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Peace Project Water Use Plan

WILLISTON RESERVOIR WOOD DEBRIS TREND ANALYSIS

Implementation Year 3

Reference: GSMON-16

Study Period: 2018

**By:
AECOM**

July, 2019

Williston Reservoir Wood Debris Trend Analysis 2009 – 2018

Draft

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Executive Summary

This report describes results of a desktop analysis of trends in debris amounts in Williston Reservoir between a 2009 baseline and 2018.

Williston Reservoir is located in northeastern British Columbia within the Mackenzie River Basin. A baseline study was previously performed (AECOM Tecscult 2010) by interpretation of aerial photographs taken in 2009 for locating and quantifying the importance of large woody debris along the shoreline and on the water surface. That study also included field inventories to determine standard values of wood per type of mapped debris. Subsequently, AECOM (2011) prepared a Debris Management Strategy that BC Hydro implemented for cleaning targeted areas. AECOM (2018) also undertook an earlier trend analysis for the years 2009 to 2011 over targeted areas (620 sample squares of 500 x 500 m randomly selected) that were studied with air photos taken in 2011.

For this current report, AECOM interpreted a newer set of air photos, taken in 2018 to facilitate monitoring the changing patterns of woody debris and to identify trends for the whole reservoir, and compared results with the baseline. This report presents the analysis of woody debris for the whole reservoir between 2009 and 2018.

Between 2009 and 2018, the Williston Reservoir saw a reduction of over 20% (272,921 m³) in woody debris. The majority of the debris was still located in Finlay Arm in 2018, but at 54%, down from 58% of the total in Williston Reservoir in 2009. The Parsnip and Peace Arms each saw small percentage increases proportional to the total in Williston Reservoir. The Finlay and Parsnip Arms have been subject to successful cleaning programs that have reduced amounts of dense and moderately dense woody debris ribbons. In the dense and moderately dense categories, Finlay Arm debris has been reduced by 36% and Parsnip Arm debris has been reduced by 24%. Conversely, the Peace Arm experienced a small increase in dense woody debris (15%), likely due to the relatively small initial amount of debris located in that Arm. Erosion is a significant process in the reservoir, with 256 ha of land having been eroded between 2009 and 2018. It is estimated that erosion contributes over 2,000 m³ per year to woody debris in the reservoir.

As the reservoir is constantly receiving new debris from its tributaries, shoreline erosion, and degradation of forest stands with felled forests by natural processes, maintaining the debris removal program for the foreseeable future will continue to have beneficial effects. The reduction in amount of woody debris is evidence of the program's effectiveness in controlling woody debris on the reservoir. Sites of high potential for cleaning should be targeted, and sites already cleaned should be revisited after a few years, as their configuration favours accumulation of woody debris.

Table of Contents

1.	Introduction	1
2.	Study Area and Context	1
3.	Previous Studies	4
3.1	Williston Debris Field Survey, Inventory and Contribution Analysis Report (AECOM Tecsuit 2010)	4
3.2	Williston Reservoir Debris Management Strategy (AECOM 2011)	4
3.3	Williston Reservoir Debris Trend Analysis 2009-2011 (AECOM 2018)	4
3.4	Woody Debris Strategic Management Plan (DWB 2015).....	4
3.5	Targetted Debris Management	4
4.	Study Objectives	7
5.	Methods	7
6.	Results	9
6.1	Extent of Woody Debris in 2009 and 2018	9
6.2	Volume (m ³) of Woody Debris in 2009 and 2018	19
6.3	Woody Debris Trends From 2009 to 2018.....	29
6.3.1	Changes in Area between 2009 and 2018	29
6.3.2	Changes in Volume of Woody Debris between 2009 and 2018	30
6.4	Analysis of Woody Debris Trends between 2009 and 2018.....	33
6.4.1	Dynamics	33
6.4.2	Woody Debris Source Estimates.....	34
6.4.3	Debris Trends	36
7.	Discussion and Conclusion.....	52
	References	53

Tables

Table 1	Length of Shoreline and Area Covered by Each Sector of Williston Reservoir (percentages are those of the entire reservoir)	3
Table 2	Classification Used to Characterize Woody Debris and Forest Stands in Williston Reservoir	8
Table 3	Summary Comparison of Woody Debris Areal Extent between 2009 and 2018, by Sector and Type	11
Table 4	Unitary Value of Solid Wood Volume by Woody Debris Type.....	19
Table 5	Summary Comparison of Wood Debris Volumes between 2009 and 2018, by Sector and Type	20
Table 6	Volumes of Woody Debris Harvested between 2009 and 2018 (data: BC Hydro).....	31
Table 7	Total changes in Volume between 2009 and 2018.....	37
Table 8	Relative Percentage Volume Changes between 2009 and 2018.....	40
Table 9	Debris Source Summary, 2009 and 2018.....	42
Table 10	Estimated Volume of Recruitment of Woody Debris Resulting from Shoreline Erosion	43

Figures

Figure 1	Location of the Williston Reservoir	2
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Figure 2	Example of the Re-Analysis of Lower-Resolution 2009 Imagery by Using 2011 Imagery (Middle Image) to Confirm the Presence of Woody Debris	5
Figure 3	Extent of Large Woody Debris in 2009 and 2018, by Sector and Type	15
Figure 4	Extent (ha) of Forest Stands in 2009 and 2018, by Sector and Type	18
Figure 5	Volume of Large Woody Debris in 2009 and 2018, by Sector and Type.....	24
Figure 6	Volume of Wood of Forest Stands in 2009 and 2018, by Sector and Type.....	27
Figure 7	Accumulation of Woody Debris from Forest Stands Felled by Erosion in Parsnip Arm West, 2018	43
Figure 8	Indications of Debris Removal Activities in Finlay Arm West, 2018	44
Figure 9	Intensive Coastal Erosion in Finlay Arm West during the Monitoring Period	45
Figure 10	Gradual Degradation of Forest Stands in an Old Channel over the Monitoring Period	46
Figure 11	Shoreline Configuration that Favour Woody Debris Accumulation (Class B3) in the Bay Close to the Dam in Peace Arm North.....	46
Figure 12	Arrival of Wood Logs from Ospika River (Ospika Arm within Finlay Arm East).....	47
Figure 13	Arrival of Wood Logs from Pesika Creek, a Tributary at the Upper Head of Finlay Arm East.....	47
Figure 14	Arrival of Wood Logs from Finlay River	48
Figure 15	Woody Debris Likely to Originate from Both the Upstream Reservoir area, via the Finlay River, and from Riverbank Erosion.....	49
Figure 16	Arrival of Few Wood Logs from Parsnip River and Pack River.....	50
Figure 17	Recent Accumulation of Woody Debris in a Sector Previously Cleaned as Part of the Debris Removal Program, 2018.....	51

Appendices

APPENDIX A Classification Used to Characterize the Large Woody Debris and Forest Stands

APPENDIX B Tributaries of Finlay, Parsnip, and Peace Arms

APPENDIX C Maps

APPENDIX D Detailed Tables of Woody Debris Area, Volume, and Trends 2009-2018

1. Introduction

BC Hydro contracted AECOM Canada Ltd. (AECOM) to analyse spatial-distribution and volumetric trends in debris accumulation in Williston Reservoir during the 10-year period of 2009 to 2018. In part, this study is an evaluation of the effectiveness of a surface debris clearing program BC Hydro began implementing in 1968. This report describes the trend analysis and its outcome.

2. Study Area and Context

The Williston Reservoir is located in northeastern British Columbia (BC) and forms part of the headwaters of the Peace River, within the Mackenzie River Basin (Figure 1). The largest freshwater body in BC, the Williston Reservoir has a surface area of about 1,773 square kilometres (km²). The roughly T-shaped reservoir consists of three arms, named for the main three contributing river systems: the Finlay Arm, to the northwest; the Parsnip Arm, to the southeast; and the Peace Arm, which extends eastward to the W.A.C. Bennett Dam, which formed the impoundment and serves as the controlling structure. The Peace River originally began at the confluence of the Finlay and Parsnip rivers. (BC Hydro, https://www.bchydro.com/community/recreation_areas/williston.html). Table 1 provides data on the relative sizes of the three arms of the reservoir.

Constructed between 1961 and 1968, the W.A.C. Bennett Dam is one of the largest earth-fill dams in the world, at 183 m tall, 800 m thick, and 2.068 km long along its crest. The Peace River discharges through the dam and associated G.M. Shrum Generating Station toward the Peace Canyon Dam and Generating Station, 23 km downstream and completed in 1980, which re-uses some of the energy storage capacity from the reservoir. The Site C Dam, currently under development, is so-called because it will be the third dam in the sequence (BC Hydro, https://www.bchydro.com/community/recreation_areas/williston.html).

Under the annual water-level regime in the Williston Reservoir, the water level is at its maximum of approximately 672 m at the end of each August, and minimum of approximately 660 m each April, with total drawdown of about 12 m. This fluctuation in water levels results in deposition, recruitment, floatation, and redistribution of woody debris each year. Woody debris becomes stranded along the reservoir shoreline during drawdown and may be refloated in spring and summer as water level rises.

Accumulation of woody debris in the Williston Reservoir is a challenge that originates with management of timber harvest before inundation (DWB 2015). Clearing was restricted primarily to the main navigational channel, auxiliary channels, and the dam construction area, and totalled approximately 38,729 hectares (ha) of vegetated area. The total surface area of reservoir is about 177,300 ha, meaning that the cleared area accounts for less than 22 percent of the reservoir area (though not all of the remaining area was forested). Most of the clearing was conducted by using a Letourneau Tree Crusher for areas of both merchantable and non-merchantable timber and scrub, and much of the merchantable timber was salvaged as it floated on the rising reservoir waters after 1968 as the impoundment process was underway. Over the ensuing years, timber salvage (including that from submerged forest stands) was impeded by the large volumes of floating wood debris. All salvage was overseen by the BC Forest Service until 1978, when BC Hydro assumed responsibility for management of disposal activities. The BC Forest Service continued to administer salvage sales, while its engineering division assumed responsibility for clearing non-merchantable material. BC Hydro was responsible for sale of all merchantable floating debris and disposal of all other floating debris, except at the east end of the Peace Arm, and for funding of salvage and debris cleanup and disposal.

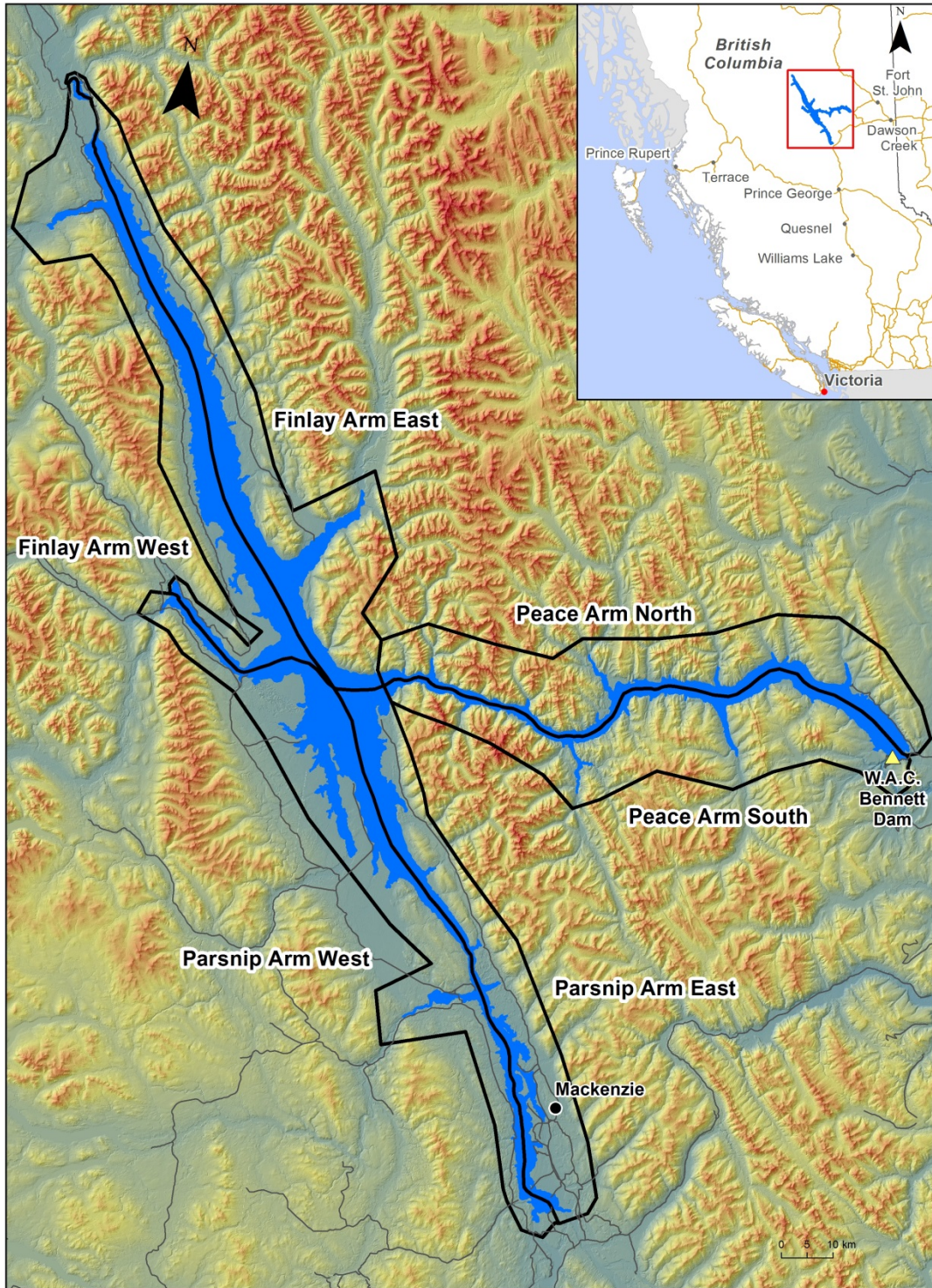


Figure 1 Location of the Williston Reservoir

Table 1 Length of Shoreline and Area Covered by Each Sector of Williston Reservoir (percentages are those of the entire reservoir)

Sector	Coastline (km) ^a	Area (ha and %)	
Finlay Arm East	301	43 283	24%
Finlay Arm West	351	37 654	21%
	652	80 937	45%
Parsnip Arm East	334	25 815	14%
Parsnip Arm West	511	39 106	22%
	845	64 922	36%
Peace Arm North	228	17 284	10%
Peace Arm South	228	17 044	9%
	456	34 328	19%
Total :		180 186	

a: excluding the perimeter of the temporary islands

A large volume of woody debris within the reservoir can have several potential impacts. Large pieces of woody debris can affect dam operation, by blocking or impeding discharge facilities. Smaller woody pieces can block trash racks at the intakes affecting power generation capacity. Floating woody debris is also a major safety concern for boaters and recreational users of the reservoir. Furthermore, woody debris may contribute to bank erosion and destruction of some vegetation and wetlands. Positive effects of the debris, on the other hand, are that it provides habitat for wildlife and air dust control on reservoir beaches, and in some instances can provide protection against shoreline erosion.

As stated in the BC Hydro Work Order, sources of debris contribution to the Williston Reservoir are assumed to include, and not necessarily be limited to:

- Timber not cleared from the area before impoundment
- Recruitment from shoreline erosion and blowdown
- Recruitment from tributaries during spring freshet
- Recruitment from industrial operations, such as log booming

3. Previous Studies

3.1 Williston Debris Field Survey, Inventory and Contribution Analysis Report (AECOM Tecsuit 2010)

AECOM Tecsuit (2010) prepared a report for BC Hydro that provided:

- Estimation of existing debris volume within the reservoir
- Identification of the various sources of debris and their relative contribution to the total debris volume
- Recommendations as to uses for the debris

Based on interpretation of aerial photographs taken during an overflight in 2009, AECOM Tecsuit (2010) integrated information on woody debris with a digital map of the reservoir supplied by BC Hydro. The product was a baseline map layer that would constitute the reference baseline for future monitoring. The amount of wood per type of debris was quantified in cubic metres through a field survey.

3.2 Williston Reservoir Debris Management Strategy (AECOM 2011)

AECOM (2011) developed a management strategy for woody debris on Williston Reservoir to help guide the actions of BC Hydro and the Tsay Keh Dene First Nation. The strategy was designed to help set the direction for managing the woody debris, and included consideration of various options, a timeframe for implementing the necessary projects, and costing elements.

3.3 Williston Reservoir Debris Trend Analysis 2009-2011 (AECOM 2018)

AECOM (2018) monitored the change in woody debris volume and distribution in Williston Reservoir between 2009 and 2011, at 620 randomly selected, 500 m x 500 m sampling areas. That analysis confirmed the effectiveness of the debris removal program.

AECOM (2018) reviewed the baseline study using 2011 imagery to reinterpret faint parts of 2009 imagery and confirm interpretation of wood logs, and whether it was necessary to delineate additional debris areas that were unclear on the 2009 imagery. Figure 2 presents an example of the resolution difference.

3.4 Woody Debris Strategic Management Plan (DWB 2015)

DWB Consulting Services (2015) further developed a management strategy for a short list of options considered by AECOM (2011).

3.5 Targeted Debris Management

Woody debris management on behalf of BC Hydro has included removal of woody debris and logs from the reservoir shoreline since 2009. Reports on debris management implementation include those prepared by Cho Cho Enterprises (2010, 2011, 2012), Cho Cho Industries (2013, 2014a, 2014b, 2016, 2017, 2018), and DWB Consulting Services (2015,).



Figure 2 Example of the Re-Analysis of Lower-Resolution 2009 Imagery (Upper Image) by Using 2011 Imagery (Middle Image) to Confirm the Presence of Woody Debris (highlighted in the Lower Image)

4. Study Objectives

For an up-to-date characterization of the entire reservoir, BC Hydro has contracted AECOM again to map woody debris from aerial photographs taken in 2018, and to characterize its change over the last decade.

The goal of this assignment was to provide a desktop analysis of debris trends in Williston Reservoir over the 10-year monitoring period, through the following objectives:

- Inventory the current state of debris in the reservoir
- Identify trends and changes since the 2009 baseline work
- Complete a debris contribution analysis

5. Methods

The 2009 and 2018 aerial photos are compared for six sectors of the Williston Reservoir: Finlay Arm East, Finlay Arm West, Parsnip Arm East, Parsnip Arm West, Peace Arm Northhand Peace Arm South. For the baseline and 2018 update only areas within the reservoir have been classified. The comparison is followed by analysis of the woody debris changes in the sampling cells to identify whether trends identified in the earlier trend analysis (AECOM 2018) have continued through 2018.

Images taken in 2011 and 2018 are of greater resolution than those used for the baseline study (AECOM Tecsalt 2010). Specifically, the pixel size is 20 cm for 2011 and 2018, and 33 cm for the 2009 imagery. The revision of the baseline, using 2011 imagery, by AECOM (2018) has been repeated in the present study for some areas, using 2018 imagery to reinterpret faint areas on the 2009 imagery. This approach was required mainly to confirm the importance of downed wood areas in forest stands close to large beached debris. As a consequence, some values could differ slightly from the updated version of the baseline of 2009 presented by AECOM (2018) in the 2009-2011 trend analysis.

In 2009 and 2018 the shoreline of the reservoir was delineated as part of the debris analysis inventory work. Through the known shoreline extent, shoreline erosion was calculated by comparing the 2009 reservoir area with the 2018 reservoir area. Other differences were used including the loss of degraded forests, increase in River areas and the decrease in area outside of the reservoir. The calculated differences represent the eroded area over the nine years. The volume of debris was calculated using a weighted average of the types of forest stands eroded and their estimated volume per hectare.

The classification method used to characterize the woody debris and forest types in 2009, 2011, and again in 2018 is presented in Table 2. Descriptions of class codes are provided in Appendix A.

Table 2 Classification Used to Characterize Woody Debris and Forest Stands in Williston Reservoir

Code	Description
Woody Debris on Beach or Flats	
B1	Scattered or low-density, beached woody debris
B2	Moderately dense woody ribbons on beach
B3	Dense woody ribbons or piles on beach
BB	Wood bundle on beach
BF	Scattered woody debris on flats
BH	Harvested woody debris area (<i>area cleaned in 2018, but covered by woody debris or man-made wood stacks in 2009</i>)
BM	Man-made wood stack on beach
BS	Stumps on beach
Floating or Submerged Woody Debris	
F1	Low-density floating wood logs
F2	Moderately dense floating wood logs
F3	Dense floating wood logs
FB	Floating wood bundle
FO	Floating log boom (<i>term is used as the place where logs are collected into booms</i>)
FS	Submerged stumps (<i>area identified as "Stumps on beach" in other imagery, but not clearly visible in the actual view</i>)
Forest Stand	
S1	Low-density, downed wood in forest stand occasionally flooded
S2	Moderately dense downed wood in forest stand occasionally flooded
S3	Dense downed wood in forest stand occasionally flooded
SL	Low-density forest stand occasionally flooded
SM	Moderately dense forest stand occasionally flooded
SD	Dense forest stand occasionally flooded
Additional Terms for Following the Dynamic of Woody Debris Areas	
H2	Water (hiding potential woody debris area detected in the other study, 2009 or 2011))
RN	Reservoir area without woody debris
RR	River (<i>new branch cutting a former woody debris area in 2009; this code is used for identifying the cause of the changes</i>)
TE	Eroded area (enlargement of the beach area towards a former forest stand or an upland terrace)
WS	Wood stack (commercial pile of logs)

6. Results

AECOM presents results of this trend analysis in three sections:

- Section 6.1 describes the difference in area covered by woody debris between 2009 and 2018, based on reinterpretation of 2009 air photos, and identifies the relative importance of each type of woody debris.
- Section 6.2 describes the difference in wood volume that the aerial changes represent for each type of wood debris.
- Section 6.3 provides an analysis of the changes over the 10-year period.

Detailed results are included in the Appendices to this report:

- Appendix A Classification Use to Characterizes Large Woody Debris and Forest Stands
- Appendix B Tributaries of Finlay, Parsnip, and Peace Arms
- Appendix C Maps
- Appendix D Detailed Tables of Woody Debris Area, Volume, and Trends 2009-2018

6.1 Extent of Woody Debris in 2009 and 2018

The area covered in 2009 and 2018 by each type of large woody debris is presented in Table 3. Table 3 summarizes detailed information presented in Appendix D, Tables D1, D2, and D3.

In 2009, Finlay Arm represented 45% of the total area of the reservoir (Table 1), but contained 56% of the area covered by large woody debris mapped for the whole reservoir in 2009. A similar concentration was observed for coverage of forest stands, with downed woods in Finlay Arm totalling 58% of the coverage for the whole reservoir, compared to 41% for Parsnip Arm and 1% for Peace Arm.

Finlay Arm is also characterized by a prominence of “dense woody ribbons or piles on beach” (Class B3) in 2009. Indeed, that class represented 28% of all main beached woody debris in the entire reservoir, followed by “moderately dense woody ribbons” (Class B2; 19%) and by “scattered or low-density beached woody debris” (Class B1; 9%). In Parsnip Arm, we observe a dominance of “moderately dense woody ribbons” (Class B2; 15% of the amount of main beached debris in the whole reservoir), followed by dense woody debris (Class B3) at 14% and low-density woody debris (Class B1) at 8%. The distribution of debris within each of the woody debris on beach classes in Parsnip Arm is the same distribution as the whole reservoir (Table D1).

In 2009, the proportion of woody debris in Peace Arm North and South was far lower than the proportion of the reservoir these sectors represent. Peace Arm contained only 7% of main beached woody debris (and 1% of forest stands with downed trees), though it represents 19% of the reservoir area. This low proportion is related to the more rugged terrain with fewer flat areas where woody debris can accumulate, and also to it having smaller tributaries with lower potential to transport fallen trees (Appendix B). Moderately dense ribbons were more frequent in Peace Arm, compared to those in Parsnip Arm. That class accounted for 4% of the main beached debris observed in the reservoir, followed by 2% for low-density ribbons (Class B1) and 1% for dense ribbons (Class B3).

In 2009, 22% of the forest stands in Finlay Arm and 26% of the forest stands in Parsnip Arm not cleared prior to flooding contained noticeable numbers of downed trees (Classes S1, S2 and S3). For Peace Arm, degradation processes had affected only 16% of existing forest stands located inside the limits of the reservoir. In general, the greatest occurrence of downed trees was observed in the lowest terraces and the ancient channels where the current is faster and flood conditions last longer.

In 2018, the relative extents of the three main types of woody debris (B1, B2 and B3) in Finlay Arm were nearly equal. Furthermore, medium density ribbons (Class B2) were more frequent than dense beached debris (Class B3), contrary to what was observed in 2009. In total, Finlay Arm contained 51% of the extent of main beached debris observed in the reservoir, with Parsnip Arm having 39%, and Peace Arm having 11% (Table D2).

Finlay Arm contained 16%, 19%, and 16% of classes B1, B2, and B3, respectively, mapped in the whole reservoir in 2018. In Parsnip Arm, these three classes, respectively, represent 14%, 14%, and 10% of the extent of main woody debris in the reservoir. In Peace Arm, these proportions are smaller, at 6%, 4%, and 2%, respectively.

The proportions of forests where downed trees were observed were 21% in Finlay Arm, 24% in Parsnip Arm, and 17% in Peace Arm in 2018.

