Lakelse Lake Sockeye Rehabilitation Program:

Spawning Channel / Improved Spawning Habitat Project

Prepared for:

The Pacific Salmon Commission
600 – 1155 Robson Street
Vancouver, British Columbia
V6E 1B5

Compiled by:

Department of Fisheries and Oceans Canada
North Coast Resource Restoration Unit
Sandra Devcic, P.Eng., a/Restoration Engineer
Lana Miller – Restoration Biologist
North Coast Area Resource Restoration Unit
Oceans, Habitat and Enhancement Branch

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Executive Summary

Progress was made on four proposed projects in the Lakelse watershed in 2008/09 intended to improve spawning and incubation habitat for declining sockeye populations.

Feasibility studies for the Scully 'flow augmentation' project continued including a detailed topographic survey of a potential diversion route, additional reconnaissance of the route and diversion location as well as conceptual design sketches. The next phase will involve finalising desired flow regimes, pipeline diversion location and cost estimates as well as partner/stakeholder consultation.

Four pilot spawning platforms were installed on the Mount Layton Hotsprings property in Scully-Mid Channel and an incubation study was conducted to assess incubation survival in the imported gravel compared to two control sites. The gravel itself was assessed through sieve analysis at the time of installation and after one year. Incubation studies indicated that egg/alevin survival was poor in the spawning platforms and in the control site just upstream of the gravel placement. Incubation survival was better in the control site in Scully South Channel (the former mainstem which is now fed entirely by subgravel flows). It was hypothesised that siltation of gravel additions may have contributed to poor intergravel flows and subsequent incubation mortality. Hydrogen sulphide was detected (by odour) which may also have impacted egg survival. No further gravel additions are planned for this reach of Scully Creek.

Several test pits which had been monitored for ground water quality and quantity were connected via excavation of a 'test ditch'. The channel was then connected to existing downstream off-channel habitat. The increase in habitat from the new ditch as well as the increase in flows to downstream habitat have greatly improved the amount and quality of off-channel ground water habitat in this reach of Williams Creek. Coho and cutthroat juveniles were trapped in the new habitat and several coho redds were also documented.

The continued feasibility of a larger extension of the channel, with possible intake addition to improve flows and access were continued. Additional test pits were excavated and monitored over a 500m length of proposed (future) channel. Water quality appeared to be good in the test pits, however depth of groundwater was somewhat deep in a couple of the pits, indicating that the channel would likely have to be augmented with surface flows via an intake. The channel was surveyed and a potential intake site identified.

Acknowledgements

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North Coast DFO personnel directly involved included:

Don Hjorth - Resource Restoration Engineer
Lana Miller - Resource Restoration Biologist
Sandra Devcic – Restoration Engineering Technician
Darren Chow – Acting Resource Restoration Biologist
Margaret Kujat - Biological Technician & Lakelse Sockeye Recovery Plan Coordinator,
Rob Dams – Community Advisor
Mitch Drewes - Habitat Technician
Gavin Grubb – Biological Technician, Smithers
Matthew Jarnigan – Biological Technician, Terrace
Stephen Leask – YMCA Intern with the Resource Restoration Unit
Steve Cox-Rogers – Sockeye Biologist, Stock Assessment.

Additional assistance was provided by:

Chris Broster, Ministry of Environment – advice and assistance
Mike Leggat, Ministry of Environment – flow and water quality monitoring, assistance with incubation study data collection

Other personnel involved included:

Ongoing support and assistance from members of the Lakelse Lake Watershed Society based out of the Lakelse Lake area, including Ian and Wilma Maxwell, Ken Fraser.

Ken Simons from Ken’s Trucking, for the provision of gravel for spawning platforms.

Ernie Kuehne and John McAlpine from Nechako Northcoast Construction for spawning gravel placement.
Terry Montague from T. Montague Contracting for test pit and test ditch excavation.

Esther Guimond for designing and conducting the incubation study.
Jordan Beblow of Cambria Gordon Ltd. for assisting with the incubation study.

Bert Orleans and Al Moler at Mt. Layton Hotsprings for keen interest, support and generous access to the site at all times of the year. Also for snow clearing to permit access to the spawning platforms in winter.

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1.0 Introduction

In recent years, sockeye recruitment in the Lakelse system has fallen dramatically, due partially to reduced and degraded spawning habitat in the major spawning tributaries to Lakelse Lake (DFO, 2006). A recent sedimentation study of Williams Creek (the main sockeye spawning tributary) suggested that the causes of reduced spawning habitat are a combination of ongoing flood scouring each fall and continued sedimentation/siltation of historic spawning grounds from combined human (logging) and geological activity. Other tributaries are affected by flow diversions and beaver activity. The Lakelse Sockeye Recovery Team believes that spawning habitat enhancement may be one of the most suitable options to increase fry recruitment to the lake. As a result, a multi-year approach was developed to systematically increase spawning habitat and productive capacity in the Lakelse watershed over several years, with the long term goal of providing quality spawning habitat to support 4-7 thousand adults in Scully and 20-30 thousand adults in Williams Creek.

Fisheries and Oceans Canada has lead the implementation of the projects to date which started with a literature review and summary of past impacts, assessments and projects in 2006/07 (Rabnett, 2008). The resulting report identified and prioritized opportunities for improving sockeye spawning habitat in tributary streams to Lakelse Lake that currently or historically supported sockeye populations. In 2008, several of those opportunities were developed and monitored:

- Pilot spawning platforms were installed and monitored in Scully Mid (Hotsprings Channels) to try to improve degraded spawning habitat that appeared to have poor spawning substrates and incubation survival in previous studies (Fisheries and Oceans, 2002).
- Test pits and a test ditch were excavated in Williams Creek to ascertain ground water quality/quantity and substrate quality in potential side channel opportunities to create stable off-channel spawning habitat for sockeye in an unstable reach of this system.
- A study to examine the feasibility of diverting some surface water flows from Scully Mid Channel (mainstem) back to Scully South (former mainstem and current groundwater channel) was initiated.

1.1 Scully Mid Channel Spawning Platforms and Monitoring

The current mainstem of Scully Creek consists of a higher gradient confined system that spills onto a highly impacted fan where gravel aggradation results in braiding and instability for approximately one kilometre before water flows into a low gradient wetland area. Flows become confined again before crossing Highway 37 South and into two constructed channels (Scully Mid and Scully North) on an agricultural property known as the Mount Layton Hotsprings. Both channels are dominated by marine clay substrates and lack much gravel for spawning salmon. The channels are impacted by eroding banks and a lack of intact riparian vegetation (Triton, 1996). Past sampling of redds seemed to indicate that incubation survival in these channels was very poor (Fisheries and Oceans, 2002). Several log weirs were installed in Scully Mid Channel many years ago by the landowner to try to improve fish habitat and reduce bank erosion (Triton, 1998). Some of the log weirs are still functioning and were considered good potential control structures to slow the downstream migration of gravel additions. This pilot project involved adding spawning gravel just upstream of four of the most suitable weirs to see if it would create favourable spawning habitat. In order to verify the results expected, an incubation study was conducted during the fall and winter of 2008/09. Gravel sampling also took place at the time of gravel installation (July 2008) and at the end of the spawning season (March 2009) to examine gravel quality and the potential contribution to incubation success.

Photo 1 – Lakelse Lake, looking North towards agricultural fields and constructed channels of Scully Mid and Scully North. Scully South groundwater channel (former mainstem) in foreground with intact riparian.

1.2 Williams Creek Test Ditch and Test Pits

Williams Creek is the largest of 13 Lakelse Lake tributaries historically supporting up to 80% of Lakelse Lake sockeye with returns recorded up to 50,000 in 1945 and averaging over 10,000 from 1933 to 1968. A decrease in returns to numbers averaging 1-2000 has been recorded since this time. This decline appears to be largely the result of extensive logging throughout the watershed including logging of riparian areas and active channel crossings. Large flood events occurred during and post logging which resulted in increased sediment accumulations of 73,000 ± 6,000m^3/yr (Rabnett, 2008). While these excessive sediment loads have now largely been transported by natural river flows into Lakelse Lake and riparian recovery is ongoing, lack of suitable stable spawning habitat continues to be the main factor limiting sockeye production in Williams Creek.

The Lakelse Sockeye Spawning Habitat Rehabilitation Study conducted by Rabnett in 2007-08 identified Reach 3 of Williams Creek (Upper Williams Creek) as extending from 1.9 km upstream of the confluence of Williams Creek and Sockeye Creek for 2.9 km., ending just above the Old Lakelse Lake Road bridge. This area used to support spawning sockeye but is currently dominated by cobble/boulder substrate and several unstable areas of braided channel and bank failures (Biolith, 1998). Investigations of several groundwater sites in the area of this reach were determined to have potential for the development of more stable off-channel spawning habitat, pending further study. This phase of work involved the excavation of a groundwater-fed test ditch and several groundwater test pits to evaluate subsurface potential and the feasibility of creating a surface-water fed side channel.

Photo 2 – Lakelse Lake – Looking North in spring towards mouth of Williams Creek at top right.

1.3 Scully Flow Augmentation Feasibility

As stated above, the current mainstem of Scully Creek consists of a higher gradient confined system that spills onto a highly impacted fan where gravel aggradation results in braiding and instability for approximately one kilometre before water flows into a low gradient wetland area. Flows become confined again before crossing Highway 37 South and into two constructed channels on an agricultural property (Scully Mid and Scully North). Historically, the wetland area and downstream habitats received only high water overflow and some subgravel flows with the majority of surface water flowing into the most southern-channel, Scully South. Impacts to the fan (logging, linear development) have resulted in the complete diversion of all surface flows towards the agricultural property with only subgravel flows feeding Scully South.

Both Scully Mid and North are dominated by marine clay substrates and lack much gravel for spawning salmon. Past sampling of redds seemed to indicate that incubation survival in these channels was very poor (Fisheries and Oceans Canada, 2002). Incubation studies in Scully South seem to indicate that incubation survival is good, however the lack of flushing surface flows has resulted in significant beaver activity in that watercourse. Access to spawning habitat in some years is limited and the beaver dams result in flooding and silting of formerly productive spawning areas. Additional flows to Scully South may improve flushing of fine sediments, reduce beaver activity and increase attraction flows for sockeye to better spawning habitat. A study to determine the feasibility of diverting some flows from the existing surface water channel back to Scully South was initiated.

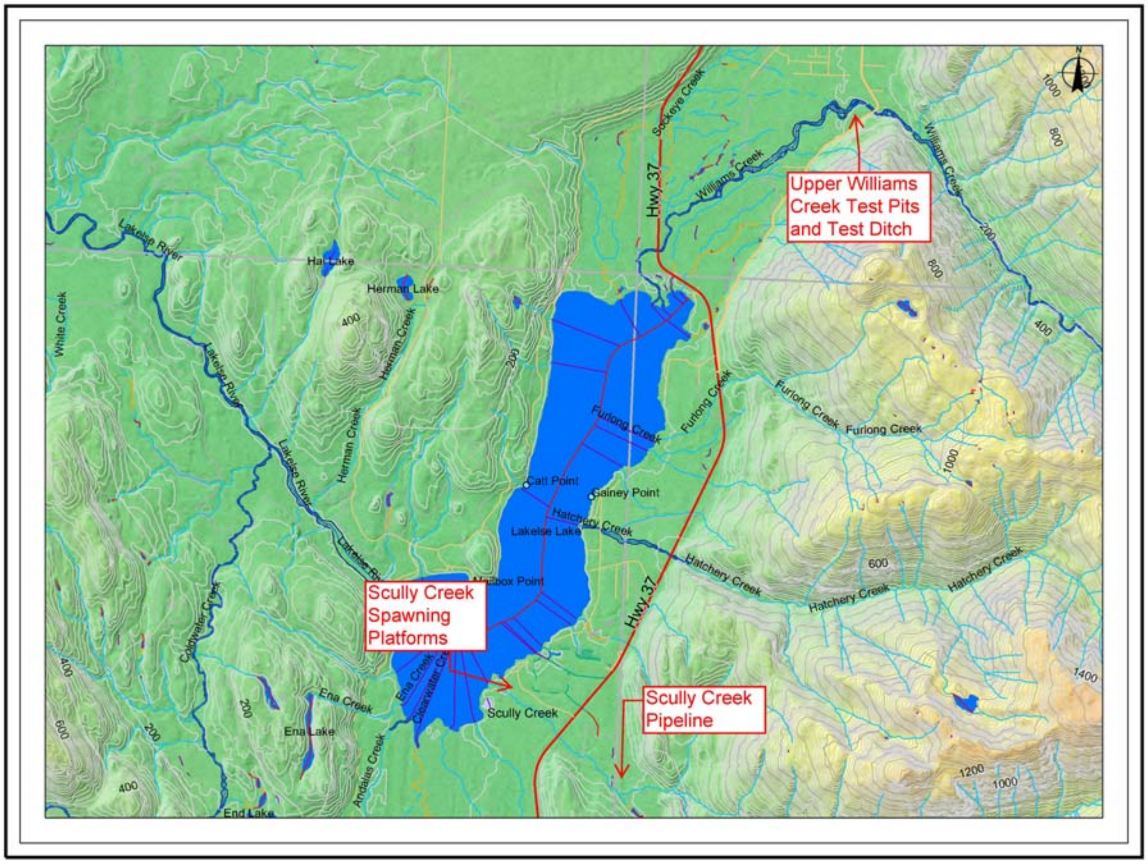

Figure 1: Lakelse watershed map showing project locations.

2.0 Methods

2.1 Scully Mid Channel Spawning Platforms Construction

On April 1, 2008, Allnorth Consultants Ltd. completed a site survey of Scully Mid Channel in the area of proposed spawning platform development using a total station survey instrument. The survey started at the Highway 37 North crossing and continued downstream for approximately 750 meters, collecting data such as gradient and log weir locations and installing survey points for future reference. On June 25, 2008, DFO staff conducted initial reconnaissance along this same length of stream to identify potential pilot gravel placement sites based on water depth, gradient, bank stability, equipment access, existing substrate and condition of the downstream log weir. Sites were then assessed to be poor, moderate, good or excellent candidate sites.

In late July 2008, screened and washed spawning gravel provided by Ken's Trucking was installed in the four selected locations in Scully Mid Channel by Nechako North Coast. The grading limits for the screened spawning gravel were to meet the specifications outlined in Table 1. Prior to placement in the creek, samples of the gravel were sent to a geotechnical testing laboratory for washed sieve analysis, to ensure the grading limits were within the requested specifications. The test results would also be used as a baseline to assess the accumulation of fines in the gravel over time and the potential impacts on the survival of salmon eggs/alevins.

Grading Limits for Spawning Gravel

Sieve Size [Square Opening]	Total Passing Sieve Percent by Weight
75mm[3in]	100%
50mm[2in]	75% - 85%
38mm[1 1/2in]	50% - 75%
25mm[1in]	30% - 50%
20mm[3/4in]	10% – 30%
12mm[1/2in]	0% - 10%

Table 1 - Sockeye Spawning Gravel Specifications

A filter cloth weir was constructed downstream of the four sites to attempt to slow any fine sediments from entering downstream habitats during gravel installation. Site isolation and salvage were not conducted due to the relatively high velocities in the channel and the inability to maintain isolation fences for the duration of construction. The timing window for instream work was intended to coincide with the least risk for fish present.

No alterations were made to the streambed prior to gravel placement, but each of the log weirs at the downstream end of the four selected sites were examined to ensure they were stable and likely to hold gravel in place for a number of years. One log weir required some additional rock support which was placed downstream of the weir and along the right bank at the time of gravel placement.

A road adjacent to the right bank of the creek on the edge of an agricultural field was used for machine access. A small amount of brushing was conducted at ~6 locations and gravel was stockpiled adjacent to the creek at each location by a dump truck and then placed in the creek with the excavator. A survey level, rod and marked stakes were used to monitor gravel depth. Gravel was placed using an excavator operated by John McAlpine of Nechako Northcoast Construction to an average depth of approximately 0.4 meters. After construction, an asbuilt survey of the four pilot spawning platforms was conducted by Allnorth Consultants using a total station survey instrument.

Photo 3 - Gravel being placed in Scully Mid-Channel by excavator.

2.1.1 Scully Spawning Platforms Incubation Study

In the fall of 2008, an incubation study was initiated by consultant Esther Guimond from Vancouver Island and local DFO staff with help from BC Ministry of Environment intern, Mike Leggatt and Terrace-based biological contractors Jordan Beblow (Cambria Gordon Ltd.) and Margaret Kujat. The study is detailed in a report by Esther in Appendix 4.

In summary, eight Jordan-Scotty cassette incubators with 100 eggs per cassette were buried at four sites for a total of 32 cassettes. Two of the three sites (Site 2 and 3) in Scully Creek Mid-channel were located on the recently constructed spawning gravel platforms, while the third site in Scully-Mid (Site 4), and the site in Scully south channel (Site 1) were located in unenhanced 'natural' spawning gravel as control sites. Assessment of incubation success was checked during two stages: 12 weeks after installation at the hatching stage; and 25 weeks after installation at the fry/emergence stage. For each assessment of incubation success, four cassettes from each incubation site were removed and assessed. Cassettes were not replaced in the gravel after assessment due to the amount of disturbance that would be required to excavate and replant the incubators.

Photo 4 - Scully Creek - loading cassettes with eggs.

Photo 5 - Scully Creek - installing cassettes into the streambed.

Water column and intergravel water quality parameters were assessed during four environmental monitoring visits to the four incubation sites – December 2, 2008, January 7/8, March 12, and April 7, 2009. Water column and intergravel dissolved oxygen, conductivity, pH, as well as water depth and velocity were measured at each of the four incubation sites.

2.1.2 Scully Spawning Platforms Gravel Sampling

In an attempt to capture the rate of sedimentation of the newly installed gravel, sampling and analysis was required before and after installation. Gravel samples were taken from the material before it was placed in the creek in July 2008 and then the gravel was sampled again in March 2009 to coincide with the end of the incubation study. When the gravel was placed in July 2008, the new gravel was sampled after it was stockpiled on site. The sampling technique employed was that used by BC Ministry of Transportation to sample large gravel stockpiles. The undisturbed areas were exposed (the center of the pile), then a shovel was inserted horizontally to withdraw the sample. This method tends to maintain the sample in as representative a state as possible. Nine samples were collected in total and delivered to McElhanney Consulting Services in Terrace BC for washed sieve analysis. For the March sampling, DFO staff built a freeze core sampler that was able to collect intact/complete substrate samples underwater. The sampler used pressurized CO2 injected into a probe submerged in the gravel. The pressurized CO2 froze a large sample of substrate to the probe which was then removed from the streambed and collected into a bag. Eighteen samples total were collected from all four pilot spawning platforms and the two control sites (three from each site). All samples were independently analyzed by a local geotechnical lab using washed sieve analysis.

Photo 6 - Scully Creek - freeze core sampler at one of the spawning platforms.

Photo 7 - Scully Creek - freeze core sampler with intact sample frozen to probe.

2.2 Williams Creek Test Pits and Test Ditch

Earlier assessments had identified three relic channels in reach 3 of Williams Creek located approximately 3km from the mouth and in the vicinity of an active groundwater channel. Test pits were excavated in February 2008 in ~100 meter intervals in the three relic channels to examine substrates, groundwater quality and quantity. Terry Montague of T. Montague Contracting used an excavator to dig each test pit to a depth of approximately three meters. Substrate layers were recorded/described based on dominant materials (organic/duff layer, sand/gravel, etc). Depth of groundwater was measured using survey rod and dissolved oxygen and temperature were measured using an Oxyguard meter. Four-inch perforated PVC pipe was installed in the center of each pit and excavated material was back-filled into the pit. Water levels, dissolved oxygen and temperature were monitored periodically throughout the year using the Oxyguard Handy Polaris Meter.

In February 2009, several successful test pits were connected via a 'test ditch' to better monitor flows and water quality. A 4 meter 'plug' of undisturbed ground was retained at the downstream end of the proposed test ditch to provide a buffer between the channel excavation and downstream fish habitat. The channel was excavated 2.5 to 3 meters deep and approximately 0.5 meters into the water table for ~200 meters in an upstream direction parallel to Williams Creek. Excavated material was spread throughout the forest floor adjacent to the channel on both right and left banks. The channel was graded to approximately 0.3% and complexed with fallen large woody debris. One deeper pool was also excavated to provide some deeper cover and rearing habitat. At the end of the channel construction, the test ditch was connected to an existing groundwater channel that flows into a Williams Creek side channel. Disturbed soils were seeded with a local erosion mix in April, 2009.

After the channel excavation, five additional test pits were excavated along a proposed surface water channel route from the upstream end of the new test ditch upstream towards Old Lakelse Lake Road bridge on Williams Creek. The test pits were placed ~100 meters apart and excavation was discontinued when no water was found at a ~3m depth in the last 2 test pits. Later sampling indicated that at certain times of year, ground water levels were high enough to be measured in these originally 'dry' test pits.

The relic channels, test pit locations, test ditch and proposed surface water channel were surveyed by Allnorth Consultants in the spring of 2009 using a total station to document the channel as built and provide data necessary for the potential development of a surface water channel with intake on Williams Creek.

Photo 8 - Williams Creek - Typical test pit along proposed surface water channel route

2.3 Scully Flow Augmentation Feasibility

In order to assess the watershed and begin to establish a route that would be suitable for a stable diversion of flows from Scully mainstem to Scully South, existing information from maps and air photos of the area as well as previously collected hydrology data (Fisheries and Oceans, 2005) were examined. The diversion required a stable location to avoid frequent maintenance and to maximize the chances of success. Because there had been significant industrial activity and instability on the fan, a site close to the fan apex was selected. The site and route was examined on the ground on several occasions in 2008 and 2009.

Average flows in Scully South were collated using data collected from Mike Leggat in 2008 and 2009 (Leggat, 2009)) and unpublished data collected by DFO staff over the years. A preferred flow was determined based on Hwy culvert capacity, channel capacity and desired spawning velocities (Slaney and Zaldokas, 1997).

Once an intake site and proposed route had been selected for the proposed pipeline, McElhanney Consulting Services was contracted to survey the route and pick up the preliminary topography so that the pipeline could be conceptually sketched. Due to the time of year and thickness of the brush in spots, a total station was used to collect the survey data, and AutoCAD was used to draft the plans and profiles that were later marked up by hand by Don Hjorth (see Appendix 3).

3.0 Results

3.1 Scully Mid Channel Spawning Platforms Construction

Based on the Allnorth Consultants site survey of Scully Mid Channel and DFO reconnaissance along this same length of stream to identify potential pilot gravel placement locations, four candidate sites were selected for the pilot spawning platforms. The plans that were used to identify the sites are shown in Figures 2, 3, 4 and Table 2.

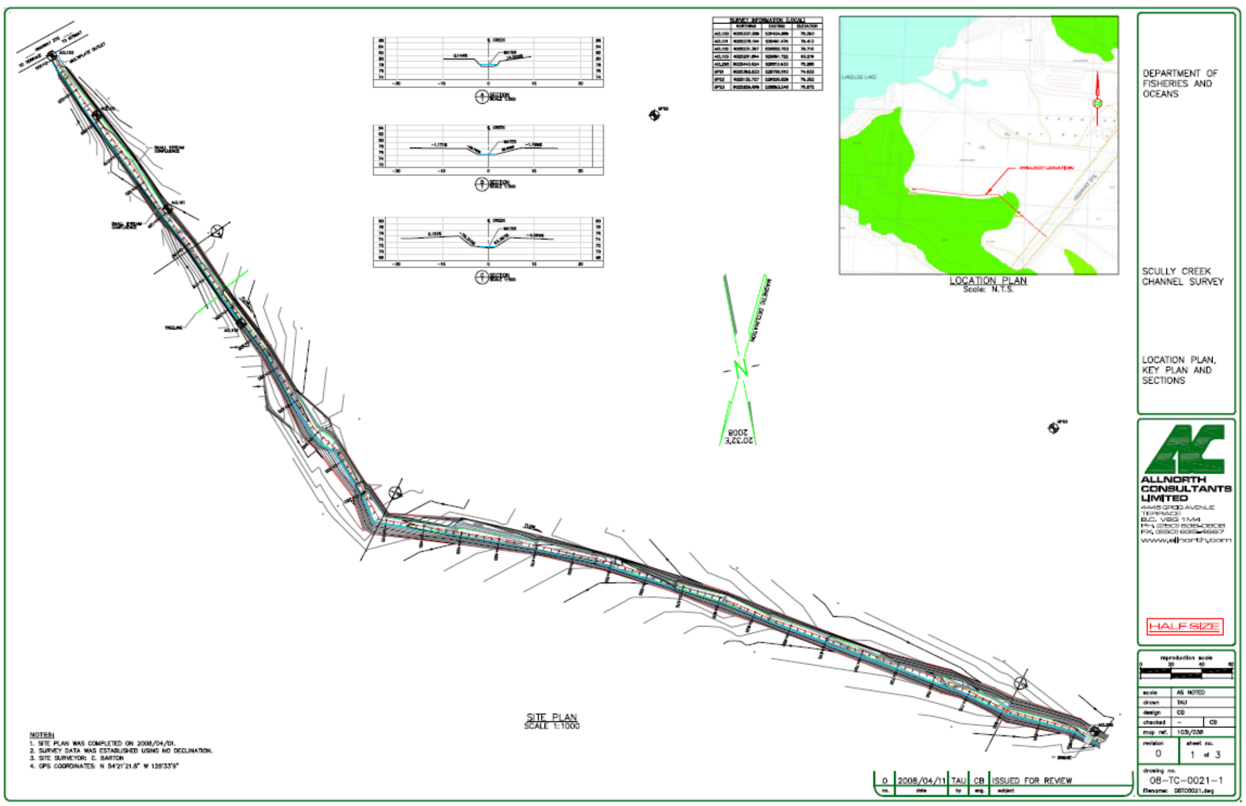

Figure 2 – Allnorth site survey plan view of Scully Mid Channel (or Hotsprings Channel)

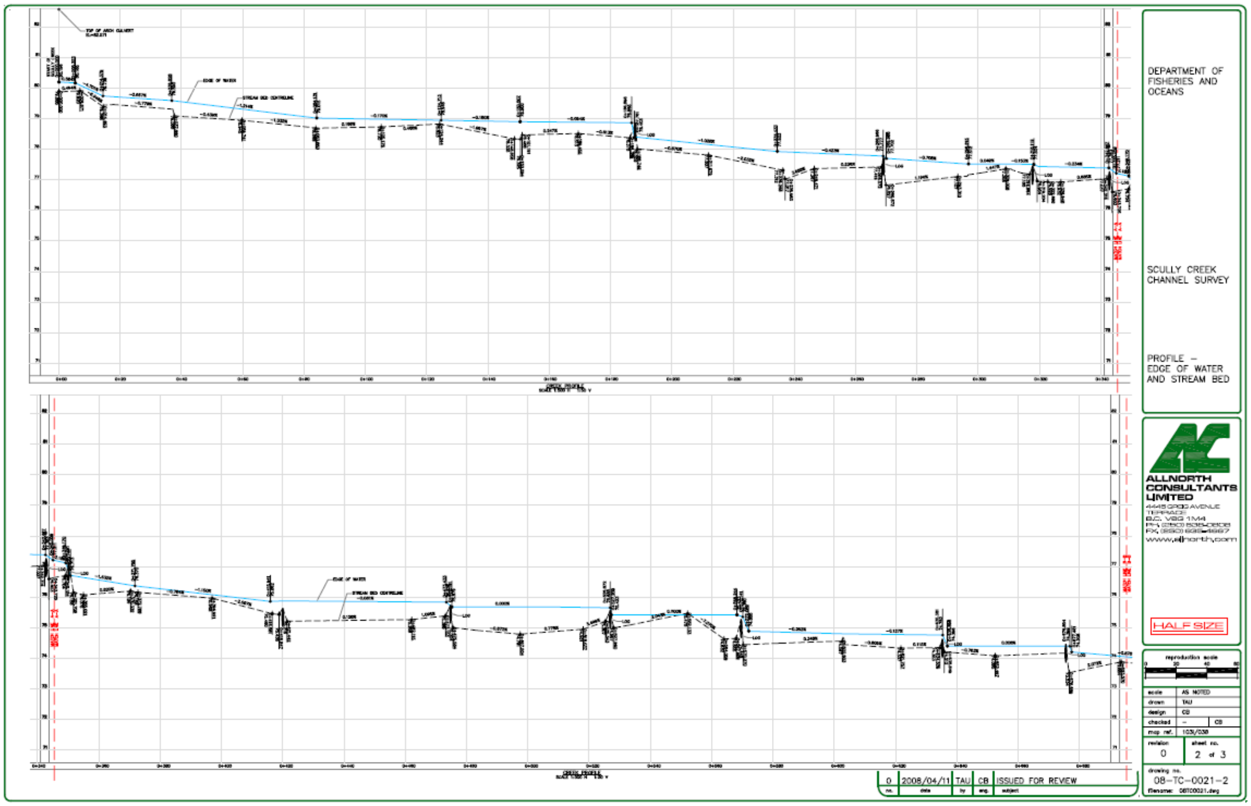

Figure 3 – Scully Mid-Channel stream profiles from 0+00 to 0+690

Figure 4 – Scully Mid-Channel stream profiles, 0+690 – 0+890

Scully Mid-Channel (also called Scully Center Channel) Potential Gravel Placement Sites 25-Jun-08			
Allnorth distance from Hwy 37S	Site length	Site rating for gravel place't	Comments
628 to bridge		poor	fast, narrow, steep gradient, shallow in parts, failing banks
599-628	**29m**	**good**	**loose sand, some clay**
566-599		poor	fast, cobble substrate, no intact log
524-566m	**39m**	**Good**	**sand substrate, intact log at 566m**
512-524	12m	good	Good/ok site to intact log - but short (12m)
473-506			steep gradient (+2% to -7%) - requires re-grading
418-473m	**55m**	**Excellent**	**Nice glide, deep enough for gravel and good access**
381-418m		poor	
381m			rock/filter cloth weir is recommended to reinforce log and keep gravel from potentially going under the log
351-381	**30m**	**excellent site**	**log intact at downstream end, but see comment above**
351m			intact log with a big drop
325-342m	**17m**	**good**	**Nice site, but small**
316-325			Huge pool, too deep to fill
286-316	**30m**	**good**	**Nice site, but part of section is too shallow, sandy substrate**
275m			rock weir
240-269m	29m	ok	potential reach, intact log at 268m
222-240		poor	
203-222m	19m	ok	possible site but deep pool at 222m (would eventually fill with gravel)
203m			top of Bert's field
0-203m		Poor	Steep gradient, poor access (intact riparian)

Table 2 – DFO reconnaissance notes regarding potential gravel placement sites.

