, and the draft limit for the February forecast is used.

April ~ August observed flow (Maf)	Mica April 1 draft limit (ft)
<60	2420
75	2410
90	2405
100	2400
>100	No limit

   Arrow: Stabilize Arrow Lakes reservoir at a mid elevation of 1425 ft (similar to Alt 7 TT). Reservoir level will be allowed to rise above this level up to 1444 ft for periodic wetland flooding benefit and Canadian flood control in 20% of years. In the monthly model, this will be modelled as a simple step function. This study is not attempting to maintain flood protection for Castlegar/Trail, nor is it attempting to optimize the use of the storage above 1425 ft for Canadian flood control.

   Duncan: Although not included in the modelling of the alternative, the benefits/impacts of the following constraint on Duncan will be described:

   - limit draft to the current flood control rule curves
   - only use top 15ft of reservoir in 20% of years when the April to August flow is high (exceed 80% probability). The new upper operating level will be set 15ft below full pool (Full pool elevation Duncan: 1892 ft)

Note that this alternative has not been optimized for ecosystem function and instead is intended to explore different possibilities for potential ecosystem benefits. Further mapping and other analysis would be needed to refine the alternative.

Although this Treaty Terminate alternative is designed for ecosystem benefits in Canada, the resulting flows across the US-Canada border will increase flow in the Columbia River in the U.S. in the spring and early summer and may have additional benefits/impacts to U.S. salmon recovery efforts and other ecosystem values.

3.0 Hydrological Results

The Columbia simulation model produces reservoir levels and discharge data sets at different locations within the basin. The figures in this section show daily median hydrological outputs for the two new water management alternatives at four locations in the Columbia River:

- Kinbasket reservoir elevation;

- Mica dam discharge ("Mica Flow rate")
- Arrow Lakes reservoir elevation;
- Hugh Keenleyside dam discharge ("Arrow Flow rate")

The hydrological data generated by the simulation model is generated monthly using inflows from the 1929 to 1999 period. The monthly reservoir elevations are linearly interpolated and shown as smooth curves in the elevation graphs. In contrast, the monthly dam discharge flow rates are set to the same value for each day for each month.

3.1 Arrow Reservoir stabilized at mid-elevation (Alt 7 TT)

Figure 1 shows the hydrographs associated with Alt 7 TT. The Treaty Continue reference case (Alt Ref TC) and Treaty Terminate reference case (Alt Ref TT) are included in the figure for comparison.

Alt 7 TT was designed to explore the consequences associated with holding Arrow Lakes Reservoir lower than optimal for power year round to allow vegetation to extend into lower elevations, provide improved habitat for nesting birds, increase the length of flowing river, and provide shore based recreation in the Revelstoke reach.

Reviewing the charts in Figure 1, it can be seen that Kinbasket reservoir is operated in a similar way in Alt 7 TT and the two reference cases. Arrow Lakes reservoir operation is similar to Alt Ref-TT except the reservoir is stabilized around 1425 ft (or 1420 ft) instead of around 1442 ft. In both Alt 7 TT and Alt Ref-TT, Arrow reservoir drafts a few feet in November to keep the turbines fully loaded while Mica flows are reduced. Arrow reservoir also drafts a few feet in March because of maintenance outages in April.

Discharges from Hugh Keenlyside Dam are also similar between Alt 7 TT and Alt Ref TT.

3.2 Ecosystem Function (Alt 8 TT)

Figure 2 shows the hydrographs associated with Alt 8 TT. Ref TC and Ref TT are provided for comparison purposes.

Alternative 8 TT was designed to support ecosystem functions by reducing the draft at Kinbasket in average and low water years and only used the top 15 ft to flood in about 20 per cent of the years with the intent to mimic a wetland function around the reservoir. The graph of the median Mica reservoir elevation in Figure 2 shows that constraints accomplished the goal, however, there were some unanticipated consequences. Figure 3-3 shows Mica elevations for all of the years modelled. As the draft constraints are applied only in years when the forecast at the Dalles is greater than 100 MAF (approximately 50 percentile), the draft in other years is deeper than in Alt Ref TT because the start of the draft in the fall is already about 15 ft lower than it otherwise would have been. The result is a divergence between the years with constrains that limit the draft to no deeper than 2400 ft and years with no constraints.

For Arrow reservoir, the elevation in Alt 8 TT is the same as in Alt 7 TT. The exception is in the highest 20 percent of water years when the reservoir is allowed to fill as shown in Figure 3-4. The reservoir is filled across April/May reaching 1442 ft in June and 1444 ft in July. The reservoir is then drafted back down to 1425 ft by the end of September. As part of the consultation, some residents living around Arrow reservoir indicated that the reservoir could fill for just a two week period and then draft back down. Drafting the reservoir from 1444 ft to 1425 ft in two weeks would require a release of 200 kcfs on top of passing inflows. This high release from Arrow reservoir in addition to flows from the Kootenay system in July would cause flooding issues in Castlegar and Trail.

Alt 8 TTdoes accomplish its goal of moving discharged water from winter to the spring. Mica discharges in January through March are much lower with higher values in June and July. Arrow discharges are lower in winter and fall and higher April through July. The trout requirements of increasing flows April through June is met, although the flows for white fish in January through March are not as good in comparison to Alt Ref TT.

3.3 Summary

Figure 3 shows the median elevations for Kinbasket and Arrow Lakes reservoirs for all of the Treaty Terminate modelled alternatives and Alt Ref TC.

4.0 Performance Measure Results

This section summarizes how environmental and social interests in Canada may be affected by the two new water management alternatives analysed under a Treaty Terminate scenario. The results are discussed in comparison to TC-Ref and TT-Ref.

