

UPPER MUSKWA RIVER WATERSHED

2001 BULL TROUT SPAWNING ASSESSMENT

Prepared for:
Muskwa-Kechika Trust Fund
B.C. Ministry of Sustainable Resource Management
Room 150, 10003-110th Avenue
Fort St. John, B.C.
V1J 6M7

Prepared by:
Brad Culling and Ted Euchner
Diversified Environmental Services
Box 6263
Fort St. John, B.C.
V1J 4H7

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PROJECT REFERENCE INFORMATION

MELP Region	07
MELP District	Fort St. John
FW Management Units	7-42, 7-50
Forest Region	Prince George
Forest District	Fort Nelson
First Nations Claim Area	Treaty 8

WATERSHED INFORMATION

Watershed Group	Middle Muskwa River Upper Muskwa River
Watershed Name	Muskwa River
Watershed Code	212-580800
TRIM Maps	094G.071, 094K.009, 019, 020
BEC Zone	SWB
Access	Helicopter

CONTRACTOR INFORMATION

Project Manager:	B. Culling/T. Euchner Diversified Environmental Services Box 6263, Fort St. John, B.C. (250) 787-9101
Field crew:	B. Culling, T. Euchner
Report prepared by:	B. Culling, T. Euchner
Report edited by:	D. Culling

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1. INTRODUCTION

The Muskwa River watershed is a major sub-basin of the Fort Nelson River system and drains a vast area of northeastern British Columbia, including significant portions of the east slopes of the Rocky Mountains and western edge of the Alberta plateau.

The majority of the upper Muskwa River and its major tributaries, including the Tuchodi River, Gathto Creek, Kluachesi Creek, and Crehan Creek, lie within the Muskwa-Kechika Management Area (M-KMA), a tract of land given special management status due to its extremely high wildlife, wilderness and recreational values. Within the boundaries of the M-KMA, the upper Muskwa River drainage is encompassed by Northern Rocky Mountains Provincial Park.

Bull trout (*Salvelinus confluentus*) are one of several sport-fish species native to the Muskwa River drainage. The species is blue-listed in British Columbia (B.C. CDC Vertebrate Tracking List April 2002) and is of special management concern throughout its North American range due to its sensitivity to exploitation and habitat alteration.

Historically, limited anecdotal information suggested that regionally important sub-populations of migratory, fluvial bull trout spawned within the upper Muskwa drainage, however, no information on population status or the location of critical habitats were available.

In recent years, knowledge of general fish distribution within the Muskwa River drainage expanded with the completion of a partial *Overview Inventory* of the Middle Muskwa Watershed Group conducted by BC Environment in 1998 (MELP 1998), and an assessment of bull trout use of the Tuchodi River, funded by BC Parks in 2000 (DES 2000). During the course of the latter project, a migratory sub-population of large, fluvial bull trout was discovered spawning in upper Dead Dog Creek, a major tributary to the Tuchodi River. In an effort to collect additional information on the migratory movements of these fish, five telemetry transmitters were implanted in mature bull trout on the Dead Dog Creek spawning zone and monitoring by fixed-wing aircraft between September 11, 2000 and December 23, 2000.

The current project was funded by the Muskwa-Kechika Trust Fund the following spring and consisted of two components: 1) to continue monitoring telemetry transmitters deployed in August 2000 in order to document the upstream, pre-spawning movements of Dead Dog bull trout, and 2) to conduct an assessment of the Dead Dog Creek bull trout spawning run for the purpose of establishing base-line data on population size and structure, against which future population status and trends could be compared.

Due to the apparent premature failure of the deployed transmitters, the first component of the study could not be completed. At this point, funds ear-marked for telemetry monitoring were re-allocated to expand the scope of the second component of the project.

Prior to the commencement of the current project, the Dead Dog Creek spawning run was the only sub-population of large, migratory bull trout identified in the Muskwa River drainage. However, during the course of a concurrent project, also funded by the M-K Trust Fund (DES 2002), two additional spawning runs of migratory, fluvial bull trout were identified: one on Gathto Creek and the other on a tributary to Crehan Creek.

The second component of the current project was modified to capture data collected from the two additional spawning areas and allow for base-line assessments of all three migratory sub-populations.

2. PROJECT AREA

The Muskwa River originates in the Rocky Mountains of northeastern British Columbia, approximately 170 km southwest of Fort Nelson. The river flows eastward through the Eastern Muskwa Ranges and Muskwa Foothills ecosections, then swings north along the Muskwa Plateau ecosection, before joining the Fort Nelson River within the Fort Nelson Lowlands ecosection. The current project area consists of the Upper Muskwa Watershed Group, as defined by the British Columbia Watershed Atlas, and the upper portion of the Middle Muskwa Watershed Group. For purposes of this report, the “upper Muskwa River drainage” refers to the Muskwa River and its tributaries upstream of, and including, the Tuchodi River drainage. Figure 1 identifies the three bull trout spawning sites assessed within this area.

Rugged mountains, with significant expanses of rock and ice dominate the western portion of the project area, with topography becoming less severe to the east. The three spawning grounds comprising the focus of this report all lie within the Spruce-Willow-Birch (SWB) biogeoclimatic zone. The Alpine Tundra (AT) zone accounts for a significant proportion of the adjacent terrain. Early seral vegetative communities, resulting from prescribed fire, are common on south-aspect slopes along major river valleys.

The majority of the project area, including the Dead Dog, Gathto and Crehan spawning sites, can only be reached by helicopter or horseback. Riverboats provide seasonal access along the Muskwa River mainstem and lower Gathto Creek, subject to flow conditions.

Recreation is the primary land use and currently accounts for virtually all human activity. Commercial activities are associated with recreational use by both residents and non-residents, and include guide-outfitting, packing and wilderness accommodations. With the exception of limited past seismic exploration there is currently no industrial land use.

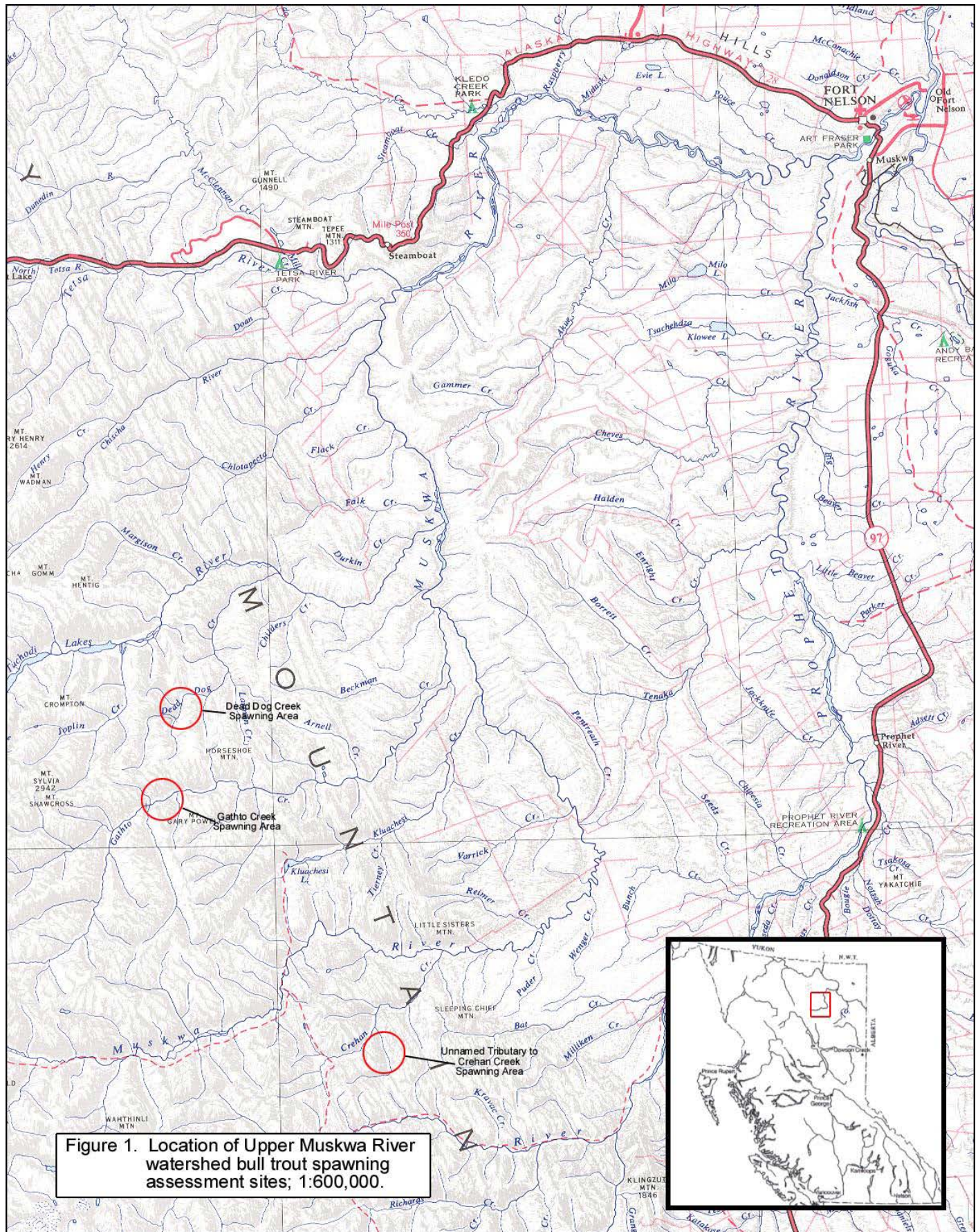
3. METHODS

3.1 Telemetry Monitoring

Aerial searches for telemetry transmitters were conducted using a Piper PA12 fixed-wing aircraft fitted with two directional antennae, one facing forward and the second facing downward. Stream channels were flown in both directions at airspeeds of 60 to 70 knots.

