Status and Trends of Fish Habitat Condition on Private Timberlands in Southeast Alaska: 2006 Summary

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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EXECUTIVE SUMMARY

In 1992 the Sealaska Corporation and the Alaska Forest Association initiated a monitoring program to examine the effectiveness of riparian buffer zones on private timberlands to protect fish habitat. This program included monitoring studies between 1992 and 1997 that addressed riparian stand composition, channel morphology, fish habitat, large woody debris (LWD), stream shading, spawning gravel sedimentation, mass wasting, and sediment supply. During 1998 to 2001, the program expanded cooperators with the addition of the Alaska Departments of Environmental Conservation and Natural Resources through the Community Water Quality Grant program. The research shifted from routine monitoring of fish habitat conditions to studies of windthrow effects on LWD supply in buffer zones and LWD recruitment and transport mechanisms in streams. In 2003 to 2005, the fish habitat and channel conditions monitoring program was resumed by the Sealaska Corporation in collaboration with the Alaska Department of Natural Resources through the Alaska Clean Water Action Grant program. Data were collected at previously surveyed reaches and at new reaches that were added for status and trend monitoring. In 2006 we repeated data collection at selected old and new trend monitoring study reaches to expand the status and trend monitoring program. This report presents the data that were collected during the field surveys in 2006. A schedule for future trend monitoring is included.

1.0 BACKGROUND AND OBJECTIVES

The Alaska Forest Resources and Practices Act (Act) was amended in 1990, and the revised Forest Resources and Practice Regulations (Regulations) were adopted in 1993 (Alaska Department of Natural Resources [ADNR] 2000, 2003). The Act required that riparian buffer zones be retained along all streams with anadromous fish for the protection of fish habitat and water quality. The Regulations specified that resource management agencies and forest landowners were to conduct monitoring to evaluate the effectiveness of best management practices (BMPs) to protect public resources.

In 1992 Sealaska Corporation and the Alaska Forest Association initiated a monitoring program to examine the effectiveness of riparian buffer zones on private timberlands to protect fish habitat. This program included monitoring studies between 1992 and 1997 that addressed riparian stand composition, channel morphology, fish habitat, large woody debris (LWD), stream shading, spawning gravel sedimentation, mass wasting, and sediment supply (Pentec Environmental, Inc. 1994, 1995, 1996a, 1996b; Martin et al. 1998; Perkins 1999). During 1998 to 2001, the program expanded cooperators with the addition of the Alaska Departments of Environmental Conservation and Natural Resources through the Community Water Quality Grant program. The research shifted from routine monitoring of fish habitat conditions to studies of windthrow effects on LWD supply in buffer zones and LWD recruitment and transport mechanisms in streams (Martin 2001; Martin and Benda 2000, 2001; Martin and Grotefendt 2001, 2005, 2007). These studies established a large network of buffer zone monitoring sites and contributed new information that improved our knowledge and understanding of buffer zone characteristics, LWD recruitment, and the fate of LWD in streams.

In 2003 the fish habitat and channel conditions monitoring program was resumed by the Sealaska Corporation in collaboration with the ADNR through the Alaska Clean Water Action Grant program (Martin and Shelly 2004, 2005, 2006). Data were collected at previously surveyed reaches and at new reaches that were added for status and trend monitoring. An analysis of habitat trends was performed for a subset of reaches that had multiple years of monitoring data and were suitable for trend analysis. These data were divided into two analysis groups: those with data only post-harvest and those with data pre- and post-harvest. The results of this analysis changed with each successive year of monitoring data. Following 2003, no significant trends were detected. After 2004, we found significant trends in habitat conditions were emerging for some habitat variables at both the post-harvest and pre- and post-harvest study sites. In addition, the results suggested that the full impacts of logging on habitat may not be observed initially after timber harvest; rather habitat responses are occurring over time (delayed response) and are predicted to continue into the future. The magnitude and duration of habitat response after logging is unknown at this time. Therefore, continued monitoring is needed at the existing and newly established study sites to document and examine the post-harvest response trends. A long-term strategy for trend monitoring using a pulsed sampling approach (Bryant 1995) was developed during 2005 to facilitate trend monitoring in a cost-effective manner. In 2006 we initiated the pulse monitoring strategy (see Martin and Shelly 2006).

In 2006 the objectives of the monitoring program were as follows:

1. Continue the status and trend monitoring of fish habitat conditions that was initiated by the forest industry during the 1990s.

2. Collect pre-harvest data for a subset of long-term trend monitoring study reaches to establish a baseline for future post-harvest comparison.

3. Continue data collection at a subset of existing long-term trend monitoring study reaches to maintain continuity in the long-term record.

4. Document the 2006 findings in a data report and provide a temporal context for using these data in future analyses.

This report summarizes the data that were collected during the 2006 field season. We are in the processing of evaluating how the pre-harvest data from the new monitoring reaches compare to the existing long-term trend monitoring reaches. We plan to present the results of these analyses in the 2007 report.

2.0 STUDY AREA

In 2006 we repeated data collection at the 13 study sites that compose both old and new (established in 2003-2004) trend monitoring study reaches. The survey reaches were located in three basins in the Hoonah area and in seven basins in the Craig area (Figure 1). Most of the reaches in both areas were MM channel type (Table 1). Only the Eagle and Coco study reaches occurred in timber harvest units with buffer zones on both sides of the stream. We surveyed these reaches to maintain continuity for the long-term record. Timber harvest adjacent to some of the unlogged reaches is expected during 2007 (i.e., Gartina 2, Trocadero Sec 21 and Sec 26) and harvest plans for the remaining reaches are unknown at this time. The locations of the study reaches within each basin and the locations of timber harvest units and roads are shown on basin maps in Appendix A.

Table 1. Physical characteristics, timber harvest period, and survey history at 2006 study reaches.

Stream Reach	Reach length (m)	Channel width (m)	Channel type[a]	Buffer zone present	Harvest period	Yr. first surveyed	No. of surveys
Hoonah Area							
Eagle 1	925	10.4	MM	2 sides	1992-93	1994	8
Eagle 3	585	8.2	MM	2 sides	1992-93	1994	7
Game 8	216	4.4	MM	unlogged	none	1997	4
Gartina 1b	290	4.4	MM	unlogged	none	2003	4
Gartina 2	286	5.9	FP	unlogged	none	2003	4
Craig Area							
Coco 1a	449	8.2	MM	2 sides	2002	1994	8
Coco 2a	355	5.1	MM	2 sides	2003	1994	8
Estrella 1	521	11.7	FP	unlogged	none	1995	7
Fish Eye 1	470	9.8	MM	unlogged	none	2004	3
Hetta 1	361	8.5	FP	unlogged	none	2004	3
Trocadero Sec 21	344	7.5	MM	unlogged	none	2004	3
Trocadero Sec 26	265	9.2	MM	unlogged	none	2004	3
View Cove 1	355	6.7	MM	unlogged	none	2004	3

[a] From Paustian et al. (1992)

