Appendix A

Watershed Maps

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

Greater Vernon Services

Field Map

Legend

198 Stream Crossing (ID)

Watershed Boundary

Sub-basin Boundary

Roads

- HY
- INF
- LR
- MLR
- PLR
- PTR
- SR
- TMP

Contour (NRCAN)

Contour (metre and feet)

Hydrology

- Lake
- Indefinite Lake
- Intermittent Lake
- Wetland
- Streams

Forest Cover/ECA Recovery

- 0% (<3m)
- 25% (3-<5m)
- 50% (5-<7m)
- 75% (7-<9m)
- 90% (>9-<12m)
- Immature (>12m <80 Years)
- Mature Forest

Projection: UTM Zone 11
Datum: NAD83
1:30,000

450 225 0 450 900 1,350 1,800
metre

DOBSON Engineering Ltd.

Map Produced for:
Dobson Engineering Ltd.
#4-1960 Springfield Road
Kelowna, BC, V1Y 5V7

FPS Drafting & Geomatics Ltd.

Map Produced by:
FPS Drafting & Geomatics Ltd.
2784Paris Street
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Duteau Residual

Aberdeen Residual

Heart Sub-basin

Flyfish Sub-basin

Duteau U/S of Grizzly Sub-basin

Appendix B

Field Assessment Results and Photographs

KERR WOOD LEIDAL
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2007 Contaminants Inventory Summary

Summary Notes by B. Gaucher

Industrial/Forest Development Impacts

Mainline roads

- The main roads traveled during the assessment include Aberdeen, 2700, Brunnet, Dee Lake, Crescent, Haddo, Goat, Wallaston, and Curtis FSR
- Heavily roaded, providing liberal access to all users
- 200 stream crossings (includes all roads, status and non-status)
- Surface erosion appears low to negligible on roads throughout the watershed, however fines were identified suspended in many puddles indicating chronic delivery, albeit low in production.
- Ditchlines/fill slopes typically vegetated with shrubs and grasses
- Typical problems encountered include;
    - undersized, or failing culverts
    - ditch/fill erosion near crossings
    - minimal cover over metal culverts
    - aging bridge structures (i.e. above headgates, Curtis, and

Typical cut/fill along Aberdeen




Branch and Spur Roads

- Road surface and prism typically vegetated
- Surface erosion noted was typically in wheel ruts
- Overland roads, particularly around lakes and in the Flyfish/Doreen Lake area have large potholes that retain water
- Provide access to most lakes within watershed
- Deactivation (water management) structures noted appeared to be functioning, however minor breaching and failures were identified.
-

Logging Activities

- Riparian/wetland areas logged in past along tributary streams and mainstem channel
- Landslide into Upper Duteau Creek (Buchannan Road system), rehabilitated through FRBC, appears stable and no longer a sediment source

Reservoir Development

- Development of dams, through roads and clearing has allowed for easy access by all users
- Stumps left in reservoir basin
- Headgates located on fan

Range Use Impacts

- Some evidence of cattle use identified at most (80%) stream crossings visited in the watershed.
- Creating stream channels in previously grassed drainages, particularly where past logging activities have opened access to naturally wet drainage courses.
- Cattle accessing lakes and reservoirs throughout the watershed
- Only one cattle watering station noted, located adjacent to a mapped stream crossing.
- Cattle excrement noted within stream channels, diversion channels and lakeshores (Lake bottom in Grizzly Swamp).
-

Wildlife Impacts

- There was little evidence with regard to wildlife activity; cattle trampling around stream crossings may have masked it.
- Three Whitetail deer, one Black Bear, and two wolves were seen during the assessment.

Recreational Use Impacts

- Numerous Forest Recreation Sites as well as impromptu camping sites around almost all lakes/reservoirs in the watershed
- Most camp sites appeared clean with limited garbage noted, some refuse was identified, typically in the form of battles and cans, however other items were found
- Unattended fires were noted (extinguished by assessor)
- ATV and 4WD trails noted around lakeshores as well as within the drawn down reservoir of Grizzly Swamp
- Boat launches showed low to negligible amounts of sediment delivered to the waterbody
- ATV and 4WD vehicle tracks noted along face of Grizzly swamp saddle dams
- Abandoned/stolen/vandalized vehicles noted at Haddo Lake
- Moderate use of deactivated roads, breaching shallow deactivation structures

Natural Impacts

- Instabilities upstream of intake
- Aging Cottonwoods creating bank instabilities

bg/

THEN and NOW

2007 - second channel on right from bank trampling.

2005 single channel, likely caused by trampling

Duteau Creek Contaminant Source Survey - Roads					Road Running Surface					Ditches														
Sites Surveyed October 24-26, 2007					Left Surface		Right Surface			RF Ditch		RB Ditch		LF Ditch		LB Ditch						*1 = presence, 0 = absence		
Xing ID	Structure Type	Struct. Size	Erodibility	Road Use	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Substrate	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Photos	Road Score	Ditch Score	Combined Score	Cattle	Recreation	Wildlife
1	5	600	0.85	1	0	0.8	0	0.8	0.85	0	0.8	0.7	1	0	0.8	0.7	1		0.00	1.19	0.20	1	0	1
2	5	400	0.85	0.93	0	0.9	0	0.9	0.85	0	0.8	0	0.8	0.6	0.9	0	0.8		0.00	0.46	0.08	1	0	1
17	1	10.5m x 3.5m	0.95	1	0.6	0.9	0.6	0.9	0.95	0.6	0.8	0.7	0.9	0.7	1	0.6	0.8	P111-113, 117	1.03	2.18	0.53	1	0	1
18	5	1000	0.85	0.95	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8	P118	0.78	0.00	0.13	0	0	0
19	5	500	0.85	0.93	0.6	0.8	0.6	0.8	0.85	0	0.8	0	1	0	0.8	0	1	P119	0.76	0.00	0.13	0	0	0
20	5	500	0.8	1	0	0.8	0	0	0.8	0	0.8	0	0.9	0	0.8	0	0.9		0.00	0.00	0.00	1	1	1
22	8	-	0.95	0.93	0	0.9	0	0.9	0.9	0	0	0	0.8	0	0	0	0.8		0.00	0.00	0.00	1	1	1
23	5	400	0.95	0.93	0.6	0.9	0.6	0.9	0.95	0.85	1	0	0.9	0	0.9	0.8	1		0.95	1.57	0.42	1	1	1
24	8	-	0.85	1	0.6	0.9	0.6	0.9	0.85	0	0.8	0.6	0.8	0	0.8	0	0.9		0.92	0.41	0.22	0	0	0
29	5	600	0.85	0.95	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8		0.78	0.00	0.13	1	0	1
30	5	600	0.9	0.93	0.7	0	0.7	0	0.9	0	0.8	0	0.8	0	0.8	0	0.8		0.00	0.00	0.00	1	0	1
31	5	500	0.9	0.93	0	0.9	0	0.9	0.9	0	0.9	0.7	1	0.7	1	0	0.8		0.00	1.26	0.21	1	1	1
32	8	-	0.8	0.8	0	1	0	1	0.8	0	0.8	0	1	0	0.8	0	1		0.00	0.00	0.00	1	1	1
41	5	800	0.85	1	0.6	1	0.6	1	0.85	0.7	1	0.6	0.8	0.7	1	0.7	1	P114-116	1.02	2.19	0.54	0	0	0
44	5	400	0.85	0.95	0	0.8	0	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8		0.00	0.00	0.00	1	0	1
51	5	500	0.9	1	0.6	0.9	0.6	0.9	0.9	0	0.8	0.7	0.9	0	0.8	0.7	0.9		0.97	1.13	0.35	1	0	1
64	5	900	0.85	1	0.6	0.9	0.6	0.9	0.85	0.6	0.9	0.6	0.8	0.7	0.9	0.6	0.8		0.92	1.81	0.45	0	0	0
70	1	6m x 2m	0.85	0.93	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0.6	1	0	0.8	P87-89	0.76	0.51	0.21	1	0	1
71	2	5m x 2m	0.85	0.95	0.6	0.8	0.6	0.8	0.85	0.6	1	0	0.8	0.7	1	0	0.8	P83-84, 85-86	0.78	1.11	0.31	1	0	1
73	5	400	0.9	1	0.6	0.9	0.6	0.9	0.9	0	0.8	0.6	0.9	0	0.8	0.6	0.9		0.97	0.97	0.32	1	0	1
75	5	300	0.9	1	0.6	0.9	0.6	0.9	0.9	0	0.8	0	0	0	0	0	0		0.97	0.00	0.16	1	0	1
76	5	500	0.85	1	0.6	0.9	0.6	0	0.85	0	0	0	0.8	0	0.8	0.7	1		0.46	0.60	0.18	0	0	0
81	5	1200	0.9	1	0.6	1	0.6	1	0.9	0.7	0.8	0.7	0.8	0.7	0.8	0	0.9		1.08	1.51	0.43	1	0	1
95	8	-	0.9	0.93	0.8	1	0.7	1	0.9	0	0.8	0	0.8	0	0.8	0	0.8		1.26	0.00	0.21	1	1	1
96	5	600	0.85	0.93	0	0.8	0	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8		0.00	0.00	0.00	0	0	0
97	8	-	0.8	0.93	0.8	1	0.8	1	0.85	0	0.8	0	0.8	0	0.8	0	0.8		1.19	0.00	0.20	1	1	1
98	2	8000x1800	0.85	0.95	0.6	0	0.6	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8		0.39	0.00	0.06	1	0	1
100	5	900	0.85	0.95	0.7	0.8	0.7	0.9	0.85	0	0.8	0	0.8	0	0.8	0.6	0.8		0.96	0.41	0.23	0	1	0
101	5	1000	0.95	0.95	0.6	0.8	0.6	0.8	0.95	0	0.8	0	0.8	0	0.8	0.8	1	P82	0.87	0.76	0.27	1	0	1
104	8	-	0.9	0.93	0.8	1	0.7	1	0.9	0	0.8	0	0.8	0	0.8	0	0.8		1.26	0.00	0.21	1	1	1
105	1	6.5m x 2m	0.85	0.95	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0	0	0.6	0.8	P78-81	0.78	0.41	0.20	1	0	1
108	5 (elip)	1600x1200	0.9	1	0.6	0.9	0.6	0.9	0.9	0	0.9	0	0.9	0	0.9	0	0.9		0.97	0.00	0.16	1	0	1
109	2	2.5m x 2m	0.9	0.95	0.6	0.8	0.6	0.8	0.9	0	0.8	0	0.8	0	0.8	0	0.8	P75-76	0.82	0.00	0.14	0	0	0
110	5	1000	0.85	0.95	0.6	0.8	0.6	0.8	0.85	0	0.8	0.8	0	0	0.8	0	0.8	P77	0.78	0.00	0.13	0	0	0
113	5	600	0.85	0.95	0.6	0	0.6	0.8	0.85	0	0.8	0	0.8	0	0	0	0	P71-72	0.39	0.00	0.06	0	0	0
114	5	1100/900/	0.9	1	0	0.9	0	0.9	0.9	0	0.9	0.6	0.9	0	0.9	0	0.9		0.00	0.49	0.08	1	0	1
116	5	800	0.9	1	0	0.9	0	0.9	0.9	0	0.8	0	0.8	0	0.8	0	0.8		0.00	0.00	0.00	1	0	1
118	8	-	0.9	0.93	0	0.8	0	0.8	0.9	0	8	0	0.8	0	0.8	0	0.8		0.00	0.00	0.00	1	0	1
119	5	900	0.9	0.93	0	0.8	0	0.8	0.9	0	0.8	0	0.8	0	0.8	0	0.8		0.00	0.00	0.00	1	0	1
120	45	600	0.9	0.95	0.7	1	0.7	1	0.85	0.7	1	0.7	0.9	0.7	0.9	0	0.8		1.20	1.67	0.48	1	0	1
122	2	3m x 2m	0.85	0.95	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0	0	0.8	0	0.8	P73-74	0.78	0.00	0.13	0	0	0
123	5	300	0.9	0.93	0.7	0.8	0.6	0.8	0.9	0	0.8	0	0.8	0	0.8	0	0.8		0.87	0.00	0.15	1	0	1
133	5	500	0.9	1	0.6	0.8	0.7	0.8	0.9	0	0.8	0	0.8	0	0.8	0	0.8		0.94	0.00	0.16	1	0	1
137	5	500	0.85	0.93	0.6	0.8	0	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8		0.38	0.00	0.06	1	0	1
141	5	500	0.9	0.95	0.6	0.9	0.7	0.9	0.8	0	0.8	0	0.8	0	0.8	0	0.8		1.00	0.00	0.17	1	0	1
142	5	600	0.9	1	0.6	0.8	0.6	0.8	0.9	0	0.8	0	0.8	0	0.8	0	0.8		0.86	0.00	0.14	1	0	1
144	5	500	0.85	0.95	0.6	0.9	0.6	0.9	0.8	0.6	0.9	0.6	0.9	0.6	0.9	0.6	0.9		0.87	1.73	0.43	1	0	1
146	5	900	0.85	0.92	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8	P54-55	0.75	0.00	0.13	1	0	1
147	7	-	0.9	0.93	0.6	1	0.6	1	0.9	0	0.8	0	0.8	0	0.8	0	0.8		1.00	0.00	0.17	1	1	1
149	1	8000x2700	0.9	0.95	0.6	1	0.6	0	0.9	0	0.8	0	0.8	0	0.8	0	1		0.51	0.00	0.09	1	0	1
150	5	600	0.9	0.98	0.7	0.8	0.7	0.8	0.8	0	0.8	0	0.9	0	0.8	0	0.8		0.99	0.00	0.16	1	0	1
151	5	900	0.9	1	0.6	0.9	0.6	0.9	0.9	0.9	1	0.6	0.9	0.6	0.8	0.6	0.9		0.97	2.21	0.53	1	0	1
156	5	500/400	0.85	1	0	0.9	0	0.9	0.85	0	0.8	0	0.8	0	0.8	0	0.8		0.00	0.00	0.00	0	0	0
157	5	500,400	0.85	1	0.7	1	0.7	1	0.8	0	0.8	0.6	0.8	0	0.8	0.6	0.8	P12-13	1.19	0.77	0.33	1	0	1
158	5	500	0.85	1	0.7	1	0.8	1	0.8	0	0.8	0	0.8	0	0.8	0	0	P9-11	1.28	0.00	0.21	1	0	1
159	5	600	0.85	1	0.6	0.8	0.8	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P14-15	0.95	0.00	0.16	1	0	1
161	5	900	0.9	1	0.7	1	0.7	1	0.8	0	0.8	0.6	0.9	0	0.8	0.6	0.9	P5-6	1.26	0.86	0.35	1	0	1
163	7	n/a	0.8	0.92	0.6	1	0.6	1	0.8	0	0.8	0	0	0	0.8	0.6	0.8	P65-66, 67-68	0.88	0.38	0.21	1	1	1
164	1	7m x 2.5 m	0.85	1	0.6	0.8	0.6	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P1-4	0.82	0.00	0.14	1	0	1

Duteau Creek Contaminant Source Survey - Roads					Road Running Surface					Ditches														
Sites Surveyed October 24-26, 2007					Left Surface		Right Surface			RF Ditch		RB Ditch		LF Ditch		LB Ditch						*1 = presence, 0 = absence		
Xing ID	Structure Type	Struct. Size	Erodibility	Road Use	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Substrate	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Erosion Level	Delivery Potential	Photos	Road Score	Ditch Score	Combined Score	Cattle	Recreation	Wildlife
169	5	500	0.95	0.95	0.6	0.8	0.6	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P24	0.87	0.00	0.14	1	0	1
171	1	6.5m x 2.5m	0.95	0.95	0.6	1	0.6	1	0.95	0.7	1	0.6	0.8	0.6	1	0.6	0.8	P25-29	1.08	2.15	0.54	1	0	1
175	5	900	0.85	0.93	0.6	0.8	0	0.8	0.85	0	0.8	0.7	1	0	0.8	0.6	1	P47-48	0.38	1.11	0.25	0	0	0
176	5	500	0.85	0.95	0.6	1	0.8	1	0.85	0	0.9	0.7	0.9	0	0.9	0	0.8	P19-20	1.13	0.54	0.28	1	0	1
177	5	500	0.8	0.98	0.7	0.8	0.7	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	JP17-18	0.88	0.00	0.15	1	0	1
178	1	8m x 3m	0.95	0.95	0.6	1	0.6	1	0.8	0	0	0	0	0	0.8	0	0.8	P23	1.08	0.00	0.18	1	0	1
180	5	400	0.95	0.93	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0	0.8	0	0.8	P31-32	0.85	0.00	0.14	1	0	1
181	7	n/a	0.85	0.95	0.6	0.8	0.6	0.8	0.85	0	0.8	0	0.8	0	0.8	0.6	0.8	P69-70	0.78	0.41	0.20	1	1	1
182	5	400,500	0.9	1	0.6	0.8	0.6	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P16	0.86	0.00	0.14	1	0	1
183	5	400	0.85	0.93	0	0.8	0	0.8	0.85	0.6	1	0	0.8	0.6	1	0	0.8	P45-46	0.00	1.02	0.17	1	0	1
184	5	500	0.8	0.92	0	0.8	0	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P52-53	0.00	0.00	0.00	0	0	0
185	7	n/a	0.8	0.92	0.6	1	0.7	1	0.8	0	0	0	0	0	0	0.6	0.8	P49-51	0.96	0.38	0.22	1	1	1
187	5	500	0.9	0.93	0.6	0.8	0.6	1	0.9	0	0.8	0	0	0	0.8	0	0.8	P37	0.90	0.00	0.15	0	0	0
189	8	n/a	0.8	0.93	0.7	1	0.6	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P43	0.88	0.00	0.15	1	1	1
190	5	500	0.95	0.95	0.8	0.8	0.8	0.8	0.95	0	0.8	0.7	1	0.7	0.8	0.8	1	P40-42, 44	1.16	1.96	0.52	1	0	1
191	5	500	0.95	0.93	0.6	0.9	0.6	0.9	0.95	0.8	1	0	0	0.7	1	0	1	P33	0.95	1.43	0.40	1	0	1
192	5	800	0.8	0.93	0	0.8	0	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P30	0.00	0.00	0.00	0	0	0
195	5	900	0.8	0.93	0.6	0.8	0.6	0.8	0.8	0.6	0.8	0	1	0.6	1	0.6	1	P38-39	0.71	1.34	0.34	1	0	1
196	5	800	0.9	0.95	0.6	0.8	0.6	0.8	0.9	0	0.8	0	0.8	0	0.8	0	0	P36	0.82	0.00	0.14	0	0	0
197	5	400	0.95	0.95	0.7	0	0.7	0.9	0.95	0	0.8	0.6	0.8	0	0.8	0	0	P34-35	0.57	0.46	0.17	1	0	1
198	2	5.5m x 1m	0.9	0.95	0.6	0.8	0.6	0.8	0.9	0	0.8	0	0.8	0	0.8	0.8	0.8	P56-61, 64	0.82	0.58	0.23	1	0	1
G1	5	700	0.8	1	0.6	0.8	0.6	0.8	0.8	0	0.8	0	0.8	0	0.8	0	0.8	P7-8	0.77	0.00	0.13	1	0	1
G2	1	6.5m x 3.5m	0.95	0.98	0.6	0.8	0.6	0.8	0.95	0	0.8	0	0.8	0	0.8	0	0.8	P21-22	0.89	0.00	0.15	1	0	1
82																								

Appendix C

GVW Water Quality Data

KERR WOOD LEIDAL
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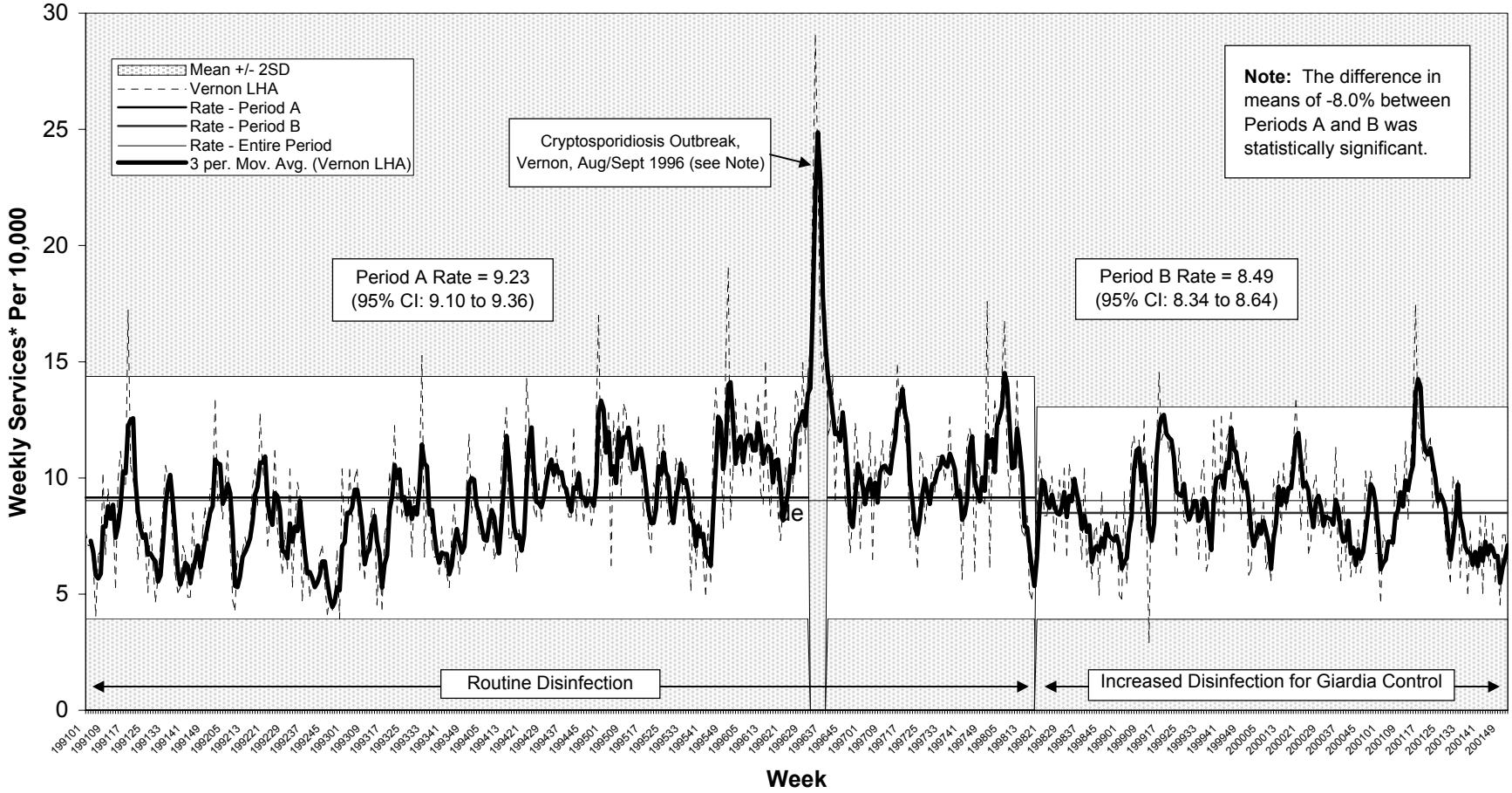
MSP Services for Intestinal Infectious Diseases, Weekly Rates, Vernon LHA 22, Okanagan HSDA B.C., Jan. 1991 - Dec. 2002



* Specialties: General Practice, Pediatrics, Internal Medicine, Public Health, Geriatric Medicine and Emergency Medicine Services for ICD9: 001-009, 558, and 787 billed through the Medical Services Plan (MSP). Service codes considered are regional and complete exams, consultations, and home and emergency visits. These data represent the number of individual services per week. Pathology services were excluded.

Note: The cryptosporidiosis outbreak among Vernon-area residents was believed to be associated with an earlier Kelowna outbreak. The data in the outbreak weeks are excluded in Period A. Within the Vernon LHA, the City of Vernon (34,000) and Coldstream (8,000) have chlorinated water. An additional 15,000 people, approximately 25% of the population of Vernon LHA, are served by the North Okanagan Water Authority (NOWA), which implemented an increased level of disinfection for giardia control as of May 1998, the beginning of period B. Given the close geographic proximity of the water systems in the City of Vernon and NOWA, Vernon LHA residents may consume water from both systems. Inter-area and intra-area variations must be interpreted with caution, as data relating to physician services utilization may be influenced by many factors, including severity of symptoms, physician access, and diagnostic coding practices. MSP data are current as of April 17, 2003.

001 - Cholera
002 - Typhoid & Paratyphoid fevers
003 - Other salmonella infections
004 - Shigellosis
005 - Other food poisoning (bacterial)
006 - Amoebiasis
007 - Other protozoal intestinal diseases
008 - Intestinal infections due to other organisms
009 - Ill-defined intestinal infections
558 - Other noninfective gastroenteritis and colitis

Source: Medical Services Plan; and Okanagan HSDA.

Prepared by: Population Health Surveillance and Epidemiology - 11/05/07.

Appendix D

2007 Hydrology Report completed for Tolko

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DUTEAU CREEK COMMUNITY WATERSHED

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT OF MOUNTAIN PINE BEETLE INFESTED STANDS AND PROPOSED RETENTION PLAN

PREPARED FOR

TOLKO INDUSTRIES LTD

BY

DOBSON Engineering Ltd.

JANUARY 2008

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DUTEAU CREEK COMMUNITY WATERSHED
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT OF MOUNTAIN PINE BEETLE INFESTED STANDS AND PROPOSED RETENTION PLAN

Summary

- On December 31, 2006 the ECA for snow sensitive zone (SSZ) above Headgates was 30.1% and for the SSZ above Haddo was 34.0%.
- The projected ECA if the mountain pine beetle kills all the remaining mature pine in the SSZ would be 57.7% above Headgates and 55.5% above Haddo.
- Based on the proposed Retention Plan, the projected ECAs for the SSZ above Headgates would be 58.6% and above Haddo would be 56.8%.
- The peak flow hazards at December 31, 2006 are estimated to be moderate at Headgates and moderate at Haddo
- The peak flow hazards assuming all the mature pine dies would be high at Headgates but remain moderate at Haddo due to the potential attenuation of the peak by the three reservoirs.
- The peak flow hazards based on the proposed Retention Plan would remain the same as for the previous scenario i.e. high at Headgates and moderate at Haddo.
- It is recommended that the proposed retention plan proceed since the potential benefits of reduced peak flow impacts and water quality impacts are significantly better for the proposed retention plan than if there was no salvage logging.
- The proposed salvage harvesting would increase the ECA for the snow sensitive zone above Headgates to 59% from 58% if there was no salvage harvesting and to 57% above Haddo from 55%. The increase in ECA for the harvesting scenario is due to the loss of non-pine species in the logged blocks.
- Areas that are harvested and replanted would recover faster than areas left to natural regeneration and over a 30-year period the ECA would be ~21% for the combined areas salvaged + past logging versus 38% if there was no salvage logging.
- When planning salvage logging priority should be given to those areas with pine >70% that account for ~94% of the pine stands in the SSZ above Headgates and 97% of the pine leading stands above the outlet of Haddo.

1. INTRODUCTION

This report has been prepared for Tolko Industries Limited (Tolko) to update the watershed ECAs and to assess the potential hydrologic impacts of the loss of forest cover as a result of the expansion of the mountain pine beetle and the proposed retention plan for the Duteau Creek Community Watershed. Duteau Creek is a tributary to Bessette Creek that is a tributary to the Shuswap River.

The last major hydrologic review of the Duteau Creek watershed was completed in 1999 when the Interior Watershed Assessment Procedure (IWAP) was updated. The initial IWAP was completed in 1996. The 1999 IWAP concluded that all the hazards were rated as low at that time. The ECA for the watershed was 21.5% and for the watershed above the Aberdeen Reservoir it was 24%.

