DINOSAUR RESERVOIR SHORELINE ENHANCEMENT STRUCTURE MONITORING

FISH AND WILDLIFE COMPENSATION PROGRAM - PEACE PROJECT NO. PEA-F17-F-1468

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EXECUTIVE SUMMARY

Between 2002 and 2006, the former Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) installed 84 woody debris structures along the shoreline of Dinosaur Reservoir with the intent of enhancing rearing habitat for fish residing in the reservoir. Inspections of the structures have taken place periodically since 2006 and annually since 2014. An assessment of the habitat functionally of the structures conducted in 2015 concluded that only 16 of the original 84 structures were intact and that of these, only 9 were providing functional rearing cover.

Based on the recommendations of the 2015 assessment, a public safety inspection of the 74 remaining intact and partially-intact structures was conducted in 2016 prior to the annual Dinosaur Reservoir Father's Day fishing Derby. The status and condition of the remaining structures was largely unchanged from 2015, with one partially-failed structure having disintegrated and one structure missing an individual component.

In addition, non-functional cable, clamps, and anchors were salvaged from the shoreline at the site of failed structures during 2016.

As per the 2015 recommendations, further repair of damaged structures and construction of new structures was not undertaken in 2016.

Improving the understanding of the status and trends of aquatic ecosystem health is an objective of the Fish and Wildlife Compensation Program - Peace (FWCP - Peace) identified in the Peace Basin Reservoir Action Plan (FWCP 2014). Specifically, the plan identifies the need to continue management of the remaining structures in Dinosaur Reservoir (Action 2b-2). Future activities related to the remaining Dinosaur Reservoir enhancement structures should be confined to an annual pre-Father's day inspection to identify potential navigation hazards and incrementally hardware debris from disintegrated structures.

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1 INTRODUCTION

Dinosaur Reservoir occupies the former Peace River Canyon between the WAC Bennett Dam and Peace Canyon Dam. Early compensation measures for the aquatic impacts related to construction of the Peace Canyon Dam and creation of the resulting reservoir included operation of the Peace Canyon Fish Hatchery for a five-year pilot term. An intensive evaluation program, conducted concurrent with hatchery operations between 1983 and 1987, included fish sampling throughout the reservoir and its tributaries. Early in the evaluation, it appeared that a large proportion of stocked juveniles spent little time in the reservoir before being entrained through the Peace Canyon Dam (Hammond 1984, 1986, 1987). By 2002, various fisheries assessments consistently identified a lack of shoreline habitat complexity and refuge for juvenile fish to be factors limiting fish production and recruitment in Dinosaur Reservoir (Pattenden and Ash 1993, Blackman *et al.* 2004, Blackman and Cowie 2005).

In 2002, the PWFWCP implemented a five-year habitat improvement project that introduced woody debris structures along the shoreline of Dinosaur Reservoir to increase the amount of available rearing habitat for sport-fish, including rainbow trout. The project included the placement of 84 structures at selected locations in the reservoir and the monitoring of fish use at treatment and control sites (Blackman *et al* 2004, Blackman and Cowie 2005, Bouillon 2014).

Four types of woody debris enhancement structures were constructed, namely triangles, rafts, booms and “other”. Triangle structures consisted of whole tree trunks arranged in a triangle shape with the base or tree butts anchored to shore by cable. The tree tops, which protruded into the reservoir were pulled together to form the apex of the triangle and cabled together. The space within the triangle was filled with other logs and woody debris to create a floating mat of large woody debris. Raft structures consisted of bundles of tree trunks cabled together in a parallel fashion and anchored to shore by cable at one end of the raft. Booms consisted of remnant log-boom assemblies salvaged from within the reservoir or logs cabled end-to-end and anchored to shore at both ends of the series of logs. Structures described as “other” are believed to have been single or paired logs anchored to shore at one end.