3.2 Spawning Assessment

All access to spawning sites was by Bell 206B helicopter. The following activities were conducted to collect information on which to base indices of future population trends, to generate an estimate of current spawning run size, to determine the timing of migration and spawning, and to document general winter incubation conditions:



1. Pre-spawn Sampling

During the month prior to spawning, opportunistic random sampling by angling was conducted in suitable holding habitat on stream reaches downstream of all three spawning sites. The object of this activity was to collect incidental information on pre-spawning migration timing and identify potential holding/staging areas.

2. Stream Walk Redd Counts

Redds and spawning fish were enumerated during intensive stream walks of all three spawning zones on August 27-28 and September 07, 2001. The timing of the August 27-28 inspection was based on observations made at Dead Dog Creek the previous season (DES 2000). The upper and lower limits of each spawning zone, as defined by the presence of mature fish or redds, were identified during low-level, helicopter over-flights. Stream walks were conducted from downstream of the lowermost fish/redd to a point upstream of the uppermost fish/redd. To minimize the number of fish missed, at least one person walked within the wetted width of the stream, in order to "spook" fish from cover, i.e. over-hanging vegetation, undercut bank, and riffle or boulder turbulence. A Garmin GPS II Plus was used to record UTM coordinates at stream walk start and end points and at each redd or redd cluster observed. Aerial and ground view photographs were taken of representative spawning sites and redds within each spawning zone.

3. Winter Inspection

Winter flow and ice conditions were documented during an inspection of all three spawning zones on February 27, 2002. Observations of surface discharge and ice cover were noted and photographs were taken.

Some sampling activities were completed in conjunction with sampling conducted during the concurrent *Upper Muskwa Watershed Group Overview Inventory* (DES 2002).

A sub-sample of mature bull trout were captured by angling at or downstream of each of the three spawning zones. Fork length, sex and maturity stage were recorded and a pelvic fin ray was collected for aging purposes. Evidence of prior handling (i.e., missing fin rays) was also noted. In coordination with the August 27 stream walk at the Crehan Creek spawning zone, a 300 m stream sample site was evaluated as part of the concurrent *Upper Muskwa Watershed Group Overview Inventory* (DES 2002). Habitat data collected during the sample site assessment is presented in DES (2002).

Biophysical habitat parameters within the Dead Dog Creek spawning zone were documented in August 2000 and are presented in DES (2000).

4. RESULTS

Impassable waterfalls and chutes are common features in the upper Muskwa River drainage, and preclude fish access to a significant proportion of the drainage network. Barriers to fish movement within the project area were assessed and mapped (DES 2000 and DES 2002). The prevalence of migrational impasses greatly simplified the search for critical spawning habitat used by migratory bull trout.

The Tuchodi River, Kluachesi Creek and Crehan Creek are the only significant tributaries with bull trout spawning and rearing potential that do not contain impassable barriers. Bull trout spawning activity in the Tuchodi River drainage was assessed by DES (2000). No evidence of mainstem spawning activity was found after intensive sampling for rearing juveniles and redd searches by boat and helicopter. The presence of moderate densities of juvenile bull trout in upper Dead Dog Creek, however, led to the discovery of the Dead Dog spawning zone. An assessment of all other significant Tuchodi River tributaries found that only Joplin Creek supported additional spawning activity. Several mature bull trout were sampled at the base of a 10 m waterfall in late August 2000 (DES 2000). Suitable spawning habitat was restricted to isolated patches of gravel/cobble in the plunge pool and adjacent boulder pockets. Although the fish were in spawning condition, no redds were readily apparent. The average fork length of mature fish (388 mm; n=14) was much smaller than in typical migratory sub-populations. Although the Joplin Creek run appeared much smaller and more localized than the Dead Dog Creek run and was not assessed during the current project, its significance should not be dismissed.

An impassable chute and bedrock constriction on Gathto Creek restricts fish use to the lower 65 km of mainstem. Since barriers restrict access to almost all lower Gathto Creek tributaries, the anecdotal evidence indicating bull trout use suggested a mainstem-spawning sub-population.

Mainstem impasses prevent access to the upper 40 km of the Muskwa River and access to all tributaries upstream of Crehan Creek is restricted by impassable barriers along the walls of the Muskwa River valley. The Crehan Creek drainage appeared to have moderate spawning potential for bull trout; this was supported by local anecdotal evidence.

The Kluachesi Creek drainage is the only other significant sub-drainage accessible to fish, but appeared to have only limited bull trout spawning potential during the assessment of five *Overview Inventory* sample sites (DES 2002). The Kluachesi Creek mainstem was assessed to offer little bull trout spawning potential, as is generally typical of lake-headed systems (T. Down, pers. comm.). Tierney Creek is one of two significant tributaries to Kluachesi Creek. Both are seasonally accessible to fish and have moderate potential as seasonal rearing habitat for mountain whitefish and Arctic grayling (DES 2002). Spawning potential for bull trout, however, appeared restricted by colluvial substrates containing a high proportion of fines; no juvenile bull trout were captured or observed.

Despite these observations, anecdotal reports suggests the presence of adult bull trout in Kluachesi Creek. A group camped at the mouth of Kluachesi Creek on September 15, 1977 were observed to have angled several bull trout up to 7 pounds (3.2 kg) (B. Webster, pers. comm.). The holder of the local guide-outfitting area reports the presence of numerous bull trout in the 5 to 10 pound (2.3 to 4.5 kg) range, near his camp on Tierney Creek in recent years (B. Tompkins, pers. comm.).

The following sections describe observations made during site visits to the three confirmed migratory bull trout spawning zones on Dead Dog Creek, Gathto Creek and an unnamed tributary to Crehan Creek between July and September 2001. A summary of the results of replicated stream walks at these sites can be found in Appendix I. Location and other relevant data recorded during redd counts is presented in Appendix II

and observations and data pertaining to individual fish are found in Appendix III. An index to photodocumentation contained on the accompanying photoCD is listed in Appendix IV.

4.1 Dead Dog Creek

4.1.1 Telemetry Monitoring

Telemetry monitoring flights were conducted on May 21, 23, 26, 30 and July 27, 2001 in an effort to locate five mature bull trout implanted with transmitters on the Dead Dog Creek spawning zone on August 30, 2000. The fish had last been located five months previous, on December 23, 2000 (DES 2000). On that day, four of the fish had appeared to have settled into over-wintering habitat in an 18 km stretch of the lower Muskwa River mainstem, immediately upstream of the mouth of Akue Creek, approximately 132 km downstream of the Dead Dog Creek spawning zone (DES 2000). The fifth fish had been located at the inlet to Upper Tuchodi Lake on November 19 and December 23, 2000. It's status was questionable and regarded as a potential mortality.

Despite considerable search effort, none of the four lower Muskwa transmitters could be located during the May to July 2001 monitoring flights. The following segments of stream were searched during the May flights:

- Muskwa River mainstem from the Fort Nelson River upstream to the mouth of Kluachesi Creek,
- Fort Nelson River from the mouth of the Sahtaneh River to the confluence with the Muskwa River,
- Tuchodi River mainstem from the mouth upstream to the inlet to Upper Tuchodi Lake,
- Dead Dog Creek from the mouth to the Dead Dog spawning zone,
- Kledo Creek mainstem,
- Lower Steamboat Creek,
- Lower Tetsa River mainstem,
- Lower Raspberry Creek,
- Lower Chischa Creek,
- Lower Chlotopecta Creek,
- Gathto Creek from the mouth to the lower impasse,
- Lower Kluachesi Creek,
- Lower Prophet River,
- Lower Akue Creek.

The final flight, on July 27, involved a search of the Dead Dog Creek mainstem, upstream from its confluence with the Tuchodi River. Transmitter batteries are assumed to have failed during the preceding winter.

The fifth transmitter was found at its November and December 2000 location at the inlet to Upper Tuchodi Lake, suggesting that the fish died there the previous fall.

4.1.2 Spawning Assessment

Dead Dog Creek is the largest tributary to the Tuchodi River and the only significant tributary without an impassable mainstem barrier. Four visits to the Dead Dog Creek

spawning zone were made between July 27 and September 07, 2001. On July 27, 2001, a 2-pass, low-level, helicopter inspection of Dead Dog Creek was conducted between its confluence with the Tuchodi River and the Dead Dog Creek spawning zone, 27.5 km upstream, to confirm the presence of migrating or staging bull trout. Adult Arctic grayling and mountain whitefish were observed, however, no mature bull trout were sighted either at the spawning zone or downstream. On the same day, angling with bait and spoons was undertaken at the confluence and at three locations along the mainstem, where suitable adult holding habitat was present. No mature bull trout were captured or observed.

On August 28, 2001, a 2.9 km segment of Dead Dog Creek, encompassing the Dead Dog spawning zone, was walked (Fig 2; Plate 1). Thirteen mature bull trout (5 males and 8 females) were observed; 5 of these fish were captured and sampled. The largest, a 735 mm female (Plate 2), had been captured and sampled on August 23 of the previous summer, approximately 4.5 km downstream (DES 2000). Two active redds and 2 incomplete or "test" redds were observed within the surveyed segment, indicating that spawning activity was in its early stages (Plate 3). A second stream segment, 2.2 km in length, beginning approximately 1.5 km downstream of the spawning zone was also walked and angled on August 28, in an effort to determine if migrating fish were holding below the primary spawning zone. No mature bull trout were observed, although 2 adult grayling were noted. Three grizzly bears were also observed on this segment of stream; they did not appear to be engaged in fishing.