Table 2 provides the results by geographic area. The focus is on mean annual values unless otherwise stated. The effects of post-2024 flood management (i.e. called upon operations) have not been modelled.

When interpreting the results, it is important to keep in mind that the modelling was done on a monthly time step using observed inflows. The modelling did not simulate how operations change as inflow volume forecasts change. This is especially important across the late winter and spring

As per Columbia River Treaty Review Technical Studies Report, the interests for the different alternatives are shaded orange (dark text) if the difference is in a preferred direction (i.e. ‘better’) by an amount detailed in Appendix F (referred to as the Minimum Significant Increment of Change (MSIC)) relative to the Ref TC alternative. A blue shaded (white text) value is ‘worse’ than the reference column by an amount greater than the MSIC. Changes that are within the MSIC in either direction are not shaded. The column labelled ‘Dir’ indicates the preferred direction of change (H=Higher, L=Lower) in the numbers in each row and the column labelled “PM” indicates the PM Information Sheet in Appendix F.

Table 2: Performance of Alternatives

Objective	Performance Measure	Units	Dir	Ref TC	Ref TT	7TT 1425	7TT 1420	Alt 8 TT Ecosystem	PM
Kinbasket									
Veg & Wildlife	Elevation bands flooded > 18 wks	# 2m bands	L	6.1	6.8	6.8	6.8	5.9	(#5)
Aquatic Productivity	Residence time	Days	H	622	687	678	681	504	(#7)
Heritage	Site erosion	Weighted Days	L	203	203	203	202	239	(#3)
Heritage	Site inundation	Weighted Days	H	524	556	554	553	526	(#3)
Rec - Water - Canoe	Pref range: 2404 < days < 2475	Days	H	148	145	145	145	178	(#2)
Rec - Water - Columbia	Pref range: 2375 < days < 2475	Days	H	52	51	52	52	88	(#2)
Rec - Shore - Columbia	Pref range: 2444 < days < 2473	Days	H	175	175	174	174	172	(#2)
Dust	Areal extent	SqKm - Days	L	1,468	1,393	1,433	1,459	1,107	(#6)
Erosion	Elev>=2470	Days	L	54	70	70	71	5	(#4)
Navigation	Downie Timber access (>=2360)	Ave Days/yr	H	348	362	362	361	344	(#1)
Mid Columbia River									
Veg & Wildlife - Veg Flooding	Hectares flooded >18 wks	Hectares	L	2,352	3,234	1,871	979	1,871	(#11)
Veg & Wildlife - Nesting birds	% Useable habitat	Percent	H	20	-	61	78	49	(#13)
Veg & Wildlife - Fall Mig. Birds	% Useable habitat	Percent	H	15	-	94	95	74	(#13)
Aquatic - River Habitat	Functional large river habitat	Km	H	31	18	33	35	32	(#12)
Aquatic - Sturgeon	Larval habitat availability	Km	H	2.84	2.77	2.85	2.85	2.83	(#12)
Rec - Boat Access	Days > 1435	Days	H	64	153	-	-	17	(#10)
Rec - Shore Access	Days < 1435	Days	H	119	-	183	183	166	(#10)
Arrow Lakes									
Aquatic - Kok Trib. Access	Days > 1430'	Days	H	60	82	0	0	4	(#20)
Aquatic Productivity	Epilimnetic residence time	Days	H	107	95	87	84	78	(#7)
Heritage	Site erosion	Weighted Days	L	227	365	253	238	257	(#17)
Heritage	Site inundation	Weighted Days	H	190	763	-	-	41	(#17)
Recreation - General	1425 < days < 1440	Days	H	97	197	197	0	197	(#16)
Dust	days < 1410	Days	L	41	-	-	-	-	(#18)
Navigation	Weighted-Days	Days	H	245	329	329	88	329	(#15)
Lower Columbia River									
Boat Access	40000 < days < 103000	Days	H	95	79	94	93	96	(#26)
Shoreline Access	60000 < days < 99000	Days	H	79	61	60	60	62	(#26)
Flooding at Genelle (1)	days > 165 kcfs	Days	L	2	6	6	6	7	(#27)
Flooding at Genelle (2)	days > 177 kcfs	Days	L	1	3	3	3	4	(#27)
Whitefish / Trout	INDEX	INDEX	H	-	0.63	0.63	0.50	1.14	APPX E
TGP	days > 115%	Days	L	NA	NA	NA	NA	NA	(#28)
Sturgeon	Pulse provided	Yes / No	H	No	No	No	No	No	NA
System Wide									
Relative loss in Power Values	Incremental Cost	$M/yr	L	-	180	197	203	456	(#30)

Legend
Better than highlighted alt
Worse than highlighted alt
Highlighted alt

4.1 Arrow Reservoir stabilized at mid-elevation (Alt 7 TT)

Kinbasket Reservoir and Mica Dam Discharge

As discussed in section 3.1, the Mica reservoir elevation and discharge are very similar between Alt-7 TT and the TT-Ref alternative so not surprisingly, the performance of the alternatives is almost identical for Mica.

Mid-Columbia River

The big difference in performance of Alt 7 TT is in the Mid-Columbia River (Columbia River from Revelstoke Dam downstream to the beginning of Arrow Lakes Reservoir). Performance measures in

this reach are better when Arrow Lakes Reservoir levels are lower, and worse when Arrow Lakes Reservoir levels are higher. When reservoir levels are high, areas of important habitat for vegetation, birds and other wildlife are inundated. Alt 7 TT stabilizes Arrow Reservoir at either 1425 ft or 1420 ft, and this translates to significantly better performance for vegetation and wildlife including nesting and migratory birds. Compared to TC-Ref, the stable reservoir at 1425 ft provides an additional 480 ha of area that can support vegetation and an additional 890 ha is gained by stabilizing the reservoir 5 ft lower at 1420 ft.