The results of the five year habitat improvement project were reviewed by Environmental Dynamics Inc. (EDI) in 2008. The review stated that the project met most of the PWFWCP strategic objectives; however, several aspects of the program made it difficult to draw conclusions about its success with respect to providing fish habitat and improving recruitment (EDI 2008). The authors made several recommendations for follow-up monitoring, including developing a rigid sampling design using paired controls and multiple sampling techniques, defining clear targets to measure project success, developing a consistent reporting structure between years, and assessing the benefits of the project with respect to social aspects and conservation values.

Post-construction inspections of the enhancement structures have occurred intermittently since 2006 and annually since 2014. An inspection undertaken by BC Hydro on June 5, 2014 (Bouillon 2014) did not include an assessment of habitat functionality and was only intended to identify potential issues of navigational and public safety. During this inspection three structures were described as missing and 81 were described as intact or partially intact. The following year, on June 15, 2015, DES conducted an assessment of the habitat functionality of the enhancement structures and concluded that the majority of the structures were in disrepair (n=61) or missing (n=7) (DES 2016). Only 16 enhancement structures (10 triangles, 2 booms and 4 rafts) appeared to resemble their original configuration. Of the remaining 10 triangles, 9 were no longer providing floating, overhead cover as originally intended due to sediment deposition underneath or water-logging and sinking of the logs forming the frame of the structure.

Based on preliminary results of the June 2015 inspection, plans to assess fish utilization of the structures were abandoned and effort was redirected toward trial remedial work of several structures. A cluster of triangle structures located at Site 10 was identified as having potential to provide increased habitat benefit with the least remedial effort. Repairs to 4 damaged structures were undertaken with the assistance of members of the West Moberly and Saulteau First Nations, using the residual components of 3 failed structures (DES 2016).

2 GOALS AND OBJECTIVES

Improving the understanding of the status and trends of aquatic ecosystem health is an objective of the FWCP identified in the Peace Basin Reservoir Action Plan (FWCP 2014).

Specifically, the plan identifies the need to continue management of the remaining structures in Dinosaur Reservoir (Action 2b-2).

Three recommendations resulted from the 2015 assessment. These included, 1) continuation of annual public safety inspections of the remaining enhancement structures prior to the annual Father's Day Fishing Derby, 2) salvage of residual cable, cable clamps, duckbill anchors and other unused hardware at the site of failed enhancement structures, and 3) discontinue construction/repair of additional structures.

The objective of the 2016 monitoring program was to address the recommendations of the 2015 assessment. The following sections summarize activities undertaken in 2016 to address recommendations 1 and 2 above.

3 STUDY AREA

Dinosaur Reservoir is located on the Peace River system immediately downstream of the Williston Reservoir. Dinosaur Reservoir extends 21 km upstream from the face of the Peace Canyon Dam to the tailrace of the WAC Bennett Dam. As a run-of-the-river reservoir, the water level in Dinosaur Reservoir remains relatively stable throughout the year, fluctuating up to 2 m daily under normal operations. The reservoir volume is exchanged approximately every 3 days, with productivity controlled largely by limnological conditions in Williston Reservoir, located immediately upstream. The bathymetry of Dinosaur Reservoir is extremely steep and littoral areas are largely absent (Pattenden and Ash 1993). The shoreline enhancement structures constructed between 2002 and 2006 are located in the lower two thirds of the reservoir (Fig. 1).

4 METHODS

On June 17, 2016, a safety and integrity inspection of the remaining 74 shoreline enhancement structures was undertaken. Enhancement sites were accessed by boat using UTM coordinates describing the location of each structure (Appendix I). At each location, the presence or absence of a structure was confirmed and, if present, the condition of each structure was recorded.