Table 3 Summary Comparison of Woody Debris Areal Extent between 2009 and 2018, by Sector and Type

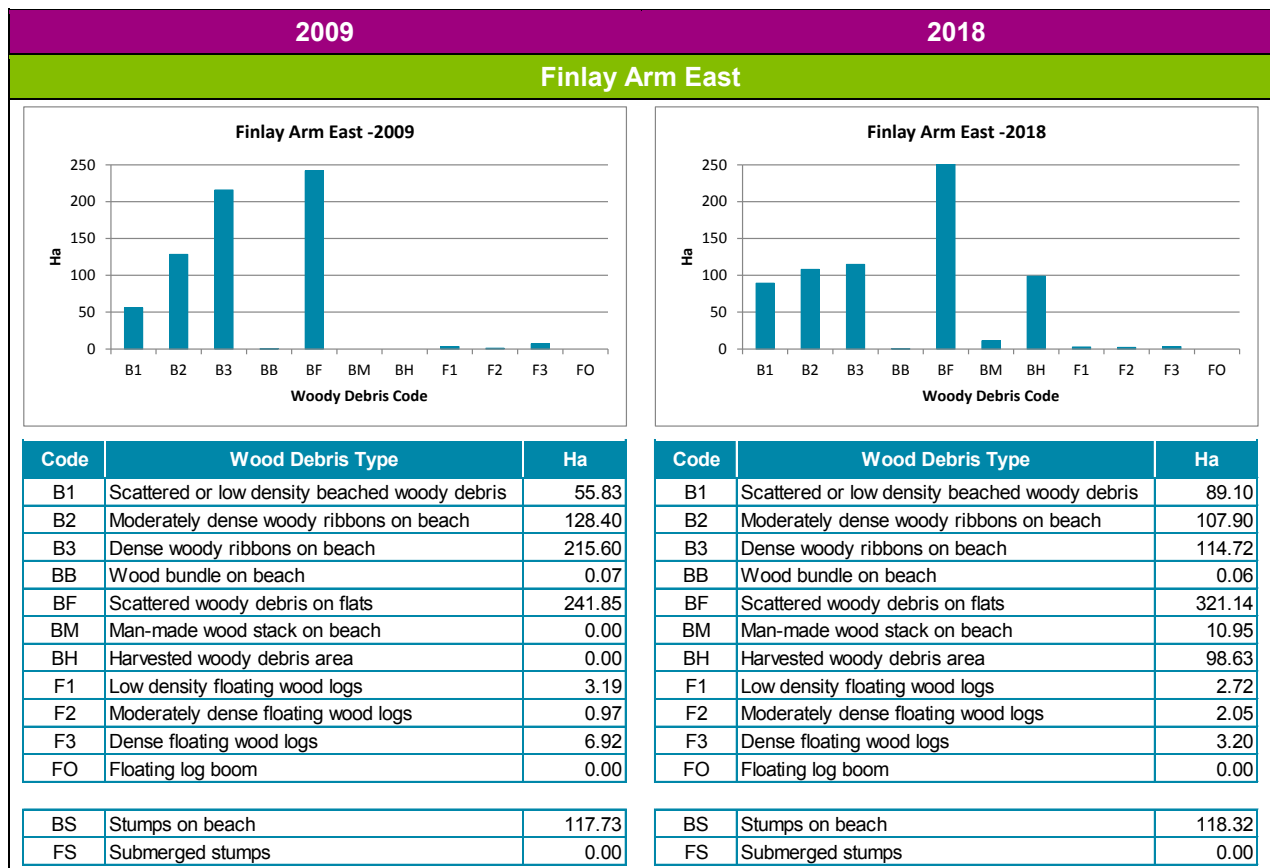
Reservoir Sector	Total Woody Debris All B and F Classes						Total Woody Debris and Forest Stands All B, F, and S Classes (Excluding Stumps)						Stumps Classes BF and FS					
	2009		2018		Change		2009		2018		Change		2009		2018		Change	
Year:	2009		2018		Change		2009		2018		Change		2009		2018		Change	
Unit:	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Finlay Arm East	652.83	34.3	651.84	32.3	-0.99	-0.2	1,213.58	27.7	1,171.31	27.8	-42.27	-3.5	117.73	5.4	118.32	5.5	0.59	0.5
Finlay Arm West	451.90	23.7	436.37	21.6	-15.53	-3.4	1,414.51	32.3	1,314.91	31.2	-99.60	-7.0	138.84	6.4	142.89	6.6	4.05	2.9
Finlay Arm Total	1,104.73	58.0	1,088.21	53.9	-16.52	-1.5	2,628.09	60.0	2,486.22	58.9	-141.87	-5.4	256.57	11.9	261.21	12.1	4.64	1.8
Parsnip Arm East	245.23	12.9	271.57	13.5	26.34	10.7	467.31	10.7	472.19	11.2	4.88	1.0	614/82	28.4	606.56	28.2	-8.26	-1.3
Parsnip Arm West	451.05	23.7	510.61	25.3	59.56	13.2	1,161.29	26.5	1,094.19	25.9	-67.10	-5.9	1,250.74	57.9	1,247.03	57.9	-3.71	-0.3
Parsnip Arm Total	696.28	36.6	782.18	38.7	85.90	12.3	1,628.60	37.2	1,566.38	37.1	-62.22	-3.8	1,865.56	86.3	1,853.59	86.1	-11.97	-0.6
Peace Arm North	51.50	2.7	71.12	3.5	19.62	38.1	61.44	1.4	79.63	1.9	18.19	29.6	8.89	0.5	9.89	0.5	0.00	0.0
Peace Arm South	51.41	2.7	77.54	3.8	26.13	50.8	64.13	1.5	88.15	2.1	24.02	37.5	29.09	1.3	29.30	1.4	0.21	0.7
Peace Arm Total	102.91	5.4	148.66	7.4	45.75	44.5	125.57	2.9	167.78	4.0	42.21	33.6	38.98	1.8	39.19	1.8	0.21	0.5
Overall Total	1,903.92	100.0	2,019.05	100.0	115.13	6.0	4,382.26	100.0	4,220.38	100.0	-161.88	-3.7	2,161.11	100.0	2,153.99	100.0	-7.12	-0.3

Figure 3 and Figure 4 enable a better comparison of the extent of the various woody debris types and forest stands in each sector, as mapped in 2009 and 2018. For Finlay Arm East, we observed an important proportion of “scattered woody debris on flats” (Class BF), given that this sector is characterized by large plains and low terraces where woody debris can be trapped when the level of water is gradually lowered. Similar conditions were observed in Parsnip Arm West where that Class BF is also important. We will see in the next section, however, that, since this class contains very small amounts of woody debris, it is not of great concern for the debris removal program.

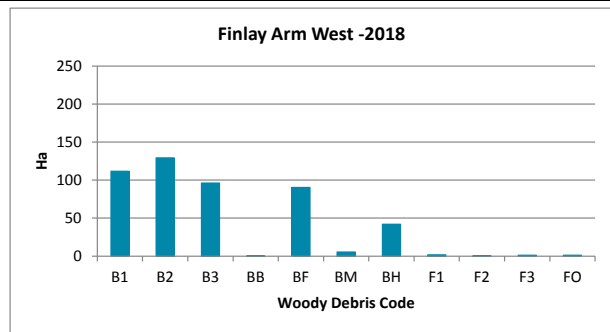
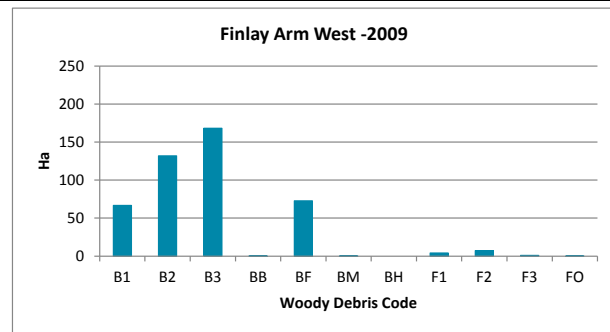
Floating debris in the whole reservoir totalled 48 ha in 2009, and 24 ha in 2018. In 2009, it was observed as large patches of floating trunks over the main waterbody, and also in smaller groups captured in creeks and narrow bays. In 2018, almost all floating debris was observed in narrow bays distant from the main waterbody at its lowest level. In general, this class could be merged with standard beached debris, given that several of those zones are dry during summer.

Indications of debris removal activities (Class BM) were clearly observed in Finlay Arm and Parsnip Arm, in 2018. They covered a high proportion of the coastline of Finlay Arm East, and a dense sector in Finlay Arm West, close to Parsnip Arm West. Debris removal activities were also evident in Parsnip Arm, but less extensive. For Peace Arm, those activities were almost exclusively concentrated close to the dam.

In Figure 4, we observe that the proportion of forest stands with downed wood remained quite low in both 2009 and 2018, except in Finlay Arm East & West and Parsnip Arm West.



Finlay Arm West



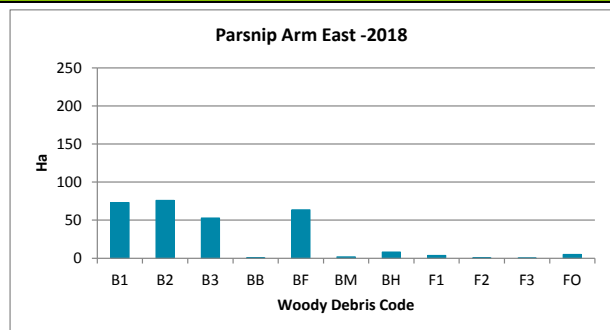
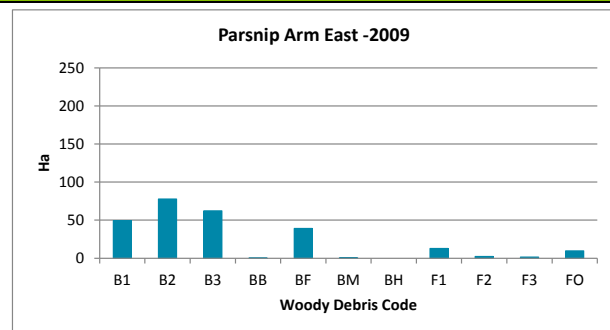
Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	66.78
B2	Moderately dense woody ribbons on beach	131.77
B3	Dense woody ribbons on beach	168.08
BB	Wood bundle on beach	0.25
BF	Scattered woody debris on flats	72.66
BM	Man-made wood stack on beach	0.07
BH	Harvested woody debris area	0.00
F1	Low density floating wood logs	4.00
F2	Moderately dense floating wood logs	7.36
F3	Dense floating wood logs	0.93
FO	Floating log boom	0.20

Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	111.72
B2	Moderately dense woody ribbons on beach	129.18
B3	Dense woody ribbons on beach	96.20
BB	Wood bundle on beach	0.12
BF	Scattered woody debris on flats	90.30
BM	Man-made wood stack on beach	5.45
BH	Harvested woody debris area	41.89
F1	Low density floating wood logs	1.79
F2	Moderately dense floating wood logs	0.39
F3	Dense floating wood logs	1.22
FO	Floating log boom	1.20

BS	Stumps on beach	136.89
FS	Submerged stumps	1.95

BS	Stumps on beach	142.39
FS	Submerged stumps	0.50

Parsnip Arm East



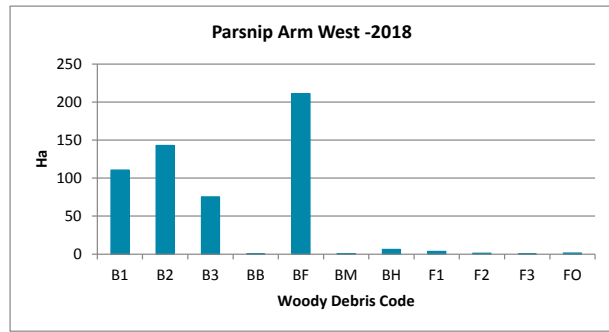
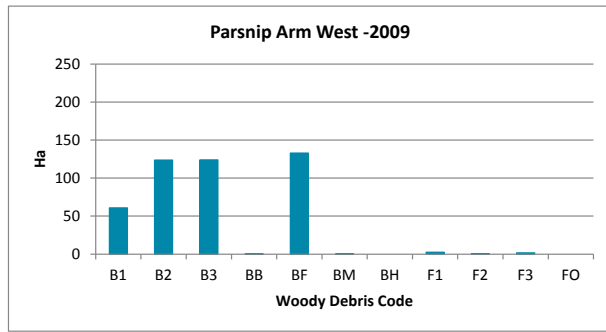
Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	49.33
B2	Moderately dense woody ribbons on beach	77.73
B3	Dense woody ribbons on beach	62.11
BB	Wood bundle on beach	0.19
BF	Scattered woody debris on flats	39.16
BM	Man-made wood stack on beach	0.31
BH	Harvested woody debris area	0.00
F1	Low density floating wood logs	12.66
F2	Moderately dense floating wood logs	2.36
F3	Dense floating wood logs	1.38
FO	Floating log boom	9.53

Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	72.88
B2	Moderately dense woody ribbons on beach	75.98
B3	Dense woody ribbons on beach	52.75
BB	Wood bundle on beach	0.33
BF	Scattered woody debris on flats	63.57
BM	Man-made wood stack on beach	1.87
BH	Harvested woody debris area	8.11
F1	Low density floating wood logs	3.66
F2	Moderately dense floating wood logs	0.49
F3	Dense floating wood logs	0.04
FO	Floating log boom	4.77

BS	Stumps on beach	610.09
FS	Submerged stumps	4.73

BS	Stumps on beach	603.11
FS	Submerged stumps	3.45

Parsnip Arm West



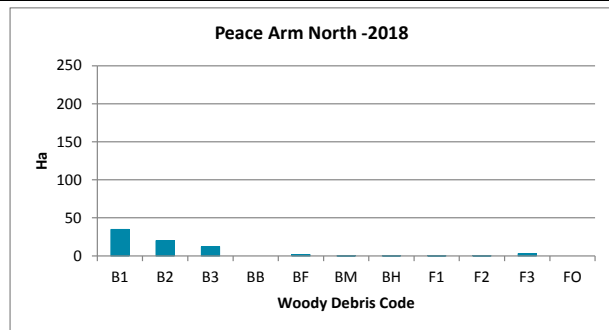
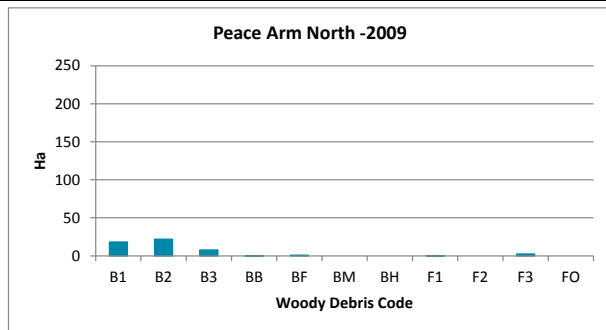
Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	60.80
B2	Moderately dense woody ribbons on beach	123.62
B3	Dense woody ribbons on beach	123.99
BB	Wood bundle on beach	0.20
BF	Scattered woody debris on flats	132.94
BM	Man-made wood stack on beach	0.04
BH	Harvested woody debris area	0.00
F1	Low density floating wood logs	2.58
F2	Moderately dense floating wood logs	0.42
F3	Dense floating wood logs	1.68
FO	Floating log boom	0.00

Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	110.69
B2	Moderately dense woody ribbons on beach	142.94
B3	Dense woody ribbons on beach	75.26
BB	Wood bundle on beach	0.22
BF	Scattered woody debris on flats	210.97
BM	Man-made wood stack on beach	0.71
BH	Harvested woody debris area	6.17
F1	Low density floating wood logs	3.51
F2	Moderately dense floating wood logs	1.23
F3	Dense floating wood logs	0.12
FO	Floating log boom	1.42

BS	Stumps on beach	1 234.25
FS	Submerged stumps	16.49

BS	Stumps on beach	1 224.31
FS	Submerged stumps	22.72

Peace Arm North



Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	18.28
B2	Moderately dense woody ribbons on beach	21.96
B3	Dense woody ribbons on beach	7.76
BB	Wood bundle on beach	0.01
BF	Scattered woody debris on flats	0.91
BM	Man-made wood stack on beach	0.00
BH	Harvested woody debris area	0.00
F1	Low density floating wood logs	0.07
F2	Moderately dense floating wood logs	0.00
F3	Dense floating wood logs	2.51
FO	Floating log boom	0.00

Code	Wood Debris Type	Ha
B1	Scattered or low density beached woody debris	34.66
B2	Moderately dense woody ribbons on beach	19.85
B3	Dense woody ribbons on beach	12.04
BB	Wood bundle on beach	0.00
BF	Scattered woody debris on flats	1.37
BM	Man-made wood stack on beach	0.07
BH	Harvested woody debris area	0.12
F1	Low density floating wood logs	0.21
F2	Moderately dense floating wood logs	0.08
F3	Dense floating wood logs	2.84
FO	Floating log boom	0.00

BS	Stumps on beach	6.18
FS	Submerged stumps	3.71

BS	Stumps on beach	9.89
FS	Submerged stumps	0.00

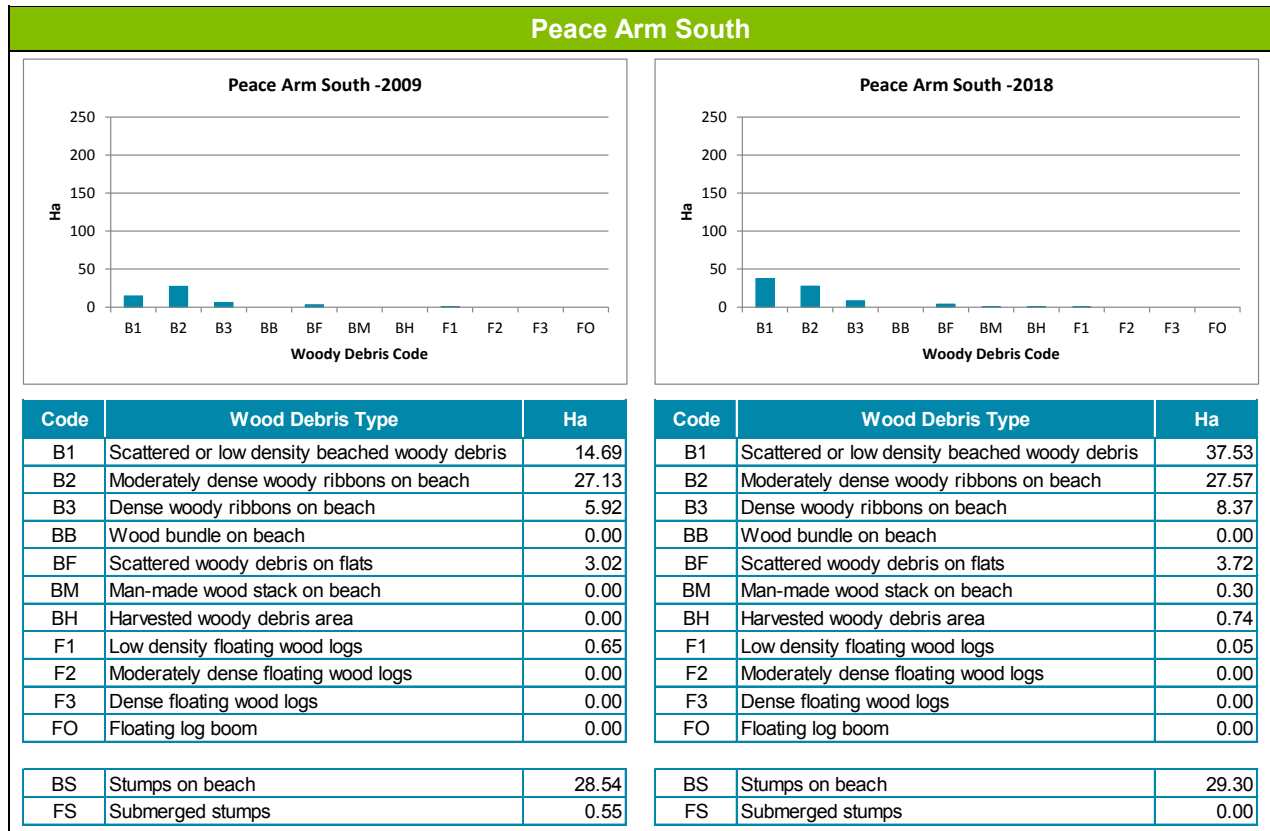
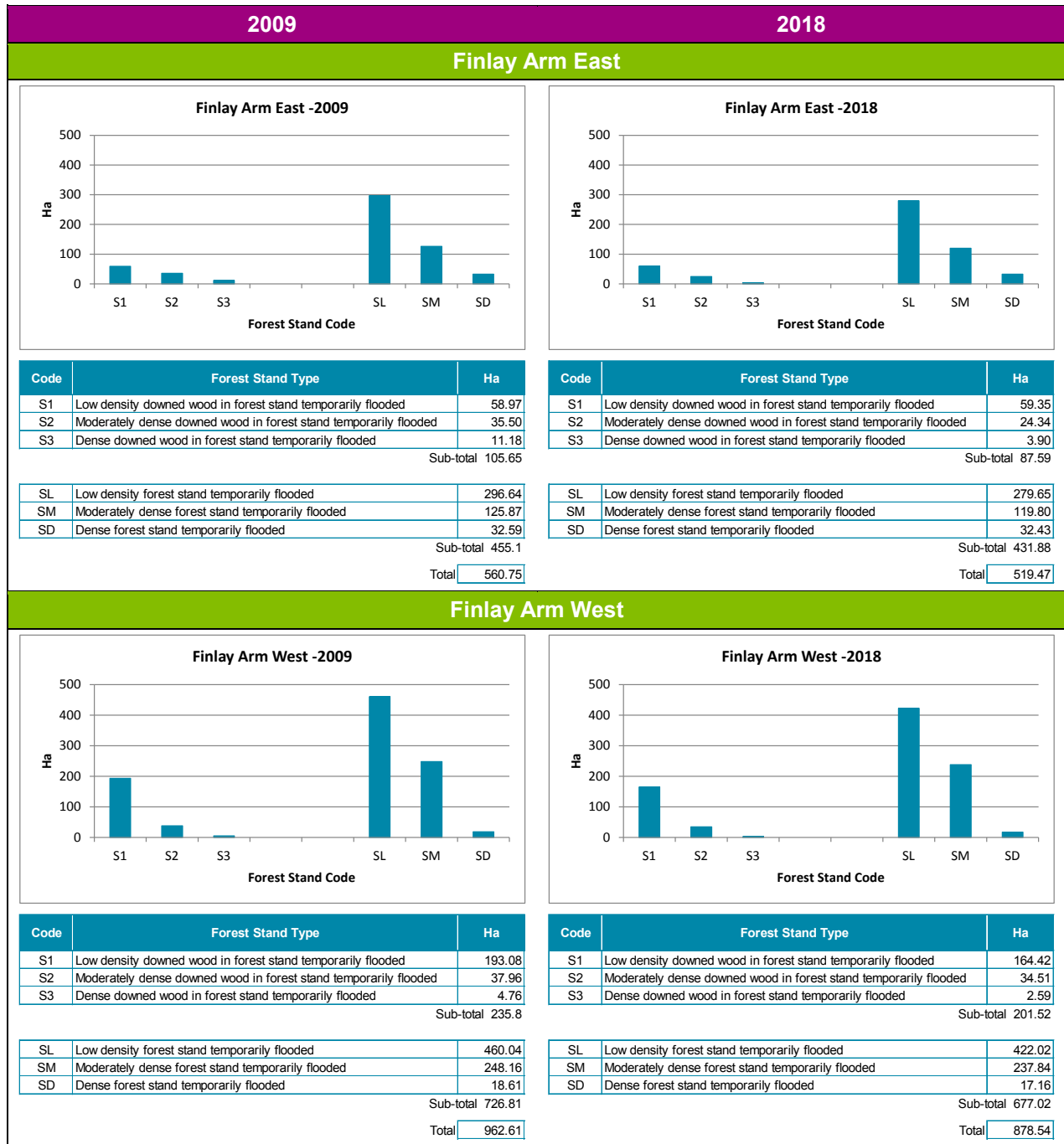
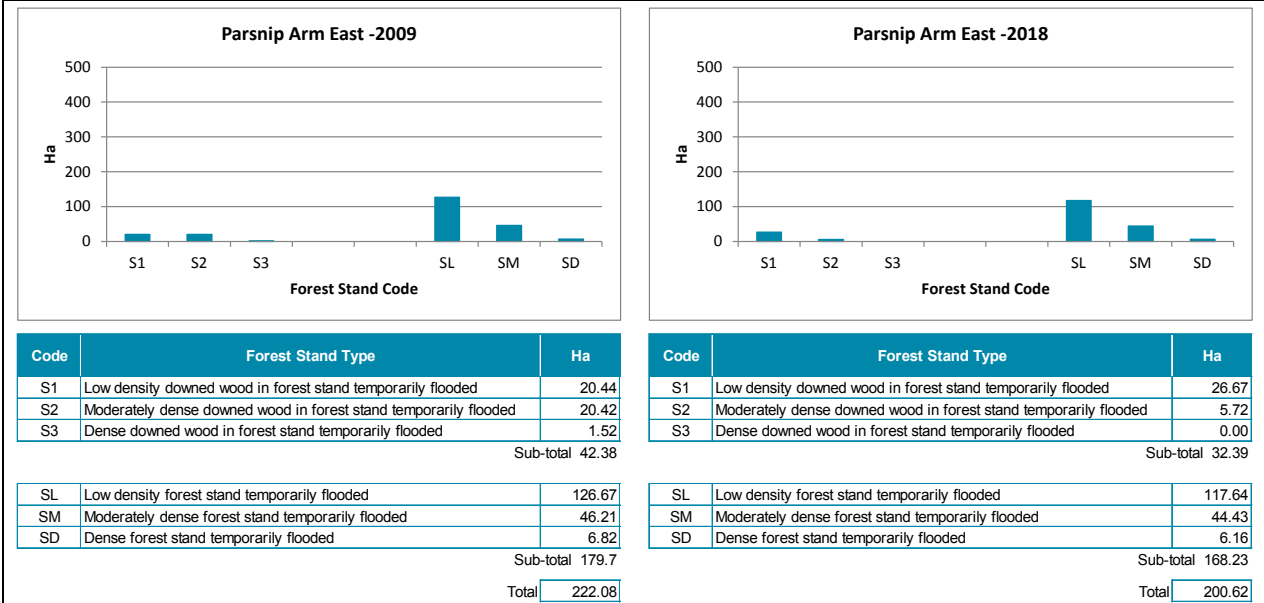


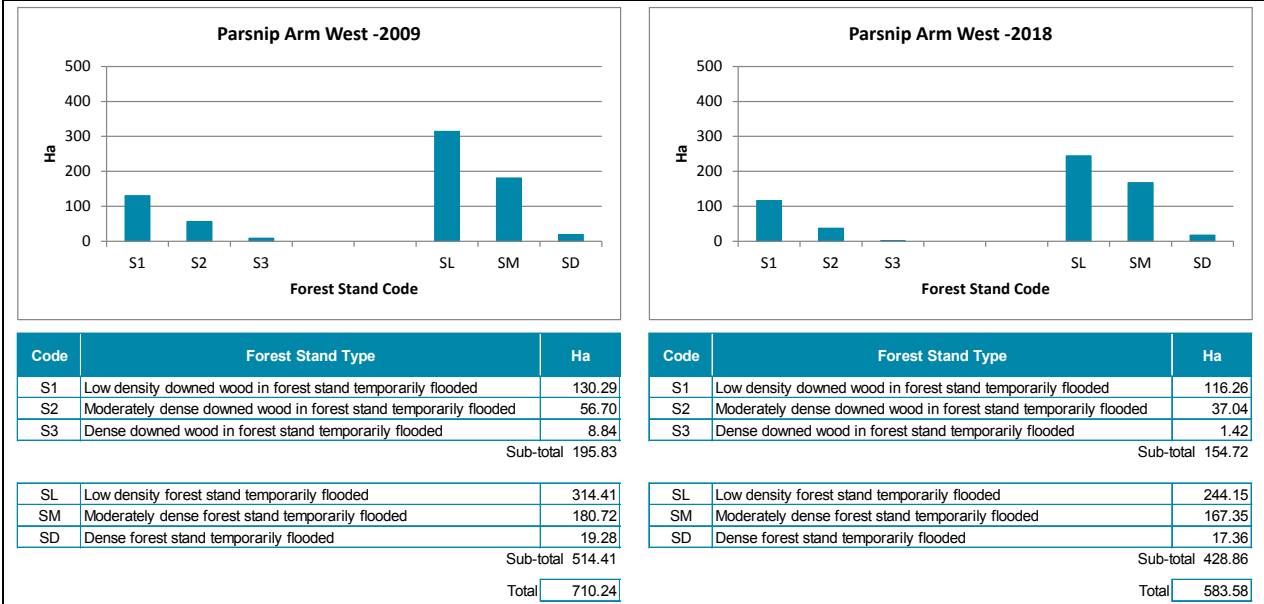
Figure 3 Extent of Large Woody Debris in 2009 and 2018, by Sector and Type