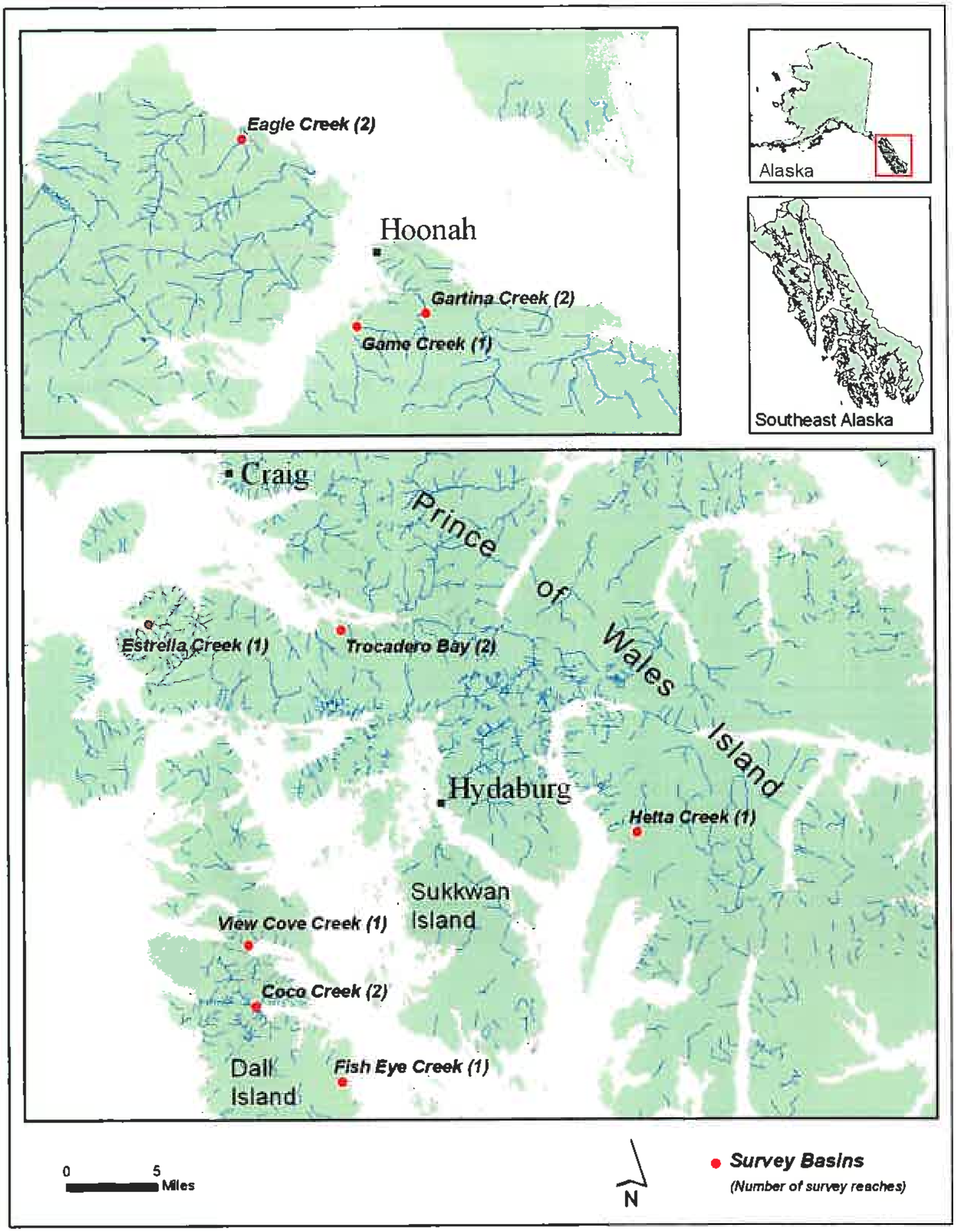


Figure 1. **Location of stream basins that were surveyed during 2006. Number in parentheses denotes the number of stream reaches that were surveyed at each basin.**

3.0 METHODS

Habitat measurements were taken from each channel unit (e.g., pools and riffles) within a stream reach. Channel units were defined by depth, velocity, and morphological characteristics similar to those described by Bisson et al. (1982). Channel units were stratified into main channel, associated unit, or off-channel categories. Units that contained the stream thalweg during summer base flow were defined as main channel units. Pools embedded within or adjacent to a main channel unit were categorized as associated units. Off-channel units included pools, ponds, or side channels that had a surface connection with the main channel and occurred within the active flood plain. Main channel and associated pools were further subdivided into primary pools and other pools based on the minimum area and minimum residual depth criteria defined by the Washington Timber-Fish-Wildlife Ambient Monitoring Program (Table 2).

Table 2. Minimum area and residual depth criteria for pools based on stream width (from Schuett-Hames et al. 1994).

Bankfull width (m)	Area (m^2)	Residual depth (m)
0 - 2.5	0.5	0.10
2.5 - 5	1.0	0.20
5 - 10	2.0	0.25
10 - 15	3.0	0.30
15 - 20	4.0	0.35
> 20	5.0	0.40

Habitat variables were computed from measurements of each channel unit. Unit length was measured along the centerline of the channel with a hip chain to the nearest 1 m, and the unit width (wetted) was measured to the nearest 0.5 m at two or three locations with a graduated rod. The product of unit length and mean width provided an estimate of wetted unit area. The percentage of habitat area for each primary pool type relative to the total wetted area of the reach was defined as the relative pool area (RPA). The percentage of the study reach length with primary pool habitat was defined as the relative pool length (RPL). Pool frequency was computed by dividing the number of pools in a reach by the reach length and standardized to 100 m. Pool spacing was computed by dividing the reach length, expressed in units of bankfull channel width, by the number of primary pools (including associated units) in the main channel portion of a reach. The number of channel widths in a reach was equal to the reach length divided by the mean channel width.

The tail crest and maximum depths of pools were measured with a graduated rod to the nearest 1.0 cm. The residual depth of pools (Lisle 1987) was computed from the difference between the maximum depth and the tail crest depth.

All LWD occurring either in the bankfull influence zone of the active channel (i.e., Zones 1 and 2 of Robison and Beschta 1990) or above the active channel (Zone 3 of Robison and Beschta 1990) was measured. LWD was defined as any piece of wood that was a minimum 0.1 m in diameter at the small end of the log and a minimum 2 m long. Each piece was assigned to a size group based on the estimated diameter at the center of the log: small (10-30 cm), medium (30-60 cm), and large (> 60 cm). During the 1998 and 2003 to 2006 surveys, the length of each piece was measured to the nearest 3-m interval; no length data were collected from earlier surveys. Piece volume was computed from piece length and diameter data using the geometry for a cylinder.

LWD was assigned to one of two location categories: pieces in jams or pieces located between jams. Jams were defined as LWD accumulations (two or more pieces) that block at least 20% of the bankfull channel width. Jam length (length of channel cover by a jam) and the length of interjam zones were measured with a hip chain.

LWD pieces that could be linked to their riparian location or source of recruitment were defined as recruits (i.e., recruits are a subset of LWD data). Recruits are pieces (usually whole trees) that are clearly attached to the adjacent bank (e.g., rooted to bank or trunk extending into riparian forest) or are contained in a slump/bank-slide deposit. All recruits were assigned a decay class using a modified version of a snag classification system by Hennon et al. (2002). Decay class was determined for the portion of a log that was on the bank or was least disturbed by stream flow. Decay classes were as follows: "green" (green leaves or needles retained), "twig" (twigs retained), "branch" (secondary branches retained), "primary" (only primary branches and some nubs retained), "nubs" (no branches and only nubs retained, and "old" (all advanced decay conditions including soft rotten and moss covered logs with dependent saplings growing on the bole). The green decay class included a small number of live trees where the bole was down in the channel and functioning as LWD.

Bankfull channel width (referred to as channel width [cw]) and substrate size composition measurements were taken at two to five stations located at riffle units within each survey reach. Channel width was defined by topographic breaks along the bank and by scour lines along the active channel edge where perennial vegetation gave way to mineral substrate on the streambed (Harrelson et al. 1994). Channel widths were measured to the nearest 0.1 m at riffles in straight and uniform sections of the reach that were free of hydraulic obstructions (e.g., logs, boulders, or bedrock). A pebble count (Wolman 1954) of 100 particles was taken on the riffle at each channel width measurement location to determine the bed material size composition. Bed material measurements were taken at one-step intervals along cross-channel traverses directly adjacent to the channel width measurement location. The d_{50} particle size was interpolated from a cumulative frequency distribution of the pebble size data as per Harrelson et al. (1994).

Photos were taken during each survey at each pebble count/channel width station to document channel position, bed and bank composition, channel disturbances, and LWD patterns.

4.0 RESULTS

Summaries of LWD recruitment, LWD loading, pool characteristics, and substrate particle size are presented in Tables 3 through 7. All raw data are contained on a compact disc that was submitted under separate cover to the ADNR.

The summary tables show that in-channel recruitment of new LWD (i.e., green recruits) was not observed at any of the unlogged monitoring reaches but was observed at two of the logged reaches (i.e., Coco 2a and Eagle 1; Table 3). New LWD recruits account for 12% and 2% of the in-channel LWD at Coco 2a and Eagle 1, respectively. The relative change in LWD as a result of new recruits is expected to influence the degree of channel response. We plan to investigate this relationship in future analyses.

LWD loading densities and volume were highly variable among the study reaches (Table 4). LWD pieces at seven of the nine unlogged reaches exceeded levels at the logged reaches; however, only two of the unlogged reaches had a greater LWD volume than at the logged reaches. Jam frequency was greater at four of the unlogged reaches compared to the logged reaches (Table 5). Although we have collected jam frequency data since 2003 we had not reported it before this time. We suspect that jam frequency may be a useful indicator of channel response to logging and plan to investigate this relationship in future analyses. Also, jam counts may be less subject to error than individual LWD counts because accurate counts of the latter may be hindered by the visibility of all pieces in large jams.

Pool frequency ranged from 2.1 to 8.4 pools/100 m, and RPA ranged from 6% to 75% (Table 6). Pool frequency was greater at five of the nine unlogged reaches compared to the logged reaches, and pool area (RPA) exceeded the logged reaches' at four of the unlogged reaches.

Streambed substrate was dominated by gravel (i.e., 2-64 mm) and cobble (i.e., 64-256 mm) size material at all reaches (Table 7). Sand (< 2 mm) and boulder (> 256 mm) size substrate were observed but were rare.

Table 3. Number of LWD recruits, recruit rate, and percentage of recruits by decay class for each stream reach during 2006.