The selected sites are labelled by chainage, and were ranked in order of pilot spawning platform potential. A record of the reconnaissance is found in Table 1. Site 1 is 0+420 to 0+475, Site 2 is 0+351 to 0+381, Site 3 is 0+527 to 0+570 and Site 4 is 0+599 to 0+635.

Over a period of four days, gravel was placed at each site to a depth of 0.4 meters on average. The pilot gravel placement at all four sites totalled approximately 1120 square meters of enhanced spawning habitat.

Photo 9 - Scully Creek - physical appearance of spawning platform gravel placed in the creek.

Photo 10 - Scully Creek - reinforced log weir at downstream end of one of the spawning platforms.

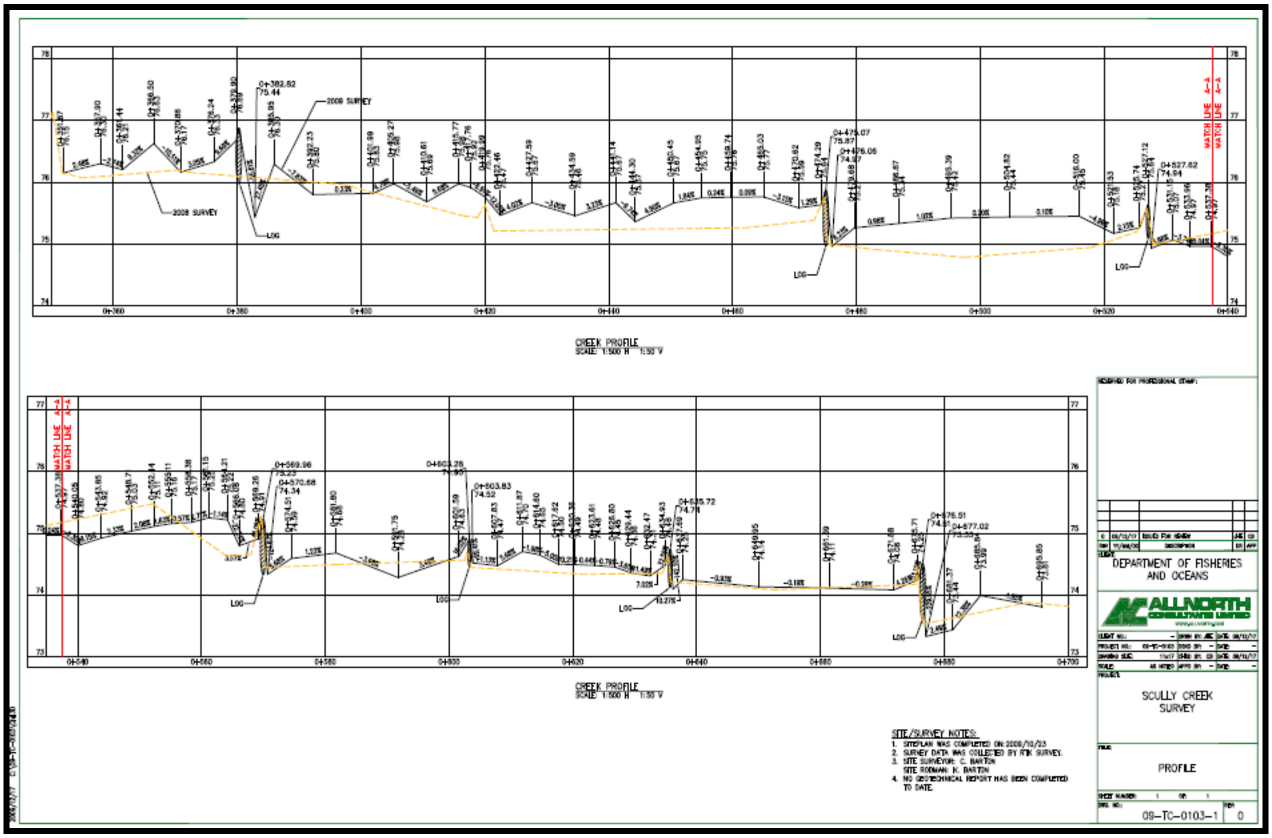

Figure 5 – Pre and post gravel placement profiles in Scully Mid Channel.

3.1.1 Scully Spawning Platforms Incubation Study

Results of the incubation study are documented in detail in Esther Guimond's report in Appendix 4. The following is a brief summary of the results and discussion from that report.

The main objective of this study was to determine the effectiveness of the gravel additions to the mid channel of Scully Creek for Sockeye salmon spawning. Based on results from incubation assessments in recently constructed spawning gravel placement projects in other areas, it was expected that there would be a high incubation survival due to the high quality of the introduced gravels (Guimond 2006, 2007). Our results for the Scully Creek study showed poor survival rates overall with mean survival for the eyed egg-to-hatch stage ranging from 0 - 44.8% (Figure 6). Eyed egg-to-fry survival was much poorer with a range from 0 - 12%. Most of the mortality in the individual incubation cassettes was at the eyed egg stage. The high survival for the eyed eggs incubated at Snootli hatchery (the source of eggs for this study) eliminated any uncertainty in egg survival due to egg viability.

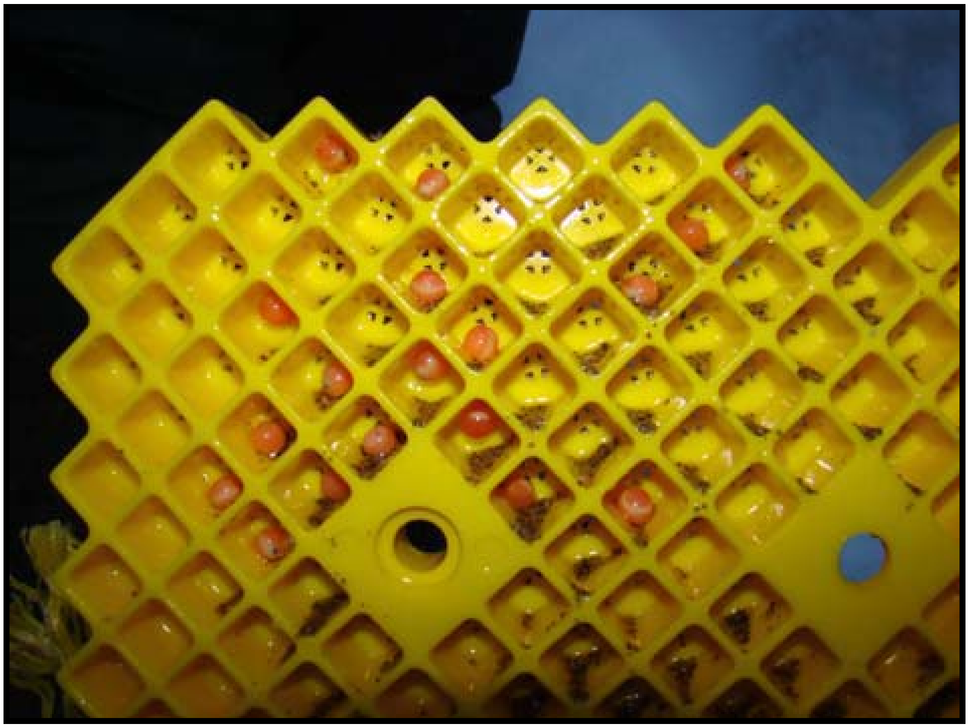

Photo 11 - Scully Creek - removed cassette showing dead eggs and some fines.

Survival for eyed egg-to-hatch and eyed egg-to-fry was greatest at the 'control' Site 1 (Scully south) while survival for the two developmental stages was poor at all three incubation sites in Scully mid channel. There was no significant difference among sites (ANOVA, $\alpha = 0.05$) for the eyed egg-to-fry-stage, however survival at Site 1 was significantly different than at Site 2 for the eyed egg-to-hatch stage (Tukey-Kramer comparison of means test; $\alpha = 0.05$). Interestingly, the cassettes that had the greatest survival to hatch at South Scully (Site 1) were located in a shallow riffle area that had a high amount of fines but significant downwelling of surface water to the hyporheic environment. Therefore, this may have offset some of the negative effects of the low permeability from the high percentage of fines at this site.

During the first incubation assessment at the hatch stage (January), a sulphurous odour (i.e. rotten egg smell) was noted when some of the incubation cassettes were removed from the gravel, particularly at Site 2. Hydrogen sulphide (H_2S) is a highly poisonous and soluble gas and an indicator of anoxic conditions. Due to the toxic nature of H_2S, additional water quality monitoring and water sample collection at the Scully mid channel spawning gravel pads should be conducted to determine whether H_2S may have been a contributing factor to the poor incubation survival observed during the incubation assessment.

While it is dissolved oxygen that is the essential parameter for embryo survival and development, the function of the hyporheic environment to deliver the oxygen to the embryo and remove metabolic waste products also plays a key role (Coble 1961). In other words, incubation survival can be poor in situations of both low dissolved oxygen but high apparent velocity, and in high dissolved oxygen but low apparent velocity. Low DO measurements (at or less than 6 mg/l) were recorded at the four incubation sites on the final incubation check.

3.1.2 Scully Spawning Platforms Gravel Sampling

The results of the substrate composition assessed in April 2009 in the spawning platforms suggest that the amount of fines at all sites could have reduced incubation success. Analysis of the spawning gravel showed an increase in the amount of fines at the two spawning pads (Sites 2 and 3) during the incubation period. A more detailed reporting of the results of the analysis can be found in Appendix D of the Incubation Study which can be found in Appendix 4 of this report.

Analyzing the hydrographs generated from stream discharge rating curves showed two extreme flow events in Scully mid. The first event occurred on October 22, 2008 with a peak flow of 4.1 m^3/s and the second event, of similar magnitude, occurred on Nov 30/Dec 1, 2008. These two events were likely responsible for some scouring of the cassettes and piezometers and the deposition of sediment at some cassette locations observed at Sites 2 and 3.

3.2 Williams Creek Test Pits and Test Ditch

Three relic channels were found during initial site reconnaissance for possible off-channel spawning habitat development in Williams Creek. The channels were all in the vicinity of an existing groundwater channel in mature forest with some level of flood protection. In January 2008, test pits were dug in each relic channel and monitored intermittently over the remaining period of 2008. Dissolved oxygen, water temperature, water depth, water quality and substrate quality were examined during these visits.

After reviewing the data collected, one of the three sites was abandoned as a poor candidate for further development (little or no measurable groundwater). The test pits in the most downstream channel were subsequently removed (see Appendix 3 for survey drawings of the proposed channel options). The most promising site for future surface water channel development had additional test pits excavated and survey data collected upstream to the bridge across Williams Creek on Old Lakelse Lake Road. The best site for groundwater channel development was further developed into a test ditch and connected to a smaller groundwater channel flowing into Williams Creek. The excavated area was limited to 200 meters in length and ~2 meters in width as the groundwater table became too deep (~3m) for further channel development. Flows were estimated to range from ~0.5 to 2 cubic feet per second (cfs) and appeared to double downstream flows in the existing groundwater channel. The new habitat is characterized by excellent water quality and gravel substrates and some large woody debris for cover. Some minor sampling was conducted in the larger pool and over 30 juvenile coho and rainbow/steelhead trout were found. Several coho redds were also documented in the new channel in the fall of 2009.

Photo 12 - Williams Creek - Typical test ditch construction.

Photo 13 - Williams Creek - Juvenile salmonids sampled in the test ditch.

The channels and test pit locations were surveyed on several occasions by Allnorth Consultants Ltd. These surveys provide a record of topographic locations and elevations for future reference. The elevations of the proposed surface water channel in relation to the receiving waters downstream, potential intake location upstream and groundwater depth will be used to design the side-channel if deemed feasible.

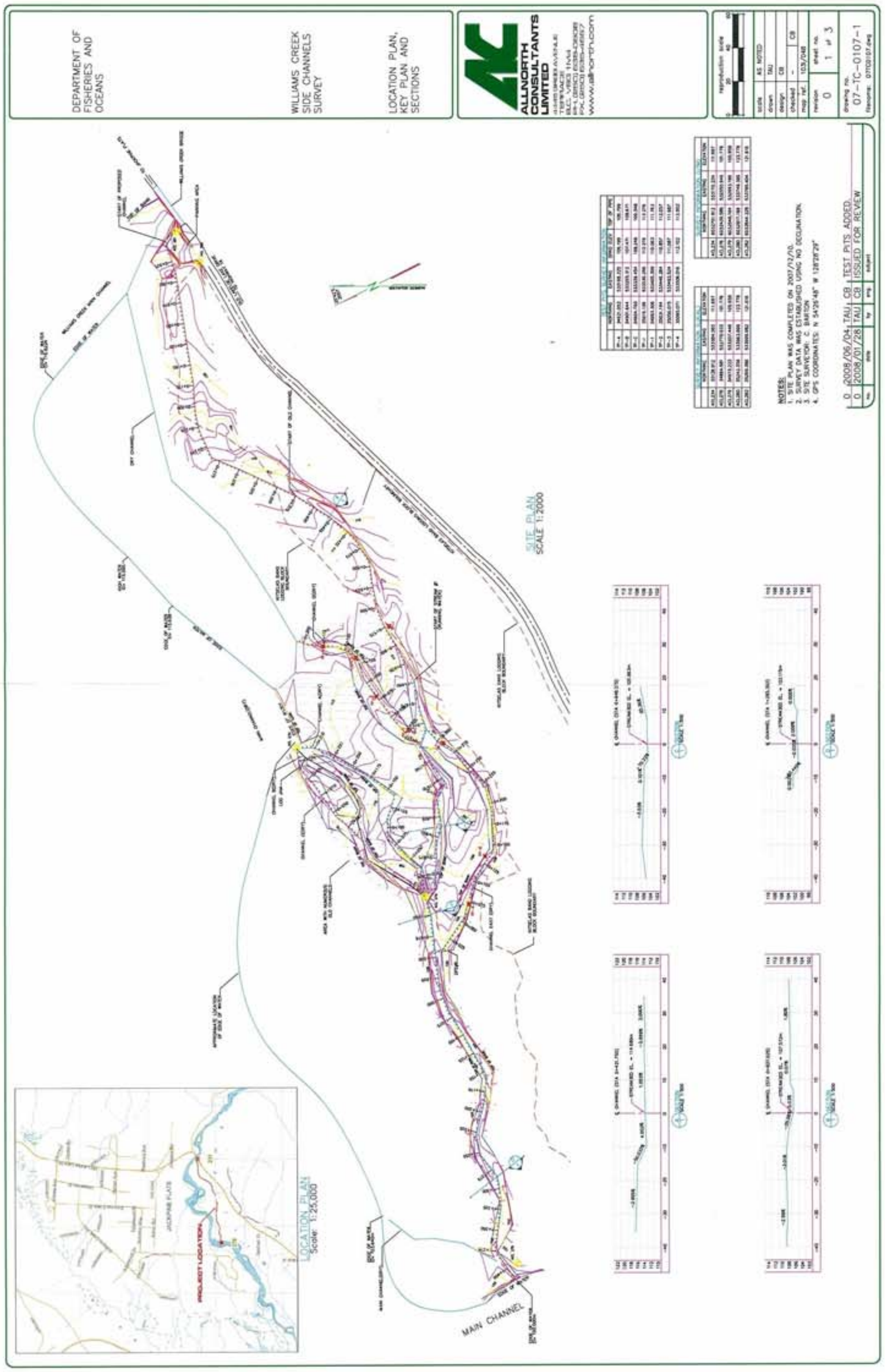

Figure 6 - Williams Creek – survey of relic channels, test pit sites & propose surface water route.

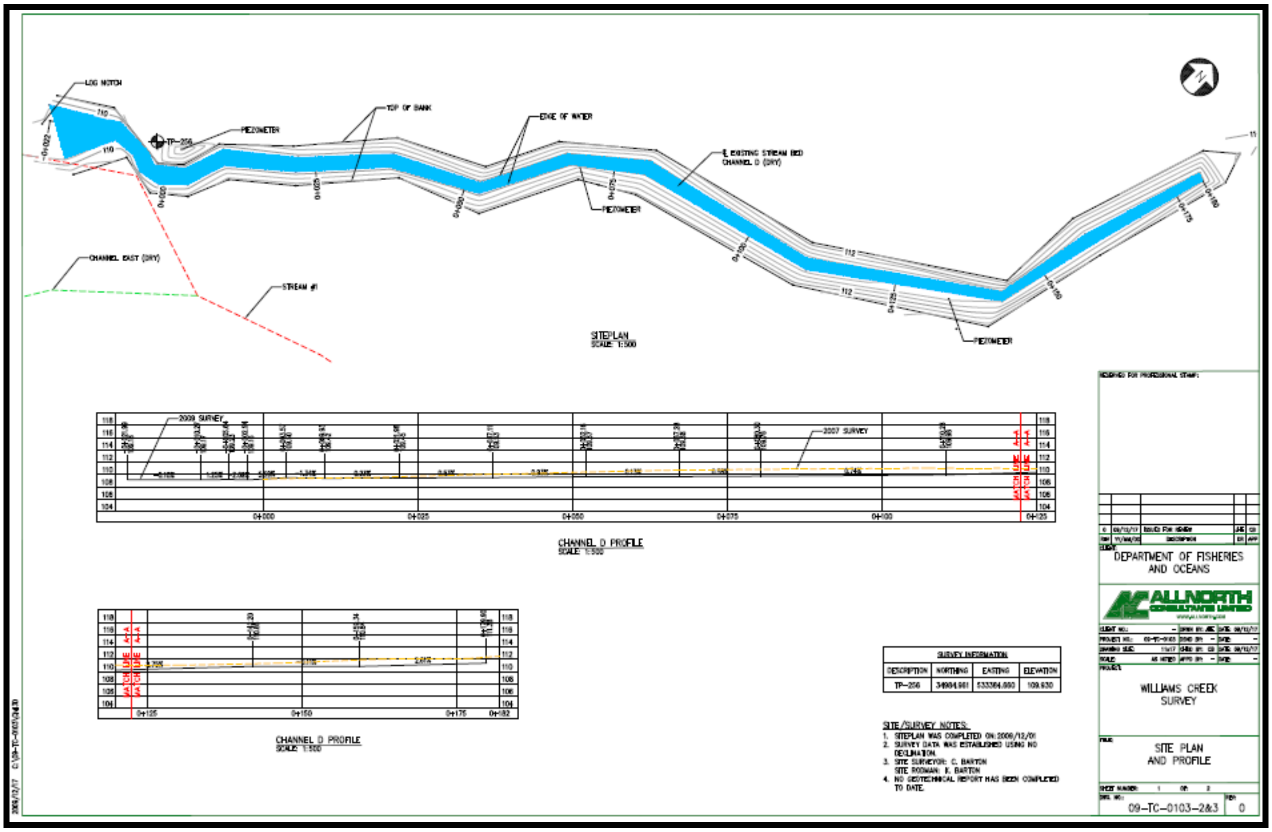

Figure 7 – Williams Creek as-built plan of the new test ditch.

3.3 Scully Flow Augmentation Feasibility

Once the drawings had been prepared, the grades and sections of pipe were sketched out as shown in Appendix 3. Several different sizes of pipe were considered, but the arrangement selected was intended to minimize cost and reduce maintenance. Although an above ground pipeline and open channel were considered, a subsurface pipeline was chosen due to the amount of recreational and industrial (gas pipeline, BC Hydro Right of Way) use in the area. The proposed manholes would allow for cleaning if necessary, and minimize vandalism.

The intake proposed is a custom design with flow control built into the system through the openings. The intent was to minimize the number of times that someone would need to go up to the site and remove or add covers to the structure. There is a lot of bear activity in the Scully Creek Watershed, so for safety reasons, the inlet was designed to be self regulating, only taking water from the system when flows reached certain elevations. Pipe anchors were added in sections due to the steepness of the system.

With additional information on prices, hydrology and finalizing the intake design and location, it is expected that minor revisions would be necessary, but further site investigation should be conducted in advance of any decision to view the locations following another freshet.

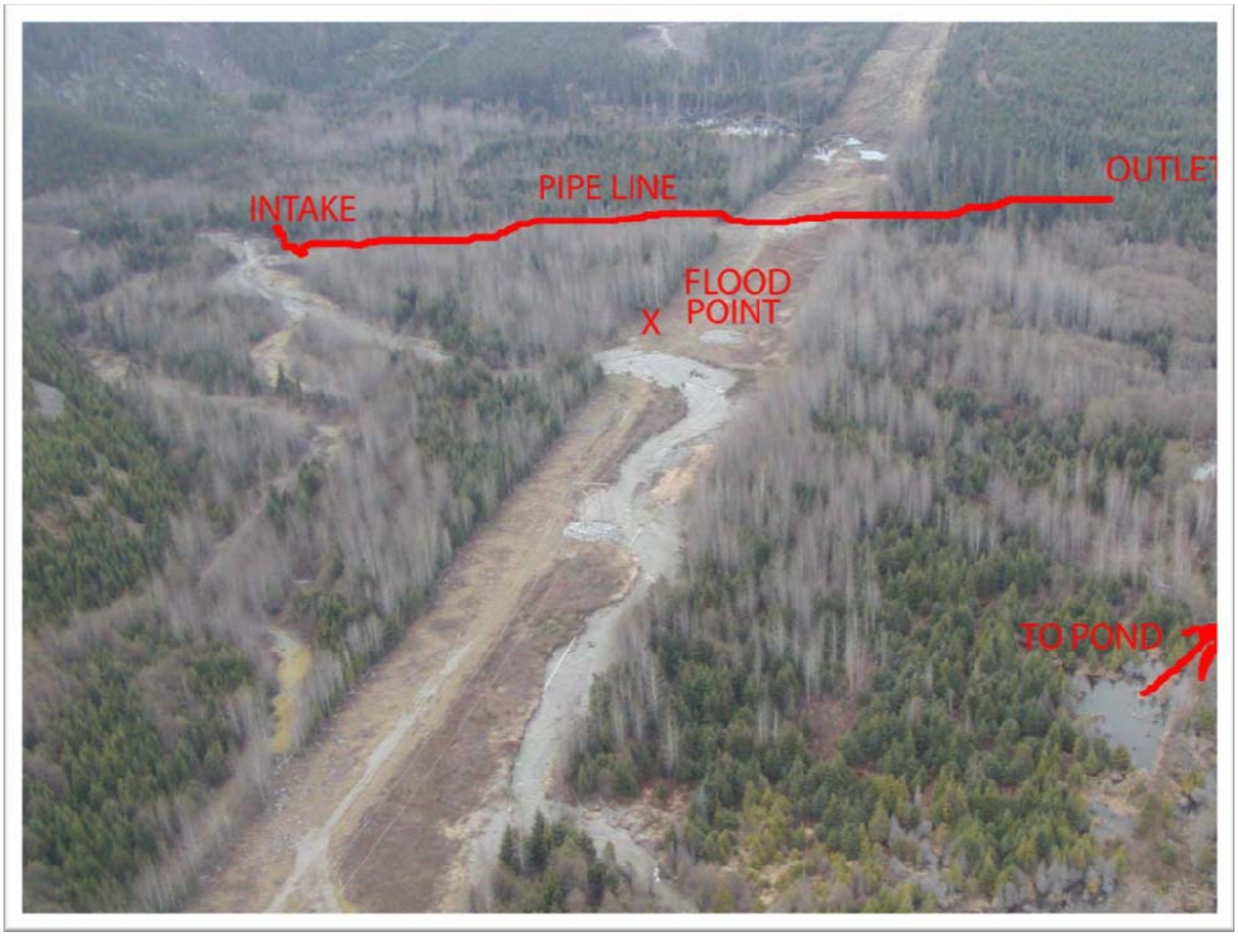

Photo 14 - Approximate location of proposed intake, outlet and pipeline route for the Scully Flow Diversion.