Parsnip Arm East



Parsnip Arm West



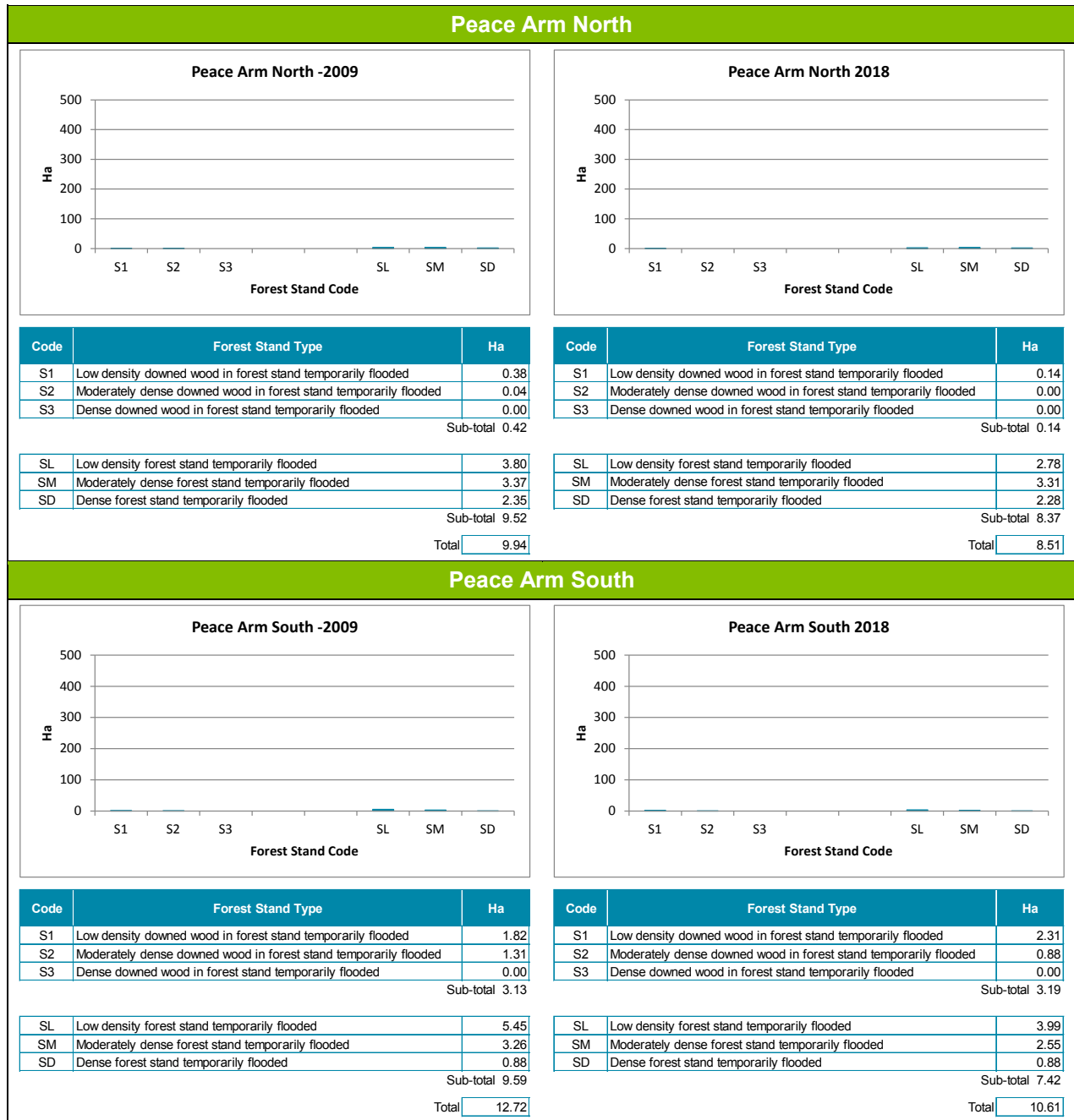


Figure 4 Extent (ha) of Forest Stands in 2009 and 2018, by Sector and Type

6.2 Volume (m³) of Woody Debris in 2009 and 2018

The unitary values used to compute volumes from the type of woody debris and their areal coverage are presented in Table 4. These values are based on a ground inventory performed by AECOM in June 2009, as described in the Williston Debris Field Survey Inventory and Contribution Analysis Draft Report (March 2010).

Table 4 Unitary Value of Solid Wood Volume by Woody Debris Type

Code	Woody Debris Type	Unitary value
B1	Scattered or low density beached woody debris	0.032 m ³ /m ²
B2	Moderately dense woody ribbons on beach	0.072 m ³ /m ²
B3	Dense woody ribbons on beach	0.141 m ³ /m ²
BB	Wood bundle on beach	100 m ³ /bundle
BF	Scattered woody debris on flats	0.005 m ³ /m ²
F1	Low density floating wood logs	0.030 m ³ /m ²
F2	Moderately dense floating wood logs	0.060 m ³ /m ²
F3	Dense floating wood logs	0.110 m ³ /m ²
S1	Low density downed wood in forest stand temporarily flooded	0.020 m ³ /m ²
S2	Moderately dense downed wood in forest stand temporarily flooded	0.040 m ³ /m ²
S3	Dense downed wood in forest stand temporarily flooded	0.080 m ³ /m ²
SL	Low density forest stand temporarily flooded	50 m ³ /ha
SM	Moderately dense forest stand temporarily flooded	100 m ³ /ha
SD	Dense forest stand temporarily flooded	200 m ³ /ha
BM	Man-made wood stack on beach	<i>depends on the provenance</i>
BS-FS	Stumps on beach or on flats	0.000 m ³ /m ²

Volumes represented in 2009 and 2018 by each type of large woody debris are presented in Table 5. Table 5 summarizes detailed information presented in Appendix D, Tables D6, D7, and D8.

In 2009, the volume of beached debris of Finlay Arms was 70% “dense woody ribbons on beach” (Class B3) and 24% “moderately dense woody ribbons on beach” (Class B2) (Table D6 and Figure 5). Although “low-density beached woody debris” (Class B1) represented 16% of the area covered by beached debris in Finlay Arm, it accounted for only 5% of wood volume accumulated along the shoreline in that region. In relation to the whole stock accumulated along the reservoir, Finlay Arm contained 3%, 14%, and 40% of Classes B1, B2, and B3, respectively. For Parsnip Arm, these percentages were, respectively, 3%, 11% and 20% of the stock in the whole reservoir. In relation to its own stock, woody debris in Parsnip Arm was 8%, 33%, and 59% in Classes B1, B2, and B3, respectively. As observed in Finlay Arm, the main volumes were concentrated in dense ribbons (Class B3).

The volume of accumulated beached debris was lowest in Peace Arm. Furthermore, the main amounts for that region (i.e., 54%) were derived from the moderately dense ribbons (Class B2), since they are almost four times more extensive than dense ribbons (Class B3) (Table D6). In relation to the whole stock of beached debris in the reservoir, the Peace Arm contained about 1%, 3%, and 1% of Classes B1, B2 and B3, respectively.

The volume of debris in the forest stands, within the reservoir, not cleared prior to flooding was mainly concentrated in the downed wood that remained close to its original location. Low-density downed wood (Class S1) and moderately dense downed wood (Class S2) contained the majority of woody debris in zones occasionally flooded (Figure 6) in 2009 and 2018. In 2018, however, we observed more frequently a parallel alignment and dense concentration of trunks, indicating wave action.

Table 5 Summary Comparison of Wood Debris Volumes between 2009 and 2018, by Sector and Type

Reservoir Sector	Total Woody Debris All B and F Classes						Total Woody Debris and Forest Stands All B, F, and S Classes (Excluding Stumps)						Stumps Classes BF and FS (no change)			
	2009		2018		Change		2009		2018		Change		2009		2018	
Year:	2009		2018		Change		2009		2018		Change		2009		2018	
Unit:	m ³	%	m ³	%	m ³	%	m ³	%	m ³	%	m ³	%	m ³	%	m ³	%
Finlay Arm East	436,256	32.5	302,649	28.3	-133,607	-30.6	436,817	32.5	303,168	28.3	-146,009	-28.8	0	0	0	0
Finlay Arm West	366,065	27.3	278,736	26.1	-87,329	-23.9	367,028	27.3	279,615	26.1	-99,325	-20.9	0	0	0	0
Finlay Arm Total	802,321	59.8	581,385	54.5	-220,936	-27.5	803,844	59.9	582,783	5.45	-245,334	-25.0	0	0	0	0
Parsnip Arm East	170,013	12.7	161,071	15.1	-8,942	-5.3	170,235	12.7	161,272	15.1	-16,134	-8.2	0	0	0	0
Parsnip Arm West	299,534	22.3	235,346	22.0	-64,188	-21.4	300,244	22.4	235,930	22.1	-86,849	-22.1	0	0	0	0
Parsnip Arm Total	469,547	35.0	396,417	37.1	-73,130	-15.6	470,479	35.0	397,201	37.1	-102,893	-17.5	0	0	0	0
Peace Arm North	35,828	2.7	45,852	4.3	10,024	28.0	35,838	2.7	45,861	4.3	9,891	26.8	0	0	0	0
Peace Arm South	32,896	2.5	44,017	4.1	11,121	33.8	32,909	2.5	44,028	4.1	10,885	31.5	0	0	0	0
Peace Arm Total	68,727	5.1	89,869	8.4	21,145	30.8	68,747	5.1	89,888	8.4	20,776	29.1	0	0	0	0
Overall Total	1,340,592	100.0	1,067,671	100.0	-272,921	-20.4	1,343,070	100.0	1,069,872	100.0	-327,541	-19.9	0	0	0	0

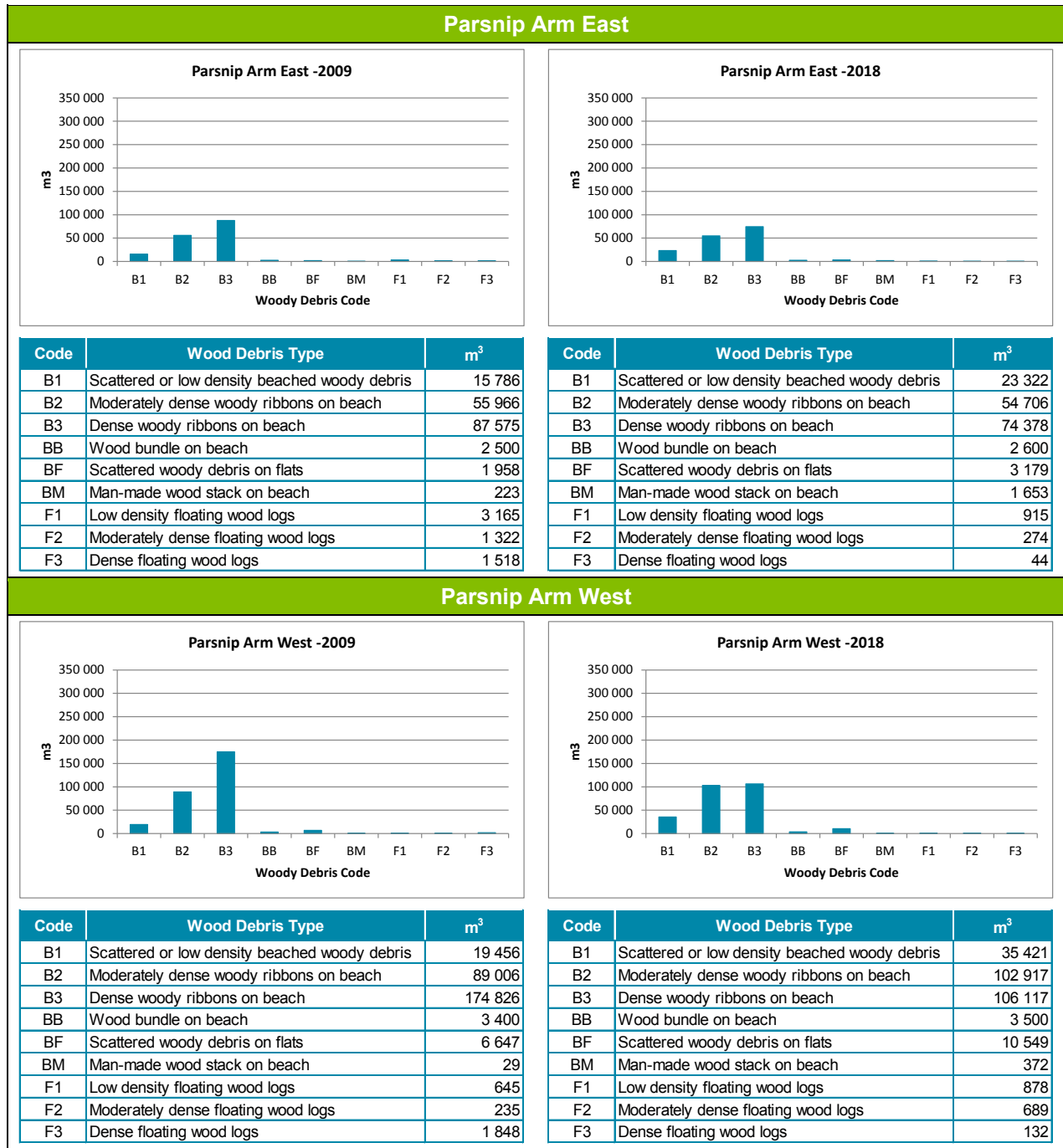
In relation to the whole reservoir, Finlay, Parsnip, and Peace Arms, respectively, accounted for 54%, 37%, and 9% of the total stock of large woody debris in 2018 (Classes B1, B2, and B3) (Table 5 and Table D7). Most of the beached woody debris in Finlay Arm and Parsnip Arm was still derived from the dense ribbons (Class B3). For Peace Arm, the amount was concentrated mainly in moderately dense ribbons (Class B2), as observed in 2009. More specifically, Finlay Arm was characterized by 12%, 32%, and 56% of woody volumes, respectively, in Classes B1, B2, and B3. The same numerical rank was observed in Parsnip Arm, though the difference between moderately dense ribbons (Class B2) and dense ribbons (Class B3) was less: Classes B1, B2, and B3 contained, respectively, 16%, 36% and about 48% of the debris of that region. For Peace Arm, the proportions of these classes were 27%, 40%, and 33%, respectively, the only Arm in which Class B2 represented the highest volume (Appendix D, Table D6).

Figure 5 and Figure 6 provide more details about the woody debris and forest stands in each sector. The woody debris volume from "scattered woody debris on flats" (Class BF) was very low, though it covered a large area representing about 60% that of the beached ribbons. Class BF accounted for less than 5% of the wood volume accumulated in the reservoir. Finlay Arm East and Parsnip Arm West were characterized by a significant proportion of "scattered woody debris on flats" (Class BF), consistent with their having large plains and low terraces where woody debris could be trapped when the level of water is gradually lowered.

The wood volumes in the floating debris totalled 7,356 m³ in Finlay Arm, 2,932 m³ in Parsnip Arm, and 3,235 m³ in Peace Arms. These volumes were almost exclusively concentrated in creeks and narrow bays that could be dry during the summer. These volumes correspond to less than 1% of those accumulated in the beached ribbons.

We also observed in Figure 6 that the volumes in the degraded forests are quite important, in Findlay Arm East & West and Parsnip Arm West which represent a potential source of debris that could be mobilized to the main shoreline.







Peace Arm South -2009

Woody Debris Code	Volume (m³)
B1	~5,000
B2	~20,000
B3	~10,000
BB	~500
BF	~50
BM	0
F1	~20
F2	0
F3	~3,000

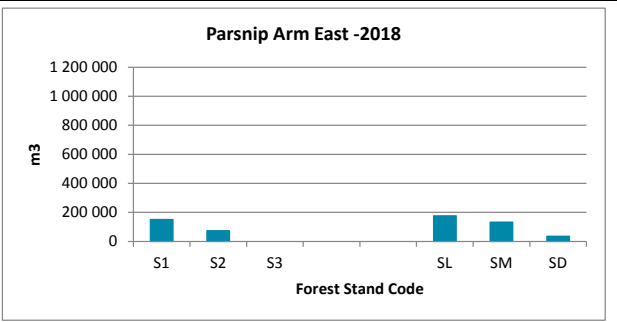
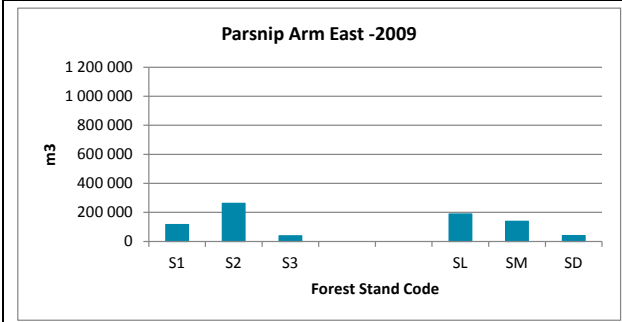
Peace Arm South -2018

Woody Debris Code	Volume (m³)
B1	~5,000
B2	~25,000
B3	~10,000
BB	~500
BF	~50
BM	0
F1	~20
F2	0
F3	~3,000

Figure 5 Volume of Large Woody Debris in 2009 and 2018, by Sector and Type



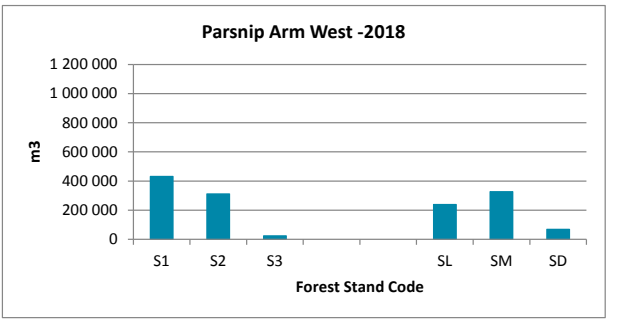
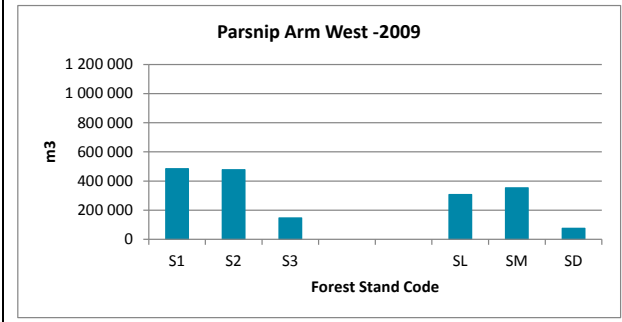
Parsnip Arm East



Code	Forest Stand Type	m³
S1	Low density downed wood in forest stand temporarily flooded	116 280
S2	Moderately dense downed wood in forest stand temporarily flooded	262 730
S3	Dense downed wood in forest stand temporarily flooded	39 100
Sub-total		418110
SL	Low density forest stand temporarily flooded	189 650
SM	Moderately dense forest stand temporarily flooded	138 400
SD	Dense forest stand temporarily flooded	40 800
Sub-total		368850
Total		786 960

Code	Forest Stand Type	m³
S1	Low density downed wood in forest stand temporarily flooded	151 810
S2	Moderately dense downed wood in forest stand temporarily flooded	73 530
S3	Dense downed wood in forest stand temporarily flooded	0
Sub-total		225340
SL	Low density forest stand temporarily flooded	176 100
SM	Moderately dense forest stand temporarily flooded	133 000
SD	Dense forest stand temporarily flooded	36 800
Sub-total		345900
Total		571 240

Parsnip Arm West



Code	Forest Stand Type	m³
S1	Low density downed wood in forest stand temporarily flooded	484 500
S2	Moderately dense downed wood in forest stand temporarily flooded	477 300
S3	Dense downed wood in forest stand temporarily flooded	147 050
Sub-total		1108850
SL	Low density forest stand temporarily flooded	307 650
SM	Moderately dense forest stand temporarily flooded	353 700
SD	Dense forest stand temporarily flooded	75 400
Sub-total		736750
Total		1 845 600

Code	Forest Stand Type	m³
S1	Low density downed wood in forest stand temporarily flooded	432 250
S2	Moderately dense downed wood in forest stand temporarily flooded	311 750
S3	Dense downed wood in forest stand temporarily flooded	23 800
Sub-total		767800
SL	Low density forest stand temporarily flooded	238 900
SM	Moderately dense forest stand temporarily flooded	327 500
SD	Dense forest stand temporarily flooded	68 000
Sub-total		634400
Total		1 402 200

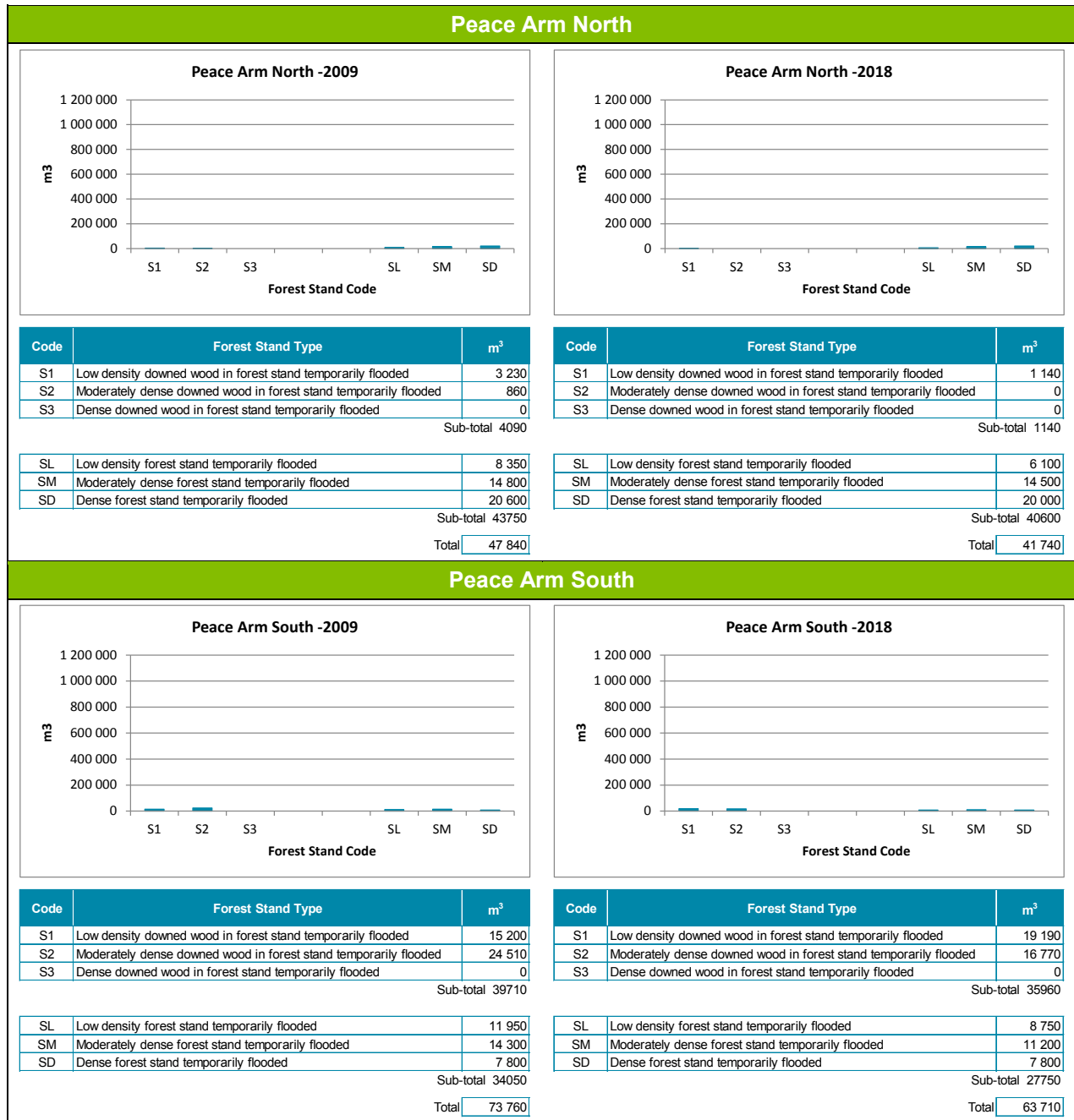


Figure 6 Volume of Wood of Forest Stands in 2009 and 2018, by Sector and Type

6.3 Woody Debris Trends from 2009 to 2018

This section describes changes that occurred in woody debris in Williston Reservoir between 2009 and 2018. The first section focusses on variations in extent and location, and the second section on debris volumes. Detailed data tables are provided in Appendix D.

6.3.1 Changes in Area between 2009 and 2018

The period of monitoring is characterized by a significant reduction of the area covered by woody debris in the whole reservoir. This observation is particularly evident in the extent of dense woody ribbons (Class B3) in Finlay Arm.

A reduction of about 101 hectares of dense ribbons (Class B3) occurred in Finlay Arm East (Table 3 and Table D3). The same trend is observed in Finlay Arm West, with a total reduction of 72 ha for that type of debris. The extent of moderately dense ribbons (Class B2) has also been reduced, by 21 ha in Finlay Arm East and 3 ha in Finlay Arm West. The same process is observed in Parsnip Arm, with a reduction of 2 ha and 9 ha of Classes B2 and B3 in the East sector, and 21 ha and 49 ha for the same classes in the West sector. The same trend is observed for floating debris inside bays and creeks, resulting in a total reduction of 22 ha for the whole reservoir (12 ha in Finlay Arm, 12 ha in Parsnip Arm, and 0.02 in Peace Arm). Dense ribbons (Class B3) in Peace Arm, however, show a different trend, an increase of 7 ha. Conversely, the extent of moderately dense ribbons (Class B2) has been reduced by 2 ha.

These values correspond with a reduction of 45% from the extent in 2009 of dense ribbons (Class B3) in Finlay Arm, and a reduction of 31% in Parsnip Arm. For Peace Arm, the extent of moderately dense ribbons (Class B2) has been reduced only by 3%. Overall, the extent of Class B2 has been reduced by approximately 10% in the North sector, while it has increased by 2% in the South sector. On an annual basis, the reduction of dense debris (Class B3) in Finlay and Parsnip Arms reached an average of 19 ha and 6 ha, respectively (Appendix D, Table D4). For moderately dense ribbons (Class B2), the annual rate of reduction is 3 ha in Finlay Arm, 2 ha in Parsnip Arm, and 0.2 ha in Peace Arm.

The extents of low-density ribbons (Class B1) and scattered woody debris on flats (Class BF) have increased between 2009 and 2018 in all sectors. A significant part of this increase could simply be an artefact of better spatial resolution of the newer set of aerial photographs. In all cases, scattered debris should be considered to be more an indication of displacement of debris, since these classes do not represent significant wood volumes overall.

The monitoring period is also characterized by debris removal activities, mainly in Finlay Arm East and Parsnip Arm East, although there were also debris removal activities noted in Finlay Arm West and Parsnip Arm West. Debris removal was also observed in a few sites in Peace Arm, mainly close to the W.A.C. Bennett Dam. Map 1 in Appendix C depicts the main zones where debris removal was most obvious on the newer set of air photos.