	Recruits (no.)				Decay class (%)						
Stream reach	Above channel	In channel	Total	In channel (no./100 m)	Green	Twig	Branch	Primary	Nubs	Old	In channel green (no./100m/yr)
Coco 1a	19	34	53	7.6	9.4	20.8	9.4	3.8	11.3	45.3	0.00
Coco 2a	51	34	85	9.4	8.2	47.1	11.8	10.6	3.5	18.8	1.10
Eagle 1	38	51	89	5.5	9.0	9.0	16.9	7.9	16.9	40.4	0.11
Eagle 3	7	29	36	4.9	0.0	5.6	5.6	13.9	33.3	41.7	0.00
Estrella 1	18	62	80	11.7	1.3	2.5	11.3	1.3	13.8	70.0	0.00
Fisheye 1	10	53	63	11.5	0.0	1.6	1.6	4.8	34.9	57.1	0.00
Game 8	17	30	47	13.9	0.0	0.0	14.9	17.0	19.1	46.8	0.00
Gartina 1b	7	13	20	4.4	0.0	0.0	20.0	5.0	25.0	50.0	0.00
Gartina 2	10	20	30	7.3	0.0	0.0	3.3	13.3	23.3	60.0	0.00
Hetta 1	20	42	62	11.8	0.0	4.8	11.3	1.6	25.8	56.5	0.00
Trocadero Sec 21	28	45	73	12.7	0.0	8.2	1.4	5.5	30.1	54.8	0.00
Trocadero Sec 26	2	45	47	17.0	0.0	0.0	0.0	10.6	44.7	44.7	0.00
View Cove 1	14	26	40	8.1	2.5	5.0	10.0	10.0	30.0	42.5	0.00

Table 4. LWD loading (number and volume) by stream reach during 2006.

Stream reach	LWD Pieces (no.)					LWD Volume (m^3)				
	Above channel	In channel	Total	In channel (no./100 m)	In channel (%)	Above channel	In channel	Total	In channel (m^3/100 m)	In channel (%)
Coco 1a	19	80	99	18	81	37.0	116.4	153.4	26.0	76
Coco 2a	51	80	131	22	61	95.2	122.8	218.0	33.9	56
Eagle 1	38	196	234	21	84	90.7	198.2	288.9	21.3	69
Eagle 3	7	145	152	24	95	10.3	108.5	118.8	18.3	91
Estrella 1	18	220	238	42	92	49.0	280.0	328.9	53.0	85
Fisheye 1	10	139	149	30	93	11.5	146.8	158.3	31.8	93
Game 8	17	74	91	34	81	12.3	51.4	63.7	23.8	81
Gartina 1b	7	50	57	17	88	5.2	27.1	32.3	9.1	84
Gartina 2	10	82	92	30	89	10.7	47.8	58.5	17.4	82
Hetta 1	20	146	166	41	88	35.1	186.8	222.0	52.5	84
Trocadero Sec 21	28	96	124	27	77	34.1	71.4	105.4	20.1	68
Trocadero Sec 26	2	115	117	43	98	0.6	82.8	83.3	31.2	99
View Cove 1	14	64	78	20	82	21.4	80.6	102.0	25.0	79

Table 5. Number of LWD jams and jam frequency by stream reach during 2006.

Stream reach	Number of jams	Jam frequency (no./100 m)
Coco 1a	12	2.7
Coco 2a	10	2.8
Eagle 1	9	1.0
Eagle 3	10	1.7
Estrella 1	12	2.3
Fisheye 1	12	2.6
Game 8	11	5.1
Gartina 2	9	3.3
Gartina 1b	6	2.0
Hetta 1	12	3.4
Trocadero Sec 21	8	2.3
Trocadero Sec 26	11	4.2
View Cove 1	8	2.5

Table 6. Pool statistics for all primary pools within the main channel by stream reach during 2006.

Site	Number	Pool frequency (no./100 m)	Pool spacing (cw/pool)	RPA (%)	RPL (%)	Residual depth (cm)		
						Mean	Median	Maximum
Coco 1a	21	4.7	2.7	34.28	32.66	47.9	42	78
Coco 2a	14	3.9	4.9	25.16	20.72	36.9	32.5	62
Eagle 1	20	2.1	3.7	23.16	24.81	52.0	46	106
Eagle 3	15	2.5	3.2	24.35	23.44	64.2	51	157
Estrella 1	31	5.9	1.3	56.12	49.43	52.2	49	102
Fisheye 1	11	2.4	4.5	5.66	9.09	33.5	32	51
Game 8	11	5.1	4.3	23.87	20.83	33.1	31	54
Gartina 1b	11	3.7	6.1	35.11	30.07	37.3	31	64
Gartina 2	23	8.4	2.0	74.93	66.18	56.9	45	162
Hetta 1	27	7.6	1.3	42.53	43.82	45.8	43	89
Trocadero Sec 21	11	3.1	4.3	23.96	21.69	36.8	36	60
Trocadero Sec 26	17	6.4	1.9	33.68	29.43	38.9	35	92
View Cove 1	11	3.4	4.5	24.85	19.25	34.6	32	60

Table 7. Substrate particle size (mm) by location and stream reach during 2006.

Stream reach	Cross section no.	D_{16}	D_{50}	D_{84}
Coco 1a	47	15.5	43.7	91.0
Coco 1a	160	5.3	23.8	72.3
Coco 1a	305	16.0	45.3	107.6
Coco 2a	887	2.0	18.2	84.6
Coco 2a	950	20.2	55.2	119.7
Coco 2a	1060	21.5	64.0	205.7
Coco 2a	1150	windowthrow inhibited survey		
Coco 2a	1220	16.9	51.3	138.8
Eagle 1	0	10.2	30.8	87.5
Eagle 1	170	11.2	38.1	96.2
Eagle 1	305	7.5	32.4	86.6
Eagle 1	474	15.8	58.7	123.1
Eagle 1	570	10.7	33.1	92.4
Eagle 1	715	7.1	40.8	145.8
Eagle 1	865	13.5	54.8	129.4
Eagle 3	55	8.4	31.5	121.9
Eagle 3	175	16.3	46.8	115.1
Eagle 3	307	9.0	29.3	77.4
Eagle 3	515	15.2	42.9	117.9
Estrella 1	0	3.4	13.0	28.9
Estrella 1	128	6.0	13.0	27.7
Estrella 1	300	5.7	23.1	66.2
Estrella 1	573	5.6	16.6	38.4
Fisheye 1	3	2.0	11.5	50.0
Fisheye 1	245	14.6	56.5	214.4
Fisheye 1	320	2.6	11.5	31.5
Game 8	73	4.2	22.6	77.0
Game 8	128	4.6	20.7	65.9
Game 8	202	4.3	19.8	61.9
Gartina 2	130	3.8	13.1	26.0
Gartina 2	205	4.8	15.3	34.5
Gartina 2	290	5.6	15.8	38.3
Gartina 1b	377	12.7	36.9	83.8
Gartina 1b	483	17.3	44.7	107.6
Gartina 1b	585	10.4	48.1	373.9
Hetta 1	76	5.2	22.0	53.9
Hetta 1	168	6.1	24.4	53.4
Hetta 1	275	9.4	23.8	58.3
Trocadero Sec 21	0	9.4	24.9	58.9
Trocadero Sec 21	135	12.2	42.0	105.2
Trocadero Sec 21	316	9.8	29.4	109.7

Table 7. (continued).

Stream reach	Cross section no.	D_{16}	D_{50}	D_{84}
Trocadero Sec 26	0	10.1	36.1	107.9
Trocadero Sec 26	105	10.8	35.2	102.7
Trocadero Sec 26	255	12.7	32.0	106.7
View Cove 1	57	6.4	19.9	47.1
View Cove 1	135	9.3	23.5	56.2
View Cove 1	355	4.0	12.5	29.1

5.0 FUTURE MONITORING

Over the past two years, we shifted to an alternating (pulsed) monitoring schedule. We established two data groups; one group of stream reaches (annual panel) that would be monitored annually, and a second larger group (pulsed panel) that would be monitored on a pulsed schedule (Table 8). All study reaches (existing and newly established in 2003-2004) were surveyed during a pulse period that was three to four years long (2003 to 2006). In 2006, we continued monitoring at the newly established study reaches but reduced the number of surveys at the existing reaches. The latter subset of reaches forms the annual panel. The pulsed strategy was implemented to minimize monitoring cost over time yet maintain our ability to detect trends (Bryant 1995). Annual monitoring was maintained at several reaches to document habitat changes that may occur in response to major storm events during the pulse intervals. We learned from our past studies (Martin and Shelly 2005) that knowledge of storm related impacts can help us to interpret how habitat responses relate to logging versus natural environmental processes.