4.0 Discussion

The purpose of the projects outlined in this report are part of a multi-phase approach to improving spawning and incubation habitat in the Lakelse watershed, with the ultimate goal of improving fry recruitment and adult returns to this system. 120 square meters of new spawning habitat was created as part of a pilot program in the agricultural channels of Scully Creek.

Previous studies had indicated a lack of quality spawning gravel and low incubation survival in those channels. Log weirs installed by the landowner in the mid 1990's were used as downstream control structures for four experimental spawning platforms. Gravel was placed in the four locations and studies were undertaken to assess the success of this experimental technique. A topographic survey of the gravel sites was completed just after installation and then again after one year. Some scour was apparent, but the platforms appeared relatively stable and can be monitored into the future for stability.

A study was conducted to compare incubation survival in the new gravel compared to two control sites. The full consultant's report of this study by Esther Guimond is in Appendix 4.

Survival was poor in the new gravel and in the control site located just upstream from the experimental gravel placement sites. Survival was better in the control site located in Scully South, the former mainstem that is characterised by ground water and sub-gravel flows. It was hypothesized that the poor survival could be related to water quality issues. Taken directly from Esther's report, during the first incubation assessment at the hatch stage (January), a sulphurous odour (i.e. rotten egg smell) was noted when some of the incubation cassettes were removed from the gravel. Hydrogen sulphide (H_2S) is a highly poisonous and soluble gas and an indicator of anoxic conditions.

Due to the toxic nature of H_2S, additional water quality monitoring and water sample collection at the Scully mid channel spawning gravel pads is recommended to determine whether H_2S may have been a contributing factor to the poor incubation survival observed during the incubation assessment. Low intergravel DO's and flow may also be an issue and could be related to a high percentage of fines in the intergravel spaces, determined through gravel sampling before and after the incubation study. Additional water quality testing is scheduled; at this time, there are no plans for further gravel installations in the agricultural channels of Scully Creek.

An area in Williams Creek characterised by ground water and old relic channels was explored for the development of off-channel spawning habitat for sockeye. Many test pits were excavated to examine substrates and study the groundwater channel potential in this area. A 200m-long, 2 meter wide groundwater channel was excavated adjacent to Williams Creek. The channel connected several test pits for improved monitoring of groundwater quantity and quality. Several coho redds and juvenile salmonids were documented in the channel in the first year. Based on test pit data, no further extension of this channel is planned at this time due to the depth of groundwater further upstream and prohibitive cost of excavating a channel deeper than 3 meters. Additional survey work was conducted to explore the feasibility of creating a surface-water fed channel in this area. The next phase of this project will involve design and cost estimates for the development of this channel and potential enhancement features such as incubation boxes.

It should be noted that this reach of Williams Creek is adjacent to formerly productive mainstem sockeye spawning habitat impacted by logging, but current sockeye spawning occurs approximately 2 km downstream. Plans to transplant adults and/or fry to the proposed off-channel habitat are proposed. There are also longer-term plans for the development of a spawning channel in the lower reaches of Williams Creek adjacent to active spawning areas. The main spawning portion of Williams Creek is within BC Parks land, which requires a more lengthy approval process and partnership with that provincial agency for any development within the park. BC Parks is a stakeholder in the Lakelse Sockeye Recovery Planning process and talks are ongoing towards the development of off-channel spawning habitat within the park.

In Scully Creek, progress was made in the feasibility study examining a diversion of surface flows back to the former mainstem, Scully South. Surveys were conducted and conceptual designs initiated. The next phase will involve finalising the layout and design, pricing out supplies and getting cost estimates from contractors for construction. Consultation with stakeholders and potential project partners, acquisition of permits and eventually funding to undertake the project, if deemed feasible, are also an important part of the next phase.

5.0 References

Biolith Scientific Consultants Inc. 1998. Level 1 Detailed Assessment of Fish and Fish Habitat in Williams, Sockeye and Blackwater Creeks. Prepared for Ministry of Environment.

Fisheries and Oceans Canada. 2002. Schulbuckhand (Scully) Creek Restoration Feasibility Study. Unpublished report for BC Hydro by DFO Resource Restoration Unit. 17p.

Fisheries and Oceans Canada. 2005. (Scully) Creek Off-channel Habitat/Flow Augmentation Feasibility Study. Unpublished report for the Pacific Salmon Commission by DFO Resource Restoration Unit. 17p.

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Rabnett, K. 2008. Lakelse Sockeye Spawning Habitat Rehabilitation Feasibility Program. Prepared for Fisheries and Oceans Canada and the Pacific Salmon Commission Northern Fund.

Slaney, P., Zaldokas, D. 1997. Watershed Restoration Technical Circular No. 9. Watershed Restoration Program. Ministry of Environment, Lands and Parks.

Triton Environmental Consultants. 1996. Lakelse WRP Project - Level I Fisheries Assessment. Prepared for Lakelse WRP Steering Committee.

Triton Environmental Consultants. 1998. Level II WRP Assessment – Scully Creek. Prepared for Ministry of Environment, Lands and Parks.

APPENDIX 1

Financial Report

Project Budget Form H-10

Name of Project: Lakelse Lake Sockeye Rehabilitation Program:

Spawning Channel/ Improved Spawning Habitat Project

ELIGIBLE COSTS					TOTAL BUDGET	OTHER FUNDING	PSC N. FUND GRANT AMOUNT	ACTUAL AMOUNT SPENT	VARIANCE	EXPLANATION
Labour										
Wages & Salaries										
Position	# of crew	# of work days	hrs per day	rate per hour	**Total (In-kind & cash + PSC Amount)**	**In-Kind & Cash**	**PSC Amount**			
Lakelse Coordinator	1	30	8	25	6,000		6,000	6,938	116%	See Note 1
DFO Biologist	1	25	8	40	8,000	8,000				
DFO Engineering Technician	1	15	8	40	4,800	4,800				
DFO Engineering	1	10	8	60	4,800	4,800				
Person Days (# of crew x work days)				**sub total**	23,600	17,600	6,000	6,938		
Labour - Employer Costs (percent of wages subtotal amount)										
	rate	0%		**sub total**						
Subcontractors & Consultants	# of crew	# of work days	hrs per day	rate per hour						
Engineering Firm	2	17	8	60	16,320		16,320	18,808	115%	See Note 3
Biological Consultant	1	15	8	40	4,800		4,800	10,503	219%	See Note 1
Insurance if applicable	rate	0%								
				sub total	21,120		21,120	29,311		
Volunteer Labour	# of crew	# of work days	hrs per day							
Skilled	2	15	8		6,000	6,000				
Un-skilled										
Insurance if applicable	rate	17%			1,000		1,000	0	0%	See Note 2
				sub total	7,000	6,000	1,000	0		
				Total Labour Costs	51,720	23,600	28,120	36,250		

Site / Project Costs	Detail (use additional page for details if needed)						
Travel (do not include to & from work)	Travel for consultants, project partners, volunteers	4,000	2,000	2,000	2,734	137%	See Note 1
Small Tools & Equipment							
Site Supplies & Materials	spawning gravel, road upgrade material, filter cloth	11,850		11,850	7,295	62%	See Note 4
Equipment Rental	Excavator, gravel trucks, pumps	10,500		10,500	10,401	99%	
Work & Safety Gear	Waders, hi vis vests, pfd's	1,000	500	500	500	100%	
Repairs & Maintenance							
Permits							
Technical Monitoring	Intergravel water sampling probe, temp loggers (4)	1,060	250	810	750	93%	
Other site costs	Technical equipment (survey gear, etc.)	2,000	2,000				
	Total Site / Project Costs	30,410	4,750	25,660	21,680		

ELIGIBLE COSTS				BUDGET	OTHER FUNDING	CONTRIBUTION FUNDING			
Training (e.g Swiftwater, bear aware, electrofishing, etc).				**Total (PSC + In-kind + cash)**	**In-Kind & Cash**	**PSC Amount**			
Name of course	# of crew	# of days							
Swiftwater for volunteers	2	3		1,200		1,200	0	0%	See Note 2
			Total Training Costs	1,200		1,200	0		

Overhead / Indirect Costs (not to exceed 20% of PSC Amount)							
Office space; including utilities, etc.		2,000	500	1,500	1,255	84%	See Note 5
Insurance		1,500		1,500	0	0%	See Note 2
Office supplies		1,200	600	600	92	15%	See Note 5
Telephone & long Distance		500	200	300	300	100%	
Photocopies & printing		800	300	500	0	0%	See Note 5
Other overhead costs	Computers, network services, financial admin.	2,000	400	1,600	1,402	88%	See Note 5
	Total Overhead Costs	8,000	2,000	6,000	3,050		

Capital Costs / Assets	Detail (use additional page for details if needed)						

Assets are things of value that have an initial cost of $250 CAN or more and which can be readily misappropriated for personal use or gain or which are not, or will not be, fully consumed during the term of the project.

	Total Capital Costs						
	Project Total Costs	91,330	30,350	60,980	60,980		

Budget Summary

(PSC + in-kind + cash)

Total Labour Costs	51,720
Total Site / Project Costs	30,410
Total Training Costs	1,200
Total Overhead Costs	8,000
Total Capital Costs	-
Project Total	91,330

Notes:

1 The Lakelse Coordinator was being shared between Project NF-2008-H-8 and E-1. The RRU's biologist began maternity leave in February '09 and at the time, there was no backfill lined up. In order to continue work on the project, additional tasks were assigned to existing biological and technical people already contracted to the project. To accommodate the overages, we looked for savings in other areas.

2 Perhaps due to the anticipated reduction in projects in the upcoming year, none of the groups/individuals involved in the project seized the opportunity for swiftwater training or insurance coverage. The funds were reallocated within the project to assist with the extra amounts dedicated to professional services.

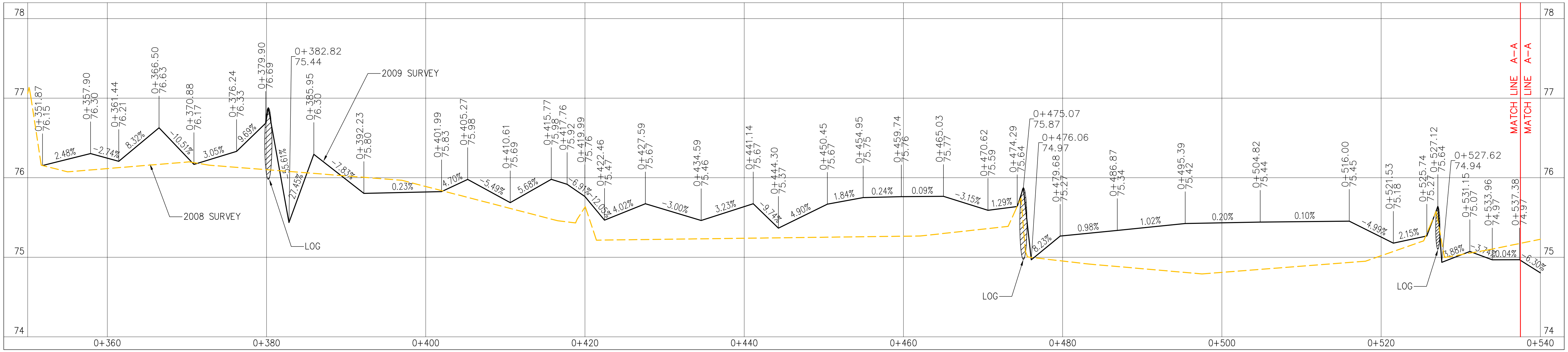
3 Some additional costs were incurred for engineering services in order to support the conclusions of the incubation study. The extra fees were to conduct washed sieve analysis on samples of the spawning gravel before placement and 9 months approx. after it was placed.

4 A late contribution from DFO's Community Advisor in Terrace resulted in a savings in material costs. The extra funds were used to cover overages in other areas.

5 Areas where savings were achieved to assist with overages in other areas.

APPENDIX 2

Survey Drawings



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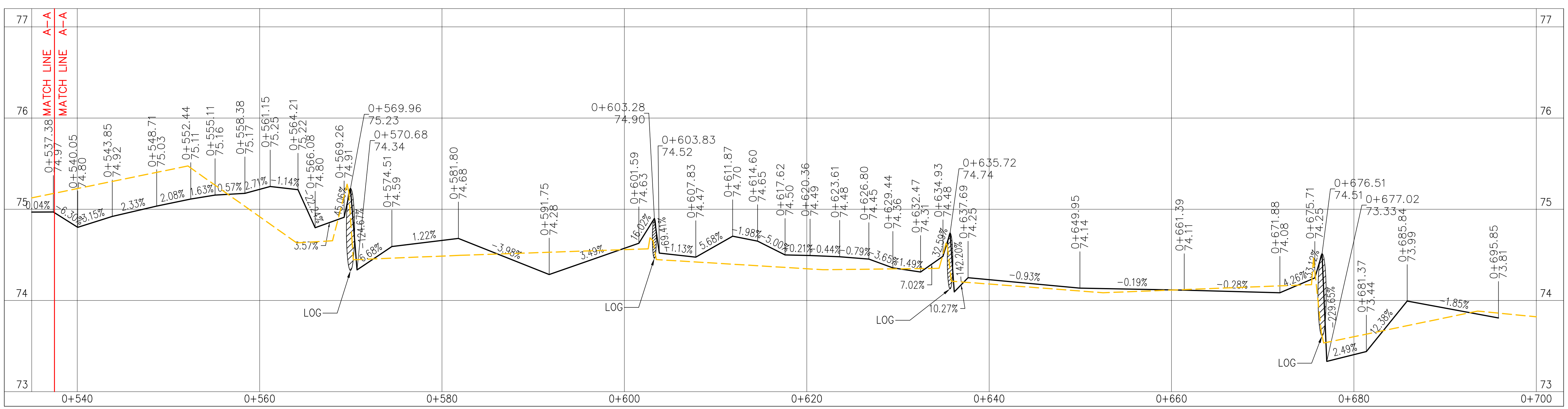

CREEK PROFILE
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SITE/SURVEY NOTES:

1. SITEPLAN WAS COMPLETED ON: 2009/10/23
2. SURVEY DATA WAS COLLECTED BY RTK SURVEY.
3. SITE SURVEYOR: C. BARTON
   SITE RODMAN: K. BARTON
4. NO GEOTECHNICAL REPORT HAS BEEN COMPLETED TO DATE.

RESERVED FOR PROFESSIONAL STAMP:

REV	YY/MM/DD	DESCRIPTION	DR	APP
0	09/12/17	ISSUED FOR REVIEW	JHE	CB

CLIENT:
DEPARTMENT OF FISHERIES AND OCEANS

ALLNORTH CONSULTANTS LIMITED
WWW.ALLNORTH.COM

CLIENT NO.: –	DRWN BY: JHE	DATE: 09/12/17	
PROJECT NO.: 09–TC–0103	DSND BY: –	DATE: –	
DRAWING SIZE: 11x17	CHKD BY: CB	DATE: 09/12/17	
SCALE: AS NOTED	APPD BY: –	DATE: –	

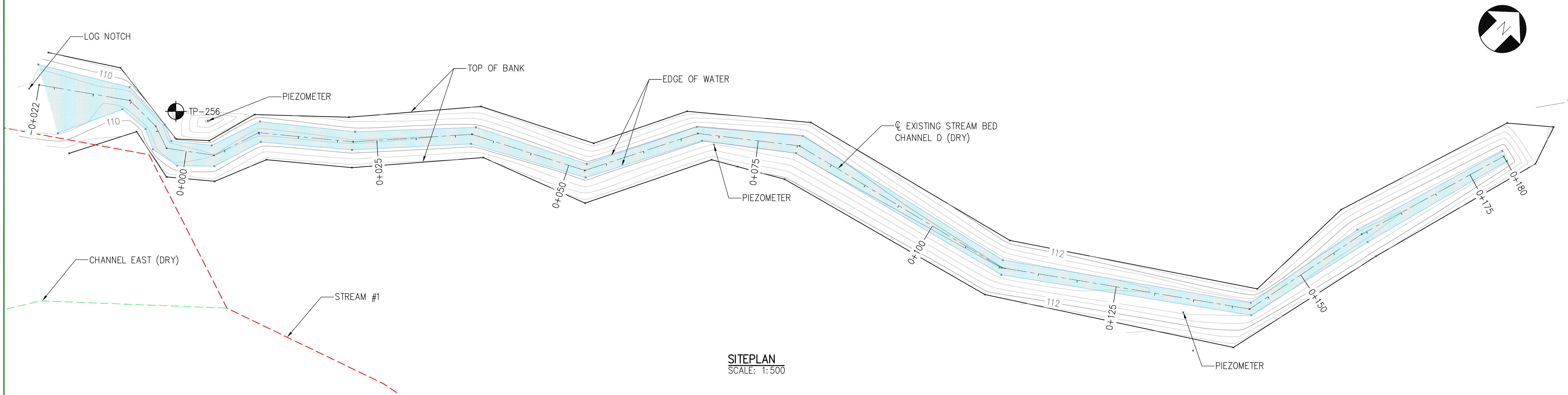
PROJECT:
SCULLY CREEK SURVEY

TITLE:
PROFILE

SHEET NUMBER: 1 OF: 1

DWG. NO.: 09–TC–0103–1 REV: 0

2009/12/17 C:\09–TC–0103\Civil3D



SITEPLAN
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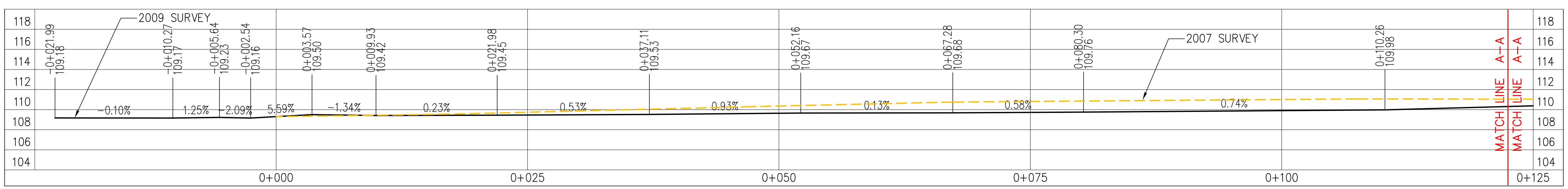

CHANNEL D PROFILE
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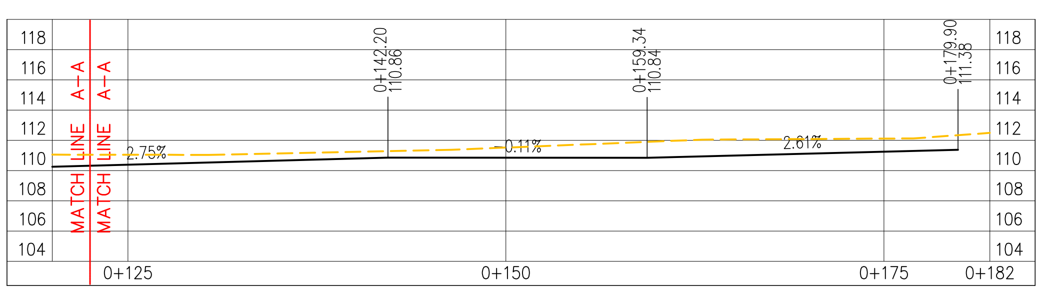


CHANNEL D PROFILE
SCALE: 1:500

SURVEY INFORMATION			
DESCRIPTION	NORTHING	EASTING	ELEVATION
TP-256	34984.961	533384.660	109.930

SITE/SURVEY NOTES:

1. SITEPLAN WAS COMPLETED ON: 2009/12/01
2. SURVEY DATA WAS ESTABLISHED USING NO DECLINATION.
3. SITE SURVEYOR: C. BARTON
   SITE RODMAN: K. BARTON
4. NO GEOTECHNICAL REPORT HAS BEEN COMPLETED TO DATE.

RESERVED FOR PROFESSIONAL STAMP:

REV	YY/MM/DD	DESCRIPTION	DR	APP
0	09/12/17	ISSUED FOR REVIEW	JHE	CB

CLIENT:
DEPARTMENT OF FISHERIES AND OCEANS

ALLNORTH CONSULTANTS LIMITED
WWW.ALLNORTH.COM

CLIENT NO.: –	DRWN BY: JHE	DATE: 09/12/17
PROJECT NO.: 09-TC-0103	DSND BY: –	DATE: –
DRAWING SIZE: 11x17	CHKD BY: CB	DATE: 09/12/17
SCALE: AS NOTED	APPD BY: –	DATE: –

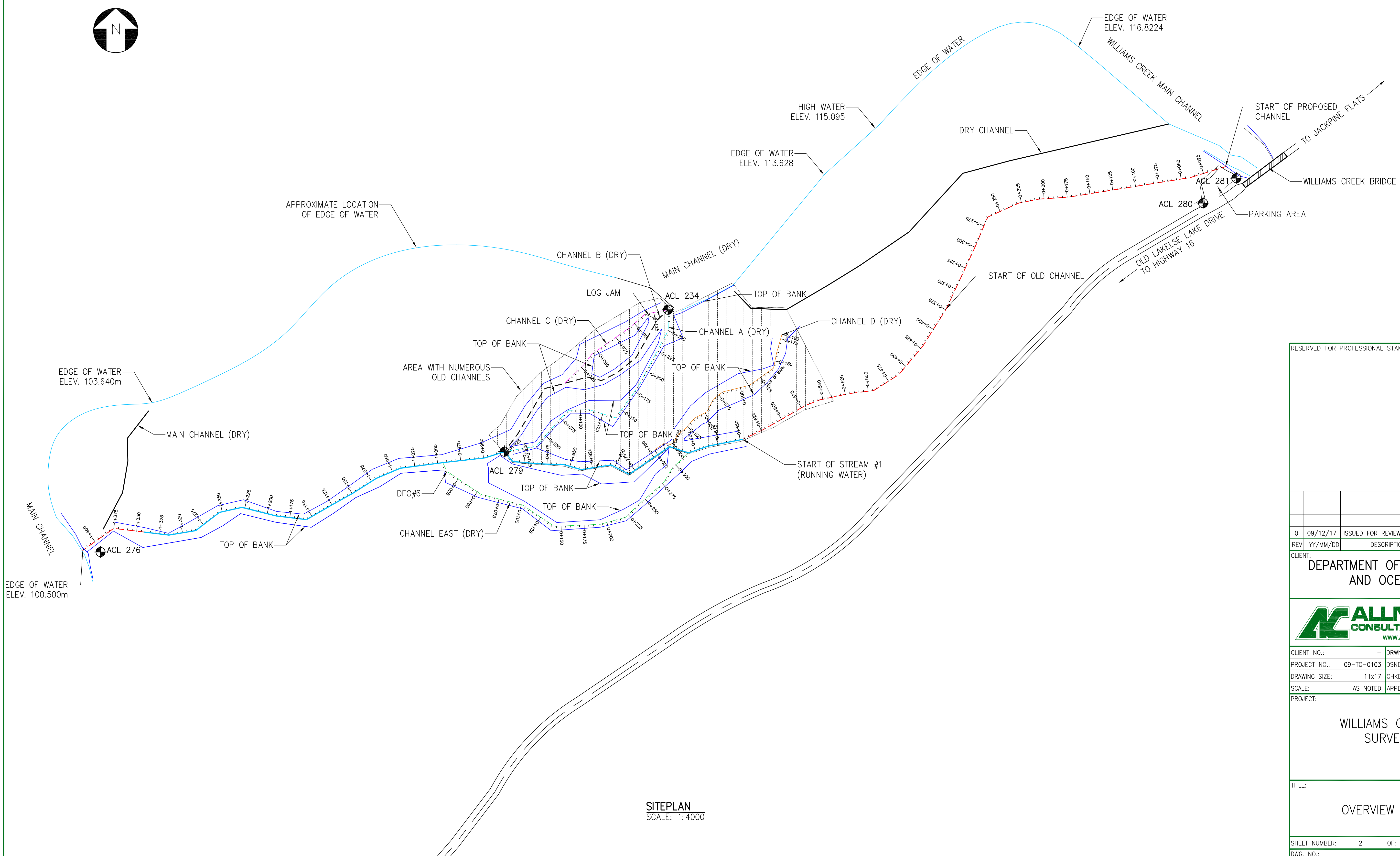
PROJECT:
WILLIAMS CREEK SURVEY

TITLE:
SITE PLAN AND PROFILE

SHEET NUMBER: 1 OF: 2

DWG. NO.: 09-TC-0103-2&3 REV: 0

2009/12/17 C:\09-TC-0103\Civil3D



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CLIENT:
DEPARTMENT OF FISHERIES AND OCEANS

ALLNORTH CONSULTANTS LIMITED
WWW.ALLNORTH.COM

CLIENT NO.: –	DRWN BY: JHE	DATE: 09/12/17
PROJECT NO.: 09-TC-0103	DSND BY: –	DATE: –
DRAWING SIZE: 11x17	CHKD BY: CB	DATE: 09/12/17
SCALE: AS NOTED	APPD BY: –	DATE: –