The monitoring period of 2009 to 2018 is also characterized by a reduction in the extent of forest stands. Through 2018, 104 ha (18%) of downed wood forests have been lost, and 173 ha (9%) of forest stands have been lost by erosion and shoreline regression, or converted to downed wood forests. Map 2 and Map 3 illustrate the zones where the extent of downed wood forest increased and where significant erosion processes occurred in the Williston reservoir.

Table D5 in Appendix D contains a series of graphs by sector that better illustrate the various changes in each type of woody debris and forest stand in the reservoir.

6.3.2 Changes in Volume of Woody Debris between 2009 and 2018

The effects of changes in areas described in the previous sections are more evident when assessed by wood volumes. In total, a woody debris reduction of 316,009 m³ is indicated by the disappearance of dense and the moderately dense ribbons, beached or floating (Classes B3, B2, F3, and F2) (Table 3 and Table D3). Almost 73% of this reduction occurred in Finlay Arm, and 27% in Parsnip Arm.

The loss of forest stands represents a reduction of 54,620 m³ (6,069 m³/yr). This volume, however, contributes to the increase of woody debris on the beaches, and is automatically included when mapping the beached debris. This is particularly the case for stands with downed wood, and also for forest stands downed and subsequently removed by erosion.

A reduction of an average of 35,112 m³ occurred annually in dense ribbons (Class B3), an annual average of 3,761 m³ in moderately dense ribbons (Class B2), and an annual average of 1,472 m³ in floating debris trapped in narrow bays (Classes F1, F2, and F3). These values correspond to an annual reduction of 6% of dense and moderately dense ribbons (Classes B3 and B2) in Finlay Arm (Appendix D, Table D4). The same ratio is observed for floating debris in Finlay Arm. For Parsnip Arm, the annual reduction is almost 5% for Classes B3 and B2, and about 7% for floating debris.

The Peace Arm has had an overall increase of 9,489 m³ (1,054 m³/yr), concentrated in dense ribbons (Class B3). The reduced extent of moderately dense ribbons (Class B2) is not sufficiently intensive to counteract this trend, since it results in a reduction of only 1,203 m³ of woody debris (-134 m³/yr). The graphs presented in Appendix D, Tables D5 to D15 depict more clearly changes in the various types of woody debris and forest stands for each sector.

Much of the reduction in woody debris is a direct result of the harvesting program that took place during the monitoring period, and that is still active. Table D15 in Appendix D presents the amounts that are removed annually (approximately 20,000 m³/yr) through this program, based on indicators observable on 2018 air photos (see Map 1, Appendix C). This value is considered conservative, as it was not possible to include the amounts of woody debris that could have been deposited between 2009 and 2018, and that have been removed in the meantime. In addition, a precautionary approach was applied by retaining only those areas where the actions of the harvest program could be confirmed with certainty. This average value of 20,000 m³/yr seems representative, however, based on the BC Hydro log book (Table 6). These data give an annual average of about 21,656 m³/yr, after applying a factor of 0.65 to the original values to convert the apparent staked volumes to actual logged cubic metre values.

Table 6 Volumes of Woody Debris Harvested between 2009 and 2018 (data: BC Hydro)

Calendar year	Volumes of woody debris removed (m ³) ^a									
	2009 ^b	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Notes/Location			No report			Amount piled	Amount piled	Amount piled	Amount piled	Amount piled
Finlay Reach total	439	439		3 250						
Parsnip Reach total						4 550				
Moody (N and S)							753	5 163	21 260	14 684
Lafferty							3 506	13 702		
Collins Bay							1 814	3 260		2 217
TKD Beach				6 500	3 250		1 170	2 194	4 823	4 706
Billy's Bay								156	2 298	
Raspberry Harbroure						10 400		5 260		
Bob Fry (N and S)						3 900				
Chaunumon						3 900				9 302
Chowika					780					
Middle Creek South									21 021	
Bruin										5 382
Ole Creek/Stromquist										5 509
Corless (A, B, and C)										7 149
Bevel									28 777	
Davis South									10 608	
Van Somer									4 440	
Annual total (m³)	439	439	0	9 750	4 030	22 750	7 243	29 735	93 227	48 949
Cumulative total (m³)	439	878	878	10 628	14 658	37 408	44 651	74 386	167 613	216 562
									Annual average (m ³ /yr):	21 656

a: the original values obtained from BC Hydro were converted to solid m³ by using a conversion factor of : 0.65 (apparent stacked m³ to solid m³)

b: TOR was approved March 23, 2009

Work began on land based operations May 2009 (F10)

6.4 Analysis of Woody Debris Trends between 2009 and 2018

6.4.1 Dynamics

Table 7 and Table 8 present changes that occurred in the various types of debris and forest stands between 2009 and 2018. The column “in 2009” corresponds to the type that was mapped at that time. The columns A to T list the new type observed in 2018, with the affected area in ha (Table 7) and in percentage (Table 8). In this section we describe the percentage changes to provide a better understanding of the dynamic that has occurred. These percentages correspond to the ratio of new areas covered by a given type (row) in 2009.

- The most significant changes in the amounts of woody volumes concern dense ribbons (Class B3). For Finlay Arm East, about 30% of dense woody ribbons (Class B3) (row 103, Table 8) remained unchanged (junction between row 103 and column C).
- 31% have been harvested as part of the debris removal program (row 103 and columns E and F).
- Indicators of natural displacement of the existing dense debris have been observed, given that 16% of the former piles were converted to lower density ribbons (Classes B1 and B2) (row 103; columns A and B). Of those classes, 22% have been removed entirely (103-D and 103-J).
- 49% of the area eroded has been converted from forest stands out of the reservoir to bare flats (cell 116-R).
- 28% of the region affected by erosion is now covered by moderately dense ribbons (cell 116-B).
- 13% of the region affected by erosion now contain dense ribbons (116-C).
- 11% of the eroded zone was deposited with low-density ribbons (116-A).
- 17% of areas lost to dense downed wood stands are now covered with dense debris (111-C).
- 10% of lost moderately dense ribbons, and 6% of the lost low-density ribbons observed, have been converted to dense ribbons (cells 102-C and 101-C).

The dense ribbons were slightly less modified in Finlay Arm West, compared to the Finlay Arm East. In this sector, 36% of the existing dense ribbons remained unchanged (119-C). 17% have been harvested (cells 119-E and 119-F), and 28% have been almost completely removed by natural processes (cells 119-D and 119-J). The conversion of dense, downed-wood forests was less intensive in area, but a higher proportion has been converted to low-density ribbons (43%) (128-A) and moderately dense ribbons (34%) (128-B). 59% of the lands above the limit of the reservoir that have been eroded are now bare flats (133-R), while 41% have received new debris ribbons (133-A, 133-B and 133-C). Most of the time, these ribbons are composed of the original trees that now lie on the ground and point toward the reservoir (Figure 7).

At Parsnip Arm East, a similar trend is observed with dense debris ribbons (row 136), except that they have not been subjected to as many human-made removal activities as those observed at Finlay Arm. Indeed, 37% of the dense ribbons existing in 2009 are unchanged. 28% of those sites are now bare soils, while the density has been reduced by 27%, transferring 10% of the affected sites to low-density ribbons (136-A), and 17% to moderately dense ribbons (136-B). Once again, shoreline erosion is observed in that sector. Mostly, the area added to the reservoir appears as bare flats with little woody debris likely introduced from these areas (150-R). The debris removal programme accounts for 3% to 5% of the loss observed in the beached debris (134-E, 134-F, 135-E, 135-F, 136-E, and 136-F). Most of the time, however, the affected areas in the woody debris have become bare soils (134-J, 135-J, and 136-J). On

the other hand, any increased extent observed resulted from the conversion of forest stands with downed wood.

At Parsnip Arm West, most of the wood ribbons have been converted to one of the other classes in the same group or converted to bare beach, similarly observed in other areas. For dense ribbons, 34% remain unchanged (cell 153-C), while 21% were converted to moderately dense ribbons and 7% to low-density ribbons (cells 153-B and 153-A). Around 5% was harvested (cells 153-D and 153-E), and 32% was washed out (cell 153-J). Among forest stands, by area, it is mainly those with low amounts of downed wood that have been converted to ribbons of woody debris. Finally, the reservoir has claimed 27 ha by erosion of lands outside of its limit. The downed trees have formed moderately dense ribbons over 34% of the eroded area (167-B).

The transformation of woody ribbons was less intensive in Peace Arm North compared to other sectors. Indeed, 53% remained unchanged (170-C), and only 25% was entirely washed out (170-J). About 1% has been harvested as part of the removal program, while some was partly reworked by wave action and reservoir level fluctuation (?), resulting in their conversion, 13% to moderately dense woody ribbons, and 8% to low-density ribbons (cells 170-B and 170-A). In terms of area, 19 ha have been reworked and converted, at 64%, to bare soils (181-R). Low density ribbons have been accumulated in 21% of this zone (181-A). The remaining 12% and 3% are now covered by moderately dense woody ribbons and dense woody ribbons (181-B and 181-C).

The same areal extent of woody ribbons is modified in Peace Arm South, compared with the northern sector (around 46 ha in both sectors; Table 8), though these ribbons are transformed more intensively: only 28%, 29%, and 25%, respectively, of the Classes B1, B2, and B3 remained unchanged (cells 182-A, 182-B and 182-C). In dense ribbons, the changes have consisted mainly of a decrease of density and, therefore, in their conversion to moderately dense ribbons (37%) (cell 184-B) and low-density ribbons (13%) (cell 184-A). By contrast, several ribbons in these two classes were completely reworked, totalling 60% of low-density ribbons (182-J) and 38% of moderately dense ribbons (183-J).

Reservoir shoreline erosion claimed an upland area of 256 ha between 2009 and 2018 (Appendix D, Table D4). Based on the relative extent of the various forest stands along the reservoir, and based on their standing stock (Table 4), an average of 2,045 m³ of woody debris was added annually in the form of accumulated piles and ribbons along the coast. The maximum amount would have been 5,680 m³ if only very dense forest stands were affected.

6.4.2 Woody Debris Source Estimates

Table 9 presents a summary of debris source trends between 2009 and 2018.

Among potential contributors of woody debris directly influenced by the reservoir operations, shoreline erosion was the predominant contributor to woody debris amounts. AECOM TecSult (2010) did not identify any blowdown areas that could be a potential source of debris. Any input to the reservoir from windfall would be isolated events and not significant. Boomed shipping of logs within Williston Reservoir was once common, but has become quite uncommon now. If booming and log storage resume in the future, the risk of debris contribution could be easily controlled. Slopes that exceed 20 degrees directly facing the reservoir may be subject to landslides and contribute debris (AECOM TecSult 2010). Such slopes are found only in the Peace Arm area. In the event of landslides, woody debris would be bound up in large volumes of non-woody debris in the short term. Landslides in harvested terrain do not contribute appreciable amounts of woody debris, as little or no logging is being conducted on the upland slopes along Peace Arm, and no trace of slippage into the reservoir directly arising from logging operations has been identified.

Overall, annual inputs of new woody debris from onshore sources have declined significantly, from an estimated 13,200 m³ in 2009 to 2,045 m³ in 2018. The 2009 estimate was based off of an observed amount of erodible shoreline 1,320 km with an estimated 1 m of shoreline erosion per year resulting in

132 hectares eroded. The eroded area was estimated to contribute 100 m³ per hectare of woody debris. This estimate was considered to be on the higher end which the 2018 calculation demonstrates. Between 2009 and 2018, just over 28 hectares eroded per year with an average of 72 m³ per hectare contributed to the woody debris in the reservoir. In 2009 an estimate wasn't provided for converted stands and was passively assumed to be within the shoreline erosion category. In 2018, with the ability to calculate the change in conversion of forest stands an average of 2,807 m³ are contributed to the debris in the reservoir. The only identified source of woody debris unrelated to the reservoir operation is tree fall occurring near the mouths of tributaries, which is estimated to have remained at about 2,200 m³.

6.4.3 Debris Trends

From the analysis of Table 7 and Table 8, and Maps 1 to 8, the following trends are observed:

- About 20,000 m³ to 21,700 m³ of woody debris is recollected annually as part of the removal program (Table 6 and Appendix D, Table D15) (Figure 8). This program is very effective at reducing the amounts of woody debris in the reservoir, as it can be observed when comparing Maps 6 and 7, along with the location of the main areas of harvesting (Map 1). This positive effect is particularly obvious for the dense woody ribbons, since those contain most of the volume of wood in the reservoir.
- Reservoir shoreline erosion is greater in Finlay Arm West (Figure 9) and Parsnip Arm West, than along other parts of the reservoir shoreline, although it also affects the eastern parts of those arms (Map 3). Erosion is much less prevalent in Peace Arm, except for the portion between Dunlevy Creek and the dam, on the north side. On average, the shoreline retreats annually by 0.04 m to 0.28 m (Table 10), but the retreat is variable: several sites have retreated by 50 m to 100 m (Figure 9), while other zones have remained unaffected. In total, forest loss due to shoreline erosion processes generates about 2,000 m³ of woody debris per year, considering the types and extent of forest stands along the impacted sections of the reservoir.
- Amounts harvested annually through the debris removal program are much larger than recruitment from the fallen forest stands.
- Recruitment of woody debris is strongly related to the fall of stands that already have large numbers of stems on the ground (Figure 10). These stands represent an annual volume of about 4,400 m³ (Appendix D, Table D13). This amount is larger than recruitment from shoreline erosion, though the woody debris does not immediately move along the shoreline, as occurs for the eroded areas. Recruitment of woody debris does not appear in Table 7 as the volumes are derived from shoreline erosion and converted stands.
- Analysis of changes that occurred for each type of woody debris, as presented in Appendix D, Table D7 and Table D8, and as illustrated in Maps 4a and 4b, indicates that woody ribbons stranded on beaches are frequently reworked by natural agents. The zones where stock increases are observed remain mixed with neighbouring sites where the stranded debris is decreasing. Maps 5a and 5b illustrate changes related to shoreline erosion. The overall pattern remains that the migration of woody debris appears to be relatively minor, but sufficient to generate net differences when comparing the 2009 and 2018 map layers.
- Time sequence photography at regular annual or bi-annual intervals would be needed to identify patterns of arrival and movement of woody debris in the reservoir. The shape of the shoreline and debris deposition potential would also need to be considered, as there may be a significant difference between the point of arrival of a log and its entanglement along the shore (Figure 11). Nevertheless, several sources of woody debris can be identified by considering sites where notable increases of woody debris are observed (Map 4a), along with the increase of downed trees in forest stands (Map 2), where erosion regression is occurring (Map 3), and the location of main tributaries:
 - o Finlay River (Finlay Arm), Pesika Creek (upper head of Finlay Arm East), Mesilinka and Osilinka Rivers (Omineca Arm connecting Finlay Arm West and Parsnip Arm West), Manson River (Manson Arm within Parsnip Arm West), and Ospika River (Ospika Arm within Finlay Arm East) are main contributors of new logs in the reservoir (Figure 12, Figure 13, Figure 14 and Figure 15); though no data are available for quantifying the amounts of debris that could arrive from the tributaries, the estimate of 2,200 m³ that was presented in the baseline study by AECOM TecSult (2010) is consistent with current observations.

- The rate of debris recruitment from Parsnip River and Pack River appears to be less important than arrivals from Finlay River (Figure 16).
- The sub-watersheds of Peace Arm contribute less debris than those of Finlay and Parsnip Arms and, therefore, the rate of recruitment of wood logs from tributaries there is much lower. Floating debris could arrive from other arms, but the rate of transportation appears slow. An important agglomeration of dense floating debris is observed close to the dam, at the end of Peace Arm North. Debris removal activities are performed here (Figure 11).
- The debris removal program has targeted most major sites of debris accumulation with efficiency. Comparison of Maps 6 and 7, along with the location of the main sites of removal activities (Map 1), confirms the positive effects of this program.
- As the reservoir is constantly receiving new debris from its tributaries, shoreline erosion, and degradation of forest stands with felled forests, maintaining the debris removal program for the foreseeable future will continue to have beneficial effects, although the pace may be gradually reduced. In any case, it is recommended that sites already cleaned be revisited after a few years, as their configuration favours accumulation of woody debris (Figure 17), and it is most efficient to concentrate efforts on sites with the highest density of woody debris.
- Maps 8 and 9 illustrate major sites of woody debris accumulation in 2009 and 2018. The second map could be used to guide the planning of further debris removal activities. For instance, the program already performed in Omineca Arm should be maintained. Several areas already covered in the Finlay East Arm should be re-visited as new woody debris has been deposited. The upper head of Ospika Arm (Finlay Arm East) could be addressed, but accessibility is difficult where main debris is concentrated. Debris removal activities in Finlay Arm West could be extended to areas close to Chunamon Creek, as that region contains several large areas of dense woody debris (Class B3) accumulation zones.

Table 7 Total changes in Volume between 2009 and 2018

Sector	Row	Column: in 2009 ↓	New type and extent in 2018 (ha)																						
			A B1	B B2	C B3	D BF	E BH	F BM	G F1	H F2	I F3	J RN	K RR	L S1	M S2	N S3	O SD	P SL	Q SM	R TE	S XI	T XS			
Finlay Arm East	1	B1	18.2	5.3	3.4	5.5	6.8	0.4	0.2	0.0		15.7	0.2												
	2	B2	16.2	39.5	12.8	5.8	22.7	3.1	0.3	0.4	0.4	26.0	0.3								0.0				
	3	B3	12.4	21.7	64.2	13.2	60.6	7.1	0.2	0.2	0.8	34.4	0.0												
	4	BF	2.2	0.6	0.9	205.7	4.9	0.0	0.0			27.2	0.0												
	5	F1	0.0				0.2			1.4	0.1	0.0	1.5												
	6	F2	0.0	0.0						0.1			0.8												
	7	F3	0.5	0.1	0.3	0.1	1.5			0.2	0.9	1.7	1.6												
	8	RN	27.8	30.0	24.9	80.6	0.8	0.3	0.2	0.4	0.3	41 775	0.0										3.8		
	9	S1	2.3	2.1	2.0	4.1	0.8	0.0				3.3	0.1	42.6	1.1								0.4		
	10	S2	1.9	1.0	0.8	0.6	0.0					0.9		7.8	21.8	0.7							0.2		
	11	S3	4.0	1.6	1.9	0.2	0.1					0.1			0.3	3.1							0.0		
	12	SD	0.0	0.0	0.1							0.0					32.4						0.1		
	13	SL	1.0	1.3	1.5	0.4	0.2			0.1		1.6	0.0	7.8	1.0	0.1		279.7					1.9		
	14	SM	0.3	0.5	0.2	0.0								0.2	1.1	0.2					119.8		3.5		
	15	XI	0.0	0.0																			0.0	60.9	
	16	XO	1.2	3.2	1.5						0.0												5.5		

Sector	Row	Column: in 2009 ↓	New type and extent in 2018 (ha)																				
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
			B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS	
Finlay Arm West	17	B1	20.0	4.8	3.1	3.6	5.7	0.2	0.1	0.0											0.3		
	18	B2	31.7	46.1	12.6	3.7	6.0	1.1	0.2	0.1												2.3	
	19	B3	9.2	23.4	59.1	4.5	24.8	3.7		0.0	0.1											0.2	
	20	BF	0.5	0.6	0.4	35.2	0.5															0.1	
	21	BM		0.0	0.0		0.1	0.0															
	22	F1	0.0			0.1			0.5	0.0					3.4								
	23	F2			0.1	0.1	0.0		0.1	0.1					7.0								
	24	F3									0.7				0.2								
	25	RN	30.6	26.0	10.3	35.1	1.6	0.4	0.7	0.1	0.4				35 977	0.2						7.5	
	26	S1	5.0	8.2	3.1	3.5	1.6		0.0						7.8	0.4	151.5	8.1				3.9	
	27	S2	4.5	1.4	1.0	0.3	1.1								4.0	0.0	0.6	23.0	1.6			0.3	
	28	S3	2.1	1.6											0.1			1.0					
	29	SD		0.4	0.0										0.0		0.0		17.2			1.0	
	30	SL	2.0	3.7	2.7	0.1	0.2	0.0	0.0	0.1					1.1	0.7	10.9	1.6		422.0	6.1	8.7	
	31	SM	0.7	1.4	0.4				0.0		0.0				4.3	0.9	1.3	1.8		231.6		5.6	
	32	XI	0.1	1.4	0.0		0.0								0.0							2.7	156.8
	33	XO	2.5	9.0	2.6				0.0						0.1							20.6	

Sector	Row	Column: in 2009 ↓	New type and extent in 2018 (ha)																				
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
			B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS	
Parsnip Arm East	34	B1	8.9	3.6	1.9	3.3	2.5	0.0	0.0	0.0													
	35	B2	12.0	22.3	10.4	1.4	2.2	0.4	0.0	0.0	0.0												0.1
	36	B3	5.8	10.6	22.2	1.8	2.5	0.9	0.1														
	37	BF	2.0	0.2	0.3	18.3	0.2																
	38	BM	0.0	0.0	0.0		0.1	0.1															
	39	F1	1.3	0.2	0.0	0.5	0.1		2.1	0.0	0.0				8.4								
	40	F2	0.5	0.3	0.0	0.0			0.1	0.1					1.3								
	41	F3	0.1	0.1	0.2	0.2			0.0						0.8								
	42	RN	31.9	28.6	14.2	34.5	0.2	0.3	0.4	0.2	0.0				24 602	0.0				0.5	0.0	0.4	
	43	S1	1.4	0.5	0.4	0.3	0.0	0.0							1.0	0.0	16.1	0.6					
	44	S2	3.2	1.7	0.6	2.0	0.0		0.1	0.0					4.7		3.7	4.2					
	45	S3	0.2	0.5	0.2	0.2									0.4		0.1						
	46	SD	0.1	0.4	0.0										0.1					6.2			
	47	SL	0.3	0.4	0.1	0.1	0.0	0.0							1.6	0.0	6.7	0.3		117.1			
	48	SM	0.1	0.5	0.1			0.0							0.3		0.0	0.5		44.5		0.3	
	49	XI	0.3	0.3	0.0			0.0														0.6	839.3
	50	XO	1.8	3.5	0.5				0.9						0.1							11.4	

Sector	Row	Column: in 2009 ↓	New type and extent in 2018 (ha)																				
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
			B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS	
Parsnip Arm West	51	B1	15.1	6.8	2.5	5.0	0.9	0.0	0.0	0.0												0.0	
	52	B2	16.9	40.7	13.6	4.4	1.9	0.3	0.1	0.1												0.0	0.0
	53	B3	8.3	25.2	40.2	4.0	2.5	0.0	0.0	0.4	0.0											0.0	
	54	BF	1.1	0.3	0.6	82.4																0.0	
	55	BM					0.0																
	56	F1	0.1	0.2		0.1			0.7						1.6								
	57	F2		0.0	0.0	0.0			0.1	0.1					0.3								
	58	F3	0.0	0.4	0.3	0.1			0.0	0.1	0.1				0.7								
	59	RN	40.0	43.8	11.9	95.3	0.7	0.1	2.5	0.6	0.1				36 482	1.8						0.3	0.0
	60	S1	7.2	3.2	1.4	9.2		0.0							15.2	0.1	83.6	8.4	1.4			0.6	
	61	S2	5.2	3.5	1.7	4.6			0.0	0.0					7.4	0.2	5.2	27.0				0.6	
	62	S3	3.6	1.7	0.1	1.1									2.1		0.1					0.3	
	63	SD	0.2	0.9	0.1	0.0									0.2		0.0			17.4		0.4	
	64	SL	2.8	1.8	0.6	3.3	0.0	0.0							30.0	0.7	25.2	1.3		244.0		3.6	0.0
	65	SM	1.2	1.2	0.2				0.0	0.0					6.2	0.1	2.2	0.3	0.0	0.2	167.3	1.7	
	66	XI	0.1	0.3	0.0			0.0							0.2	0.1	0.1					0.6	93.2
	67	XO	3.8	9.0	0.8	0.0					0.0				0.9							12.0	

Sector	New type and extent in 2018 (ha)																					
	Row	Column:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
	in 2009 ↓	B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS	
Peace Arm North	68	B1	3.4	2.0	0.2	0.0	0.0	0.0		0.0												
	69	B2	4.0	4.1	2.1	0.2	0.1															
	70	B3	0.6	1.0	4.0						0.0											
	71	BF	0.0			0.2																
	72	F1																				
	73	F3									2.5											
	74	RN	20.3	9.7	4.8	0.8		0.1	0.2	0.1	0.3	17174									0.0	
	75	S1	0.0	0.1	0.0							0.1		0.1								
	76	S2											0.0									
	77	SD	0.0	0.0	0.0												2.3					
	78	SL	0.2	0.1	0.1	0.2			0.0			0.5						2.8				
	79	SM	0.0	0.0	0.0							0.0							3.3			
	80	XI	0.0	0.0																	0.0	0.6
81	XO	4.0	2.2	0.6	0.0															12.2		

Sector	New type and extent in 2018 (ha)																					
	Row	Column:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
	in 2009 ↓	B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS	
Peace Arm South	82	B1	4.0	1.3	0.1	0.3					8.6											
	83	B2	5.1	7.5	2.7	0.1	0.6	0.2			9.9											
	84	B3	0.7	2.1	1.4	0.1	0.1	0.0			1.2											
	85	BF	0.1	0.0	0.0	0.7					1.8											
	86	F1									0.7											
	87	RN	23.3	14.4	3.6	2.4		0.1	0.1		16904										0.0	
	88	S1	0.1	0.2	0.0						0.2		1.2	0.0								
	89	S2	0.1	0.1	0.1	0.0					0.3		0.0	0.7								
	90	SD															0.9					
	91	SL	0.3	0.1	0.0	0.0					0.2		0.7	0.0				4.0				
	92	SM	0.0	0.1	0.0						0.1		0.4	0.1					2.6			
	93	XI																			0.2	
	94	XO	2.3	1.1	0.1	0.1		0.1													4.5	

Table 8 Relative Percentage Volume Changes between 2009 and 2018

Sector		New type and extent in 2018 (ha)																					
		Column:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
		Row:	in 2009 ↓	B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS
Finlay Arm East	101	B1	33%	10%	6%	10%	12%	0.7%	0.4%					28%	0.4%								
	102	B2	13%	31%	10%	5%	18%	3%	0.2%	0.3%	0.3%	20%	0.2%										
	103	B3	6%	10%	30%	6%	28%	3%	0.1%	0.1%	0.4%	16%											
	104	BF	0.9%	0.3%	0.4%	85%	2%																
	105	F1	0.3%				6%			43%	3%	1%	47%										
	106	F2	2%							11%		87%											
	107	F3	7%	0.9%	5%	2%	21%			3%	14%	25%	24%										
	108	RN	0.1%	0.1%	0.1%	0.2%						100%											
	109	S1	4%	4%	3%	7%	1%					6%	0.2%	72%	2%							0.6%	
	110	S2	5%	3%	2%	2%	0.1%					2%		22%	61%	2%						0.4%	
	111	S3	36%	14%	17%	2%	1%					1%			2%	28%							
	112	SD		0.1%	0.2%							0.1%					100%					0.2%	
	113	SL	0.3%	0.4%	0.5%	0.1%	0.1%					0.5%		3%	0.3%		94%					0.6%	
	114	SM	0.2%	0.4%	0.1%							0.1%		0.9%	0.2%					95%	3%		
	115	XI																				0.1%	100%
	116	XO	11%	28%	13%																	49%	