The 2.9 km Dead Dog spawning zone walk was replicated 10 days later on September 07, 2001. Using the same methodology, 27 redds were enumerated. No mature bull trout were observed and spawning activity appeared to be finished. The number of redds recorded was considered conservative due to the degree of redd superimposition at some sites.

A final inspection of the Dead Dog Creek spawning zone was made on February 27, 2002. In contrast to common examples of bull trout spawning habitat, almost all of the egg deposition area was ice-covered. In addition to the wetted width of the stream, the entire channel width was heavily glaciated throughout much of the spawning zone (Plates 4 and 5). Ice up to 1 metre in depth appeared to result from the "freeze and over-flow" cycle associated with surface discharge and/or groundwater seepage. Flow conditions at substrate level within the primary channel were largely obscured and could not be documented. A short segment of secondary channel along the east bank was clear of ice and snow as a result of a small volume of relatively warm water (5.5°C) seeping from the streambank (Plate 6). Primary channel water temperature was 1.0°C.

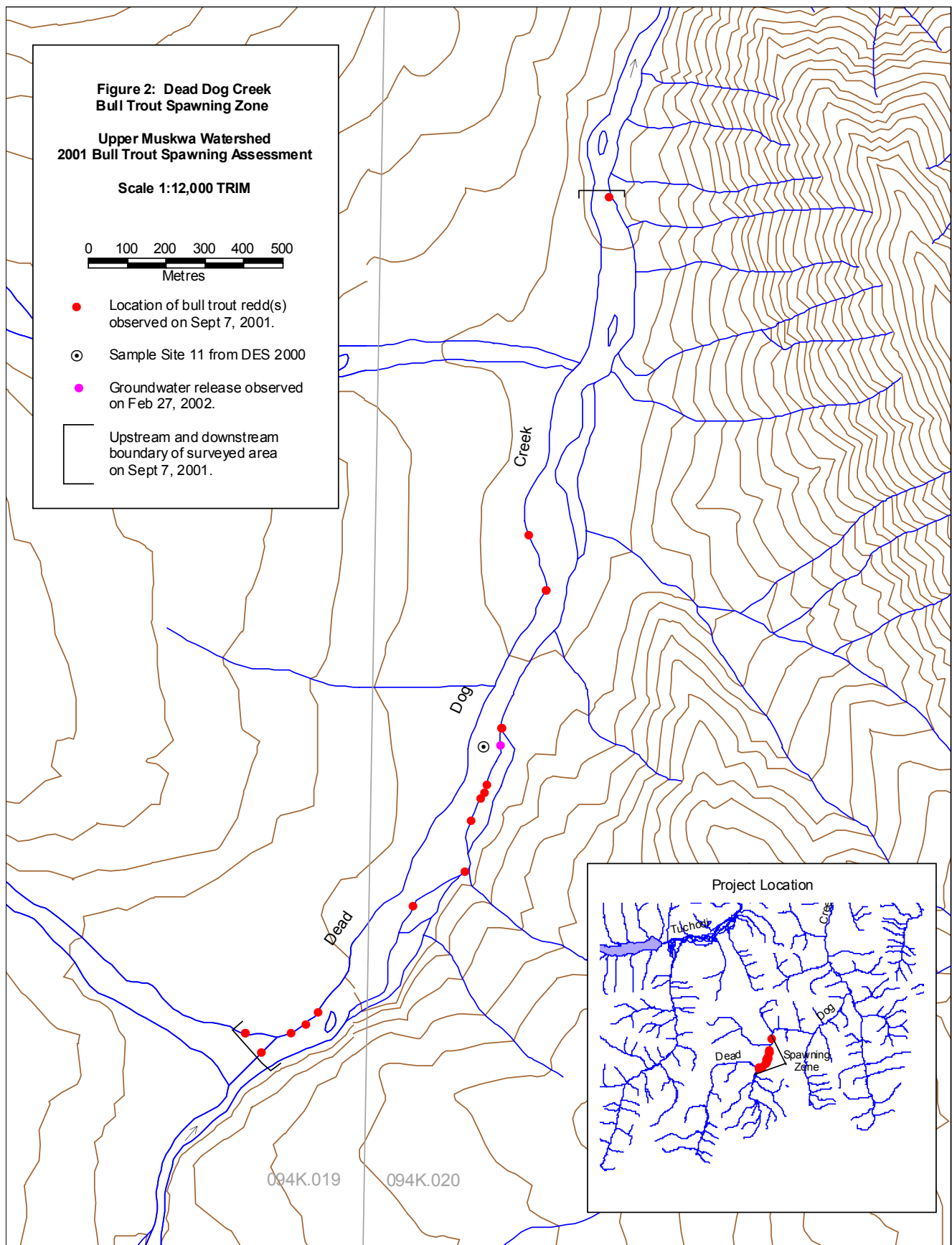




Plate 1. Dead Dog Creek spawning zone – August 23, 2000; aerial view upstream from approximate centre of zone.



Plate 2. 735 mm female bull trout in Dead Dog Creek spawning zone – August 28, 2001.



Plate 3. Aerial view of large bull trout redd at upstream end of Dead Dog Creek spawning zone – August 28, 2001.



Plate 4. Dead Dog Creek spawning zone – February 27, 2002; aerial view upstream from approximate centre of zone.



Plate 5. Dead Dog Creek spawning zone – February 27, 2002; aerial view downstream from approximate centre of zone.



Plate 6. Warm water seepage from east bank of Dead Dog Creek spawning zone – February 27, 2002; view downstream.

4.2 Gathto Creek

Gathto Creek is the second largest sub-basin of the upper Muskwa River drainage. A narrow chute and bedrock confinement, located 65 km upstream from the mouth, defines the upstream limit of fish distribution (Plate 7). All portions of the drainage upstream of this barrier are non fish-bearing (DES 2002). Impassable barriers on the lower reach of almost all tributaries entering downstream of this impassable chute severely limit access to potential tributary spawning and rearing habitats.



Plate 7. Impassable barrier defining the upstream limit of fish distribution on Gathto Creek; upstream aerial view.

Although the existence of a spawning sub-population of migratory Muskwa bull trout in Gathto Creek was not confirmed prior to this project, limited anecdotal information (B. Tompkins, pers. comm.) and the results of a creel survey in 2000 (DES 2000) suggested the possibility. On July 24, 2001, high densities of young-of-the-year (YOY) bull trout were captured at a mainstem *Overview Inventory* sample site located approximately 6 km below the lower mainstem impasse (DES 2002). The presence of the YOY age class indicated the likelihood of significant spawning activity within the 6 km of accessible habitat upstream of this point. Angling with bait and spoons in suitable holding water at the base of the lower impasse on July 24, however, produced only adult Arctic grayling and one sub-adult bull trout. A significant unnamed tributary (WSC 212-580800-44400-60500) enters this section of Gathto Creek from the south. A 35 m waterfall limits the usable portion of this tributary to the lower 1.7 km. The plunge pool at the base of the waterfall was angled on August 22, 2000 (T. Euchner, pers. obs.). No mature bull trout were captured or observed.

On August 28, 2001 a multiple-pass, low-level helicopter search was conducted along this 6 km segment of stream in an effort to locate spawning fish and redds suspected to be present. Two large male bull trout were spotted immediately downstream of a small side channel located 4 km downstream of the mainstem barrier (Plate 8; Fig 3). A ground inspection of the area revealed three redds and two pairs of spawning bull trout within the 480 m wetted length of the side channel. In addition, seven mature bull trout were angled from under LWD cover in a holding pool 150 m downstream of the mouth of the side channel. The side channel has no surface connectivity to Gathto Creek at its upstream end and appears to be fed by sub-surface flow under the primary channel and seepage from a beaver impounded area to the north.



Plate 8. Gathto Creek side channel bull trout spawning zone – August 28, 2001; aerial view downstream.

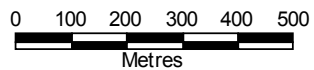
A replicate inspection was conducted 10 days later on September 07, 2001. Twenty-three redds were recorded (Plates 9 & 10). As with the Dead Dog count, this number was considered conservative due to the degree of redd superimposition at some sites. Two male and two female bull trout were observed in the side channel, although spawning activity appeared well past its peak. No redds or other evidence of spawning activity was observed along the primary channel or in other secondary channels of Gathto Creek during either the ground or aerial inspections.

The final inspection of the Gathto Creek side channel spawning zone was completed on February 27, 2002. The primary channel of Gathto Creek, in the vicinity of the side channel, was obscured by ice cover, however, the segment of side channel where spawning activity had occurred remained ice free (Plates 11 & 12). Surface flow in the Gathto Creek mainstem was significantly less than during the early fall inspection, however, discharge volume in the side channel appeared largely unchanged.