PROJECT:
WILLIAMS CREEK SURVEY

TITLE:
OVERVIEW PLAN

SHEET NUMBER: 2 OF: 2

DWG. NO.: 09-TC-0103-2&3 REV: 0

2009/12/16 C:\09-TC-0103\Civil3D

APPENDIX 3

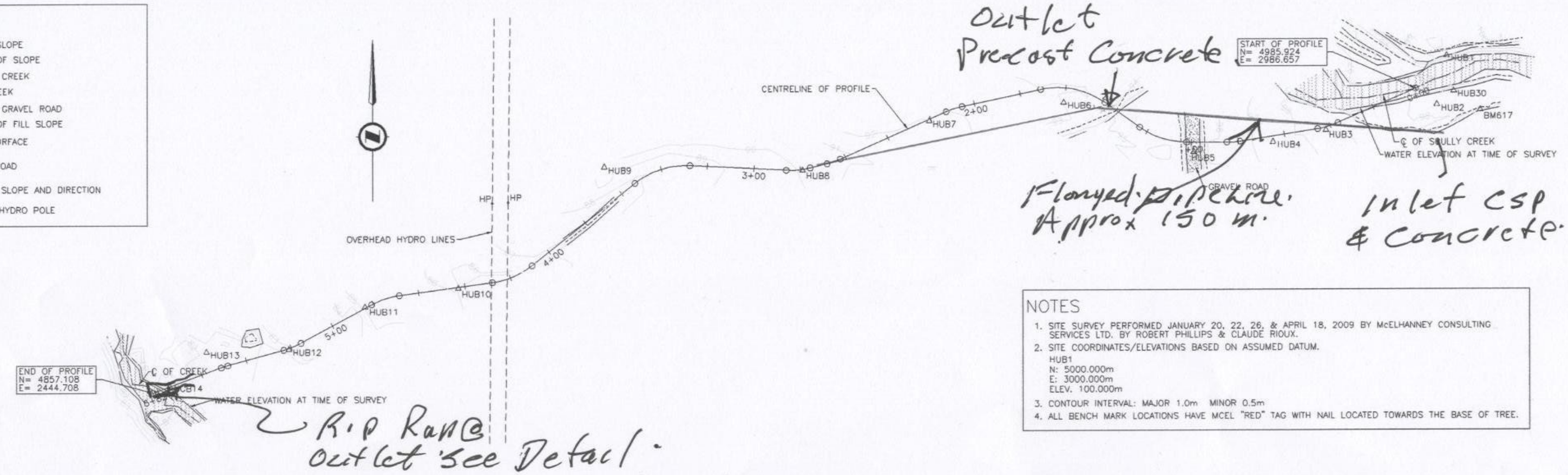
Conceptual Design – Scully Pipeline

LEGEND

	TOP OF SLOPE
	BOTTOM OF SLOPE
EW	EDGE OF CREEK
	℄ OF CREEK
	EDGE OF GRAVEL ROAD
	BOTTOM OF FILL SLOPE
	WATER SURFACE
	GRAVEL ROAD
1.0%	SURFACE SLOPE AND DIRECTION
HP	WOODEN HYDRO POLE

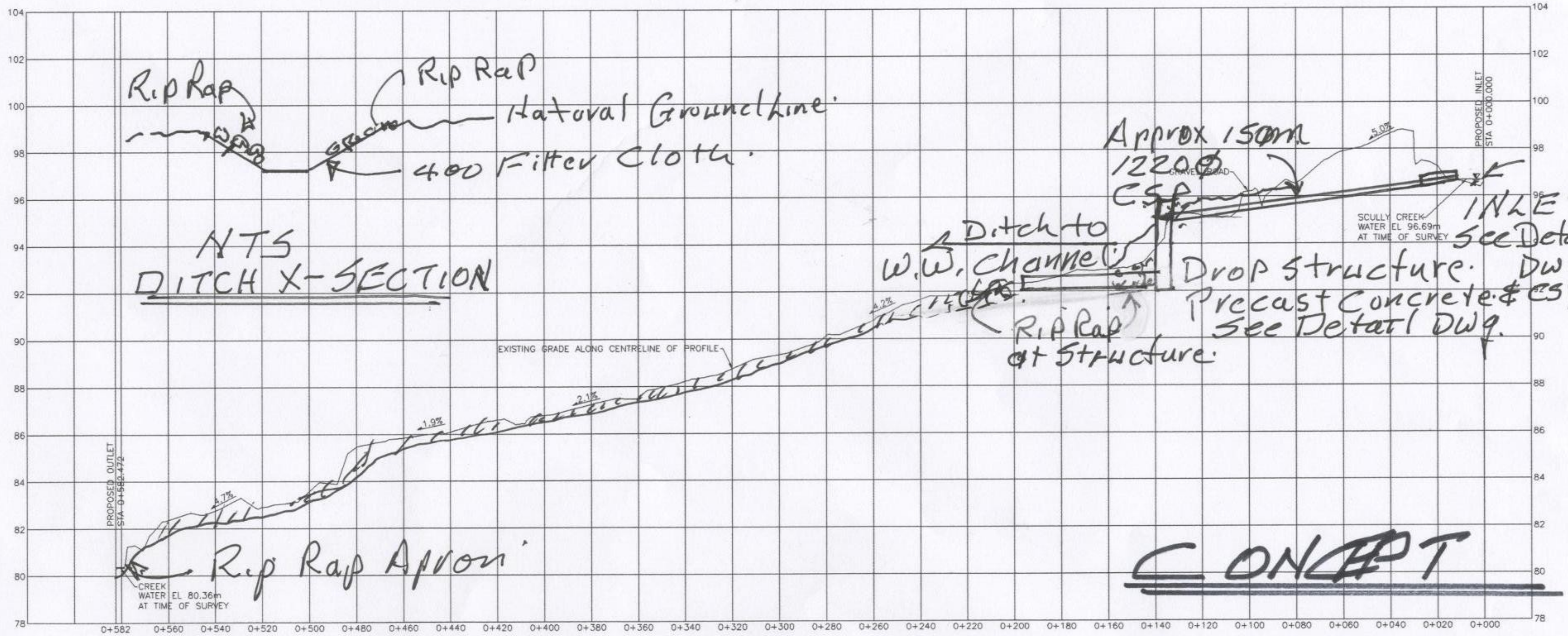
CONTROL LIST

DESCRIPTION	NORTHING	EASTING	ELEVATION
HUB1	5000.000	3000.000	100.000
HUB2	4979.034	2995.856	98.553
HUB3	4968.105	2948.122	98.626
HUB4	4963.120	2925.502	97.544
HUB5	4958.910	2891.548	96.458
HUB6	4980.225	2835.764	93.149
HUB7	4972.573	2777.907	91.934
HUB8	4951.608	2723.668	90.169
HUB9	4953.316	2638.640	89.355
HUB10	4901.590	2575.821	86.031
HUB11	4893.645	2535.836	85.173
HUB12	4875.570	2503.084	82.820
HUB13	4874.454	2467.814	82.585
HUB14	4859.988	2451.891	81.280
HUB30	4984.854	3003.070	98.629
BM617	4976.759	3014.352	100.031



NOTES

1. SITE SURVEY PERFORMED JANUARY 20, 22, 26, & APRIL 18, 2009 BY McELHANNEY CONSULTING SERVICES LTD. BY ROBERT PHILLIPS & CLAUDE RIOUX.
2. SITE COORDINATES/ELEVATIONS BASED ON ASSUMED DATUM.
   HUB1
   N: 5000.000m
   E: 3000.000m
   ELEV. 100.000m
3. CONTOUR INTERVAL: MAJOR 1.0m MINOR 0.5m
4. ALL BENCH MARK LOCATIONS HAVE MCEL "RED" TAG WITH NAIL LOCATED TOWARDS THE BASE OF TREE.



No.	Date	Revision	Dr.
A	01/05/09	ISSUED TO CLIENT	SD

McElhanney
McElhanney Consulting Services Ltd.
SUITE #1 - 5008 POHLE AVENUE
TERRACE, B.C. V8G 4S8 CANADA
PH (250) 635-7163
FAX (250) 635-9586

Designed: RJH | Checked: | Date: APRIL 2009
Drawn: SD | Surveyed: RP
SCALE : 1:1000(H) 1:100(V)
0 10 20 30 40 50 60 70 80m
(ALL DIMENSIONS ARE IN METRES)
Approved Sealed

FISHERIES AND OCEANS CANADA
SCULLY CREEK PIPELINE SURVEY
PROPOSED PIPELINE ROUTE PLAN & PROFILE

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Client Drawing No
MCSL Project No. 2321-01061-0
Drawing No. 1061-0-01
Sheet of
Revision A
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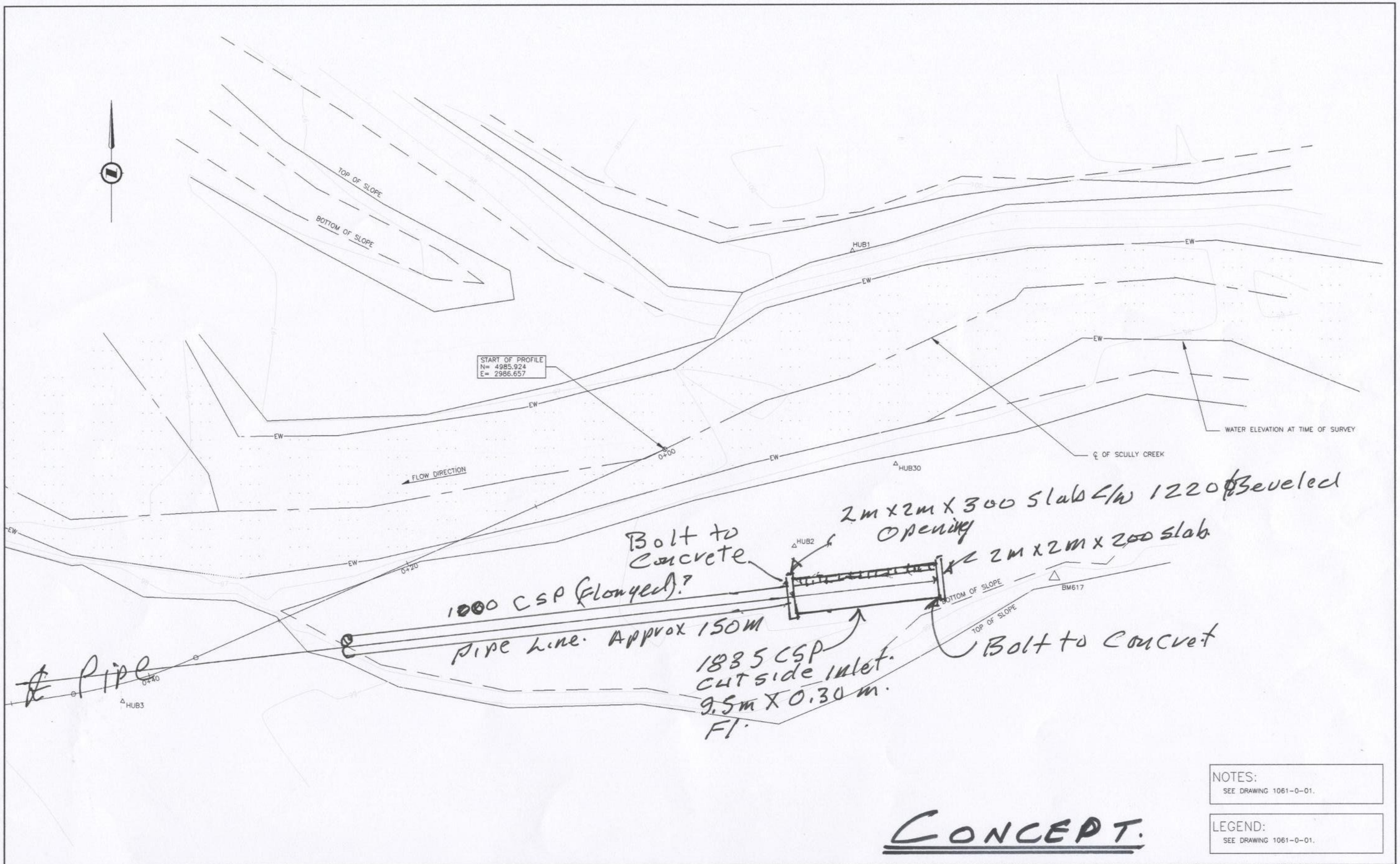

No.	Date	Revision	Dr.
A	01/05/09	ISSUED TO CLIENT	SD

McElhanney
McElhanney Consulting Services Ltd.
SUITE #1 - 5008 POHLE AVENUE, TERRACE, B.C. V8G 4S8 CANADA
PH (250) 635-7163
FAX (250) 635-8586

Designed: RJH	Checked:	Date: APRIL 2009
Drawn: SD	Surveyed: RP	

SCALE : 1:125
0 1 2 3 4 5 6 7 8 9 10m
[ALL DIMENSIONS ARE IN METRES]

Approved Sealed

FISHERIES AND OCEANS CANADA
SCULLY CREEK PIPELINE SURVEY
PROPOSED PIPELINE INLET AREA PLAN

Client Project No.
Client Drawing No.
MCSL Project No. 2321-01061-0
Drawing No. 1061-0-02
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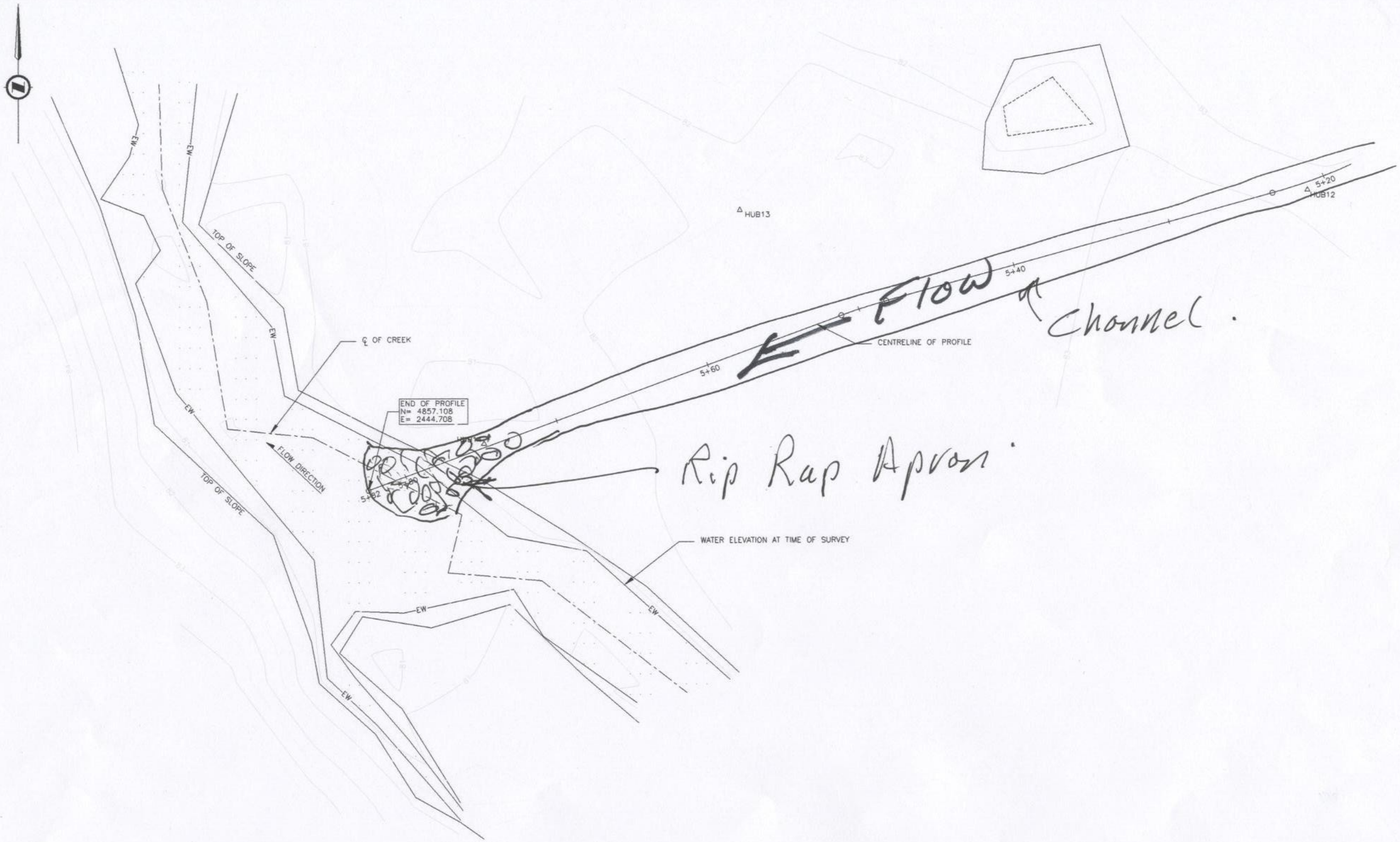
Revision A
Destroy all prints bearing previous number ▲



CONCEPT

NOTES:
SEE DRAWING 1061-0-01.

LEGEND:
SEE DRAWING 1061-0-01.

No.	Date	Revision	Dr.
A	01/05/09	ISSUED TO CLIENT	SD

McElhanney
McElhanney Consulting Services Ltd.
SUITE #1 - 5008 POHLE AVENUE
TERRACE, B.C. V8G 4S8 CANADA
PH (250) 635-7163
FAX (250) 635-8586

Designed: RJH	Checked:	Date: APRIL 2009
Drawn: SD	Surveyed: RP	

SCALE : 1:125
0 1 2 3 4 5 6 7 8 9 10m
(ALL DIMENSIONS ARE IN METRES)

Approved Sealed

FISHERIES AND OCEANS CANADA
SCULLY CREEK PIPELINE
PROPOSED PIPELINE OUTLET AREA PLAN

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Client Drawing No
MCSL Project No. 2321-01061-0
Drawing No. 1061-0-03
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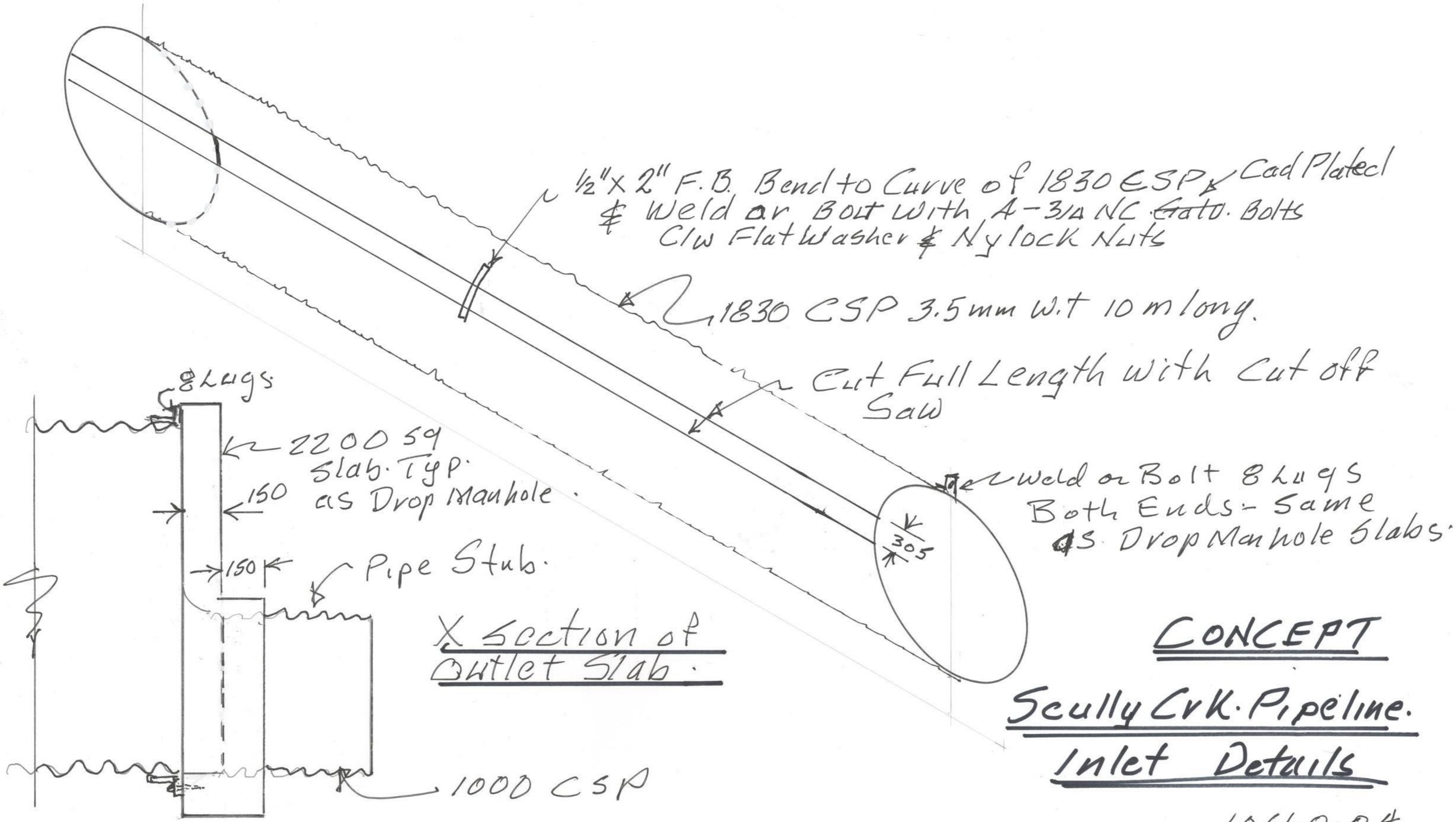
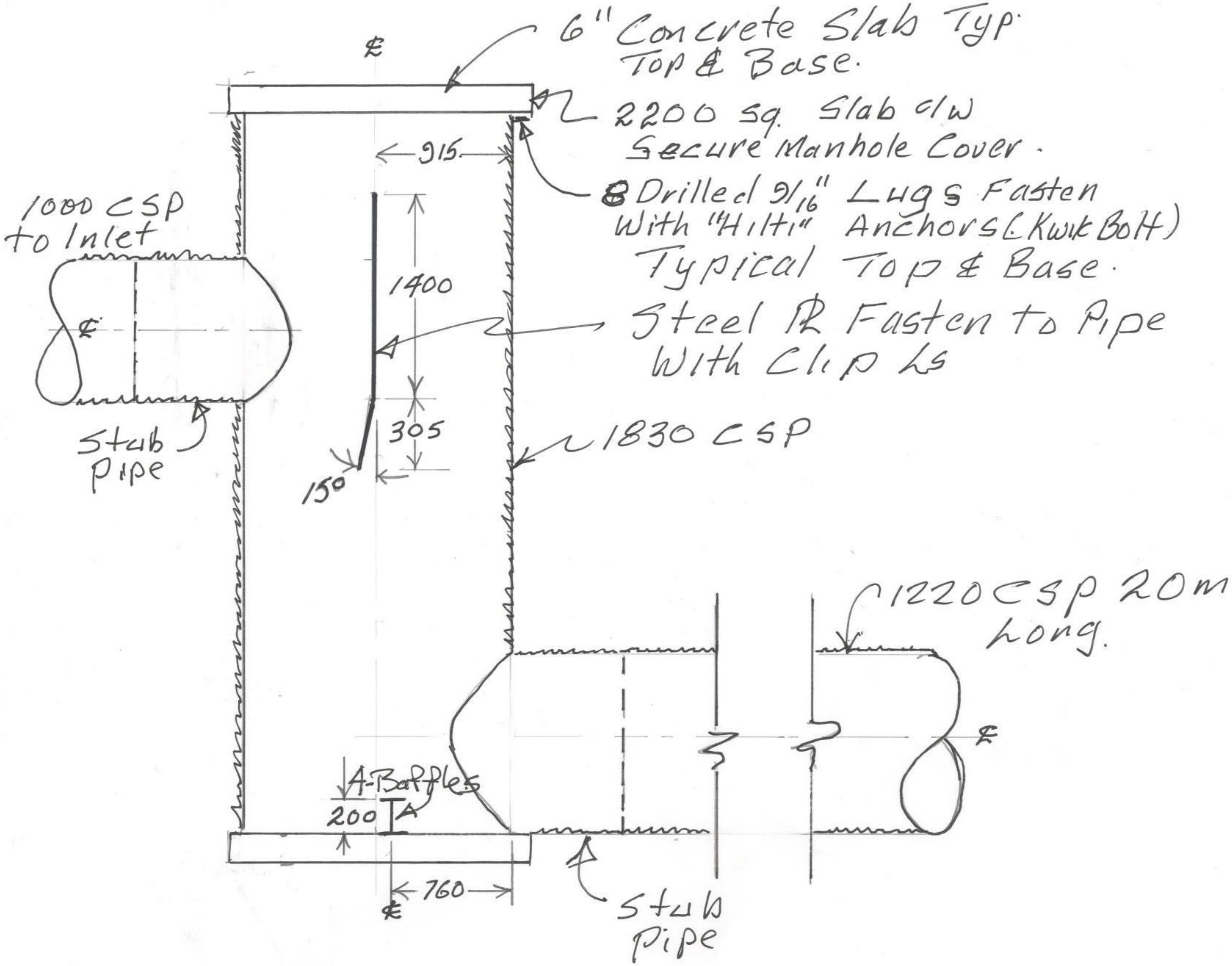


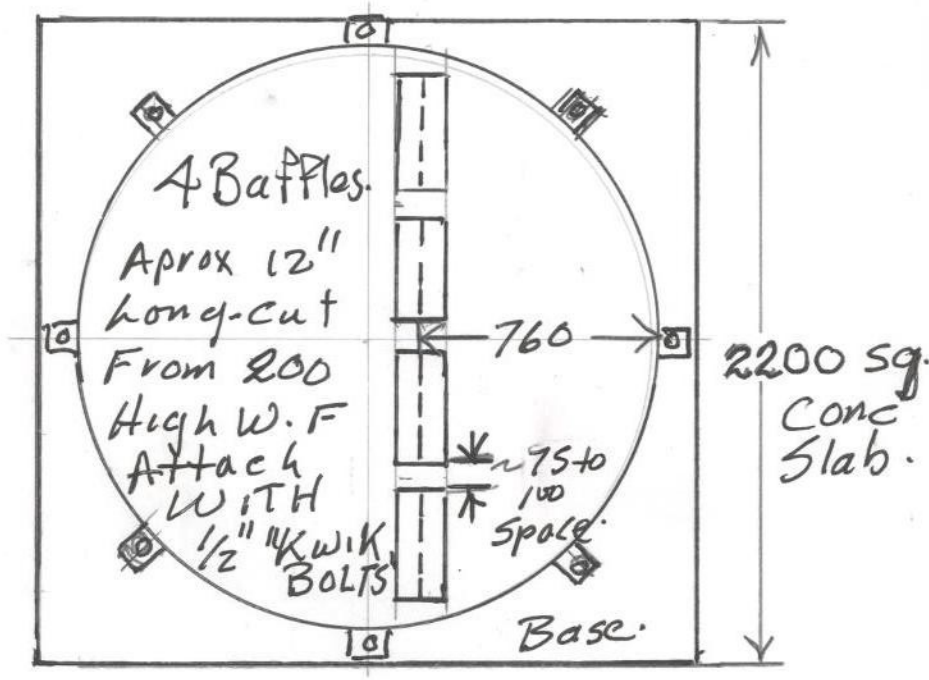
CONCEPT

Scully Crk. Pipeline.

Inlet Details

1061-0-04





Scully Pipline Drop Structure. Concept

1061-0-05

APPENDIX 4

Consultant's Report for Scully Creek
- Mid Channel Incubation Study

Prepared by: Ester Guimond (Consultant - Courtney, BC)

Scully Creek Sockeye Egg Incubation Assessment 2008-2009

Prepared For

Fisheries and Oceans Canada
North Coast Resource Restoration Division

10 June 2009

By

E. Guimond

473 Leighton Avenue
Courtenay, BC, V9N 2Z5
(250) 338-8827
guimonde@telus.net

EXECUTIVE SUMMARY

The middle channel of Schulbuckhand (alias Scully) Creek, downstream of Highway 37, was the focus of a sockeye spawning habitat restoration project which saw the addition of approximately 750 square metres of spawning gravel in July 2008. This project was part of a larger ongoing habitat project in the Lakelse Lake Watershed in efforts to reverse the declining trend of the sockeye salmon population.