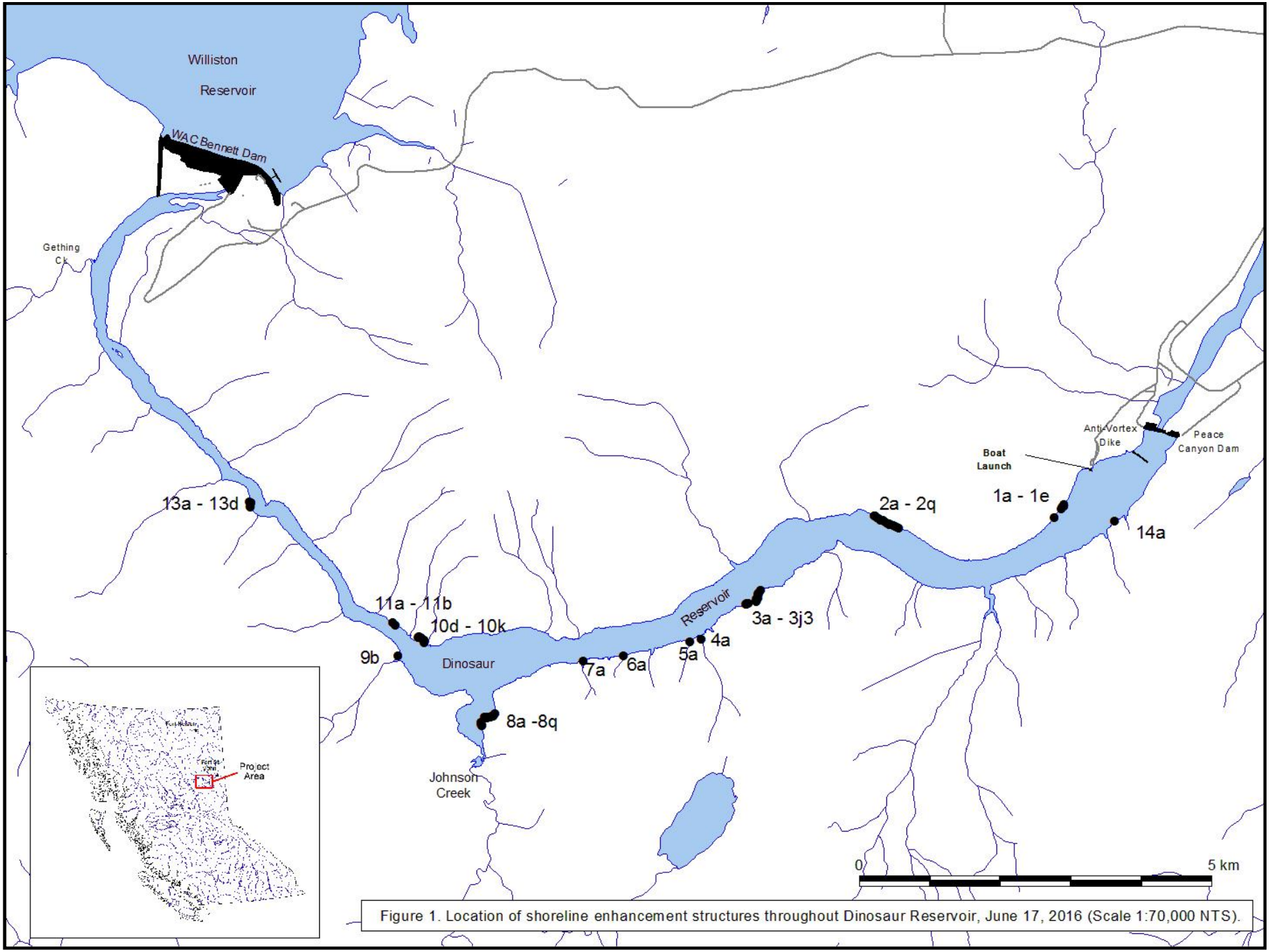

Figure 1. Location of shoreline enhancement structures throughout Dinosaur Reservoir, June 17, 2016 (Scale 1:70,000 NTS).