Recently we learned that the logging plans have changed for some of the new study reaches. When we established these sites in 2003/2004, all of the sites were expected to be conventionally logged and have 66-ft buffers. Currently, four sites will be conventionally logged during 2007-2008, four are scheduled to be helicopter logged during 2007-2008, and one site will probably never have logging within 300 ft of the stream (i.e., no potential riparian disturbance). The sites with conventional logging are expected to have standard buffer strips (i.e., 66 ft wide), and the sites that are logged by helicopter will probably have variable width buffer strips next to small clearcut patches. The intensity of harvest at the helicopter sites is highly variable; therefore, comparisons of logging effects between helicopter and standard buffers is problematic.

The shift in logging plans (Table 9) has changed the proposed sample population and caused us to rethink the future monitoring schedule. First, we recommend continued monitoring at the new sites that will be conventionally logged (i.e., 2007-2008) for several more years. This will provide 4 to 5 years of pre-harvest and 3 to 4 years of immediate post-harvest data. These sites would be combined with the existing sites on a pulsed monitoring schedule. Second, we think the helicopter sites could potentially be grouped with Estrella to form a new group of unlogged or minimally impacted reference monitoring sites. These sites could be compared to the post-harvest and pre/post harvest trend sites in an unpaired treatment versus reference analysis. The reference designation would depend on the proximity and intensity of helicopter harvest. Only sites with a minimum 300-ft buffer with less than 10% tree removal would be considered a reference site. After 2007 we would know for certain which sites could be designated as reference sites and plan the future monitoring accordingly. Eventually we would proceed to a pulsed schedule as shown in Table 9.

Table 8. **Trend monitoring schedule proposed in 2006 (Martin and Shelly 2006). Cells highlighted in yellow indicate monitoring during post-harvest period; cells highlighted in green indicate monitoring during pre-harvest period. Cells with an "X" indicate existing data.**

				Existing Monitoring Schedule													Proposed Monitoring Schedule								
Area	Stream	Ch. Type	Harvest Year	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Post-Harvest Data Group																									
Craig	Cabin 4b	FP	1992	X	X		X						X	X	X		annual			pulsed			annual		
Craig	Cabin 5	FP	1992	X	X		X						X	X	X										
Hoonah	Eagle 1	MM	1993	X	X	X	X						X	X	X	X									
Hoonah	Eagle 3	MM	1993	X	X	X	X							X	X	X									
Hoonah	E. Eagle 1	FP	1993	X	X	X	X						X	X	X										
Hoonah	E. Eagle 2a	MM	1993	X	X	X	X						X	X	X										
Hoonah	Game 6a	FP	1992	X	X	X	X	X						X	X										
Pre- and Post-Harvest Data Group																									
Craig	Caldera	MM	2000		X	X	X						X	X	X										
Craig	Coco 1a	MM	2002	X	X	X	X						X	X	X	X									
Craig	Coco 2a	MM	2003	X	X	X	X						X	X	X	X									
Hoonah	Game 3.	MM	2002	X	X	X	X	X					X	X	X										
Hoonah	Game 4a	MM	1998	X	X	X	X	X					X	X	X										
Craig	Raven	MM	1999			X	X						X	X	X										
New Pre- and Post-Harvest Data Group																									
Hoonah	Game 8	MM	None				X							X	X	X									
Hoonah	Gartina 1b	MM	None										X	X	X	X									
Hoonah	Gartina 2	FP	None										X	X	X	X									
Craig	Estrella	FP	None		X	X	X						X	X	X	X									
Craig	Fish Eye	MM	None											X	X	X									
Craig	Hetta	MM	None											X	X	X									
Craig	Trocadero S21	MM	None											X	X	X									
Craig	Trocadero S26	MM	None											X	X	X									
Craig	View Cove	MM	None											X	X	X									

Table 9. Proposed future trend monitoring schedule by analysis group, timber harvest period, and survey time. Cells highlighted in yellow indicate monitoring during post-harvest period; cells highlighted in green indicate monitoring during pre-harvest period. Cells with an "X" indicate existing data. Cells with an "H" or "C" indicate helicopter and conventional logging, respectively. Cells with a "?" indicate the buffer width (i.e., 66 ft or > 66 ft) is unknown at this time.

		Ch.	Harvest	Existing Monitoring Schedule														Proposed Monitoring Schedule							
Area	Stream	Type	Year	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
				Post-Harvest Data Group																					
Craig	Cabin 4b	FP	1992	X	X		X						X	X	X										
Craig	Cabin 5	FP	1992	X	X		X						X	X	X										
Hoonah	Eagle 1	MM	1993	X	X	X	X						X	X	X	X									
Hoonah	Eagle 3	MM	1993	X	X	X	X							X	X	X									
Hoonah	E. Eagle 1	FP	1993	X	X	X	X						X	X	X										
Hoonah	E. Eagle 2a	MM	1993	X	X	X	X						X	X	X										
Hoonah	Game 6a	FP	1992	X	X	X	X	X						X	X										
				Pre- and Post-Harvest Data Group																					
Craig	Caldera	MM	2000		X	X	X						X	X	X										
Craig	Coco 1a	MM	2002	X	X	X	X						X	X	X	X									
Craig	Coco 2a	MM	2003	X	X	X	X						X	X	X	X									
Hoonah	Game 3.	MM	2002	X	X	X	X	X					X	X	X										
Hoonah	Game 4a	MM	1998	X	X	X	X	X					X	X	X										
Craig	Raven	MM	1999			X	X						X	X	X										
				New Pre- and Post-Harvest Data Group																					
Hoonah	Game 8	MM	None				X							X	X	X	H								
Hoonah	Gartina 1b	MM	None										X	X	X	X		H	?	?	?				
Hoonah	Gartina 2	FP	None										X	X	X	X	C								
Craig	Estrella	FP	None		X	X	X						X	X	X	X									
Craig	Fish Eye	MM	None											X	X	X	H	?	?	?	?				
Craig	Hetta	MM	None											X	X	X		C							
Craig	Trocadero S21	MM	None											X	X	X	C								
Craig	Trocadero S26	MM	None											X	X	X	C								
Craig	View Cove	MM	None											X	X	X	H	?	?	?	?				

6.0 REFERENCES

Alaska Department of Natural Resources (ADNR). 2000. Alaska forest resources and practices regulations. ADNR, Division of Forestry, Juneau, Alaska.

Alaska Department of Natural Resources (ADNR). 2003. Alaska forest resources and practices act. ADNR, Division of Forestry, Juneau, Alaska.

Bisson, P. A., J. A. Nielson, R. A. Palmason, and L. E. Grove. 1982. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. Pages 62-73 *in* N. B. Armantrout, editor. Acquisition and utilization of aquatic habitat inventory information. Proceedings of a symposium held October 28-30, 1981, Portland, Oregon, Western Division, American Fisheries Society. American Fisheries Society, Bethesda, Maryland.

Bryant, M. D. 1995. Pulsed monitoring for watershed and stream restoration. Fisheries 20:6-13.

Harrelson, C. C., C. L. Rawlins, and J. P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. General Technical Report RM-245, U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colorado.

Hennon, P. E., M. H. McClellan, and P. Palkovic. 2002. Comparing deterioration and ecosystem function of decay-resistant and decay-susceptible species of dead trees. Pages 435-444 in W. Laudenslayer, P. Shea, B. Valentine, C. Weatherspoon, and T. Lisle, editors. Symposium on the Ecology and Management of Dead Wood in Western Forests, 2–4 November 1999, Reno, Nevada. Gen. Tech. Rep. PSW-GTR-181. U.S. Department of Agriculture Forest Service, Albany, California.

Lisle, T. E. 1987. Using "residual depth" to monitor pool depths independently of discharge. Research Paper PSW-394. U.S. Department of Agriculture Forest Service, Pacific Southwest Forest and Range Experimental Station, Berkeley, California

Martin, D. J., 2001. The influence of geomorphic factors and geographic region on large wood debris loading and fish habitat in Alaska coastal streams. North American Journal of Fisheries Management 21:429-440.

Martin, D. J., and L. E. Benda. 2000. Patterns of wood recruitment and transport in Game Creek. Report of Martin Environmental to the Central Council of Tlingit and Haida Indian Tribes of Alaska and Alaska Department of Environmental Conservation, Juneau, Alaska. Community Water Quality Grant No: NP-01-14.

Martin, D. J., and L. E. Benda. 2001. Patterns of in-stream wood recruitment and transport at the watershed scale. Transactions of the American Fisheries Society 130:940-958.

Martin, D. J., and R. A. Grotefendt. 2001. Buffer zones and LWD supply. Report of Martin Environmental to Alaska Forest Association and Alaska Department of Environmental Conservation, Juneau, Alaska. Community Water Quality Grant No: NP-01-12.

Martin, D. J., and R. A. Grotefendt. 2005. The effectiveness of standard buffer strips to supply LWD to streams in Southeast Alaska. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources, Juneau, Alaska. Alaska Clean Water Action Grant No. NA04NOS4190030.

Martin, D. J., and R. A. Grotefendt. 2007. Stand mortality in buffer strips and the supply of woody debris to streams in Southeast Alaska. Canadian Journal of Forest Research.37:36-49.