Sector		New type and extent in 2018 (ha)																					
		Column:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
		Row:	in 2009 ↓	B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS
Finlay Arm West	117	B1	33%	8%	5%	6%	9%	0.3%	0.1%				38%	0.1%							0.4%		
	118	B2	24%	35%	10%	3%	5%	0.8%	0.1%	0.1%		21%	0.1%								2%		
	119	B3	6%	14%	36%	3%	15%	2%				25%	0.1%								0.1%		
	120	BF	0.7%	0.8%	0.6%	49%	0.7%					48%	0.2%									0.1%	
	121	BM					88%	13%															
	122	F1	0.5%			2%				12%		86%											
	123	F2			1%	0.8%	0.1%			1%	2%	95%											
	124	F3										80%	20%										
	125	RN	0.1%	0.1%		0.1%						100%											
	126	S1	3%	4%	2%	2%	0.8%					4%	0.2%	78%	4%							2%	
	127	S2	12%	4%	3%	0.7%	3%					11%	0.1%	2%	61%	4%						0.7%	
	128	S3	43%	34%								2%					21%						
	129	SD		2%	0.1%									0.2%			92%					5%	
	130	SL	0.4%	0.8%	0.6%							0.2%	0.2%	2%	0.3%			92%	1%			2%	
	131	SM	0.3%	0.6%	0.2%							2%	0.4%	0.5%	0.7%					93%	2%		
	132	XI	0.1%	0.9%																		2%	97%
133	XO	7%	26%	8%				0.1%					0.2%								59%		

Sector		New type and extent in 2018 (ha)																					
		Column:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
		Row:	in 2009 ↓	B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS
Parsnip Arm East	134	B1	19%	8%	4%	7%	5%	0.1%				58%											
	135	B2	16%	30%	14%	2%	3%	0.5%				35%			0.2%								0.1%
	136	B3	10%	17%	37%	3%	4%	2%		0.1%		28%											
	137	BF	5%	0.6%	0.8%	48%	0.4%					45%	0.1%										
	138	BM	7%	11%	7%		54%	21%															
	139	F1	11%	2%	0.1%	4%	0.5%			17%	0.2%	66%											
	140	F2	21%	14%						4%	5%	56%											
	141	F3	6%	10%	11%	15%				0.7%		57%											
	142	RN	0.1%	0.1%	0.1%	0.1%						100%											
	143	S1	7%	2%	2%	2%	0.2%	0.1%						5%	79%	3%							
	144	S2	16%	8%	3%	10%	0.1%		0.3%			23%		18%	21%								
	145	S3	13%	30%	16%	10%						27%		4%									
	146	SD	1%	5%	0.6%							2%					91%						
	147	SL	0.3%	0.3%	0.1%							1%		5%	0.2%			93%					
	148	SM	0.3%	1%	0.2%							0.5%		0.1%	1%					96%			0.6%
	149	XI																				0.1%	100%
150	XO	10%	19%	3%				5%					0.5%								63%		

Sector	Row	Column: in 2009 ↓	New type and extent in 2018 (ha)																			
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
			B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS
Parsnip Arm West	151	B1	26%	12%	4%	9%	2%					49%										
	152	B2	14%	34%	11%	4%	2%	0.3%				35%										
	153	B3	7%	21%	34%	3%	2%			0.3%		32%										
	154	BF	0.8%	0.3%	0.5%	64%						34%	0.5%									
	155	BM						100%														
	156	F1	4%	6%		3%			25%			62%										
	157	F2			3%					14%	14%	70%										
	158	F3	1%	22%	17%	5%			2%	6%	4%	43%										
	159	RN	0.1%	0.1%		0.3%						100%										
	160	S1	6%	2%	1%	7%						12%		64%	6%	1%					0.4%	
	161	S2	9%	6%	3%	8%						13%	0.3%	9%	49%						1%	
	162	S3	40%	19%	0.7%	12%						24%		1%							3%	
	163	SD	1%	5%	0.4%	0.1%						1%		0.2%			90%				2%	
	164	SL	0.9%	0.6%	0.2%	1%						10%	0.2%	8%	0.4%			78%			1%	
	165	SM	0.7%	0.7%	0.1%							3%	0.1%	1%	0.1%			0.1%	93%		0.9%	
	166	XI	0.1%	0.3%									0.2%	0.1%	0.1%						0.6%	99%
	167	XO	14%	34%	3%	0.2%					0.1%			3%							45%	

Sector	Row	Column: in 2009 ↓	New type and extent in 2018 (ha)																			
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
			B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS
Peace Arm North	168	B1	19%	12%	1%	0.1%	0.2%	0.1%		0.2%		68%										
	169	B2	19%	20%	10%	0.9%	0.3%					50%										
	170	B3	8%	13%	53%						0.4%	25%										
	171	BF	2%			19%						79%										
	172	F1										100%										
	173	F3									100%											
	174	RN	0.1%	0.1%								100%										
	175	S1	11%	32%	5%							22%			30%							
	176	S2											100%									
	177	SD	0.4%	2%	0.9%											97%						
	178	SL	4%	2%	2%	5%			0.3%			13%					73%					
	179	SM		0.3%	0.9%													99%				
	180	XI		5%																	96%	
	181	XO	21%	12%	3%															64%		

Sector	Row	Column: in 2009 ↓	New type and extent in 2018 (ha)																			
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
			B1	B2	B3	BF	BH	BM	F1	F2	F3	RN	RR	S1	S2	S3	SD	SL	SM	TE	XI	XS
Peace Arm South	182	B1	28%	9%	0.9%	2%						60%										
	183	B2	20%	29%	10%	0.5%	2%	0.6%				38%										
	184	B3	13%	37%	25%	1%	3%	0.5%				21%										
	185	BF	4%	1%	2%	27%						66%										
	186	F1										100%										
	187	RN	0.1%	0.1%								100%										
	188	S1	8%	11%	2%							13%		65%	2%							
	189	S2	5%	10%	5%	2%						25%			50%							
	190	SD														100%						
	191	SL	6%	1%	0.6%	0.4%						4%		13%	0.7%			74%				
	192	SM	0.6%	2%	1%							3%		11%	4%			79%				
	193	XI																			100%	
	194	XO	28%	14%	1%	0.6%		0.9%												56%		

Table 9 Debris Source Summary, 2009 and 2018

Source	Annual Volume Estimate (m ³)	
	2009	2018
<i>Direct Influence of Reservoir Regime</i>		
Tree Blowdown along the Shoreline	Negligible	Not applicable
Log Boom Losses	Negligible	Not applicable
Reservoir Slopes	Negligible	Not applicable
Slides in Harvested Terrain	Negligible	Not applicable
Shoreline Erosion	13,200	2,045
Converted Stands	Not calculated	2,807
<i>Unrelated to Reservoir Regime</i>		
Tributary Streams	2,200	2,200
Total Volume	15,200	7,052

Table 10 Estimated Volume of Recruitment of Woody Debris Resulting from Shoreline Erosion

Sector	Shoreline (km) ^a	Eroded area (ha)		Average retreat of the coast line (m)	Average annual recruitment of woody debris from forest stands (m ³) ^b	Maximum annual recruitment of woody debris from forest stands (m ³) ^c
		2009-2018	Annual			
Finlay Arm East	301	29	3.24	0.11	233	648
Finlay Arm West	351	87	9.70	0.28	698	1,939
Total	652	116	13	0.20	483	1,343
Parsnip Arm East	334	23	2.55	0.08	183	510
Parsnip Arm West	511	87	9.68	0.19	697	1,936
Total	845	110	12	0.14	494	1,372
Peace Arm North	228	20	2.23	0.10	161	447
Peace Arm South	228	9	1.00	0.04	72	199
Total	456	29	3	0.07	117	323
Total	1,953	256	28.40	0.15	2,045	5,680

a: excluding the perimeter of the temporary islands

average

b: using the average volume (m³/ha) of forest stands based on their relative occurrence in the project area: 72 m³/ha

c: using the volume (m³/ha) of dense forest stands: 200 m³/ha :from 2009 to 2018

Figure 7 Accumulation of Woody Debris from Forest Stands Downed by Erosion in Parsnip Arm West, 2018 with 2009 shoreline (in yellow).

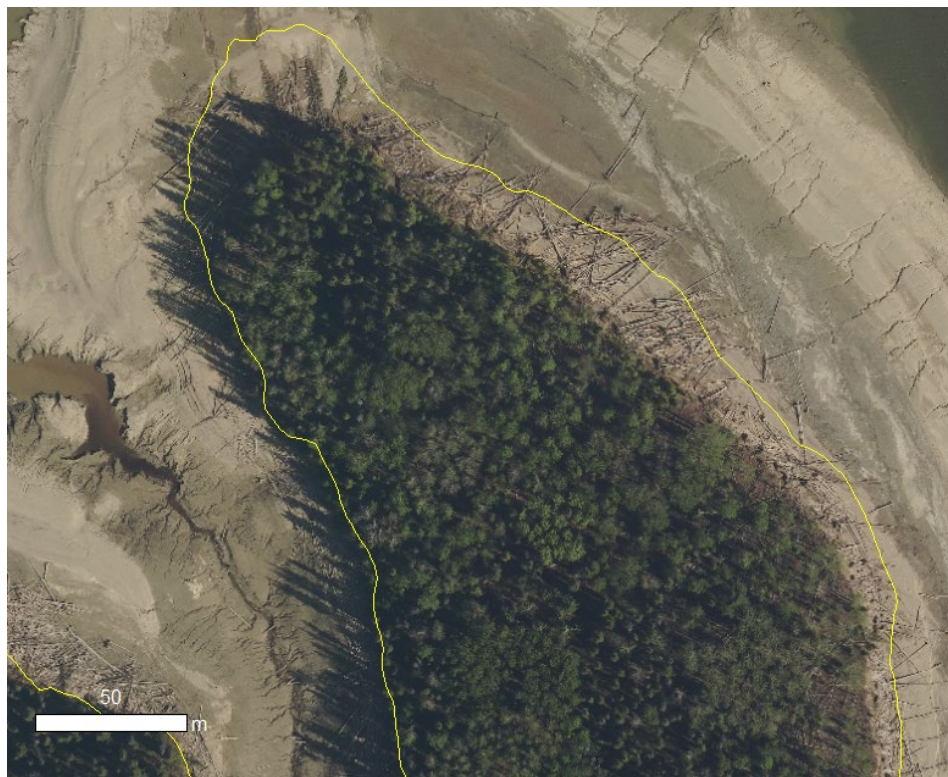


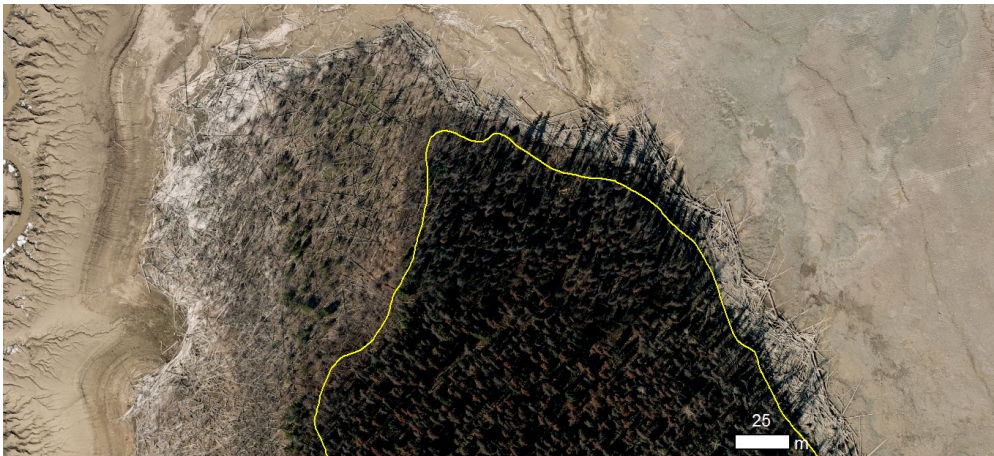
Figure 8 **Indications of Debris Removal Activities in Finlay Arm West, 2018**



Figure 9 Intensive Coastal Erosion in Finlay Arm West during the Monitoring Period with 2009 shoreline (in yellow).



2009



2011



2018

Figure 10 Gradual Degradation of Forest Stands in an Old Channel over the Monitoring Period



Figure 11 Shoreline Configuration that Favour Woody Debris Accumulation (Class B3) in the Bay Close to the Dam in Peace Arm North with 2019 shoreline (in yellow).



Figure 12 Arrival of Wood Logs from Ospika River (Ospika Arm within Finlay Arm East)



2011

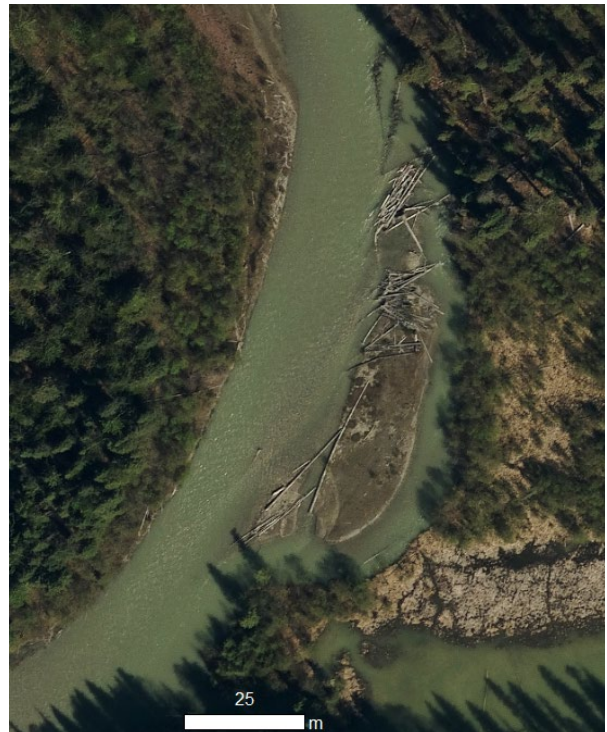


2018

Figure 13 Arrival of Wood Logs from Pesika Creek, a Tributary at the Upper Head of Finlay Arm East



2011



2018

Figure 14 **Arrival of Wood Logs from Finlay River**



2009



2011



2018

Figure 15 Woody Debris Likely to Originate from Both the Upstream Reservoir area, via the Finlay River, and from Riverbank Erosion

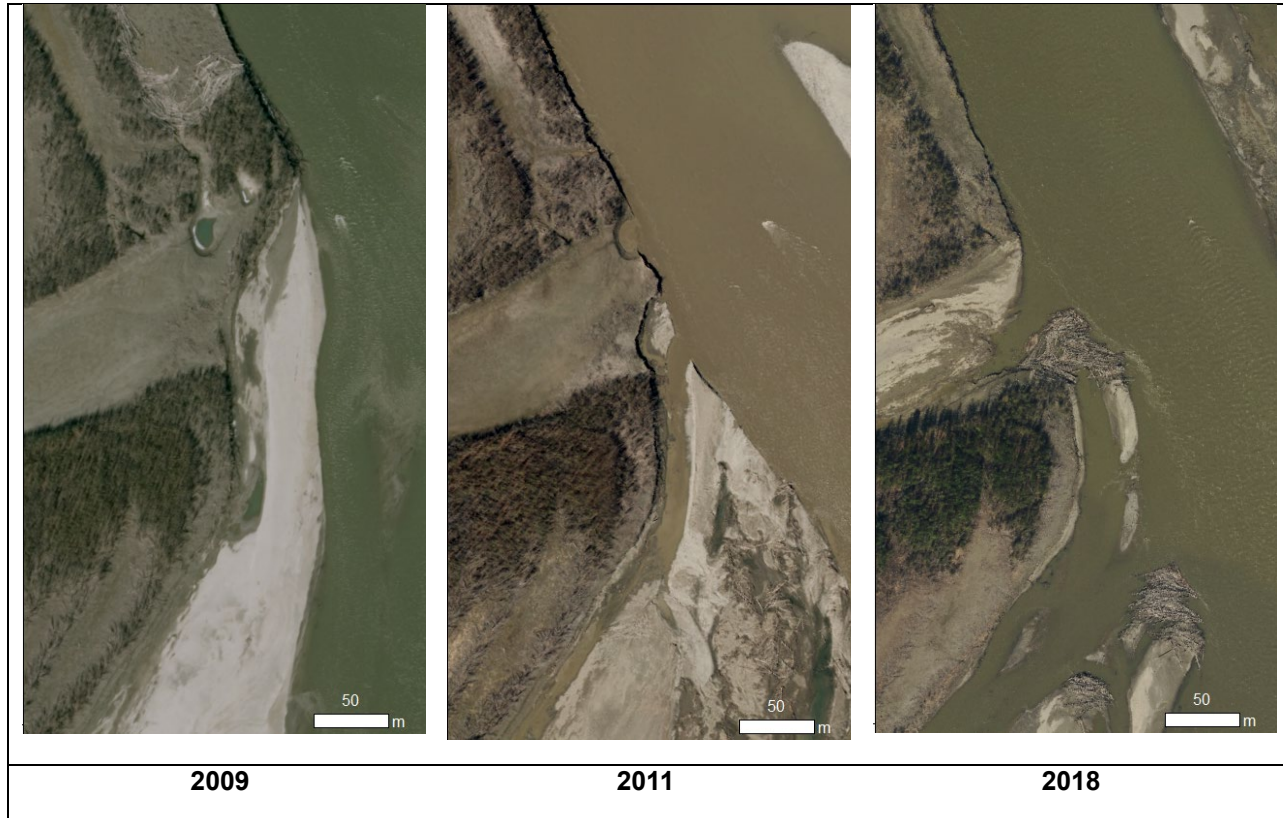


Figure 16 Arrival of Few Wood Logs from Parsnip River and Pack River with 2009 shoreline (in yellow).



2009

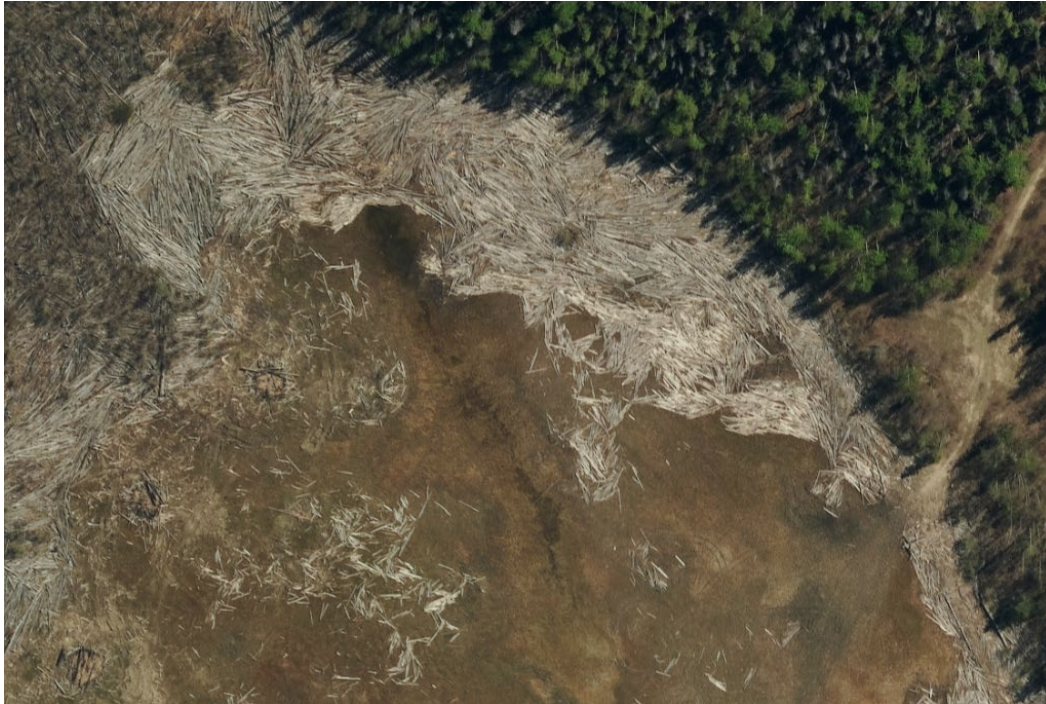


2011



2018

Figure 17 Recent Accumulation of Woody Debris in a Sector Previously Cleaned as Part of the Debris Removal Program, 2018



7. Discussion and Conclusion

Baseline imagery from 2009 has been compared to 2018 imagery through air photo interpretation to identify the dynamics of woody debris in the Williston Reservoir. Due to the superior resolution of the 2018 photographs, additional comparisons were made between the images to verify that changes recorded were not a result of the difference in resolution. Changes in areal extent (hectares) of wood debris, delineated in GIS, were calculated and verified conversion ratios were used to convert hectares to wood volume in cubic metres. The results enable a greater understanding of the dynamics of wood debris in Williston Reservoir.

In 2009, the reservoir contained an estimated 1,340,592 m³ of wood debris of all types and, by 2018, this volume was estimated at 1,067,671 m³, a reduction of 272,921 m³, or just over 20%. In 2009, Finlay Arm had the most beached woody debris, at 767,547 m³, while Parsnip Arm had 446,057 m³, and Peace Arm had significantly less, at only 65,185 m³. By 2018, the volume of beached woody debris in Finlay Arm had decreased to 532,357 m³, and also decreased in Parsnip Arm, to 371,632 m³ while Peace Arm increased slightly to 86,021 m³. Finlay Arm has the largest amount of debris, and reduction efforts through the 2009 to 2018 cleaning program were successful in reducing the dense ribbons and moderately dense ribbons. Due to the success of the cleaning program in reducing dense and moderately dense ribbons, an increase in low-density ribbons has been observed, likely due to the small debris left unremoved. This trend was also observed in the Parsnip Arm, but the Peace Arm saw an increase in dense woody debris. The increase was minimal, at just over 1,000 m³ per year, and likely due to the low amounts of debris to be found in that part of the reservoir.

Shoreline erosion is a significant process affecting the reservoir. Between 2009 and 2018, erosion regression resulted in the loss of 256 ha of upland, and resulted in an estimated average of 2,045 m³ of woody debris entering the reservoir per year. Erosion of the shoreline is not evenly distributed around the reservoir, but rather is concentrated in some areas and not apparent in others, as might be expected depending on the hydrology of the reservoir, exposure to wave action (aspect and fetch) and the nature (i.e., geology and erosion susceptibility) of the bank materials.

As the reservoir is constantly receiving new debris from tributaries, shoreline erosion, and degradation of forest stands with downed forests by natural processes, maintaining the debris removal program for the foreseeable future will continue to have beneficial effects. The reduction in amount of woody debris is evidence of the program's effectiveness in controlling woody debris on the reservoir. Sites of high potential for cleaning success should be targeted, and sites already cleaned should be revisited after a few years, as their configuration favours accumulation of woody debris.

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APPENDIX A
Classification Used to Characterize the
Large Woody Debris and Forest Stands

Table A-1 presents the classification codes and description used for mapped GIS layers of 2009, 2011 and 2018. Each classification is more fully described in the following paragraphs.

Table A-1 Classification Applied for Characterizing Woody Debris in Williston Reservoir

Code	Description
Woody debris on beach or flats	
B1	Scattered or low-density beached woody debris
B2	Moderately dense woody ribbons on beach
B3	Dense woody ribbons or piles on beach
BB	Wood bundle on beach
BF	Scattered woody debris on flats
BH	Harvested woody debris area
BM	Man-made wood stack on beach
BS	Stumps on beach
Floating or submerged woody debris	
F1	Low density floating wood logs
F2	Moderately dense floating wood logs
F3	Dense floating wood logs
FB	Floating wood bundle
FO	Floating log boom
FS	Submerged stumps
Forest stand	
S1	Low density downed wood in forest stand temporarily flooded
S2	Moderately dense downed wood in forest stand temporarily flooded
S3	Dense downed wood in forest stand temporarily flooded
SL	Low density forest stand temporarily flooded
SM	Moderately dense forest stand temporarily flooded
SD	Dense forest stand temporarily flooded
Additional types for following the dynamic of woody debris areas	
H2	Water (hiding potential woody debris area detected in the other study)
RN	Reservoir area without woody debris
RR	River (new branch cutting a former woody debris area)
TE	Eroded area







Woody debris on beach or flats (drawdown zone)

Beached debris is defined as accumulations of woody debris gathered in long ribbons or in piles along the coastline. Three classes of woody debris density are used: B1, scattered; 2) B2, moderately dense; and B3, dense. Scattered debris on the drawdown plain is identified by the code BF. Usually, denser accumulations are observed in shallow natural bays near the upper elevation limits of the reservoir.

Code BF also includes stumps (code BS; in most cases, former snags on beaches and flats were already lying on the ground in 2009 imagery). Even though they are unlikely to become floating debris, stumps constitute a hazard to recreational use of the reservoir.

A few lost wood bundles (BB) could be observed, mostly on the drawdown plain. They are easily identified, given that logs are cut at both ends and piled in rectangular shapes. The classes “Man-made wood stack on beach” (BM) and “Harvested woody debris area” (BH) were added, given that important woody debris removal activities are conducted in the reservoir.

The next figures depict the various types of beached woody debris that are mapped for the assessment of their sources and quantity, and for the trend analysis (Figure A-1 and Figure A-2).

Imagery of 2011	Oblique aerial picture
Scattered or low-density beached woody debris (B1)	
	
Moderately dense woody ribbons on beach (B2)	
	
Dense woody ribbons or piles on beach (B3)	
	

Wood bundle on beach (BB)



Scattered woody debris on flats (BF)



Stumps on beach or drawdown area (BS)



Figure A-1 **Examples of the Various Classes of Woody Debris on Beach or Flats**





Imagery of 2009	Imagery of 2011
Harvested woody debris area (BH)	
	
Man-made wood stack on beach (BM)	
 <p data-bbox="289 1184 704 1213"><i>Woody debris before removal activities</i></p>	 <p data-bbox="932 1184 1321 1213"><i>Same area during removal activities</i></p>

Figure A-2 Examples of the Classes used for Areas where Wood Logs are Being Removed

Floating debris

Floating debris is of the same nature and origin as beached debris. The variation in quantity between these categories is a function of the reservoir water level. Deposition and floatation of the woody debris may occur on annually as a result of reservoir operations. Woody debris becomes stranded on the reservoir shoreline during drawdown and some pieces may refloat in spring and summer as water levels rise. The gradation of class densities used for beached debris has been also applied for floating pieces: F1, low-density; F2, moderately dense; and F3, dense floating wood logs. For areas not captured by the Williston air photos (e.g., the open water area of Finlay Arm), the location and characterization of debris accumulations were determined by conducting a helicopter survey in 2010. These polygons were conserved as they were used for the revised baseline map.

Floating debris is found over the main waterbody, typically in the form of large patches of wood. However, most of it has been regrouped in log booms and recovered during the cleaning activities (Figure A-3). As a result, little floating debris was observed on the reservoir during the baseline study.