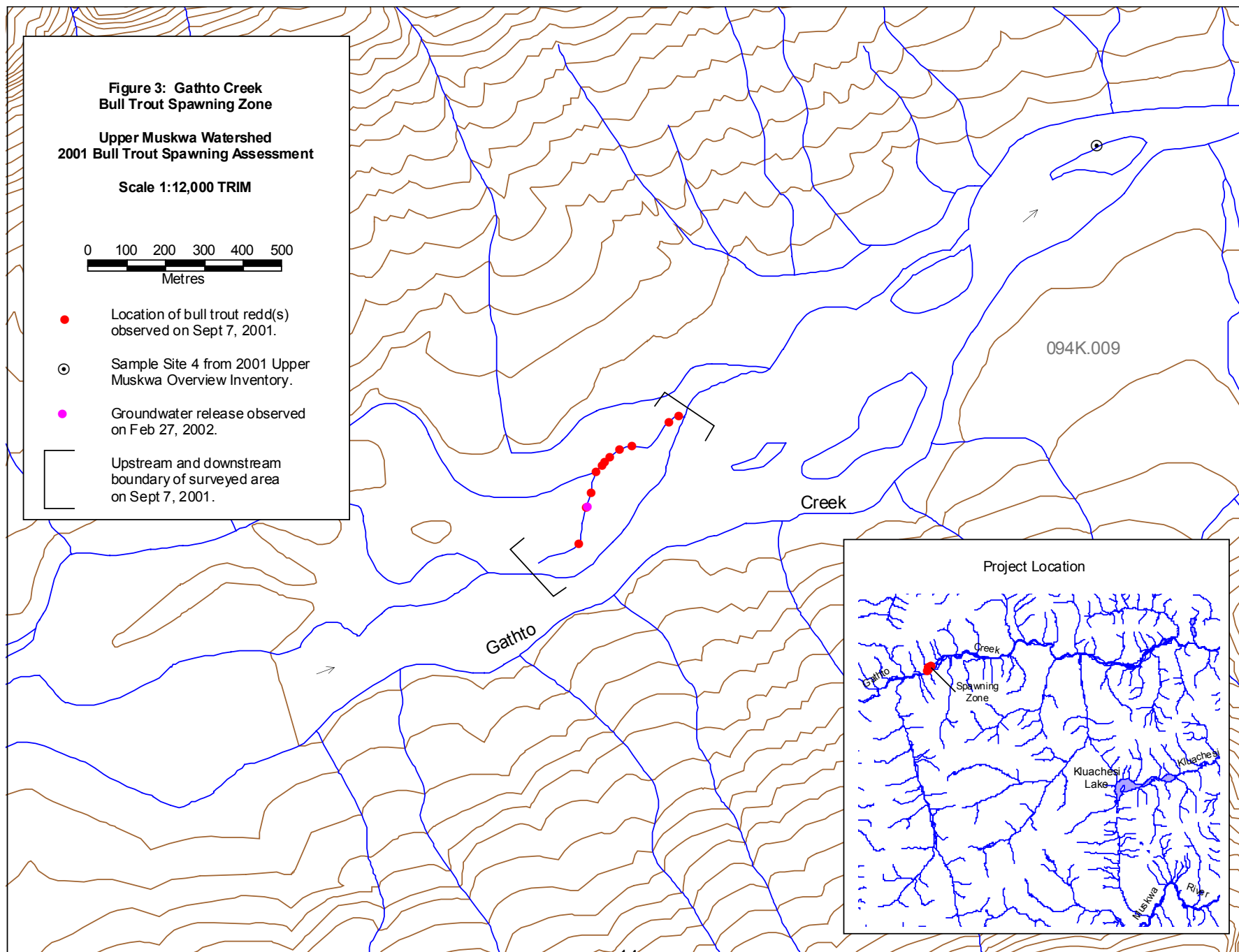
**Figure 3: Gathto Creek
Bull Trout Spawning Zone**

**Upper Muskwa Watershed
2001 Bull Trout Spawning Assessment**

Scale 1:12,000 TRIM



- Location of bull trout redd(s) observed on Sept 7, 2001.
- ⊙ Sample Site 4 from 2001 Upper Muskwa Overview Inventory.
- Groundwater release observed on Feb 27, 2002.
- Upstream and downstream boundary of surveyed area on Sept 7, 2001.



Project Location

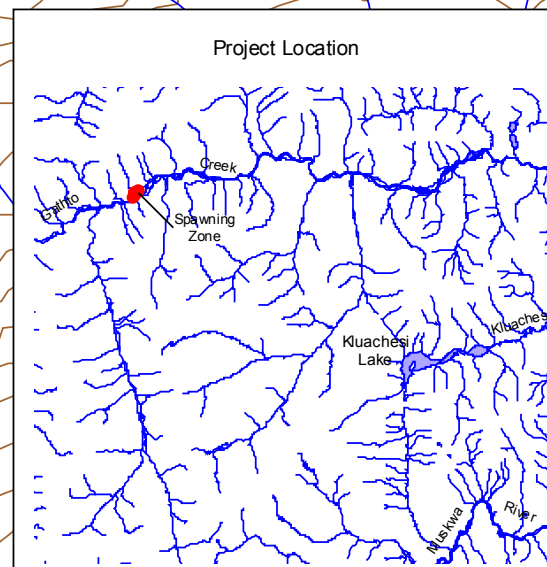




Plate 9. Bull trout redd site in Gathto Creek side channel - September 07, 2001;
view downstream.



Plate 10. Large bull trout redd in Gathto Creek side channel - September 07, 2001.

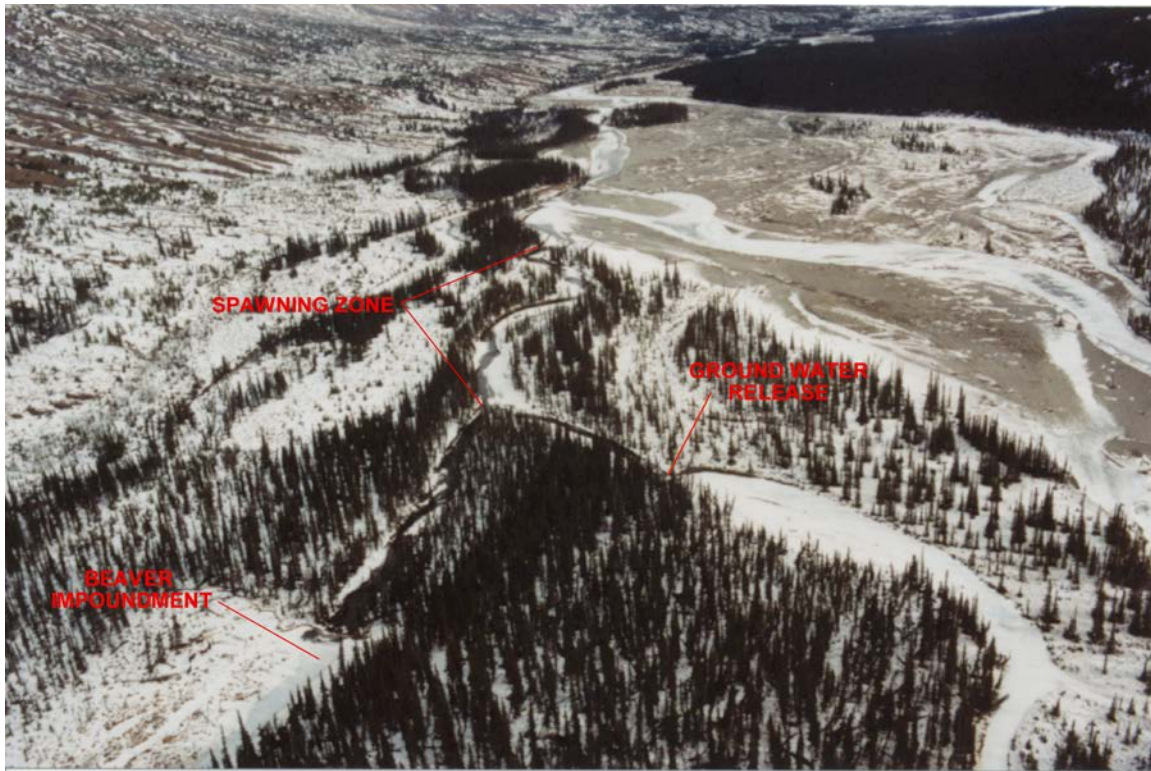


Plate 11. Gathto Creek side channel bull trout spawning zone – February 27, 2002; aerial view downstream.



Plate 12. Gathto Creek side channel; typical redd site along over-hanging bank below riffle – February 27, 2002; view downstream.

Water temperature in the lower portion of the side channel was 2.8°C. Water temperatures in the upper side channel and in the seepage channel entering from the beaver impoundment to the immediate north (Fig 3; Plate 11) were 2.0°C and 3.0°C, respectively. The temperature of surface flow in the Gathto Creek mainstem adjacent to the side channel was 0.5°C.

Substrate at redd sites within the Gathto Creek side channel appeared to contain a higher proportion of fines than typically observed at bull trout spawning zones in the region. Nonetheless, the presence of live eggs at the time of the February inspection and the presence of high densities of YOY 4 km downstream during the July 24, 2001 sampling suggests at least moderate success in the incubation and emergence phases.

It should also be noted that the July 24, 2001 mainstem sampling was conducted immediately after a major flood event in which discharge and turbidity in Gathto Creek reached levels not observed by local residents in many years (B. Tompkins, pers. comm.). This illustrates the resilience of bull trout fry and their ability to avoid being flushed from rearing habitats during such events.

4.3 Crehan Creek

Crehan Creek is the largest Muskwa River tributary upstream of Sleeping Chief Mountain, a landmark located near the point where the Muskwa mainstem reaches the edge of the Taiga Plains and swings northward. Crehan Creek comprises the only tributary habitat in the uppermost portion of the Muskwa drainage, where seasonal access is not precluded by impassable barriers (DES 2002). This fact, coupled with local reports of occasional “big dollies” (T. Vince, pers. comm.) suggested the possibility of a third migratory sub-population and the presence of critical spawning habitat within the Crehan Creek drainage.