Martin, D. J., M. E. Robinson, and R. A. Grotefendt. 1998. The effectiveness of riparian buffer zones for protection of salmonid habitat in Alaska coastal streams. Report of Martin Environmental to Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Martin, D. J., and A. Shelly. 2004. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2003 summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources, Juneau, Alaska. Alaska Clean Water Action Grant No: NA170Z23325.

Martin, D. J., and A. Shelly. 2005. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2004 summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources, Juneau, Alaska. Alaska Clean Water Action Grant No: NA04NOS4190030.

Martin, D. J., and A. Shelly. 2006. Status and trends of fish habitat condition on private timberlands in Southeast Alaska: 2005 summary. Report of Martin Environmental to Sealaska Corporation and Alaska Department of Natural Resources, Juneau, Alaska. Alaska Clean Water Action Grant No: NA05NOS4191147.

Paustian, S. J., A. Anderson, D. Blanchet, S. Brady, M. Cropley, J. Edgington, J. Frysell, G. Johnejack, D. Kelliher, M. Kuehn, S. Maki, R. Olsen, J. Seesz, and M. Wolanek. 1992. A channel type users guide for the Tongass National Forest, Southeast Alaska. R10 Technical Paper 26. U.S. Department of Agriculture Forest Service, Alaska Region, Juneau, Alaska.

Pentec Environmental, Inc. 1994. Fish habitat and channel conditions of nine streams in forested lands of Southeast Alaska and Afognak Island. Prepared for Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Pentec Environmental, Inc. 1995. A preliminary assessment of fish habitat and channel conditions for streams on forested lands of Southeast Alaska, final report. Prepared for Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Pentec Environmental, Inc. 1996a. Fish habitat and channel conditions for streams on forested lands of coastal Alaska: an assessment of cumulative effects, 1994 assessment, final report. Prepared for Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

Pentec Environmental, Inc. 1996b. Fish habitat and channel conditions for streams on forested lands of coastal Alaska: an assessment of cumulative effects, 1995 assessment, review draft report. Prepared for Sealaska Corporation, Juneau, Alaska, and Alaska Forest Association, Ketchikan, Alaska.

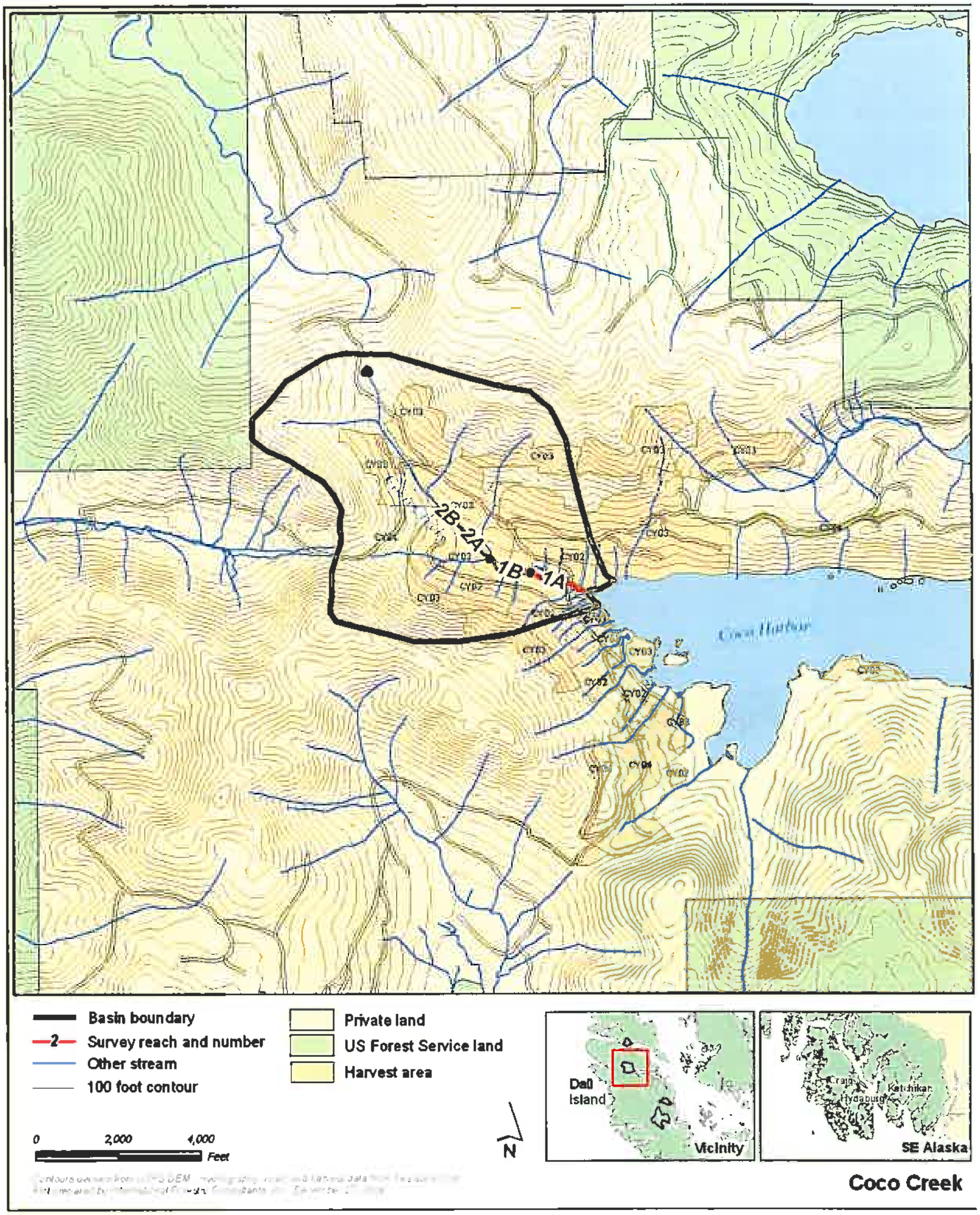
Perkins, S. J. 1999. Landslide inventory and sediment-response study for monitored Sealaska Streams. Report prepared by Susan J. Perkins, Consulting Geomorphologists for Sealaska Corporation.

Robison, E. G., and R. L. Beschta. 1990. Characteristics of coarse woody debris for several coastal streams of southeast Alaska, USA. Canadian Journal of Fisheries and Aquatic Sciences 47:1684-1693.

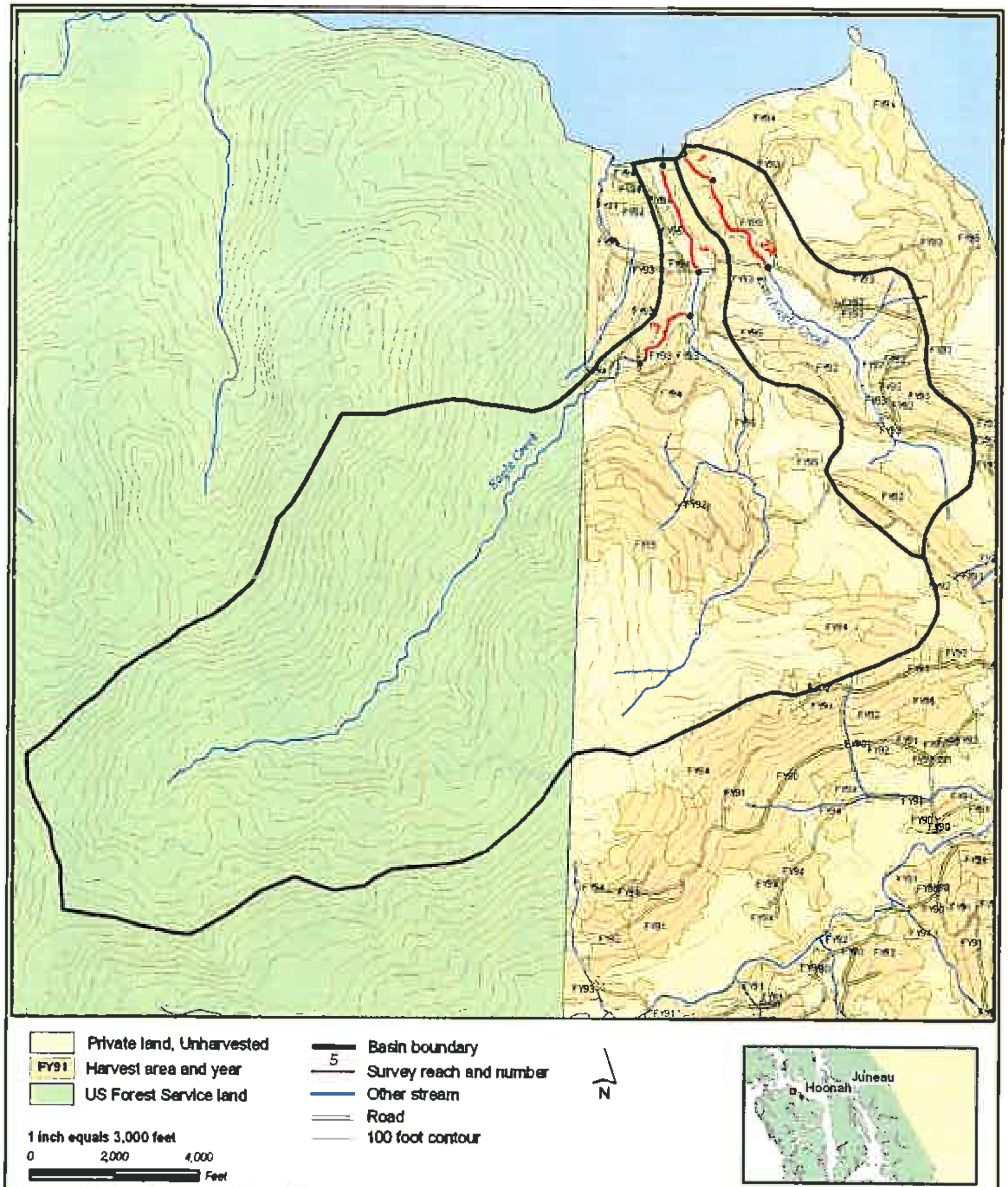
Schuett-Hames, D., A. Pleus, L. Bullchild, and S. Hall. 1994. Timber-Fish-Wildlife ambient monitoring program manual. TFW-AM-94-001, Northwest Indian Fisheries Commission, Olympia, Washington.