The condition of the structures was described using the following criteria:

Intact: Structure resembles its original configuration. No logs are broken and no cables are missing. Structure is anchored firmly to shore,

Intact?: Structure appears intact or partially intact but its original configuration is uncertain,

Failed: Structure no longer resembles its original configuration. Logs are broken. Cables are missing or broken. Anchors are detached or missing,

Absent: Not found. No evidence of a structure at the provided coordinates.

Each structure was photographed and notes regarding habitat functionality and changes to the structure's configuration compared to 2015 results were recorded. Structures deemed to be a potential boating hazard were marked with flagging ribbon.

5 RESULTS AND OUTCOMES

The results of the June 17, 2016 inspection of the enhancement structures are summarised in Table 1. Field notes and inspection results for each structure are located in Appendix II. The coordinate locations for the remaining 74 structures were inspected during the survey. Seventy-one of the structures inspected in 2016 appeared unchanged from the previous survey year (Plates 1 to 3). Only three structures appeared to have changed since the 2015 inspection or appeared to be a potential navigational hazard. A log boom at Site 6a appeared to have lost one of the two logs that formed the structure in 2015. A triangle structure at Site 8e could not be located and only the shoreline anchor cable remained at the site. The apex of the triangle structure at Site 10k, which was repaired in 2015, was marked with flagging ribbon as one of the logs forming the frame protruded into the reservoir beyond the remainder of the structure and laid just above the surface of the water.

Table 1. Summary of results from survey conducted on June 17, 2016.

Type	Total	Intact	Intact?	Failed	Absent
Triangle	55	13	2	39	1
Boom	7	2	3	2	
Raft	10	4	3	3	
Other	2			2	
Total	74	19	8	46	1
%	100	25.7	10.8	62.1	1.4

Intact? – It is uncertain whether the structure is intact and resembles its original form.

Of the 74 structures remaining, 19 were found to be structurally intact (25.7%); of these, 9 were not providing functional sport-fish rearing cover. Of the remaining 55 structures, 46 had suffered major structural failures and no longer resembled their original configuration (62.1%), 8 were partially intact but their original configuration was unclear (10.8%), and 1 could not be found (1.4%).

A more detailed discussion of failure rates and potential factors influencing the success of the program can be found in the 2015 summary report (DES 2016).

On September 14, 2016, each of the enhancement structure sites was revisited at low water level and all non-functional hardware from failed structures was salvaged. This included all cable fragments and clamps no longer connected to intact structure components and all duckbill anchors and associated anchor cables no longer embedded in the shoreline. Two hundred and twenty kilograms (484 lbs) of unused residual hardware was collected and disposed of at the regional landfill. Cables and anchors securing partially intact structures and individual residual structure components greater than 1 m in length were left in place in order to provide marginal rearing cover, limited shoreline erosion protection benefits and to minimize free-floating navigational hazards.

6 RECOMMENDATIONS

With respect to the shoreline enhancement structures installed in Dinosaur Reservoir, the following actions are recommended:

- The inspection of the structures should be repeated prior to the annual Father's Day Fishing Derby on June 18. 2017. The goal of the inspection should be to confirm that none of the remaining structures or their remnant components pose a public hazard and take appropriate measures to eliminate any hazard identified.
- Residual cable, clamps and duckbill anchors should be collected from the shoreline of the reservoir as additional structures fail and hardware becomes non-functional. Cable still anchoring residual structure components to shore should be left in place to provide marginal rearing cover and shoreline erosion protection.
- For reasons discussed in DES 2016, the construction of new structures and repair of existing failed structures is not recommended at this time.

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Appendix I

Location of Structures

Appendix I: Location of enhancement structures in Dinosaur Reservoir (NAD 83, UTM Zone 10V).