Duteau Creek is a major source of supply for Greater Vernon Services providing domestic and irrigation water. The system includes three reservoirs on the upland plateau; Grizzly, Aberdeen and Haddo. There is also a diversion of runoff into Aberdeen from Gold and Paradise Creeks that are part of the Harris Creek watershed. This diversion is licensed during the spring runoff period only. The water intake is located in the lower watershed at

Headgates. As indicated previously Duteau Creek is a tributary to the Shuswap River that is part of the Fraser River basin, however the water supplied to Greater Vernon Services is diverted into the Okanagan Basin that is part of the Columbia River basin.

In 1999 an Interior Watershed Assessment Procedure report was completed for the watershed. In addition there are other reports that were completed as part of the Watershed Restoration Program funded work over the period of 1994-2000 as well as hydrology reports for specific forest development plans for Riverside Forest Products Ltd. and Tolko up to 2006.

This is not the first occurrence of the pine beetle in the watershed. There has been extensive harvesting focused on pine stands impacted by the beetle since the early 1980s. The expansion of those infestations declined in the late 1980s to endemic levels. The current infestation is moving southeast across the interior of the province from intensive epicenters to the north and west of the Okanagan. Based on the projections by the Ministry of Forests it is expected that the populations in the watershed should reach a maximum in 2009 and then decline as the extent of mature pine diminishes.

If there is anything positive that can be said about the potential impacts in the watershed it is that the amount of mature pine is less than in some other watersheds due to the previous infestations and harvesting that has occurred since the 1980s. These areas are now reforested and have advanced hydrologic recovery.

The loss of most or all mature lodgepole pine in the Duteau Creek watershed will affect the hydrology. It is the loss of canopy and related decrease in evapotranspiration combined with increased water yields, particularly in the snow accumulation zone in the upper watershed area that will result in increased peak flows that is of primary concern. This assessment has been focused on the snow sensitive zone, the source for the spring freshet and peak stream flows. Loss of canopy closure results in increased snow accumulation on the ground and subsequent increase in melt rates. The decrease in evapotranspiration due to the tree mortality further exacerbates the problem resulting in the potential for even greater water yields. The areas above the reservoirs and in the southwest corner of the watershed are of particular concern for loss of forest cover. In both instances these areas are within the snow sensitive zone and contain high volumes of lodgepole pine that are susceptible to the mountain pine beetle.

Tolko provided the data used to carry out the hydrologic assessments for the watershed. This data in conjunction with its Retention Plan will be used to estimate the potential impacts of the proposed salvage logging.

The watershed drains to the north off the Aberdeen Plateau to its confluence with Bessette Creek in Lumby. Duteau Creek above Headgates has a watershed area of approximately 22,331 ha *[refer to Map 1– Appendix A]*. The source area includes the upper portions of Gold and Paradise Creeks, tributaries to Harris Creek that have been diverted into Aberdeen Reservoir. Storage has been developed in the Aberdeen, Haddo and Grizzly reservoirs. The community watershed intake is located in the lower watershed at Headgates.

The terrain in the upper watershed is generally benign gently rolling plateau with no evidence of instability. The mainstem downstream of Haddo Reservoir flows through a deep, steep valley until it emerges near Headgates. There have been slope failures along this steep valley that have impacted the creek and there is a potential that high flows in the future could result in further erosion at these sites. The soil erosion hazard is considered to be low based on the results of previous assessments completed as part of the Interior Watershed Assessment Procedure. Although channels are typically stable on the upper plateau they will

be susceptible to impacts from the loss of canopy in the riparian areas where mature lodgepole pine is the dominant species, and to increases in peak flow.

2. ASSESSMENT

2.1 Current Watershed Condition

The current watershed condition is based on the ECAs to December 31, 2006. The values presented in Table 1 illustrate the estimated hydrologic recovery for all blocks including any blocks planned for harvest by December 31, 2006. The values of interest are those for the

Table 1.
Current ECAs (December 31, 2006)

Drainage	Area (ha)	Total Area Harvested (ha)/(%)	Current Total ECA (ha)/(%)	Current ECA below snowline (ha)(%)	Current ECA above snowline (ha)(%)
Duteau Creek above Headgates	22,331.0	9,854.6/ 44.1	6,676.9/ 29.9	3,728.5/ 29.7	2,948.4/ 30.1
Duteau Creek above Haddo Outlet	10,086.5	4,347.9/ 43.1	3,125.2/ 31.0	894.0/ 25.3	2,231.2/ 34.0
Watershed	22,331.0				

- Growth of trees is modeled using Variable Density Yield Predictor (VDYP) and site index values.
- Site index values are updated using the BC Ministry of Forests Site Index estimates by Site Series (SIBEC) - Second Approximation published in 2003.
- All stands ≥12m in height are considered to be fully recovered, hydrologically, and have been excluded from the ECA calculations.
- Snow zone ECA is calculated as the non-recovered area in the snow sensitive zone divided by the total area of the snow sensitive zone.

snow sensitive zone (SSZ). For the SSZ, the current ECA based on past harvesting is estimated to be 30.1% for the watershed above Headgates and 34.0% for the watershed above the outlet of Haddo Reservoir. The total watershed area above the intake harvested by December 31, 2006 totals 6,676.9 ha (29.9% of the area). The ECA for the SSZ above the intake (30.1%) translates into a moderate peak flow hazard. For the watershed above the Haddo Reservoir, the ECA was 34% and the peak flow hazard is also moderate.

2.2 Field Inspections

The watershed was inspected in the fall of 2006 by staff from Dobson Engineering with an emphasis on sediment production and delivery to streams as well as mainstem stream channel condition. In addition general observations of road prism condition and other issues were noted. Maps supplied by Tolko were utilized to locate inspection sites and recent forest development.

Seven stream crossings were visited within the watershed. In general the channels are in fair condition and disturbances were typically related to past industrial activities (forestry) and cattle activity along stream banks.

The following is a summary of the stream sites visited. The photographs referenced are provided in Appendix B.

2.2.1 Stream Inspections

Site 1

Photos 1 – 3 illustrate the typical road conditions along the Aberdeen FSR. Site 1 is located at ~23 km on Aberdeen FSR (Photo 4) at the culvert crossing of the drainage channel between the Grizzly and Haddo reservoirs. At this location, three metal culverts convey flow across the road prism. Fill erosion is occurring at the inlet and outlet side of the culverts (all showing signs of corrosion), and the streambed is elevated at the inlet from deposition (Photo 5) that is reducing the peak flow capacity. Cattle have also accessed and disturbed the riparian area.

Upstream of the crossing (60 m) the outlet channels from the two saddle dams join to make one channel (Photo 6). The channel is moderately degraded, with signs of recent bank erosion, aggradation increases towards the crossing. This disturbance is likely associated with the flow releases from the two dams. At 60 m downstream of the crossing the channel is slightly aggraded with small cobbles and gravel. There is a limited supply of LWD, braided sections, and some sidebars present (Photo 7).

Site 2

Site 2 is located at the stream crossing near the 27 km board on Aberdeen FSR. Erosion of the fillslope (Photo 8) and ditch flow is delivering small amounts of sediment to the stream. Cattle activity was also noted around the crossing on the upstream side, a cattle drift fence was located along the downstream side of the road.

At 70 m upstream of the crossing the channel flows through a low gradient U-shaped swale with a 5 m to 10 m floodplain. The bed consisted of cobble and gravel (some boulders noted) and appeared slightly degraded. Low to moderate cattle activity was noted along the banks (Photo 9).

Site 3

Site 3 is located on Philpot Main at the bridge crossing of Duteau Creek. There is cattle drift fencing on both sides of the crossing. Trampling can be seen in the sidebar on the upstream side of the bridge. Sediment delivery from the road prism was considered low at this location.

Approximately 100 m upstream the channel contains a large amount of LWD both spanning and in the channel (Photo 11). The riparian stand remains intact. Sediment wedges are present behind LWD and gravel bars. The streambed consists of sands and gravels, with some cobbles and boulders, and appears moderately aggraded. Bank trampling was noted with numerous trails along the riparian area. Overbank deposits of sediment were also identified on the hummocky terrain (Photo 12).

Site 4

Site 4 is located at the next crossing of Duteau Creek, upstream of site 3, at a secondary road 200 m off Aberdeen FSR at the 30km board. It is likely that this culvert was removed rather than washed out but this has not been confirmed and the crossing is an armoured ford (Photo 13).

At 60 m upstream of the crossing the channel appears slightly degraded with bed and banks of cobble/gravel/sand (Photo 14). This may be the source of sands at site 3). Large woody debris was abundant across the channel, creating at least one side channel.

Photos 15 – 30 have been included to illustrate the road and crossing conditions at other locations in the watershed that were noted during the travel from site 4 to site 5.

Site 5
Site 5 is located on Haddo Main at the bridge crossing of Duteau Creek at 12.2 km (Photo 31). Erosion and sediment control structures have been installed including a steel cattle guard crossdrain and armoured ditchline with a sump (Photos 32 and 33). The sump was full of turbid water and appeared to be functioning but this site should be reviewed since it is apparent that there is a considerable volume of standing water in the sump and the silt fence in the foreground in Photo 33 is either not required or is not correctly installed.

Upstream of the bridge the stream flows through a flat wetland area. The stream appears to be moderately aggraded (Photos 36 and 37). The channel is braided and large woody debris (perpendicular and parallel to the channel) was present. Mid-channel and side channel bars were present and re-vegetation was occurring. Some cattle activity was also observed.

Site 6
Site 6 is located on Curtis Main at the crossing of Heart Creek near CP355-11 (Photos 38, 39). Cattle drift fencing is in place on both sides of the crossing (Photos 40, 42, and 43). Sediment delivery from the road prism was low at this location.

Upstream of the crossing (~100 m) the area is hummocky with abundant LWD spanning and resting within the low gradient channel (Photo 43). The streambed consists of sand/gravel/cobble and appears partially aggraded (some side channel bars were noted). Photo 44 illustrates a culvert that has inadequate road fill cover and is exposed to damage by vehicle traffic.

Site 7
Site 7 is located on Curtis Main at the bridge crossing on the stream channel connecting Curtis Lake and Aberdeen Reservoir near CP 275-5 (Photo 45). Cattle are accessing the stream from both sides of the bridge (Photo 47).

The stream channel directly upstream of the bridge is braided with lateral bars and abundant small woody debris (Photo 46). Streambed materials are gravel/sand/cobble and the channel appears to be partially aggraded. At 100 m upstream of the bridge crossing the stream channel appeared partially degraded in comparison (Photo 48) with a larger component of cobble and boulders. Limited large woody debris was present in the channel and localized bank scour was evident upstream of a LWD jam (Photo 49). Harvesting of the riparian stands in the 1980's impacted the channel and there is more recent disturbances including bank trampling.

2.2.2 Road Inspections
The main roads inspected included: Aberdeen FSR, 2700, Brunnet Main, Haddo Main, Goat Main, and Curtis Main. In general the roads were in good condition with low sediment production and delivery. Problems were typically at stream crossings and were related to road fill erosion at culverts, cattle activity at crossings and general maintenance issues. The following is a summary of the road assessment by road system.

Aberdeen Main
Aberdeen Main from 10 km to 39 km is in good condition (Photo 1). The ditchlines and cutslopes were typically well vegetated and not a sediment source. Problems were related to fill erosion at crossdrain and stream culverts (Photos 2, 3, 8, and 27).

From 29 km to the 39 km (watershed boundary) on Aberdeen Main, the road is in fair condition. Numerous intermittent stream crossings appear to have undersized or failing culverts. Where the streams have overtopped the roads due to undersized culverts twin culverts have been installed. Ditch erosion and a failing wood culvert were also identified.

2700 Road
The 2700 Road is in good condition, typically overland type construction (Photo 20), sediment production and delivery is low. Typical problems along this road are related to cattle access at the stream crossings (Photo 21).

Brunnet Main
Brunnet Main is in good condition, typically a rolling grade with numerous low gradient grassed-in drainages. Sediment production was low to moderate along some sections of ditch (Photos 22, 23, and 24), but delivery was typically to crossdrain culverts and grassed wet areas.

Haddo Main and Goat FSR
Haddo Main and Goat FSR were in good condition and no issues were identified. The road prism outside of the running surface was well vegetated and not considered a sediment source.

Curtis Main
Curtis Main borders the northern portion of Aberdeen Reservoir. The road grade is rolling with many overland sections (Photo 39). Some maintenance issues were noted as potholes are abundant (Photo 44) and cattle activity near streams is evident (Photos 38 and 47). The road is in good condition and not considered a sediment source.

2.3 Hydrologic Impact of Loss of Mature Lodgepole Pine
The zone of specific interest is that area within the snow sensitive zone that is the source of the peak flows during the spring runoff period. For this assessment the snow sensitive zone in the Duteau Creek watershed is approximated as the upper 40% of the watershed *[refer to Map 1 - Appendix A]*. This area is based on the results of snowline monitoring of other watersheds in the Okanagan Valley from 1999 to 2001[1].

Table 2 provides an estimate of the ECAs given the loss of all mature lodgepole pine forest cover plus all harvesting to the end of 2006. The pine considered in Table 2 is the "net area" of pine for all polygons >40% pine. The definition of net area is the area remaining after all non-pine species have been excluded.

In the following discussion the term "effective ECA" will be used to describe the potential hydrologic impacts of the loss of the mature pine. The "effective ECA" is the ECA for the gross area of a forest cover polygon that contains >40% mature pine as well as other non-pine species, combined with the ECA for all past harvesting – limited to the snow sensitive zone. To calculate the ECA value, the area has been discounted by 50% to approximate the impact on snow accumulation and melt in mixed stands (>40% pine) including dead pine and with consideration for any secondary structure. Increases in peak flows generated in the snow sensitive zone typically result from increased snow accumulation and faster melt rates. The effective ECA value is different from the ECA values in Table 2 that are based on net areas of pine (as has been discussed previously). Unfortunately there is very limited data available regarding the effect on runoff from the loss of canopy in dead pine stands[2].

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[1] Dobson Engineering Ltd., 2002, *Synthesis of the 1999 to 2001 Snow Course and Snowline Results For the Chase Creek Watershed.*

[2] *Review and Synthesis of Potential Hydrologic Impacts of Mountain Pine Beetle and Related Harvesting Activities in British Columbia*, J.F. Hélie; D.L. Peters; K.R. Tattrie; J.J. Gibson, Mountain Pine Beetle Initiative Working Paper 2005–23, Canadian Forestry Service, 2005; *Determining the impact of MPB-killed forest and elevated harvesting on snow accumulation and the projected impacts on melt and peak flow.* BC Ministry of Forests, S. Boon, UNBC, FIA-FSP Report #M065006; *Snow Surveys in Supply Block F Prince George, January to April 2006,* P. Beaudry, P. Beaudry and Associates Ltd. CANFOR report, 2006.

Table 2.
ECAs assuming loss of all mature Lodgepole Pine over the next 3-5 years including areas harvested to December 31, 2006

Drainage	Area (ha)	Total Area Impacted incl MPB (ha)/(%)	Total ECA[1] (Net Area) (ha)/(%)	ECA below snowline[1] (Net Area) (ha)/(%)	Area above snowline (ha)	ECA above snowline[1] (Net Area) (ha)/(%)
Duteau Creek above Headgates	22,331.0	14,215.1/ 63.7	11,037.4/ 49.4	5,381.1/ 42.9	9,796.7	5,656.3/ 57.7
Duteau Creek above Haddo Outlet	10,086.5	6,553.6/ 65.0	5,330.8/ 52.9	1,693.8/ 48.0	6,555.1	3,637.0/ 55.5
Watershed	22,331.0					

1. The area value in this column is the combined area of past harvesting (recovery modeled) + the net area of lodgepole pine. The % value is the ECA for the area of past harvesting as a % + the net pine area as a %, not discounted since it is a net value, i.e. all non-pine species removed. This ECA represents a "worst-case" from a hydrologic perspective as it assumes that when the mature pine dies it will act hydrologically similar to a clear-cut.

It has been documented that there is still some interception of snow in dead stands therefore the accumulation of snow on the ground may be greater than under a live stand but less than for a clear-cut. Also the standing dead stems may affect the melt rates that will be greater than for a live stand but likely less than for a clear-cut.

Preliminary research results for stands in the northern interior indicate that the potential ECA for dead pine stands in that area may be in the 50% range of those for a clear-cut. The adjustment factor is intended to represent the "average" stand; the actual value will depend upon the species composition and the secondary structure. There are a number of research projects in progress[3] that are focused on this issue by researchers from the Ministry of Forests and Range in Kamloops, Williams Lake and Prince George, various consultants and the Faculty of Forestry at UBC. Until the results from these research projects are available to better define how snow accumulates and melts in dead pine stands, the application of a 50% adjustment factor for the ECAs from live stands to dead stands is the recommended for the Okanagan. *[The decision to apply a factor to adjust the ECAs from those of a clear-cut evolved from a review of the limited data available for both the southern and northern interior and from discussions with R. Winkler and P. Teti, Research Hydrologists with the MoFR.]*

Data on the pine stands by polygon was provided by the licensees including a percentage of mature pine for polygons <40% pine, 40-50%, 51-60%, 61-70% and >70% pine. For the purposes of the assessment, those stands with <40% mature pine were not considered in the proposed harvesting since even if all the mature pine was killed by the beetle, it was assumed that there was no hydrologic impact due to the extent of non-pine species. For those polygons where the mature pine ranged from 40% - 70% of the stand, the effective area of the polygon was adjusted using a factor based on the analysis undertaken for the *Watershed Assessment Guidebook*, 1999 version, Appendix 2[4] to compensate for the hydrologic value of the non-pine species. A summary of the gross pine distribution is provided in Tables 3 and 4 and Figures 1 - 4. The gross pine distribution is the gross area of

[3] Projects include work by: R. Winkler, MoFR, Kamloops (research projects include Upper Penticton Creek and Mason Lake); P. Teti, MoFR, Williams Lake (research projects in various pine stands in the Cariboo),
[4] Interior Watershed Assessment Procedure Guidebook (IWAP), Ministry of Forests, Second edition, version 2.1, 1999.

polygons with mature pine >40% including all species. These values are important from a forest planning perspective as they represent the actual areas that might be salvaged and include all the species as identified in the MoFR forest cover database.

Duteau Creek above Headgates
A review of Figure 1 indicates that for the SSZ past harvesting has occurred on 42.4% of the area, the mature pine >40% accounts for a further 30.0% of the area. Stands with pine <40% plus the non-pine types account for a total of only 27.5% of the area. The total area that will impact the hydrology will total ~72% of the entire snow sensitive zone area.

For the total watershed upstream of Headgates, referring to Figure 2, past logging plus the pine leading stands account for approximately 67% of the area while the stands with <40% mature pine plus the non-pine stands accounting for 33% of the sub-basin.

The "effective" ECAs assuming all the mature pine dies would be ~44% for the SSZ (Table 5). The potential peak flow impacts have been assessed with consideration for the results of the research carried out in the Upper Penticton Creek watershed by the research staff with the Southern Interior Forest Region and reported in Extension Note 67[5], as well as known channel conditions. Based on the results reported in the extension note, an ECA of 43.9% would increase the 50-year peak flow by approximately 21% for the SSZ that would represent a high peak flow hazard for the watershed upstream of Headgates.

Table 5.
ECA for Past Harvesting and for Loss of Mature Pine

Drainage	Area above snowline (ha)	Current ECA above snowline[1] (ha/%)	Effective ECA due to Pine Mortality (Gross Area) (ha/%)	Combined ECA (%)
Duteau Creek above Headgates	9,796.7	2,948.4/ 30.1	2,707.9/ 13.8[2]	43.9
Duteau Creek above Haddo Outlet	6,555.1	2,231.2/ 34.0	1,405.8/ 10.7[2]	44.7

1. ECA includes all past harvesting. The area value here is the gross area of all polygons with mature pine >40% only and the % value is based on a 50% reduction of the area to account for the hydrologic effects of a mixed stand + the standing dead pine + secondary structure.

Duteau Creek above Haddo Outlet
A review of Figure 3 indicates that for the SSZ past harvesting has occurred on 40.7% of the area, the mature pine >40% accounts for a further 23.5% of the area. Stands with pine <40% plus the non-pine types account for a total of only 35.9% of the area. The total area that will impact the hydrology will total ~64% of the entire snow sensitive zone area.

For the sub-basin, referring to Figure 4, past logging plus the pine leading stands account for approximately 67% of the sub-basin with the stands with <40% mature pine plus the non-pine stands accounting for ~33% of the sub-basin.

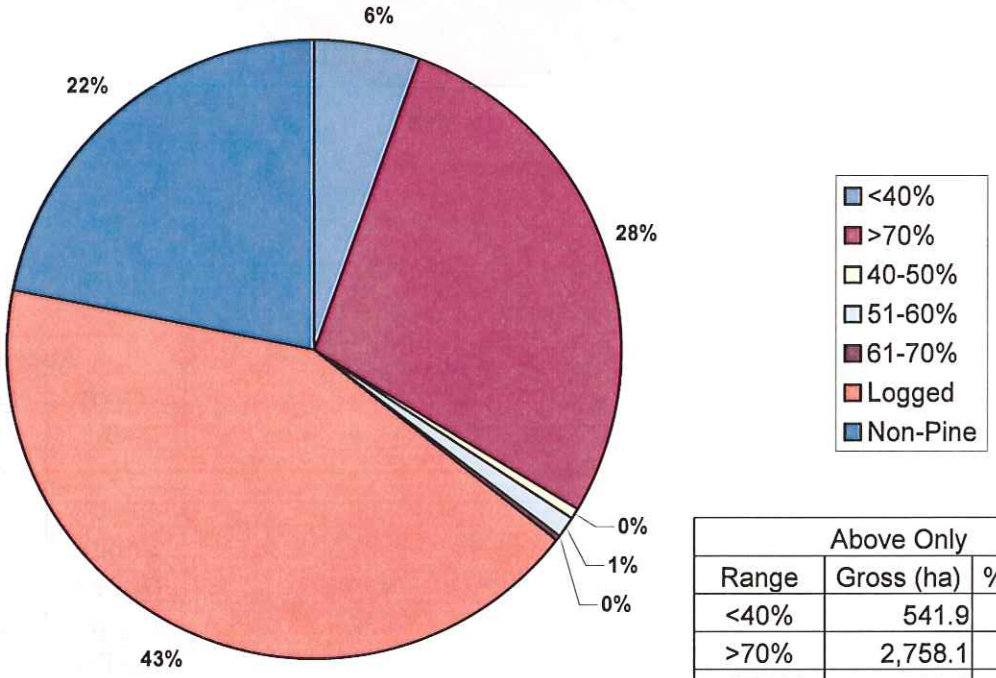
[5] Extension Note 67, Schnorbus et al, Ministry of Forests, Forest Sciences Program, 2004

Table 3. Distribution of Mature Lodgepole Pine in Duteau Creek at Headgates

BAND	PL_BAND	Gross	Net Area
Above	<40	541.9	0.0
	>70	2,758.1	2,631.7
	40-50	39.8	15.9
	51-60	129.2	51.7
	61-70	14.4	8.6
	Log	4,156.2	4,121.5
	No Pine	2,157.1	2.9
Below	<40	506.2	0.0
	>70	1,488.0	1,414.0
	40-50	355.8	142.3
	51-60	79.2	31.7
	61-70	107.7	64.6
	Log	5,833.6	5,733.1
	No Pine	4,163.8	0.0

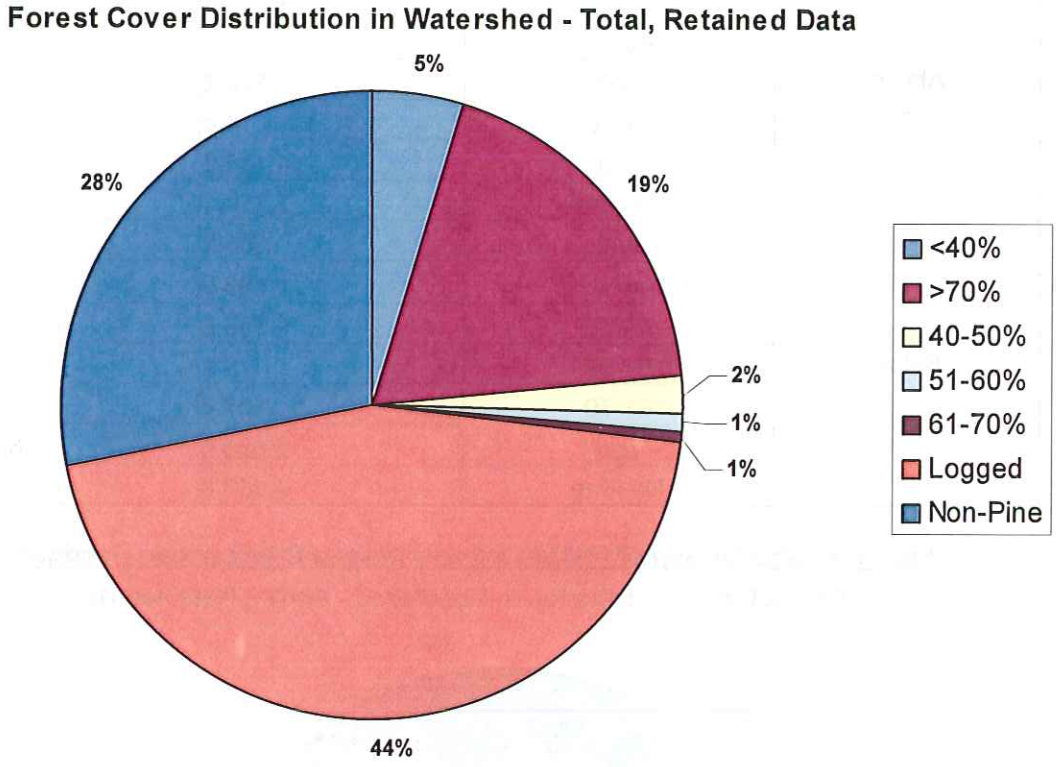
Figure 1. Distribution of Mature Pine in Duteau Creek above Headgates

Forest Cover Distribution in Watershed - Above, Retained Data



Above Only		
Range	Gross (ha)	%of Total
<40%	541.9	5.5
>70%	2,758.1	28.2
40-50%	39.8	0.4
51-60%	129.2	1.3
61-70%	14.4	0.1
Logged	4,156.2	42.4
Non-Pine	2,157.1	22.0
	9,796.7	100.0

Figure 2. Distribution of Mature Pine in Duteau Creek above Headgates

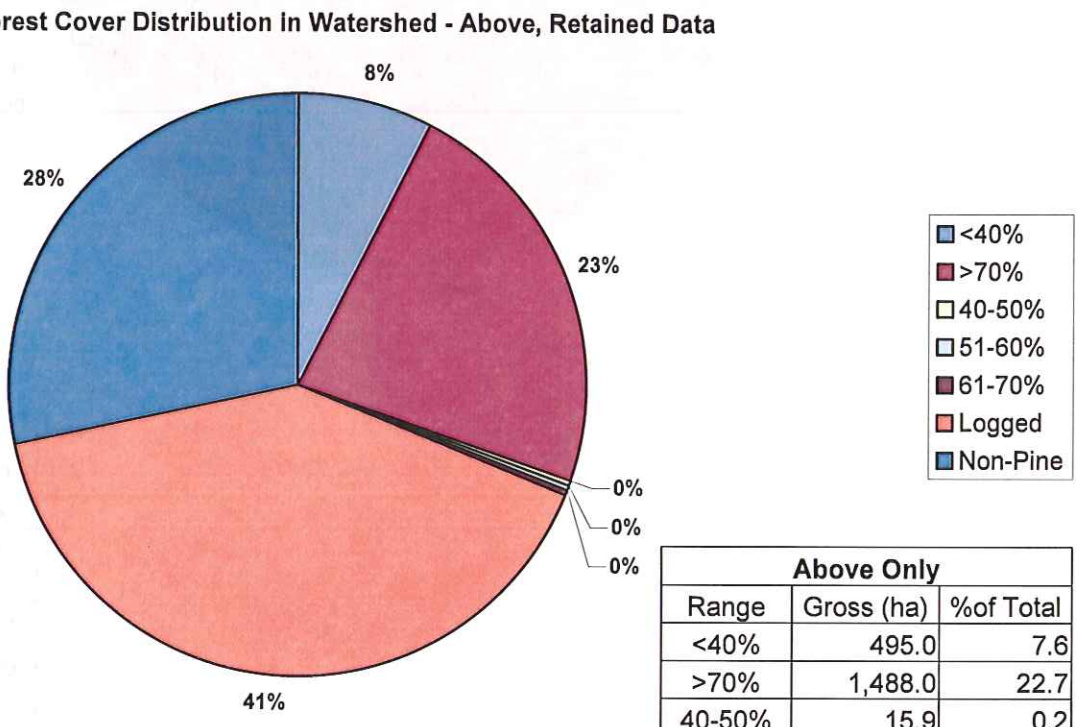


Above & Below		
Range	Gross	%of Total
<40%	1,048.1	4.7
>70%	4,246.1	19.0
40-50%	395.5	1.8
51-60%	208.4	0.9
61-70%	122.1	0.5
Logged	9,989.9	44.7
Non-Pine	6,320.9	28.3
	22,331.0	100.0