Wolman, M. G. 1954. A method of sampling coarse riverbed material. Transactions of the American Geophysicists Union 35(6):951-956.

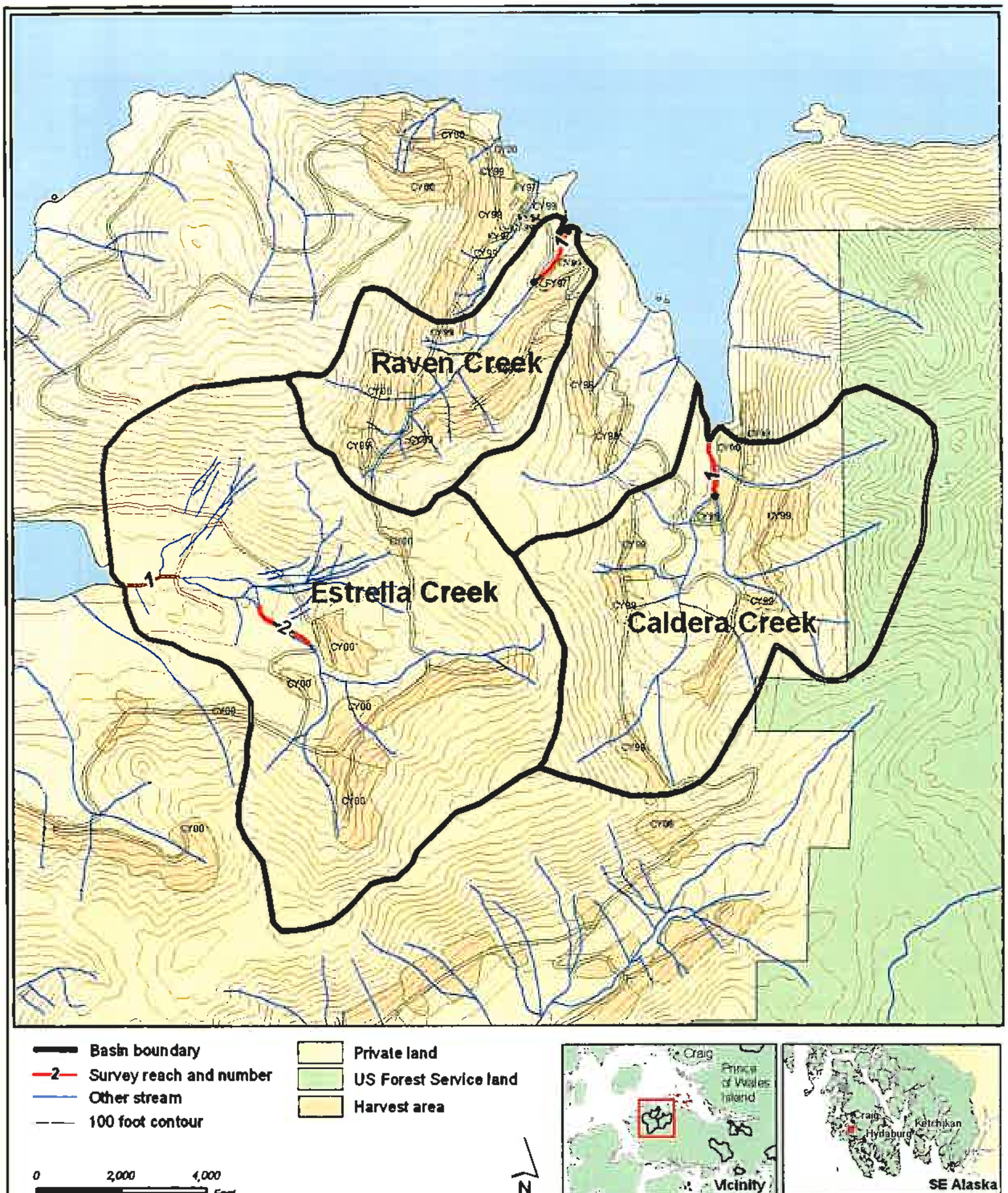
Appendix A—Basin Maps



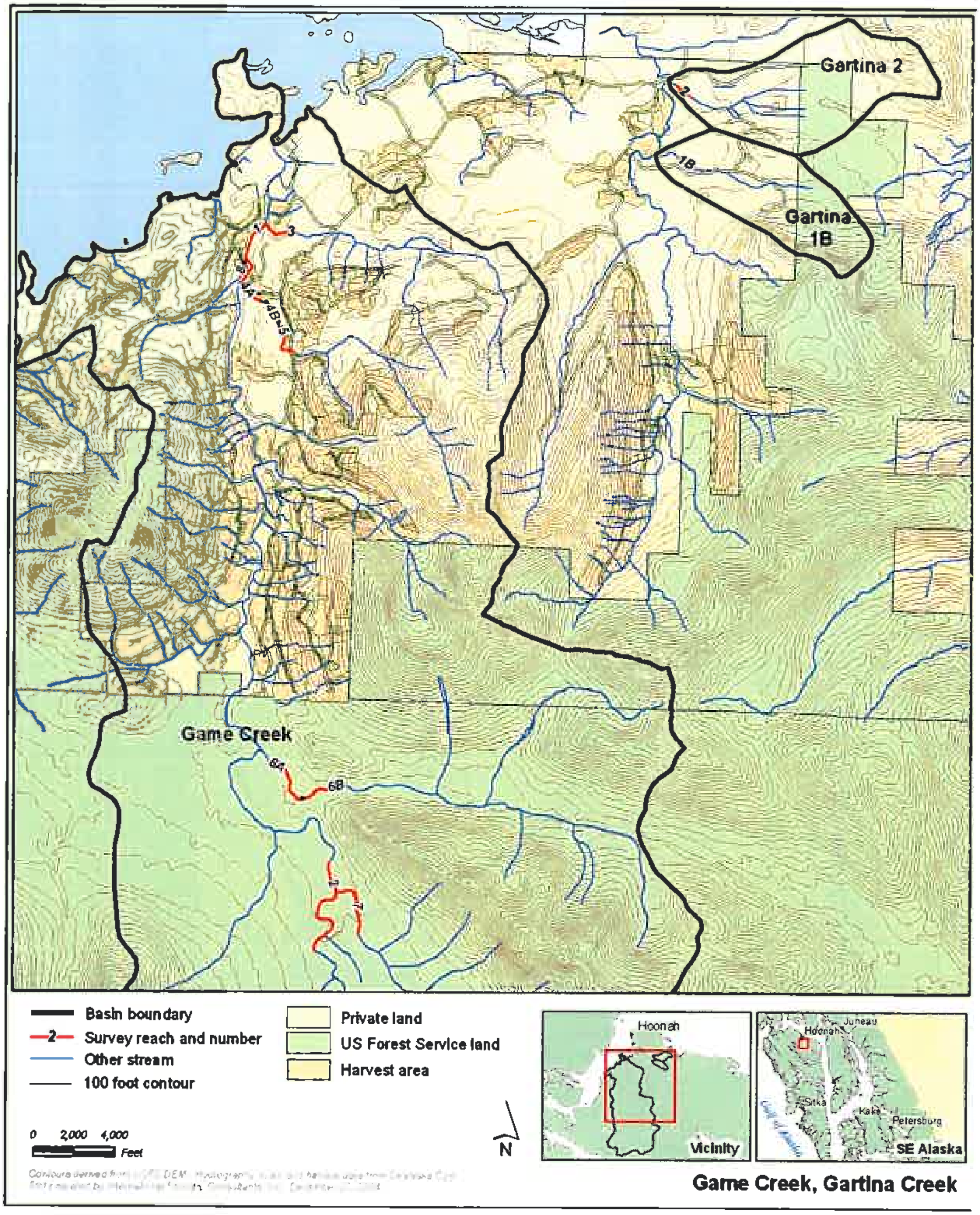
2B
2A
1B
1A
Coco Harbor
Basin boundary
2 Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0
2,000
4,000
Feet
N
Dall Island
Vicinity
Craig
Hydaburg
Ketchikan
SE Alaska
Coco Creek