Site #	Type	Easting	Northing
1a	triangle	561496	6203467
1b	triangle	561487	6203441
1c	raft	561471	6203427
1d	raft	561449	6203402
1e	triangle	561354	6203287
2a	triangle	559151	6203140
2b	triangle	559124	6203148
2c	triangle	559103	6203158
2d	triangle	559075	6203169
2e	triangle	559048	6203185
2f	triangle	559024	6203190
2g	other	559016	6203200
2h	triangle	559006	6203201
2i	triangle	558982	6203211
2j	triangle	558947	6203229
2k	triangle	558929	6203246
2l	triangle	558911	6203247
2m	triangle	558892	6203252
2n	triangle	558867	6203276
2o	triangle	558841	6203285
2p	triangle	558825	6203311
2q	triangle	558808	6203312
3a	triangle	557207	6202255
3b1	triangle	557180	6202225
3b2	triangle	557170	6202220
3c1	triangle	557167	6202204
3c2	triangle	557167	6202200
3d	triangle	557162	6202181
3e1	triangle	557158	6202145
3e2	raft	557145	6202140
3f	raft	557142	6202111
3boom(g)	boom	557134	6202096
3boom(h)	boom	557024	6202070
3j1	triangle	557008	6202067
3j2	triangle	557000	6202063
3j3	triangle	556992	6202058
4a	boom	556361	6201571

Site #	Type	Easting	Northing
5a	boom	556201	6201525
6a	boom	555260	6201328
7a	boom	554703	6201252
8a1	triangle	553459	6200514
8c	triangle	553432	6200484
8d	other	553421	6200480
8e*	triangle	553409	6200474
8f	triangle	553390	6200466
8g	triangle	553385	6200467
8h1	triangle	553375	6200469
8h2	triangle	553365	6200469
8i	triangle	553358	6200468
8j	triangle	553352	6200463
8k	triangle	553344	6200460
8l	triangle	553338	6200458
8m	triangle	553312	6200460
8n	triangle	553253	6200386
8o	triangle	553262	6200370
8p	triangle	553263	6200355
8q	triangle	553265	6200338
9b	boom	552107	6201401
10d	triangle	552371	6201595
10e	triangle	552378	6201600
10f1	triangle	552395	6201596
10f2	triangle	552400	6201594
10g	triangle	552416	6201576
10h	triangle	552431	6201569
10i	triangle	552448	6201549
10j	triangle	552454	6201537
10k	triangle	552452	6201519
11a	raft	552048	6201770
11b	raft	552007	6201796
13a	raft	549990	6203432
13b	raft	549994	6203449
13c	raft	550003	6203488
13d	raft	549985	6203512
14a	triangle	562207	6203231

* denotes structure not found during 2016 Pre-Father's Day Inspection.