On July 26, 2001, a 550 mm, age 11+, mature adult female bull trout and a YOY juvenile were captured at an *Overview Inventory* sample site on the lower reach of Crehan Creek (DES 2002). The mature fish was assumed to be migrating to spawning habitat upstream and the YOY juvenile was assumed to be rearing downstream of spawning habitat. At the request of the local guide-outfitter, no investigations further upstream were made at this time to avoid conflict with sheep hunters.

On August 27, a low-level helicopter reconnaissance of the upper Crehan Creek drainage was conducted in concert with the *Upper Muskwa Watershed Group Overview Inventory* (DES 2002). Much of the upper Crehan Creek mainstem was found to be of low suitability for bull trout due to the presence of low-gradient, pool/run habitat and silt-dominated substrates. A significant unnamed tributary, entering the middle mainstem from the southeast (WSC 212-580800-71000-47800), appeared to have the highest spawning potential. Active redds and mature fish were highly visible along a 600 m segment of the tributary located approximately 3.5 km upstream of the confluence with Crehan Creek (Fig 4; Plates 13 & 14).

A 1.8 km segment of the tributary encompassing the area of spawning activity was inspected during a stream walk on August 27, 2001. Thirteen mature bull trout and six redds were observed. No fish or redds were noted outside the inspected segment during follow-up helicopter over-flights.

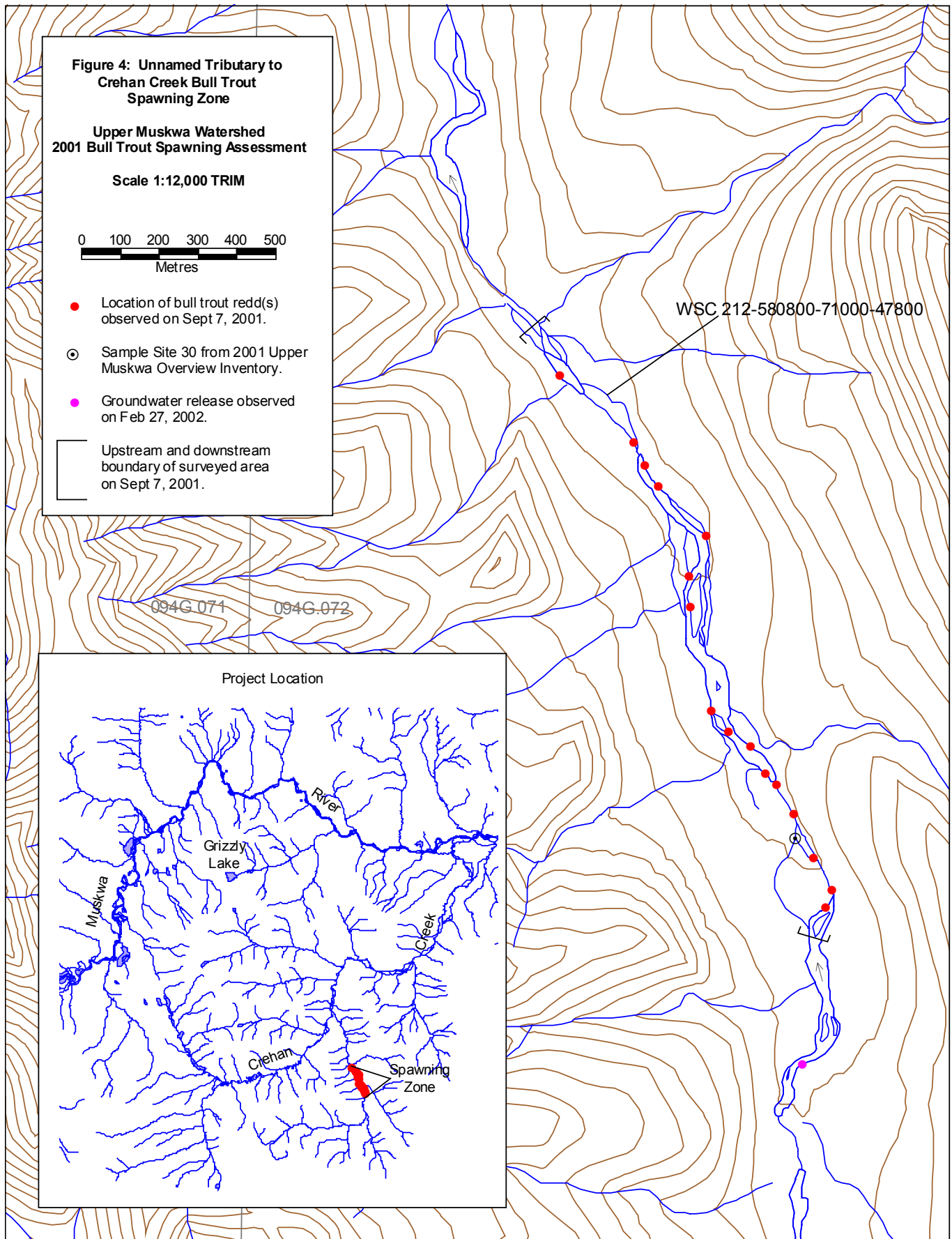




Plate 13. Crehan Creek tributary bull trout spawning zone – August 27, 2001;
aerial view upstream.



Plate 14. Aerial view of bull trout redd in Crehan Creek tributary –August 27, 2001.

An *Overview Inventory* sample site was evaluated within the spawning zone on August 27, 2001 (DES 2002). Fork lengths and aging structures were collected from two male and one female mature bull trout (Plate 15). Several yearling juveniles were also sampled.



Plate 15. 700 mm male bull trout spawning in Crehan Creek tributary - August 27, 2001.

The Crehan Creek stream walk was replicated 11 days later, on September 07, 2001. Thirty-four redds (Plate 16) and three mature bull trout, approximately 40 cm in length, were recorded. Spawning activity appeared to have concluded. Again, no redds or bull trout were observed outside the area inspected during the stream walk. A secondary unnamed tributary enters the approximate centre of the spawning zone from the east. An impassable waterfall occurs 150 m above the mouth; no bull trout were observed in the accessible portion of this tributary, although several adult mountain whitefish and Arctic grayling were noted.

The final inspection of the Crehan Creek tributary spawning zone was conducted on February 27, 2002. The primary channel was largely covered with ice and snow throughout the length of the spawning zone (Plate 17). A conspicuous groundwater spring entered the channel from the east streambank, near the top of the spawning zone (Plate 18), approximately 400 m upstream of the point where the uppermost redd had been recorded during the August 27 and September 07 visits. Upstream of this spring, the primary channel appeared to be devoid of surface discharge.



Plate 16. Typical bull trout redd in Crehan Creek tributary spawning zone – September 07, 2001.



Plate 17. Crehan Creek tributary bull trout spawning zone – February 27, 2002; aerial view downstream.



Plate 18. Groundwater spring entering the channel from the east streambank near the top of the Crehan Creek tributary bull trout spawning zone – February 27, 2002 (UTM 10.453823.6400986).

The temperature of water flowing from the spring was 3.0°C and the channel remained ice-free for approximately 200 m downstream. Although surface discharge in the primary channel was not significant immediately downstream of the upper spring, flow volume increased considerably and incrementally within 200 m downstream, indicating additional groundwater inputs (Plate 19). At approximately 250 m, the channel became increasingly obscured by ice and snow (Plate 20), but surface flow could be heard under occasional areas of shell ice. Water temperature dropped to 1.0°C in the vicinity of the uppermost redd site and to 0.5°C in the lower portion of the spawning zone. Significant glaciation was common along both streambanks indicating further groundwater inputs along much of the length of the spawning zone (Plate 21). The lower portion of the spawning zone was heavily glaciated across the entire channel width, similar to the Dead Dog Creek site (Plate 22). Virtually all redd sites recorded during the September 07, 2001 stream walk were obscured under ice cover during the February 27, 2002 inspection.



Plate 19. Crehan Creek tributary approximately 200 m downstream of groundwater spring entering channel from the east streambank - February 27, 2002.



Plate 20. Upper portion of Crehan Creek tributary spawning zone, approximately 650 m downstream of groundwater spring - February 27, 2002.



Plate 21. Streambank glaciation indicating groundwater inputs along the upper portion of the Crehan Creek tributary spawning zone - February 27, 2002.



Plate 22. Extensive glaciation in the lower portion of the Crehan Creek tributary spawning zone - February 27, 2002.

5. DISCUSSION

5.1 Migration Timing

Information on migration timing of Muskwa River bull trout was to be gathered through the monitoring of telemetry transmitters implanted in spawning Dead Dog bull trout on August 30, 2000. Due to apparent transmitter failure, the movement of these fish from Muskwa mainstem over-wintering habitat to tributary spawning habitat, between early summer and late August 2001, could not be monitored. Limited insight into spawning migration timing was gained through incidental point sampling and observations made during the late August and early September spawning zone inspections.