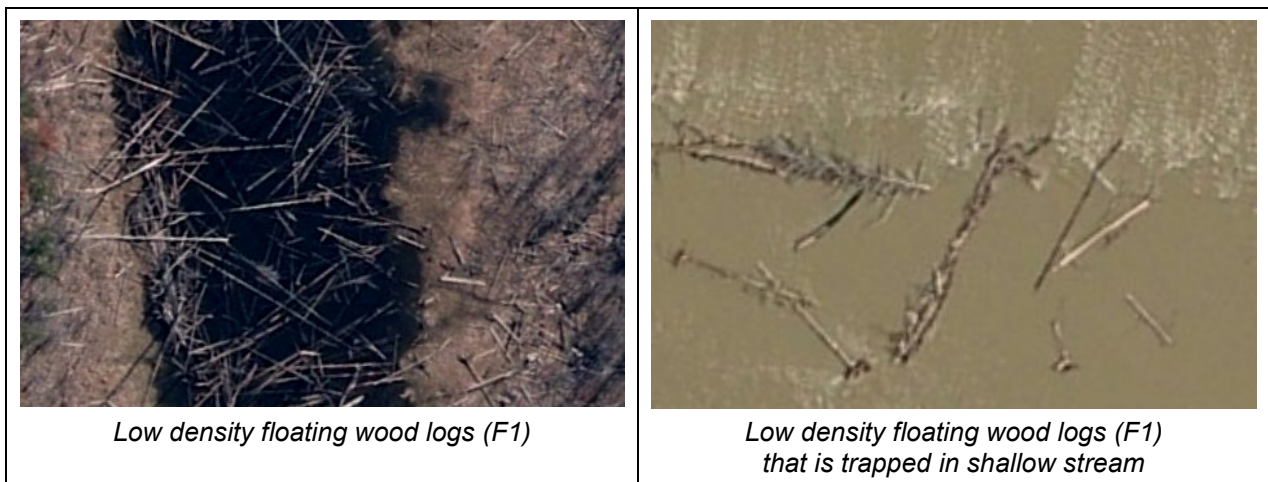
Figure A-3 Large floating debris (F3) and log booms (FO) managed during the cleaning program

For the revised version of the baseline map layer, wood debris floating in creeks and narrow bays were included in this group, given that it is likely prone to be transported to the main waterbody. In general, low-density and moderately dense floating wood debris consists of trees mobilized by bank/shoreline erosion. This material is located close to main streams and frequently trapped along the contact line with the drawdown area.

To enable analysis of wood debris trends and dynamics, stumps on beach or drawdown areas (BS) that are temporarily covered by water during the photo-interpretation of the second mosaic have been identified as “Submerged stumps” (FS). For scattered woody debris on the drawdown plain (BF), the polygons have been identified as “Water” (H2), given that it was not possible to confirm the presence of such debris or its removal by natural processes or anthropic activities. Therefore, the woody debris in these areas is considered to have not changed.

The polygons where woody debris were observed in 2009 have been identified as “River” (RR), when such material is located in 2011 over a new river branch or channel from which all woody debris has been removed and the sediments excavated.

The next figures depict the various types of floating woody debris that were identified on the mosaics of 2009 and 2011 for the assessment of their sources and quantity, and for the trend analysis (Figure A-4).



Low density floating wood logs (F1)

*Low density floating wood logs (F1)
that is trapped in shallow stream*



Figure A-4 **Examples of the Various Classes of Floating Woody Debris**

Forest stands and timber not cleared prior to flooding

Stands of dead or living trees remain along the periphery of the reservoir above the main ribbons of woody debris and the upper limit of the drawdown zone. These stands are located on flat areas that are occasionally flooded during the maximum level of the reservoir.

The forested areas have been delineated and characterized in accordance with the density of their standing trees (SL, SM and SD) and, when existing, in accordance with the density of large woody debris on ground (S1, S2 and S3) (Table A-1 and Figure A-5 and Figure A-5). Realignment of logs by wave action to form discontinuous ribbons is observed in areas containing downed wood, mainly for the denser class (S3).

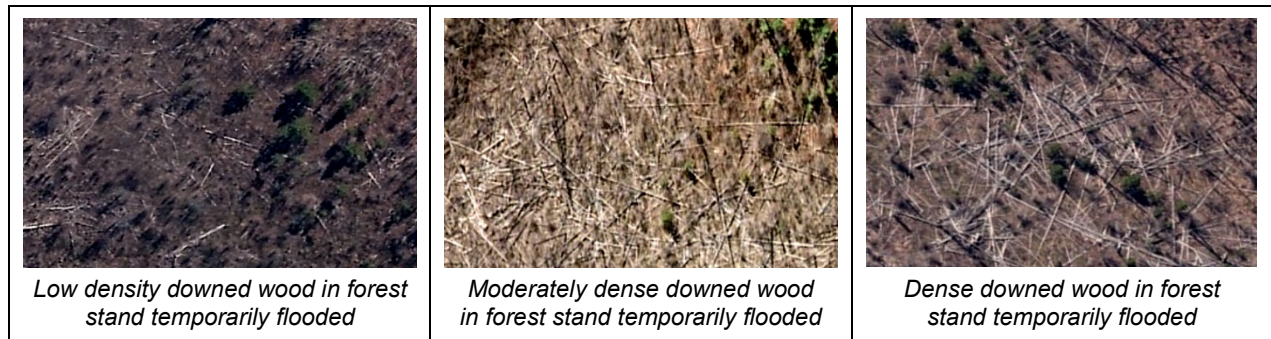
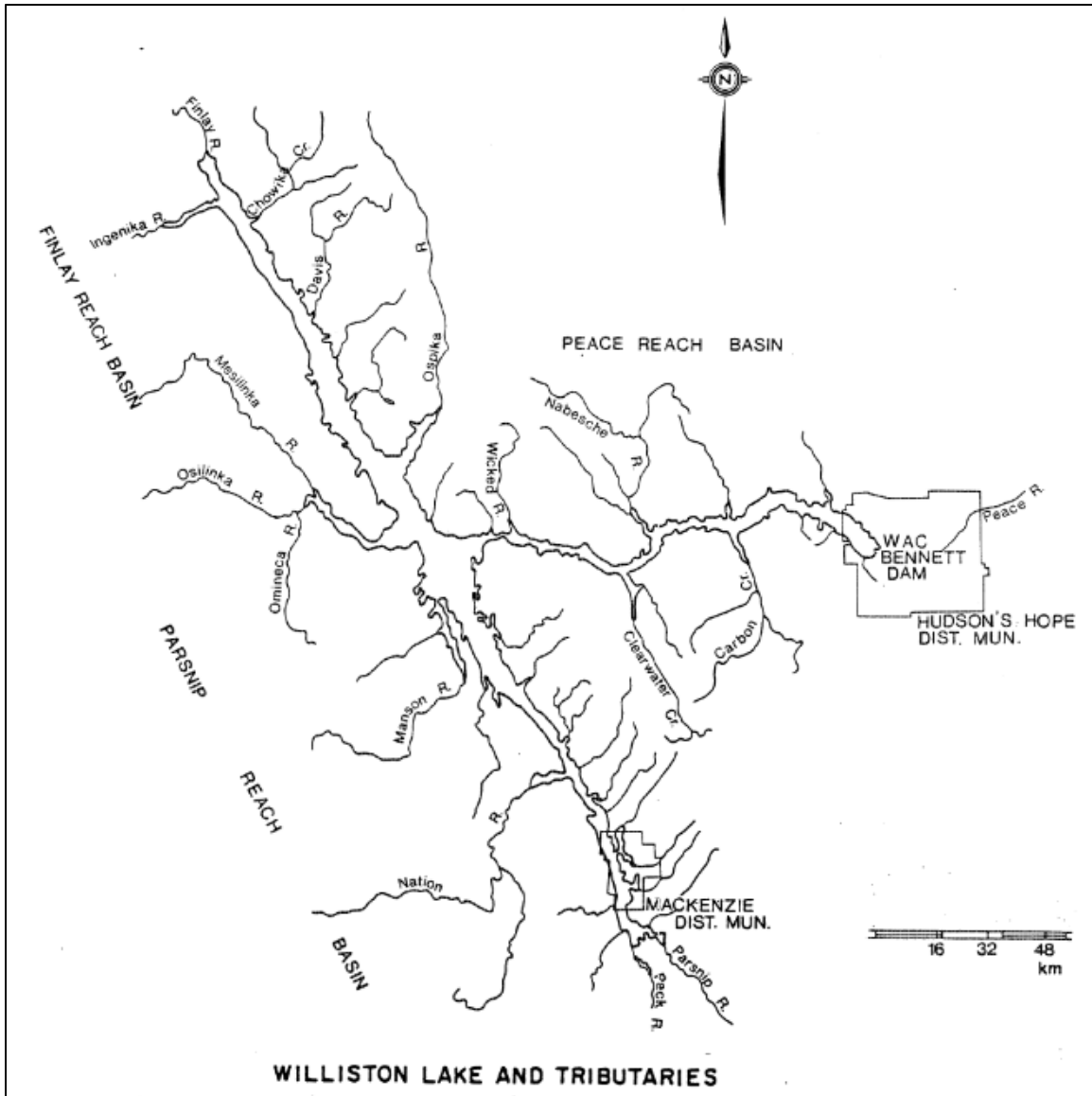
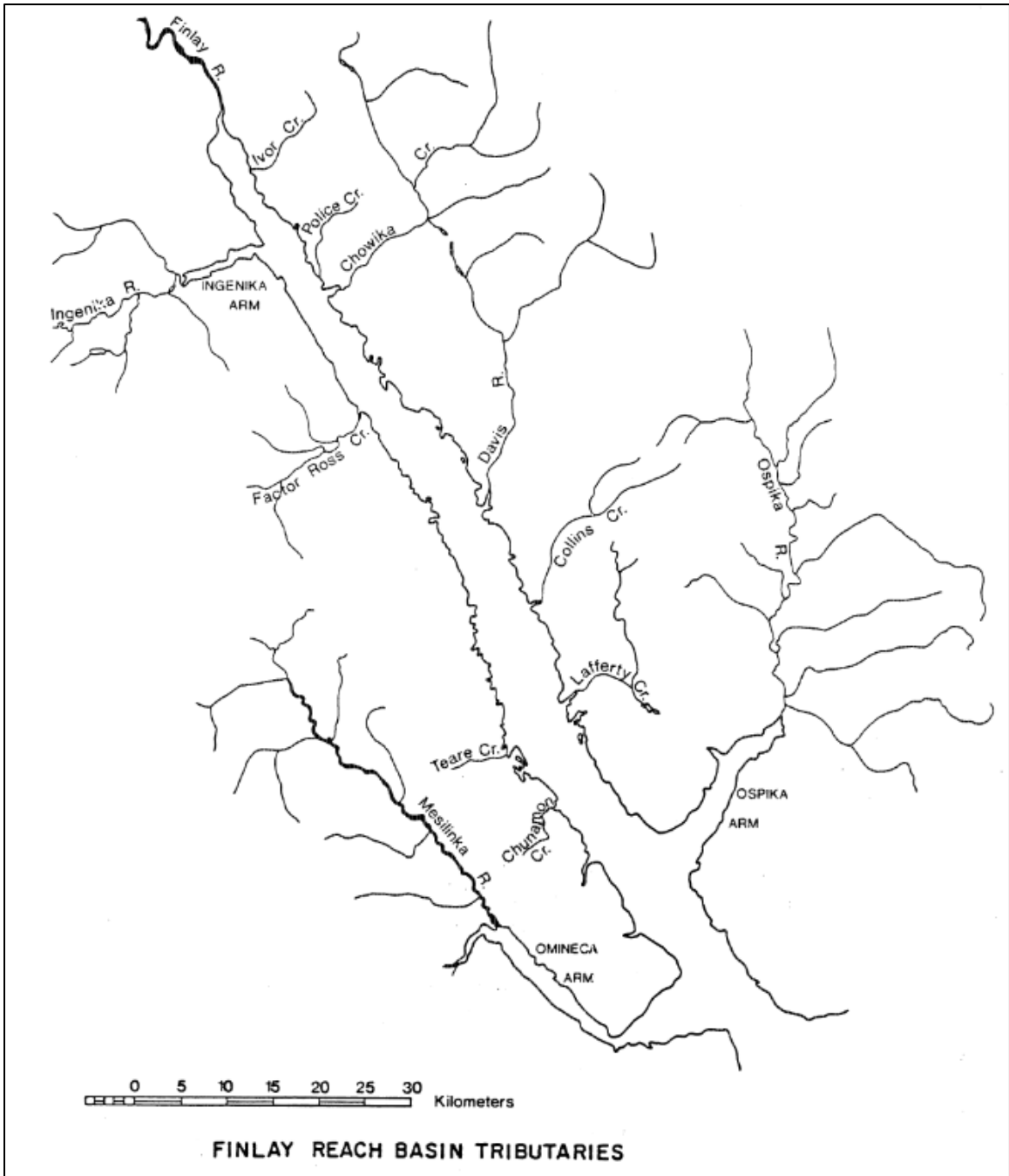
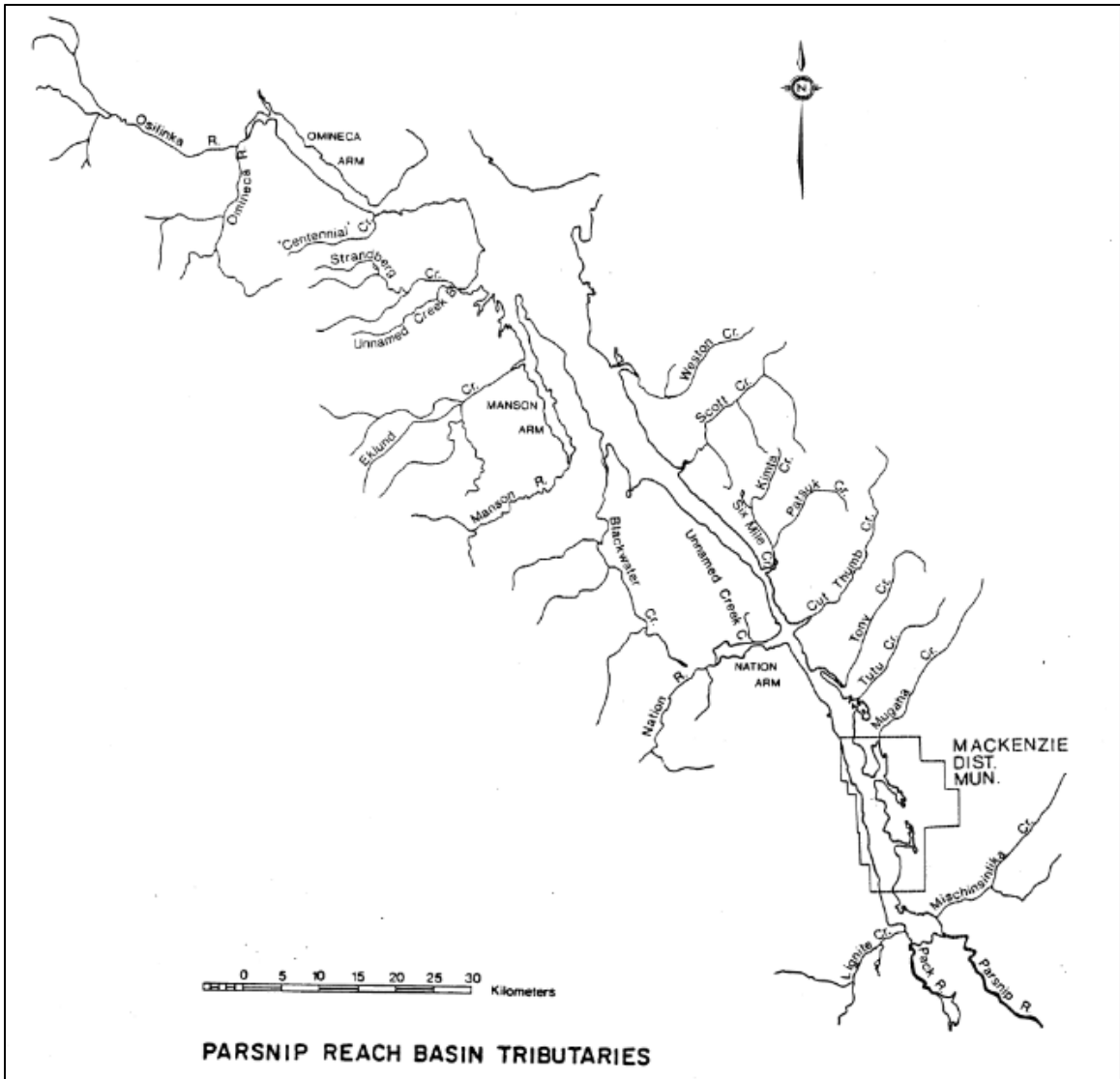


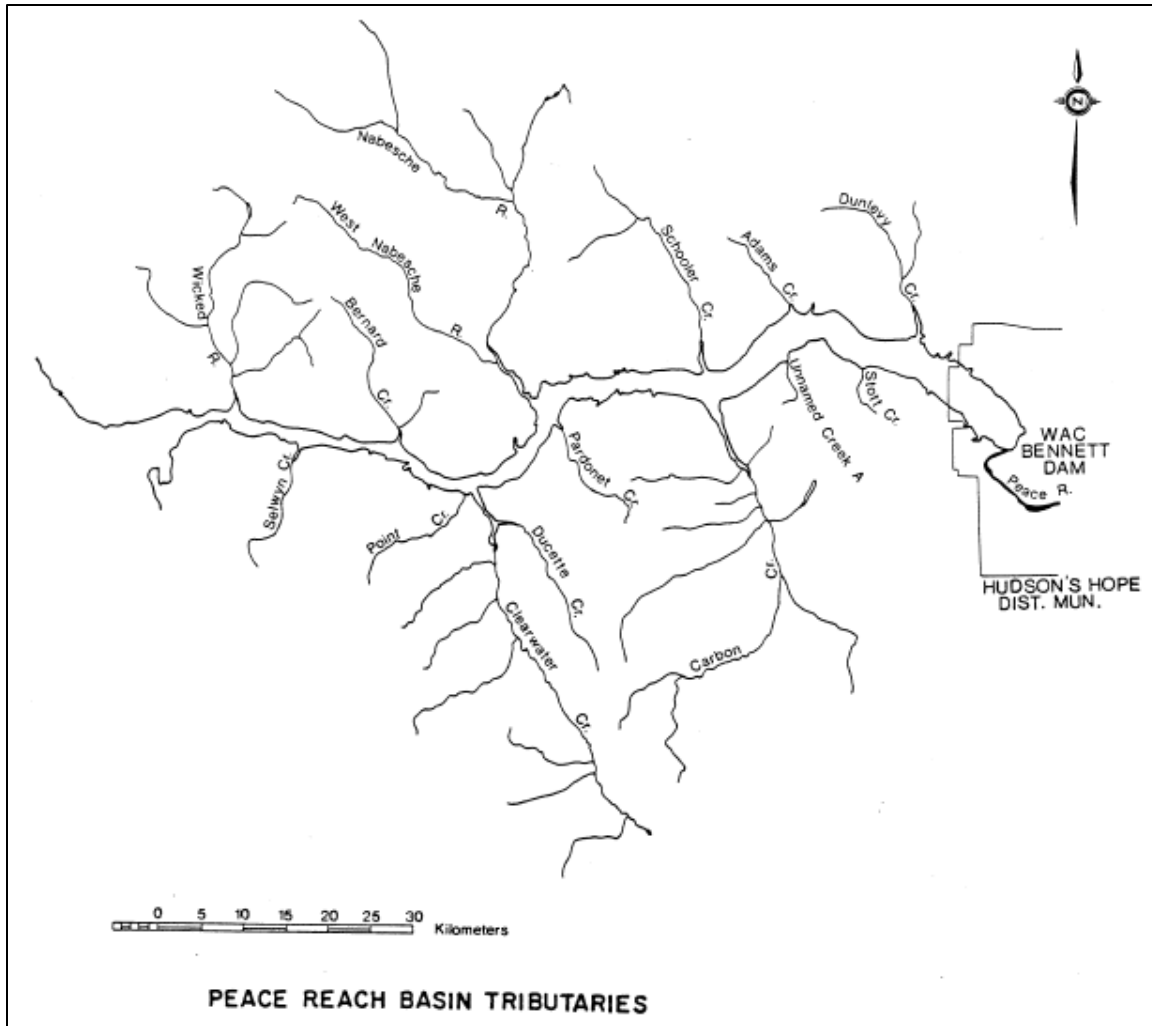
Figure A-5 **Examples of the Various Classes of Downed Wood in Forest Stands Temporarily Flooded**

APPENDIX B
Tributaries of Finlay, Parsnip, and
Peace Arms









Maps from Bruce and Starr 1985.

APPENDIX C

Maps

APPENDIX D
Detailed Tables of Woody Debris Area,
Volume, and Trends 2009-2018

Table D3 Total Changes in Area between 2009 and 2018

Sector	Woody debris on beach			Wood bundle on beach		Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	Bb	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	ha			ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
Finlay Arm East	33.27	-20.50	-100.88	-0.01	0	10.95	79.29	-3.11	-0.99	-18.06	-23.22	-42.27	0.59
Finlay Arm West	44.94	-2.59	-71.88	-0.13	-12	5.38	17.64	-8.89	-15.53	-34.28	-49.79	-99.60	4.05
Total	78.21	-23.09	-172.76	-0.14	-12	16.33	96.93	-12.00	-16.52	-52.34	-73.01	-141.87	4.64
Parsnip Arm East	23.55	-1.75	-9.36	0.14	1	1.56	24.41	-12.21	26.34	-9.99	-11.47	4.88	-8.26
Parsnip Arm West	49.89	-20.50	-48.73	0.02	1	0.67	78.03	0.18	59.56	-41.11	-85.55	-67.10	-3.71
Total	73.44	-22.25	-58.09	0.16	2	2.23	102.44	-12.03	85.90	-51.10	-97.02	-62.22	-11.97
Peace Arm North	16.38	-2.11	4.28	-0.01	-2	0.07	0.46	0.55	19.62	-0.28	-1.15	18.19	0.00
Peace Arm South	22.84	0.44	2.45	0.00	0	0.30	0.70	-0.60	26.13	0.06	-2.17	24.02	0.21
Total	39.22	-1.67	6.73	-0.01	-2	0.37	1.16	-0.05	45.75	-0.22	-3.32	42.21	0.21
Grand total	190.87	-47.01	-224.12	0.01	-12	18.93	200.53	-24.08	115.13	-103.66	-173.35	-161.88	-7.12

Sector	Woody debris on beach			Wood bundle on beach		Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris and Forest Stands	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	Bb	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	% (vs all Bs and Fs 2009)			% (Bs and Fs 2009)		% (Bs and Fs 2009)	% (Bs and Fs 2009)	% (Bs and Fs 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)
Finlay Arm East	59.6%	-16.0%	-46.8%	-14.29%	0		32.8%	-28.1%	-0.2%	-17.1%	-5.1%	-3.5%	0.5%
Finlay Arm West	67.3%	-2.0%	-42.8%	-52.00%	-12		24.3%	-72.3%	-3.4%	-14.5%	-6.9%	-2.9%	2.9%
Total	63.8%	-8.9%	-45.0%	-43.75%	-12		30.8%	-51.3%	-1.5%	-15.3%	-6.2%	-5.4%	1.8%
Parsnip Arm East	47.7%	-2.3%	-15.1%	73.68%	1		62.3%	-74.5%	10.7%	-23.6%	-6.4%	1.0%	-1.3%
Parsnip Arm West	82.1%	-16.0%	-39.3%	10.00%	1		58.7%	3.8%	13.2%	-21.0%	-16.6%	-5.8%	-0.3%
Total	66.7%	-10.8%	-31.2%	41.03%	2		59.5%	-57.1%	12.3%	-21.5%	-14.0%	-3.8%	-0.6%
Peace Arm North	89.6%	-9.6%	55.2%	-100.00%	-2		50.5%	21.3%	38.1%	-66.7%	-12.1%	29.6%	0.0%
Peace Arm South	155.5%	1.6%	41.4%		0		23.2%	-92.3%	50.8%	1.9%	-22.6%	37.5%	0.7%
Total	119.0%	-3.4%	49.2%	-100.00%	-2		29.5%	-1.5%	44.5%	-6.2%	-17.4%	33.6%	0.5%
Grand total	71.8%	-9.1%	-38.4%	1.39%	-12		40.9%	-50.5%	6.0%	-17.8%	-9.1%	-3.7%	

Table D4 Annual Changes in Area (Average between 2009 and 2018)

Sector	Woody debris on beach			Wood bundle on beach		Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	Bb	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	ha/yr			ha/yr	ha/yr	ha/yr	ha/yr	ha/yr	ha/yr	ha/yr	ha/yr	ha/yr	ha/yr
Finlay Arm East	3.70	-2.28	-11.21	0.00		1.22	8.81	-0.35	-0.11	-2.01	-2.58	-4.70	0.07
Finlay Arm West	4.99	-0.29	-7.99	-0.01		0.60	1.96	-0.99	-1.73	-3.81	-5.53	-11.07	0.45
Total	8.69	-2.57	-19.20	-0.01		1.82	10.77	-1.34	-1.84	-5.82	-8.11	-15.76	0.52
Parsnip Arm East	2.62	-0.19	-1.04	0.02		0.17	2.71	-1.36	2.93	-1.11	-1.27	0.54	-0.92
Parsnip Arm West	5.54	-2.28	-5.41	0.00		0.07	8.67	0.02	6.62	-4.57	-9.51	-7.46	-0.41
Total	8.16	-2.47	-6.45	0.02		0.25	11.38	-1.34	9.54	-5.68	-10.78	-6.91	-1.33
Peace Arm North	1.82	-0.23	0.48	0.00		0.01	0.05	0.06	2.18	-0.03	-0.13	2.02	0.00
Peace Arm South	2.54	0.05	0.27	0.00		0.03	0.08	-0.07	2.90	0.01	-0.24	2.67	0.02
Total	4.36	-0.19	0.75	0.00		0.04	0.13	-0.01	5.08	-0.02	-0.37	4.69	0.02
Grand total	21.21	-5.23	-24.90	0.01		2.11	22.28	-2.69	12.78	-11.52	-19.26	-17.98	-0.79