Appendix II

Results of June 17, 2016 Inspection

Site #	Type	PhotoID	Status	Hazard	Change?	Comments
1a	triangle	1a-2016	F	N	N	anchor cables present but wood missing
1b	triangle		F	N	N	anchor cables present but wood missing
1c	raft	1c-2016	F	N	N	single log cabled to shore at one end, no other logs present
1d	raft	1d-2016	I	N	N	four logs cabled together and protruding into lake, partially submerged
1e	triangle		F	N	N	single log cabled to shore at one end, stranded on shore at low water, no other logs present
2a	triangle		F	N	N	single log cabled to shore at one end, stranded on shore at low water, no other logs present
2b	triangle	2b-2016	F	N	N	two logs present, each cabled to shore at one end, no longer forming apex, possibly water-logged, stranded at low water
2c	triangle	2c-2016	F	N	N	three logs present laying parallel together and ends protruding into water and submerged, possibly water-logged
2d	triangle	2d-2016	F	N	N	two logs present, each cabled to shore at one end, no longer forming apex, possibly water-logged, stranded at low water
2e	triangle		I?	N	N	logs forming triangle present but unclear if they are positioned as they were originally, some wood remaining inside
2f	triangle		F	N	N	two logs present, each cabled to shore at one end, no longer forming apex, possibly water-logged, stranded at low water
2g	other	2g-2016	F	N	N	two logs present, each cabled to shore at one end, no longer forming apex, possibly water-logged, stranded at low water
2h	triangle		F	N	N	two logs present, each cabled to shore at one end, no longer forming apex, possibly water-logged, stranded at low water
2i	triangle	2i-2016	F	N	N	remnants of two logs beached and cabled to shore
2j	triangle		F	N	N	remnants of two logs beached and cabled to shore
2k	triangle	2k-2016	F	N	N	remnants of two logs beached and cabled to shore
2l	triangle		I	N	N	intact however stranded above wetted perimeter and infilled with sediment below wood
2m	triangle		F	N	N	single broken log remaining anchored to shore and protruding a short distance into water
2n	triangle	2n-2016	I	N	N	intact however stranded above wetted perimeter and infilled with sediment below wood
2o	triangle	2o-2016	I	N	N	intact however stranded above wetted perimeter and infilled with sediment below wood
2p	triangle	2p-2018	I	N	N	intact however stranded above wetted perimeter and infilled with sediment below wood
2q	triangle		I	N	N	intact however stranded above wetted perimeter and infilled with sediment below wood
3a	triangle	3a-2016	F	N	N	2 logs cabled at butts to shore and lying parallel to shore above present water level, flagged in 2014
3b1	triangle	3b1-2016	I	N	N	intact however stranded above wetted perimeter and infilled with sediment below wood
3b2	triangle	3b2-2016	F	N	N	three logs cabled together forming a triangle but stranded at present water level, no wood inside
3c1	triangle		F	N	N	2 logs cabled together lying parallel to each other and protruding into water

Site #	Type	PhotoID	Status	Hazard	Change?	Comments
3c2	triangle		F	N	N	coordinates very close to structure at 3c1 and unclear which is which, nothing present
3d	triangle		F	N	N	single log fragment and an anchor cable present
3e1	triangle		F	N	N	single log fragment and an anchor cable present
3e2	raft		F	N	N	single log remaining protruding into water, doesn't appear to be anchored
3f	raft		F	N	N	random log boom fragments stranded on beach
3boom(g)	boom	3boom(g)-2016	I	N	N	single paired log boom section floating in bay
3boom(h)	boom	3boom(h)-2016	F	N	N	beached fragments of log boom present
3j1	triangle	3j1-2016	F	N	N	2 logs anchored at shore forming a triangle but submerged at apex and not clearly connected
3j2	triangle		F	N	N	2 logs anchored at butts, parallel together and protruding into water
3j3	triangle	3j3-2016	F	N	N	2 logs anchored at butts stranded on shore above wetted perimeter, could be pulled out and reconnected?
4a	boom	4a-2016	I?	N	N	two single logs cabled end to end and stranded on shore, uncertain whether this was the original construction
5a	boom	5a-2016	I	N	N	4 logs cabled in pairs and floating in small bay
6a	boom	6a-2016	I?	N	Y	2015 - 2 logs cabled end to end, one stranded on shore, one partially submerged and protruding into water. 2016 - One log remaining
7a	boom	7a-2016, 7a-2-2016	I?	N	N	3 logs cabled end to end, stranded on shore, cabled to rock at one end
8a1	triangle	8a1-2016	F	N	N	2015 - single log cabled to shore
8c	triangle	8c-2016	F	N	N	miscellaneous logs cabled to shore and stranded above wetted perimeter
8d	other		F	N	N	one log remaining and 1 anchor cable
8e	triangle	8e-2016	A	N	Y	2015 - two logs, one cabled to shore, both cabled together at apex, second log broken at butt. 2016 - Could not be located.
8f	triangle		F	N	N	log fragment and anchor cable remaining
8g	triangle		F	N	N	one log remaining and 1 anchor cable
8h1	triangle	8h1-2016	F	N	N	two logs cabled at butt protruding into water but not connected at apex, submerged and possible water logged
8h2	triangle	8h2-2016	I	N	N	logs forming triangle but apex is submerged and no logs remain inside
8i	triangle	8i	F	N	N	single log remaining and submerged
8j	triangle	8j-2016	F	N	N	single log remaining and submerged
8k	triangle		F	N	N	single log remaining and floating
8l	triangle		F	N	N	2 logs remaining and submerged
8m	triangle	8m-2016	F	N	N	2 logs cabled parallel to each other and protruding into water but submerged
8n	triangle	8n-2016	F	N	N	2 logs stranded on shore, possible could bee reconnected at apex