The type of vegetation that establishes in the reservoir is likely to be different between Alt 7 TT and TC-Ref and this difference is not captured in the performance measure. The depth, timing, and duration of inundation are important factors that affect species composition and diversity of vegetation. With less inundation the species would be expected to evolve from grasses and sedges, to a cottonwood community, to dense woody stands of trees, potentially benefiting wildlife. However, the type of vegetation that establishes may not return to pre-dam conditions due to many factors such as the erosion and deposition of soil within the reservoir.

With lower Arrow levels the length of functional large river habitat increases. In comparing Alt 7 TT with TC-Ref there is a marginally significant (11%) difference in the average river length, although the seasonal difference in this river length would be significantly different and this difference is not captured by the performance measure. In Alt 7 TT, the functional river length would be the same throughout the year whereas in TC-ref, the functional river length would fluctuate from about 50 km in early spring when the reservoir is at its lowest to almost zero in July when the reservoir is full.

The recreation interests in the mid-Columbia reach have opposite goals. Boating interests prefer the reservoir to be greater than 1435 ft while shore based recreation prefer the reservoir to be less than 1435 ft. With Alt 7 TT, would favour shore based recreation over boating recreation, and vice-versa for TT-Ref. The boating performance measure is not tied directly to boat ramps but instead includes the quality of boating and fishing opportunities from boats.

Arrow Reservoir

The performance measures for Arrow Reservoir were designed to capture differences between alternatives with fluctuating levels throughout the drawdown zone therefore do not capture changes to those interest that may occur over time if the reservoir is stabilized at a specific elevation. This fact needs to be remembered when interpreting the results of the alternatives.

For example, Alt 7 TT does not perform well in the performance measure for kokanee tributary access as the reservoir is always below the elevation of 1430 ft where blockages occur. These blockages tend to be created by the large fluctuation in water levels and over time could erode, or could be removed by physical works so do not necessarily mean Alt 7 TT would be worse for tributary access. If stabilization of water levels allows vegetation to stabilize the banks of streams on the alluvial fans, it should provide more, better quality spawning habitat for kokanee.

Another example is the heritage performance measures, which shows worse results in comparison of Alt 7 TT to TC-ref for both erosion and inundation. For erosion, the stable reservoir is at an elevation with more identified sites so the calculate weighted-days performance measure is worse. With the sites either permanently inundated (sites below 1420 ft) or permanently exposed (sites above 1430 ft) it is quite possible that more of the sites could be more easily protected. Many participants at the archaeology session of the technical conference indicated that a stable reservoir would have benefits not captured in the performance measures.

The performance measures that perform worse in Alt 7 TT in comparison to TC-Ref is the aquatic productivity measured by residence time and recreation. Residence time decreases as the volume of water decreases (i.e. lower reservoir elevations) and the through put of water increases (i.e.

discharge from Arrow). In Alt 7 TT, the lower reservoir level will cause a lower retention of nutrients. The lower productivity may in part be counter balanced by an increase in littoral productivity caused by more complex vegetation communities established around the reservoirs edge.

The preferred elevations for shore based recreation at Arrow Reservoir is 1425- 1435 ft and the preferred range for boating recreation is 1435 – 1444 ft. The overall recreation performance measure used in the analysis is 1425 – 1440 ft[4]. A stable elevation at 1425 ft is right at the bottom of the recreation range and may be acceptable to recreation interests. The boating recreation performance measure includes other values such as aesthetics, which would likely also improve as vegetation is re-established around the reservoir. The changes will affect the various communities around the reservoir differently and it is unclear how all recreational interests will perceive the changes. Beach that is often inundated in early summer will be available, although this beach may be further from the water in some locations.

Celgar's commercial forestry operations are affected when the reservoir is at 1420 ft and below. As a result the navigation performance measure is slightly worse when the reservoir is stabilized at 1420 ft in comparison to 1425 ft.

Lower Columbia River

Discharges from Arrow in Alt 7 TT are very similar to TT-Ref, so the resulting performance measures are also similar.

4.2 Ecosystem Function (Alt 8 TT)

Kinbasket reservoir and Mica dam

The constraints on Mica in Alt 8 TT are designed to only use the top 15 ft of the reservoir in 20 percent of the years and limit the draft of Mica in average and drier water years. The goal of only utilizing the top 15 ft in 20 percent of years is to improve the vegetation around the reservoir and to increase riparian function and associated benefits to wildlife. The performance measure for vegetation and wildlife, however, indicates a "worse than" situation in Kinbasket, and does not adequately measure the potential for increased wetland and riparian vegetation ecosystem in the 15 ft elevation band as a result of the decreased inundation at that elevation in the reservoir under the Eco-system regime.

The vegetation performance measure is calculated based on the number of 2m elevation bands between ~1410 ft and 1475 ft that are inundated for greater than 18 weeks during the growing season from May 1 to September 30. Examining the median reservoir elevation in Figure 4 indicates that more land is inundated in May and June in Alt 8 TT, while less land is inundated from June through September. In low water years, Alt 8 TT inundates more land throughout the growing season. The resulting performance measure shows a poorer performance. However there would

[4] Note that as with the previous round of modelling, alternatives that hold the reservoir near full pool during the summer are penalized on this measure if the water is held slightly above 1440 ft (see Appendix F, PM info sheet #16 for more details). In reality, however, BC Hydro could hold both Alt 8 TT slightly below 1440' with an approximate $2million / yr power loss and with relatively small effects on other interests. Rather than remodel this alternative, it was decided to credit simply credit each of them with the maximum possible mean value for the recreation season.

likely be a difference in type of vegetation that establishes, especially in the top 15 ft of the reservoir and this difference is not captured in the performance measure.