Table 4. Distribution of Mature Lodgepole Pine in Duteau Creek at Haddo Reservoir Outlet

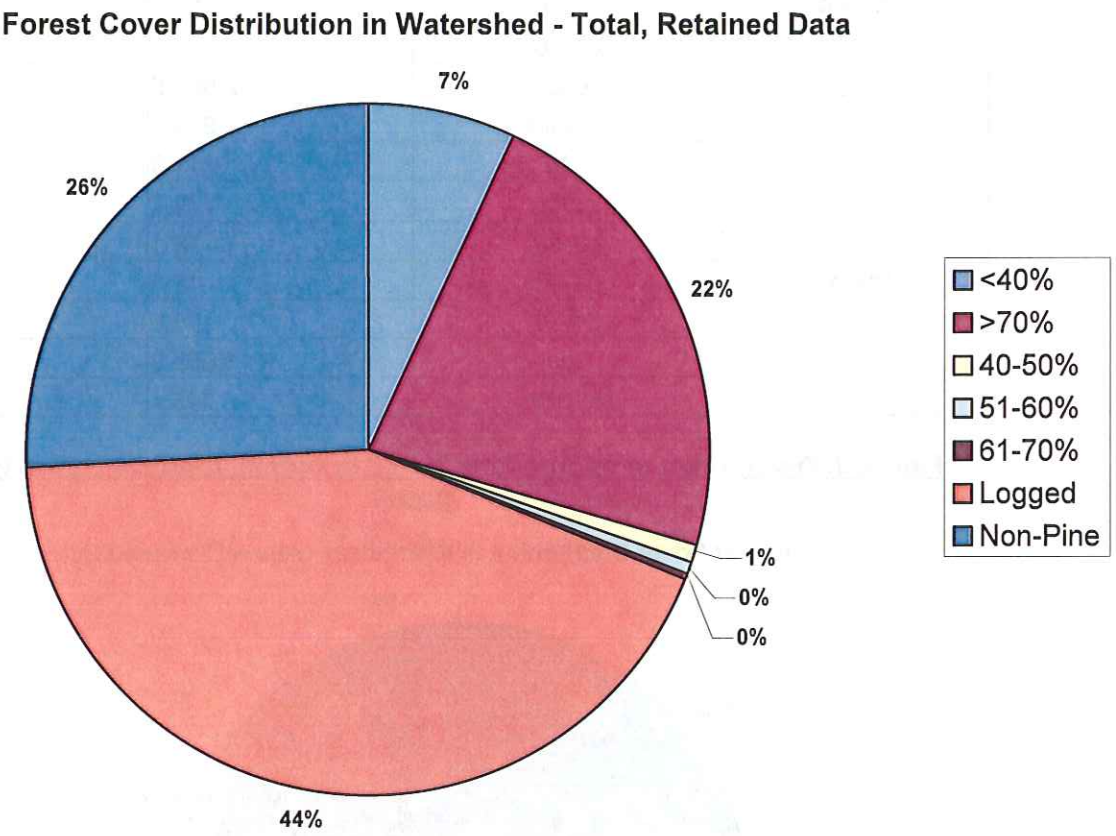
BAND	PL_BAND	Gross	Net Area
Above	<40	495.0	0.0
	>70	1,488.0	1,384.6
	40-50	15.9	6.4
	51-60	31.1	12.4
	61-70	3.9	2.3
	Log	2,667.5	2,666.7
	No Pine	1,853.7	2.9
Below	<40	211.0	0.0
	>70	779.7	751.9
	40-50	78.1	31.2
	51-60	16.8	6.7
	61-70	16.6	10.0
	Log	1,685.9	1,681.3
	No Pine	743.1	0.0

Figure 3. Distribution of Mature Pine in SSZ in Duteau Creek at Haddo Reservoir Outlet



Above Only		
Range	Gross (ha)	%of Total
<40%	495.0	7.6
>70%	1,488.0	22.7
40-50%	15.9	0.2
51-60%	31.1	0.5
61-70%	3.9	0.1
Logged	2,667.5	40.7
Non-Pine	1,853.7	28.3
	6,555.1	100.0

Figure 4. Distribution of Mature Pine in Duteau Creek at Haddo Reservoir Outlet



Above & Below		
Range	Gross (ha)	%of Total
<40%	706.1	7.0
>70%	2,267.7	22.5
40-50%	94.0	0.9
51-60%	48.0	0.5
61-70%	20.5	0.2
Logged	4,353.4	43.2
Non-Pine	2,596.8	25.7
	10,086.5	100.0

The "effective" ECAs for the sub-basin assuming all the mature pine dies would be ~45% (Table 5). The potential peak flow impacts have been assessed with consideration for the results of the research carried out in the Upper Penticton Creek watershed by the research staff with the Southern Interior Forest Region and reported in Extension Note 67[6], as well as known channel conditions. Based on the results reported in the extension note, an ECA of 45% would increase the 50-year peak flow by approximately 21% for the SSZ that would represent a moderate peak flow hazard at the reservoir outlet.

Table 6 summarizes the ECAs for Tolko's past harvesting and for the areas with pine leading within the snow sensitive zone. The area of mature pine is the actual combined areas for polygons with mature pine >40%. The associated percentage value has a 50% reduction factor applied to compensate for the standing timber plus any secondary structure. The data in Table 6 has been extracted from Figures 1 and 3.

To appreciate the potential hydrologic impacts of salvage harvesting, if for example 50% of the area of mature pine in the SSZ was salvaged above Headgates, the post harvesting ECA would increase to approximately 51%. This ECA could result in the 50-year peak flow increasing by ~24% that would increase the peak flow hazard to high. For the sub-basin above Haddo Reservoir the ECA would increase to approximately 50% and the 50-year peak flow would increase by approximately 23% that would be a moderate peak flow hazard due to the attenuation of the peak flow by the three reservoirs.

For the watershed above the reservoirs the terrain is typical of a plateau, gentle slopes and rolling. More than half of the SSZ is situated above the reservoirs *[refer to Map 1 - Appendix A]* with most of the spring runoff being stored on the three reservoirs. The impact of storing the runoff should reduce the increase in peak flow from the loss of the pine above the reservoirs on the flows downstream (assuming that the reservoirs have capacity prior to freshet, which is normally the case). The remainder of the SSZ is situated in the southwest corner of the watershed where runoff is not regulated by reservoirs. Any increases in peak flows from this part of the watershed will have a direct effect on the peak flows at Headgates. However, the peak flows from this area are attenuated somewhat by the low gradient channels across the plateau and the presence of small lakes and wetlands.

Table 6.
ECA for Past Harvesting and for Loss of Mature Pine

Watershed Unit	Snow Sensitive Zone Area (ha)	Harvested ECA [1] (ha)(%)	Mature Pine[2] (ha)(%)
Duteau Creek above Headgates	9,796.7	2,948.4/ 30.1	2,707.9/ 13.8[2]
Duteau Creek above Haddo Outlet	6,555.1	2,231.2/ 34.0	1,405.8/ 10.7[2]

1. ECA includes all past harvesting, plus areas with mature pine.
2. This value has been reduced by 50% to compensate for the standing timber + secondary structure.

[6] Extension Note 67, Schnorbus et al, Ministry of Forests, Forest Sciences Program, 2004

2.4 Hydrologic Impacts of Proposed Retention Plan

Assumptions:
The following assumptions have been made when considering the hydrologic impacts of the proposed retention plan:

1. Grey attack stands have a similar impact on the hydrology as a clear-cut with regards to snow accumulation and rates of melt. This differs from the approach used in section 2.3 and is the result of preliminary research for the Okanagan in 2007.l
2. That the guidance in the 1999 IWAP Guidebook (Appendix 2) regarding the ECA of partial cuts is a reasonable approach to represent the hydrologic value of non-pine species in a pine leading stand >40% mature pine.
3. That regenerating stands have achieved full hydrologic recovery with regards to snow accumulation at a height of 12 m.
4. Extension Note 67 (Figure 2, page 3) should only be considered as a general guide to illustrate the potential impacts of harvesting and loss of forest cover on peak flows.

Tolko has completed a retention plan for the Duteau watershed that is summarized on the Duteau Creek Retention Plan Map (Appendix A – Map 2). For additional information the reader is referred to the *Duteau Creek Retention Plan* available from Tolko. It should be noted that Tolko has added additional buffers around lakes and reservoirs, where possible, to reduce disturbance. This portion of the hydrologic review focuses on the impact of the areas proposed for harvesting combined with those areas of pine that will not be harvested and compares the results to the loss of the pine with no harvesting summarized in section 2.3. Detailed summaries of the retention plan are provided in Appendix C.

Table 7 summarizes the proposed salvage harvesting plan illustrating what the ECA would be for the areas proposed to be harvested plus past harvesting but excluding the pine that will die but will not be harvested. It also summarizes the ECA considering all past and proposed harvesting as well as the pine that will die but not be salvaged.

It is apparent from Table 7 is that for the watershed above Headgates there are ~ 2,708 ha of mature pine in the SSZ and ~1,406 ha of mature pine above the Haddo Reservoir (column 4 minus column 3). It is proposed to salvage ~1921 ha or ~71% of the stands above Headgates and 1,211 ha or ~86% of the stands above Haddo (column 5 minus column 3). The final ECA for the SSZ above Headgates after harvesting is estimated to be ~59% as compared to an ECA of 58% if there was no salvage logging, and above Haddo it would be ~57% versus 55% if there was no salvaging (column 6 vs. 4).

Table 7.
ECA Comparison at December 31, 2006 for no beetle, loss of all mature pine, and proposed retention plan for the Snow Sensitive Zone

1 Basin	*2 Area Above Snowline (ha)*	*3 ECA assuming no beetle (ha/%)*	*4 ECA Assuming all Mature Pl Dies*	*5 ECA For Proposed Harvesting (ha/ %)*	*6 ECA For Retention Plan (ha/ %)*
Duteau Creek above Headgates	9,796.7	2,948.4/ 30.1	5,656.3/ 57.7	4,869.3/ 49.7	5,767.6/ 58.6
Duteau Creek above Haddo Outlet	6,555.1	2,231.2/ 34.0	3,637.0/ 55.5	3,441.7/ 52.5	3,722.7/ 56.8

Estimates were made of the hydrologic recovery for the 30-years for two scenarios, if there was no salvage harvesting, and if the proposed salvage logging was undertaken according to the retention plan. The 30-year hydrologic recovery projections are provide in Appendix D. There are limitations on estimating the potential hydrologic impacts for areas of dead lodgepole pine left standing as compared to a stand that is clear-cut. Preliminary results from research into this question in the northern interior suggests that a grey attack stand has approximately 50% of the hydrologic impact of a clear-cut, whereas preliminary data in the southern interior suggests that the two stands may have approximately the same hydrologic impact.

If the grey attack stands are considered to have approximately the same hydrologic impact as a clear-cut, initially the no salvage option would have an ECA of ~58% compared to the salvage option that would have an estimated ECA of ~59%. At the end of 30-years the no salvage option would have recovered to ~38% whereas the salvage and plant option would have recovered to ~21%.

Based on the limited research it appears that a grey stand likely has a similar hydrologic impact to a clear-cut. This supports the conclusion that the proposed salvage harvest and plant scenario would have a significant benefit to the long-term hydrology since the recovery would be greater and occur more quickly.

It is also important to consider the potential risk of wildfire if there was no salvage in the watershed and the major long-term impacts that a large wildfire would have on water quality and quantity.

Channel Impacts and Water Quality
It is important to recognize that the potential increases in peak flows will occur across the range of flows. It is also important to understand that the frequency of high peak flows will increase due to the likely shift in the frequency curve to the left that may result in what were previously infrequent high channel changing flows occurring more often. These high flows will result in increased suspended sediment concentrations and greater bed load movement due to increased stream power. The impact of more frequent higher flows will be

that the channels will adjust to accommodate the new flow regime by increasing the channel cross section through bank erosion and bed scour. These changes will continue until the channel reaches a new dynamic equilibrium. The timeframe for these changes will depend upon the frequency and magnitude of high flows. It could take one major flood event or a number of years for smaller events.

The expected impacts on the water quality at Headgates will be increased suspended sediment concentrations and turbidity levels and increased bed load. Higher suspended sediment and turbidity will affect the treatment processes for drinking water diverted at Headgates. Higher bed load may result in increased maintenance costs if the intake pond(s) have to be dredged more frequently as well as increased monitoring especially during spring runoff and intense rainstorms.

Increases in peak flows may also compromise stream crossings, i.e. bridges and culverts that were originally sized for the 100-year peak flow based on discharges from a forested watershed. Depending upon the changes to the forest cover upstream of a crossing it may be necessary to re-evaluate the new design discharges and to replace undersized structures with appropriately sized new structures.

3. CONCLUSIONS

- The current peak flow hazard for the snow sensitive zone (as of December 31, 2006), assuming that there were no beetle impacts, is estimated to be moderate at the outlet from Haddo Reservoir and at Headgates based on the recovery of past harvesting.
- The peak flow hazard for the snow sensitive zone if all the mature pine was to die would remain moderate at the Haddo outlet due to the potential buffering of the peak flows by the reservoirs but would increase to high at Headgates assuming a 21% increase in the 50-year peak flow at this location.
- Assuming that grey stands have a similar hydrologic impact as a clear-cut, the proposed salvage harvesting would increase the ECA for the snow sensitive zone above Headgates to 59% from 58% if there was no salvage harvesting and to 57% above Haddo from 55%. The increase in ECA for the harvesting scenario is due to the loss of non-pine species in the logged blocks. The peak flow hazards associated with the proposed harvesting would remain the same as for the loss of all mature pine scenario, i.e. high at Headgates and moderate at Haddo.
- It is projected, based on the assumptions previously discussed, that areas that are harvested and replanted would recover faster than areas left to natural regeneration and over a 30-year period the ECA would be ~21% for the combined areas salvaged + past logging versus 38% if there was no salvage logging.

4. RECOMMENDATIONS

- Based on the comparison of the hydrologic impacts on peak flows of the proposed retention plan versus no salvage logging, it is recommended that the proposed retention plan proceed since the potential benefits to reducing peak flow impacts and water quality impacts that will occur from associated sediment transport over the 30-year recovery period are significantly better for the proposed retention plan than if there was no salvage logging.
- When planning salvage logging priority should be given to those areas with pine >70% that account for ~94% of the pine stands in the SSZ above Headgates and 97% of the pine leading stands above the outlet of Haddo.

- Additional care and attention needs to given to the design and layout of new roads and skid trails to minimize disturbance to the natural drainage patterns and sediment transport.
- New roads required for salvage logging, with the exception of permanent mainline roads, should be constructed as temporary roads and rehabilitated as soon as practical following harvesting and returned to productive forest.
- Stream crossings capacities on existing roads downstream from areas with significant loss of forest cover from the beetle should be reviewed to confirm that the peak flow capacity will be adequate to safely convey anticipated increased peak flows. Where structures are undersized they should be replaced with appropriately sized structures.
- If salvage harvesting is considered within the lakeshore management zone or buffers where the pine component is >70%, the risks to all resources must be considered and a decision made based on balancing these risks.

Original by:

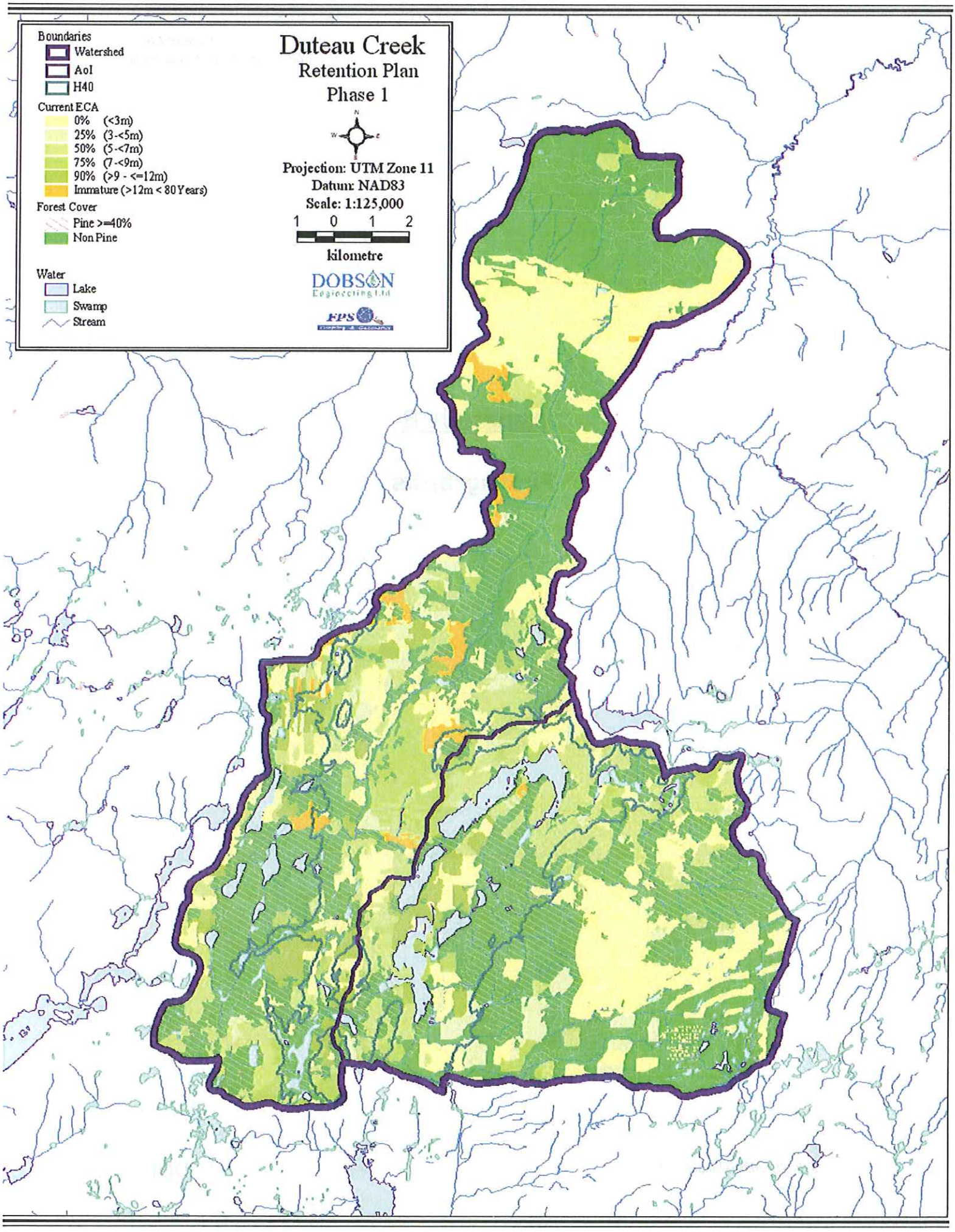
D.A. Dobson, PEng, Project Engineer

Original by:

M.E. Noseworthy, PGeo, EngL, Reviewer

Appendix A

Watershed Maps


Boundaries
Watershed
AoI
H40
Current ECA
0% (<3m)
25% (3-<5m)
50% (5-<7m)
75% (7-<9m)
90% (>9 - <=12m)
Immature (>12m < 80 Years)
Forest Cover
Pine >=40%
Non Pine
Water
Lake
Swamp
Stream
Duteau Creek
Retention Plan
Phase 1
Projection: UTM Zone 11
Datum: NAD83
Scale: 1:125,000
1 0 1 2
kilometre
DOBSON
Engineering Ltd
FPS

Appendix B

Photographs

Photo 1 - Aberdeen FSR at 13.5 km, typical road section

Photo 2 – Fill erosion at Flyfish Creek crossing of Aberdeen FSR

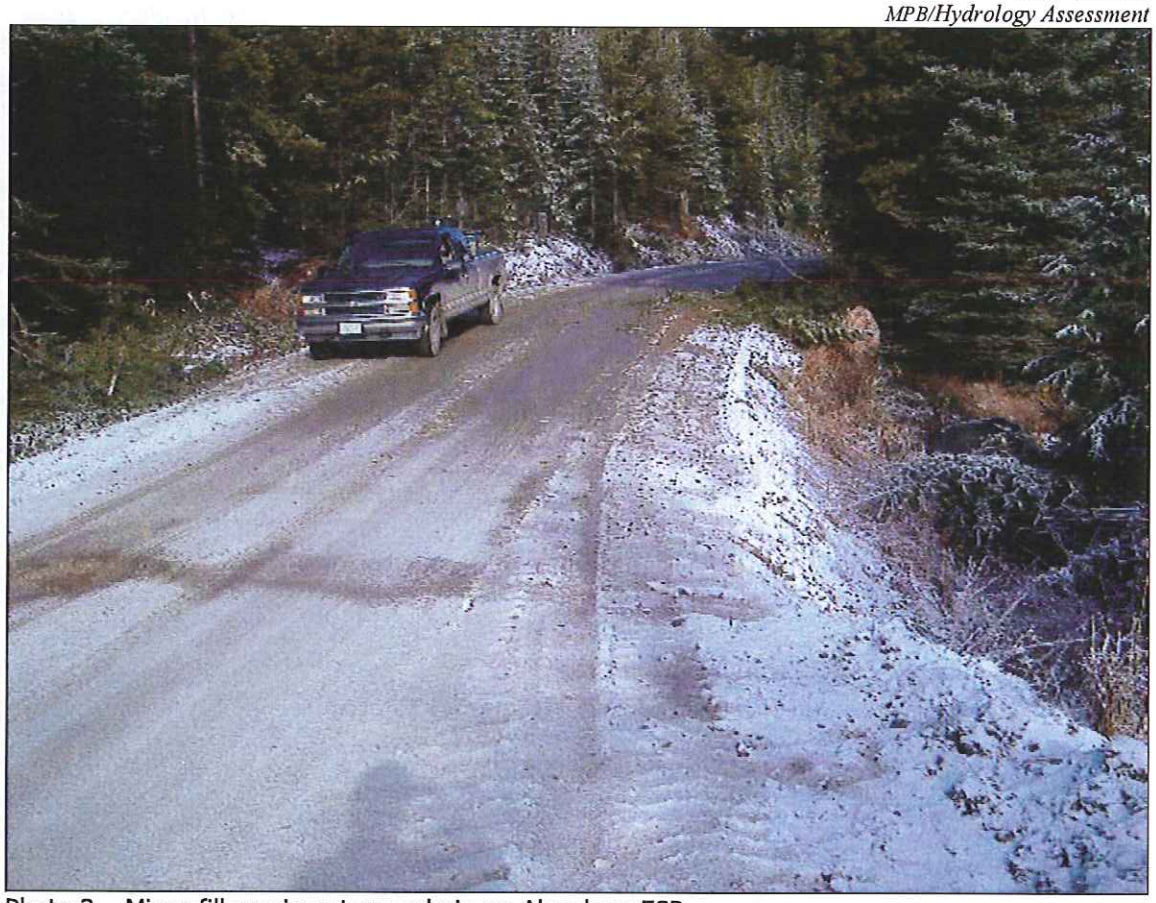


Photo 3 – Minor fill erosion at crossdrain on Aberdeen FSR

Photo 4, Site 1 – Stream crossing between Grizzly Swamp and Haddo Lake at ~23km

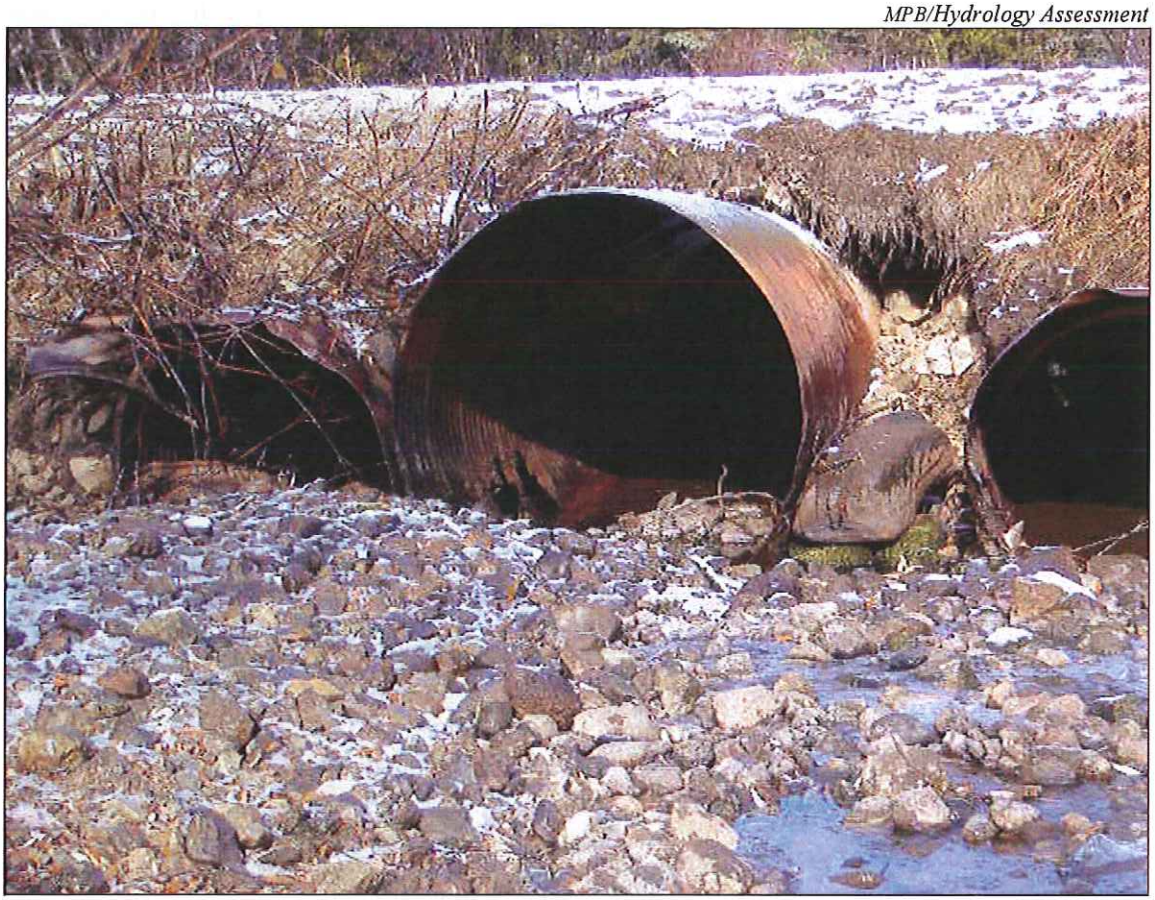


Photo 5, Site 1 – Inlet side of road prism, aging culverts

Photo 6, Site 1 – 60m upstream of crossing, junction of channels from 2 dams on Grizzly