Site #	Type	PhotoID	Status	Hazard	Change?	Comments
8o	triangle		F	N	N	random logs and fragments cabled on shore and stranded
8p	triangle	8p-2016, 8p-2-2016	I	N	N	intact and functioning somewhat, shallow and appears that sediment has accumulated under wood
8q	triangle		F	N	N	1 log remaining
9b	boom	9b-2016	F	N	N	scattered logs cabled together
10d	triangle		F	N	N	only cable remaining
10e	triangle		I	N	N	logs forming apex still remaining but no wood inside
10f1	triangle	10f1-2016, 10f1-2-2016	F	N	N	2 logs cabled together with butts on shore and protruding into lake, submerged
10f2	triangle		F	N	N	3 logs cabled end to end and stranded on shore at current water level
10g	triangle	10g-2016, 10g-2-2016	I	N	N	2015 - 2 logs cabled parallel to each other and protruding into reservoir and submerged. 2016 - repaired Nov 14, 2015
10h	triangle		I	N	N	2015 - triangle remaining however 1 retaining log is fully submerged, no logs remaining within triangle. 2016 - wood added Nov 14, 2015.
10i	triangle	10i-2016	I	N	N	2015 - 2 logs cabled at butts, apex not attached and both logs partially swung in to shore. 2016 - repaired Nov 14, 2015
10j	triangle	10j-2016	I	N	N	2015 - triangle remaining and floating, no inside logs/cover. 2016 - repaired Nov 14, 2015
10k	triangle	10k-2016, 10k-2-2016	F	Y	N	2015 - 1 log remaining and cable fragments. 2016 - repaired Nov 14, 2015, flagged in 2016
11a	raft	11a-2016	I	N	N	3 logs cabled together
11b	raft	11b-2016	I	N	N	2 logs cabled together and functioning
13a	raft	13a-2016, 13a-2-2016	I?	N	N	3 logs splayed apart and floating
13b	raft	13b-2016	I?	N	N	2 logs anchored and protruding into lake
13c	raft	13c-2016	I	N	N	4 logs cabled together and protruding into lake, no need to repair
13d	raft	13d-2016	I?	N	N	4 logs cabled at butts and protruding into lake
14a	triangle	14a-2016	I?	N	N	3 logs cabled and lying parallel to shore, cover being augmented by recently fallen fir tree on top of logs

Status	I	Intact - structure appears to be intact / no obvious signs of damage
	I?	Intact? - structure appears intact but some question whether it is in original form
	A	Absent - can't find structure or remnants at provided coordinates
	F	Failed - structure has failed,is not "functioning" as originally intended, and only log remnants and cable may present
Change?	Y	Structure has deteriorated further
	N	No physical change
Hazard	Yes	Structure components deemed a navigational hazard and flagging has been added to enhance visibility
	No	Structure components not deemed a navigational hazard and no action taken

Appendix III

Plates 1 to 3

a. Site 1d, June 15, 2015.

b. Site 1d, June 17, 2016.

c.

Plate 1a and b. Example of unchanged raft shoreline enhancement structure.

a. Site 2n, June 15, 2015.

b. Site 2n, June 17, 2016.

Plate 2a and b. Example of unchanged triangle shoreline enhancement structure.

a. Site 7a, June 15, 2015.

b. Site 7a, June 17, 2016.

Plate 3a and b. Example of unchanged log boom shoreline enhancement structure.