In order to determine the effectiveness of the July gravel enhancement project, a follow-up monitoring program was initiated in October of 2008. Monitoring focussed on the incubation success of sockeye salmon eggs at 4 sites; two were sites located on the recently constructed spawning gravel platforms in Scully Creek mid channel, another in a natural spawning site in mid Scully (control), and a fourth site was located in a natural spawning site in South Scully Creek. At each site, 8 Jordan-Scotty incubation cassettes containing 100 eyed sockeye eggs, obtained from Snootli Hatchery, were buried in the streambed. Incubation success was assessed by removing and examining 4 cassettes from each site both at the 'hatch' stage and at the 'emergence' (button-up) stage.

Surface and intergravel water temperature were continuously recorded at the two Scully Creek channels adjacent to the incubation sites using Onset Tidbit temperature data loggers. The loggers were downloaded in December to provide an estimate of egg development (Accumulated Temperature Units or ATU's) in order to schedule incubation assessments. Other environmental variables were monitored periodically throughout the incubation study. These variables included depth and velocity, intergravel and water column dissolved oxygen (DO), conductivity, and pH. Substrate composition of the screened spawning gravel was assessed by washed sieve analysis before placement in July 2008, and again at the end of the incubation period in April 2009. Samples from the two natural spawning sites were analysed in April only. Discharge data for Scully Mid and South channels was provided by Ministry of Environment as part of the "Lakelse Suspended Sediment Monitoring Program" (Leggat 2009a).

Discharge for Scully Creek mid channel during the incubation period (October 2008 – April 2009) ranged from 0.03 m^3/s to 4.35 m^3/s. The Scully Creek mid channel hydrograph shows that two high flow events occurred soon after the installation of the incubation cassettes on Oct. 15, 2008. Substrate assessments conducted before and after the incubation period showed the total percentage of grains finer than 9.5 mm at Site 2 and 3 was 1.7 % and 0.85 % respectively in July 2008, compared to 20 % and 34 % respectively in April 2009. Site 4 in Scully mid channel had the greatest amount of fine particles < 9.5 mm (68 %) followed by Site 1 in Scully south channel (42 %).

Environmental variables were monitored during four visits to the incubation sites. Average intergravel DO ranged from 6.5 to 11.7 mg/l for the 4 sites throughout the incubation period, with the lowest DO observed at Site 4.

Average incubation survival ranged from 0 to 45% at the 4 sites for the eyed egg-to-hatch stage, and from 0 to 12 % for the eyed egg-to-fry stage. There was no significant difference among sites for the eyed egg-to-fry stage, however survival at Site 1 was significantly different than at Site 2 for the eyed egg-to-hatch stage. Analysis of the data did not attempt to determine any relationships between survival and either intergravel DO or percent fines. Hydrogen sulphide (H_2S), a highly soluble and toxic gas, was detected by odour at some sites during assessment at the hatch stage. Our ability to detect this gas may be indicative of levels high enough to be lethal to developing embryos. Further water sample collection and analysis for the presence of H_2S may provide more concrete evidence of the relationship this variable may have on the incubation survival of salmonid eggs at the restored spawning habitat in mid Scully creek.

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ACKNOWLEDGEMENTS

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1. INTRODUCTION

In July 2008, Fisheries and Oceans Canada (DFO) North Coast Resource Restoration Unit completed a spawning habitat enhancement project in the Mid channel of Schulbuckhand (alias Scully) Creek on the Mount Layton Hot Springs property at Lakelse Lake. This project was part of a larger ongoing habitat project in the Lakelse Lake Watershed in efforts to reverse the declining trend of the sockeye salmon population. The spawning enhancement project included the addition of screened gravel in 4 discrete locations along a 400 m stretch of the Mid Scully Creek channel, for a total of approximately 750 m^2 of spawning habitat area. A sockeye incubation study was implemented in October 2008 in order to determine the effectiveness of this spawning habitat enhancement project. Information gained from this monitoring program will be useful for developing future habitat restoration options in the Lakelse Watershed.

2. STUDY AREA

Scully Creek is located near the city of Terrace, on the southeast side of Lakelse Lake. It drains a watershed area of approximately 29 km^2. Much of the drainage is within a large low gradient alluvial fan containing many hot springs on the lake floodplain. As a result of past flood events, Scully Creek enters Lakelse Lake though three branches. The historic main South channel is now mainly groundwater fed, while the Middle and North channels receive 55% and 45% respectively of the surface flow (Leggat 2009a). The latter two channels flow through a large wetland complex, much of which has been drained for agricultural development downstream of Highway 37 (Figure 1; Appendix A).

3. METHODS

3.1 Site Selection

Three sites were selected in Scully Creek mid channel downstream of Highway 37 and a fourth site in Scully Creek south channel just upstream of the Highway 37 culvert. Two of the three sites in Scully Creek mid channel were located on recently constructed spawning gravel platforms, while the third site in Scully mid, and the fourth site in Scully south channel were located in unenhanced 'natural' spawning gravel as control sites (the latter site is utilized frequently by sockeye adults). Locations of the four incubation sites are described in Table 1 and illustrated in Figure 1.

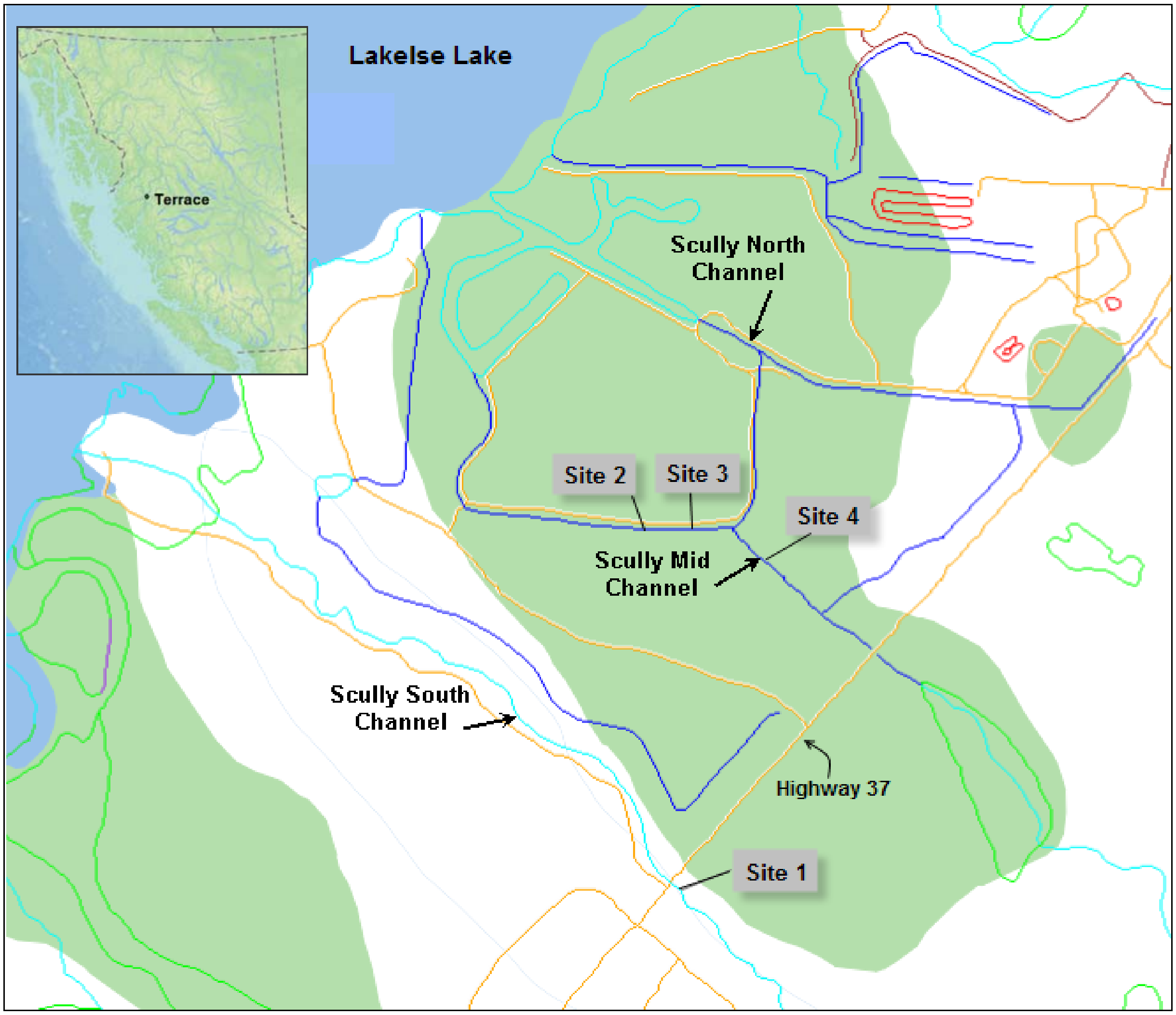

Figure 1. Scully Creek channels downstream of Highway 37.

Table 1. Incubation sites in Scully Creek Mid and South channels.

Incubation Site	Location	# of Incubators	Installation Description
Site 1	Scully Creek South Channel (groundwater)	8	Due to the small area of suitable spawning gravel, cassettes were buried in pairs, ~12 inches apart, in 4 locations
Site 2	Scully Creek Mid Channel Spawning Platform #2	8	Cassettes were buried along two transects across the spawning pad, 4 in each transect
Site 3	Scully Creek Mid Channel Spawning Platform #3	8	Cassettes were buried randomly within the spawning pad, 4 located in optimum locations, and 4 in marginal locations
Site 4	Scully Creek Mid Channel Unenhanced (Control)	8	Cassettes were buried along two transects across the channel, 4 in each transect

3.2 Installation and Monitoring of Incubators

On October 15, 2008, eyed sockeye salmon eggs from Snootli Hatchery (Bella Coola) were transported to the Scully Creek project site. Approximately 400 eggs each from eight females were packed separately in specially designed egg transport containers (Appendix B - Photo 1) and shipped to Terrace by charter plane in a cooler with ice. Once at the Scully site, all eggs were pooled in a basin and then loaded into the lower half of Jordan-Scotty cassette incubators at 100 eggs per cassette (Appendix B - Photo 2). Eight incubation cassettes were buried at each incubation site. Each cassette location was characterized as either optimum or marginal quality based on visual appearance (i.e. optimum areas had higher velocities, and/or less fines than marginal areas). Incubators were buried in the stream bed at a depth of 20-30 cm. At two of the four incubation sites, cassettes were placed along two transects (4 in each transect) across the channel while at the other two incubation sites, cassette locations were more randomly distributed within the site. Incubators were flagged with an 18” piece of ¼“ poly rope and a length of flagging tape to identify locations. Cassettes were also identified from a marker on the bank in case flagging was lost or buried.

A control group of eggs remained at Snootli Hatchery. The primary purpose of this group was to demonstrate that there were no fertilization or survival issues with the batch of eggs used in the study when incubated in an ideal environment. The remaining eggs from each of the females used in the study group were incubated separately at the hatchery and survival monitored to the hatch and fry (ponding) stages.

Assessment of incubation success was checked during two stages: 12 weeks after installation at the hatching stage; and 25 weeks after installation at the fry/emergence stage. The incubators used in this study (Jordan-Scotty incubators) have blocked escape holes which permits assessment to the fry stage. For each developmental stage inspection, four cassettes from each incubation site were removed and assessed. The contents of the incubator were emptied into a shallow basin and the number of dead and live eggs/alevins and fry were enumerated. Cassettes were not replaced in the gravel after assessment due to the amount of disturbance that would be required to excavate and replant the incubators. This disturbance could adversely affect the embryos in the cassette, as well as alter the intergravel conditions of flow, permeability and dissolved oxygen delivery within the ‘egg pocket’ or the surrounding environment of other nearby cassettes, thereby skewing results for the final stage of development. Live eggs and alevins were buried in an artificial redd excavated in the streambed utilizing a 2” PVC pipe.

3.3 Environmental Monitoring

Temperature

Onset Tidbit® v2 temperature data loggers were used to continuously record intergravel and water column temperature at each of the Scully Creek channels (Scully mid channel and Scully south channel) for the duration of the study. At Scully mid, the two temperature loggers were located just downstream of Incubation Site 4, while at Scully Creek south, one Tidbit® was buried in proximity to the incubators, while the second was located on the downstream side of the Highway 37 culvert. The data loggers were downloaded in December to calculate the Accumulated Thermal Units (ATUs; daily mean temperature multiplied by the number of days of incubation) which was used to estimate the rate of development of eggs and schedule the incubator checks during the study.

Water Column and Intergravel Parameters

Water column and intergravel water quality parameters were assessed during four environmental monitoring visits to the 4 incubation sites – December 2, 2008, January 7/8, March 12, and April 7, 2009.

Collection of intergravel water samples

To monitor environmental conditions in the gravel, three mini-piezometers were installed at each incubation site. Piezometers were constructed of a 0.6 m long section of 15 mm (inner diameter) polyvinylchloride (PVC) pipe with a four 8 mm diameter holes drilled on each side in the lower 100 mm (4 inches) of the pipe. The end of the pipe was plugged and fitted with an anchor (drywall) that would help maintain its position in the gravel. The piezometers were planted with the permeable openings at approximately 0.25m depth in the undisturbed gravel, to compare with conditions in the water column. The top of the piezometer was capped to prevent surface water entry into the pipe. A hand pump was used to extract water from the piezometer during sampling.

For the last two monitoring events, water samples were extracted from the gravel using a metal syringe apparatus. The syringe (narrow insertion end) is approximately 30 cm long and contains small perforations approximately 10 cm from the tip. A water sample from 20-30 cm below the streambed was extracted from the intergravel environment and collected in the larger chamber by pulling up on the plunger (Appendix B - Photo 3). The water sample was then extruded into a graduated cylinder for measurement of water quality parameters.

Dissolved Oxygen (DO) – intergravel dissolved oxygen (in mg/L and percent saturation) was measured at each Piezometer location (3 per incubation site) and water column DO was measured from one representative location at each incubation site using an OxyGuard Handy Polaris oxygen meter. The meter was calibrated in air in the field as per the meter's instructions prior to each monitoring visit.

Conductivity — intergravel and water column specific conductivity ($\mu S \cdot cm^{-1}$) was measured at each Piezometer location (3 per incubation site) and from one representative location at each incubation site respectively, using YSI Pro Multi-Parameter Water Quality Meter.

pH — intergravel and water column pH was measured at each Piezometer location (3 per incubation site) and from one representative location at each incubation site respectively, using a YSI 63 multi-meter (first two monitoring visits) and an Oakton ® waterproof pHTestr (last two monitoring visits).

Depth and Velocity — Water column depths and velocities were measured at the same location at each cassette burial site. This location was identified as where the poly rope attached to the cassette incubator exited the gravel. Velocity was measured with a Swoffer® Model 2100 propeller type flow meter mounted to a 1.5 m top-setting rod. Readings were taken at 0.6 of the depth with the meter set to display a 20-second average. Depth was measured using the graduations on the top-setting rod.

Substrate Composition

The grading limits for the screened spawning gravel were to meet the specifications outlined in Table 2. Prior to placement in Mid Scully Creek, samples of the gravel were sent to a geotechnical testing laboratory for washed sieve analysis, to ensure the grading limits were within the requested specifications. The test results would also be used as a baseline to assess the accumulation of fines in the gravel and its impacts on the survival of salmon embryos.

Following the completion of the incubation study in April 2009, the placed spawning gravel in Mid Scully Creek was sampled again, as were the two "natural" spawning sites in Mid and South Scully Creek. Samples were collected using a freeze core sampler (Devcic 2009) and sent to the same geotechnical testing laboratory as the baseline sample for analysis (see Appendix D for analysis results from the geotechnical lab).

Table 2. Grading limits for the screened spawning gravel for the Scully Creek Spawning Habitat Enhancement Project.

Sieve Size (Square Opening)	Total Passing Sieve (Percent by Weight)
75mm (3 in)	100%
50mm (2 in)	75% - 85%
38mm (1 ½ in)	50% - 75%
25mm (1 in)	30% - 50%
20mm (3/4 in)	10% - 30%
12mm (1/2 in)	0% - 10%

4. RESULTS

4.1 Environmental Monitoring Results

Stream Discharge

Stream discharge rating curves were developed for Scully Creek mid channel (and other Lakelse Lake tributaries) as part of the "Lakelse Suspended Sediment Monitoring Program" (Leggat 2009a). The rating curve was used to generate a hydrograph for Scully Creek Mid channel (Figure 2) for the 'snow free period' of 2008, from hourly water level data collected with a WDP pressure transducer (barometrically corrected); Leggat 2009a). Maximum discharge in Scully Mid for the 2008 'snow free' period peaked at 4.1 m^3/s on October 22, 2008 immediately following installation of the incubation cassettes. Discharge data for the remainder of the incubation period, (referred herein as 'winter flows') in Scully mid channel, from Nov 2008 to April 2009, is provided in Figure 3. This hydrograph shows a second high flow event of similar magnitude occurring in Scully mid channel on Nov 30/Dec 1, 2008. These two events were likely responsible for the scouring of cassettes and piezometers and deposition of sediment at some cassette locations observed at Sites 2 ands 3.

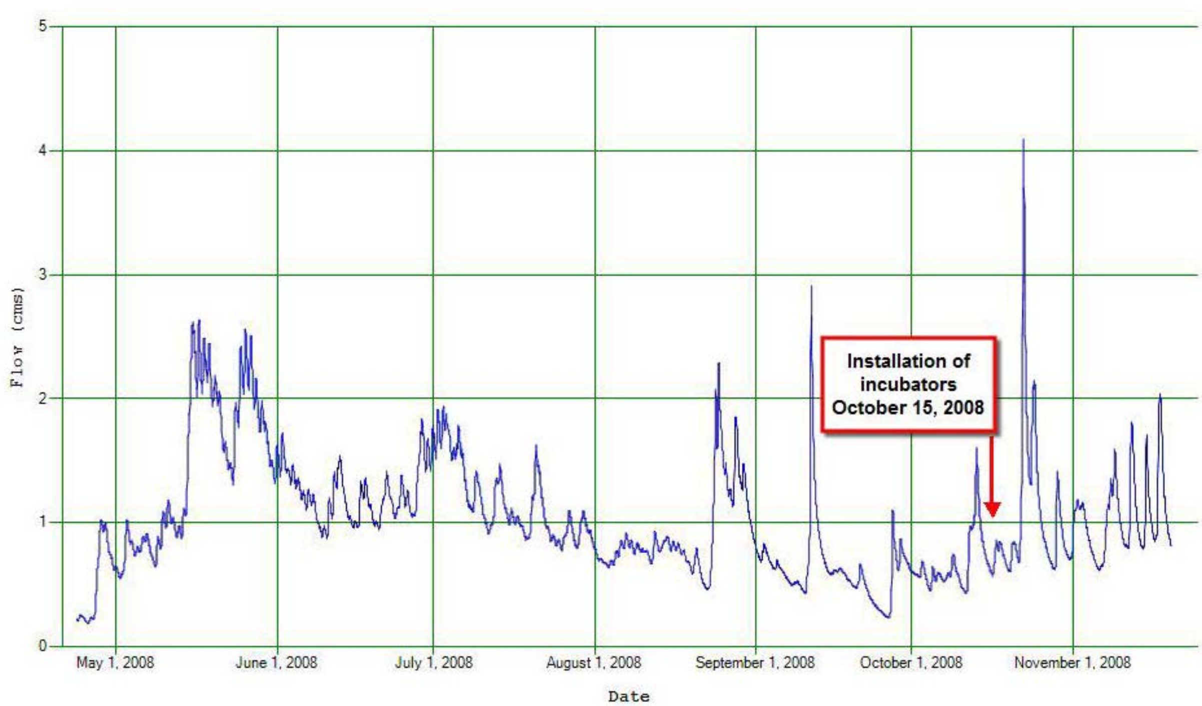

Figure 2. Scully Mid hydrograph: 2008 snow free period April 24 to November 19 (from Leggat 2009a).

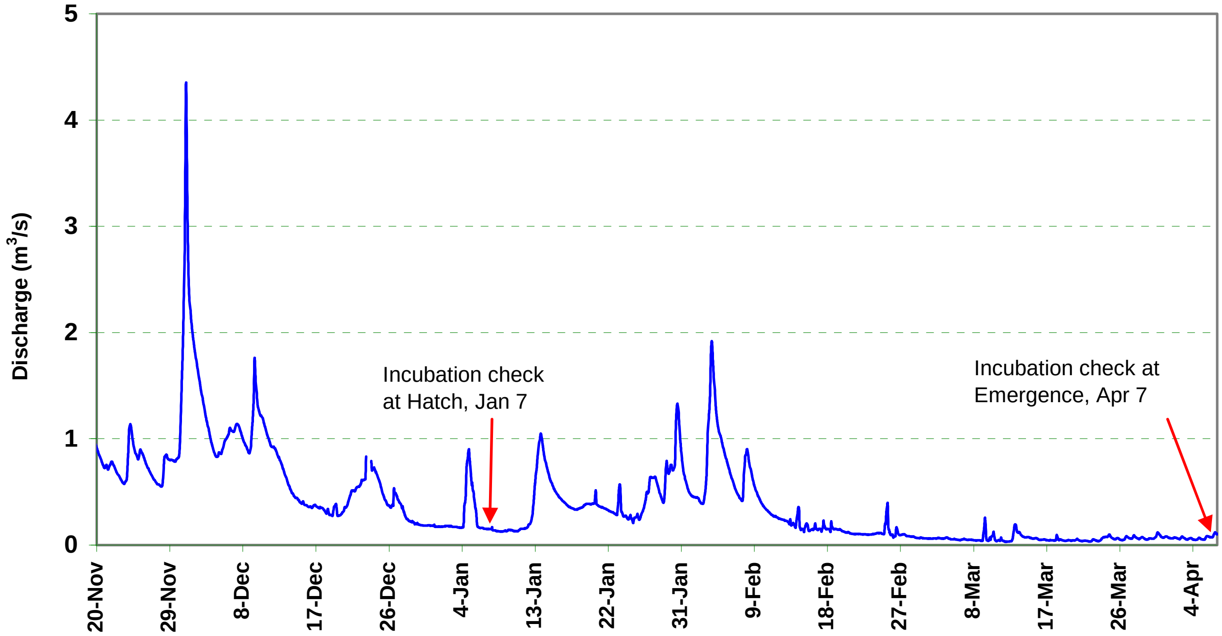

Figure 3. Scully Mid channel hydrograph for the period November 2008 - April 2009 generated from hourly water level data and rating curve calculated in Leggat 2009a.

Table 3 provides a summary of the mean, maximum and minimum discharges for Scully Mid and South channels (2008 snow free period) and for the winter period (Nov 2008 - Apr 2009) for Scully mid channel. In comparison, flows in Scully South channel were much less and the magnitude of the flood flows were greatly diminished. For the last two months of the incubation period, mean winter flow in Scully mid channel was less than 0.2 m^3/s which was the minimum flow recorded during the snow free period.

Table 3. Minimum, maximum and mean discharge for Scully mid and south channels for the snow free period (from Leggat 2009a), and for the remainder of the incubation period (Scully Mid only).

	Scully Mid	Scully South	Scully Mid Nov 20 – Apr 7
Min (m^3/s)	0.2	0.2	0.03
Max (m^3/s)	4.1	0.8	4.35
Mean (m^3/s)	1.0	0.3	0.40

Substrate Assessments

The cumulative particle size distribution for the 4 incubation sites prior to (July 2008) and immediately following (April 2009) the incubation monitoring period are shown in Figure 4. For Sites 1 and 4, gravel analyses were completed in April 2009 only. Analysis of the spawning gravel shows an increase in the amount of fines at the two spawning pads (Sites 2 and 3), during the incubation period.

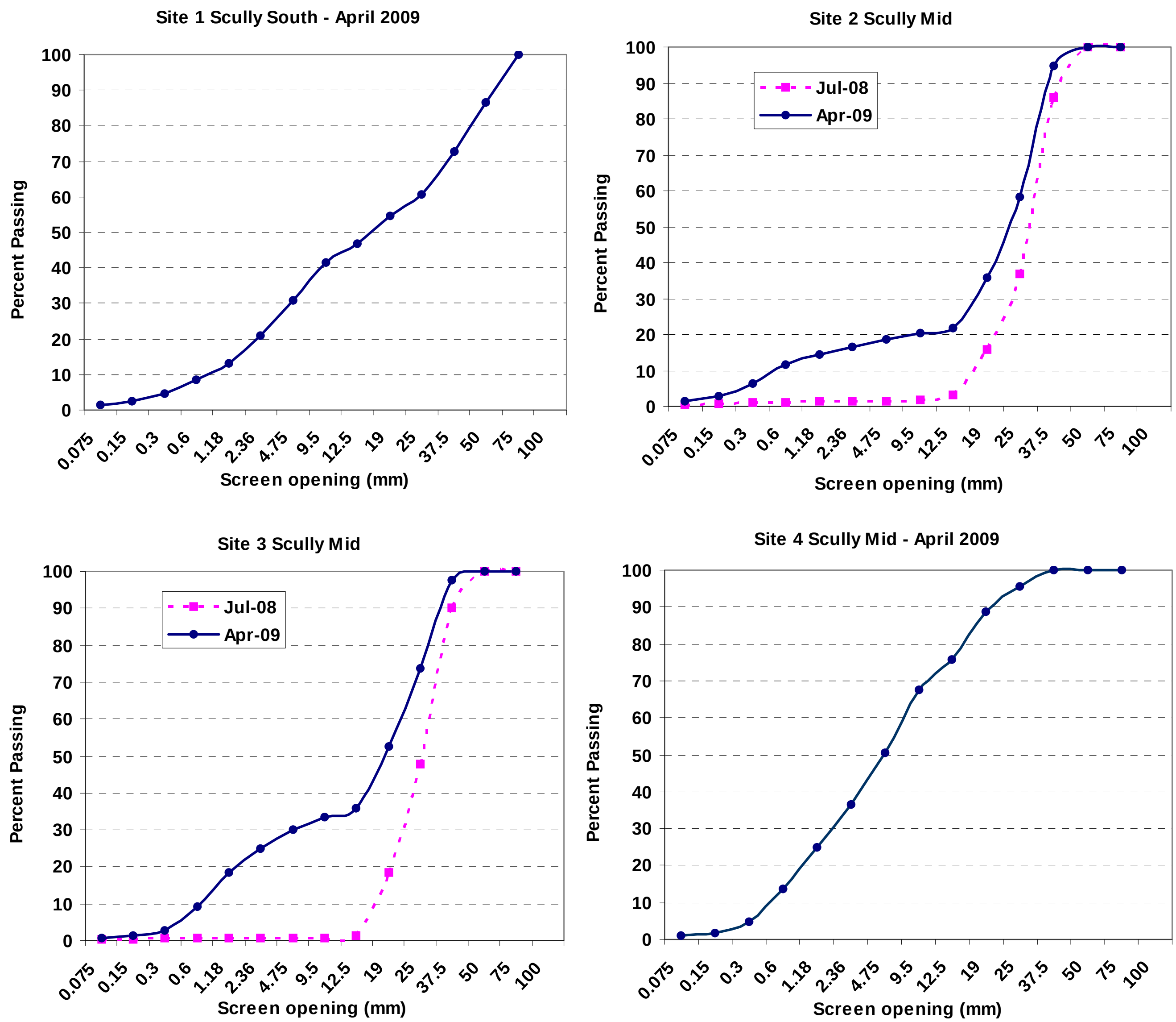

Figure 4. Cumulative particle size distribution for the 4 incubation sites from samples collected before the incubation study (July 2008) and after (April 2009).