With less inundation in the top 15 ft of the reservoir the species would be expected to evolve to more complex vegetation communities. The type of vegetation that may establish is difficult to predict as it depends on many factors such as erosion and slope within the reservoir. Most likely it would not return to pre-dam conditions as the land would still be inundated occasionally. Steeper portions of the reservoir shoreline will have less potential to support vegetation, where a lower angle fans formed at tributary confluences likely provided the highest potential. The pre-dam mapping undertaken by the Fish and Wildlife Compensation Plan could be used to estimate the area of potential vegetation development, but future plant species composition in the band is difficult to predict.

The one factor that performs worse in Alt 8 TT is the aquatic productivity as measured by residence time. Alt 8 TT has higher through put of water in the spring as Mica discharges are higher resulting in lower retention of nutrients. Whether this would be counterbalanced but increased littoral productivity if more complex vegetation is established in the top 15 ft of the reservoir is unknown.

Boat access in both the Columbia and Canoe reaches shows improvement in performance as the reservoir is not drafted as deeply in the average and deep water year. This wide boat access range from 2404 ft in the Canoe reach and 2375 ft in the Columbia captures boat access but doesn't necessarily capture the preferred levels for boating.

All of the Mica performance measure focus on changes in the top half of the reservoir and do not capture potential impacts due to the deeper draft in above water years in Alt 8 TT that was discussed in section 3.2.

Mid-Columbia River

The discussion of performance measures in the mid- Columbia reach for Alt 8 TT is very similar to Alt 7 TT described in section 4.1. The only difference between Alt 7 TT and Alt 8 TT in the mid-Columbia reach is that in Alt 8 TT the reservoir is allowed to fill to the maximum normal level of 1444 ft in 20 percent of the years. The goal of flooding the area about once in every five years is to maintain the wetland function of this reach and stop the establishment of dense woody strands of trees that have lower wildlife value. The performance measure does not capture the different type of vegetation that may be established in the two different regimes of Alt 7 TT and Alt 8 TT.

Inundating the area about once in every five years would affect nesting birds and fall migratory birds in those specific years, and results is a lower performance for those metrics relative to Alt 7 TT (though improved relative to the reference alternatives).

Arrow Reservoir

Directionally, Alt 8 TT performs similarly to Alt 7 TT when comparing to TC-Ref for the Arrow Reservoir performance measures, although there are some differences between Alt 7 TT and Alt 8 TT. With more through flow of water in the spring in Alt 8 TT, the retention time is lower. There is a week with reservoir levels in the preferred range, although it is not known if high reservoir levels in summer for about two months would be seen as a benefit or an impact on recreation under this operating alternative.

Some residents had envisioned that in a stable Arrow reservoir scenario, the reservoir could fill and retreat in about two weeks to provide flood protection to Castegar/Trail and meet the goal of providing the wetland function. Drafting the reservoir from full to 1425 ft in two weeks requires a discharge of 200 kcfs, which would cause flood damage. The discharge of 200 kcfs would be in

addition to the inflows to the reservoir that are being passed downstream and flows from Kootenay River. In high water years, the inflow to Arrow is still high. For example in the 90th percentile, the monthly flows in Jun through August are 66 to 74 kcfs and Kootenay River is is releasing 105 kcfs (June 15), 66 kcfs (July 15), and 40 kcfs (Aug 15). In high water years it could take till into the fall to draft the reservoir back down to 1425 ft in an orderly fashion.

Lower Columbia River

Alt 8 TT has the effect of significantly increasing the discharge from Arrow in spring. For example median releases increase from 16 to 41 kcfs in May and 21 to 67 kcfs in June, with slightly lower discharges in July. In the 90th percentile Arrow discharge increases from 16 to 33 kcfs in April, 28 to 55 kcfs in May, and 42 to 92 kcfs in July. The higher flows in big water years could increase flood risk to Canadian communities if the runoff is concentrated in short time periods during heat waves.

Allowing Arrow reservoir to fill from 1425 to 1444 ft provides 2.4 MAF of storage that could be used for flood risk reduction in Canada. This space was filled in Alt 8 TT in 20 percent of the years with the largest runoff volume. The modelling did not attempt to optimize the use of this space for flood risk reduction in Canada. The benefits to flood risk reduction would depend on how this storage could be used. A more detailed study would be needed to understand the risk to downstream Canadian communities of this alternative.

The shape of the Arrow hydrograph is expected to have benefits for trout and whitefish. Impacts on the multi-hypothesis fish index developed during this project have been estimated using the same methodology as before. Although the flows are higher in spring, they are not deemed sufficient to meet the proposed sturgeon flows under alt (maginitude and frequency).

Duncan

Although not explicitly modelled as part of Alt 8 TT, similar operating constraints limiting Duncan draft and only using the top 15 ft of Duncan in high runoff volume years was contemplated for the Ecosystem Function alternative. Similar to Arrow, this may provide opportunities for enhanced vegetation of riparian areas. Figure F-14 in Appendix F of the Duncan WUP Consultative Committee Report provides a chart of flooded area versus reservoir elevation. The area in the top 15 ft (572.1 m- 576.7 m) with a slope of less than 20 percent is approximately 350 ha.

In general, a Duncan ecosystem function alternative would move more water into the spring period. While potentially benefiting vegetation and wildlife in the Duncan reservoir and cotton wood requirement in the Duncan River, this Duncan ecosystem alternative would not meet the current recreation targets and may increase the risk of downstream flooding. The full range of impacts on the Duncan reservoir and downstream for a Duncan ecosystem alternative have not been accessed.