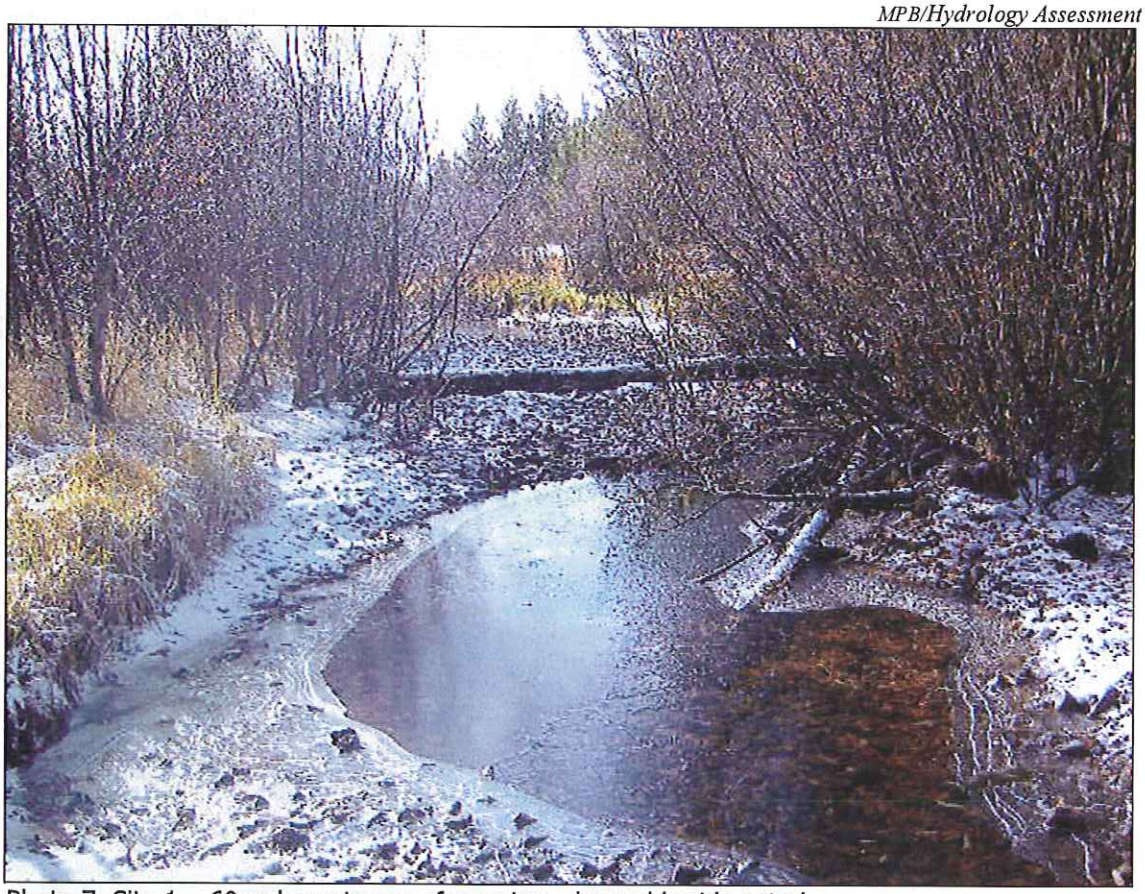


Photo 7, Site 1 – 60m downstream of crossing, channel braids noted

Photo 8 Site 2 – Fill erosion at stream crossing at ~27km on Aberdeen Main

Photo 9, Site 2 – 70m upstream of crossing, trampled banks

Photo 10, Site 3 – Duteau Creek at Philpot Road crossing, cattle trampling on inlet side

Photo 11, Site 3 – Duteau Creek 100m upstream of the Philpot Road crossing

Photo 12, Site 3 – Over-bank deposition 70m upstream of Philpot Rd crossing

Photo 13, Site 4 – Duteau Creek at Spur Road 200m off Aberdeen FSR at the 30km brd

Photo 14, Site 4 – 60m above crossing on Spur Road off of Aberdeen at 30km

Photo 15 – Intermittent stream crossing has washed across road at 30.7km on Aberdeen

Photo 16 – Intermittent crossing washed across road at 32.9 km on Aberdeen Main

Photo 17 – ditch erosion at 33.2 km on Aberdeen Main

Photo 18 – Intermittent crossing at 35 km on Aberdeen Main, collapsing wood culvert

Photo 19 – Road surface washed, intermittent creek (Heart Crk) at 38.9km on Aberdeen

Photo 20 – 2700 Road, Typical Road section, rolling overland road

Photo 21 – Intermittent stream crossing on 2700 Road, cattle trampling banks

Photo 22 – Sediment transport in ditch to crossing in CP318 LL1016 off Brunnet FSR

Photo 23 – outlet of intermittent stream crossing in CP318 LL1016

Photo 24 – Plugging culvert on Brunnet at junction with spur to CP 70-5 (NSR)

Photo 25 – Aberdeen Main at ~16km, crossing of the Doreen Lake drainage channel

Photo 26 – 100m upstream of crossing at 16km on Aberdeen Main

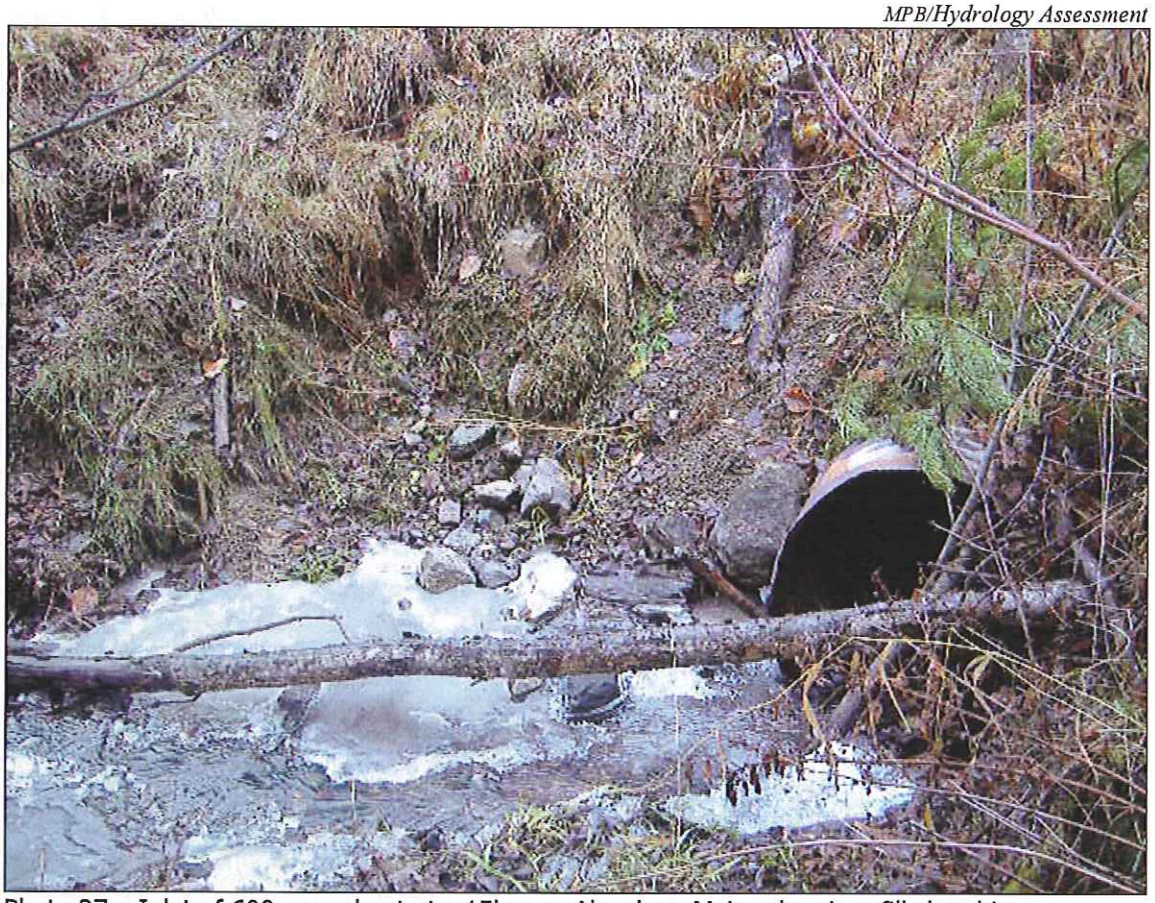


Photo 27 – Inlet of 600mm culvert at ~15km on Aberdeen Main, plugging, fill sloughing.

Photo 28 – stream at ~15km on Aberdeen Main, cattle fence 20m upstream of inlet

Photo 29 – 150m upstream of crossing at ~15km on Aberdeen Main

Photo 30 – 100m downstream of crossing at ~15km on Aberdeen Main, trampled banks

Photo 31, Site 5 – Duteau Creek at bridge on Haddo Main at ~12.2 km

Photo 32, Site 5 – Erosion and sediment control structures on approach to stream

Photo 33, Site 5 – Ditchline sump on approach to stream crossing, note dirty water

Photo 34, Site 5 – Duteau Creek upstream from bridge at 12.2 on Haddo FSR

Photo 35, Site 5 – Duteau Creek downstream from bridge at 12.2 on Haddo FSR

Photo 36, Site 5 – Duteau Crk 50m upstream from bridge, mid channel bar re-vegetating

Photo 37, Site 5 – Duteau Crk 100m upstream from bridge, braided channel

Photo 38 – Intermittent stream crossing at ~18km on Curtis Rd, cattle/logging impacts

Photo 39 – Typical road section at ~18km on Curtis Rd

Photo 40, Site 6 – Heart Creek Bridge crossing on Curtis Main, cattle fence open

Photo 41, Site 6 – Upstream view of Heart Creek from bridge crossing on Curtis Main

Photo 42, Site 6 – Downstream view of Heart Creek from bridge crossing on Curtis Main

Photo 43, Site 6 – 100m upstream from bridge crossing on Curtis Main

Photo 44 – Tributary to Heart Creek on Curtis Main, culvert lacking cover

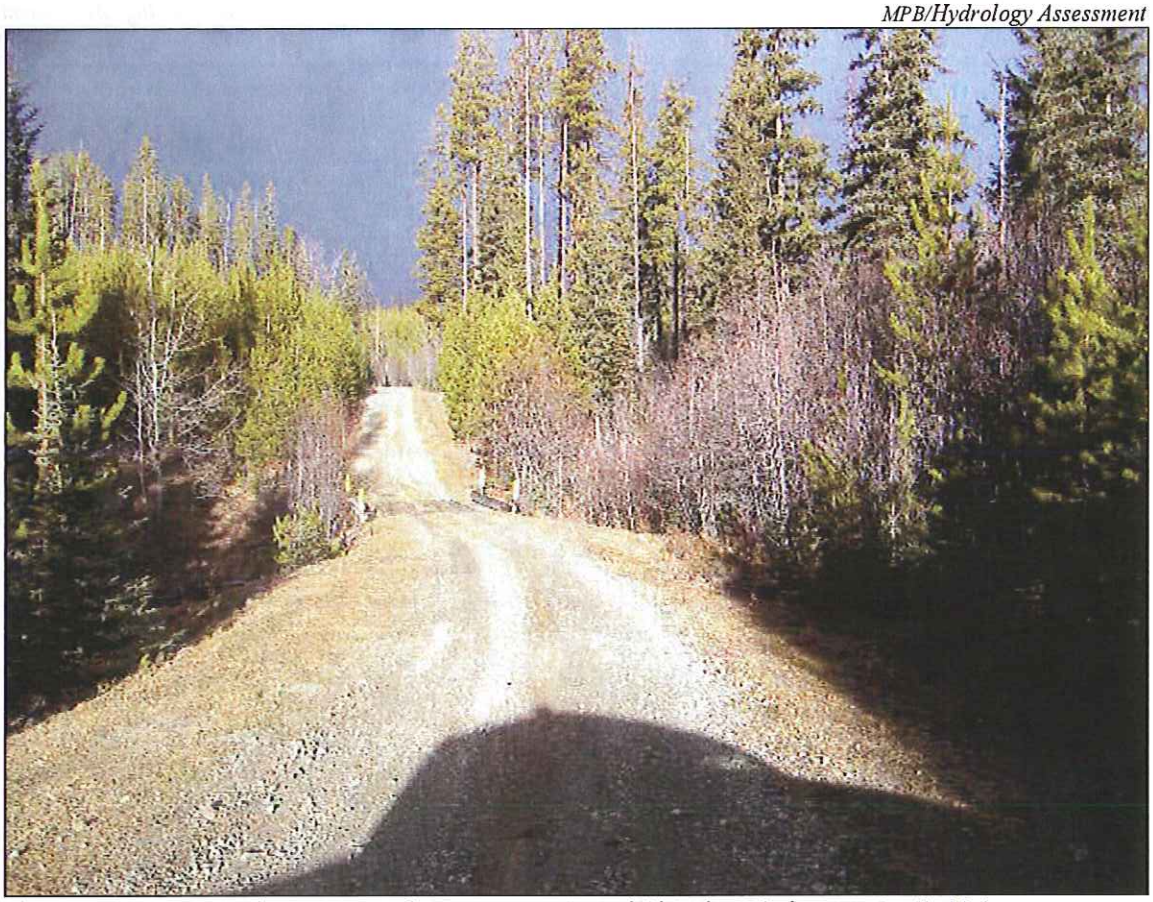


Photo 45, Site 7 – Bridge crossing between Curtis and Aberdeen Lakes on Curtis Main

Photo 46, Site 7 – Upstream view from bridge on Curtis Main

Photo 47, Site 7 – Downstream view from bridge on Curtis Main

Photo 48, Site 7 – Upstream view, 100m above bridge on Curtis Main

Photo 49, Site 7 – Downstream view, 100m above bridge on Curtis Main

Photo 50 – Stream crossing on Edwin Lake Rd, below Sinclair Lake

Appendix C

Retention Plan Summaries

Proposed Retention Plan for Duteau Creek above outlet on Haddo Reservoir

Region: Duteau Creek (above Reservoir Outlet)

Retained Data:

BASIN	BAND	PL_BAND	Gross	Net Area
Duteau Creek (above Reservoir Outlet)	Above	<40	493.2	0.0
		>70	286.6	263.2
		40-50	13.6	5.4
		51-60	31.1	12.4
		61-70	0.0	0.0
		Log	2,667.5	2,666.6
		No Pine	1,852.7	2.9
	Below	<40	206.2	0.0
		>70	337.6	324.3
		40-50	77.3	30.9
		51-60	16.8	6.7
		61-70	16.6	10.0
		Log	1,685.9	1,681.3
		No Pine	741.0	0.0

	Above Only		Above & Below	
Range	Gross	%of Total	Gross	%of Total
<40%	493.2	9.2%	699.4	8.3%
>70%	286.6	5.4%	624.2	7.4%
40-50%	13.6	0.3%	90.8	1.1%
51-60%	31.1	0.6%	48.0	0.6%
61-70%	0.0	0.0%	16.6	0.2%
Logged	2,667.5	49.9%	4,353.4	51.7%
Non-Pine	1,852.7	34.7%	2,593.7	30.8%
	5,344.7		8,426.2	

Proposed Logging Data:

BASIN	BAND	PL_BAND	Gross	Net Area
Duteau Creek (above Reservoir Outlet)	Above	<40	1.8	1.8
		>70	1,201.4	1,201.4
		40-50	2.3	2.3
		51-60	0.0	0.0
		61-70	3.9	3.9
		Log	0.0	0.0
		No Pine	1.0	1.0
	Below	<40	4.8	4.8
		>70	442.1	442.1
		40-50	0.8	0.8
		51-60	0.0	0.0
		61-70	0.0	0.0
		Log	0.0	0.0
		No Pine	2.2	2.2

	Above Only		Above & Below	
Range	Gross	%of Total	Gross	%of Total
<40%	1.8	0.2%	6.6	0.4%
>70%	1,201.4	99.3%	1,643.5	99.0%
40-50%	2.3	0.2%	3.1	0.2%
51-60%	0.0	0.0%	0.0	0.0%
61-70%	3.9	0.3%	3.9	0.2%
Logged	0.0	0.0%	0.0	0.0%
Non-Pine	1.0	0.1%	3.1	0.2%
	1,210.4		1,660.3	

Proposed Retention Plan for Duteau Creek above Headgates

Region: Duteau Creek above Headgates

Retained Data:

BASIN	BAND	PL_BAND	Gross	Net Area	
Duteau Creek (above Headgates)		<40	533.3	0.0	
		>70	871.9	833.7	
	Above	40-50	32.7	13.1	
		51-60	118.9	47.6	
		61-70	6.5	3.9	
		Log	4,156.2	4,121.5	
		No Pine	2,156.2	2.9	
		<40	501.4	0.0	
		>70	717.9	670.3	
		40-50	355.0	142.0	
	Below	51-60	79.2	31.7	
		61-70	99.5	59.7	
		Log	5,833.6	5,733.1	
		No Pine	4,156.7	0.0	

	Above Only		Above & Below	
Range	Gross	%of Total	Gross	%of Total
<40%	533.3	6.8%	1,034.7	5.3%
>70%	871.9	11.1%	1,589.8	8.1%
40-50%	32.7	0.4%	387.7	2.0%
51-60%	118.9	1.5%	198.1	1.0%
61-70%	6.5	0.1%	106.0	0.5%
Logged	4,156.2	52.8%	9,989.9	50.9%
Non-Pine	2,156.2	27.4%	6,312.9	32.2%
	7,875.8		19,619.1	

Proposed Logging Data:

BASIN	BAND	PL_BAND	Gross	Net Area	
Duteau Creek (above Headgates)		<40	8.6	8.6	
		>70	1,886.2	1,886.2	
	Above	40-50	7.0	7.0	
		51-60	10.2	10.2	
		61-70	7.9	7.9	
		Log	0.0	0.0	
		No Pine	1.0	1.0	
		<40	4.8	4.8	
		>70	770.1	770.1	
		40-50	0.8	0.8	
	Below	51-60	0.0	0.0	
		61-70	8.2	8.2	
		Log	0.0	0.0	
		No Pine	7.1	7.1	

	Above Only		Above & Below	
Range	Gross	%of Total	Gross	%of Total
<40%	8.6	0.4%	13.4	0.5%
>70%	1,886.2	98.2%	2,656.3	97.9%
40-50%	7.0	0.4%	7.8	0.3%
51-60%	10.2	0.5%	10.2	0.4%
61-70%	7.9	0.4%	16.1	0.6%
Logged	0.0	0.0%	0.0	0.0%
Non-Pine	1.0	0.0%	8.1	0.3%
	1,920.9		2,712.0	

Appendix D

Hydrologic Recovery Tables

Values in ha and %

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	20
.0	6,676.9	6,399.2	6,215.2	5,910.9	5,630.4	5,356.8	5,170.6	4,995.7	4,815.8	4,637.8	4,445.6	4,343.2	4,231.5	4,057.2	3,878.4	3,713.7	3,574.5	3,431.5	3,353.3	3,317.1	3,246.7	3,170.1	3,077.6	3,002.9	2,975.3	2,924.1	2,832.3	2,8
	29.9	28.7	27.8	26.5	25.2	24.0	23.2	22.4	21.6	20.8	19.9	19.4	18.9	18.2	17.4	16.6	16.0	15.4	15.0	14.9	14.5	14.2	13.8	13.4	13.3	13.1	12.7	
.5	3,125.2	2,985.6	2,886.0	2,746.1	2,614.5	2,473.0	2,380.0	2,280.1	2,189.3	2,085.5	2,006.5	1,956.7	1,882.6	1,823.3	1,723.9	1,611.2	1,533.3	1,457.2	1,421.0	1,404.6	1,358.9	1,317.9	1,268.3	1,224.0	1,207.8	1,182.2	1,108.7	1,0
	31.0	29.6	28.6	27.2	25.9	24.5	23.6	22.6	21.7	20.7	19.9	19.4	18.7	18.1	17.1	16.0	15.2	14.4	14.1	13.9	13.5	13.1	12.6	12.1	12.0	11.7	11.0	

Values in ha and %

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	20
.7	2,948.4	2,833.8	2,742.0	2,642.5	2,508.7	2,415.7	2,328.4	2,235.5	2,142.4	2,045.8	1,982.9	19.7	1,874.1	1,817.7	1,723.7	1,615.5	1,534.1	1,468.3	1,431.6	1,416.9	1,363.7	1,319.5	1,259.5	1,213.4	1,203.1	1,178.7	1,099.9	1,0
	30.1	28.9	28.0	27.0	25.6	24.7	23.8	22.8	21.9	20.9	20.2	19.7	19.1	18.6	17.6	16.5	15.7	15.0	14.6	14.5	13.9	13.5	12.9	12.4	12.3	12.0	11.2	
.1	2,231.2	2,182.3	2,111.9	2,062.9	1,987.6	1,938.3	1,886.8	1,825.9	1,766.7	1,698.4	1,665.9	24.9	1,572.1	1,546.9	1,477.8	1,388.5	1,335.4	1,294.8	1,267.4	1,254.9	1,213.8	1,173.3	1,135.4	1,091.2	1,082.2	1,067.5	1,000.2	9
	34.0	33.3	32.2	31.5	30.3	29.6	28.8	27.9	27.0	25.9	25.4	24.9	24.0	23.6	22.5	21.2	20.4	19.8	19.3	19.1	18.5	17.9	17.3	16.6	16.5	16.3	15.3	

Values in ha and %

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	20
.3	3,728.5	3,565.4	3,473.3	3,268.3	3,121.7	2,941.1	2,842.3	2,760.2	2,673.4	2,592.0	2,462.7	2,410.3	2,357.4	2,239.6	2,154.7	2,098.2	2,040.5	1,963.3	1,921.7	1,900.2	1,883.0	1,850.6	1,818.1	1,789.5	1,772.2	1,745.3	1,732.3	1,7
	29.7	28.4	27.7	26.1	24.9	23.5	22.7	22.0	21.3	20.7	19.6	19.2	18.8	17.9	17.2	16.7	16.3	15.7	15.3	15.2	15.0	14.8	14.5	14.3	14.1	13.9	13.8	
.3	894.0	803.3	774.1	683.1	626.9	534.7	493.3	454.2	422.5	387.1	340.5	326.5	310.6	276.5	246.1	222.7	197.9	162.3	153.5	149.7	145.0	144.6	132.9	132.9	125.6	114.7	108.5	1
	25.3	22.7	21.9	19.3	17.8	15.1	14.0	12.9	12.0	11.0	9.6	9.2	8.8	7.8	7.0	6.3	5.6	4.6	4.3	4.2	4.1	4.1	3.8	3.8	3.6	3.2	3.1	

Appendix E

1996 and 1999 IWAP Reports

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

Abstract

This report summarizes the application of the Interior Watershed Assessment Procedure in the Duteau Creek watershed. Raw data for the watershed was compiled in accordance with the IWAP procedure. The procedure used for this assessment was the final version developed by the Interior Watershed Assessment Committee which has been published as a guidebook under the Forest Practices Code titled, ***Interior Watershed Assessment Procedure Guidebook (IWAP), Level 1 Analysis,*** September 1995. The results of the office assessment were confirmed through field inspections.

Based on the watershed assessment, the overall condition of the watershed is considered to be good. The following hazard indices were determined for the entire watershed: peak flows - moderate; surface erosion - low; riparian buffers - low; landslides - low. The Equivalent Clearcut Area in the Duteau Creek watershed was determined to be 24.4%. The hazard indices for the watershed are presented in the following table.

Final Hazard Indices for the Duteau Creek Watershed

	IMPACT CATEGORY			
WATERSHED SUB-UNIT*	**Peak Flows**	**Surface Erosion**	**Riparian Buffers**	**Landslides**
Aberdeen	**MOD**	LOW	**MOD**	LOW
Heart	**MOD**	LOW	LOW	LOW
Grizzly	**MOD**	LOW	LOW	LOW
Flyfish	**MOD**	**MOD**	LOW	LOW
Entire Watershed	**MOD**	LOW	LOW	LOW

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the Entire watershed. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

RIVERSIDE FOREST PRODUCTS LIMITED
Lumby Division

Interior Watershed Assessment
for the
DUTEAU CREEK WATERSHED
Watershed Restoration Program

SUMMARY REPORT

1.0 INTRODUCTION

This report summarizes the results of the application of the Interior Watershed Assessment Procedure (IWAP) in the Duteau Creek watershed. The watershed assessment procedure was based on the ***Forest Practices Code*** guidebook, dated September 1995.

The Duteau Creek watershed is located southwest of the Village of Lumby in the Southern Interior of British Columbia and is part of the Vernon Forest District *[Map 1 - Appendix A]*. Duteau Creek is a community watershed providing water for the North Okanagan Water Authority (NOWA). The entire watershed was assessed from the NOWA domestic water intake (referred to as the point of interest [POI] in this report) to its headwaters. The majority of the Crown land in the watershed is a forest license held by Riverside Forest Products Limited - Lumby Division; a minor portion is part of a forest license held by Tolko Industries Ltd., Lavington Planer Division.

The IWAP assessment is intended to be an office analysis to determine the potential for cumulative impacts resulting from past forest development. The results have been derived from characteristics of the watershed based on topographic maps and historical forest development from forest cover maps. It is important to recognize that the results of the office assessment indicate a "potential" for hazards to exist. The results of the office assessments were confirmed through field inspections and are also summarized in this report.

1.1 History of Past Forest Development

Timber harvesting activities have been conducted in the Duteau Creek watershed over the past 60 years. In the early years, partial cutting systems such as diameter limit and selection logging were employed in the lower elevation stands of timber. Over the last 30 years, clearcut harvesting has occurred in the even-aged Lodgepole pine and Englemann spruce-subalpine fir stands at higher elevations. In the last 20 years, a significant portion of the annual harvest has come from salvage logging of Lodgepole pine stands infested by the mountain pine beetle. The current Equivalent Clearcut Area in the Duteau Creek watershed is 24.4%.

2.0 OBJECTIVES

The objective of the IWAP was to assess the potential for cumulative hydrologic impacts in the Duteau Creek watershed associated with previous forest development and road construction. There are four primary impact categories assessed:

- Peak Flows
- Surface Erosion
- Riparian Buffers
- Landslides

The results of this assessment should be considered in the review of restoration work recommended for the watershed as well as in the evaluation of future harvesting proposals in the watershed.

3.0 METHODOLOGY

The procedure used for this assessment was the final version developed by the Interior Watershed Assessment Committee. It has been published as a guidebook under the Forest Practices Code titled, ***Interior Watershed Assessment Procedure Guidebook (IWAP), Level 1 Analysis,*** dated September 1995.

The IWAP assessment is a reconnaissance level analysis. It is intended to be a coarse filter to identify the watersheds (or portions of watersheds) that may have been impacted by the cumulative effects of past forest development. The procedure is recommended for use in watersheds with areas between five square kilometers and 500 square kilometers. The Duteau Creek watershed area is approximately 19.1 km^2.

Raw data for the watershed was compiled in accordance with the IWAP procedure. The procedure consisted of collecting and collating data that describes the extent and location of harvesting activities and basic physiographic characteristics of the watershed.

Due to the drainage pattern of Duteau Creek and several creek diversions in the watershed, sub-units were identified based on their size and location as well as stream order *[Map 1 - Appendix A]*.

Riverside Forest Products Limited - Lumby Division compiled the data for the entire watershed using a Geographic Information System. Procedures used for the compilation of data for the 13 IWAP indicators are provided in Appendix B. The results were entered into an Excel IWAP spreadsheet (v1.03) developed by the Ministry of Forests to calculate the hazard index scores for each impact category.

In the absence of terrain data, the indicator for length of roads on unstable slopes was calculated using the default indicator of slopes >60%.

For a detailed explanation of the IWAP procedure, refer to the ***Interior Watershed Assessment Procedure Guidebook,*** dated September 1995.

4.0 RESULTS OF OFFICE ASSESSMENT

The results of the IWAP office assessment for Duteau Creek are summarized in Table 1 below. All moderate and high hazard index scores (between 0.50 and 1.00) have been shown in bold type. The IWAP (v1.03) raw data spreadsheets are provided in Appendix C.

