PERFORMANCE MEASURE INFORMATION SHEET #17

ARROW LAKES RESERVOIR: CULTURE & HERITAGE

Objective / Location	Performance Measure	Units	Description
Culture & Heritage / Arrow Lakes Reservoir	Archaeological Sites – Wave Erosion	Weighted-Days reservoir elevations are within sensitive elevation zones	Total number of weighted days that the reservoir is potentially eroding archaeological sites through wave action

Background

During the Columbia WUP process, it became apparent that there was a significant data gap regarding the number and condition of actively eroding archaeological sites in the drawdown zone of Arrow Lakes Reservoir. The content and significance of documented sites within the reservoir had not been comprehensively reviewed, and it is likely that additional undocumented archaeological sites exist in areas that have not been previously surveyed. Several concerns were expressed about the potential effects that physical works projects being implemented in the reservoir (i.e., wildlife habitat physical works, revegetation program, debris management and boat ramp improvement projects) could have on known and yet-to-be discovered archaeological sites. It was recognized that archaeological assessments would be required to ensure that the physical works projects are undertaken in a compatible manner with archaeological site protection requirements and that opportunities to incorporate archaeological site mitigation measures be considered in the design of these works.

As part of WUP implementation, a 2-year (2008-2009) archaeological overview was completed in Arrow Lakes Reservoir to identify and assess archaeological resource potential or sensitivity within portions of the drawdown zone. Over the two years of the study, a total of 26 new archaeological site locations were identified in Revelstoke Reach in areas proposed for revegetation, wildlife habitat physical works and bank erosion loci. Of this, 24 sites are considered to be of potentially high archaeological significance. Four of the newly discovered sites are situated in bank erosion loci identified as having potential to be affected by increased water level fluctuations associated with five-unit operations at Revelstoke Dam. Monitoring of these locations is being undertaken to better assess the potential effects of Revelstoke 5 flows on these archaeological resources. The 5-year erosion monitoring study was initiated in 2009 with the primary objective of quantitatively measuring the magnitude, severity, rate of change and estimated duration of erosion effects caused by reservoir operations on selected portions of escarpment and other significant landforms situated within the drawdown zone of the reservoir.

Performance Measure

In developing a performance measure for evaluating the NTS scenarios, an inventory of archaeological sites in the vicinity of Arrow Lakes Reservoir was obtained from the Remote Access to Archaeological Data (RAAD) database of the Archaeology Branch. The archaeology sites extracted from RAAD were selected based on their proximity to the reservoir shoreline as displayed in RAAD.

Elevations for each site were interpolated using a digital elevation model of Arrow Lakes Reservoir, which was collected between 1414 ft and 1476 ft. A 3D terrain surface was generated from the digital elevation model, and the site polygons were draped over the terrain

and the elevations were interpolated from the terrain surface heights. Some archaeology sites fell below or were beyond the DEM collection area, and were not included in the analysis. A total of 101 sites were found to exist within the lower limit of the DEM and full pool elevation of the reservoir.

The minimum and maximum site elevations were interpolated from the perimeter of the archaeology site. The results were manually inspected to ensure that significant peaks or depressions do not exist within the site boundaries that would alter the minimum or maximum value of the site.

The drawdown zone of Arrow Lakes Reservoir was divided into elevation bands between 1410 and 1444 ft, corresponding to the elevation ranges used for the vegetation performance measure. The total number of archaeological sites within each band was tallied corresponding to its minimum and maximum elevation. Each elevation band was weighted based on the number of sites inventoried in each band to provide a relative importance modifier (Table 1).

Table 1. Current Archaeological Site Inventory for Arrow Lakes Reservoir

	Elevation Range (ft)			
	1410<band<1424	**1424<band<1430**	**1430<band<1437**	**1437<band<1444**
Total sites within elevation band	48	49	65	67
Proportion of sites within band	21.0%	21.4%	28.4%	29.3%
Relative day weight	0.72	0.73	0.97	1

There are multiple ways to consider the potential for impact on impact on archaeological sites. Two different approaches are presented for consideration in evaluating NTS scenarios.

Parameter 1
The first parameter was presented at the first NTS Stakeholder Session (October 2010). The method is based on concern over the potential for erosion of archaeological sites due to wave action. The number of days that the reservoir water level is within each elevation band over the year is weighted by the number of sites known in each band. The fewer the number of wave action erosion days, the better.

Parameter 2
The second parameter emerged from discussions with First Nations. The method is based on the concept that keeping sites fully inundated can protect them from wind and wave erosion, as well as human disturbances. The number of days that the reservoir water level is at least 1 metre above each elevation band over the year is weighted by the number of sites known in each band. The greater the number of inundation days, the better. A 1-m buffer was applied to each elevation band to account for depth of erosion due to wave action.

Calculation

For each scenario:

1. Assemble the simulated results for Arrow Lakes Reservoir elevations over 60 years (1940-2000; Figure 1).

2. Parameter (1): Count the number of days over the year that the reservoir is within each elevation band for each of the 60 years.
   Weight each day by the relative day weights listed in the Table 1 above.
3. Parameter (2): Count the number of days over the year that the reservoir is 1 metre above each elevation band and thus fully inundating each elevation band for each of the 60 years.
   Weight each day by the relative day weights listed in the Table 1 above.
4. Summarize all statistics (Figures 2 and 3).