4.1 System Wide Impacts

The financial value is composed of three factors: the annual operational power benefits associated with the individual operations of each alternative, the value of the Canadian Entitlement, and the loss of firm energy. The values shown in Figure 6 are changes in financial value (millions of dollars per year) relative to the Ref TC alternative.

Relative to TC-ref, there is an annual operational value gain of $3 million/year for Alt 7 TT at 1425 ft and a loss of $3 million/year at 1420 ft. Another way of looking at the numbers is that the generation value if stabilized at 1425 ft is $6 million more than stabilizing the reservoir at 1420 ft.

Relative to TC-ref, the annual operational loss is $24 million/year. For the ecosystem Function alternative there is also a loss of 1800 GWh of firm energy. Replacement cost for this firm energy firm is $232 million per year.

The loss of Canadian Entitlement in all Treaty Terminate alternatives is $200 million/year. The value of the annual operational power benefit and the Canadian Entitlement is based on the BC Hydro electrical price forecast in 2024 (average market price of $38 MWh[5]). The firm energy value is based on BC Hydro's reference price of $129/MWh, which is the replacement cost of clean energy built in BC. The components of the power value are shown in Figure 6.

The three components of the financial value when summed together provide an annual loss relative to the TC-ref of $197 million for Alt 7 TT and $456 million for Alt 8 TT.

[5] $38 MW/hr is within the $30-$50 MW/hr range of prices used by the U.S. Entity in their Iteration #1 studies.

5.0 Summary

The two new alternatives analysed confirm the Key Findings of section 6.3 of the Technical Report.

- Operating constraints on Kinbasket reservoir have the highest costs (especially if firm energy is impacted), regardless of Treaty Termination
- With Treaty Termination, Arrow Lakes operational choices become less linked to choices made at Kinbasket
- Regardless of the Treaty's future, value trade-offs at Arrow will remain
- Treaty Terminate opens up new trade-off opportunities / constraints between Arrow and the Lower Columbia River

Based on feedback from some basin residents, a stabilized Arrow reservoir would be of interest to explore further both within the Treaty framework and under a Treaty Terminate scenario.