TABLE 1
Hazard Indices for the Duteau Creek Watershed

	IMPACT CATEGORY			
WATERSHED SUB-UNIT*	**Peak Flows**	**Surface Erosion**	**Riparian Buffers**	**Landslides**
Aberdeen	**0.67**	0.47	**0.65**	0.00
Heart	**0.51**	0.24	0.13	0.00
Grizzly	**0.62**	0.34	0.29	0.01
Flyfish	**0.53**	**0.54**	0.38	0.00
Entire Watershed	**0.56**	0.49	0.42	0.03

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the Entire watershed. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

4.1 Peak Flows

The peak flow hazard index is rated as moderate for the Aberdeen, Heart, Grizzly and Flyfish sub-units. The ECA's for these respective sub-units are 31.7% (moderate); 11.4% (low); 22.6% (moderate); and 12.6% (low) respectively. Road densities above the H_{60} in these four sub-units are high: 0.76 km/km^2; 0.92 km/km^2; 0.97 km/km^2; and 0.9 km/km^2. The combination of these factors in these sub-units combined with relatively low total road densities resulted in the moderate peak flow hazard indices. The hazard index for the entire watershed was also moderate. The peak flow scores and hazard indices are summarized in Table 2.

TABLE 2
Summary of the Data and Scores in the Peak Flow Hazard Impact Category for the Duteau Creek Watershed

	IMPACT CATEGORY			
WATERSHED SUB-UNIT*	**Peak Flow Index**	**Road Density >H_{60}**	**Total Road Density**	**Hazard Index**
Aberdeen	0.67	0.76	0.50	**0.67**
Heart	0.28	0.92	0.31	**0.51**
Grizzly	0.56	0.97	0.33	**0.62**
Flyfish	0.32	0.90	0.38	**0.53**
Entire Watershed	0.49	0.70	0.47	**0.56**

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the Entire watershed. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

4.2 Surface Erosion

The surface erosion hazard index was moderate in the Flyfish sub-unit. The moderate score in the Flyfish sub-unit is related to the moderate scores for roads within 100 m of a stream and number of stream crossings. Low hazard indices were obtained for all other sub units as well as for the entire Duteau Creek watershed. For the purpose of this assessment, all stream crossings were considered active and, therefore, may not represent the actual number of active stream crossings in the watershed. Surface erosion scores and hazard indices are summarized in Table 3.

TABLE 3
Summary of the Data and Scores in the Surface Erosion Impact Category for the Duteau Creek Watershed

	IMPACT CATEGORY					
WATERSHED SUB-UNIT	**Roads on Erodible Soils (km/ km^2)**	**Roads <100m from Stream (km/ km^2)**	**Roads on Erodible Soils <100m from Stream (km/km^2)**	**Number of Stream Crossings (no./km^2)**	**Total Road Density (km/km^2)**	**Hazard Index**
Aberdeen	0.27	0.43	0.10	0.21	0.50	0.47
Heart	0.00	0.17	0.00	0.15	0.31	0.24
Grizzly	0.00	0.35	0.00	0.21	0.33	0.34
Flyfish	0.10	0.57	0.11	0.51	0.38	**0.54**
Entire Watershed	0.37	0.50	0.25	0.29	0.47	0.49

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the Entire watershed. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

4.3 Riparian Buffers

The riparian buffers hazard index was moderate in the Aberdeen sub-unit. The moderate hazard rating was associated with the portion of streams that have been logged to the stream edge. Low hazard indices were obtained for all other sub-units as well as for the entire Duteau Creek watershed. The riparian buffers scores and hazard indices are summarized in Table 4.

TABLE 4
Summary of the Data and Scores in the Riparian Buffers Impact Category for the Duteau Creek Watershed

	IMPACT CATEGORY		
WATERSHED SUB-UNIT	**Portion of Stream Logged (km/km)**	**Portion of Fish Bearing Streams Logged (km/km)**	**Hazard Index**
Aberdeen	0.65	0.40	**0.65**
Heart	0.13	0.08	0.13
Grizzly	0.29	0.18	0.29
Flyfish	0.38	0.24	0.38
Entire Watershed	0.42	0.26	0.42

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the Entire watershed. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

4.4 Landslides

The landslides hazard indices were low for all sub-units as well as for the entire watershed. The landslides scores and hazard indices are summarized in Table 5.

TABLE 5
Summary of Data and Scores in the Landslides Impact Category for the Duteau Creek Watershed

	IMPACT CATEGORY			
WATERSHED SUB-UNIT	**Landslide Density (no/ km^2)**	**Roads on Unstable Slopes (km/km^2)**	**Logged Slopes >60% on Stream Banks**	**Hazard Index**
Aberdeen	0.00	0.01	0.00	0.00
Heart	0.00	0.00	0.00	0.00
Grizzly	0.00	0.02	0.00	0.01
Flyfish	0.00	0.00	0.00	0.00
Entire Watershed	0.03	0.01	0.00	0.03

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the Entire watershed. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

5.0 RESULTS OF FIELD ASSESSMENT

The results of the IWAP were verified in conjunction with other field assessments conducted in Duteau Creek watershed. The reliability of the IWAP office results were reviewed with the objective of confirming the hazard rating or recommending a more appropriate rating. All sub-units were included in this review.

5.1 Peak Flows

In general, the channel survey indicated that channels are stable with minor evidence of bank erosion or channel change. Stream banks are well vegetated with bank material typically composed of moss-covered cobbles and boulders.

The moderate index for peak flows in the Aberdeen, Heart, Grizzly and Flyfish sub-units should be maintained based on the current level of development. When road densities have been reduced through deactivation/restoration work, the hazard ratings in these sub-units may be reduced based on further review.

5.2 Surface Erosion

The Level 1 road assessments in the Duteau Creek watershed indicated that several roads are considered to be contributing to surface erosion. Eleven high risk sites were identified, including sites in sub-units identified with low risk hazard indices. However, these individual sites are not extensive enough to modify office derived sub-unit hazard indices.

Until the concerns with the high risk areas are remedied -- and other roads are semi–permanently or permanently deactivated or upgraded as appropriate -- the hazard index for surface erosion should remain moderate for the Flyfish sub-unit.

5.3 Riparian Buffers

Riparian vegetation assessments in the Duteau Creek watershed indicated several sites which did not meet current Forest Practices Code requirements and identified two high priority sites in the watershed. However, these individual sites are not extensive enough to modify office derived sub-unit hazard indices.

Until restoration work recommended in the riparian vegetation assessment is completed, the hazard index in the Aberdeen sub-unit should remain moderate.

5.4 Landslides

The landslides hazard index was not changed and remains low.

6.0 CONCLUSIONS

The condition of the Duteau Creek watershed is rated as good based on the results of the IWAP assessment. Cumulative impacts from past development were low for most categories other than for peak flows. There is a moderate concern for peak flows due to the current ECA level. However, the channel assessments indicated that the channels are stable.

IWAP results were obtained through an office assessment and verified through the review of road condition assessments, riparian vegetation assessments and channel assessments. Detailed explanations of these assessments can be found in the ***Duteau Creek Watershed - Results of the Watershed Restoration Project*** report (Sections III, V and VI).

A summary of the hazard ratings (based on the office review and field assessments) are shown in Table 6. The field assessments confirmed that the initial hazard ratings determined during the office review were appropriate.

TABLE 6
Final Hazard Indices for the Duteau Creek Watershed

	IMPACT CATEGORY			
WATERSHED SUB-UNIT*	**Peak Flows**	**Surface Erosion**	**Riparian Buffers**	**Landslides**
Aberdeen	**MOD**	LOW	**MOD**	LOW
Heart	**MOD**	LOW	LOW	LOW
Grizzly	**MOD**	LOW	LOW	LOW
Flyfish	**MOD**	**MOD**	LOW	LOW
Entire Watershed	**MOD**	LOW	LOW	LOW

*Note: Hazard indices for the residual area have not been included in this table. Based on IWAP guidelines, hazard ratings are not to be calculated for residual areas. Development data collected for the residual area have instead been included in the calculation of hazard indices for the Entire watershed. Any concerns identified in the residual area are addressed in the sections of the report referring to the entire watershed.

As explained earlier, it is important to recognize that the IWAP may overestimate a potential hazard rating. The procedure is still in the development stages and, therefore, may err on the conservative. The results should not be taken as absolute but rather as an indicator of a potential for problems resulting from past development.

7.0 RECOMMENDATIONS

The following recommendations are provided based on the results of this assessment:

- Cumulative impacts from forest development should be maintained at a low level for the Duteau Creek watershed since it is a community water supply.

- The results of the assessments of roads, gullies, channels and riparian areas -- completed as part of the Duteau Creek Watershed Restoration Project -- should be reviewed and the recommendations considered for implementation.

- Since terrain data was not available at the time of this assessment -- but may be available in 1997 -- consideration should be given to running the assessment again at a later date using this improved data.

original signed by

D.A. Dobson, P.Eng.

Interior Watershed Assessment

for the

DUTEAU CREEK WATERSHED

(Vernon Forest District)

Prepared for
RIVERSIDE FOREST PRODUCTS LIMITED
Lumby Division

and

TOLKO INDUSTRIES LTD.
Lavington Division

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March 1999

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RIVERSIDE FOREST PRODUCTS LIMITED
Lumby Division

Interior Watershed Assessment

for the

DUTEAU CREEK WATERSHED

(Vernon Forest District)

1.0 INTRODUCTION

At the request of Riverside Forest Products Limited, the ***Interior Watershed Assessment Procedure (IWAP)*** for the Duteau Creek watershed was updated to incorporate the terrain mapping information and new inventory data pertaining to logging history and green-up heights.

The purpose of the assessment was to determine current watershed conditions, the effect of past land-use practice on the watershed and the potential impacts from proposed forest development. The assessment follows the Interim Watershed Assessment Procedure as provided by the Ministry of Forests (MoF) and Ministry of Environment, Lands and Parks (MELP) *[refer to Section 4.0]*. This report replaces the previous watershed assessment completed in 1996.

The Duteau Creek watershed is located southwest of the Village of Lumby within the Vernon Forest District *[Figure 1]*. Duteau Creek is a community watershed providing water for the North Okanagan Water Authority (NOWA). The entire watershed was assessed upstream of the Headgates water intake (referred to as the lower point of interest [POI 1]). The majority of Crown land in the watershed is held under forest license by Riverside Forest Products Limited - Lumby Division, with a minor portion part of a forest license held by Tolko Industries Ltd., Lavington Planer Division. The Small Business Forest Enterprise Program (SBFEP) also has several timber sales proposed within the watershed.

A Watershed Assessment Committee (WAC) including representatives from Riverside Forest Products Limited - Lumby Division, the MoF, MELP, Department of Fisheries and Oceans (DFO), NOWA and Tolko Industries Ltd. was organized to provide input on related issues and concerns, and to review the results *[Appendix A]*.

The Department of Fisheries and Oceans (DFO) did not participate in the initial WAC meeting but requested to be kept informed of assessment results through receipt of the meeting minutes and the final report. Comments forwarded to the WAC will be discussed at the final WAC meeting.

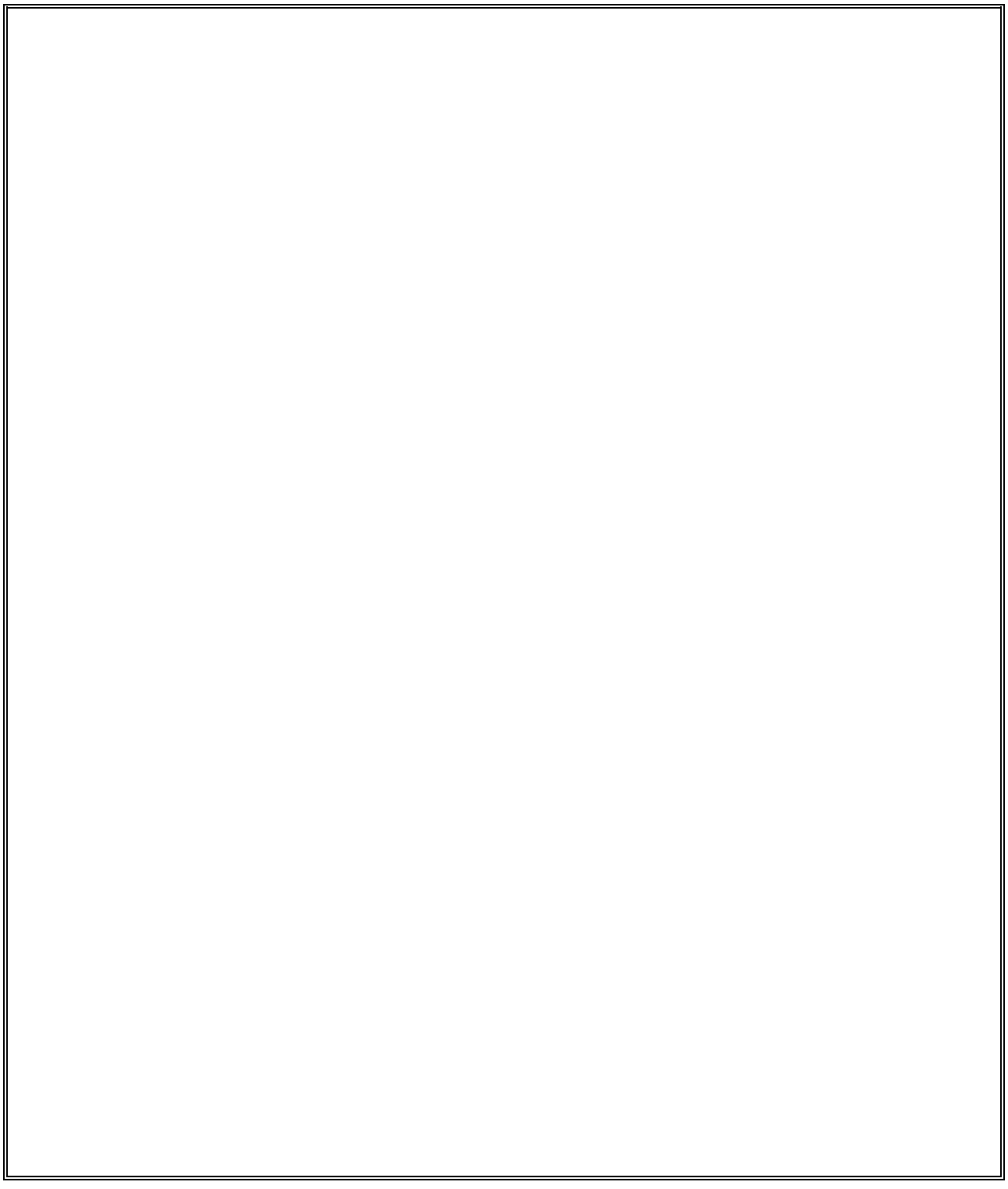

FIGURE 1
Location Map for the Duteau Creek Watershed (showing sub-basins).

2.0 RESULTS OF INITIAL ROUNDTABLE MEETING

2.1 Watershed Concerns

A summary of the comments and concerns presented during the initial roundtable meeting are listed below. Minutes from the meeting are provided in Appendix A.

NOWA

- Primarily concerned with forestry and range management, and their potential effects on water quality and quantity.
- Increases in turbidity and pathogenic organisms are specific concerns that may require special treatment at the intake.
- Cattle are a concern with respect to potential fecal contamination.
- Increased access for recreation and range use that may result from forest road construction is a concern in and around streams.
- The lower residual area adjacent to the canyon reaches is considered the most sensitive areas with respect to forest development.
- The hydrologic effects of the 1998 Aberdeen fire are not known at this time. Without understanding the cumulative effects of increased ECA in the Heart Creek basin, further development in the Aberdeen Residual and Duteau upstream of Grizzly sub-basin is a concern.
- Runoff rates into the upper reservoirs are a concern if accelerated by forest development. Slow, prolonged melt and runoff is desirable to minimize the volume spilled from the reservoirs and maximize the supply in the late summer and early fall low flow periods.
- The reservoirs should not be considered as "settling ponds" for fine sediment resulting from other uses in the watershed.
- Recreation use and cattle access in and around streams below Haddo Lake are concerns that require ongoing management.

Department of Fisheries and Oceans

- DFO was not represented at the meeting but has documented concerns with the mainstem channel downstream of Headgates intake. The channel below the intake has experienced a decline in available salmonid spawning habitat as a result of bedload capture. An agreement is in place with NOWA to maintain specified low flows over set periods of the year.

Ministry of Environment, Lands and Parks

- Similar concerns to those identified by DFO with the mainstem below the Headgates intake.
- Resident trout populations upstream of the intake and reservoirs in the upper watershed are also a concern with regard to channel stability, peak flows and potential increases in sedimentation from roads and cattle activity.

Ministry of Forests

- Specifically concerned with current and proposed ECAs in the watershed.
- Interested in the forest development plan review portion of the IWAP and its potential effects on current watershed conditions.

2.2 Specific Watershed Assessment Items

The points of interest (POI's) for watershed assessment will be at the Headgates intake and on the mainstem at the confluence with Flyfish Creek. Stream channel assessment information will be included for the reaches below Headgates, based on documented DFO fisheries concerns.

Sub-basins will be the same as in the 1996 IWAP and the H60 elevation will remain at 1,323 m. Hazard ratings for the watershed and sub-basins will be reported in tabular format. IWAP calculation data will be presented for all residual areas, sub-basins and the watershed. Specific areas of concern within the Duteau and Aberdeen residual areas will be discussed in the assessment text, but no hazard ratings will be reported for these areas. Residual area hazards are accounted for in the aggregated watershed hazard ratings for the associated POI.

The report should discuss: the hydrologic sensitivity of the watershed and sub-basins with respect to forest and other land-use development; the hydrologic implications of commercial thinning; and proposed aggregate cutblocks.

3.0 BACKGROUND INFORMATION

3.1 Physical Characteristics

Duteau Creek flows north from the Aberdeen Plateau into the White Valley and eventually into Bessette Creek at Lumby. The watershed area is approximately 17,000 ha with elevations ranging from 660 m at Headgates to over 1,800 m in the Grizzly Hills. Biogeoclimatic zones include Interior Douglas Fir (IDF) at low elevations, and Interior Cedar Hemlock (ICH), Montane Spruce (MS) and Englemann Spruce and Sub-Alpine Fir (ESSF) at mid to upper elevations.
The western half of the watershed is dominated by metamorphic rocks of the Monashee or Shuswap Metamorphic Complexes[1]. These rocks are highly foliated and folded granitic gneisses, slate, schist and quartzite[2]. A pluton of granite and granodiorite of the Nelson Plutonic Rocks is present in the middle eastern section of the watershed. Both the Monashee and Nelson groups are mantled by a discontinuous sheet of basalt lava belonging to the Chilcotin Group. This volcanic sheet has been warped and forms abrupt and conspicuous rock escarpments throughout the area[3].

The watershed upstream of Headgates intake roughly consists of two parts: a canyon section and an upland section. In the upland section, surficial materials consist of moderate to well drained moraine with intervening depressional terrain that is poorly drained and dominated by organic deposits[4]. Moraine commonly consists of a veneer or blanket of sandy bouldery till. Rockfalls exist along the extensive lower escarpments composed of columnar basalt. Steep, short slopes susceptible to small slides (consisting of stratified sands and gravels) exist at the head of the canyon section. Isolated areas of glacio-fluvial outwash are present in the uplands area associated with broad glacial meltwater channels.

[1] Jones, A. G., 1959. Geological Survey of Canada Memoir 296 Vernon Map-Area, British Columbia. Department of Mines and Technical Surveys
[2] Roed, M.A., 1998. Detailed Terrain Stability Mapping of the Duteau and Harris Creek Watersheds.
[3] ibid.
[4] ibid.

The canyon section is mapped as Class IV and V terrain with slopes consisting of rock outcrops, escarpments and steep gravelly colluvium in excess of 80% slope. Most of the landslide activity in the watershed is concentrated in this section, and includes large rockslides, debris torrents and debris avalanches[5]. A very narrow alluvial floodplain exists through the canyon dominated by boulder gravels.

Duteau Creek is a snow dominated hydrologic system with peak flows occurring from late April to mid-June. Hydrometric records are available for Duteau Creek near Lavington (WSC Station No. 08LC006) from 1919 to 1921, 1935 to 1951, and 1959 to 1996. Mean daily discharge is 0.67 m^3/s and maximum daily discharge was 16.2 m^3/s recorded in the spring of 1990. Unfortunately, maximum daily discharge is not available for the regionally high runoff years in 1996 and 1997. Flows with a return period of 30 and 40 years occurred in Bessette Creek downstream of Nicklen Creek immediately east of the Duteau watershed in 1996 and 1997, respectively.

The Duteau Creek system is regulated through three reservoirs in the upper watershed and the Headgates water intake, all operated by NOWA. The hydrologic effect of these reservoirs is to modify the runoff period and peak flows through storage. Depending upon the volume and timing of runoff, the reservoirs will have varying effects on downstream peak flows. For example, peaks will be reduced in low runoff years but may be unaffected in high runoff years.

3.2 History of Past Forest Development

Timber harvesting has occurred in the watershed over the past 60 years. From 1930 to approximately 1950, partial cutting systems were employed in the lower elevation stands. Since the 1950s, clearcutting has been the dominant silviculture treatment in the even-aged Lodgepole pine and Englemann spruce-subalpine fir stands at higher elevation. Over the last 20 years, a significant portion of the annual harvest for Riverside Forest Products Limited and Tolko Industries Ltd. has come from salvage logging of Lodgepole pine stands infested with mountain pine beetle. More recently, an outbreak of spruce bark beetle has resulted in significant salvage harvesting in Englemann Spruce stands in the upper watershed.

In 1997 and 1998, the Small Business Forest Enterprise Program completed two commercial thinning blocks in the Heart Creek sub-basin. Approximately 30% of the basal area was removed from the blocks with the intent to promote more vigorous growth in the remaining Lodgepole pine stems. Two other commercial thinning areas are proposed in the Heart and Aberdeen sub-basins.

In the summer of 1998, the Aberdeen fire burned approximately 700 ha of the area east of Aberdeen and Haddo Lakes. The fire burned a combination of standing timber and existing reforested cutblocks. The majority of the burnt standing timber was salvaged in the fall and winter of 1998 by SBFEB and Riverside Forest Products Limited.

3.3 History of Water Use

Earthfill dams were constructed in the upper watershed on Haddo and Aberdeen Lakes in the early 1900s. A diversion from the Harris Creek watershed into Heart Creek was built in the 1930s and recently refurbished in 1992. Through this diversion, Paradise and Gold Creeks are directed into Heart Creek with a total licensed capacity of 6.5 million m^3 per year of freshet runoff.

In the 1970s, an earthfill dam was constructed at Grizzly reservoir to create a third storage reservoir in the upper watershed. The reservoir was designed with additional storage that would be used to maintain summer and fall low flows for salmon spawning and egg incubation downstream of Headgates. This portion of the Grizzly reservoir project was funded by DFO. Minimum releases below Headgates were to be 0.06 m^3/s between January 1 and March 31, 0.11 m^3/s between April 1 and August 31, and 0.14 m^3/s between September 1 and December 31. DFO also has a special agreement with NOWA to provide a further release of water from Headgates upon special request, provided that the total volume released does not exceed 0.14 million m^3 per year.

[5] ibid.

The Headgates intake was originally constructed in the 1920s and rebuilt in the 1960s along with the construction of a new distribution system. The total licensed diversion through the Headgates facility exceeds 25 million m^3 per year.

4.0 PREVIOUS ASSESSMENTS/COMPLETED WORK

Funded by Forest Renewal BC, watershed assessments were completed for the watershed in March 1996 by Riverside Forest Products Limited. Components of the project included an Interior Watershed Assessment, Road Assessment, Channel Assessment, Gully Assessment and Riparian Assessment. A landslide rehabilitation assessment was also completed for the S33.1 road in the Duteau watershed of the Grizzly sub-basin in 1998.

NOWA has initiated a water quality monitoring program at three sites in the watershed. NOWA was the proponent on a recent (1998) landslide rehabilitation project on the Duteau mainstem, and has participated with MoF Range and Recreation Branches, and Riverside Forest Products Limited on several projects to control cattle and recreational access to the mainstem channel and reservoir area in 1998.

Terrain mapping, at TSIL level C, was completed for the watershed in 1998.

4.1 IWAP

The condition of the Duteau Creek watershed was rated as good in 1996 based on the results of the IWAP assessment. Moderate peak flow hazard ratings were calculated for all sub-basins and the watershed primarily as a result of the road densities above the H60 elevation. A moderate surface erosion hazard rating was calculated for the Flyfish sub-basin based on the length of road within 100 m of a stream and the number of active stream crossings. A moderate riparian hazard rating was calculated for the Aberdeen sub-basin based on the length of stream harvested to the bank. All other hazard ratings were low.

It was recommended that cumulative impacts from forest development should be maintained at a low level since Duteau Creek is a community watershed. A review and implementation of recommendations from other watershed restoration project components was suggested along with an update of the IWAP in 1997 following completion of Level C terrain mapping.

4.2 Road Condition Assessment

Approximately 300 km of road was surveyed in 1995 and 11 high risk sites were identified. Five of the 11 high priority sites were located on private land downstream of the Headgates intake.

The 11 high priority sites were recommended for prescriptions in 1996. Work on low and moderate priority sites was recommended if equipment was available during work on the higher priority areas.

Drainage improvement on the Haddo FSR east of the Duteau Creek mainstem crossing (high priority site) were undertaken by Riverside Forest Products Limited in 1998. A high priority bridge crossing was also removed from a tributary to Heart Creek in 1998.

In conjunction with NOWA, Riverside Forest Products Limited also completed road drainage improvement works on the Specs Lake Recreation Site and Grizzly reservoir access roads.

Work at Specs Lake included road relocation away from the stream channel and revegetation of a disturbed riparian area along the channel. The access road on the west side of Grizzly reservoir was deactivated to limit unauthorized vehicle access and prevent cattle from moving north along the reservoir.

4.3 Gully Assessment

Six defined gullies that were direct tributaries to the lower mainstem channel were identified and assessed using the *Gully Assessment Procedure Guidebook.* All assessed gullies were classified as low risk and no remedial works were required.

4.4 Channel Assessment

High and moderate sensitivity channel reaches were identified on aerial photography and assessed in the field. Bank erosion and sediment contribution was observed at one site downstream of the Aberdeen FSR road crossing above Grizzly reservoir. No remedial works were recommended for this or any other channel site in the watershed. An assessment of the channel on private land downstream of Headgates was recommended to identify sediment sources that may affect fish and fish habitat.

4.5 Riparian Assessment

Riparian zones along all channels in the watershed were assessed for proper riparian function. High priority sites for restoration were identified in the Heart Creek sub-basin and in a tributary channel flowing through polygon #482. Direct cattle access to tributary and mainstem channels was identified as a concern throughout the watershed upstream of the canyon. No remedial works have been undertaken on the high priority sites to date.

4.6 Water Quality Monitoring

In 1995, grab samples were gathered at seven sites in the watershed as part of the ongoing FRBC watershed project. NOWA continued the sampling program at one site in 1996 and three sites in 1997 on the Duteau Creek mainstem channel. The data is currently being catalogued and analyzed by MELP and NOWA**.**

4.7 Landslide Reports

In the spring of 1997, a slump occurred from road 533.1 at 2.4 km in the upper Duteau U/S of Grizzly sub-basin. Dobson Engineering Ltd. inspected the site in the fall of 1997 to determine the cause of the failure, and to recommend short and long-term remedial works.

The road was constructed in glacio-fluvial and glacio-lacustrine deposits, and the failure was caused by road drainage saturation of fine sediment overlying an impermeable clay layer. Deactivation of the road was recommended with bank protection along Duteau Creek.

In the fall of 1998, Riverside Forest Products Limited pulled back the headscarp of the failure to minimize further raveling and sediment input to the channel. A joint review of the site with Dobson Engineering Ltd., NOWA and Riverside Forest Products Limited is planned in 1999 to discuss further rehabilitation options.

Also in July of 1997, a landslide occurred on the west bank of Duteau Creek approximately 0.5 km downstream of the Haddo FSR crossing near Edwin Lakes. The slide occurred on an undisturbed slope as a result of saturated soil conditions and possibly localized blowdown. An older slide scar was observed immediately upstream of the recent slide site. Bioengineering prescriptions were completed by Dobson Engineering Ltd. and the work was completed by Bar-Ten Springs Enterprises and NOWA in the fall of 1998.

4.8 Range and Recreation Management

In conjunction with range tenure holders and the Ministry of Forests, Recreation Section, the following fencing and site restrictions were completed by NOWA in 1998:

- Fencing and random camping site access restrictions along Duteau Creek downstream of Haddo Lake.

- Recreational vehicle access restriction to the foreshore of Grizzly Reservoir.