Key Assumptions and Uncertainties

- Each scenario is simulated using the same set of system constraints, input assumptions (e.g., load forecasts) and historic basin inflows (1940 – 2000).
- Assumes that the relative importance of any given recorded site is equal.
- Assumes that the relative survey effort across elevation zones is equal.

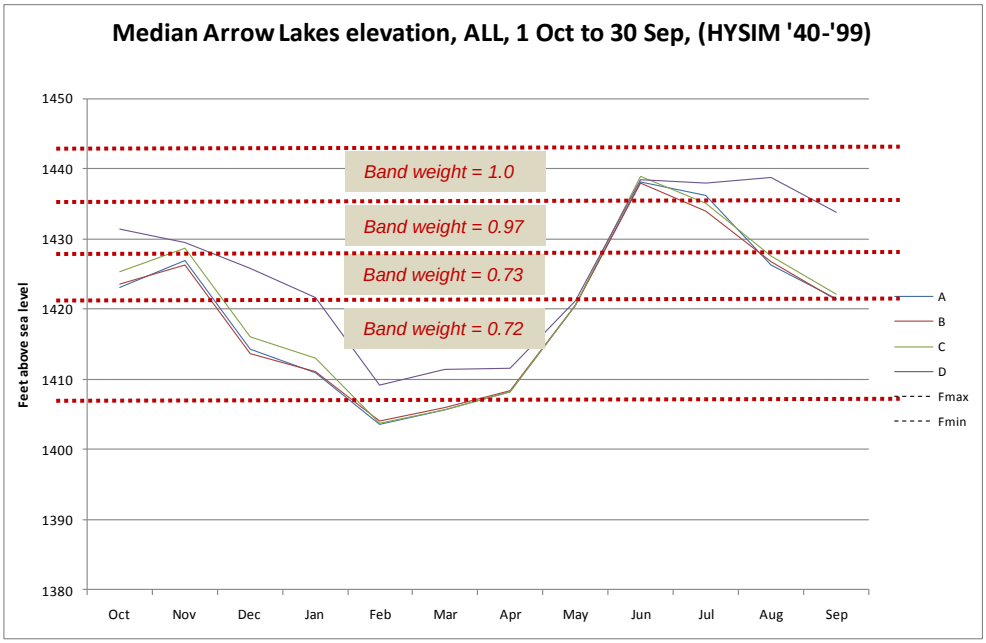


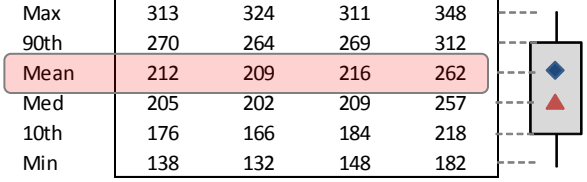
Figure 1. HYSIM Simulated Arrow Lakes Reservoir Elevations. Median over 60 years showing the weighted elevation bands for protection of identified heritage and cultural sites.

Results

Scenario D (no NTS) would cause Arrow Reservoir to fluctuate through sensitive elevation zones containing archaeological sites for a significantly greater number of days than the “with NTS” scenarios and therefore have the greatest potential for wave erosion. However, it would also provide the best protection against wind erosion and surface disturbance due to human activity as it would keep reservoir water levels higher and thus inundate the archaeological sites for a greater number of days than scenarios A, B and C.

Figure 2. Parameter (1): Erosion – Culture & Heritage – Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	313	324	311	348
90th	270	264	269	312
Mean	212	209	216	262
Med	205	202	209	257
10th	176	166	184	218
Min	138	132	148	182



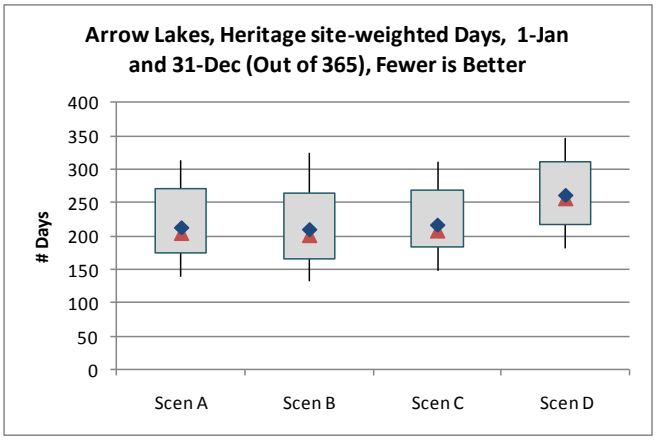


Figure 3. Parameter (2): Inundation – Culture & Heritage –Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	365	335	371	512
90th	204	198	211	286
Mean	129	115	136	221
Med	118	112	127	219
10th	48	45	64	148
Min	1	-	16	105