Site 1 had widest range of particle sizes sampled (0.075 – 75 mm) while Sites 2 and 3 sampled in July 2008 had the narrowest range (12.5 – 50 mm) as would be expected for screened and graded spawning gravel. Total percentage of grains finer than 9.5 mm at Site 2 and 3 was < 2% and <1% respectively in July 2008. This amount increased substantially over the incubation period to 20% and 34% respectively in April 2009 (Figure 4; Appendix B - Photo 7 & 8)

Various descriptors of streambed composition at each incubation site are provided in Table 4. The median particle diameter (D_{50}), the 16th percentile (D_{16}) and the 84th percentile (D_{84}) particle sizes (the sizes at which 16% and 84% of the sample, respectively, are finer) are commonly used to describe streambed composition, and to facilitate comparison between samples, or in this case, between the sites and sampling dates. An alternative measure is the geometric mean Dg = $(D_{84}*D_{16})^{0.5}$ which describes the central tendancy of the distribution, but is typically less than the D_{50} because gravel size distribution tends to be negatively skewed (i.e. the distribution tail extends into the smaller particle sizes; Kondolf 1988). The percentage of fines less than 0.85 mm and less than 6.4 mm are provided as an appraisal of the quality of the spawning gravel for incubation and emergence.

Spawning gravel containing high levels of fines has been demonstrated to adversely affect the survival of salmonid eggs and alevins (Chapman 1988). As fine sediments infill the interstitial spaces within the redd, permeability decreases thereby reducing the delivery of oxygenated water to the embryos and removal of wastes, and causing entombment of alevins. Several studies suggest that substrates should not contain more than 12-14% of fine sediments smaller than 0.85 mm in diameter for successful incubation (Kondolf 2000). For emergence, the upper threshold of the fine sediment sizes affecting emergence is more variable, and particle sizes of 3 mm, 6.35 mm and 9.52 mm are commonly reported in the literature (CCME 1999). Generally, less than 28-30% of gravels should be smaller than 6.35 mm in diameter (MOE 1998, CCME 1999). Based on these guidelines, our results of substrate composition analysed in April 2009 suggest that the percent fines content at all sites could have reduced incubation success.

Table 4. Summary of particle size descriptors (mm) based on averaged sieve analysis data for the 4 incubation sites.

Date	Site	Median Diameter (D_{50})	Upper - 84th percentile (D_{84})	Lower - 16th percentile (D_{16})	Geometric Mean (Dg)	Percentage of grains < 0.85 mm	Percentage of grains < 6.40 mm
Apr-09	Site 1	16	47	2	9.7	11	35
Jul-08	Site 2	28	36.5	19	26.3	1	1.5
Apr-09	Site 2	22.5	33	2	8.1	13	19
Jul-08	Site 3	26	35	18	25.1	1	1
Apr-09	Site 3	18	29.5	1	5.4	14	31
Apr-09	Site 4	4.7	16.5	0.8	3.6	19	58

Intergravel and Water Column Temperatures

Hourly intergravel water temperatures during the study period are shown for Scully South channel, and for the 2009 portion of the study only for Scully mid channel in Figure 5. Data from both the surface and intergravel water level recorders are illustrated; however the intergravel recorder at Scully mid channel became buried by snow and ice during the winter. The sub zero temperatures recorded by this logger for much of the winter may have been due to the influence of the ice shelf, or a malfunctioning of the logger. Spot measurements of intergravel temperature taken with the Temp function on the dissolved oxygen meter, on the last monitoring visit in April recorded values of 4.4 - 5.9 ^{o}C in Scully mid channel. However, data downloaded from the recovered buried temperature logger recorded temperatures near 0 ^{o}C giving doubt to the accuracy of this data. The temperature logger may have been damaged over the winter. Water column temperature data, therefore, was used to calculate the ATUs for each developmental stage assessed during the study at the two Scully Creek channels (Table 5). Due to the slight differences in surface versus intergravel temperatures recorded by the loggers, and the need to extrapolate data through December due to some missing data, the calculated ATUs are approximate. Surface temperatures in Scully mid channel were cooler than in Scully south channel, thus egg development was slower.

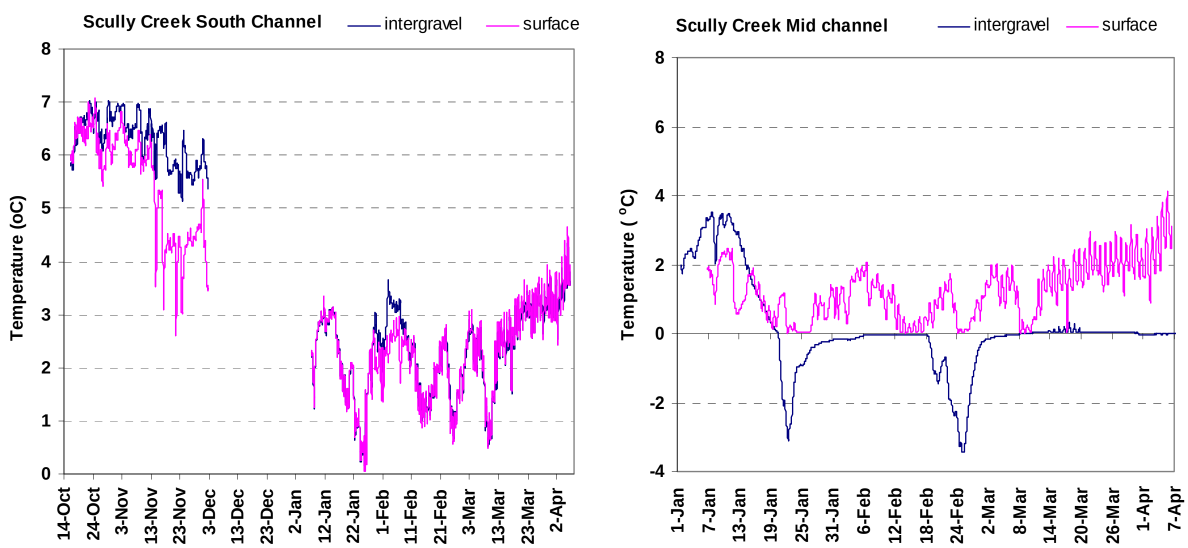

Figure 5. Comparison of hourly intergravel and water column (surface) temperatures at Scully South Channel for the duration of the incubation study, and at Scully Mid channel for the period Jan – April 2009.

Table 5. Calculated ATUs for each development stage assessed at incubation sites in the two channels of Scully Creek (South and Middle) using surface temperature data. ATUs for eyed stage provided by Snootli Hatchery.

	ATUs at Eyed Stage (Installation) Oct 15	ATUs at Hatch Jan 7 (approx)	ATUs for period Jan 6 - Apr 6	ATUs at Fry Stage (final check) Apr 7
Scully South (surface)	357	751	205.97	956.97
Scully Mid (surface)	357	~ 675	111.36	786.36
Lakelse Sockeye range from Snootli Hatchery	280 - 310	610 - 670	-	1050 - 1150

Water Column and Intergravel Water Quality

Environmental monitoring was conducted during four visits to the sites during the incubation period. During the first two visits (Dec and Jan) collection of intergravel water samples from the piezometers proved to be difficult. In some cases, the amount of water extracted from the piezometer was insufficient for measuring with the DO or conductivity meters. We suspect the small water samples from the piezometers was due to the infiltration of sand and fines into the lower section of the piezometer through the perforations, and the poor hyporheic exchange. Other times, water inside the piezometer had frozen making sample extraction impossible. Several of the piezometers had shifted during previous high flow events and were no longer vertical, and one piezometer from Site 3 was lost (scoured). In order to try and collect some intergravel data for the remainder of the study period, a "syringe-type" sampling apparatus was used on the final two monitoring events (March and April). Though this method also has some issues with data quality, it provided some comparative estimates of intergravel environmental conditions at the 4 sites. One concern with this method is the risk that intergravel measurements may be overestimated due to entrainment of surface water down the insertion point of the syringe in the gravel (Guimond and Burt 2007). However, it at least provides a rough estimate of intergravel DO conditions and enables a comparison among sites.

Results for water column and intergravel dissolved oxygen, conductivity and pH are summarized in Table 6. Values are averaged for each site over the study period using both methods of sample collection. Site 4 had the lowest average intergravel DO value overall, however both of the enhanced spawning gravel sites (Site 2 and 3) also had minimum DO values at or below the instantaneous minimum oxygen criteria level of 6 mg/l (MOE 1998).

Results for water column depth and velocity over the individual incubators (averaged for each site), measured immediately after installation (Oct 16, 2008) are summarized in Table 7.

Table 6. Average and range for intergravel and water column parameters: dissolved oxygen (DO), specific conductivity and pH.

	Water Column DO (mg/l)			Water Column DO (%)			Intergravel DO (mg/l)			Intergravel DO (%)		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Site 1	12.46	12	13.2	92.2	87.6	96	9.05	1.3	12.3	67.27	9.7	96.8
Site 2	13.19	12.2	13.8	96.1	84.6	103	11.73	6	13.7	88.64	47.4	106.6
Site 3	13.52	13.2	14.5	97.7	91.5	102	10.20	3.5	14.8	77.27	28.5	106
Site 4	13.39	12.8	14.3	96.5	88.5	101	6.52	2.7	10.6	46.47	21.2	74

	Water Column Specific Conductivity (µS•cm-1)			Intergravel Specific Conductivity (µS•cm^{-1})			Water Column pH			Intergravel pH		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Site 1	58.07	54.5	60.3	80.15	59.2	126.8	6.8	5.9	8	7.4	6.4	8.1
Site 2	32.03	28.5	36.2	45.23	37.7	54.2	6.8	5.5	8.1	7.5	6.4	8.3
Site 3	30.43	27.1	35.6	78.43	56.8	101.4	7.4	6.4	8.4	7.0	6.1	8.3
Site 4	31.25	28.5	35.3	53.97	35.7	90	7.5	6.5	8.5	7.5	6.2	8.7

Table 7. Average and range for water column depth and velocity as measured over each incubator site on October 16, 2008.

	Depth (m)			Avg_Vel (m/s)		
	Avg	Min	Max	Avg	Min	Max
Site 1	0.09	0.02	0.15	0.48	0.44	0.51
Site 2	0.17	0.12	0.25	0.37	0.23	0.60
Site 3	0.20	0.09	0.30	0.27	0.11	0.60
Site 4	0.24	0.14	0.35	0.21	0.15	0.29

4.2 Incubation Success

Due to the overall poor survival results in the cassettes planted in both the optimum quality sites and in marginal sites (Appendix C), survival results for cassettes assessed at each incubation site were pooled for each developmental stage. Means and 95% confidence limits for the pooled data are summarized by life stage in Table 8 and illustrated in Figure 6. Survival for eyed egg-to-hatch and eyed egg-to-fry was greatest at Site 1 (Scully south) while survival for the two developmental stages was poor at all three incubation sites in Scully mid channel. There was no significant difference among sites (ANOVA, $\alpha = 0.05$) for the eyed egg-to-fry-stage, however survival at Site 1 was significantly different than at Site 2 for the eyed egg-to-hatch stage (Tukey-Kramer comparison of means test; $\alpha = 0.05$). The high survival for the remainder of the eyed eggs incubated at the hatchery eliminates any uncertainty in egg survival due to egg viability.

Table 8. Mean survival (eyed egg-to-hatch and eyed egg-to-fry) from the 3 Scully Creek Mid channel and the Scully Creek South channel study sites. Values are averages for all cassette types per site with associated 95% confidence limits. Also shown are means for the control group at Snootli Hatchery.

Site	Mean Survival and 95% CL (%)			
	Eyed Egg to Hatch		Eyed Egg to Fry	
Site 1	44.8	± 22.34	12.0	± 11.28
Site 2 (Enhanced)	0.0	± 22.34	0.0	± 11.28
Site 3 (Enhanced)	13.3	± 25.8	0.0	± 15.96
Site 4 Control	7.8	± 22.34	0.0	± 11.28
Hatchery	99.24		98.04	

Notes:
1. 95% confidence limits for Sites 1-4 were based on a pooled variance for each developmental stage.

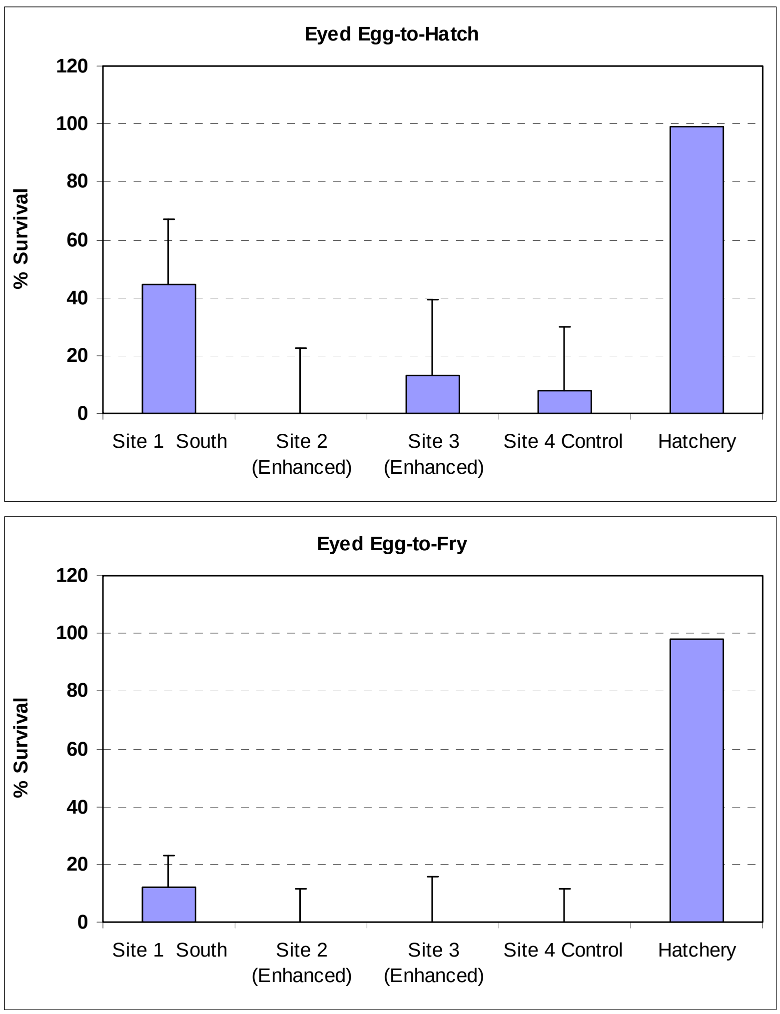

Figure 6. Survival from incubators at the 4 study sites in Scully mid and south channels and from the remaining eggs incubated at Snootli Hatchery.

5. DISCUSSION

The main objective of this study was to determine the effectiveness of the gravel additions to the mid channel of Scully Creek for sockeye salmon spawning. Based on results from incubation assessments in recently constructed spawning gravel placement projects in other areas, we would expect to see high incubation survival due to the high quality of the introduced gravels (Guimond 2006, 2007). Our results for the Scully Creek study showed poor survival rates overall with mean survival for the eyed egg-to-hatch stage ranging from zero to 44.8% (Figure 6). Eyed egg-to-fry survival was much poorer (range 0 - 12%). Most of the mortality in the individual incubation cassettes was at the eyed egg stage (mortality before hatch; Appendix B - Photo 9). Regrettably we did not retain any egg samples to determine the time/developmental stage of death. Site 1 in south Scully Creek had the best survival with 44.8% survival to the hatch stage and 12% survival to the fry stage. There was no significant difference in survival between the enhanced sites and the control site in mid Scully Creek.

Exposure to low levels of dissolved oxygen just before hatching has been found to reduce embryo survival (Alderdice et al. 1958). This period corresponds to the embryonic developmental stage requiring the highest oxygen levels (Rombough, *as cited in* Sigma Environmental Consultants Ltd. 1983). While this may have been a factor at some incubation sites, our results for intergravel DO measured during the first two monitoring visits do not reflect this (Table 6). Difficulties in obtaining adequate intergravel water samples from the piezometers at the sites may have resulted in overestimates of dissolved oxygen if air was artificially added to the samples from the manual pump while extracting the water sample. While it is dissolved oxygen that is the essential parameter for embryo survival and development, the function of the hyporheic environment to deliver the oxygen to the embryo and remove metabolic waste products also plays a key role (Coble 1961). In other words, incubation survival can be poor in situations of both low dissolved oxygen but high apparent velocity, and in high dissolved oxygen but low apparent velocity. Low DO measurements (at or less than 6 mg/l) were recorded at the four incubation sites on the final incubation check using the alternate sampling method (syringe).

Based on the results of the gravel sieve analysis conducted before and after the incubation period, the high percentage of fines may have also influenced incubation survival. At the incubation sites, the amount of fine sediments less than 0.85 mm in diameter ranged from 11% to 19%, with Scully South (Site 1) having the least amount of fines < 0.85 mm in diameter and the greatest survival overall (Table 4). Interestingly, the cassettes that had the greatest survival to hatch at South Scully were located in a shallow riffle area that had a high amount of fines but significant down-welling of surface water to the hyporheic environment. Therefore, this may have offset some of the negative affects of the low permeability from the high percentage of fines at this site.

During the first incubation assessment at the hatch stage (January), a sulphurous odour (i.e. rotten egg smell) was noted when some of the incubation cassettes were removed from the gravel, particularly at Site 2. Hydrogen sulphide (H_2S) is a product of the anaerobic decomposition of organic matter, along with methane (CH_4), and carbon dioxide (CO_2). H_2S is a highly poisonous and soluble gas and an indicator of anoxic conditions. The toxicity of hydrogen sulphide to fish is caused by the undissociated form (H_2S) and is dependent on temperature, pH and dissolved oxygen. H_2S oxidizes readily when exposed to oxygen, in effect stripping oxygen from its surrounding environment. The eggs and fry of most species are very sensitive and can be affected at levels of H_2S as low as 0.001 mg/l (Wedemeyer, 1996). Levels between 0.002 and 0.005 mg/l are often more easily detectable by odour than by laboratory means (Groves and Chandler 2005). Soil pits excavated adjacent Scully Creek Mid channel downstream of our incubation sites exposed an organic layer overlain with fine sediments and coarser fluvial sediment near the surface (Leggat 2009b). Both the mid and north channels of Scully Creek have been dug into this organic layer during the conversion of the surrounding land for agriculture. Furthermore, the influx of agricultural run-off from adjacent land use may also affect water quality during certain times of the year. Additional water quality monitoring and water sample collection at the Scully mid channel spawning gravel pads should be conducted to determine whether H_2S may have been a contributing factor to the poor incubation survival observed during our incubation assessment.

6. REFERENCES

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APPENDICES

Appendix A. Photo mosaic of Mid Scully Creek showing locations of the incubation sites.

Appendix A. Photo mosaic of Mid Scully Creek showing locations of the incubation sites.

Appendix B. Selected photos from the incubation study.

Photo 1. Pooling eyed sockeye eggs after delivery from Snootli Hatchery to Scully Creek. Eyed eggs were transported in specially designed egg tubes.

Photo 2. Loading eyed sockeye eggs into Jordan-Scotty incubation cassette loaders prior to transfer into yellow incubation cassettes (100 eggs per cassette).

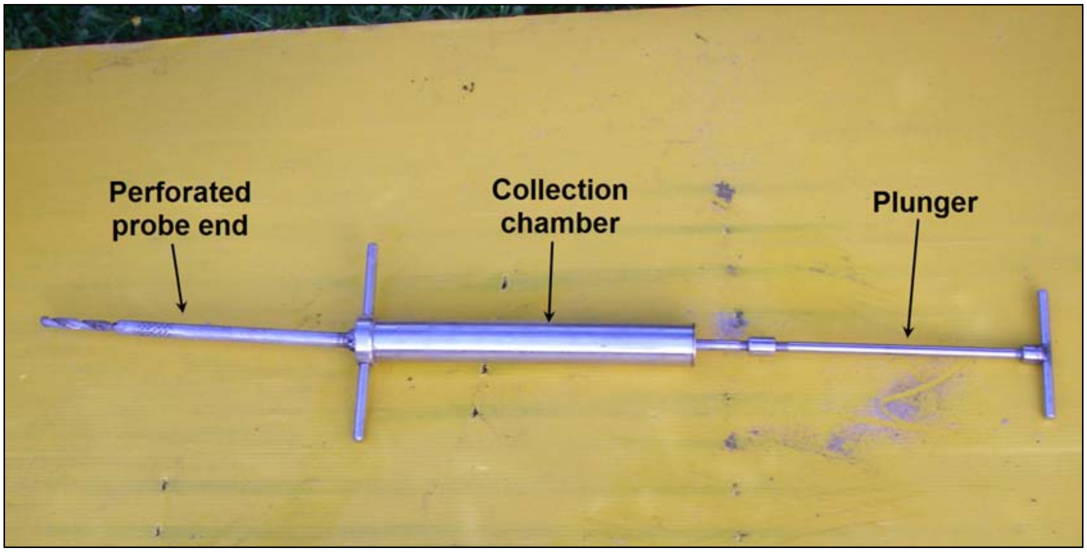


Photo 3. Syringe apparatus used to extract intergravel water samples. The narrow probe end is inserted into the gravel with the help of the foot pedal, to its full length. The plunger is pulled, drawing the water sample into the collection chamber.

Photo 4. Completed installation of piezometers and buried incubation cassettes, flagged with poly rope and tape to facilitate locating for incubation assessments, at Site 4 in Scully Creek mid channel.

Photo 5. Site 3 in Scully Creek mid channel at spawning platform #3 looking upstream.

Photo 1. Site 1 at Scully South channel upstream of the Highway 37 culvert.

Photo 7. Screened spawning gravel at Scully Mid channel, October 15, 2008.

Photo 8. Spawning gravel at Scully Mid channel, January 7, 2009. Note sand and fines within interstitial spaces.

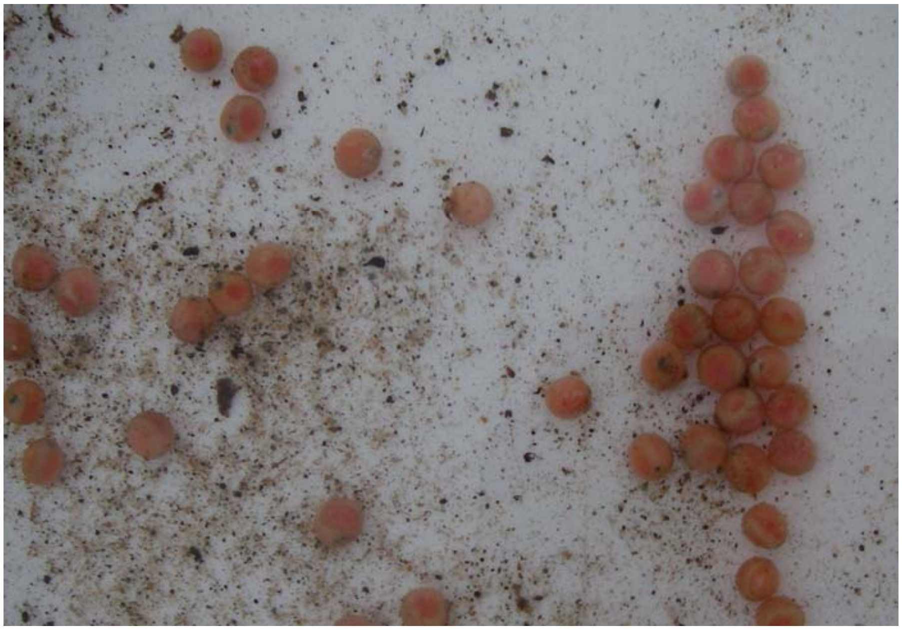


Photo 9. Mortality in one of four cassettes removed at Site 2 in Scully mid channel to assess survival to hatch stage.

Photo 10. Mortality in one of four cassettes removed at Site 2 in Scully mid channel to assess survival to the fry stage.

Appendix C. Survival rates for each incubation cassette assessed at hatch stage (January 2009) and fry stage (April 2009).

Site	Cassette #	Percent Survival to Hatch Stage	Percent Survival to Fry Stage
1	1A	100	39
	2A	97	9
	3B	0	0
	4B	0	0
	5A	3	
	6A	0	
	7B	79	
	8B	79	
	Mean	**44.8**	**12.0**
2	1B	2	
	2A	0	
	3A	0	
	4B	0	
	5B	0	0
	6A	0	0
	7A	0	0
	8B	0	0
	Mean	**0.3**	**0.0**
3	1A	n/a - scoured	
	2B	0	
	3B	0	
	4B	0	0
	5A	0	0
	6A	n/a missing	
	7B	0	
	8A	80	
	Mean	**13.3**	**0.0**
4	1B	0	
	2B	0	
	3A	0	
	4A	0	
	5B	0	0
	6B	0	0
	7A	0	0
	8A	62	0
	Mean	**7.8**	**0.0**

Appendix D. Aggregate sieve analysis results for incubation sites in Scully Creek mid and south channels, July 24, 2008 and April 1, 2009.