- Fencing and cattle guard placement in the Flyfish and Duteau Creek confluence area to prevent access to sensitive sites, and corral construction in the area to allow quick removal of stray cattle for relocation in permitted range areas (south of Haddo Lake and west of Grizzly Reservoir).

The general intent of NOWA's collaborative efforts with the MoF Range Section and grazing licensees are to restrict uncontrolled range and recreation use from the areas immediately surrounding the upper reservoirs, and riparian zones along the mainstem channel between Haddo Lake and the canyon section.

Fencing projects were completed along the Aberdeen FSR in the 1970s; between Doreen and Streak lakes in the 1980s; and along the east side of the Haddo Lake in 1991.

5.0 METHODS

The watershed assessment presented in this report is based on the 1998 interim watershed assessment procedure provided by the Kamloops Forest Region and BC Environment.

In summary, the assessment process consists of two primary components: an office assessment and a field assessment. The office assessment consists of the compilation and analysis of data to describe the basic geophysical characteristics of the watershed, along with the extent and location of past forest harvesting activities (the watershed report card).

The field assessment consists of a reconnaissance overview of the watershed to determine actual hydrologic hazards. The field assessment includes a reconnaissance level sediment source survey and channel assessment to identify sensitive and/or disturbed road segments and channel reaches. The reconnaissance level channel assessment procedure (ReCAP) is based on the *Channel Assessment Procedure Field Guidebook - December 1996*.

Accessible roads in the watershed were driven or walked where overgrown. Evidence of sediment movement on the running surface or in the ditchline was recorded and the potential delivery to streams was assessed. Stream channels were reviewed by reach at accessible sites. Evidence of flow or sediment loading related disturbance was assessed with reference to expected natural conditions. Harvested riparian areas were reviewed on aerial photographs and during the channel assessment. Riparian functions of shade, bank stability and large woody debris input were considered. Aerial photographs were used to map landslides and determine their size, age and connectivity to the channel system.

6.0 ASSESSMENT

Calculation results are presented in Table 1. A discussion of current watershed conditions based on the field assessment is provided in the following sections. Current watershed hazard ratings for each sub-basin and the watershed are listed in Table 2. Hazards for residual areas are considered in the greater sub-basin or watershed ratings and not presented in the table. A brief discussion of residual hazards has been included in the text based on a specific WAC request.

TABLE 1
Watershed Report Card 1999

Watershed Inventory Category	Duteau Residual	Flyfish Sub-basin	Aberdeen Sub-basin (POI 2)	Aberdeen Residual Area	Heart Sub-basin	Duteau U/S of Grizzly Sub-basin	Watershed (POI 1)

Area (ha)	4,355	2,129	10,480	7,129	2,087	1,264	16,962
H60 Elevation (m)	1,325	1,325	1,325	1,325	1,325	1,325	1,325
Total Area Harvested/Burnt (ha)	2,230	557	4,655	3,579	691	385	7,441
Percent Area Harvested/Burnt (%)	51	26	44	50	33	30	44
Equivalent Clear-cut Area (ECA) (ha)	1,003	200	2,670	1,875	603	192	3,873
Equivalent Clear-cut Area (ECA) (%)	23.0	9.4	25.5	26.3	28.9	15.2	22.8
ECA Above H60 (ha)	434	147	2,189	1,441	569	179	2,770
ECA Above H60 (%)	10.0	6.9	20.9	20.2	27.3	14.2	16.3
Road Density (km/km2)	1.9	1.3	1.6	1.7	1.1	1.4	1.6
High Sediment Source Roads (km)	0.2	0	0.1	0	0	0.1	0.3
Landslides (#)*	6	0	3	1	0	2	9
Road on Potentially Unstable Terrain (km)	6.6	0	1.2	0.2	0.0	1.0	7.7
Stream Crossings (#)	45	15	91	69	19	3	151
Stream Logged to the Bank (km)	22.8	6.5	46.7	36.2	9.3	1.2	76.0
Unstable Mainstem Channel (km) **	0.0	0.0	8.9	0.0	0.0	8.9	8.9

* Slides clearly visible on most recent aerial photography. Does not include channel bank failures. Additional slides that may be marked on terrain mapping are either historic and overgrown or classified as bank failures for the purpose of the watershed assessment.

** Only moderately disturbed mainstem channels upstream of POI have been included in the unstable mainstem channel calculations. There are no severely disturbed channels in the watershed.

6.1 Peak Flow

6.1.1 ECA

The upper watershed above Haddo Lake has gentle rolling terrain, porous sandy soils and a low drainage density[6]. Based on these topographic characteristics and the presence of the reservoirs in the system, the upper watershed (Aberdeen, Heart and Duteau U/S of Grizzly sub-basins) is considered to have a low sensitivity to changes in peak flow, volume and timing associated with forest development. Much of the runoff generated by snowmelt in this area contributes to local and regional groundwater flows rather than surface flow. This contribution to groundwater either emerges in the reservoirs downstream (local groundwater), or in the case of regional groundwater, possibly in the fan downstream of Whitevale Road. The mainstem channels in all sub-basins showed no evidence of recent peak flow related disturbance (Section 6.1.3), particularly following high 1996 and 1997 runoff years, indicating the effectiveness of the system in managing above average snow pack conditions. The current ECA in each of these basins is not a concern with respect to potential channel disturbance *[Table 1]* (Section 6.1.3).

Terrain in the Flyfish sub-basin and major tributary drainages upstream of the canyon in the residual area is also low and rolling. Beaver dams and marshland complexes that exist in the headwater regions of Flyfish and Crescent Creeks also assist in buffering peak flows. However, based on the direct connection of the lower drainage areas to the mainstem channel, the hydrologic sensitivity with respect to forest development is considered moderate for the Flyfish sub-basin and other direct tributary drainages in the residual area above the upstream of the canyon. The current ECA in the Flyfish sub-basin is low and not a concern with respect to potential channel disturbance *[Table 1]*.

The area along the canyon reaches (in the Duteau Residual area) and back from the break in slope above the canyon is considered highly sensitive to potential surface and groundwater alterations associated with forest development. As described in the terrain stability mapping reports, forest harvesting back from the break in slope can affect groundwater recharge and emergence along the steep canyon walls, which can further affect terrain stability. Very limited forest development has occurred along or above the canyon reaches, and no road or cutblock related landslides were recorded.

Partial cut harvesting by the Small Business Forest Enterprise program was completed in 1997 for several blocks in the Heart Creek basin. Approximately 30% of the basal area was removed in these areas to allow the suppressed Lodgepole pine to release. The harvesting occurred in the summer using low ground pressure equipment that required only narrow surface trails. No drainage infrastructure was required for the trails, and soil compaction and sub-surface drainage interruption has been negligible.
Based on snow pack measurements made elsewhere in the Kamloops Forest Region under similar stands, the effect on snow accumulation and melt with up to 30% basal area removal is negligible. Based on the snow research, the past and proposed partial cut harvest blocks with approximately 30% basal area removal have not been included in ECA calculations. A field review of the SBFEP commercial thinning blocks supported the research findings. Thinning had removed only the lower and intermediate layers with minimum affect on canopy closure.

6.1.2 Roads

Roads upstream of the canyon section in the Duteau Residual area are located on generally benign terrain where drainage diversion and concentration concerns are minimal. No evidence of ditchline scour resulting from drainage concentration was noted.

[6] Drainage density refers to the length of stream channel per kilometer squared.

The Aberdeen mainline has been built well back of the break in slope above the canyon reaches in the Duteau Residual area. Temporary access structures (roads) have been used where possible in steeper terrain along the canyon to minimize potential effects on natural hillslope drainage *[Photo 1]*.

6.1.3 Channels

Tributary channels upstream of the canyon show no evidence of peak flow related disturbance *[refer to Section 6.5]*. The mainstem channel through the canyon was active[7] during the 1996 and 1997 spring freshets, but disturbance has been limited to minor bank erosion. Stable old growth riparian vegetation has also limited potential disturbance. The upper watershed reservoirs, beaver dams and marshland complexes in the Flyfish sub-basin and Crescent Creek drainage appear to have effectively buffered the lower mainstem channel from the effects of these recent high flows. The rolling topography, porous soils and low drainage density in the upper watershed has also reduced any potential peak flow effects on channels.

6.1.4 Peak Flow Hazard

Based on observed channel stability throughout the upper tributaries and lower mainstem channel, overall topographic conditions of the watershed upstream of the canyon, and presence of three large reservoirs in the system, the current peak flow hazard associated with past forest development is considered low for all sub-basins and the watershed *[Table 2]*. Peak flow hazards for the residual areas are considered within the greater basin or watershed hazards. It is, therefore, inferred that peak flow hazards are also low for residual areas.

6.2 Surface Erosion

6.2.1 Roads

Roads on the plateau section of the watershed (Duteau Residual area above the canyon and all basins above) are located on benign terrain and surface erosion concerns are low *[Photo 2]*.

Sediment sumps are in place where feasible at road crossing locations and maintenance appears to be good. Inactive roads on the plateau are revegetated with grass and surface erosion is not a concern. Potential sediment delivery to channels in this area is very low to low, according to terrain hazard maps.

Cattle access to the channels at road crossings is causing some sedimentation *[Photos 3 and 4]*. Particular areas of concern include the Flyfish sub-basin, Aberdeen Residual area, Crescent Creek and Curtis Creek drainages.

One high and one moderate sediment source road section was identified in the watershed. The moderate sediment source location is on the Haddo FSR in the residual area immediately beyond the Duteau mainstem crossing. This road section termed “throttle hill” is a chronic source of fine sediment to the channel and has undergone recent ditchline cleaning and sediment sump construction. In spite of these works, sand and silt are still being washed into the mainstem channel, particularly during active hauling in wet weather *[Photos 5 and 6]*. Further sediment control works are required to reduce sediment input.

The high sediment source section is the failure on road 533.1 and the road running surface beyond the slide in the Duteau U/S of Grizzly sub-basin *[Photo 7]*. Secondary erosion of sand, silt and clay is occurring. A field review of this site with Riverside Forest Products Limited, NOWA and Dobson Engineering Ltd. is planned for 1999 to determine remediation alternatives.

[7] Active refers to the recent movement of boulder and cobble bed materials in the channel.

Roads in the Duteau Residual area have been constructed well back of the canyon reaches and surface erosion concerns are low. Recent development in the Duteau Residual area upslope of the mainstem channel has utilized temporary access structures (roads) where possible that have been permanently deactivated *[Photo 1]*. These types of structures reduce both short and long-term sedimentation that can occur from forest roads and should continue where possible for blocks in this sensitive hydrologic area.

The recent (1997, 1998) partial cut harvesting in Heart Creek basin was done using low ground pressure equipment in the dry summer season. An assessment of these areas revealed that ground disturbance was negligible and there were no surface erosion concerns.

6.2.2 Hillslopes

The landslide scar below the 533.1 road is an active source of fine sediment to the channel (as outlined above). The recent (1997) landslide in the upper canyon below the Haddo FSR bridge was bioengineered in the fall of 1998 to reduce erosion and stabilize the hillslope. There were no other hillslope related sediment sources noted.

6.2.3 Surface Erosion Hazard

Based on the low sediment delivery potential from roads (as determined in the field assessment and terrain maps) and limited number of past forest development related landslides in the watershed, the surface erosion hazard is considered low for the Heart, Flyfish and Aberdeen sub-basins, and the entire watershed *[Table 2]*. The surface erosion hazard in the Duteau U/S of Grizzly sub-basin is moderate based on the recent input of sand and silt to the channel from the failure on the 533.1 road, and ongoing secondary erosion of the exposed soils. This moderate hazard can be reduced after slope and channel bank restoration has been completed. The surface erosion hazards are low in both the Aberdeen and Duteau residual areas.

6.3 Landslides

Nine landslides were mapped in the watershed *[Appendix F]*. Six slides have occurred in the canyon reach of the Duteau Residual area, five of which directly impacted the channel. One rockfall mapped in the Aberdeen sub-basin did not deposit in the channel, and two slides were mapped from the 533.1 road into upper Duteau Creek

All slides through the canyon reaches are natural and additional slides in this area can be expected given Class IV and V terrain conditions. Consideration of potential groundwater flow effects should be given to new development in and around the canyon reaches.

The most recent slide in the canyon, approximately 0.5 km downstream of the Haddo FSR bridge *[Photo 8],* had a bioengineering prescription implemented in the fall of 1998 and will be monitored by NOWA for sediment stabilization.

The landslides from the 533.1 road occurred in an isolated glacio-fluvial sand and silt deposit along the Duteau U/S of Grizzly mainstem channel in the upper watershed *[Photos 9 and 10]*. Other similar surficial deposits have been mapped as Class IV or V terrain along the Duteau Creek downstream of Haddo Lake and Crescent Creek mainstem channels. The completion of terrain stability field assessments and surface soil erosion hazard assessments where required for proposed roads and cutblocks in these areas should identify any terrain or surface erosion concerns prior to development.

6.3.1 Landslide Hazard

Based on the low frequency of past forest development related slides, the landslide hazard is considered low for the Flyfish, Heart and Aberdeen sub-basins, residual areas and the entire watershed *[Table 2]*. The landslide hazard remains moderate in the Duteau U/S of Grizzly sub-

basin based on the recent road failure and potential for similar occurrences at that location. The landslide hazard in the Duteau U/S of Grizzly sub-basin can be reduced through site rehabilitation. Landslide hazards in both residual areas are also low.

6.4 Riparian

According to forest cover mapping, 76 of 226 km of stream channel has been harvested to the banks. The majority of this riparian harvesting occurred in the Flyfish basin, Crescent Creek and Curtis Creek drainages, and Aberdeen Residual area.

Small tributary channels in the sub-basins and around the reservoirs that were harvested to the banks in the past are low gradient with stable banks. The loss of riparian cover in these areas may have affected stream temperature over the short-term, but vigorous regeneration of alder, willow and conifers is now occurring. Large woody debris is still present and functional in the assessed tributaries.

Both natural and cutblock boundary blowdown has occurred in the riparian zone between Haddo Lake and the upper canyon *[Photo 11]*. Partial salvage of accessible timber was completed in 1997 (CP 599). These reaches appear to be susceptible to blowdown and are sensitive to disturbance from increased woody debris input and possible avulsions. A Riparian Management Area (RMA) strategy should be developed for these reaches – one that reduces the risk of blowdown in the RMA and recommends possible salvage methods where blowdown occurs to be implemented on a site-specific basis.

Cattle access to channels through old cutblocks in the Flyfish basin, Crescent Creek and Curtis Creek drainages, and Aberdeen Residual area is causing localized bank shearing and stream sedimentation. These areas should be brought to the attention of the MoF Range Section for assessment through the range use plan process.

6.4.1 Riparian Hazard

Based on the extent of riparian regeneration along previous harvested stream banks, the riparian hazard with respect to past forest development is considered low for all sub-basins and the watershed *[Table 2]*. Direct cattle access to tributary channels in the Flyfish and Crescent Creek basins, and Aberdeen Residual area remains a channel sedimentation concern. Blowdown along the mainstem channel below Haddo Lake is also a concern that requires management attention. Riparian hazards in both residual areas are also low.

TABLE 2
Watershed Hazards 1999

	HAZARD CATEGORY			
Drainage Area	**Peak Flows**	**Surface Erosion**	**Landslides**	**Riparian**
Flyfish Basin	Low	Low	Low	Low
Aberdeen Basin	Low	Low	Low	Low
Heart Basin	Low	Low	Low	Low
Duteau U/S of Grizzly Basin	Low	Moderate	Moderate	Low
Watershed	**Low**	**Low**	**Low**	**Low**

6.5 Channel Assessment

The mainstem channel was divided into 12 reaches based on distinct changes in channel morphology, channel gradient, or major tributary or sediment input *[Appendix D]*. At least two channel assessment sites were surveyed on each of the sub-basin tributary channels including Curtis Creek in the Heart basin and Crescent Creek in the residual area. Overview channel assessment information was also gathered for the reaches below the water intake (POI 1).

No channels in the watershed are highly disturbed. The upper Duteau Creek mainstem is moderately aggraded as a result of the 1997 and previous slides, and the lower Duteau mainstem below the intake is degraded as a result of bedload capture in the Headgates intake *[Appendix E]*. Channel descriptions are presented in descending order from the upper basins to the mouth and photographs can be found in Appendix C.

6.5.1 Duteau U/S of Grizzly Basin

Three mainstem channel reaches (J, K and L) were delineated in the Upper Duteau basin.

Reach L is a stable cascade-pool channel with large woody debris control *[Photo 12]*. The break between reaches K and L is at the landslide input location from the 533.1 road. Below this point, reach K, is moderately aggraded with sand and gravel from the most recent (1997) and previous slides (1980s) *[Photo 13]*.

The lower reach (J) is a moderately aggraded riffle-pool channel with large woody debris control *[Photo 14]*. This reach is acting as a deposition zone for gravel from upstream slide input. Sand-size sediment is actively being transported through this reach and may eventually reach the Grizzly reservoir.

Channel restoration activity on the two lower reaches is not feasible to reduce sediment transport. Stabilization of upstream sediment sources (slides at the 533.1 road) is the most effective long-term remediation alternative.

6.5.2 Heart Creek Basin

No reaches were delineated on Heart Creek. The mainstem channel has a low gradient stable riffle-pool morphology with large woody debris control *[Photo 15]*. Localized natural blowdown in the riparian zone is providing some sand and gravel input. No channel concerns were noted.

The Aberdeen fire in 1998 may have affected stream channel stability in the Heart Creek basin that could lead to increased sedimentation in the channel and downstream reservoirs. A joint MELP and NOWA review of stream channel conditions at the request of the SBFEP in Heart Creek is planned for 1999 to determine if any channel or riparian restoration activities are required.

6.5.3 Aberdeen Residual Area

Channels eligible for assessment (according to the CAP procedure) in the Aberdeen Residual area include the Curtis Creek tributary and the outlet from Haddo Lake to the Flyfish Creek confluence. Diversion ditches that connect the Grizzly reservoir (reach I), Aberdeen Lake and Haddo Lake are not applicable to channel assessment procedures.

Curtis Creek was assessed at the Curtis Mainline Road crossing. The channel has a stable riffle-pool morphology. Harvesting to the banks occurred in the 1980s but regeneration of alder, willow and some conifers has since colonized the riparian zone *[Photo 16]*. Cattle grazing on old adjacent

blocks is allowing some direct access to the channel. Minor bank shearing and fine sediment input from range use is occurring.

The outlet of Haddo Lake (reach H) is identical to reach G, which is discussed in Section 6.5.5.

6.5.4 Flyfish Basin

Flyfish Creek has numerous marshland complexes, beaver ponds and small lakes in the upper basin. The lower channel has a stable cascade-pool morphology with woody debris control *[Photo 17]*. At the confluence with the Duteau Creek mainstem, Flyfish Creek is a low gradient riffle-pool channel with no evidence of sedimentation or peak flow related concerns *[Photo 18]*.

6.5.5 Duteau Residual Area

Downstream of Haddo Lake the mainstem channel was divided into five reaches to Headgates (POI 1). Reaches H and G, immediately downstream of Haddo Lake, are low gradient riffle-pool channels. Large woody debris is abundant in these channels as a result of localized natural and cutblock boundary related blowdown in the riparian zone *[Photos 19 and 20]*. The channel bed and banks are stable through reaches H and G, and no cattle access to the channel was noted during the assessment. Lower reach G flows through Class V terrain where one old (pre-1972) bank failure was mapped. The channel banks and adjacent hillslopes in lower reach G are a natural source of sand and gravel to the channel. NOWA and Riverside Forest Products have noted cattle in the riparian areas along Reaches H and G. This area is sensitive to cattle disturbance and efforts to prevent access should continue.

Reach F is also a low gradient riffle-pool channel extending to the head of the canyon. Large woody debris is abundant from localized blowdown, particularly along old block boundaries *[Photos 11 and 21]*. The majority of blowdown was observed to be spanning the channel at the assessment location and partial salvage had already been undertaken in the adjacent block (CP 599).

Crescent Creek is a small tributary that joins reach F approximately 1.5 km downstream of the Doreen Creek confluence. NOWA has expressed concern with the channels in Crescent Creek based on observed sand and gravel bars, and direct cattle access in the upper drainage. Aggraded channel conditions were observed in the lower channel *[Photo 22]* and range use in the riparian zone was noted above and below the Aberdeen FSR crossing. In the upper drainage, a large sediment wedge was observed in the main channel from a beaver dam release in the early 1990s *[Photo 23]*. NOWA documented increased turbidity at the Headgates intake following the event[8]. This event is the source of gravel bar deposits in the lower drainage.

The upper Duteau canyon reach (E) is a stable cascade-pool channel with increased sand and gravel bedload from the recent (1997) slide approximately 0.5 km downstream of the Haddo FSR crossing *[Photos 8 and 24]*. The slide had a bioengineering prescription implemented in the fall of 1998 and no further hillslope or channel restoration is required.

Upstream of Headgates (reach D) the channel has a stable cascade-pool morphology with some temporary sand and gravel deposition from upstream slides *[Photos 25 and 26]*. The riparian vegetation is in tact along the entire canyon reach and the channel banks are stable. Woody debris accumulations are present along the channel margins throughout the canyon upstream of Headgates.

[8] Clark, R., 1998. Personal Communication, NOWA.

The intake pond was drained and dredged in the summer of 1997 as a result of increased sedimentation from upstream sources. This elevated sedimentation trend will continue over the next two to five years barring additional landslides into the canyon reaches.

An old trail paralleling the mainstem channel with a cattle bridge approximately 2,000 m upstream of the Headgates intake was noted. Minor channel bank erosion and road fill failure was observed on the road *[Photo 27],* and the bridge is rotting and will soon collapse into the channel *[Photo 28]*. According to the range permit holder for the area, the bridge and access trail is no longer required. The bridge should be removed as soon as possible and eroding fill locations along the trail should be pulled back and either bioengineered or armoured.

6.5.6 Mainstem Channel Downstream of Headgates

Downstream of Headgates (reaches B and C), the channel has a moderately degraded cascade-pool morphology as a result of bedload capture in the intake pond *[Photo 29]*. No bank disturbance or recent bedload movement was observed from the 1996 and 1997 spring freshet flows.

On the fan (reach A), the channel is also moderately degraded downstream of the Whitevale Road crossing *[Photos 30 and 31].* All of reach A is a riffle-pool channel flowing through alluvial deposits that are easily eroded if bedload supply or flow regimes are altered. The channel on the fan is valuable salmonid and resident trout spawning and rearing habitat and should be considered for enhancement. The re-introduction of spawning sized substrate below Headgates may be a possible mitigation alternative.

The lower fan channel closer to Highway 6 was not reviewed in the field. According to forest cover maps and aerial photographs, sections of the channel have been cleared to the banks for agricultural purposes.

6.6 Watershed Restoration Opportunities

- Surface erosion controls on “throttle hill” immediately beyond the Duteau mainstem crossing on the Haddo FSR.
- Removal of old cattle bridge from reach D upstream of Headgates.
- Improvement or deactivation of the access road through the canyon above Headgates.
- Joint review of the 533.1 road failures with Dobson Engineering Ltd., Riverside Forest Products Limited and NOWA to determine remediation alternatives.
- Continued range and recreation management with the intent to control sedimentation in the reservoirs, tributaries and mainstem channels through controlled watering access or the provision of off-channel watering sites.
- Salmon and trout spawning and rearing habitat enhancement of lower Duteau Creek through aggregate input to the mainstem channel below Headgates.

7.0 PROPOSED FOREST DEVELOPMENT

Development is proposed by Riverside Forest Products Limited, Tolko Industries Ltd. and the Small Business Forest Enterprise Program for the period 1999 to 2005. All proposed blocks with harvest dates between 1999 and 2005 are either approved or proposed category “A” blocks *[Appendix B]*. Cutblocks with harvest dates of 2006 are being proposed by Riverside Forest Products Limited as category “I” or information blocks.

A total of 16 clear-cut blocks are proposed by Riverside Forest Products Limited and Tolko Industries Ltd. as category "A" over the period 1999 to 2005. An additional 13 commercial thinning blocks are proposed by Riverside Forest Products Limited over the same period. One commercial thinning block is proposed by SBFEP in 1999. Approximately 30% basal area removal is planned for the commercial thinning blocks, which will have a negligible effect on canopy closure and snow accumulation (as demonstrated in the 1997 SBFEP commercial thinning blocks in the Heart Creek sub-basin). For this reason, commercial thinning block areas have not been included in ECA calculations. Two group selection blocks and one shelterwood block is proposed by Riverside Forest Products Limited in the lower residual area. Approximately 50% basal area removal is planned for these blocks which were assigned a 50% ECA for calculation purposes.

Beyond 2005, Riverside Forest Products Limited has four clear-cuts and three commercial thinning blocks proposed as category "I."

Approximately 9.1 km of road is required to access all blocks from 1999 to 2006 with one new stream crossing. Hydrologic concerns specific to proposed forest development are discussed below.

7.1 Peak Flow

7.1.1 ECA

Over the development plan period (1999 to 2005), hydrologic recovery on old cutblocks and burns will exceed the rate of proposed development. The current watershed ECA of 22.8% (1999) will decrease to 20.8% (2005) with proposed development *[Table 3]*. With the inclusion of category "I" blocks scheduled for 2006, the watershed ECA will increase to 21.5%. Above the H60 elevation, the current watershed ECA will also be reduced from 16.3% (1999) to 14.9% (2005) despite proposed development. Category "I" blocks above the H60 elevation would increase the ECA to 15.5% (2006).

The current and proposed level of development is not expected to affect peak or low flows in the Duteau Creek mainstem channel.

The current and proposed level of development is not expected to affect peak or low flows in the Duteau Creek mainstem channel.

Proposed development will increase the ECA both above the H60 elevation and overall in the Duteau U/S of Grizzly sub-basin. In spite of the ECA increase, 2005 and 2006 levels are still considered low for the sub-basin and changes in peak or low flows are not anticipated.

Other minor ECA changes in the sub-basins and residual areas are not expected to affect discharge levels.

Proposed aggregate cutblocks in the Aberdeen sub-basin will not have an increased hydrologic effect over smaller cutblocks between 10 and 20 ha in size. Snow accumulation, melt rates and overall water yield should be generally consistent between small blocks and larger aggregate blocks.

TABLE 3
ECA Trends

Drainage	1999		2005		2006	
	ECA >H60	ECA Total	ECA >H60	ECA Total	ECA >H60	ECA Total
Flyfish	6.9	9.4	5.5	7.0	5.7	7.5
Aberdeen (POI 2)	20.9	25.5	19.1	23.4	19.9	24.0
Aberdeen Residual*	20.2	26.3	17.7	23.4	18.5	23.8
Duteau U/S of Grizzly	14.2	15.2	15.7	17.0	16.6	17.9
Heart	27.3	28.9	26.1	27.4	26.9	28.3
Duteau Residual*	10.0	23.0	9.2	21.4	9.8	22.2
Watershed (POI 1)	16.3	22.8	14.9	20.8	15.5	21.5

*** Note:** ECA values for residual areas are not normally included in this table, but due to expressed concerns by members of the watershed assessment committee, they are provided here for discussion purposes only.

7.1.2 Roads

Road construction to access proposed blocks in or above the canyon reaches in the residual area is a potential concern with respect to sub-surface and surface runoff flow alterations. The use of temporary access structures where possible or deactivation of conventional roads immediately following harvest will reduce this concern.

Proposed road construction in the Aberdeen and Flyfish sub-basins is located on benign terrain where the risk of drainage alteration and/or concentration is low.

There are no other road related drainage or peak flow concerns.

7.2 Surface Erosion

Increased cattle and recreation access in and around streams and reservoirs is a potential surface erosion and water quality concern with proposed development. Road layout and deactivation plans that address future access can reduce this concern.

Limited new road construction is required to access proposed development. One short section of road in the canyon section is proposed on soils with a high or very high erosion potential according to terrain maps. Completion of surface soil erosion assessments where required will address this concern. All other proposed road is located on soils with low or moderate erosion potential.