Sector	Woody debris on beach			Wood bundle on beach		Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris and Forest Stands	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	Bb	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	% (vs all Bs and Fs 2009)			% (Bs and Fs 2009)		% (Bs and Fs 2009)	% (Bs and Fs 2009)	% (Bs and Fs 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)
Finlay Arm East	6.6%	-1.8%	-5.2%	0.00%			3.6%	-3.2%	0.0%	-1.9%	-0.6%	-0.4%	0.1%
Finlay Arm West	7.5%	-0.2%	-4.8%	-4.00%			2.7%	-8.1%	-0.4%	-1.6%	-0.8%	-0.8%	0.3%
Total	7.1%	-1.0%	-5.0%	-3.13%			3.4%	-5.7%	-0.2%	-1.7%	-0.7%	-0.6%	0.2%
Parsnip Arm East	5.3%	-0.2%	-1.7%	10.53%		54.84%	6.9%	-8.3%	1.2%	-2.6%	-0.7%	0.1%	-0.1%
Parsnip Arm West	9.1%	-1.8%	-4.4%	0.00%		175.00%	6.5%	0.4%	1.5%	-2.3%	-1.8%	-0.6%	0.0%
Total	7.4%	-1.2%	-3.5%	5.13%		71.43%	6.6%	-6.4%	1.4%	-2.4%	-1.6%	-0.4%	-0.1%
Peace Arm North	10.0%	-1.0%	6.2%	0.00%			5.5%	2.3%	4.2%	-7.1%	-1.4%	3.3%	0.0%
Peace Arm South	17.3%	0.2%	4.6%				2.6%	-10.8%	5.6%	0.3%	-2.5%	4.2%	0.1%
Total	13.2%	-0.4%	5.5%	0.00%			3.3%	-0.3%	4.9%	-0.6%	-1.9%	3.7%	0.1%
Grand total	8.0%	-1.0%	-4.3%	1.39%			4.5%	-5.6%	6.0%	-17.8%	-9.1%	-3.7%	

Table D5 Details of Changes in Area between 2009 and 2018

Sector: Finlay Arm East						
Code	Wood Debris Type	Area (ha)		Change		Annual change
		2009	2018	ha	%	
B1	Scattered or low density beached woody debris	55.53	89.10	33.27	59.9%	3.70
B2	Moderately dense woody ribbons on beach	125.40	107.90	-20.56	-16.0%	-2.28
B3	Dense woody ribbons on beach	215.60	114.72	-100.88	-46.8%	-11.21
BB	Wood bundle on beach	0.07	0.06	-0.01	-14.3%	0.00
BF	Scattered woody debris on flats	241.85	321.14	79.29	32.8%	8.81
F1	Low density floating wood logs	3.19	2.72	-0.47	-14.7%	-0.05
F2	Moderately dense floating wood logs	0.97	2.05	1.08	111.3%	0.12
F3	Dense floating wood logs	6.92	3.20	-3.72	-53.8%	-0.41
S1	Low density downed wood in forest stand temporarily flooded	58.97	59.35	0.38	0.6%	0.04
S2	Moderately dense downed wood in forest stand temporarily flooded	35.50	24.34	-11.16	-31.4%	-1.24
S3	Dense downed wood in forest stand temporarily flooded	11.18	3.90	-7.28	-65.1%	-0.81
SL	Low density forest stand temporarily flooded	296.64	279.65	-16.99	-5.7%	-1.89
SM	Moderately dense forest stand temporarily flooded	125.87	119.80	-6.07	-4.8%	-0.67
SD	Dense forest stand temporarily flooded	32.59	32.43	-0.16	-0.5%	-0.02
Indices of removal activities :						
BM	Man-made wood stack on beach	0.00	10.95	10.95	↑	1.22
BH	Man-made wood stack on beach	0.00	98.63	98.63	↑	10.96
BS-FS	Stumps on beach or on flats	117.73	118.32	0.59	0.5%	0.07

Sector: Finlay Arm West						
Code	Wood Debris Type	Area (ha)		Change		Annual change
		2009	2018	ha	%	
B1	Scattered or low density beached woody debris	66.78	111.72	44.94	67.3%	4.99
B2	Moderately dense woody ribbons on beach	131.77	129.18	-2.59	-2.0%	-0.29
B3	Dense woody ribbons on beach	168.08	96.20	-71.88	-42.8%	-7.99
BB	Wood bundle on beach	0.25	0.12	-0.13	-52.0%	-0.01
BF	Scattered woody debris on flats	72.66	90.30	17.64	24.3%	1.96
F1	Low density floating wood logs	4.00	1.79	-2.21	-55.3%	-0.25
F2	Moderately dense floating wood logs	7.36	0.39	-6.97	-94.7%	-0.77
F3	Dense floating wood logs	0.93	1.22	0.29	31.2%	0.03
S1	Low density downed wood in forest stand temporarily flooded	193.08	164.42	-28.66	-14.8%	-3.18
S2	Moderately dense downed wood in forest stand temporarily flooded	37.96	34.51	-3.45	-9.1%	-0.38
S3	Dense downed wood in forest stand temporarily flooded	4.76	2.59	-2.17	-45.6%	-0.24
SL	Low density forest stand temporarily flooded	400.04	422.02	21.98	5.5%	2.42
SM	Moderately dense forest stand temporarily flooded	248.16	237.64	-10.52	-4.2%	-1.15
SD	Dense forest stand temporarily flooded	18.61	17.16	-1.45	-7.8%	-0.16
BM	Man-made wood stack on beach	0.07	5.45	5.38	↑	0.60
BH	Man-made wood stack on beach	0.00	41.89	41.89	↑	4.65
BS-FS	Stumps on beach or on flats	138.84	142.89	4.05	2.9%	0.45

Sector: Parsnip Arm East						
Code	Wood Debris Type	Area (ha)		Change		Annual change
		2009	2018	ha	%	
B1	Scattered or low density beached woody debris	49.33	72.88	23.55	47.7%	2.62
B2	Moderately dense woody ribbons on beach	77.73	75.98	-1.75	-2.3%	-0.19
B3	Dense woody ribbons on beach	62.11	52.75	-9.36	-15.1%	-1.04
BB	Wood bundle on beach	0.19	0.33	0.14	73.7%	0.02
BF	Scattered woody debris on flats	39.16	63.57	24.41	62.3%	2.71
F1	Low density floating wood logs	12.66	3.68	-9.00	-71.1%	-1.00
F2	Moderately dense floating wood logs	2.36	0.49	-1.87	-79.2%	-0.21
F3	Dense floating wood logs	1.39	0.04	-1.34	-95.7%	-0.13
S1	Low density downed wood in forest stand temporarily flooded	20.44	26.67	6.23	30.5%	0.69
S2	Moderately dense downed wood in forest stand temporarily flooded	20.42	5.72	-14.70	-72.0%	-1.63
S3	Dense downed wood in forest stand temporarily flooded	1.52	0.00	-1.52	-100.0%	-0.17
SL	Low density forest stand temporarily flooded	126.67	117.64	-9.03	-7.1%	-1.00
SM	Moderately dense forest stand temporarily flooded	46.21	44.43	-1.78	-3.9%	-0.20
SD	Dense forest stand temporarily flooded	6.82	6.16	-0.66	-9.7%	-0.07
BM	Man-made wood stack on beach	0.31	1.87	1.56	503.2%	0.17
BH	Man-made wood stack on beach	0.00	8.11	8.11	↑	0.90
BS-FS	Stumps on beach or on flats	614.82	606.56	-8.26	-1.3%	-0.92

Sector: Parsnip Arm West						
Code	Wood Debris Type	Area (ha)		Change		Annual change
		2009	2018	ha	%	
B1	Scattered or low density beached woody debris	60.80	110.69	49.89	82.1%	5.54
B2	Moderately dense woody ribbons on beach	123.62	142.94	19.32	15.6%	2.15
B3	Dense woody ribbons on beach	123.99	75.28	-48.71	-39.3%	-5.41
BB	Wood bundle on beach	0.20	0.22	0.02	10.0%	0.00
BF	Scattered woody debris on flats	132.94	210.97	78.03	58.7%	8.67
F1	Low density floating wood logs	2.58	3.51	0.93	36.0%	0.10
F2	Moderately dense floating wood logs	0.42	1.23	0.81	192.9%	0.09
F3	Dense floating wood logs	1.68	0.12	-1.56	-92.9%	-0.17
S1	Low density downed wood in forest stand temporarily flooded	130.29	116.26	-14.03	-10.8%	-1.56
S2	Moderately dense downed wood in forest stand temporarily flooded	56.70	37.04	-19.66	-34.7%	-2.18
S3	Dense downed wood in forest stand temporarily flooded	8.84	1.42	-7.42	-83.9%	-0.82
SL	Low density forest stand temporarily flooded	314.41	244.15	-70.26	-22.3%	-7.81
SM	Moderately dense forest stand temporarily flooded	180.72	167.35	-13.37	-7.4%	-1.48
SD	Dense forest stand temporarily flooded	19.28	17.36	-1.92	-10.0%	-0.21
BM	Man-made wood stack on beach	0.04	0.71	0.67	↑	0.07
BH	Man-made wood stack on beach	0.00	6.17	6.17	↑	0.69
BS-FS	Stumps on beach or on flats	1 250.74	1 247.03	-3.71	-0.3%	-0.41

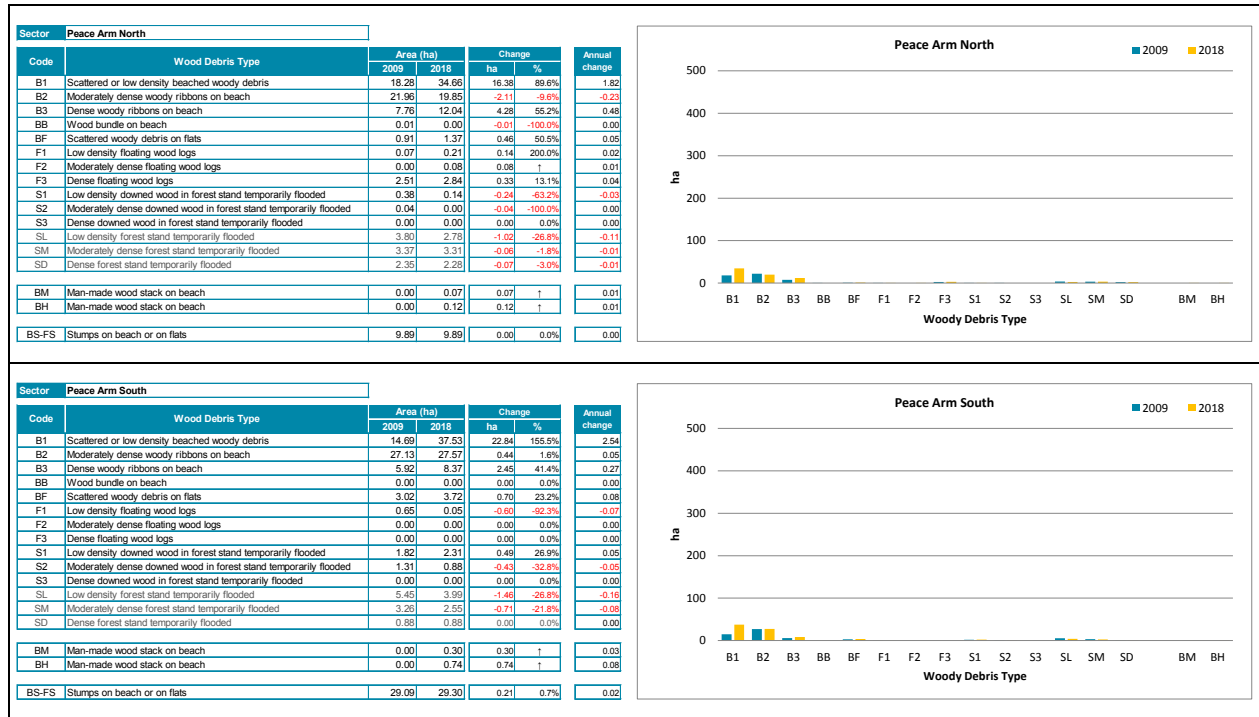


Table D8 Total Changes in Volume between 2009 and 2018

Sector	Woody debris on beach			Wood bundle on beach		Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	Nb	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	m ²			m ³		m ³	m ³	m ³	m ³	m ³	m ³	m ³	m ³
Finlay Arm East	10 646	-14 760	-142 241	0	0	12 389	3 964	-3 605	-133 607	-10 914	-1 488	-146 009	0
Finlay Arm West	14 380	-1 864	-101 351	-1 200	-12	5 961	882	-4 137	-87 329	-8 773	-3 223	-99 325	0
Total	25 026	-16 624	-243 592	-1 200	-12	18 350	4 846	-7 742	-220 936	-19 687	-4 711	-245 334	0
Parsnip Arm East	7 536	-1 260	-13 197	100	1	1 430	1 221	-4 772	-8 942	-6 430	-762	-16 134	0
Parsnip Arm West	15 965	-14 760	-68 709	100	1	343	3 902	-1 029	-64 188	-17 427	-5 234	-86 849	0
Total	23 501	-16 020	-81 906	200	2	1 773	5 123	-5 801	-73 130	-23 857	-5 996	-102 983	0
Peace Arm North	5 241	-1 519	6 034	-200	-2	2	23	443	10 024	-62	-71	9 891	0
Peace Arm South	7 309	316	3 455	0	0	156	35	-150	11 121	-92	-144	10 885	0
Total	12 550	-1 203	9 489	-200	-2	158	58	293	21 145	-154	-215	20 776	0
Grand total	61 077	-33 847	-316 009	-1 200	-12	20 281	10 027	-13 250	-272 921	-43 698	-10 922	-327 541	0

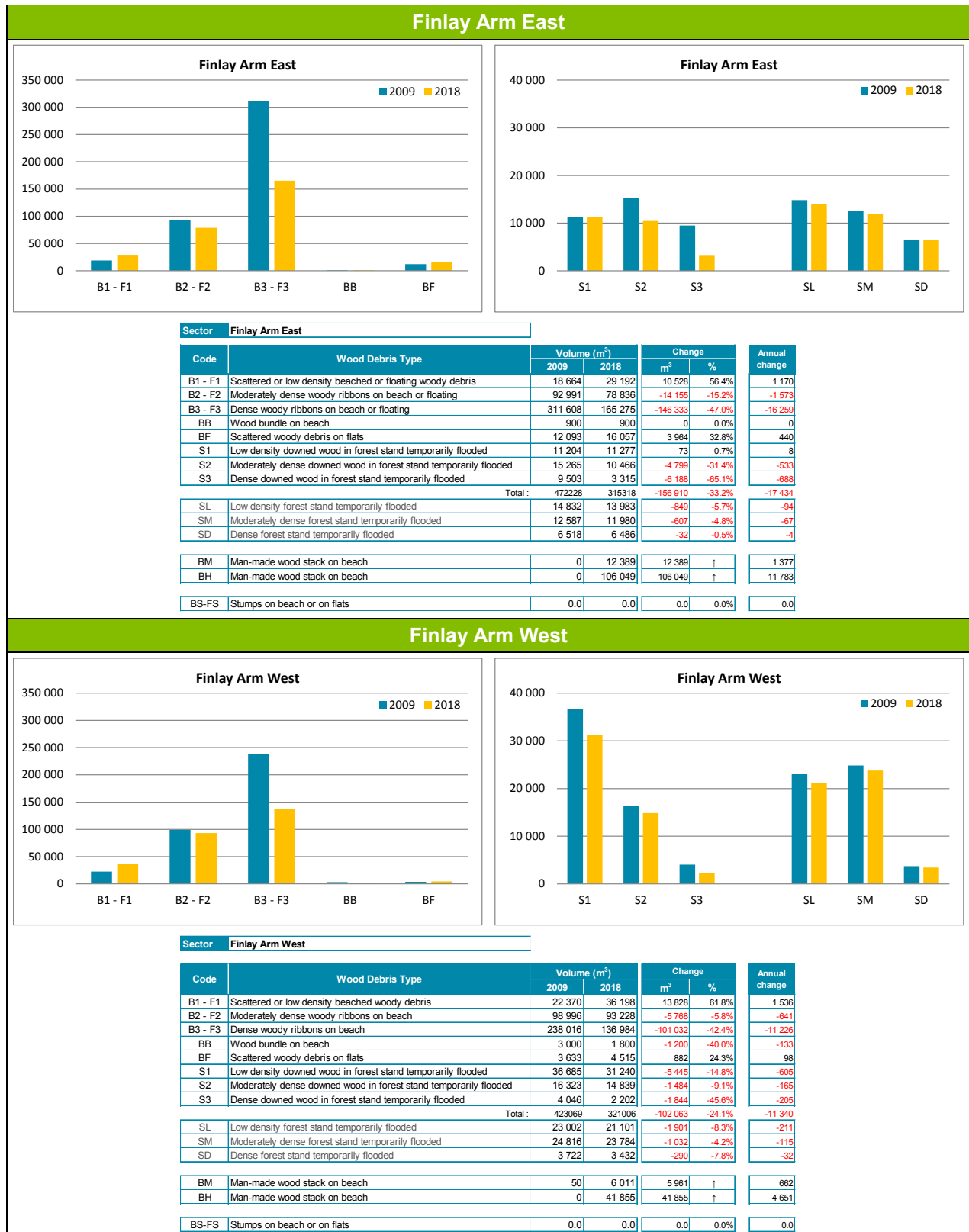
Sector	Woody debris on beach			Wood bundle on beach		Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris and Forest Stands	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	Nb	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	% (vs all Bs and Fs 2009)			% (Bs and Fs 2009)		% (Bs and Fs 2009)	% (Bs and Fs 2009)	% (Bs and Fs 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)
Finlay Arm East	59.6%	-16.0%	-46.8%	0.00%	0		32.8%	-40.3%	-30.6%	-30.3%	-4.4%	-28.8%	0.0%
Finlay Arm West	67.3%	-2.0%	-42.8%	-40.00%	-12		24.3%	-67.3%	-23.9%	-15.4%	-6.3%	-20.9%	0.0%
Total	63.8%	-8.9%	-45.0%	-30.77%	-12		30.8%	-51.3%	-27.5%	-21.2%	-5.5%	-25.0%	0.0%
Parsnip Arm East	47.7%	-2.3%	-15.1%	4.00%	1		62.4%	-79.5%	-5.3%	-46.1%	-6.2%	-8.2%	0.0%
Parsnip Arm West	82.1%	-16.0%	-39.3%	2.94%	1		58.7%	-37.7%	-21.4%	-30.8%	-13.9%	-22.1%	0.0%
Total	66.7%	-10.8%	-31.2%	3.39%	2		59.5%	-66.4%	-15.6%	-33.8%	-12.0%	-17.5%	0.0%
Peace Arm North	89.6%	-9.6%	55.1%	-50.00%	-2		50.0%	15.9%	28.0%	-69.7%	-7.1%	26.8%	0.0%
Peace Arm South	155.5%	1.6%	41.4%	0	0		23.2%	-92.0%	33.8%	-10.1%	-18.6%	31.5%	0.0%
Total	118.9%	-3.4%	49.2%	-50.00%	-2		29.4%	10.0%	30.8%	-15.4%	-12.1%	29.1%	0.0%
Grand total	71.8%	-9.1%	-38.4%	-11.76%	-12		40.9%	-49.5%	-20.4%	-26.5%	-8.0%	-19.9%	0.0%

Table D9 Annual Changes in Volume (average between 2009 and 2018)

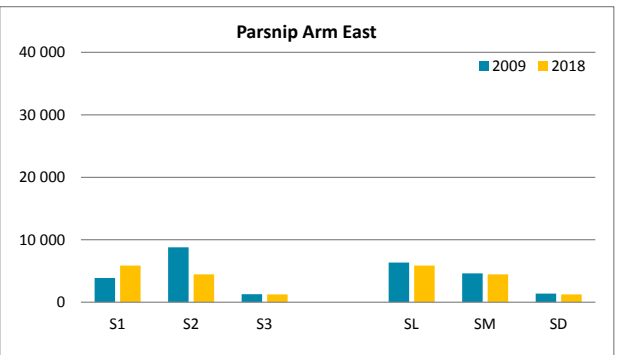
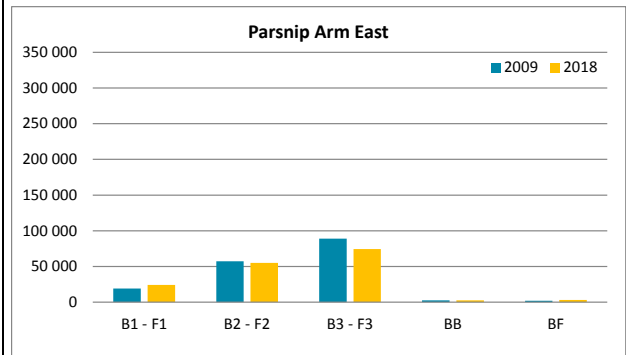
Sector	Woody debris on beach			Wood bundle on beach	Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	m ³ /yr			m ³ /yr	m ³ /yr	m ³ /yr	m ³ /yr	m ³ /yr	m ³ /yr	m ³ /yr	m ³ /yr	m ³ /yr
Finlay Arm East	1 183	-1 640	-15 805	0	1 377	440	-401	-14 845	-1 213	-165	-16 223	0
Finlay Arm West	1 598	-207	-11 261	-133	662	98	-460	-9 703	-975	-358	-11 036	0
Total	2 781	-1 847	-27 066	-133	2 039	538	-860	-24 548	-2 187	-523	-27 259	0
Parsnip Arm East	837	-140	-1 466	11	159	136	-530	-994	-714	-85	-1 793	0
Parsnip Arm West	1 774	-1 640	-7 634	11	38	434	-114	-7 132	-1 936	-582	-9 650	0
Total	2 611	-1 780	-9 101	22	197	569	-645	-8 126	-2 651	-666	-11 443	0
Peace Arm North	582	-169	670	-22	0	3	49	1 114	-7	-8	1 099	0
Peace Arm South	812	35	384	0	17	4	-17	1 236	-10	-16	1 209	0
Total	1 394	-134	1 054	-22	18	6	33	2 349	-17	-24	2 308	0
Grand total	6 786	-3 761	-35 112	-133	2 253	1 114	-1 472	-30 325	-4 855	-1 214	-36 393	0

Sector	Woody debris on beach			Wood bundle on beach	Man-made wood stack on beach	Scattered woody debris on flats	Floating or submerged woody debris	Total Woody Debris and Forest Stands	Forest stand with woody debris on ground	Forest stand without or with very few debris on ground	Total Woody Debris and Forest Stands (excl. stumps)	Stumps
	B1	B2	B3	BB	BM	BF	F1, F2 and F3	all Bs and Fs	S1, S2 and S3	SL, SM and SD	all Bs, Fs and Ss	BS and FS
	% (vs all Bs and Fs 2009)			% (Bs and Fs 2009)		% (Bs and Fs 2009)	% (Bs and Fs 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)	% (sector 2009)
Finlay Arm East	6.6%	-1.8%	-5.2%	0.00%		3.6%	-4.5%	-3.4%	-3.4%	-0.5%	-3.2%	0.0%
Finlay Arm West	7.5%	-0.2%	-4.8%	-4.43%		2.7%	-7.5%	-2.7%	-2.7%	-0.7%	-2.3%	0.0%
Total	7.1%	-1.0%	-5.0%	-3.41%		3.4%	-5.7%	-3.1%	-2.4%	-0.6%	-2.8%	0.0%
Parsnip Arm East	5.3%	-0.3%	-1.7%	0.44%	71.30%	6.9%	-8.8%	-0.6%	-5.1%	-0.7%	-0.9%	0.0%
Parsnip Arm West	9.1%	-1.8%	-4.4%	0.32%	131.03%	6.5%	-4.2%	-2.4%	-3.4%	-1.5%	-2.5%	0.0%
Total	7.4%	-1.2%	-3.5%	0.37%	78.17%	6.6%	-7.4%	-1.7%	-3.8%	-1.3%	-1.9%	0.0%
Peace Arm North	9.9%	-1.1%	6.1%	-5.50%		6.5%	1.8%	3.1%	-7.9%	-0.8%	3.0%	0.0%
Peace Arm South	17.3%	0.2%	4.6%			2.6%	-10.4%	3.8%	-1.1%	-2.1%	3.5%	0.0%
Total	13.2%	-0.4%	5.5%	-5.50%		3.0%	1.1%	3.4%	-1.7%	-1.4%	3.2%	0.0%
Grand total	8.0%	-1.0%	-4.3%	-1.30%		4.5%	-5.5%	-2.3%	-2.9%	-0.9%	-2.2%	0.0%

Table D10 Details of Changes in Volume between 2009 and 2018, by Sectors and Types of Debris



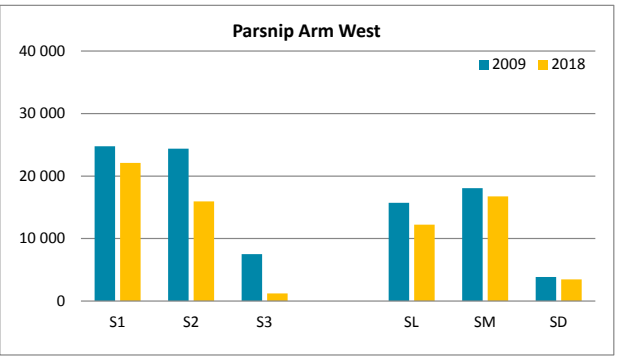
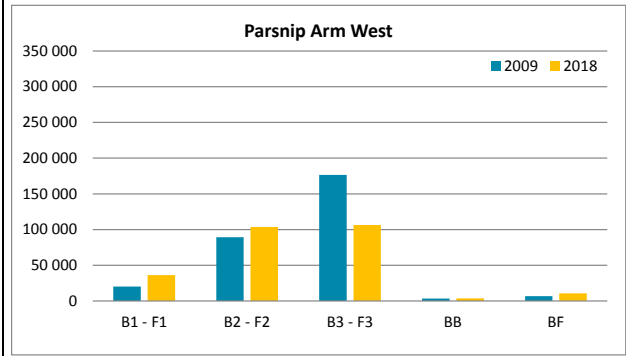
Parsnip Arm East



Sector **Parsnip Arm East**

Code	Wood Debris Type	Volume (m³)		Change		Annual change
		2009	2018	m³	%	
B1 - F1	Scattered or low density beached woody debris	18 951	24 237	5 286	27.9%	587
B2 - F2	Moderately dense woody ribbons on beach	57 288	54 980	-2 308	-4.0%	-256
B3 - F3	Dense woody ribbons on beach	89 093	74 422	-14 671	-16.5%	-1 630
BB	Wood bundle on beach	2 500	2 600	100	4.0%	11
BF	Scattered woody debris on flats	1 958	3 179	1 221	62.4%	136
S1	Low density downed wood in forest stand temporarily flooded	3 884	5 882	1 998	51.4%	222
S2	Moderately dense downed wood in forest stand temporarily flooded	8 781	4 443	-4 338	-49.4%	-482
S3	Dense downed wood in forest stand temporarily flooded	1 292	1 232	-60	-4.6%	-7
Total :		183747	170975	-12 772	-7.0%	-1 419
SL	Low density forest stand temporarily flooded	6 334	5 882	-452	-7.1%	-60
SM	Moderately dense forest stand temporarily flooded	4 621	4 443	-178	-3.9%	-20
SD	Dense forest stand temporarily flooded	1 364	1 232	-132	-9.7%	-15
BM	Man-made wood stack on beach	223	1 653	1 430	641.3%	159
BH	Man-made wood stack on beach	0	6 143	6 143	↑	683
BS-FS	Stumps on beach or on flats	0.0	0.0	0.0	0.0%	0.0