Client:	DFO
cc:	
cc:	

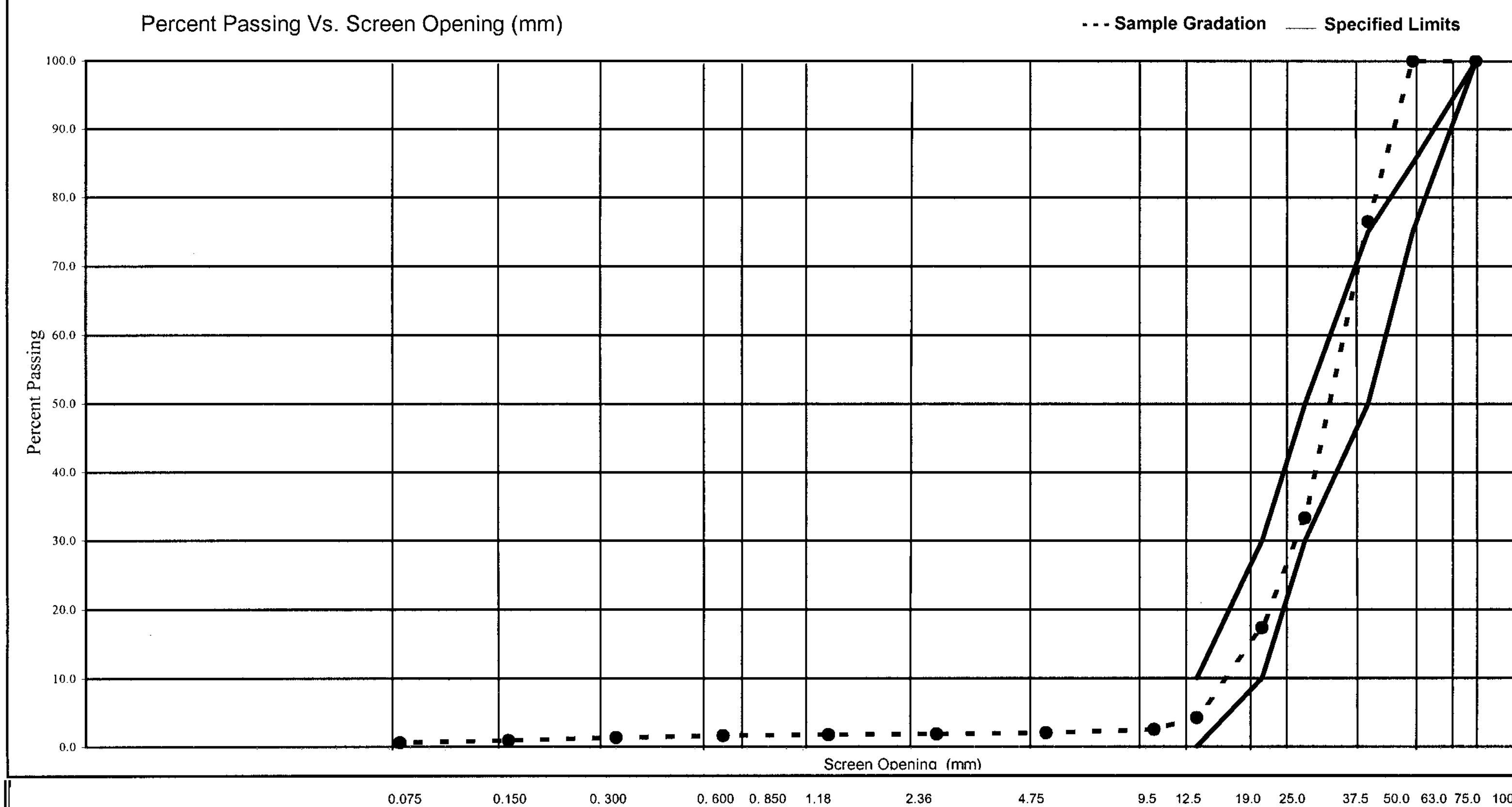
Project No:	2321-22223-0
Location:	Scully Mid, Site2
Date of Report:	24-Jul-08

Type of Sample:	Spawning gravel
Sample No:	3
Source:	Scully Mid, Site 2 Bag A
Specified Limits:	As Shown

Sampled by:	Client	Date:	07-15	Washed Analysis
Tested by:	GS/VW	Date:	07-23	Dry Analysis

MATERIAL: Native Fill | Native

Imported Fill



Screen Opening (mm)	Percent Passing Total	Speci Lim Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	76.5	50.0
25.0	33.3	30.0
19.0	17.3	10.0
12.5	4.2	0.0
9.50	2.5	
4.75	2.0	
2.36	1.8	
1.180	1.7	
0.600	1.6	
0.300	1.3	
0.150	0.9	
0.075	0.6	

Remarks:

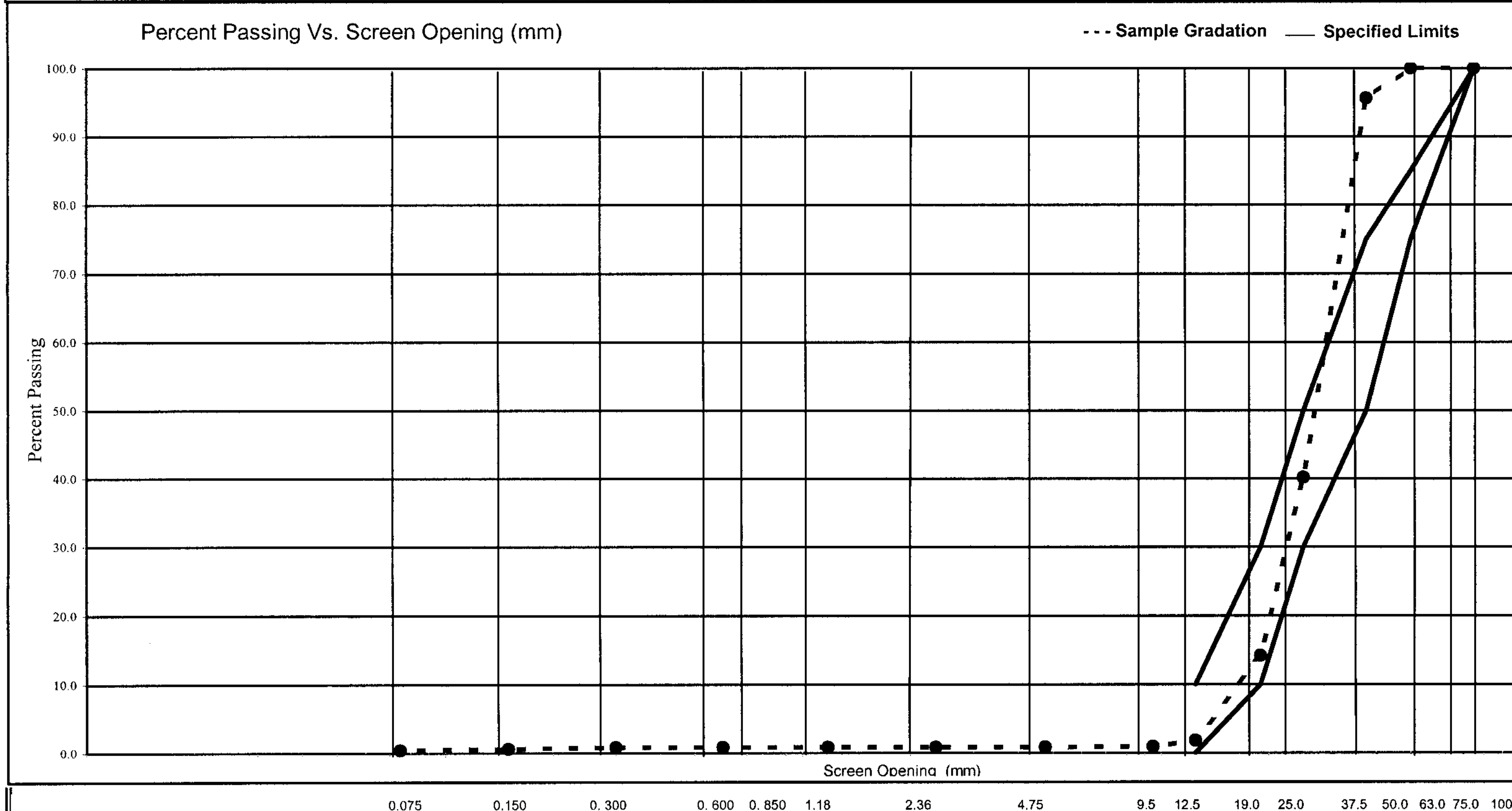
Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

Sieve (

Client:	DFO	Project No:	2321-22223-0
cc:		Location:	Scully Mid, Site2
cc:		Date of Report:	24-Jul-08

Type of Sample:	Spawning gravel	Sampled by:	Client	Date:	07-15	Washed Analysis
Sample No:	4	Tested by:	GS/VW	Date:	07-23	Dry Analysis
Source:	Scully Mid, Site 2 Bag B	MATERIAL:	Native Fill		Native	
Specified Limits:	As Shown		Imported Fill			



Screen Opening (mm)	Percent Passing Total	Speci Lim Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	95.6	50.0
25.0	40.2	30.0
19.0	14.2	10.0
12.5	1.8	0.0
9.50	0.9	
4.75	0.8	
2.36	0.8	
1.180	0.8	
0.600	0.8	
0.300	0.8	
0.150	0.6	
0.075	0.4	

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

Sieve (

Client:	DFO
cc:	
cc:	

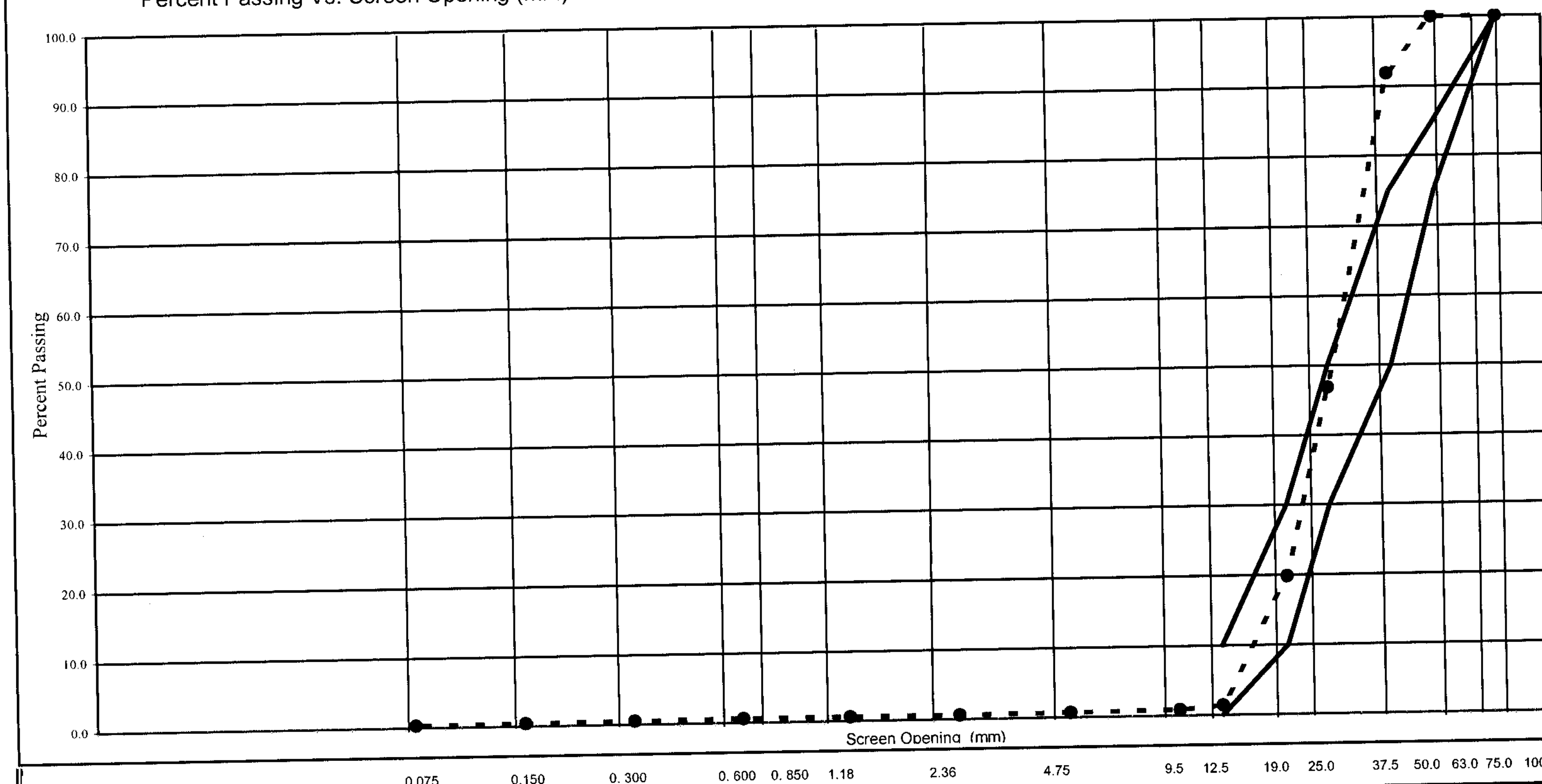
Project No: 2321-22223-0
Location: Scully Mid, Site 3
Date of Report: 24-Jul-08

Sampled by: Client Date: 07-16 Washed Analysis
Tested by: GS/VW Date: 07-23 Dry Analysis

Type of Sample: Spawning gravel
Sample No: 5
Source: Scully Mid, Site 3 Bag A
Specified Limits: As Shown

MATERIAL: Native Fill Native
Imported Fill

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Speci[fied] Lim[its] Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	91.9	50.0
25.0	46.9	30.0
19.0	19.8	10.0
12.5	1.4	0.0
9.50	0.8	
4.75	0.7	
2.36	0.6	
1.180	0.6	
0.600	0.6	
0.300	0.5	
0.150	0.4	
0.075	0.3	

Remarks:

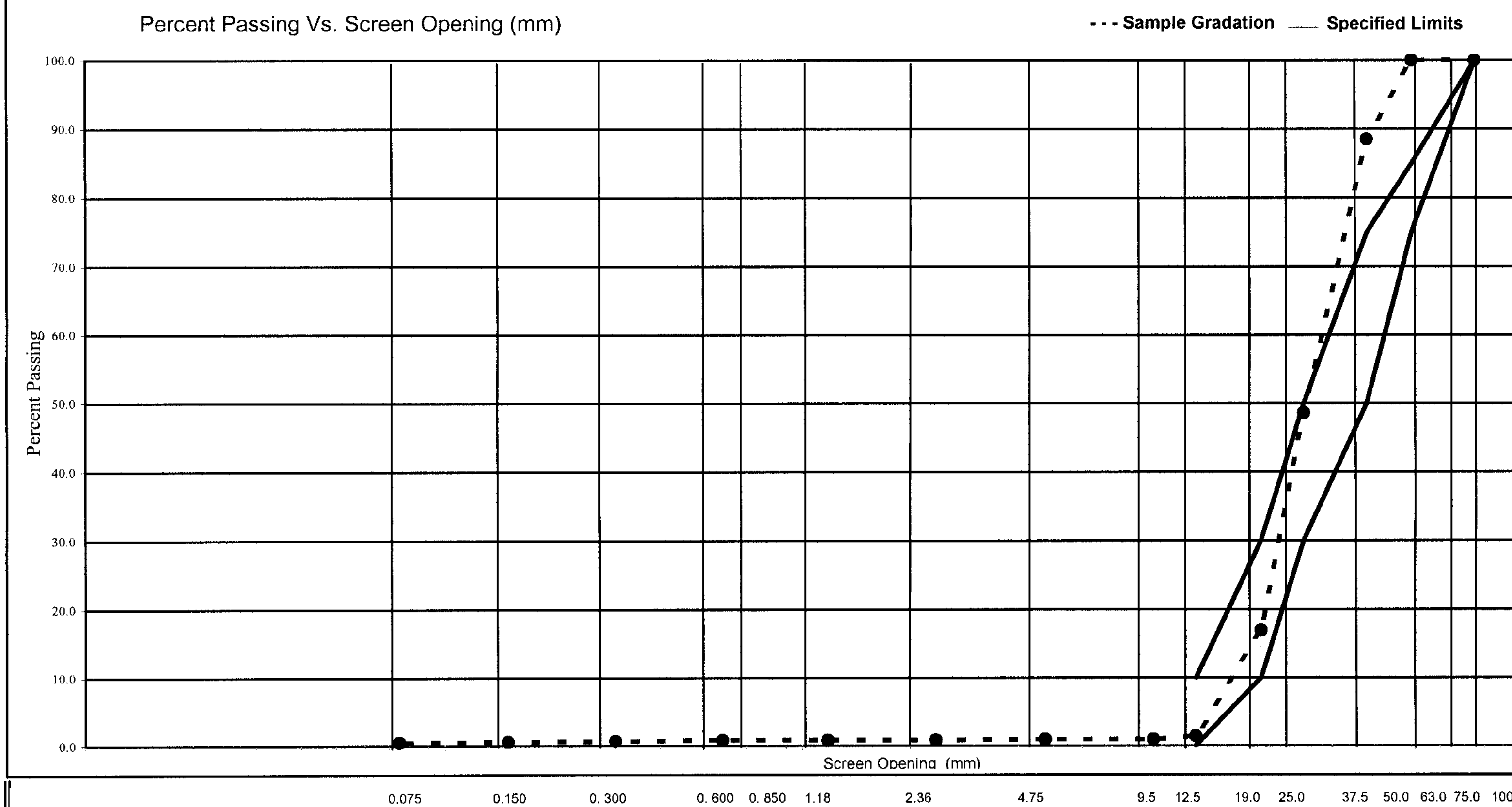
Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

Siev

Client:	DFO	Project No:	2321-22223-0
cc:		Location:	Scully Mid, Site 3
cc:		Date of Report:	24-Jul-08

Type of Sample:	Spawning gravel	Sampled by:	Client	Date:	07-16	Washed Analysis
Sample No:	6	Tested by:	GS/VW	Date:	07-23	Dry Analysis
Source:	Scully Mid, Site 3 Bag B	MATERIAL:	Native Fill		Native	
Specified Limits:	As Shown		Imported Fill			



Screen Opening (mm)	Percent Passing Total	Speci Lim Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	88.5	50.0
25.0	48.6	30.0
19.0	16.9	10.0
12.5	1.4	0.0
9.50	0.9	
4.75	0.9	
2.36	0.8	
1.180	0.8	
0.600	0.8	
0.300	0.7	
0.150	0.6	
0.075	0.5	

Remarks:

Reviewed by: G. Maltin CTech

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McElhanney

Aggregate Sieve Analysis

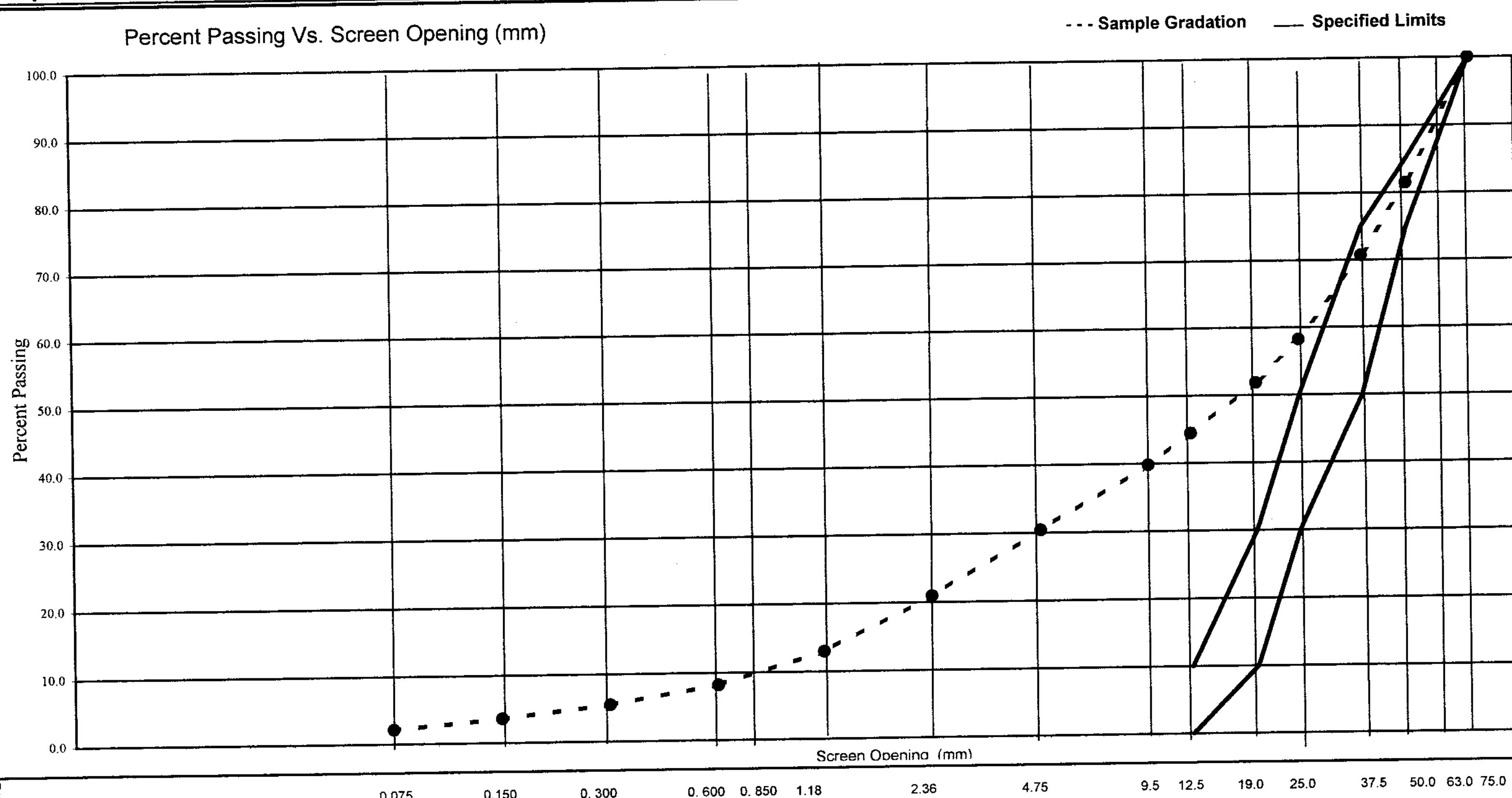
Client: DFO
cc:
cc:

Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 1
Source: South, Highway Culvert Inlet, #1
Specified Limits: As Shown

Sampled by: Client **Date:** 23-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 25-Mar-09 **Dry Analysis**

MATERIAL: Native Fill **Native**
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	81.5	75.0	85.0
37.5	70.7	50.0	75.0
25.0	58.2	30.0	50.0
19.0	51.8	10.0	30.0
12.5	44.4	0.0	10.0
9.50	39.8		
4.75	30.4		
2.36	20.9		
1.180	13.0		
0.600	8.2		
0.300	5.5		
0.150	3.6		
0.075	2.1		

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

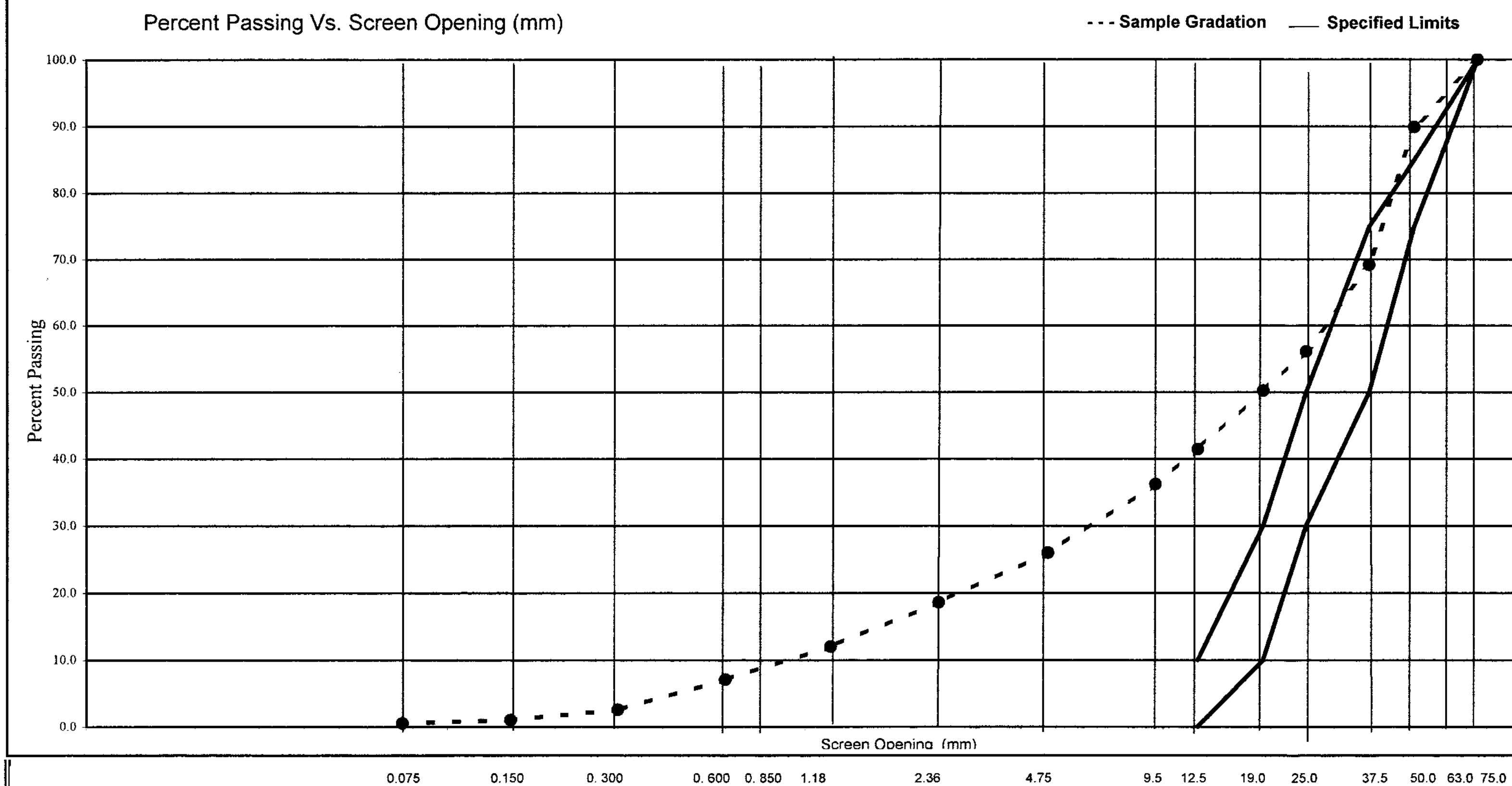
McElhanney

Aggregate Sieve Analysis

Client:	DFO
cc:	
cc:	
Project:	DFO Sieve Analysis
Project No:	2321-22240-0
Location:	Scully Creek
Date of Report:	1-Apr-09

Type of Sample:	Spawning gravel	Sampled by:	Client	Date: 23-Mar-09	Washed Analysis X
Sample No:	2	Tested by:	GS	Date: 25-Mar-09	Dry Analysis
Source:	South, Highway Culvert Inlet, #2	MATERIAL:	Native Fill		Native
Specified Limits:	As Shown		Imported Fill		

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	89.9	75.0	85.0
37.5	69.2	50.0	75.0
25.0	56.1	30.0	50.0
19.0	50.2	10.0	30.0
12.5	41.4	0.0	10.0
9.50	36.2		
4.75	26.0		
2.36	18.6		
1.180	12.0		
0.600	7.1		
0.300	2.6		
0.150	1.0		
0.075	0.5		