Aggregate blocks in the Aberdeen sub-basin have been proposed according to the Total Chance Plan (TCP). The intent of these larger blocks is to utilize temporary access structures where possible and minimize the length of active road that must be maintained to access operable timber in the watershed. This strategy maximizes the amount of available timber from a single access road, allowing the road to be deactivated sooner rather than maintained to access other small blocks along the road. The overall effect is to reduce the length of active, maintained road in the watershed that subsequently reduces the surface erosion potential over the long-term.

7.3 Landslides

Development proposed within the canyon section or back of the break in slope can affect sub-surface and surface drainage both within the block and downslope. Two partial cutblocks proposed in the upper canyon section are located on the canyon wall within Class IV or V terrain. Terrain stability field assessments (TSFA) that address both within block and downslope areas should be completed to determine suitability for development, and recommend road construction and harvest methods to reduce the risk of failures. In the lower canyon section, a partial cutblock is proposed above Class IV and V terrain. While a TSFA is not formerly required on this block, there are potential downslope stability concerns.

There are no other landslide concerns with proposed development.

7.4 Riparian

Increased access for range and recreation use in riparian areas is a potential concern with proposed development. As mentioned in Section 7.2, road layout and deactivation plans that address future range and recreation access should address this concern.

No blocks are currently proposed along the Duteau Creek mainstem between Haddo Lake and the canyon. Blowdown has occurred along this reach in the past and further salvage activity may be required. A Riparian Management Area (RMA) strategy should be developed for these reaches – one that reduces the risk of blowdown in the RMA and recommends possible salvage methods where blowdown occurs to be implemented on a site-specific basis.

There are no other riparian concerns with proposed development.

8.0 SUMMARY

8.1 Watershed Assessment Results

- The surface erosion and landslide hazards are moderate for the Duteau U/S of Grizzly sub-basin based on the 1997 slide event from the 533.1 road and active secondary erosion of the slide scar. All other watershed and sub-basins hazards are low.

- Road related surface erosion concerns were noted on Haddo FSR at “throttle hill” and the failure site on the 533.1 road. A field review of the 533.1 road site is planned for 1999.

- No channels in the watershed were determined to be highly disturbed. The Duteau U/S of Grizzly mainstem was moderately aggraded as a result of the 1997 and previous slides, and the lower Duteau mainstem below the intake is degraded as a result of bedload capture in the Headgates intake.

- Channel effects on Heart Creek from the Aberdeen fire are not known at this time. A joint MELP/NOWA field review of the area is planned for 1999 to determine if channel bank or riparian restoration is warranted.

- Tributary channels upstream of the canyon show no evidence of peak flow related disturbance. The mainstem channel through the canyon was active during the 1996 and 1997 spring freshets, but disturbance has been limited to minor bank erosion. The three reservoirs in the upper watershed, and beaver dams and marshland complexes in the Flyfish sub-basin and Crescent Creek drainage have effectively buffered the lower mainstem channel from the full effects of these recent high flows.

- An old cattle bridge and eroding access trail upstream of Headgates was noted in the field assessment. The bridge is rotting and will eventually collapse into the channel. Bridge removal and trail upgrading or deactivation would address these concerns.

- Based on topographic and soils characteristics, and the presence of the reservoirs in the system, the upper watershed (Aberdeen, Heart and Duteau U/S of Grizzly sub-basins) is considered to have a low sensitivity to changes in peak flow associated with forest development.

- Based on the direct connection of the lower drainage areas to the mainstem channel, the hydrologic sensitivity with respect to forest development is considered moderate for the Flyfish sub-basin and tributary areas in the residual area above the upstream of the canyon.

- The area along the canyon reaches and back of the break in slope above the canyon is considered highly sensitive to potential surface and groundwater alterations associated with forest development. The majority of mapped natural landscape activity has occurred in this area.

- Range use in and around streams in the Crescent, Curtis and Flyfish drainages and Aberdeen Residual area is a concern with respect to bank shearing and sedimentation.

8.2 Proposed Forest Development

- Development is proposed by Riverside Forest Products Limited, Tolko Industries Ltd. and the Small Business Forest Enterprise Program for the period 1999 to 2005. Cutblocks with harvest dates of 2006 are being proposed by Riverside Forest Products Limited as category "I" or information blocks.

- A total of 16 clear-cuts and 17 partial cutblocks are proposed over the period 1999 to 2005. An additional four clear-cuts and three partial cutblocks are planned as category "I" blocks in 2006. Riverside Forest Products Limited has proposed aggregate cutblocks in the Aberdeen sub-basin.

- Over the development plan period (1999 to 2005), hydrologic recovery on old cutblocks and burns will exceed the rate of proposed development. The current watershed ECA of 22.8% (1999) will decrease to 20.8% (2005) with proposed development. Changes in peak or low flows are not expected in the Duteau Creek mainstem channel.

- Proposed development will increase the ECA both above the H60 elevation and overall in the Duteau U/S of Grizzly sub-basin. In spite of the ECA increase, 2005 and 2006 levels are still considered low for the sub-basin and changes in peak or low flows are not anticipated.

- Other minor ECA changes in the sub-basins with proposed development are not expected to affect discharge levels.

- There are potential hillslope stability concerns with three blocks proposed along the canyon section of the residual area. Two blocks fall within and the third blocks drains onto areas mapped as Class IV and V terrain. Terrain stability field assessments that review surface and sub-surface hydrology both within and downslope of the blocks should address this concern.

- Proposed aggregate cutblocks will not have an increased hydrologic effect over smaller cutblocks between 10 and 20 ha in size. Snow accumulation, melt rates and overall water yield should be generally consistent between small blocks and larger aggregate blocks.

- The goal of larger aggregate blocks is to minimize the amount of active road required to access available timber in the watershed. This strategy maximizes the amount of available timber from a single access road, allowing the road to be deactivated sooner rather than maintained to access other small blocks along the road. The overall effect is to reduce the length of active, maintained road in the watershed that subsequently reduces the surface erosion potential over the long-term.

- Increased access for range and recreation use in riparian areas in and around streams and reservoirs is a potential concern with proposed development. Road layout and deactivation plans that address future range and recreation access should address this concern.

- Blowdown has occurred both naturally and along cutblock boundaries along Duteau Creek between Haddo Lake and the canyon. A blowdown salvage plan that permits the removal of woody debris from stream channels, based on an assessment of natural woody debris supply levels, may expedite the process and reduce potential channel disturbance. No blocks are currently proposed along these reaches.

9.0 RECOMMENDATIONS

9.1 Forest Development Plan Recommendations

- Complete terrain stability field assessments on the three partial cutblocks in the canyon section that address the potential hydrologic effects of harvesting both within cutblocks and on downslope areas.

- Design road construction and deactivation plans for proposed blocks in and around streams and reservoirs that limit future range and recreation access to the channels or lakes.

- Utilize temporary access structures where possible to harvest cutblocks along the canyon reaches. If a permanent road is required, deactivate as soon as possible following harvest.

- Review the landslide site on road 533.1 in upper Duteau Creek prior to any upstream harvesting to determine further mitigation alternatives.

- Improve sediment controls on “throttle hill” immediately beyond the Duteau Creek mainstem crossing on the Haddo FSR.

- Develop a Riparian Management Area (RMA) strategy for mainstem channels between Haddo Lake and the canyon – one that reduces the risk of blowdown in the RMA and recommends possible salvage methods where blowdown occurs to be implemented on a site-specific basis.

9.2 Other Recommendations

- Remove the cattle bridge from lower reach D and upgrade or deactivate the trail adjacent to the channel to reduce erosion and sedimentation.

- Continue proactive cattle management in conjunction with range permit holders and the MoF Range and Recreation Branches, particularly between Haddo Lake and the canyon and area around the upper reservoirs.

- Consider spawning substrate input to the Duteau Creek mainstem channel downstream of the Headgates intake.

- Complete the planned MELP/NOWA and SBFEP review of stream channels potentially affected by the Aberdeen fire, and rehabilitate disturbed stream channels and riparian areas where required.

- Assess observed bank shearing and channel sedimentation concerns in the Crescent, Flyfish and Curtis drainages and Aberdeen Residual area through the range use plan process.

MM/dd/jb

Appendix F

Stream Crossing Assessment Procedure

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

The Stream Crossing Quality Index:
A Water Quality Indicator for Sustainable Forest Management

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Abstract
One of the goals of sustainable forest management is the maintenance of water quality. One of the biggest forestry related impacts to water quality is accelerated sediment delivery to streams at road crossings. Good road building and maintenance practices will minimize the erosion hazard and related negative impacts to water quality. Based on this, several divisions of Canadian Forest Products Ltd. have recognized that a good water quality indicator should be based on a field-survey that evaluates effectiveness of controlling accelerated erosion and sediment delivery at stream crossings. This has led to the development of a sediment source hazard assessment procedure called the Stream Crossing Quality Index (SCQI). The procedure evaluates and scores the size and characteristics of road-related sediment sources at crossings and the potential for the eroded sediment to reach the stream environment. A high score infers that there is a significant erosion problem which may in turn cause sediment-related water quality problems. The SCQI is a good management tool because it identifies specific problems in the landscape and provides future direction to minimize them.

Introduction

One of the goals of sustainable forest management (SFM) is to implement best management practices so that water quality is maintained within natural ranges of variability (CCFM 2000). Within an SFM framework there is a requirement for a set of clearly defined performance criteria and indicators to gauge progress towards the goal of maintaining water quality. Designing a meaningful indicator to address this goal is not an insignificant challenge. Forestry activities are an extensive type of disturbance that generally cover many hundreds of square kilometers and numerous watersheds. Forest harvesting activities can affect many water quality characteristics, but increased sediment loading has been identified as one of the most detrimental (MacDonald *et al.* 1991). Several forest harvesting activities can cause increased erosion rates and sediment delivery to aquatic environments. However, road building and maintenance, particularly at stream crossings, is the dominant point source for forestry-generated sediment in landscapes where landslides are not a dominant process (Beaudry 2001, Beschta 1978, Bilby *et al. 1989,* Cafferata and Spittler 1998) (Figure 1).

Figure 1. Ditches, road surfaces and cut/fill slopes can be significant sources of sediment at stream crossings.

Within any given watershed, there may be dozens or even hundreds of stream crossings, each being a potential source of sediment. Although the impacts of forestry disturbances on water quality can be relatively small and subtle at any given point within a watershed, the sum of the impacts may add up to significant downstream cumulative effects. If good road building and maintenance practices can minimize (or eliminate) accelerated erosion and sediment delivery to streams, then negative impacts to water quality will be minimized. Based on this assumption, several B.C. and Alberta Divisions of Canadian Forest Products Ltd. (Canfor) have decided that a good water quality indicator should be based on a field survey that evaluates how well accelerated erosion and sediment delivery are being controlled in the vicinity of stream crossings. The stream crossing quality index (SCQI) was developed as an SFM indicator to provide a meaningful measure of the potential hazard that a stream crossing may present for water quality.

Development and Refinement of the SCQI

In 2000, the Prince George Division of Canfor considered a variety of SFM indicators for use in its forestry certification program. As an indicator of protection of water quality, Canfor was considering the concept of the stream crossing density used in the BC Watershed Assessment Procedure (WAP), i.e. # of stream crossings counted on a map divided by the watershed area (BC Government 1995). We suggested that although the stream crossing density is very simple and inexpensive to measure, a better alternative would be to complete a field assessment of the crossing and score its real potential for accelerated erosion and sediment delivery to the stream. Such a procedure would provide accurate field-based information and would be a large improvement on the stream crossing density concept that assumes that all crossings produce the same amount of sediment to the stream environment. Thus was born the concept of the SCQI, a field-based hazard assessment of the potential for accelerated erosion and sediment delivery at stream crossings.

The origins of the SCQI methodology were based on the concepts of the sediment source survey (SSS) presented in version 2.01 of the WAP (B.C. Government 1999). In the WAP, the road-related SSS is used as an indicator of the level of hazard that forestry roads have for delivering sediment to the aquatic ecosystem and thus potentially reducing water quality. One of the major refinements provided by the SCQI methodology is the systematic description and evaluation of all individual sediment sources at a crossing that have

the potential to deliver sediment to the stream network.

As an SFM indicator, the basic assumption that underlies the SCQI is that if erosion and sediment delivery in the vicinity of stream crossings is minimized, through proper road building and maintenance practices, then the potential impact to water quality from increased sediment delivery is also minimized (Figure 2). The SCQI is a useful management tool because it provides a clear incentive to improve erosion and sediment control (ESC) practices in the vicinity of stream crossings since it documents practices that create a water quality hazard and those that minimize it. Improvement of forest management practices over time is a clearly explicit goal of all forest certification schemes. The Canadian Council of Forest Ministers (CCFM 2000) clearly recognizes the potential negative impacts to water quality associated with road crossings. In their sustained forest management program they have defined one of the aquatic indicators as being: "percentage of forest area having road construction and stream crossing guidelines in place" (Indicator 3.2.2).

Figure 2. Hay mulch used effectively for both erosion and sediment control.

Method

The execution of an SCQI survey begins with the mapping of current access within the watershed and planning an effective way of completing a 100% sampling of stream crossings with that watershed. In many situations 100% sampling is not possible but at least 90 to 95% sampling is usually achieved. Stream crossings are accessed using trucks, quads or by walking.

Once the surveyor has arrived at the stream crossing, the procedure begins by evaluating the size and characteristics of all sediment sources that can potentially contribute sediment to the aquatic environment. Each stream crossing is divided into eight distinct and independent "elements". These include four road ditches that run into the stream, two road fill slopes and two road running surfaces, each of these potential sediment sources being assessed independently. The sediment source hazard score for each individual element is a product of the *erosion potential* and the *delivery potential* of that source. The *erosion potential* is calculated as a function of several factors which are:

1. the size of the sediment source
2. the soil texture of the source
3. the slope gradient of the source
4. the percentage of non-erodible cover
5. the level of road use (for road surface) and
6. the shape of the ditch (for ditch elements)

The cornerstone of the SCQI procedure is the measurement of the size of the sediment source (m^2). The other variables act as modifiers to increase or decrease the hazard associated with the size of the sediment source (Appendix 1). Each of the modifiers is scaled from 0 to 1, where zero (0) represents a condition that would eliminate the hazard (e.g. coarse gravel, no slope or an abandoned fully revegetated road) and one (1) represents a condition that would maximize the hazard (e.g. silt, slope greater than 15% or active mainline). The size of the sediment source (m^2) is multiplied by the value of each modifier to generate an *erosion potential* score for the particular element being assessed. This is then multiplied by the *delivery potential* (scaled from 0 to 1) to obtain the element score. The *delivery potential* represents a qualitative assessment of the percentage of the eroded material that will likely reach the stream. A series of definitions are provided to assist in the determination of the delivery potential, e.g. 0 means that there is no connection between the erosion source and the stream and no delivery is possible, 0.5 means that the delivery is indirect and filtered through trees grasses and/or sediment control structures, 0.8 is used when sediment is weakly filtered through a sparse grass cover and most of the material reaches the stream and 1.0 means that

delivery is evident, direct and uninterrupted with no obvious depositional zones before reaching the stream. The total score for the crossing is simply the sum of the eight scores for each of the individual elements. The final SCQI crossing score generates five hazard classes as defined in Table 1.

Table 1. Correspondence between SCQI score and hazard class.

Score	Sediment Source Hazard Class
0	None
0< score <0.4	Low
0.4 ≤ score ≤ 0.7	Moderate
0.7 < score ≤ 1.6	High
Greater than 1.6	Very High

The values for each of the modifiers are based on the concepts and values developed for the Revised Universal Soil Loss Equation (RUSLE) presented by Wall *et. al*. (2002). The universal soil loss equation was initially developed by Wischmeier and Smith (1965). The objective of the RUSLE was to provide a quantitative tool to assess the potential for soil erosion at a given site.

The SCQI procedure is a useful management tool because it identifies the specific location and magnitude of erosion problems. If scores are high, the crossing can be improved through remedial actions and current practices can be altered to avoid high scores in the future. If scores are low, then it shows that good erosion and sediment control practices are being implemented and by extension water quality is being protected. The procedure has been presented to numerous field practitioners in a series of field workshops and received a favourable response because it clearly identifies the specific location of the problem and the practice that generates the problem.

It is important to note that the SCQI method was designed to be quick (about 15 minutes per crossing) so that a maximum number of crossings can be assessed, thus providing a better landscape level perspective. The SCQI has evolved over the last three years from its initial structure based mostly on subjective assessments. The procedure is now more objective, repeatable and transparent, using values based on the RUSLE.

It must be noted that the whole SCQI approach is largely a conceptual model, based on the general concepts of the RUSLE, and was not developed based on an experimentally acquired set of empirical relationships. It provides a score in a consistent way that can be compared with other crossings in a given watershed and evaluated for how "good" or "bad" the crossings are. The SCQI does not provide a quantitative evaluation (e.g. kg/ha/yr) of exactly how much sediment is entering the stream or what the impact of that sediment has on the stream environment. The SCQI approach tells you where there are erosion and sediment control problems, how frequent in the landscape those types of problems appear and provides a basis of information to judge the magnitude of the problem and how to fix it so that impacts to water quality will be minimized. It is important to emphasize that the SCQI focuses exclusively on the evaluation of the sediment source and the potential of that sediment to reach a stream (i.e. the "hazard"). It does not in any way attempt to measure, evaluate or score the sensitivity of the stream or the impact of increased sediment delivery to the aquatic environment (i.e. it does not evaluate "consequence"). Work is currently underway to develop a methodology to evaluate the sensitivity of a stream to increased sediment loads. If this effort is successful, it could be combined with the SCQI approach to produce a true risk assessment procedure.

Evaluation of the SCQI Procedure

In 2001 an evaluation program was initiated by Canfor, Prince George Division, to test the validity of the SCQI procedure by monitoring stream turbidity levels at selected stream crossings. Several hundred stream crossings ranging over a variety of topographic and climatic conditions across the Prince George Timber Supply Area (TSA) were surveyed in the spring of 2002 to generate a population of possible sampling sites. From this database, we eliminated all large streams (relatively rare occurrence in the landscape) and streams that were too small to be instrumented. Our objective

was to focus the measurements on "small" streams with an average bankfull width of 1 to 3 metres (Figure 3) since about 90% of stream crossings in the Prince George region occur on small streams (P. Beaudry and Associates Ltd. 2002). The crossing scores were then grouped into one of three hazard levels, i.e. low, moderate or high (see Table 1). A random selection of seven stream crossings, per hazard level, was selected to serve as our experimental sample (i.e. total of 21 crossings).

Figure 3. Example of size of stream monitored and instrument set-up for measurement of turbidity. Note water is turbid as a result of rainstorm.

Each crossing was instrumented with electronic continuous turbidity sensors in an "upstream-downstream" experimental design. The assumption behind this approach is that the difference between the upstream and downstream measurements can be attributed to the erosion and sediment delivery at the stream crossing (i.e. induced turbidity). An example of the induced turbidity results, obtained from one of the monitored crossings, is provided in Figure 4. The objective was then to compare the measured induced turbidity with the hazard score generated by the SCQI procedure to see if there was an acceptable correlation.

Both the provincial (Government of BC 2001) and federal (DFO 2000) governments have produced some guidelines that relate increases in turbidity to the risk to the aquatic environment. We used an adaptation of these guidelines to define five hazard classes for our SCQI scores. The classes range from no hazard to very high hazard (Table 2). As an example, a hazard level of "high" is defined as a site that generates enough sediment to the stream that it will consistently cause an increase in turbidity between 70 NTU and 130 NTU, when significant rainfall occurs. The maximum induced turbidity for every rainfall-turbidity event measured during the field season was tabulated and crossing averages were calculated. The event-frequency distributions for each crossing were analyzed and the right tail 10% of the distributions were removed to account for extreme events occurring at very low frequencies (i.e. one large event over the entire field season) that might skew the average. It is also our opinion that most of these extreme events do not actually represent increases in turbidity, but rather an anomaly caused by debris passing over the turbidity sensor, and thus should be removed from the database.

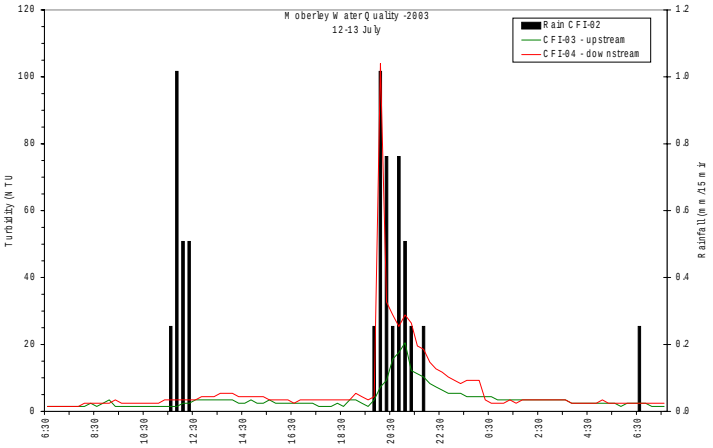

Figure 4. Example of measurement of induced (red) turbidity, where the downstream turbidity peak is about 80 NTU greater than the upstream peak (green).

Results from the 2002 turbidity measurements generally showed a good correspondence between the assessed hazard level and induced turbidity measurements. The validation process also identified some specific problems with the procedure and improvements were made accordingly during the 2003 field season. One of the major refinements was the introduction of an objective measurement of the actual size of each of the sediment sources, rather than the previously used subjective assessment of the "level of erosion". This refinement provided an opportunity to generate a more quantitatively-based score with no pre-defined upper limit. The individual crossing scores for each of the 21 sites were related to the average induced turbidity of the entire monitoring

site to determine if the SCQI score was a reasonable predictor of induced turbidity.

Table 2. Levels of risk associated with increases in turbidity (adapted from Fisheries and Oceans, 2000)

Induced Turbidity (NTU)	Risk to Fish Habitat	Sediment Source Hazard Class
0	None	None
1 to 8	Low	Low
8 to 70	Moderate	Medium
70 to 130	High	High
>130	Unacceptable	Very High

The regression analysis has shown that indeed the relationship is quite good, at least for SCQI score less than 3.5 (Figure 5). Two of the monitored crossings had scores greater than 8, and yet did not generate turbidity levels as high as the scores suggest they should have. These two points were not included in the dataset as they render the linear relationship insignificant. Based on these two "outliers", it appears that the SCQI procedure needs to be further refined for situations where the sediment source is very large. Currently, we think that as a sediment source increases in size (e.g. > 150 m^2) and the complexity and variability of the characteristics of the sediment source also increase, it becomes increasingly difficult to predict how much of the eroded material will actually reach the stream.

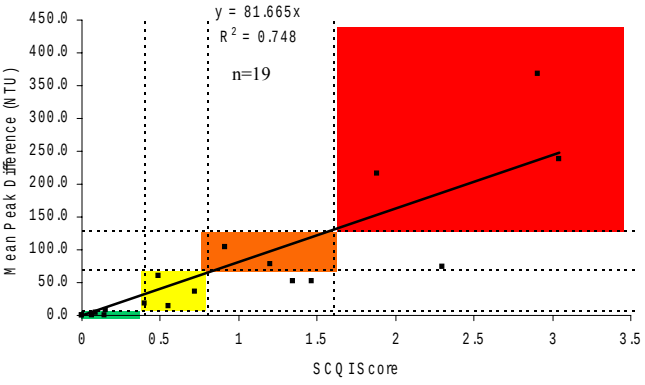

Figure 5. Relationship between SCQI score and induced turbidity (mean peak difference NTU).

Further improvements to the SCQI procedure are necessary to accommodate the complexities of larger sediment sources. Another related issue is that the upper limit of the induced turbidity scale is dependent on the sediment saturation potential of the volume of water transported in the stream and when the water is very dirty the relationship between delivery of sediment and increases in turbidity may no longer be linear.

In Figure 5, we added coloured rectangles to illustrate the areas on the graph that represent the different hazard rating classes used in the SCQI procedure and how these relate to the expected range of induced turbidity. These results clearly suggest that the procedure is very good at predicting induced turbidity (within the expected range) for the low and moderate hazard levels, and although somewhat less accurate, also good for the high and very high classes (up to scores of about 3). The three points that are outside of the coloured areas all represent the same situation, i.e. the SCQI score is predicting a situation that is a little bit worse than the actual problem, but only for situations where a significant problem already exists. Thus, for a proportion of crossings surveyed, the SCQI procedure may be overstating the size of a problem where a significant problem exists, but it accurately predicts the size of the problem where the problems are small or non-existent. Consequently, we believe that the SCQI is a good tool to identify the proportion of problem and non-problem crossings across the landscape and is thus a good SFM indicator to address the goal of protection of water quality. Work is continuing on the development and refinement of this procedure.

Hazard rating = Low.
Turbidity < 8 NTU.
SCQI < 0.4.

Hazard rating = Moderate.
8 NTU < Turbidity < 70 NTU.
0.4 ≤ SCQI ≤ 0.7.

Hazard rating = High.
70 NTU < Turbidity < 130 NTU.
0.8 ≤ SCQI ≤ 1.6.

Hazard rating = Very High.
Turbidity > 130 NTU.
SCQI > 1.6.

Conclusions

Canfor has completed SCQI surveys over a wide range of their operating areas as part of their forest certification programs (well over 3,000 crossings). These include areas within central and northern B.C. and eastern Alberta. Several independent certification audits have identified this approach as a meaningful and well structured process to objectively document the extent of effective erosion control practices in the landscape. Road construction and maintenance supervisors find this a useful tool because it locates and identifies specific problems and provides direction for remedial action with the built-in incentive of obtaining a better SCQI score in the future. The SCQI tool is also useful to show improvements in erosion control practices over time, a requirement of many forestry certification schemes.

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Appendix 1. **Modifier score values** (subject to change with further validation work)

Table A1. Sediment Source Area Scores

Size (m^2)	Score	Size (m^2)	Score
0	0	**50-100**	2
0-1	0.1	**100-150**	3
1-2	0.2	**150-200**	4
2-4	0.3	**200-250**	5
4-8	0.4	**250-300**	6
8-14	0.5	**300-350**	7
14-20	0.6	**350-400**	8
20-26	0.7	**400-450**	9
26-32	0.8	**450-500**	10
32-40	0.9	**500-550**	11
40-50	1	**550-600 etc**	12, etc

Table A2. Soil texture class modifier scores.

Soil Textural Class	***Score/Compactness Level***		
	M	***L***	***H***
Very Fine Sand	1.0	0.90	0.80
Silt	0.97	0.86	0.77
Silt -Loam	0.88	0.80	0.70
Silty Clay Loam	0.74	0.70	0.60
Clay	0.51	0.46	0.41
Sandy Loam	0.3	0.27	0.24
Medium Sand	0.16	0.14	0.13
Coarse Sand	0.014	0.013	0.011
Stones and Gravel	.007	0.006	0.006

Table A3. Slope modifier scores.

Gradient	**Score**
>12%	1.0
9-12%	.97
7-9%	.85
5-7%	.75
3-5%	0.60
1-3%	0.25
<1%	0.15
away from stream	0.00

Table A4. Road use level modifier scores.