Figures

Figure 1: Hydrology for Alternative 7 TT with 1425' and 142' variants

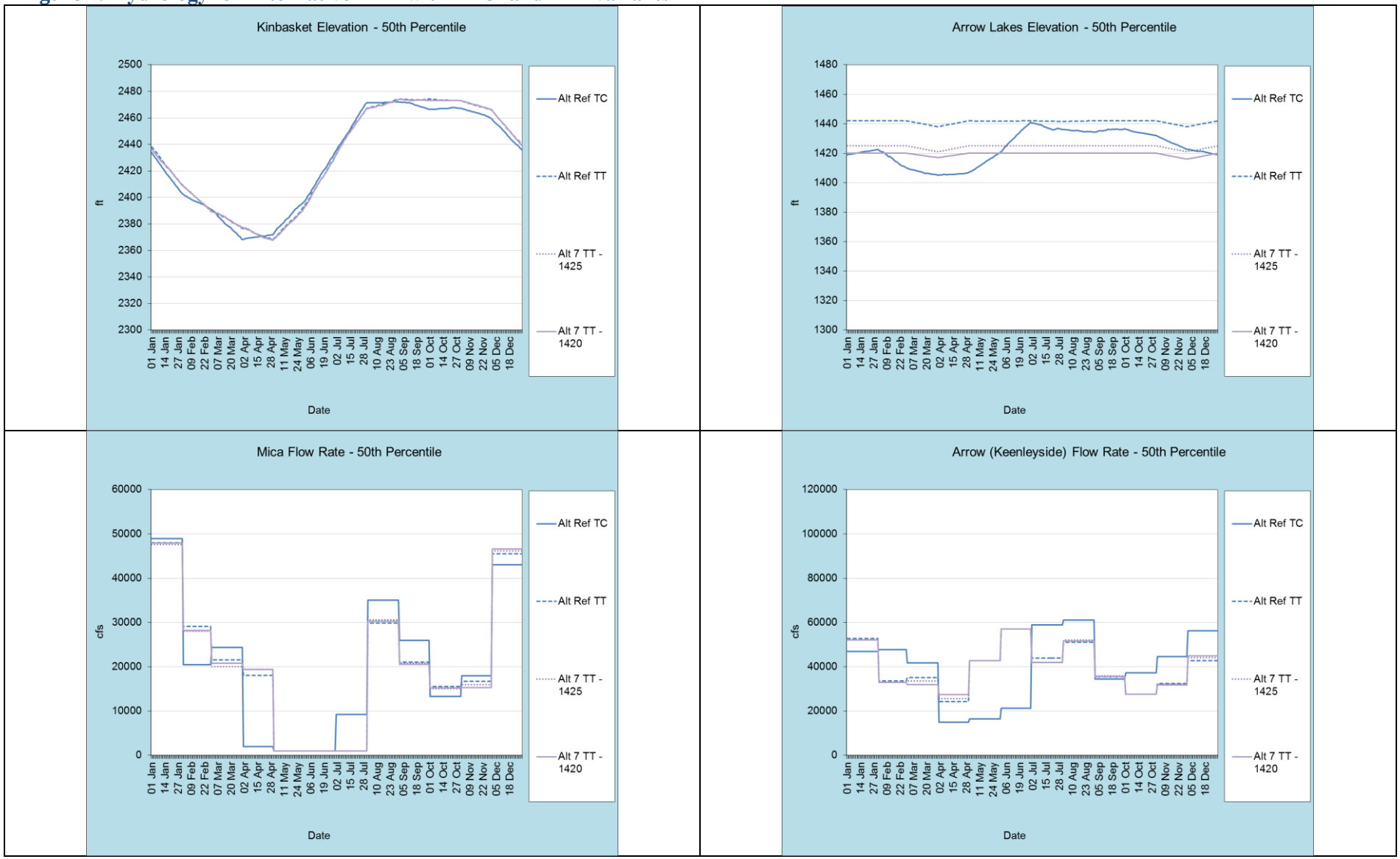