Assuming that all three spawning sub-populations over-winter in areas of the lower Muskwa mainstem, the presence of a maturing female bull trout in the lower reach of Crehan Creek on July 26, suggests considerable upstream movement and entry into tributaries at least one month prior to spawning. The fact that no bull trout were observed during aerial inspections and point sampling conducted between the mouth of Dead Dog Creek and the Dead Dog spawning zone on July 27 was somewhat puzzling but may have been related to low densities of fish widely distributed along the 27 km of stream. Also curious was the apparent absence of bull trout from a 2.2 km stream segment walked on August 28 on the reach immediately downstream of the Dead Dog spawning zone. At the time of this inspection 13 fish were enumerated on the spawning zone and redd excavation had just begun. Since the September 07 inspection revealed a significant number of new redds, it was assumed that additional fish en-route to the spawning zone would have been present downstream on August 28.

The 2000 telemetry data (DES 2000) indicated rapid emigration from the Dead Dog and Tuchodi systems immediately after the completion of spawning (approx. September 1, 2000). Of the four radio-tagged Dead Dog fish which migrated downstream to the lower Muskwa River, three had done so before September 11. This rapid emigration from Dead Dog Creek is supported by observations made in 2001 suggesting that spawning activity was in its preliminary stages on August 28 but that spawning activity was complete and all fish had abandoned the spawning zone by September 07.

5.2 Spawning Timing

The number of redds and mature fish observed on the August 27-28 and September 07, 2001 stream walks (Appendix I), indicates peak immigration, spawning and emigration took place during the 10 intervening days at all three spawning zones. Similar results were recorded at the Dead Dog Creek spawning zone in 2000, where site inspections were conducted on August 23 and August 30 (DES 2000). Nine fish were observed on active redds during the August 23 visit, although a formal redd count was not conducted. Seven days later, on August 30, 2000 extensive digging had occurred (B. Culling, pers obs.) and only 4 males, 1 spent female and 1 unclassified fish were observed within the spawning zone (DES 2000).

The Peace/Halfway bull trout population is the closest comparable fluvial population for which migration and spawning timing data exists. This population appears similar to the Muskwa population in that adults over-winter in large mainstem habitats (i.e., Peace River and lower Halfway River) and make long-distance migrations to several upper drainage spawning zones including Needham Creek, the Chowade River, Cypress

Creek and the upper Halfway River mainstem (T. Euchner, pers. obs.). Immigration into the upper Chowade spawning zone begins between August 10 and 20 and peaks around September 05 with peak spawning activity occurring between September 05 and 12 (Baxter 1996, Baxter 1997).

Observations recorded at the three Muskwa spawning zones indicate that spawning occurs 7 to 10 days earlier than in the Peace/Halfway population and that immigration, spawning and emigration are much less protracted. The spawning timing of Muskwa bull trout is consistent with a review of bull trout spawning and emigration timing in the Peace and Columbia basins which suggest earlier timing with more northerly latitudes. The narrower period of activity observed on the Muskwa spawning zones may be related to the notable absence of holding cover within the spawning zones and the associated increase in vulnerability to natural mortality.

5.3 Spawning Population Status and Comparative Significance

The total number of redds within each of the three Muskwa spawning zones, at the apparent completion of spawning activity, was established as an index baseline to medium and long-term population trends.

Redds counts are commonly used as a index to escapement and population status (Rieman and Myers 1997). The advantages of redd counts over other methods of population assessment (e.g., snorkel surveys, mark-recapture surveys, counting fences) are that they are much less expensive to conduct and are the least invasive and disruptive to bull trout (Dunham et al. 2001). Two limitations of redd counts as an indicator of population status are the assumption that numbers of redds are directly correlated to escapement and potentially high interobserver variability. An analysis of bull trout redd counts conducted in Idaho (Dunham et al. 2001) found a strong correlation between numbers of redds and numbers of the spawning fish, but found wide variability in omission and misidentification errors between observers. Potential for significant error was also found where stream segments were used as sub-samples of larger spawning areas and were prone to spatial and temporal variation in year-to-year spawning activity.

In addition to their utility as an index to population trends over time, the results of redd counts have been used to extrapolate spawning population estimates. This involves multiplying the number of redds counted by the number of spawning fish believed to be represented by each redd. The number of spawners/redd appears to vary widely between populations and is influenced by numerous factors including the ratio of males to females, the density of spawning females and the spatial distribution of spawning sites within a spawning zone (Dunham et al. 2001). Spawner/redd ratios used in extrapolating bull trout populations estimates in the Peace and Columbia basins of British Columbia ranged from 1.5 to 3.1. The lower ratio was calculated on the Wigwam River in 1998 where 1.1 females passed through a fence for each redd counted upstream of the fence and where females outnumbered males 2.5:1 (Baxter and Westover 1999). The higher figure resulted from direct observation of specific redds on the Chowade River in 1995, where males outnumbered females by a margin of 1.23:1 (Baxter 1996).

For the purpose of this assessment, conservative assumptions of 1.0 female per redd and an even sex ratio (i.e., 2.0 spawners/redd) result in spawning run estimates of 54, 46 and 68 fish for the Dead Dog, Gathto and Crehan Creek runs, respectively. Minimum spawning sub-population sizes and extrapolation assumptions can be refined with periodic replications of this assessment, particularly if at least one stream walk coincides with the narrow peak in immigration and spawning activity.

The Dead Dog, Gathto and Crehan Creek spawning zones appear to be linked to specific features related to winter groundwater inputs and are relatively limited in spatial extent. Therefore, it is feasible to replicate total redd counts over the entire length of the respective spawning zones, without considering annual spatial variations in activity inherent in sub-sample segments. The opportunity to maintain observer/recorder continuity over the long-term is also a positive consideration.

Unlike the Peace/Halfway population, where the relative significance of one spawning sub-population (Chowade) is much higher than the others, the three Muskwa sub-populations appear comparable in relative importance, although on a lower scale than the Chowade run.

5.4 Winter Incubation Conditions

Groundwater upwelling within streambeds is recognized as a key factor in bull trout spawning habitat selection (Baxter and McPhail 1999, Baxter and Hauer 2000). Although ice conditions within the three spawning zones varied widely, from ice-free to heavily glaciated, winter ground-water inputs were evident at each zone. The Gathto Creek side channel exhibited classic ice-free conditions associated with stable, relatively warm groundwater inputs and surface flow volume appeared to have changed little from the early fall inspections.

Winter flow conditions at the Crehan Creek tributary spawning zone were noteworthy in that cumulative groundwater inputs resulted in significant surface flow entering the top of the spawning zone, but that winter surface discharge was largely absent upstream of the segment selected by spawning bull trout. This difference in discharge was not observable during the early fall inspections, when juvenile bull trout and Arctic grayling were captured at a sample site several kilometres upstream (DES 2002).

The Dead Dog Creek site was the highest in elevation, had the least open water, the most extensive ice build-up and least resembled what are commonly thought of as classic winter incubation conditions. Although stable winter surface flow was evident in the primary channel thalweg, “warmer” groundwater inputs of significant volume were not obvious within the spawning zone. It was unclear if glaciation across the channel width was the result of local groundwater seepage or overflowing surface discharge from upstream. The presence of impervious clay underlying streambed substrates was noted during previous inspections and may be a factor contributing to localized upwelling through the overlying substrate (Baxter and Hauer 2000).

5.5 Further Research Recommendations

Redd counts and enumeration of spawning adults should be periodically replicated at the Dead Dog, Gathto and Crehan Creek bull trout spawning zones to provide an index of medium and long-term population trends and to refine minimum sub-population estimates and extrapolation assumptions.

The reported presence of adult bull trout in the Kluachesi Creek drainage, specifically Tierney Creek, should be re-assessed to confirm the existence or absence of an additional spawning sub-population.

An assessment of bull trout use of the Tetsa River system should be conducted to determine if that drainage contains critical spawning zones supporting an additional fluvial, migratory sub-population.

A radio-telemetry study should be undertaken to gather data on pre- and post spawning migratory movements of each spawning sub-population to identify spatial and temporal increases in vulnerability, and to further identify critical adult over-wintering habitat.

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APPENDIX I

**SUMMARY OF RESULTS OF STREAM WALKS
AT THE DEAD DOG, GATHTO AND CREHAN CREEK
SPAWNING ZONES ON AUGUST 27-28 AND SEPTEMBER 07, 2001**

Location	Date	Start UTM	End UTM	Dist (km)	Dir	# of Redds Obs	# of BT Obs	Comments
Dead Dog Creek	28-Aug-01	430096.6447919	429034.6445372	2.90	u/s	2	13 (8f, 5m)	encompasses 2.7 km spawning zone
Dead Dog Creek	28-Aug-01	432086.6448293	430976.6448466	1.20	u/s	none	none	1.5 km downstream of lower end of spawning zone
Dead Dog Creek	28-Aug-01	432086.6448293	433071.6448109	1.00	d/s	none	none	2.7 km downstream of lower end of spawning zone
Dead Dog Creek	07-Sep-01	430096.6447919	429034.6445372	2.90	u/s	27	none	high degree of redd superimposition at some sites
Gathto side channel	28-Aug-01	427766.6435619	427289.6435202	0.72	u/s	3	9	2 pairs BT in side channel; 7 BT holding in LWD/pool 150m d/s of side channel mouth
Gathto side channel	07-Sep-01	427766.6435619	427289.6435202	0.72	u/s	23	4 (2f, 2m)	high degree of redd superimposition at some sites; insp included 150m d/s of side channel mouth
Crehan Creek Trib	27-Aug-01	453885.6401182	453136.6402895	2.00	d/s	6	13	encompasses 1.8 km spawning zone; MW & GR also observed
Crehan Creek Trib	07-Sep-01	453885.6401182	453136.6402895	2.00	d/s	34	3	moderate degree of superimposition