Road Use Level	***Score***
Active mainline	1.0
Active branch line	0.99
Moderate activity (occasional grading)	0.95
Low activity (no grading, x-ing structure still present)	0.96
De-activated (xing structures removed)	
-used extensively by 4 wheelers	0.98
-minor use by 4 wheelers	0.92
-no 4 wheeler use evident	0.85
Abandoned – no access (too much veg)	0.80

Table A5. Ditch shape modifier scores

Ditch shape	***Score***
"V"shape-V.steep&V.steep	1.55
"V"shape-Steep&V.steep	1.45
"V"shape-Gentle&V.steep	1.35
"V"shape-Flat&V.steep	1.10
"V"shape-Steep&Steep	1.35
"V"shape-Gentle&Steep	1.25
"V"shape-Flat&Steep	1.00
"V"shape-Gentle&Gentle	1.15
"V"shape-Flat&Gentle	0.90
"U"shape-V.steep&V.steep	1.40
"U"shape-Steep&V.steep	1.30
"U"shape-Gentle&V.steep	1.20
"U"shape-Flat&V.steep	1.10
"U"shape-Steep&Steep	1.20
"U"shape-Gentle&Steep	1.10
"U"shape-Flat&Steep	1.00
"U"shape-Flat&Gentle	0.90
"U"shape-Flat&Flat	0.85
"U"shape-Gentle&Gentle	1.00

Appendix G

Sample Grazing License

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

PROVINCE OF BRITISH COLUMBIA

MINISTRY OF FORESTS

GRAZING LICENCE

For Ministry Use Only:

FILE #	15700-20	**AGREEMENT #**	RAN 075035 Replaces RAN 071617
STOCK RANGE	North Okanagan,	**RANGE UNIT AND #**	King Edward Swallwell 3320-13,22,23,24;Vernon 3289-1,4,6,7,8,13,

BETWEEN: **HER MAJESTY THE QUEEN IN RIGHT OF THE PROVINCE OF BRITISH COLUMBIA**
c/o:
THE DISTRICT MANAGER

of: Vernon Forest District
2501-14th Avenue
Vernon,British Columbia
V1T 8Z1

("the Province")

AND: **Coldstream Ranch Ltd.**
8604 Highway #6, Coldstream,
British Columbia
V1B 3C1

("the Agreement Holder")

This agreement is dated for reference this 16th day of September,2002

The Province hereby grants rights to the Agreement Holder over Crown range in accordance with the *Range Act* on the following terms and conditions:

1. TERM

The Term of this Agreement will be as follows:

	Year	Month	Day
Start:	2003	January	1st
Expiry:	2012	December	31st

("the Term")

2. AGREEMENT AREA

The area over which the rights are granted is the Crown range outlined in bold black on the attached Exhibit A map, less any of the following:

a) exclusions noted on the Exhibit A
b) exclusions arising from Exhibit B conditions
c) exclusions arising from the Range Use Plan associated with this agreement.

("the Agreement Area")

3 RIGHTS

The Agreement Holder will have the right to graze livestock on the Agreement Area under the terms and conditions of this Agreement and its associated Range Use Plan.

4. PRIVATE LAND

(a) Appurtenancy N/A
This Agreement will be appurtenant to the private lands shown on Exhibit C of this Agreement. If there is no Exhibit C, the Agreement will be appurtenant to the private lands held by the Agreement Holder (the "Private Land") as shown on the Application giving rise to this Agreement ("the Application")
(b) Common Grazing of Unfenced Private Land

5. AMOUNT OF FORAGE

The Agreement Holder will graze livestock which consume 2696 animal unit months ("AUMs") per year (Authorized Yearly Use) on the Agreement Area, unless otherwise authorized (in writing) by the District Manager.

6. RANGE USE PLAN

The Agreement Holder will prepare and maintain a Range Use Plan as required in the *Range Act* and the *Forest Practices Code of British Columbia Act.*

7. PERIODIC REPORTS

The District Manager, acting reasonably, may request the Agreement Holder from time to time to prepare and send a report on specified matters associated with the Agreement. The Agreement Holder will comply with the request.

8. INCREASE IN GRAZING USE

The District Manager may increase the number of AUMs in Authorized Yearly Use (paragraph 5) in return for range management services performed on the Agreement Area.

9. FINANCIAL

(a) The Agreement Holder will pay ground rent, grazing fees, fines and any other financial assessments as required under the *Range Act*.

(b) The Agreement Holder will pay the interest on overdue accounts and any other financial assessments provided for by law and arising from the use of Crown range.

(c) Fees and all other financial assessments must be paid as specified on the Province's invoices or statements. The District Manager may require payment of fees in advance of livestock turnout.

10. COMPLIANCE WITH LAWS

The Agreement Holder will comply with all provisions of the following Acts and their regulations: the *Range Act*, the *Forest Practices Code of British Columbia Act*, the *Livestock Act* and the *Animal Disease Control Act*. Any breach of these *Acts* or their regulations will be considered to be a breach of this Agreement.

11. TEMPORARY REDUCTION IN GRAZING USE FOR ENVIRONMENTAL REASONS

(a) The District Manager may, by issuing a written order, require a temporary reduction or adjustment in grazing use because of the adverse effects of weather, fire, flood or other environmental factors.

(b) If the District Manager issues an order pursuant to (a) and the order results in a reduction of 20% or more of Net Authorized Yearly Use, the amount of fees will be reduced proportionately.

(c) Paragraph (b) above will not apply if the agreement holder is entitled to a reduction of fees according to section 10.1 of the Range Regulations.

12. LIVESTOCK OWNERSHIP AND CONTROL

The Agreement Holder will graze on the Agreement Area only livestock which the Agreement Holder owns or controls by lease. The Agreement Holder will not allow any livestock to be grazed on the Agreement Area which are owned or controlled by lease by any other person. The District Manager must approve any livestock lease agreements. The District Manager may grant an exemption to the provisions of this paragraph.

13. INFECTIOUS OR CONTAGIOUS DISEASES

(a) The Agreement Holder will not allow any livestock to be on the Agreement Area or on any Unfenced Private Land, or on any land subject to a Private Land Requirement which has any infectious or contagious disease or other condition that is a material risk to other livestock, wildlife or humans.

14. COMPLIANCE WITH LIVESTOCK ASSOCIATION

Unless exempted by the District Manager, the Agreement Holder will comply with local Livestock Association's reasonable rules and fee assessments for the construction and maintenance of authorized range improvements on the Agreement Area, or for services on the Agreement Area.

15. CLAIMS

(a) The Agreement Holder will reimburse the Province for any loss caused to the Province as a result of the Agreement Holder's negligent or wilful default in the use of the Agreement Area.

(b) The Province will not be responsible for the death, injury, or theft of livestock, or theft or damage to property belonging to the Agreement Holder.

(c) The Province will not be responsible for any damage to range developments, except damage wilfully done by the Province or resulting from activities specifically authorized by the Province.

(d) The Agreement Holder will have no claim against the Province for reimbursement for loss arising from deficiencies in the quality or quantity of forage on the Agreement Area.

16. NOTICES

Any notices will be served in the manner provided in the *Range Act*.

17. SPECIAL CONDITIONS

Conditions set out on any Exhibit B will form part of this Agreement. If there is any contradiction between any such conditions and any other terms of this Agreement, the Special Conditions will prevail.

Notice to Agreement Holder on Obligations, Compliance and Enforcement

The obligations of the Agreement Holder in the use of Crown range arise both from this Agreement and from relevant legislation such as the *Range Act* and the *Forest Practices Code of British Columbia Act*. Lack of compliance could subject the Agreement Holder to a variety of remedies such as administrative penalties, tickets, suspension and cancellation of this Agreement or prosecution for offences. Among the topics requiring attention is the maintenance responsibility of the Agreement Holder for range developments.

District Manager's Signature	Signature of Witness	Name of Witness
_____	_____	_____

Agreement Holder's Signature*	Signature of Witness	Name of Witness
_____	_____	_____
_____	_____	_____
_____	_____	_____

* or Authorized Signatory if the Agreement Holder is a corporation

Appendix H

Grazing Tenure Map

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

The Grazing Tenure Map is currently available as a paper copy only and is therefore not included in this draft

Appendix I

Drinking Water Source Protection Memorandum of Understanding, Southern Interior Drinking Water Team Membership

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

MEMORANDUM OF UNDERSTANDING

BETWEEN

Ministry of Agriculture and Lands
Ministry of Energy, Mines and Petroleum Resources
Ministry of Environment
Ministry of Community Services
Ministry of Health
Ministry of Forests, Range and Housing
Ministry of Transportation
Office of the Provincial Health Officer
Fraser Health Authority
Interior Health Authority
Northern Health Authority
Vancouver Coastal Health Authority
Vancouver Island Health Authority

REGARDING

INTER-AGENCY ACCOUNTABILITY AND COORDINATION ON DRINKING WATER PROTECTION

VERSION 7: OCTOBER 16 · 2006

1 Background

1.1 In March, 2002 the Province adopted an *Action Plan for Safe Drinking Water in British Columbia* which sets out a multi-faceted and multi-agency approach to the protection of public health as it relates to drinking water quality.

1.2 The Action Plan sets out government's commitment to an integrated approach for drinking water protection. The ADMs' Committee on Water and the Directors' Inter-Ministry Committee on Drinking Water are the facilitating bodies for the Action Plan.

1.3 The Action Plan also states the accountability of different ministries for the coordination of source protection, land use planning and infrastructure:

(a) The Ministry of Environment will be responsible for source water quality standards, monitoring, compliance and enforcement, and resource ministries will continue to be responsible for protecting drinking water sources under their legislated mandates.

(b) The Ministry of Agriculture and Lands will work with communities to help make appropriate land use decisions that carefully consider drinking water protection.

(c) The Ministry of Community Services will work in partnership with federal and local governments to help ensure required infrastructure is in place.

1.4 The *Drinking Water Protection Act* (DWPA) is one element of the Action Plan. It is the principal statute concerning drinking water protection.

1.5 Many other statutes deal with matters of relevance to drinking water protection, and through which government seeks to achieve various legislative objectives related to matters such as resource extraction, land use and environmental practices. Many of these statutes contain their own provision for drinking water protection, most particularly source water protection.

1.6 The role of drinking water officers under the DWPA complements the roles of statutory officials under other statutes, and the DWPA contains numerous provisions to balance respect for other statutory mandates while at the same time ensuring that public health protection respecting drinking water is achieved.

1.7 The DWPA requires the Provincial health officer to perform an oversight and accountability function regarding the administration of the DWPA. This includes a duty to report to the Minister of Health and potentially to Cabinet any situation that

(a) in the opinion of the Provincial health officer, significantly impedes the protection of public health in relation to drinking water, and

(b) arises in relation to the actions or inaction of one or more ministries, government corporations or other agents of the government.

1.8 In light of all the above, the parties to this MOU have entered into this understanding with a view to ensuring each agency's accountability in respect of their actions concerning drinking water protection.

1.9 This MOU is not intended to address issues of consultation and/or coordination between the parties to this agreement and federal agencies.

2 Guiding principles

2.1 In fulfilling the terms of this MOU the parties[1] will be governed by the following guiding principles:

Constructive – The parties will foster constructive working relationships.

Proactive – The parties will work to ensure that any potential concerns regarding inter-agency cooperation are identified in a proactive manner and that steps are taken to avoid them, or to address them as soon as possible.

Information sharing – Each agency, through either the ADMs' or the Directors' Committees, will share with the other agencies information relevant to the matters covered by the MOU. This will include:

- sharing of information respecting the development or amendment of legislation, policy, practices, etc. that may affect drinking water protection (in advance where possible)
- sharing information from the ADMs' and Directors' Committees with officials[2] responsible for implementing the regional protocols (discussed below)
- clear communication regarding the goals and purposes of the various regulatory mandates, particularly those which are results based.

Respect for mandates – All of the parties will recognize and respect the mandates and statutory decision-making functions of the other parties.

Partnership – The parties will give effect to this MOU in manner that reflects a sense of partnership and shared responsibility for drinking water protection and risk management.

Efficiency and Practicability – The parties seek to ensure that the goals of the MOU are achieved in a manner that minimizes the need for the development of additional referrals systems and other activities that will impose significant resource requirements on staff. The parties will also support an appropriate degree of flexibility among regions in implementing the regional protocols (discussed below), so as to reflect the particular needs and circumstances of the various regions. Communication and referrals on resource activities that are part of the regional protocol will be based on best available information at the time of the application.

[1] "Parties" means the agencies as represented on the ADMs' Committee on Water.
[2] i.e., officials from any agency.

3 Establishment of regional drinking water teams

3.1 For each region, a regional drinking water team will be established, with representation from each agency that is party to this agreement, as well as representation from local governments that wish to participate.

3.2 The members of the regional drinking water teams will serve as the principal contact for discussion of regional inter-agency drinking water issues.

3.3 Each health authority will designate a drinking water officer to serve as a coordinator of the respective regional drinking water teams. The coordinator will maintain an up-to-date contact list for members of the regional drinking water team and make that available to all team members.

3.4 Regional drinking water teams may communicate by whatever means is considered the most efficient and effective and all may meet, in whole or in part, at times mutually agreeable to all the members. The coordinator for each team will schedule at least one meeting each year to which all members of the regional drinking water teams will be invited to attend. If a subset of the membership meets, the coordinator of the drinking water team will communicate the outcome of the meeting to all members within a week of the meeting.

4 Commitment to the establishment of regional protocols

4.1 Each of the Parties to this MOU will participate in the development of regional protocols to give operational effect to the purposes of this MOU.

4.2 For the purposes of the regional protocols, the regions will be defined by the geographic areas of each of the five health authorities, as set out in Appendix A. Due to the absence of coincident boundaries among the agencies, discussions may need to occur among multiple offices to identify appropriate committee membership for each regional protocol.

4.3 The regional protocols will be developed by the regional teams, and they will set out the types of decisions that should as a general rule be the subject of some form of coordination or consultation, recognizing however that the decision whether or not to undertake inter-agency coordination in any particular case is ultimately a matter for the discretion of officials[3] (unless some legal requirement to do so exists).

4.4 Regional drinking water teams may develop whatever form of protocol they determine appropriate to achieve the goals and meet the requirements of this MOU, but they are encouraged to consider using the form of protocol set out in Appendix B, and to consider coordination regarding those activities set out in Appendix C that are relevant to that

[3] i.e., officials from any agency.

region. Regional protocols may include strategies for engaging local stakeholders interested in community drinking water issues.

4.5 Regional protocols must be developed for each region no later than October, 2007. A copy of such protocols must be provided to the Directors' Inter-agency Committee on Drinking Water when it is completed, and at any time it is amended.

4.6 Nothing in this MOU or any regional protocol developed under it is intended to be legally binding, and neither creates any legal rights or duties. Moreover, nothing in this MOU or a regional protocol shall be taken to limit or constrain the exercise of discretion by a party in respect of a statutory power or decision.

5 Commitment to include drinking water coordination activities within each ministry and agency

5.1 Each agency that is party to this MOU will undertake the necessary internal steps to ensure its commitment to inter-agency coordination of drinking water issues and the implementation of this MOU.

6 Process for review and performance management

6.1 On or before June 30 of each year, beginning June 2008, each drinking water team will provide to the Directors' Inter-agency Committee on Drinking Water a summary report of its activities for the previous fiscal year.

6.2 The Directors' Inter-agency Committee on Drinking Water will review the reports of the regional drinking water teams and provide an annual overview report to the ADMs' Committee on Water.

6.3 The Directors' Inter-agency Committee may at any time provide recommendations to the regional drinking water teams, with a view to ensuring the effective and efficient implementation of this MOU.

7 Process for dealing with disagreements or unresolved issues

Disagreements or unresolved issues in implementation of regional protocols

7.1 Responsibility for addressing disagreements or unresolved issues concerning implementation of the regional protocols rests with the regional team members and their supervisors as appropriate. If however the regional teams draw to the attention of the Directors' Inter-agency Committee on Drinking Water any disagreements or unresolved issues arising in relation to the implementation of a regional protocol, the Directors' Committee may review and discuss the matter, with a view to recommending to the ADMs' Committee any amendments to this MOU that may prevent such occurrences from occurring in future.

Disagreements or unresolved issues in implementation of this MOU

7.2 If any disagreements or unresolved issues arise in the implementation of this MOU , the relevant members of the Directors' Inter-agency Committee on Drinking Water will discuss the matter and attempt to resolve it. If that does not prove successful, those parties will refer the matter to the relevant members of the ADMs' Committee. In the event that the Assistant Deputy Ministers of the agencies concerned are unable to resolve the disagreement in a mutually acceptable manner, they will refer to matter to the Deputy Provincial health officer, who may consult with the parties with a view to resolving the matter.

8 Costs

8.1 Each agency will bear its own costs of undertaking the activities associated with this MOU.

Grant Parnell, Assistant Deputy Minister, Crown Land Administration, Ministry of Agriculture and Lands — Dec 8/06. — Date

Harvey Sasaki, Assistant Deputy Minister, Risk Management and Competitiveness, Ministry of Agriculture and Lands — 06.12.08 — Date

Eric Partridge, Assistant Deputy Minister, Mining and Minerals, Ministry of Energy, Mines and Petroleum Resources — 06.11.07 — Date

Jim Mattison, Assistant Deputy Minister, Water Stewardship, Ministry of Environment — 2006.12.11 — Date

Dale Wall, Assistant Deputy Minister, Ministry of Community Services — 2006.12.14 — Date

Andrew Hazlewood, Assistant Deputy Minister, Population Health and Wellness, Ministry of Health — Nov 03/06. Date

Jim Snetsinger, Chief Forester, Ministry of Forests, Range and Housing — Dec 12/06 Date

for Peter Milburn, Assistant Deputy Minister, Highways Department, Ministry of Transportation — 06/12/4 Date

Dr. Perry Kendall, Provincial Health Officer, Office of the Provincial Health Officer — 31/Oct/2006 Date

Dr. Roland Guasparini, Chief Medical Health Officer, Fraser Health Authority — 24 January 2007 Date

Dr. Rob Parker, Chief Medical Health Officer, Interior Health Authority — Dec 28/2006 Date

Dr. David Bowering, Chief Medical Health Officer, Northern Health Authority — Jan 9/2007 Date

for Dr. John Blatherwick, Chief Medical Health Officer, Vancouver Coastal Health Authority — 02/NOV/2006 Date

Dr. Richard Stanwick, Chief Medical Health Officer, Vancouver Island Health Authority — Jan 17/07 Date

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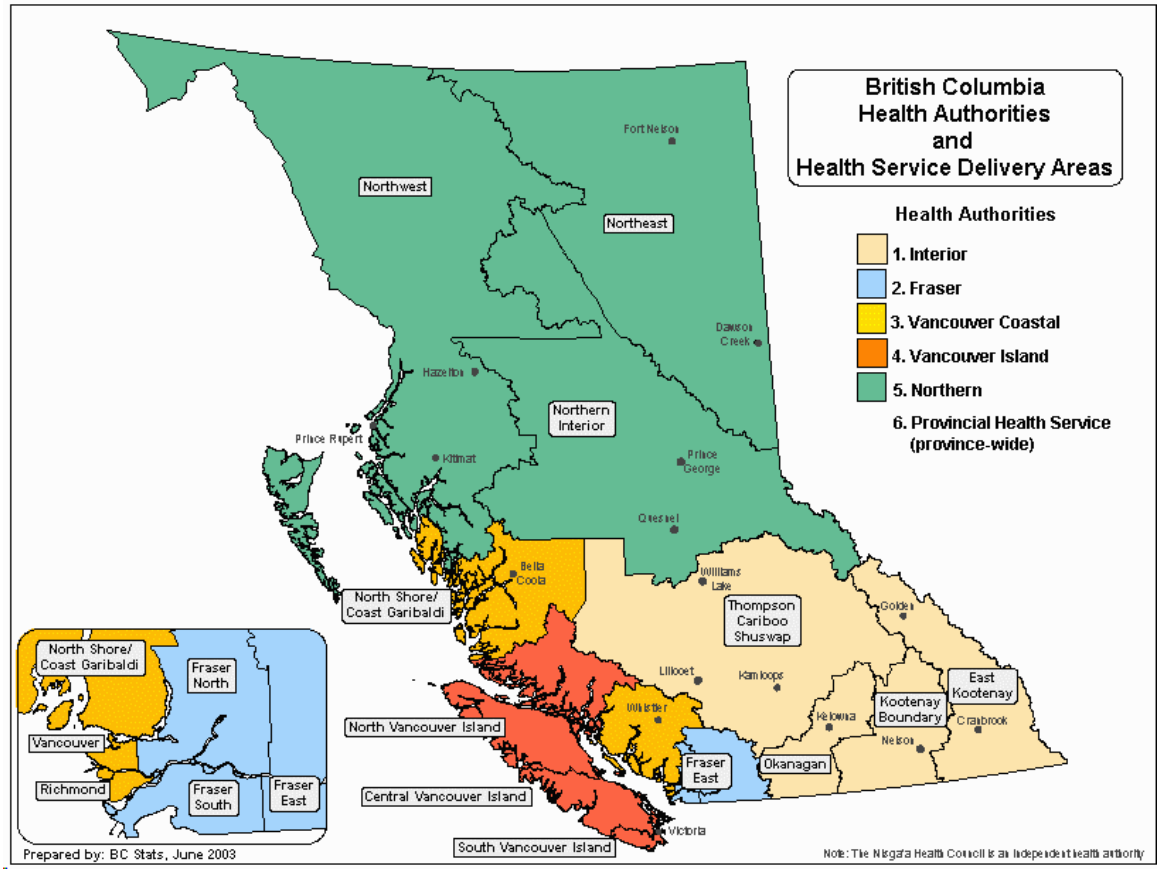
Appendix A

Map of Health Authorities



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Appendix B

Suggested template for Regional Protocols

REGIONAL DRINKING WATER TEAM

The members of the _____ Regional Drinking Water Team, including contact information and the names of alternate members, are set out in the attached table.

Each agency will bear the costs of its participation in the Regional Drinking Water Team and the meetings referred to below.

MEETING SCHEDULE

Regular meetings

The Regional Drinking Water Team will hold a regular meeting at least *[SPECIFY FREQUENCY]*. Such meetings will be arranged by *[SPECIFY DRINKING WATER OFFICER OR OTHER PERSON]* upon at least 3 weeks notice to all the other parties. All parties will send a representative to such meetings.

Parties will attempt to participate in regular meetings in person, but may arrange to participate by conference call if personal attendance is not practicable.

The team members will rotate the responsibility for organizing and hosting regular meetings, and in preparing minutes that result from such meetings.

Additional meetings

Additional meetings may be held at any time that any of the team members wishes to propose and organize such a meeting. In providing notice of additional meetings, the person proposing the meeting should give as much notice as is reasonable in the circumstances, and must indicate the purpose of subject matters(s) to be addressed in the meeting. The other parties may attend such additional meetings at their discretion.

Parties may participate in additional meetings in person or by teleconference.

Matters for consideration at meetings

The Regional Drinking Water Team will establish its own agendas for regular and additional meetings. This may include, but is not limited to:

- Discussion of routine consultation and activities taken pursuant to the protocol (see next section)

- Proactive identification of drinking water protection issues that may warrant inter-agency consultation and coordination even before a specific statutory decision or function is contemplated

- Consultation with local stakeholders interested in community drinking water/watershed protection issues

- *[Others?]*

MATTERS FOR WHICH COORDINATION AND CONSULTATION WILL BE ROUTINELY CONSIDERED

Staff of the parties to the protocol will, as a general matter, apply the principles set out in the following chart concerning inter-agency consultation when exercising their statutory functions relevant to drinking water protection.

However, in any case where an official from an agency determines that some other approach is more appropriate on the facts of any particular case, he or she may adopt the principles that are considered appropriate.

[Insert chart based on proposal set out in Appendix C of MOU[4], but tailored to needs and circumstances of the region.]

DEALING WITH DISAGREEMENT OR UNRESOLVED ISSUES

In the event issues arise about which the team members disagree, or cannot be resolved, and which have potential impact on drinking water protection and related matters, the team members involved will refer the matter to their immediate supervisors for consideration and direction.

If as a result of the referrals discussed above a team members considers that a matter is not resolved to the mutual satisfaction of the agencies concerned, he or she must advise the person from that agency that is a member of the Directors' Inter-agency Committee on Drinking Water.

COMMUNICATION STRATEGIES

The parties will adopt the following communication techniques and strategies to ensure open and effective communication regarding drinking water protection issues:

- Copies of this protocol and the related MOU will be provided to [specify]
- The parties will share information in a timely way regarding developments within their respective agencies that are relevant to the matters covered in this protocol.
- *[Others?]*

[4] Appendix C is a table including agencies' decisions related to drinking water and the associated legislation.

PREPARATION OF AN ANNUAL REPORT

8.2 On or before June 30, beginning June 2008, of each year, each drinking water team will provide to the Directors' Inter-agency Committee on Drinking Water a summary report of its activities for the previous fiscal year. Responsibility for preparing the report will rotate annually among members of the Regional Drinking Water Team.

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Appendix C

Please note: THE FOLLOWING EXAMPLE IS FOR ILLUSTRATIVE PURPOSES ONLY. This chart is intended to be completed by the regional drinking water teams. The actual contents of the chart would need to be discussed and considered by relevant ministry staff.

Chart of key statutory decisions for which regional inter-agency coordination may be appropriate

ACT	DECISION OR ACTION BEING CONSIDERED OR TAKEN	AGENCIES WITH WHICH TO COORDINATE* "c" - consider consulting and pursue as appropriate "i" - share for information purposes "r" - request input before decision-making (*May be departed from where the official concerned views the type or degree of coordination set out below is not appropriate in the circumstances)									
		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
Dike Maintenance Act											
Drinking Water Protection Act	Construction permits										
	Operating permits										
	Hazard Abatement Orders										
	Public reporting requirements (e.g., boil water notices)										
	Assessment (technical committee)										
	Assessment response plan										
	Emergency Plans										
	DWPP (request for)										

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		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
Environmental Assessment Act											
Environment Management Act	Pollution abatement order										
	Pollution prevention orders										
	Pollution information order										
	Waste discharge (Schedule 1)										
	Area-based planning										
	Substitution orders										
	Remediation orders (CS)										
	Animal Waste Control Regulation										
	Organic Matter										
	Recycling Regulation										
Farm Practices Protection Act	Farm bylaws through the local government act										
Fisheries Act											
Fish Protection Act	Riparian Area Regulation										
Forest Act	Tenure/licence award										

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		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
Forest Practices Code	Road construction permits										
	Watershed Assessments in community watersheds(until 2006)										
	Forest Development Plan Approval										
	Cutting permits										
	Setting water quality objectives (known)										
Forest and Range Practices Act	Forest Stewardship Plans										
	Range Stewardship Plans										
	Range Use Plan										
	Woodlot Regulation										
	Community Watershed designation (MSRM)										
	Community Watershed objectives (MWLAP)										
Geothermal Resources Act	Tenure (MEM)										
	Exploration and Development Approvals (MEM?)										

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		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
Integrated Pest Management Act	Service license approvals (including conditions)										
	Directives and orders										
	Selective permitting										
Land Act	Plan approvals and objectives										
	Fee simple										
Land Amendment Act	Water Objectives (MSRM)										
Lands, Parks and Housing Act	Same powers under both (Land Act LWBC) Land Act: application-based, proactively look for opportunities (e.g., sale of Crown land)										
	Crown Land Allocation Framework (CLAF)										
	Recreational Lot Sales Strategy										
Livestock Act	Fencing										
	Land clearing										
Local Government	Regional Growth Strategies										

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		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
Act/ Community Charter	OCPs										
	Subdivsion zoning bylaws										
	Variances										
	Borrowing powers regarding water DWO determines non-potable										
	Liquid Waste Management Plans										
	Amendments to municipal boundaries										
	Adoption of OCP										
	Adoption of Zoning Bylaws										
Local Government Grants Act	Infrastructure funding										
Local Services Act	Subdivision regulation (unserviced areas within RDs, approval by MOT)										
Mines Act	Sand and gravel, placer, and hardrock. mining										
	Approvals and permits										

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		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
	Remediation orders										
	Dumps										
	Dams										
	Remediation for acid rock drainage										
	Gravel pits										
Parks Act	Water supplier provisions										
	Park Use Permits										
Petroleum and Natural Gas Act	Tenure (MEM)										
	Exploration and Development Approvals										
Range Act											
Transportation Act	New highway development										
	Road maintenance standards and agreements for 10 years										
	Permit to construct works on Crown lands										
	Transportation of Dangerous Goods										
Water Act	Water licences										
	Dam building										

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		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
	Storage										
	Water Users' Communities										
	Section 9 approvals: "changes in and about a stream"										
	Issuance of permits over Crown land (pipes);										
	Dam and dyke approvals. (Potential for flooding of intake works for wells or surface intakes.)										
	Flood proofing of wells										
	Well construction										
	Water Management Plans (MSRM/MWLAP)										
Water Utilities Act	Excludes sections strictly for energy utilities										
	Certificate of public convenience and necessity										
Water Utilities Commission Act											

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		DWO	**MAL**	**MCS**	**MEMPR**	**MOFR**	**Local Gov't**	**MOE**	**MOT**	**PHO**	
Weed Act	Spraying										
Wildfire Act											
Wildlife Act											

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