Figure 2: Hydrology for Alternative 8 TT - Ecosystem

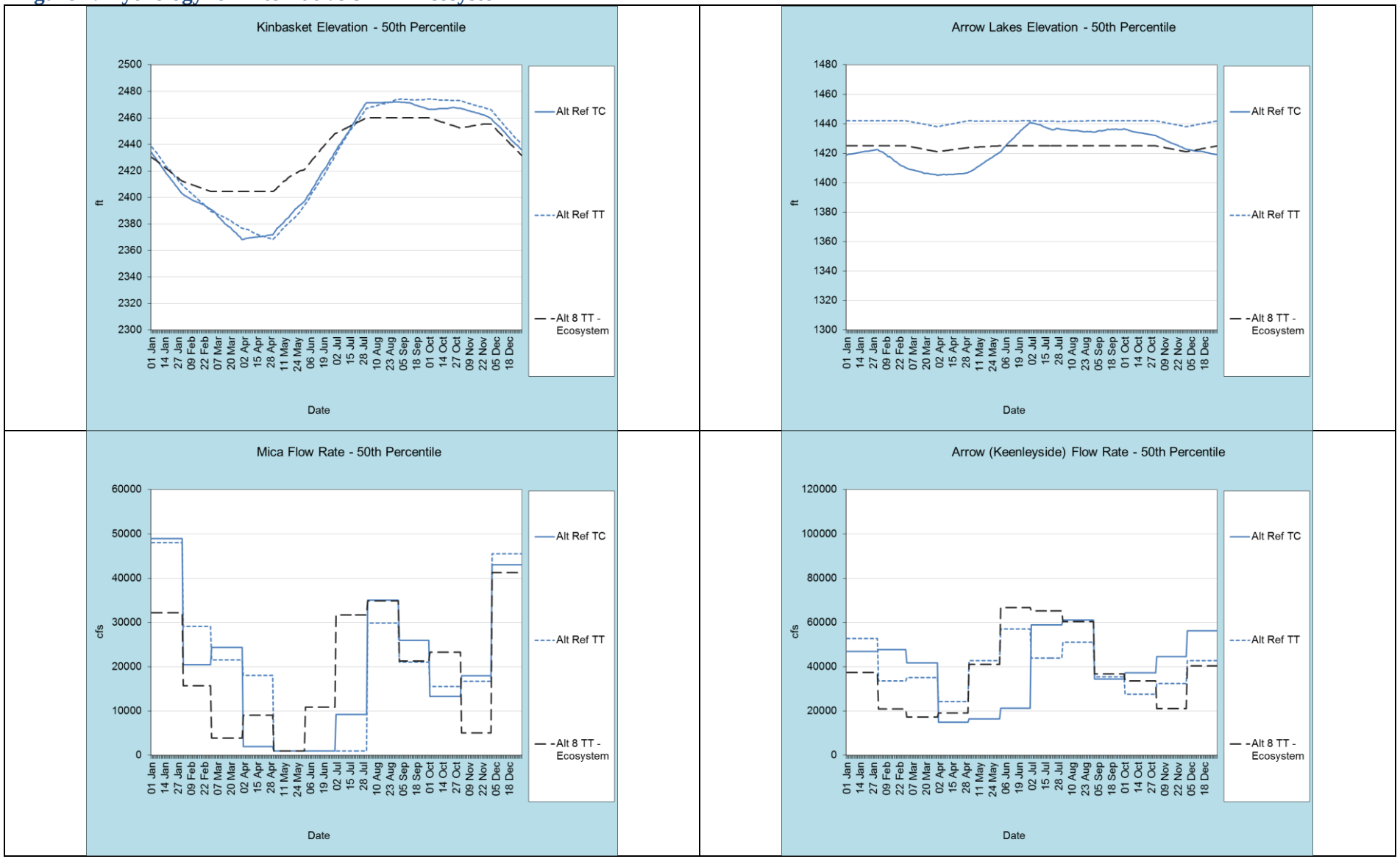
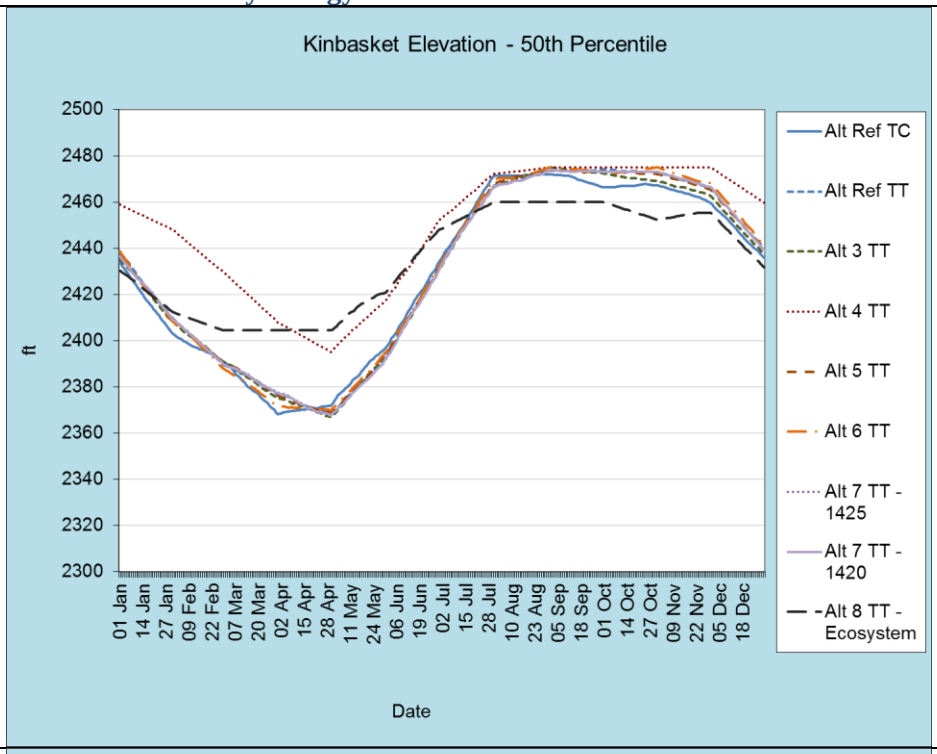