APPENDIX II

**BULL TROUT REDD LOCATIONS
RECORDED DURING AUGUST 27-28 AND SEPTEMBER 07, 2001
STREAM WALKS AT THE DEAD DOG, GATHTO AND CREHAN CREEK
SPAWNING ZONES.**

Location	Date	UTM Coordinates	# of Redds	Comments
Dead Dog Creek	28-Aug-01	10.429770.6446496	2	small or incomplete redds
Dead Dog Creek	28-Aug-01	10.429639.6446056	1	
Dead Dog Creek	28-Aug-01	10.429194.6445522	1	
Dead Dog Creek	07-Sep-01	10.430015.6447661	1	
Dead Dog Creek	07-Sep-01	10.429840.6446791	2	
Dead Dog Creek	07-Sep-01	10.429791.6446644	1	small redd
Dead Dog Creek	07-Sep-01	10.429791.6446644	1	large redd may have been used by multiple pairs
Dead Dog Creek	07-Sep-01	10.429738.6446292	1	small redd
Dead Dog Creek	07-Sep-01	10.429738.6446292	1	incomplete or test redd
Dead Dog Creek	07-Sep-01	10.429738.6446292	1	medium-size redd
Dead Dog Creek	07-Sep-01	10.429733.6447684	1	large redd
Dead Dog Creek	07-Sep-01	10.429701.6447239	3	medium-size redds
Dead Dog Creek	07-Sep-01	10.429657.6446108	4	medium-size redds
Dead Dog Creek	07-Sep-01	10.429654.6446053	12	extensive digging (3.5m x 14m); estimate 12 superimposed redds
Dead Dog Creek	07-Sep-01	10.429584.6445924	1	small redd
Dead Dog Creek	07-Sep-01	10.429512.6445832	2	medium-size redds
Dead Dog Creek	07-Sep-01	10.429312.6445558	1	medium-size redd
Dead Dog Creek	07-Sep-01	10.429288.6445520	1	medium-size redd
Dead Dog Creek	07-Sep-01	10.429200.6445504	1	medium-size redd - present on previous inspection
Dead Dog Creek	07-Sep-01	10.429134.6445449	1	medium-size redd
Dead Dog Creek	07-Sep-01	10.429081.6445468	2	medium-size redds - immediately upstream of "fork" in clear trib
Dead Dog Creek	07-Sep-01	10.429081.6445468	1	small redd - immediately upstream of "fork" in clear trib
Gathto Creek	28-Aug-01	10.427766.6435619	3	u/s of coordinates in side channel
Gathto Creek	07-Sep-01	10.427627.6435562	5	2 male, 2 female BT still present
Gathto Creek	07-Sep-01	10.427600.6435547	3	1 redd 2m x 1m, 2 redds .5m x 1m
Gathto Creek	07-Sep-01	10.427510.6435493	3	superimposed 4m x 2m
Gathto Creek	07-Sep-01	10.427480.6435475	2	superimposed 3m x 1m
Gathto Creek	07-Sep-01	10.427450.6435457	3	small redd
Gathto Creek	07-Sep-01	10.427438.6435447	1	large redd 2m x 1m
Gathto Creek	07-Sep-01	10.427420.6435439	1	large redd 2m x 1m
Gathto Creek	07-Sep-01	10.427414.6435420	2	1 redd 4m x .75m, 1 redd 1m x .5m
Gathto Creek	07-Sep-01	10.427396.6435365	2	1 redd 1m x .5m; 1 redd 1m x .75m
Gathto Creek	07-Sep-01	10.427389.6435328	1	1m x .5m
Gathto Creek	07-Sep-01	10.427364.6435236	1	1m x .4m

Location	Date	UTM Coordinates	# of Redds	Comments
Crehan Creek	27-Aug-01	10.453898.6401429	6	6 redds observed from this point downstream to 10.453196.6402780
Crehan Creek	27-Aug-01	10.453879.6401385	1	most u/s redd
Crehan Creek	07-Sep-01	10.453887.6401383	1	1m x 1m
Crehan Creek	07-Sep-01	10.453899.6401434	1	1m x 2m
Crehan Creek	07-Sep-01	10.453847.6401512	1	.75m x 1.5m
Crehan Creek	07-Sep-01	10.453800.6401630	3	2 superimposed (1.5m x 4m); 1 small (.5m x .5m)
Crehan Creek	07-Sep-01	10.453754.6401708	3	2 small (.5m x .5m); 1 large (1m x 2m)
Crehan Creek	07-Sep-01	10.453736.6401736	5	1 large (1m x 2m); 4 small (.5m x 1m)
Crehan Creek	07-Sep-01	10.453677.6401797	1	.5m x 0.75m
Crehan Creek	07-Sep-01	10.453630.6401842	1	1m x .5m
Crehan Creek	07-Sep-01	10.453589.6401898	1	.75m x 1m
Crehan Creek	07-Sep-01	10.453539.6402164	1	1m x 1.5m
Crehan Creek	07-Sep-01	10.453528.6402244	4	4 large redds (1m x 1m, 1m x 1.5m & two 1.5m x 2.5m)
Crehan Creek	07-Sep-01	10.453559.6402345	1	1m x .5m
Crehan Creek	07-Sep-01	10.453447.6402473	7	seven (1m x .5m) in a row under overhanging willow along east bank
Crehan Creek	07-Sep-01	10.453412.6402531	2	2 redds (1m x .5m); 2 40cm bull trout present
Crehan Creek	07-Sep-01	10.453389.6402591	1	1 redd (1.5m x 1m); 1 40cm bull trout
Crehan Creek	07-Sep-01	10.453212.6402763	1	1m x 1.5m

APPENDIX III

**SUMMARY OF MATURE BULL TROUT OBSERVED
AT THE DEAD DOG, GATHTO AND CREHAN CREEK
SPAWNING ZONES.**

Location	Date	Method	Fork Length (mm)	Sex	Maturity	Age	Comments
Dead Dog Creek	28-Aug-01	AN	615	F	maturing	-	within spawning zone
Dead Dog Creek	28-Aug-01	VO	300 (estimate)	M	-	-	within spawning zone
Dead Dog Creek	28-Aug-01	AN	590	M	ripe	-	within spawning zone
Dead Dog Creek	28-Aug-01	AN	685	F	spent	-	within spawning zone
Dead Dog Creek	28-Aug-01	AN	600	F	spent	-	within spawning zone
Dead Dog Creek	28-Aug-01	VO	400 (estimate).	M	-	-	within spawning zone
Dead Dog Creek	28-Aug-01	VO	450 (estimate)	F	-	-	within spawning zone
Dead Dog Creek	28-Aug-01	VO	450 (estimate)	F	-	-	within spawning zone
Dead Dog Creek	28-Aug-01	VO	450 (estimate)	F	-	-	within spawning zone
Dead Dog Creek	28-Aug-01	VO	450 (estimate)	F	-	-	within spawning zone
Dead Dog Creek	28-Aug-01	VO	500 (estimate)	M		-	within spawning zone
Dead Dog Creek	28-Aug-01	AN	735	F	part spent	11+	recapture from 2000
Dead Dog Creek	28-Aug-01	VO	450 (estimate)	M	-	-	within spawning zone
Gathto Creek	27-Jul-01	AN	354	F	maturing	7+	upstream at base of mainstem barrier
Gathto Creek	28-Aug-01	VO	600 (estimate)	M	mature	-	700 m d/s of side channel
Gathto Creek	28-Aug-01	AN	388	M	ripe	6+	mainstem at bottom of side channel
Gathto Creek	28-Aug-01	AN	660	F	part spent	12+	mainstem at bottom of side channel
Gathto Creek	28-Aug-01	AN	374	F	mature	6+	mainstem at bottom of side channel
Gathto Creek	28-Aug-01	AN	440	F	ripe	8+	mainstem at bottom of side channel
Gathto Creek	28-Aug-01	AN	360	M	mature	6+	mainstem at bottom of side channel
Gathto Creek	28-Aug-01	AN	650	M	mature	11+	mainstem at bottom of side channel
Gathto Creek	28-Aug-01	AN	575	M	ripe	11+	mainstem at bottom of side channel
Gathto Creek	28-Aug-01	VO	-	M	spawning	-	on redd in side channel
Gathto Creek	28-Aug-01	VO	-	M	spawning	-	on redd in side channel
Gathto Creek	28-Aug-01	VO	-	F	spawning	-	on redd in side channel
Gathto Creek	28-Aug-01	VO	-	F	spawning	-	on redd in side channel
Gathto Creek	07-Sep-01	VO	-	M	-	-	lower end of side channel
Gathto Creek	07-Sep-01	VO	-	M	-	-	lower end of side channel
Gathto Creek	07-Sep-01	VO	-	F	-	-	lower end of side channel
Gathto Creek	07-Sep-01	VO	-	F	-	-	lower end of side channel

Location	Date	Method	Fork Length (mm)	Sex	Maturity	Age	Comments
Crehan Creek	26-Jul-01	EF	550	F	maturing	11+	d/s in lower Gathto mainstem
Crehan Creek Trib	27-Aug-01	AN	466	M	mature	9+	within spawning zone
Crehan Creek Trib	27-Aug-01	AN	700	M	mature	13+	within spawning zone
Crehan Creek Trib	27-Aug-01	AN	605	F	spent	12+	within spawning zone
Crehan Creek Trib	27-Aug-01	VO	-	-	-	-	addition 10 spawning BT observed
Crehan Creek Trib	07-Sep-01	VO	400 (estimate)	-	-	-	within spawning zone
Crehan Creek Trib	07-Sep-01	VO	400 (estimate)	-	-	-	within spawning zone
Crehan Creek Trib	07-Sep-01	VO	400 (estimate)	-	-	-	within spawning zone