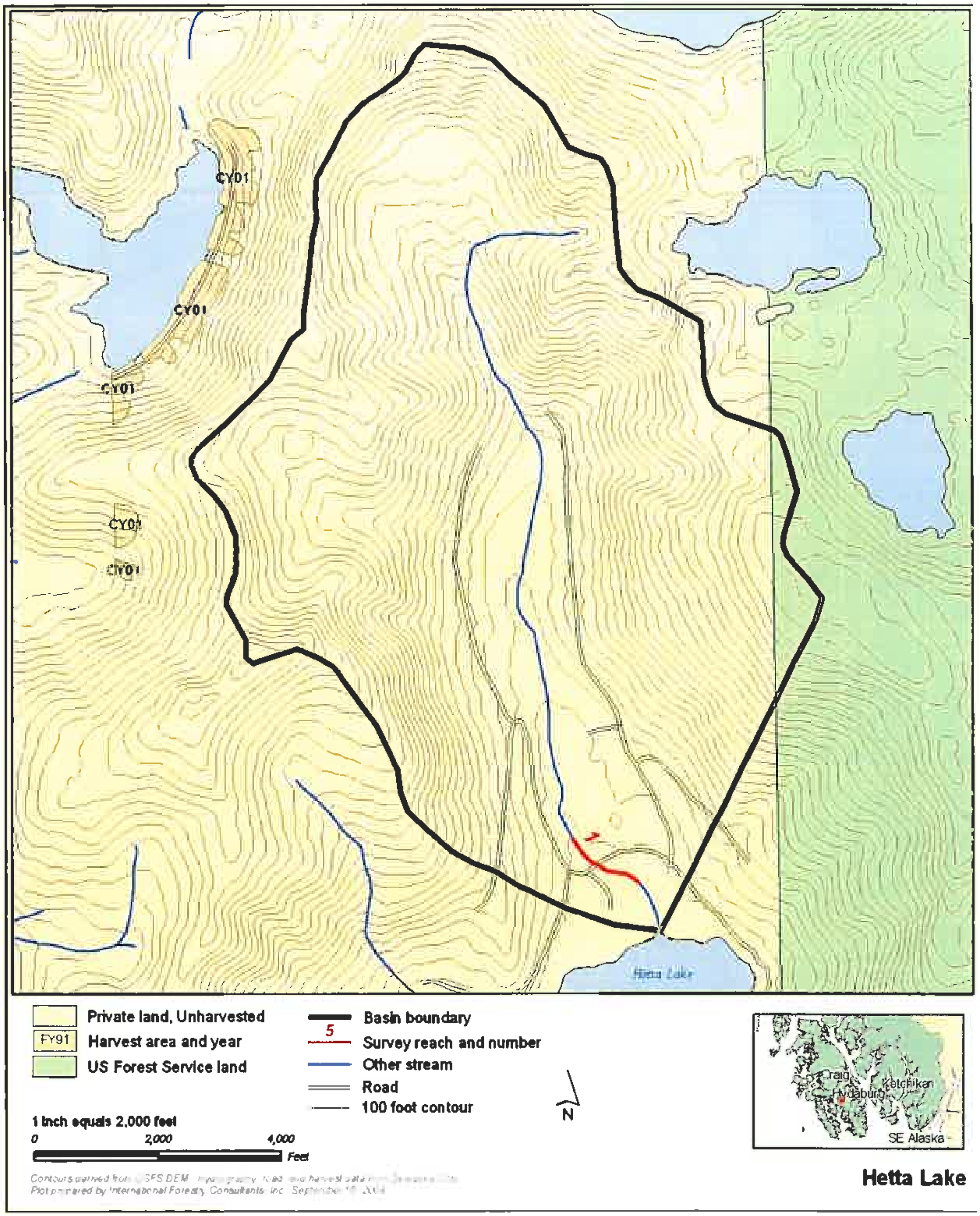


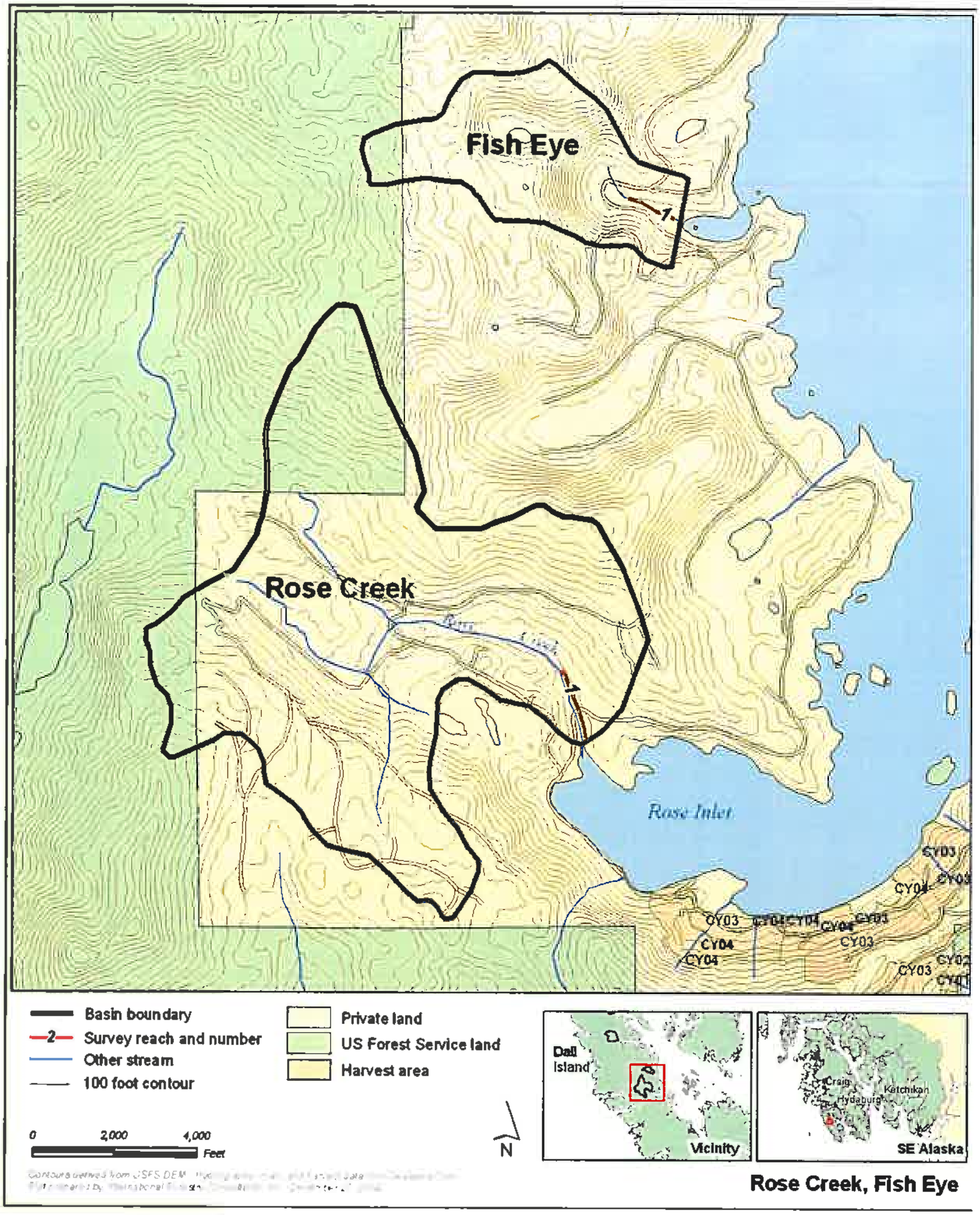
Eagle Creek and East Eagle Creek

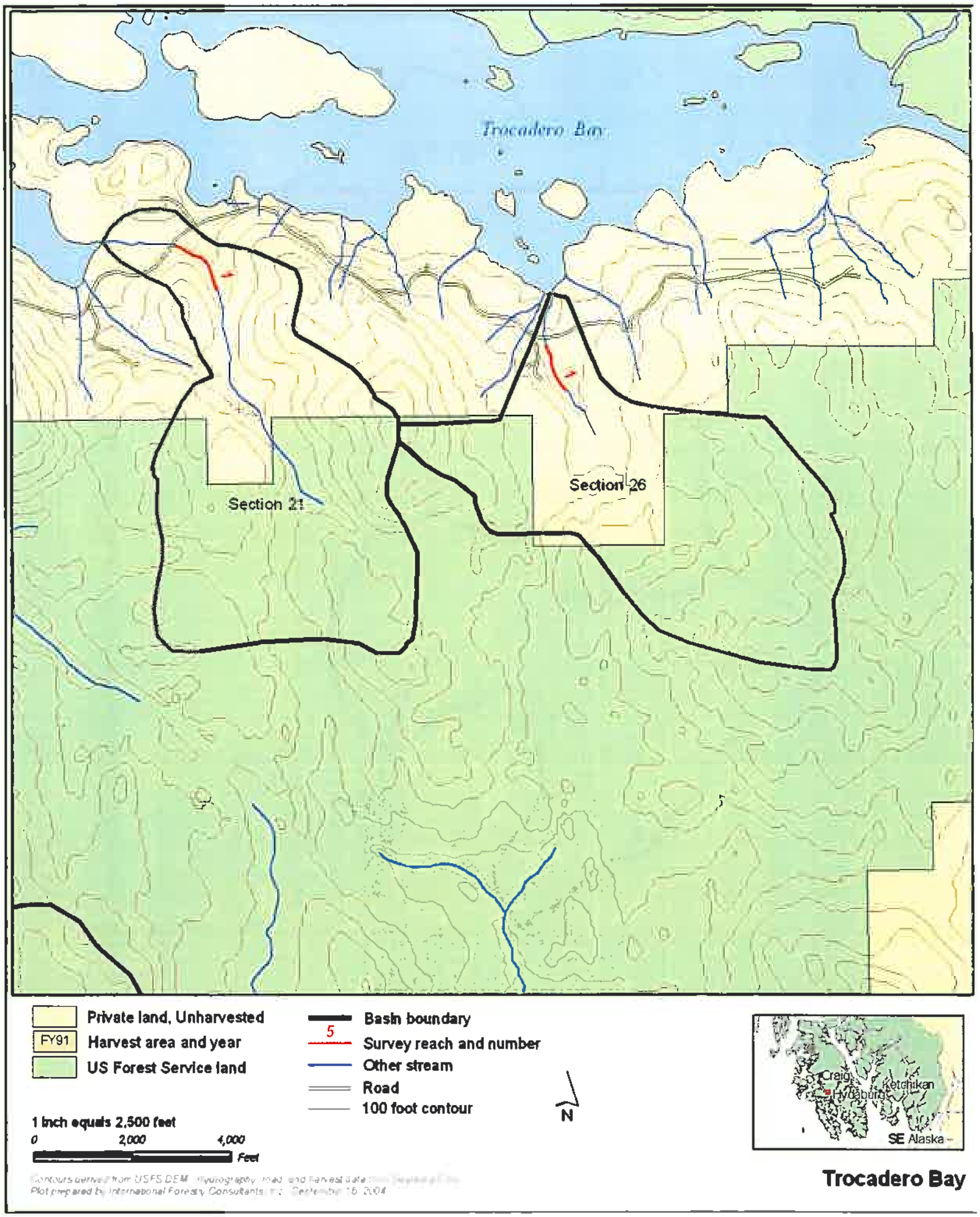


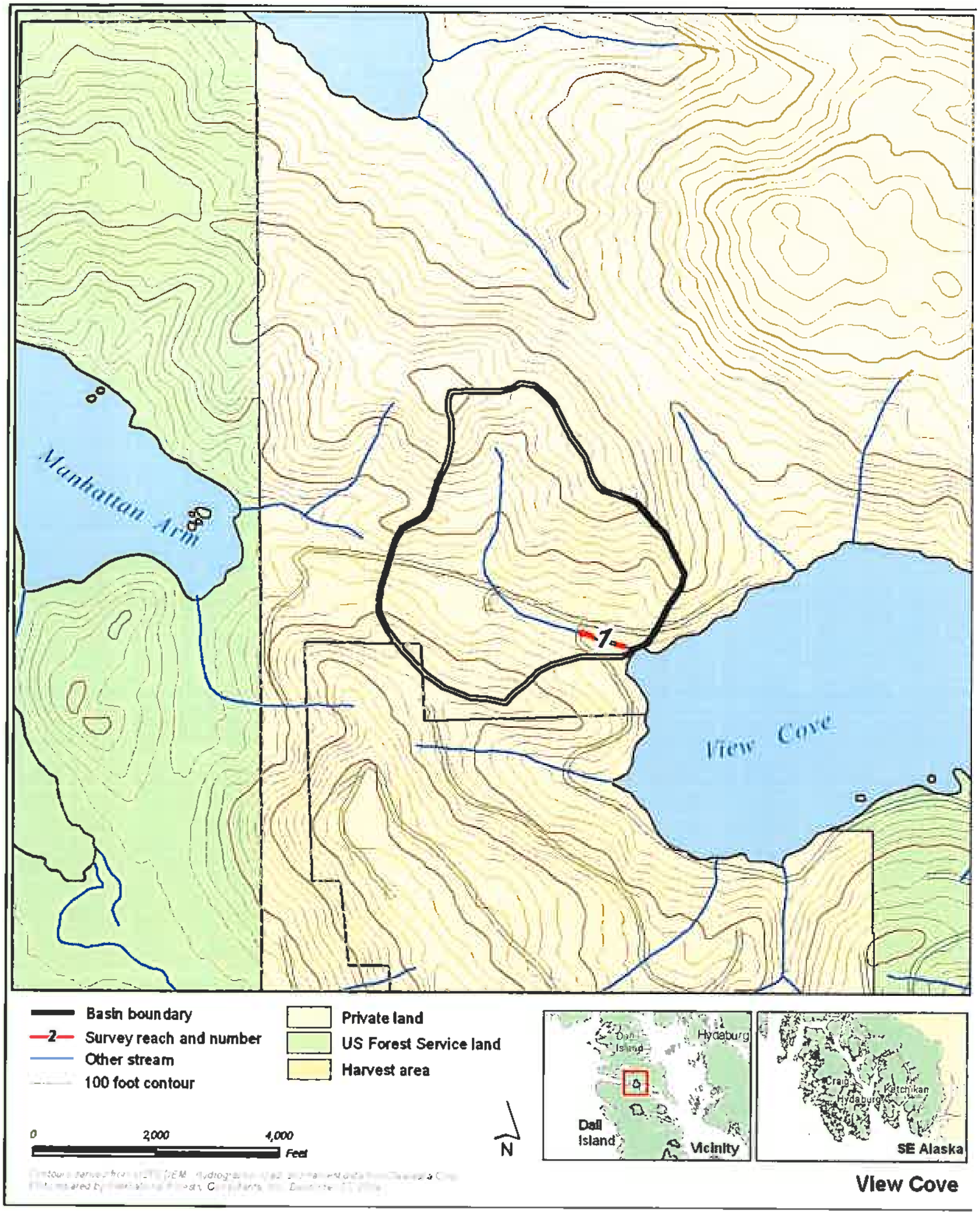
Estrella Creek, Raven Creek, Caldera Creek


Gartina 2
2
1B
Gartina 1B
3
4A
4B
5
Game Creek
6A
6B
7
Basin boundary
2 Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0 2,000 4,000
Feet
N
Hoonah
Vicinity
Juneau
Sitka
Kake
Petersburg
SE Alaska
Game Creek, Gartina Creek


CY01
CY01
CY01
CY01
CY01
1
Hetta Lake
Private land, Unharvested
FY91
Harvest area and year
US Forest Service land
5
Basin boundary
Survey reach and number
Other stream
Road
100 foot contour
N
1 inch equals 2,000 feet
0
2,000
4,000
Feet
Craig
Hydaburg
Ketchikan
SE Alaska
Hetta Lake


Fish Eye
Rose Creek
Rose Inlet
1
CY03
CY04
CY02
Basin boundary
2 Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0
2,000
4,000
Feet
N
Dall Island
Vicinity
Craig
Hydaburg
Ketchikan
SE Alaska
Rose Creek, Fish Eye


Trocadero Bay
Section 21
Section 26
Private land, Unharvested
FY91
Harvest area and year
US Forest Service land
Basin boundary
5
Survey reach and number
Other stream
Road
100 foot contour
1 inch equals 2,500 feet
0
2,000
4,000
Feet
N
Craig
Hydaburg
Ketchikan
SE Alaska
Trocadero Bay


Manhattan Arm
View Cove
1
Basin boundary
2 Survey reach and number
Other stream
100 foot contour
Private land
US Forest Service land
Harvest area
0
2,000
4,000
Feet
N
Dall Island
Hydaburg
Dall Island
Vicinity
Craig
Ketchikan
Hydaburg
SE Alaska
View Cove