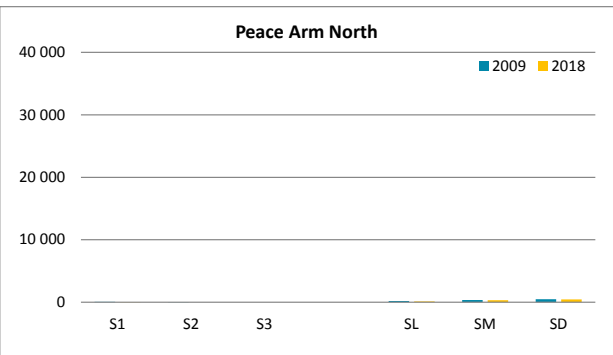
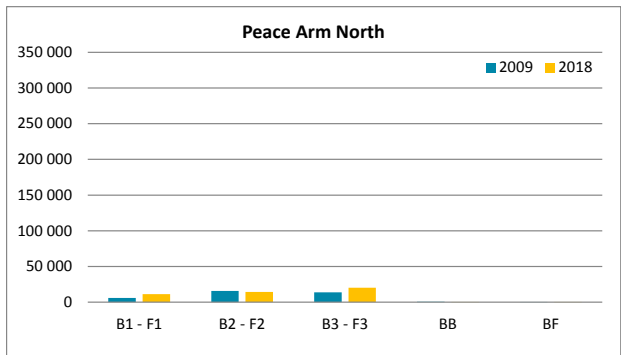
Parsnip Arm West



Sector **Parsnip Arm West**

Code	Wood Debris Type	Volume (m³)		Change		Annual change
		2009	2018	m³	%	
B1 - F1	Scattered or low density beached woody debris	20 101	36 299	16 198	80.6%	1 800
B2 - F2	Moderately dense woody ribbons on beach	89 241	103 606	14 365	16.1%	1 596
B3 - F3	Dense woody ribbons on beach	176 674	106 249	-70 425	-39.9%	-7 825
BB	Wood bundle on beach	3 400	3 500	100	2.9%	11
BF	Scattered woody debris on flats	6 647	10 549	3 902	58.7%	434
S1	Low density downed wood in forest stand temporarily flooded	24 755	22 089	-2 666	-10.8%	-296
S2	Moderately dense downed wood in forest stand temporarily flooded	24 381	15 927	-8 454	-34.7%	-939
S3	Dense downed wood in forest stand temporarily flooded	7 514	1 207	-6 307	-83.9%	-701
Total :		352713	299426	-53 287	-15.1%	-5 921
SL	Low density forest stand temporarily flooded	15 721	12 208	-3 513	-22.3%	-390
SM	Moderately dense forest stand temporarily flooded	18 072	16 735	-1 337	-7.4%	-149
SD	Dense forest stand temporarily flooded	3 856	3 472	-384	-10.0%	-43
BM	Man-made wood stack on beach	29	372	343	↑	38
BH	Man-made wood stack on beach	0	5 309	5 309	↑	590
BS-FS	Stumps on beach or on flats	0.0	0.0	0.0	0.0%	0.0

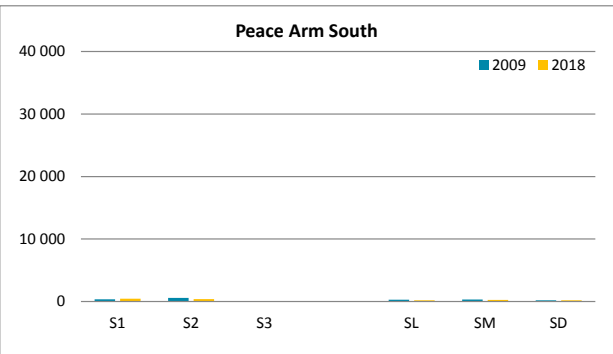
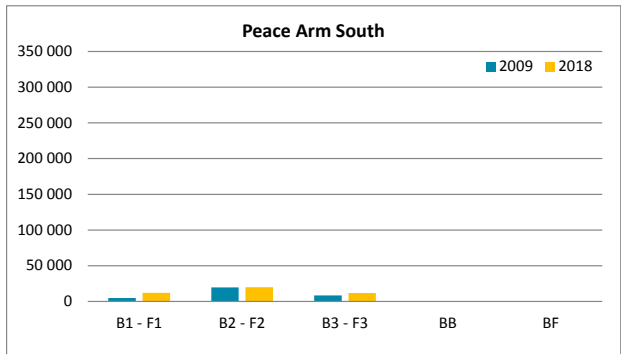
Peace Arm North



Sector: **Peace Arm North**

Code	Wood Debris Type	Volume (m³)		Change		Annual change
		2009	2018	m³	%	
B1 - F1	Scattered or low density beached woody debris	5 888	11 144	5 276	89.9%	586
B2 - F2	Moderately dense woody ribbons on beach	15 811	14 337	-1 474	-9.3%	-164
B3 - F3	Dense woody ribbons on beach	13 703	20 100	6 397	46.7%	711
BB	Wood bundle on beach	400	200	-200	-50.0%	-22
BF	Scattered woody debris on flats	46	69	23	50.0%	3
S1	Low density downed wood in forest stand temporarily flooded	72	27	-45	-62.5%	-5
S2	Moderately dense downed wood in forest stand temporarily flooded	17	0	-17	-100.0%	-2
S3	Dense downed wood in forest stand temporarily flooded	0	0	0	0.0%	0
Total :		35917	45877	9 960	27.7%	1 107
SL	Low density forest stand temporarily flooded	190	139	-51	-26.8%	-6
SM	Moderately dense forest stand temporarily flooded	337	331	-6	-1.8%	-1
SD	Dense forest stand temporarily flooded	470	456	-14	-3.0%	-2
BM	Man-made wood stack on beach	0	2	2	↑	0
BH	Man-made wood stack on beach	0	66	66	↑	7
BS-FS	Stumps on beach or on flats	0.0	0.0	0.0	0.0%	0.0

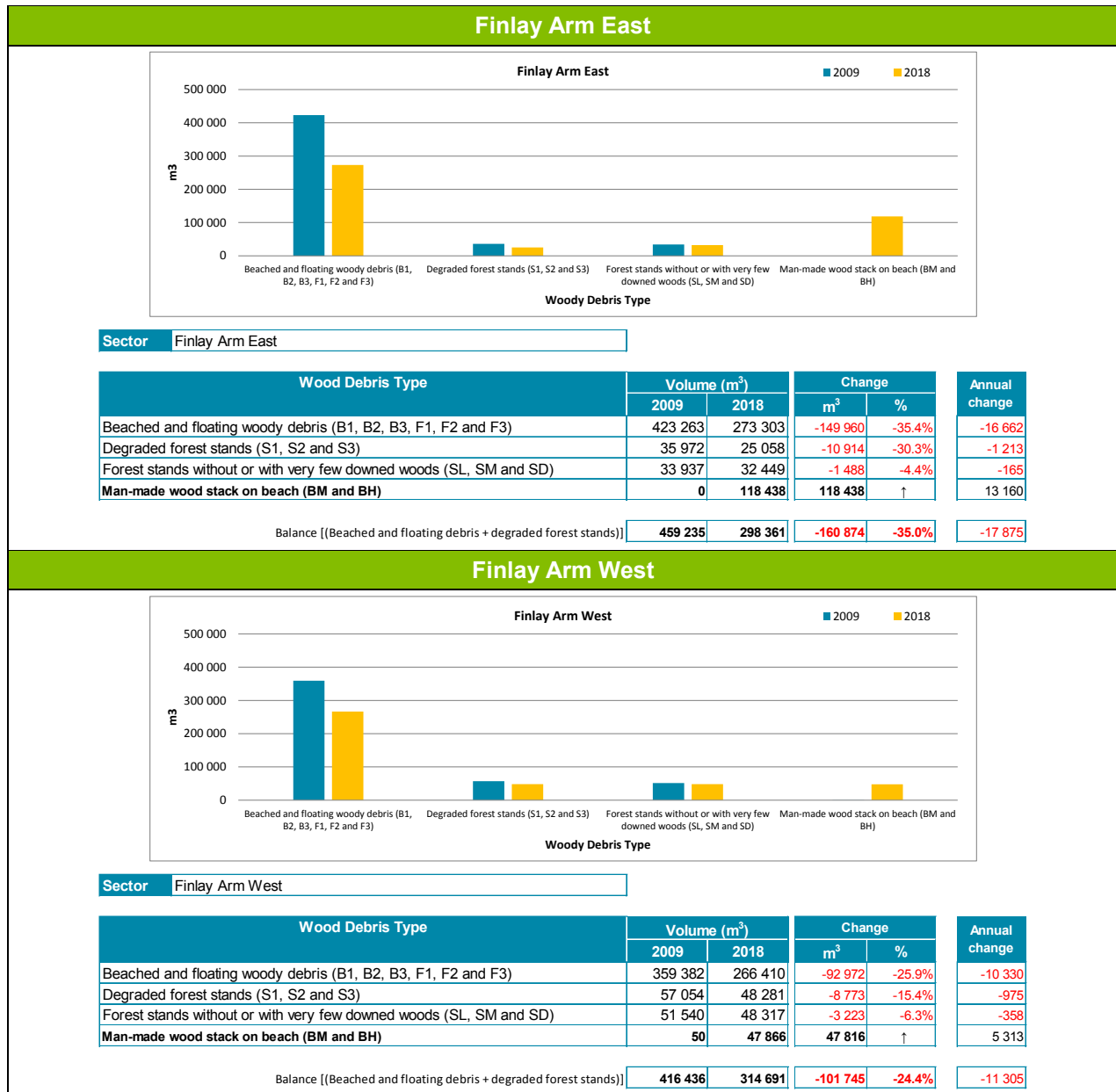
Peace Arm South



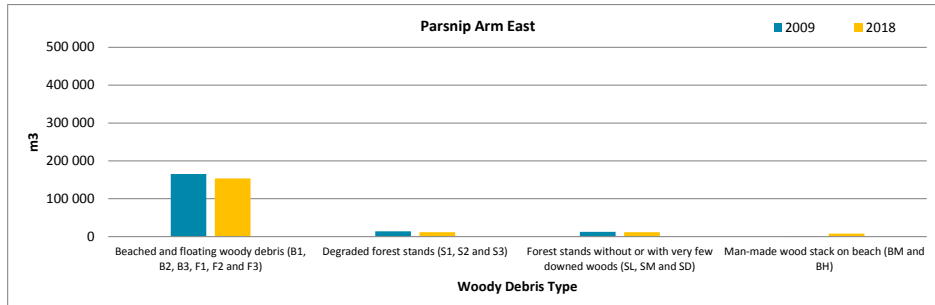
Sector: **Peace Arm South**

Code	Wood Debris Type	Volume (m³)		Change		Annual change
		2009	2018	m³	%	
B1 - F1	Scattered or low density beached woody debris	4 864	12 023	7 159	147.2%	795
B2 - F2	Moderately dense woody ribbons on beach	19 534	19 850	316	1.6%	35
B3 - F3	Dense woody ribbons on beach	8 347	11 802	3 455	41.4%	384
BB	Wood bundle on beach	0	0	0	0.0%	0
BF	Scattered woody debris on flats	151	186	35	23.2%	4
S1	Low density downed wood in forest stand temporarily flooded	346	439	93	26.9%	10
S2	Moderately dense downed wood in forest stand temporarily flooded	563	378	-185	-32.9%	-21
S3	Dense downed wood in forest stand temporarily flooded	0	0	0	0.0%	0
Total :		33805	44878	10 873	32.2%	1 208
SL	Low density forest stand temporarily flooded	273	200	-73	-26.7%	-8
SM	Moderately dense forest stand temporarily flooded	326	255	-71	-21.8%	-8
SD	Dense forest stand temporarily flooded	176	176	0	0.0%	0
BM	Man-made wood stack on beach	0	156	156	↑	17
BH	Man-made wood stack on beach	0	631	631	↑	70
BS-FS	Stumps on beach or on flats	0.0	0.0	0.0	0.0%	0.0

Table D11 Detailed Changes in Volume between 2009 and 2018, by Main Debris Type



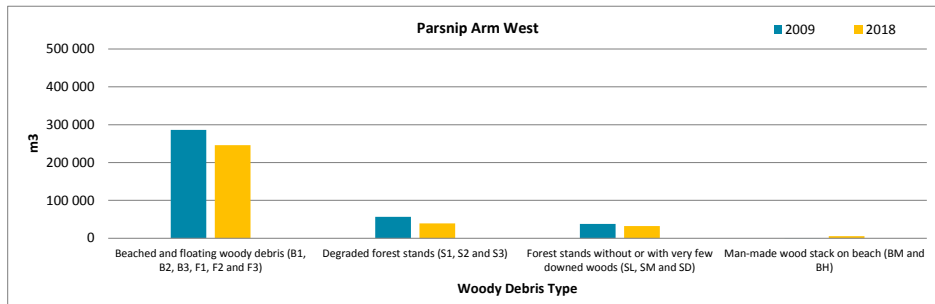
Parsnip Arm East



Sector

Wood Debris Type	Volume (m³)		Change		Annual change
	2009	2018	m³	%	
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	165 332	153 639	-11 693	-7.1%	-1 299
Degraded forest stands (S1, S2 and S3)	13 957	11 557	-2 400	-17.2%	-267
Forest stands without or with very few downed woods (SL, SM and SD)	12 319	11 557	-762	-6.2%	-85
Man-made wood stack on beach (BM and BH)	223	7 796	7 573	↑	841
Balance [(Beached and floating debris + degraded forest stands)]	179 289	165 196	-14 093	-7.9%	-1 566

Parsnip Arm West



Sector

Wood Debris Type	Volume (m³)		Change		Annual change
	2009	2018	m³	%	
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	286 016	246 154	-39 862	-13.9%	-4 429
Degraded forest stands (S1, S2 and S3)	56 650	39 223	-17 427	-30.8%	-1 936
Forest stands without or with very few downed woods (SL, SM and SD)	37 649	32 415	-5 234	-13.9%	-582
Man-made wood stack on beach (BM and BH)	29	5 681	5 652	↑	628
Balance [(Beached and floating debris + degraded forest stands)]	342 666	285 377	-57 289	-16.7%	-6 365

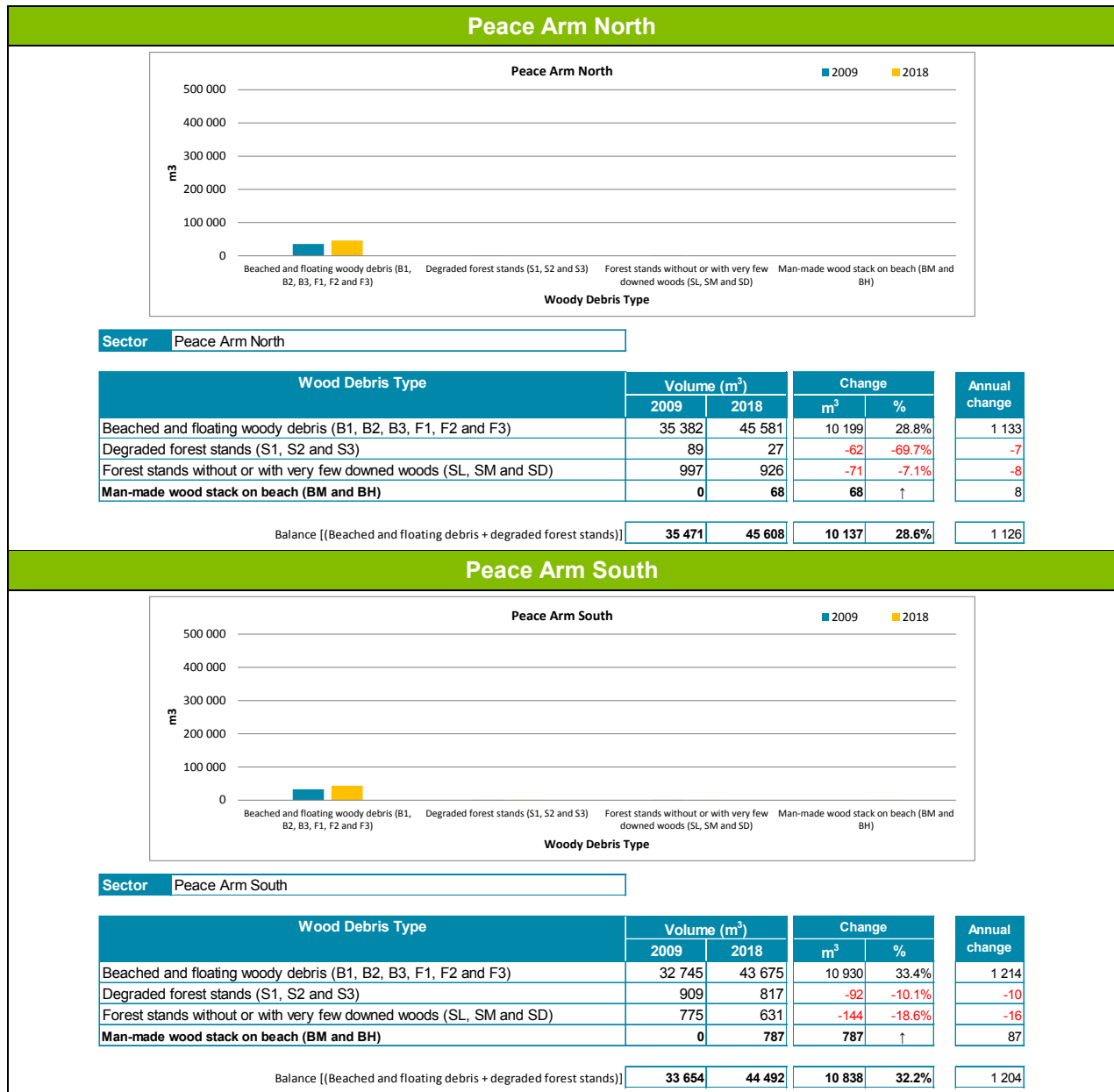
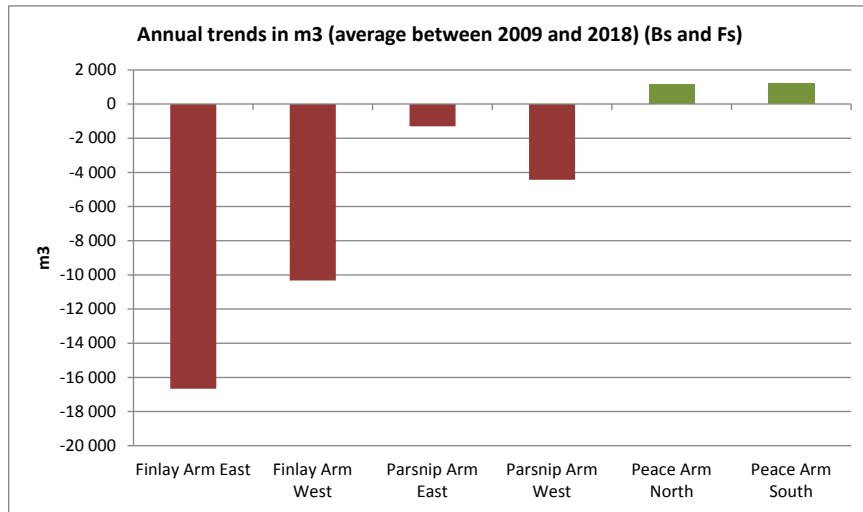
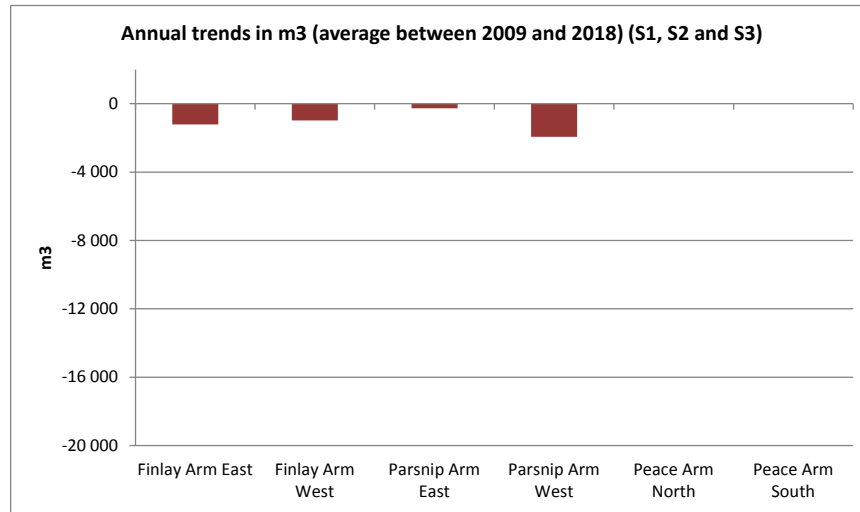


Table D12 Annual trends in Volume by Sector, for Debris Classes B1, B2, B3, F1, F2, and F3



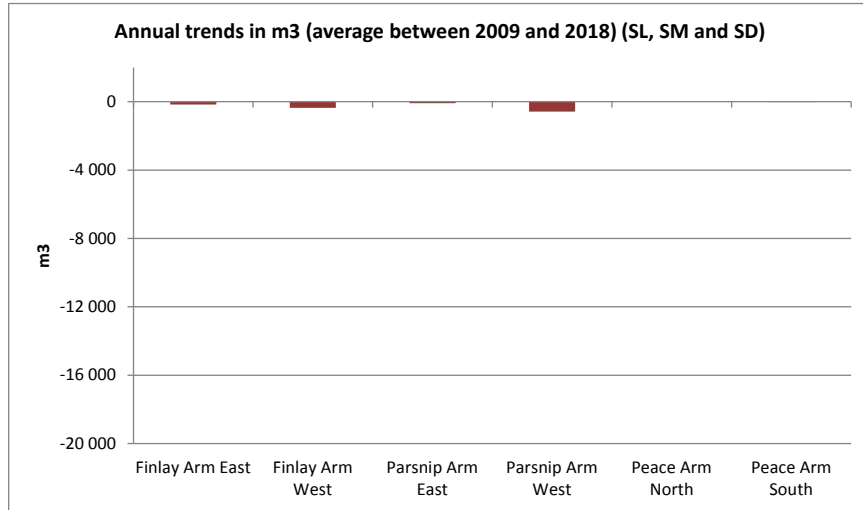
Wood Debris Type	Volume (m³)		Change		Annual change
	2009	2018	m³	%	
Sector Finlay Arm East					
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	423 263	273 303	-149 960	-35.4%	-16 662
Sector Finlay Arm West					
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	359 382	266 410	-92 972	-25.9%	-10 330
Sector Parsnip Arm East					
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	165 332	153 639	-11 693	-7.1%	-1 299
Sector Parsnip Arm West					
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	286 016	246 154	-39 862	-13.9%	-4 429
Sector Peace Arm North					
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	35 382	45 581	10 199	28.8%	1 133
Sector Peace Arm South					
Beached and floating woody debris (B1, B2, B3, F1, F2 and F3)	32 745	43 675	10 930	33.4%	1 214

Table D13 Annual Trends in Volume by Sector, for Degraded Forest Stands S1, S2, and S3



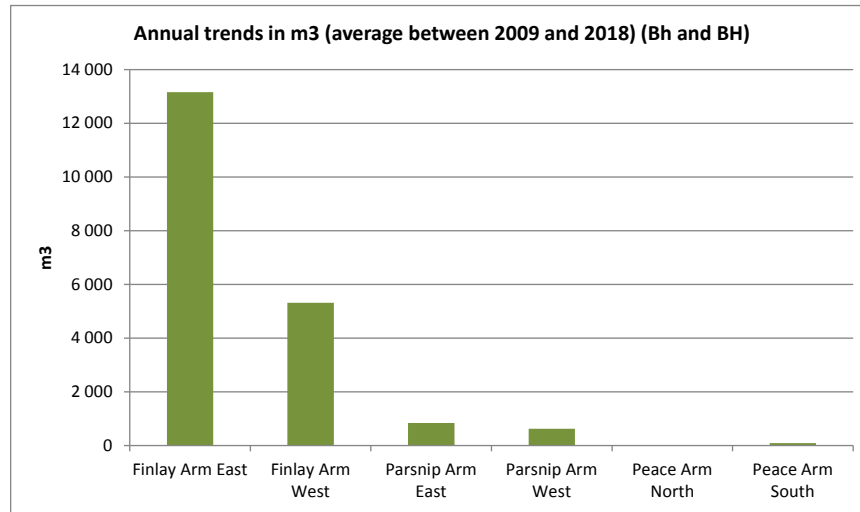
Degraded Forest Stands		Volume (m³)		Change		Annual change
		2009	2018	m³	%	
Sector	Finlay Arm East					
	Degraded forest stands (S1, S2 and S3)	35 972	25 058	-10 914	-30.3%	-1 213
Sector	Finlay Arm West					
	Degraded forest stands (S1, S2 and S3)	57 054	48 281	-8 773	-15.4%	-975
Sector	Parsnip Arm East					
	Degraded forest stands (S1, S2 and S3)	13 957	11 557	-2 400	-17.2%	-267
Sector	Parsnip Arm West					
	Degraded forest stands (S1, S2 and S3)	56 650	39 223	-17 427	-30.8%	-1 936
Sector	Peace Arm North					
	Degraded forest stands (S1, S2 and S3)	89	27	-62	-69.7%	-7
Sector	Peace Arm South					
	Degraded forest stands (S1, S2 and S3)	909	817	-92	-10.1%	-10

Table D14 Annual Trends in Volume by Sector, for Forest Stands SL, SM, and SD



Wood Debris Removal Activities		Volume (m³)		Change		Annual change
		2009	2018	m³	%	
Sector	Finlay Arm East					
	Forest stands without or with very few downed woods (SL, SM and SD)	33 937	32 449	-1 488	-4.4%	-165
Sector	Finlay Arm West					
	Forest stands without or with very few downed woods (SL, SM and SD)	51 540	48 317	-3 223	-6.3%	-358
Sector	Parsnip Arm East					
	Forest stands without or with very few downed woods (SL, SM and SD)	12 319	11 557	-762	-6.2%	-85
Sector	Parsnip Arm West					
	Forest stands without or with very few downed woods (SL, SM and SD)	37 649	32 415	-5 234	-13.9%	-582
Sector	Peace Arm North					
	Forest stands without or with very few downed woods (SL, SM and SD)	997	926	-71	-7.1%	-8
Sector	Peace Arm South					
	Forest stands without or with very few downed woods (SL, SM and SD)	775	631	-144	-18.6%	-16

Table D15 Annual Trends in Volume by Sector, for Stacked and Harvested Areas (BM and BH)



Wood Debris not observed anymore in 2011		Volume (m³)		Change		Annual change
		2009	2018	m³	%	
Sector	Finlay Arm East					
	Man-made wood stack on beach (BM and BH)	0	118 438	118 438	↑	13 160
Sector	Finlay Arm West					
	Man-made wood stack on beach (BM and BH)	50	47 866	47 816	↑	5 313
Sector	Parsnip Arm East					
	Man-made wood stack on beach (BM and BH)	223	7 796	7 573	↑	841
Sector	Parsnip Arm West					
	Man-made wood stack on beach (BM and BH)	29	5 681	5 652	↑	628
Sector	Peace Arm North					
	Man-made wood stack on beach (BM and BH)	0	68	68	↑	8
Sector	Peace Arm South					
	Man-made wood stack on beach (BM and BH)	0	787	787	↑	87
Total :						20 037