APPENDIX IV

PHOTODOCUMENTATION INDEX

IMAGE #	DATE	LOCATION	VIEW	COORDINATES
1	27-Feb-02	Crehan Creek tributary	u/s from groundwater spring	57 44.492 123 46.485
2	27-Feb-02	Crehan Creek tributary	groundwater spring	57 44.492 123 46.485
3	27-Feb-02	Crehan Creek tributary	groundwater spring	57 44.492 123 46.485
4	27-Feb-02	Crehan Creek tributary	d/s from groundwater spring	57 44.492 123 46.485
5	27-Feb-02	Crehan Creek tributary	d/s view 200m d/s of groundwater spring	
6	27-Feb-02	Crehan Creek tributary	groundwater seepage from bank	57 45.248 123 46.564
7	27-Feb-02	Crehan Creek tributary	u/s view on upper portion of spawning zone	57 45.259 123 46.576
8	27-Feb-02	Crehan Creek tributary	d/s view of overflow area in lower portion of spawning zone	57 45.559 123 46.823
9	27-Feb-02	Crehan Creek tributary	d/s view of overflow area in lower portion of spawning zone	57 45.652 123 46.820
10	27-Feb-02	Crehan Creek tributary	d/s view of overflow area in lower portion of spawning zone	
11	27-Feb-02	Crehan Creek tributary	d/s aerial view from top of spawning zone	
12	27-Feb-02	Crehan Creek tributary	d/s aerial view from top of spawning zone	
13	27-Feb-02	Gathto Creek side channel	d/s view from approx. 100 m u/s of bottom of side channel	
14	27-Feb-02	Gathto Creek side channel	u/s view from approx. 100 m u/s of bottom of side channel	
15	27-Feb-02	Gathto Creek side channel	u/s view from centre of side channel	58 03.284 124 13.747
16	27-Feb-02	Gathto Creek side channel	d/s view near top of open water section of side channel	
17	27-Feb-02	Gathto Creek side channel	u/s view from top of open water section	58 03.212 124 13.812
18	27-Feb-02	Gathto Creek side channel	d/s view from top of open water section	58 03.212 124 13.812
19	27-Feb-02	Dead Dog Creek	u/s view of open water section within spawning zone	
20	27-Feb-02	Crehan Creek tributary	d/s view within centre portion of spawning zone	57 45.080 123 46.526
21	27-Feb-02	Crehan Creek tributary	across channel view	57 45.101 123 46.530
22	27-Feb-02	Crehan Creek tributary	u/s view of uppermost redd site recorded in September	57 45.131 123 46.410
23	27-Feb-02	Crehan Creek tributary	d/s view within upper portion of spawning zone	57 45.203 123 46.520
24	27-Feb-02	Crehan Creek tributary	d/s view - 3 redds sites near groundwater seepage	57 45.259 123 40.576
25	27-Feb-02	Crehan Creek tributary	u/s view - 5 redds sites	57 45.328 123 46.654
26	27-Feb-02	Crehan Creek tributary	d/s view - redd sites under overhanging willow at "Moore Falls"	57 45.350 123 46.682
27	27-Feb-02	Crehan Creek tributary	u/s view of overflow area in lower portion of spawning zone	57 45.559 123 46.823
28	27-Feb-02	Crehan Creek tributary	d/s view of overflow area in lower portion of spawning zone	57 45.559 123 46.823
29	27-Feb-02	Crehan Creek tributary	u/s view of channel below overflow area	57 45.652 123 46.820
30	27-Feb-02	Crehan Creek tributary	d/s view of overflow area "u/s of redds 1 + 4"	57 45.707 123 46.930
31	27-Feb-02	Crehan Creek tributary	u/s view of overflow area "7 redds"	57 45.707 123 46.930
32	27-Feb-02	Crehan Creek tributary	u/s aerial of groundwater spring	57 44.942 123 46.485
33	27-Feb-02	Crehan Creek tributary	u/s aerial of groundwater spring	57 44.942 123 46.485
34	27-Feb-02	Crehan Creek tributary	d/s aerial from u/s of groundwater spring	57 45.395 123 46.523
35	27-Feb-02	Crehan Creek tributary	d/s aerial of overflow (from d/s of coordinates)	57 45.395 123 46.523
36	27-Feb-02	Gathto Creek side channel	d/s aerial view	

IMAGE #	DATE	LOCATION	VIEW	COORDINATES
37	27-Feb-02	Gathto Creek side channel	d/s aerial view	
38	27-Feb-02	Gathto Creek side channel	cross-channel aerial view	
39	27-Feb-02	Gathto Creek side channel	u/s view "at 1st redd"	58 03.332 124 13.597
40	27-Feb-02	Gathto Creek side channel	d/s view "at 3 redds"	58 03.284 124 13.747
41	27-Feb-02	Gathto Creek side channel	u/s view "at 3 redds"	58 03.284 124 13.747
42	27-Feb-02	Gathto Creek side channel	u/s view from upper extent of open water area	58 03.212 124 13.812
43	27-Feb-02	Gathto Creek side channel	d/s view from upper extent of open water area	58 03.212 124 13.812
44	27-Feb-02	Dead Dog Creek	u/s view	58 09.162 124 11.605
45	27-Feb-02	Dead Dog Creek	d/s view	58 09.162 124 11.605
46	27-Feb-02	Dead Dog Creek	d/s view of "side channel"	58 09.115 124 11.630
47	27-Feb-02	Dead Dog Creek	u/s aerial view from bottom of reach	
48	27-Feb-02	Dead Dog Creek	aerial view east of spawning zone at outfitter's cabin	
49	27-Feb-02	Dead Dog Creek	aerial view east of ground water area u/s of outfitter's cabin	
50	27-Feb-02	Dead Dog Creek	d/s aerial view from top of spawning zone ("forks")	
51	27-Feb-02	Dead Dog Creek	u/s aerial view towards "forks" at top of spawning zone	
52	27-Aug-02	Crehan Creek tributary	aerial view of redd	
53	27-Aug-02	Crehan Creek tributary	BT redd	
54	27-Aug-02	Crehan Creek tributary	BT redd	
55	27-Aug-02	Crehan Creek tributary	d/s view of multiple redds	
56	27-Aug-02	Crehan Creek tributary	d/s view of multiple redds	
57	27-Aug-02	Crehan Creek tributary	BT pair on redd	
58	27-Aug-02	Crehan Creek tributary	BT pair on redd	
59	27-Aug-02	Crehan Creek tributary	BT pair on redd	
60	27-Aug-02	Crehan Creek tributary	BT pair on redd	
61	27-Aug-02	Crehan Creek tributary	466 mm BT male (UM39-1)	
62	28-Aug-02	Dead Dog Creek	735 mm BT female - recapture from 2000 field season	58 08.735 124 12.005
63	28-Aug-02	Dead Dog Creek	735 mm BT female - close-up of healed fin ray scar	58 08.735 124 12.005
64	28-Aug-02	Dead Dog Creek	u/s view of large BT redd	
65	28-Aug-02	Dead Dog Creek	large BT redd at "fork" at top of spawning zone	
66	28-Aug-02	Dead Dog Creek	d/s aerial view of BT redd at "forks" at top of spawning zone	
67	28-Aug-02	Dead Dog Creek	d/s aerial view of BT redd at "forks" at top of spawning zone	
68	28-Aug-02	Dead Dog Creek	u/s aerial view of BT redd at "forks" at top of spawning zone	
69	28-Aug-02	Gathto Creek	BT angled from Gathto Creek at mouth of side channel	
70	28-Aug-02	Gathto Creek side channel	d/s aerial view	
71	28-Aug-02	Gathto Creek side channel	d/s aerial view	
72	28-Aug-02	Gathto Creek side channel	Gathto Creek mainstem and side channel - view north	

IMAGE #	DATE	LOCATION	VIEW	COORDINATES
73	28-Aug-02	Gathto Creek side channel	aerial view of side channel confluence d/s of spawning channel	
74	7-Sep-02	Dead Dog Creek	BT redds	
75	7-Sep-02	Dead Dog Creek	BT redds	
76	7-Sep-02	Dead Dog Creek	u/s aerial view of superimposed BT redds	
77	7-Sep-02	Gathto Creek side channel	BT redd	
78	7-Sep-02	Crehan Creek tributary	BT redd	
79	7-Sep-02	Crehan Creek tributary	multiple BT redds under overhanging willows - view east	
80	7-Sep-02	Crehan Creek tributary	aerial view of BT redd	
81	7-Sep-02	Crehan Creek tributary	aerial view of BT redd	
82	7-Sep-02	Crehan Creek tributary	aerial view of BT redd	
83	7-Sep-02	Crehan Creek tributary	d/s aerial view of BT redd	
84	7-Sep-02	Crehan Creek tributary	aerial view of redds near LWD, undercut bank, deep pool	
85	7-Sep-02	Crehan Creek tributary	aerial view of BT redd	
86	7-Sep-02	Gathto Creek side channel	BT redd	
87	7-Sep-02	Gathto Creek side channel	d/s view of BT redd site	
88	7-Sep-02	Gathto Creek side channel	BT redd	
89	27-Aug-02	Crehan Creek tributary	700mm male bull trout	
90	27-Aug-02	Crehan Creek tributary	700mm male bull trout	
91	27-Aug-02	Crehan Creek tributary	605mm spent female bull trout	