Figure 3: Median Reservoir Hydrology for All Alternatives



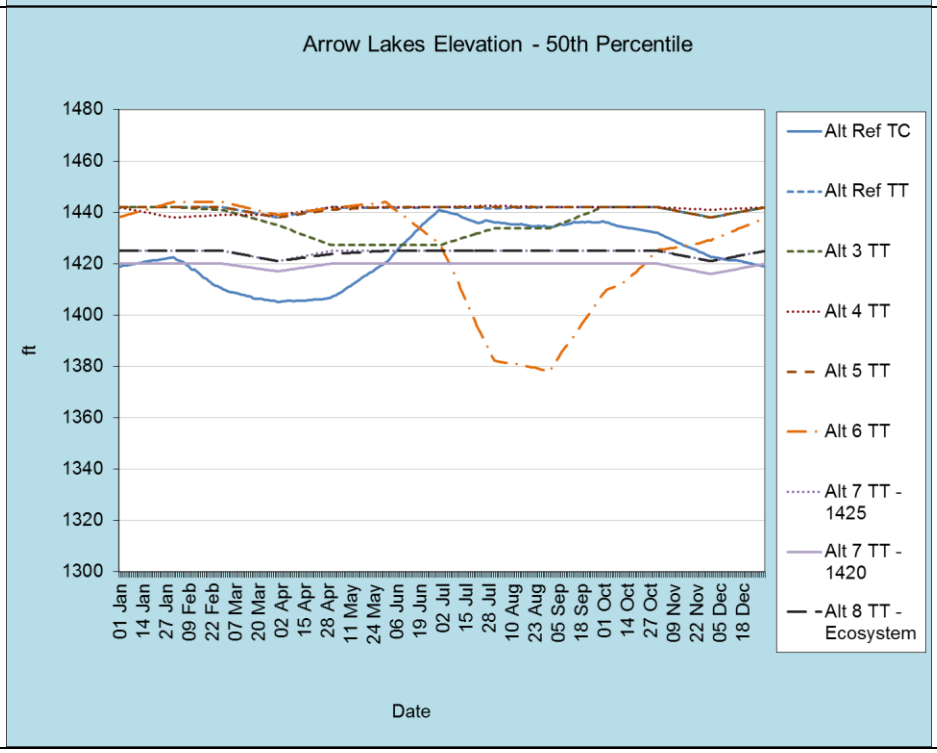


Figure 4: Kinbasket elevation, annual variability

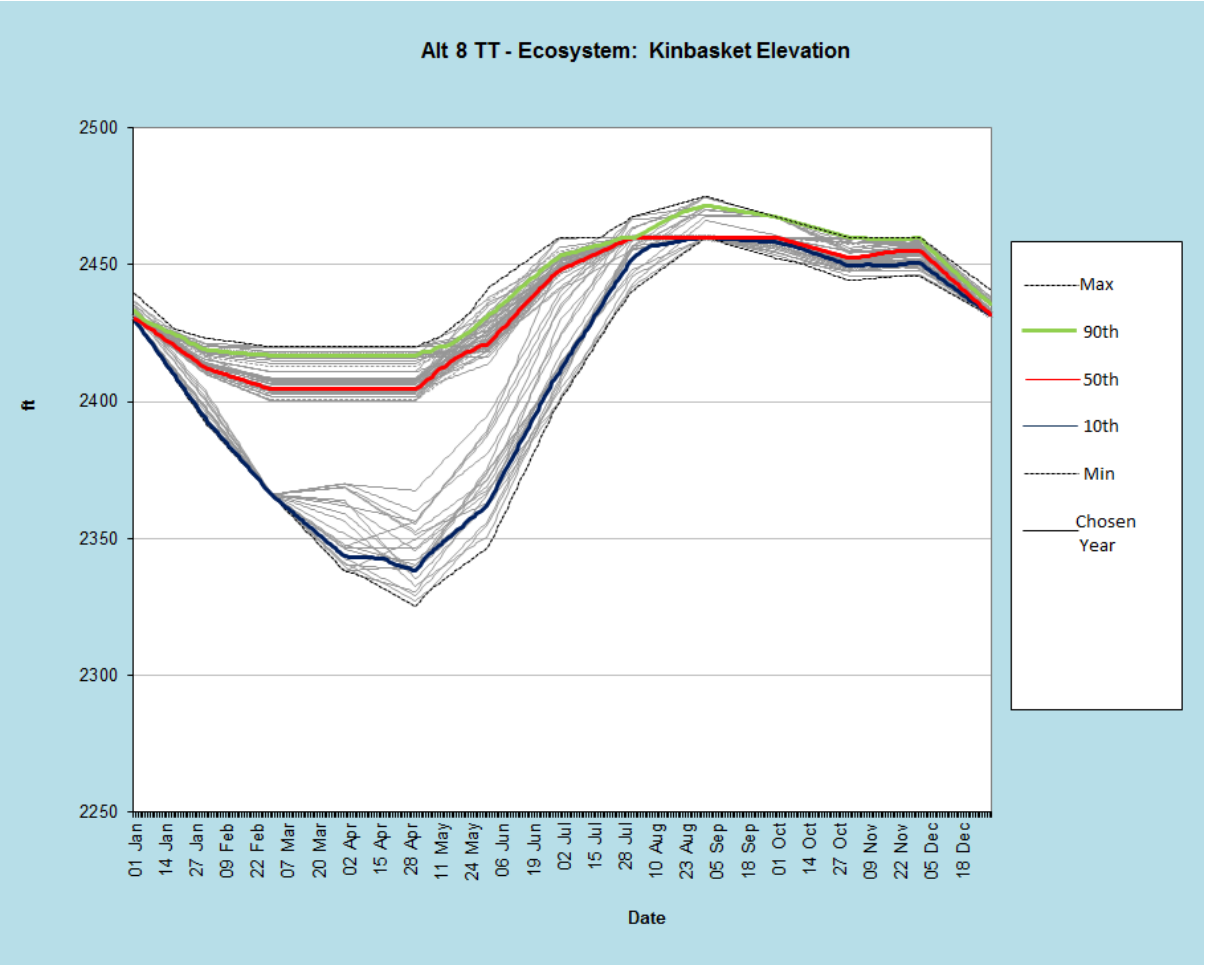


Figure 5: Arrow Lakes reservoir elevation, annual variability

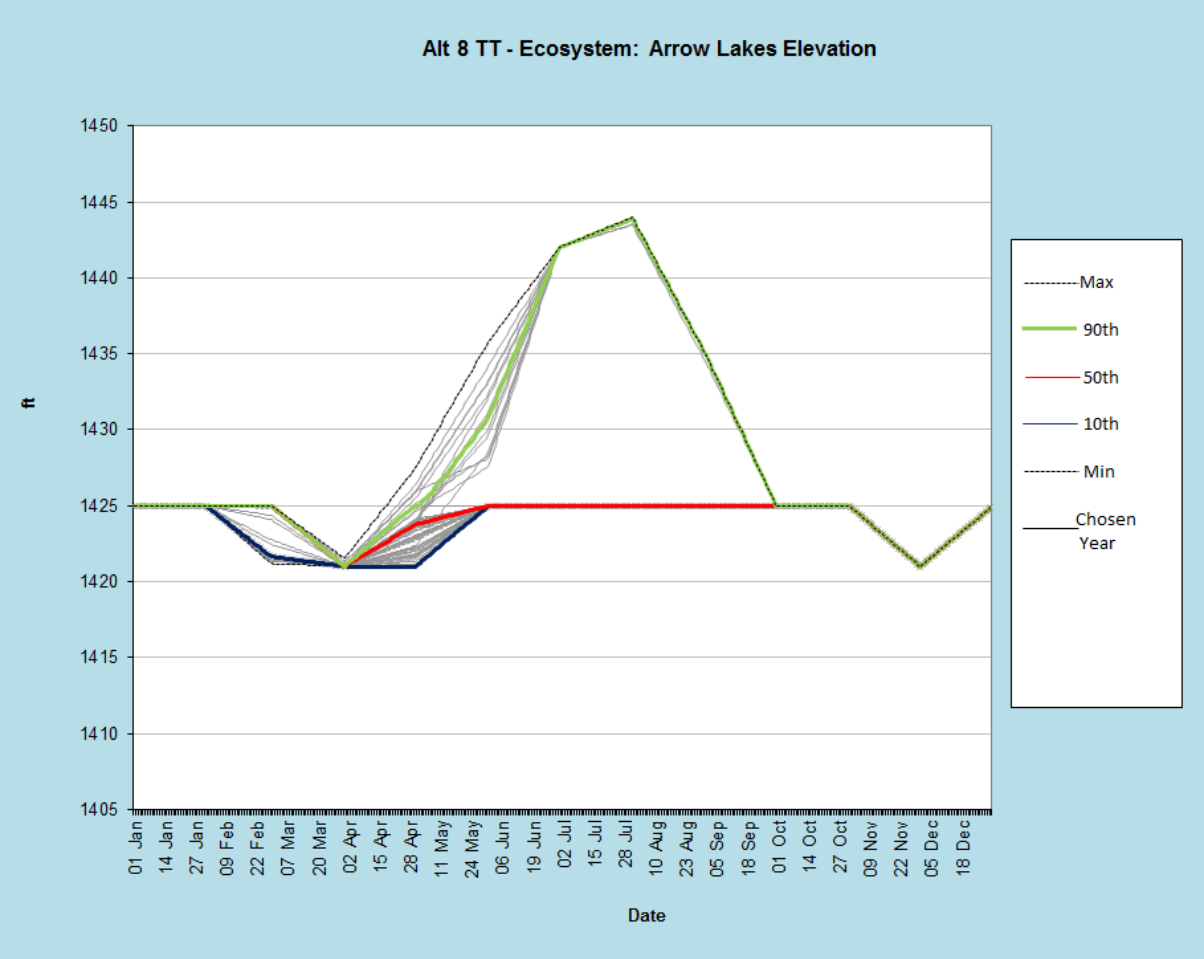


Figure 6: Breakout of major components in value of power generation calculation