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

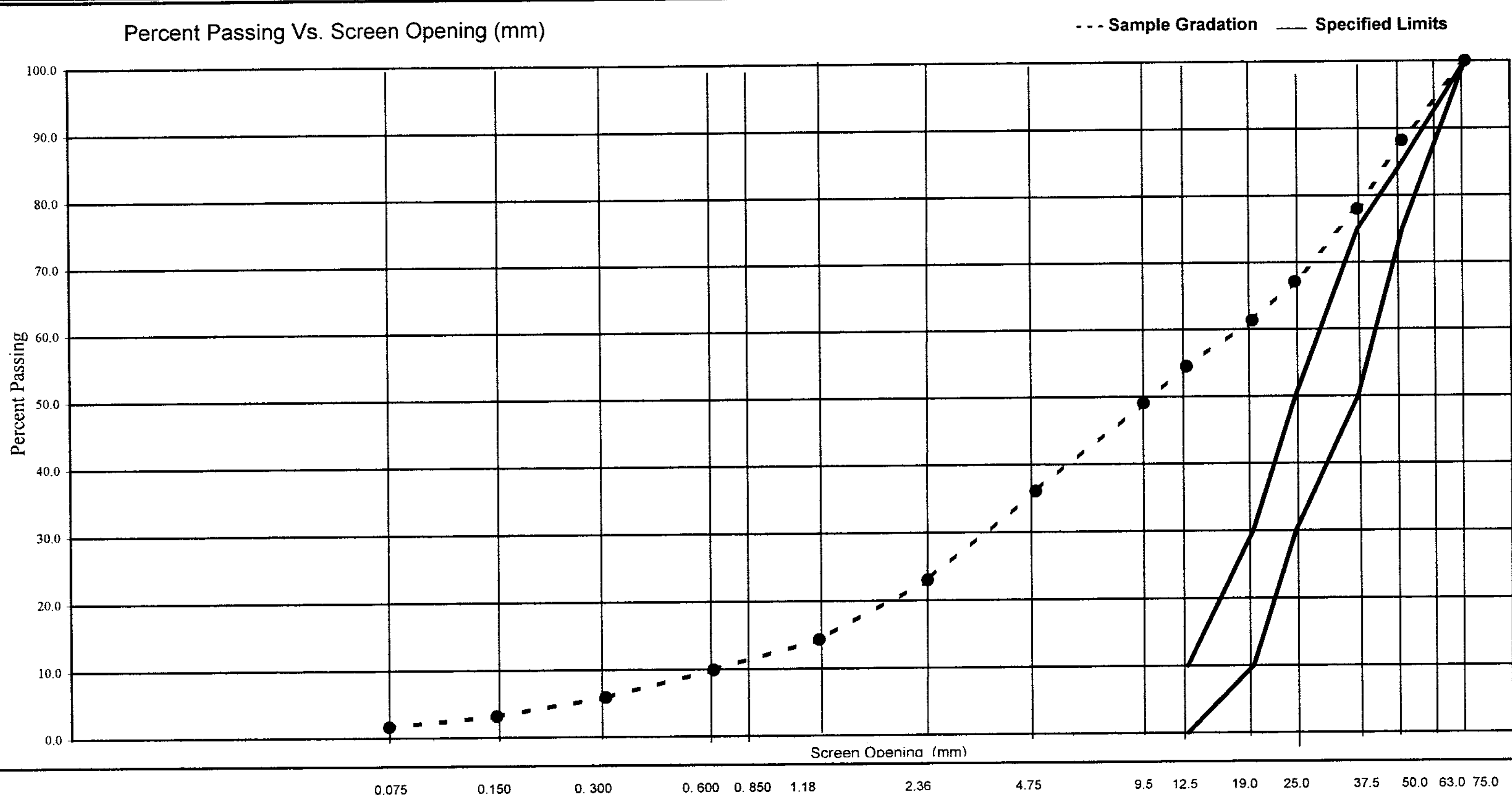
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Client: DFO
cc:
cc:

Type of Sample: Spawning gravel
Sample No: 3
Source: South, Highway Culvert Inlet, #3
Specified Limits: As Shown

Sampled by: Client **Date:** 23-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 25-Mar-09 **Dry Analysis**

MATERIAL: Native Fill Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	88.2	75.0	85.0
37.5	78.0	50.0	75.0
25.0	67.1	30.0	50.0
19.0	61.3	10.0	30.0
12.5	54.5	0.0	10.0
9.50	49.0		
4.75	36.0		
2.36	23.0		
1.180	14.3		
0.600	9.9		
0.300	5.9		
0.150	3.2		
0.075	1.6		

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

Client: DFO
cc:
cc:

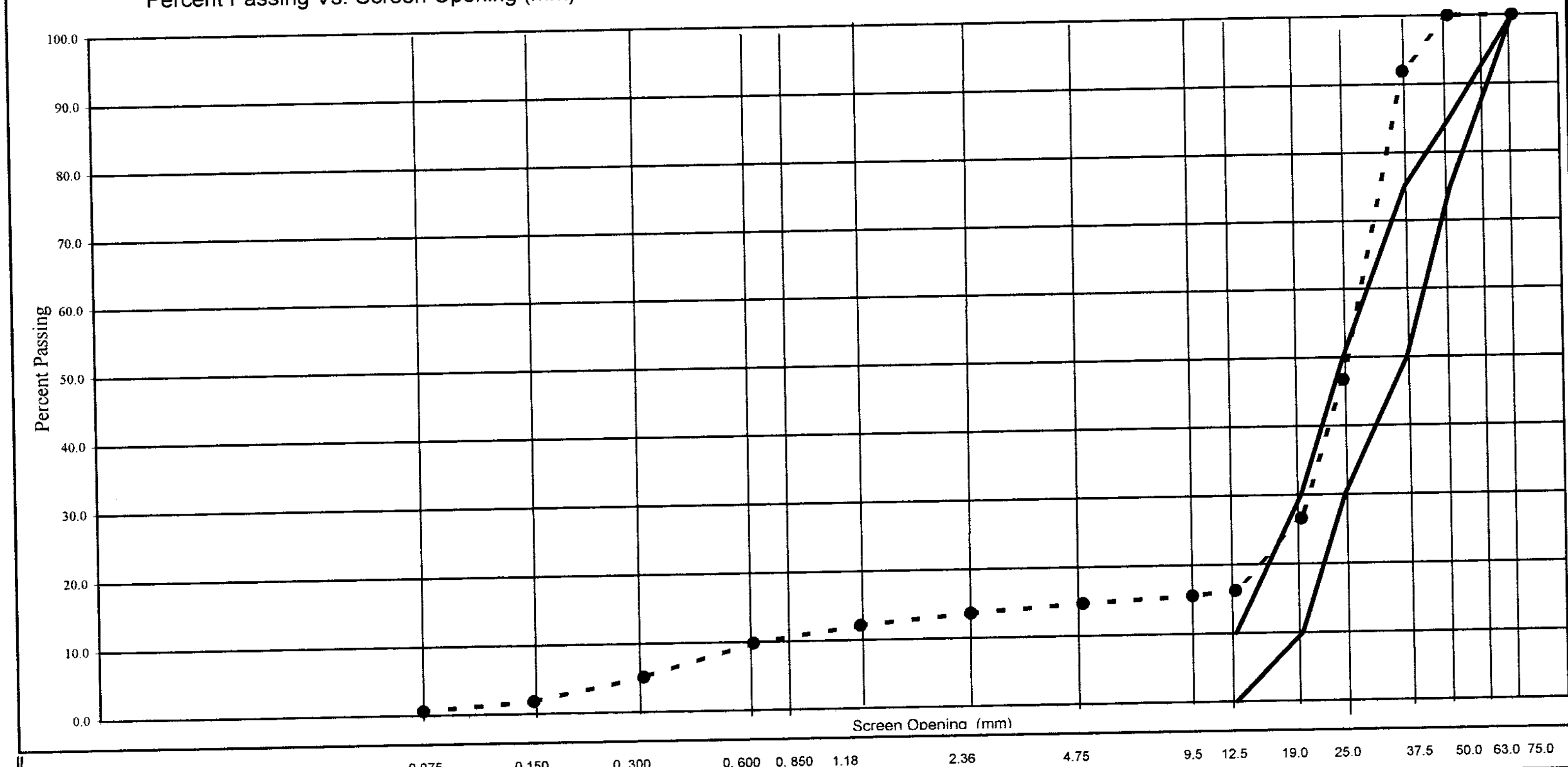
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 7
Source: Mid-channel, 0-0.25m
Specified Limits: As Shown

Sampled by: Client **Date:** 25-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 28-Mar-09 **Dry Analysis**

MATERIAL: Native Fill Native
Imported Fill

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	91.9	50.0	75.0
25.0	46.7	30.0	50.0
19.0	26.6	10.0	30.0
12.5	16.2	0.0	10.0
9.50	15.5		
4.75	14.7		
2.36	13.6		
1.180	12.1		
0.600	9.8		
0.300	5.1		
0.150	1.8		
0.075	0.6		

Remarks:
Sample #1, Spawning Platform #2, Stn 0+527 - 0+570, Freeze Core

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

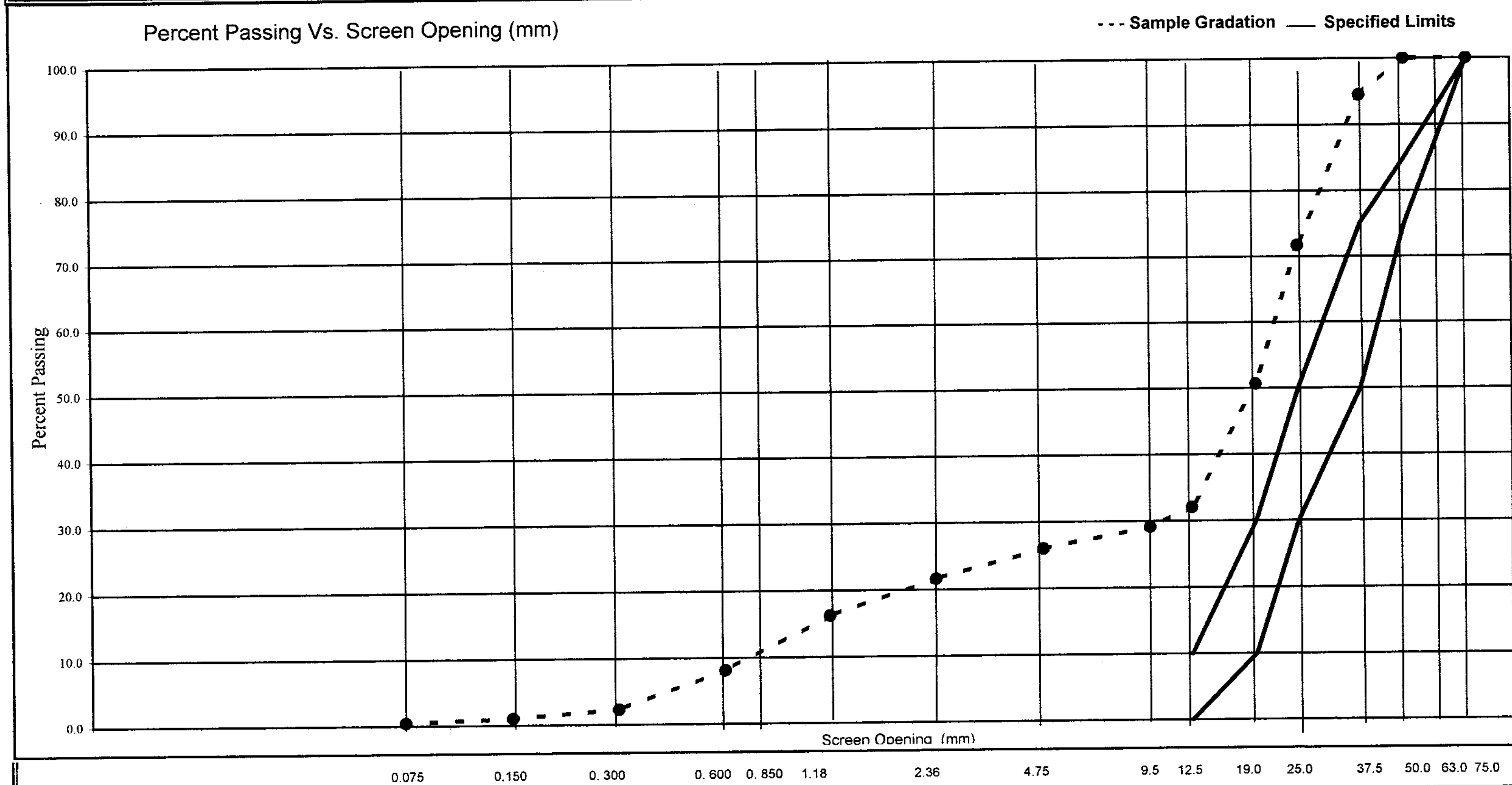
Client: DFO
cc:
cc:

Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 8
Source: Mid-channel, 0-0.15m
Specified Limits: As Shown

Sampled by: Client **Date:** 25-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 27-Mar-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill **Native**



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	94.5	50.0	75.0
25.0	71.7	30.0	50.0
19.0	50.6	10.0	30.0
12.5	32.0	0.0	10.0
9.50	29.1		
4.75	26.0		
2.36	21.6		
1.180	16.2		
0.600	8.1		
0.300	2.3		
0.150	1.0		
0.075	0.4		

Remarks:
Sample #1, Spawning Platform #3, Stn 0+420 - 0+475

Reviewed by: G. Maltin CTech [signature]

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

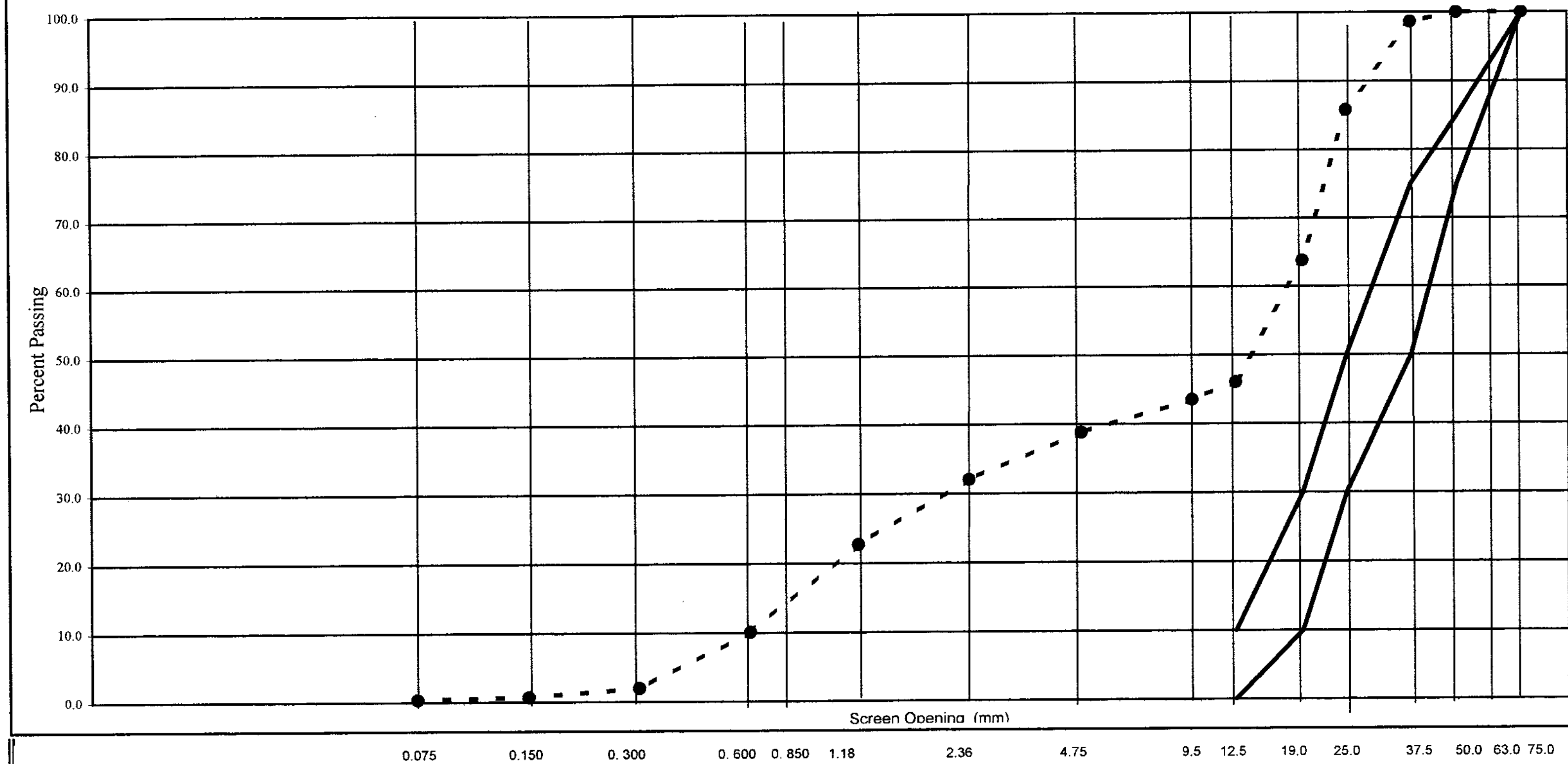
Client: DFO
cc:
cc:

Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 9
Source: Mid-channel, 0-0.15m
Specified Limits: As Shown

Sampled by: Client **Date:** 25-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 27-Mar-09 **Dry Analysis**

MATERIAL: Native Fill Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	98.6	50.0	75.0
25.0	85.8	30.0	50.0
19.0	63.8	10.0	30.0
12.5	46.0	0.0	10.0
9.50	43.5		
4.75	38.8		
2.36	32.0		
1.180	22.7		
0.600	10.1		
0.300	2.0		
0.150	0.7		
0.075	0.3		

Remarks:
Sample #2, Spawning Platform #3, Stn 0+420 - 0+475

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

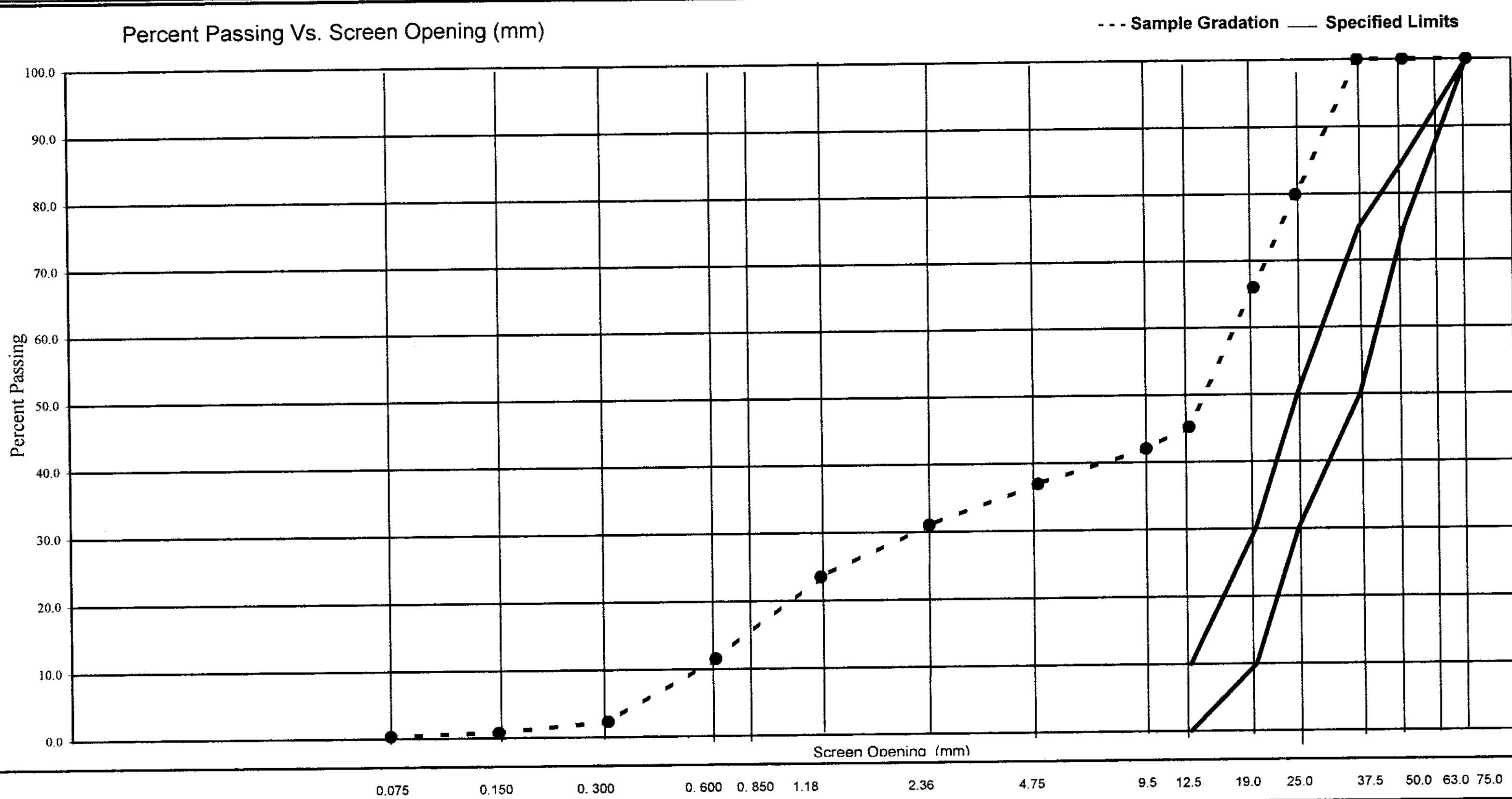
Client: DFO
cc:
cc:

Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 10
Source: Mid-channel, 0-0.15m
Specified Limits: As Shown

Sampled by: Client **Date:** 25-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 26-Mar-09 **Dry Analysis**

MATERIAL: Native Fill Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	79.9	30.0	50.0
19.0	66.0	10.0	30.0
12.5	45.2	0.0	10.0
9.50	42.0		
4.75	36.9		
2.36	31.0		
1.180	23.5		
0.600	11.5		
0.300	2.3		
0.150	0.8		
0.075	0.3		

Remarks:
Sample #3, Spawning Platform #3, Stn 0+420 - 0+475

Reviewed by: G. Maltin CTech [signature]

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

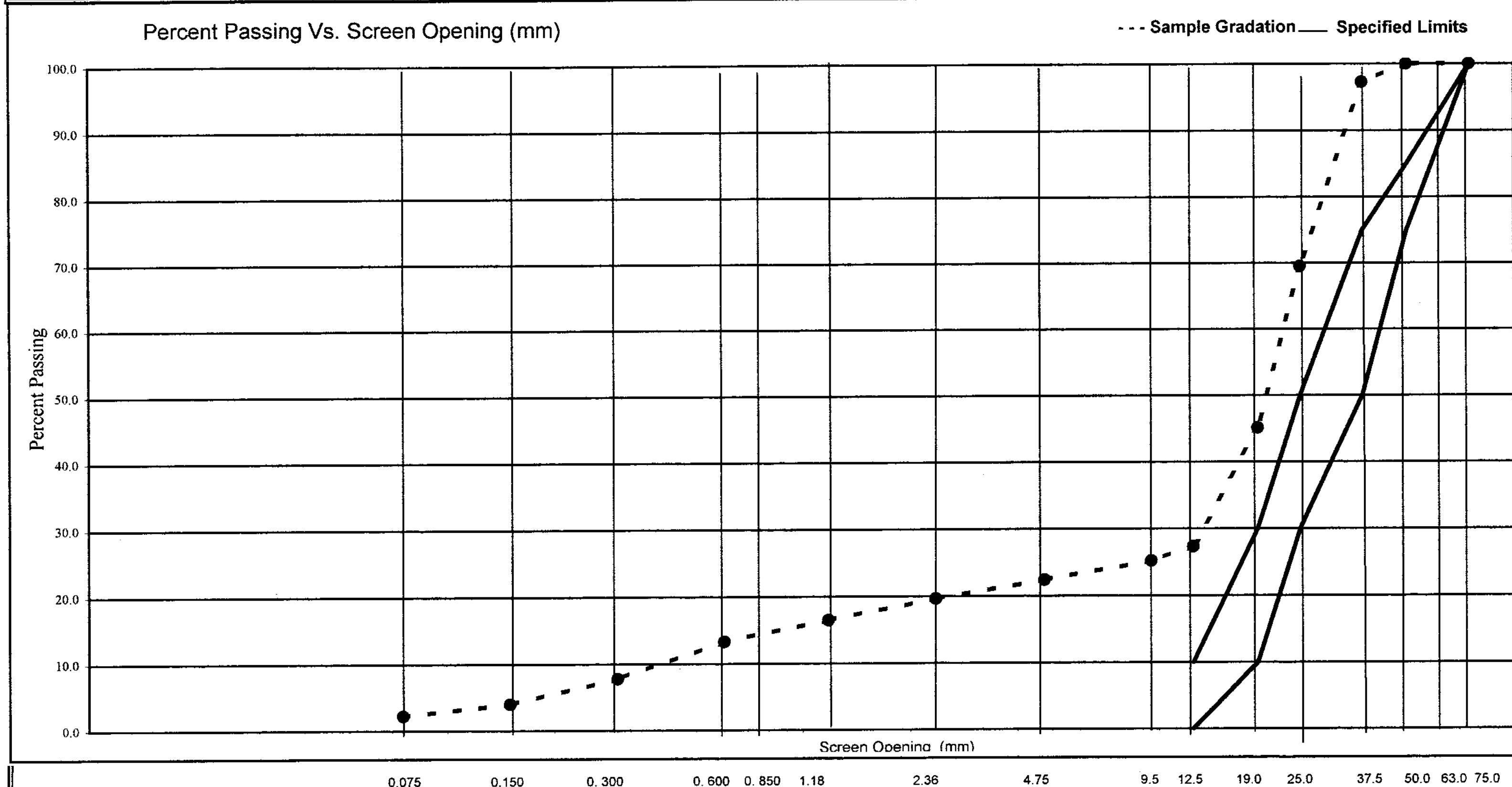
Client: DFO
cc:
cc:

Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 14
Source: Mid-channel, 0-0.3m
Specified Limits: As Shown

Sampled by: Client **Date:** 6-Apr-09 **Washed Analysis** X
Tested by: VW **Date:** 7-Apr-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill / Native



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	97.3	50.0	75.0
25.0	69.5	30.0	50.0
19.0	45.1	10.0	30.0
12.5	27.3	0.0	10.0
9.50	25.2		
4.75	22.4		
2.36	19.6		
1.180	16.5		
0.600	13.3		
0.300	7.8		
0.150	4.0		
0.075	2.2		

Remarks:
Sample #2, Spawning Platform #2, Freeze Core, Stn 0+527 - 0+570
Client note - possible sample below new gravel.
Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Client: DFO
cc:
cc:

Project: DFO Sieve Analysis

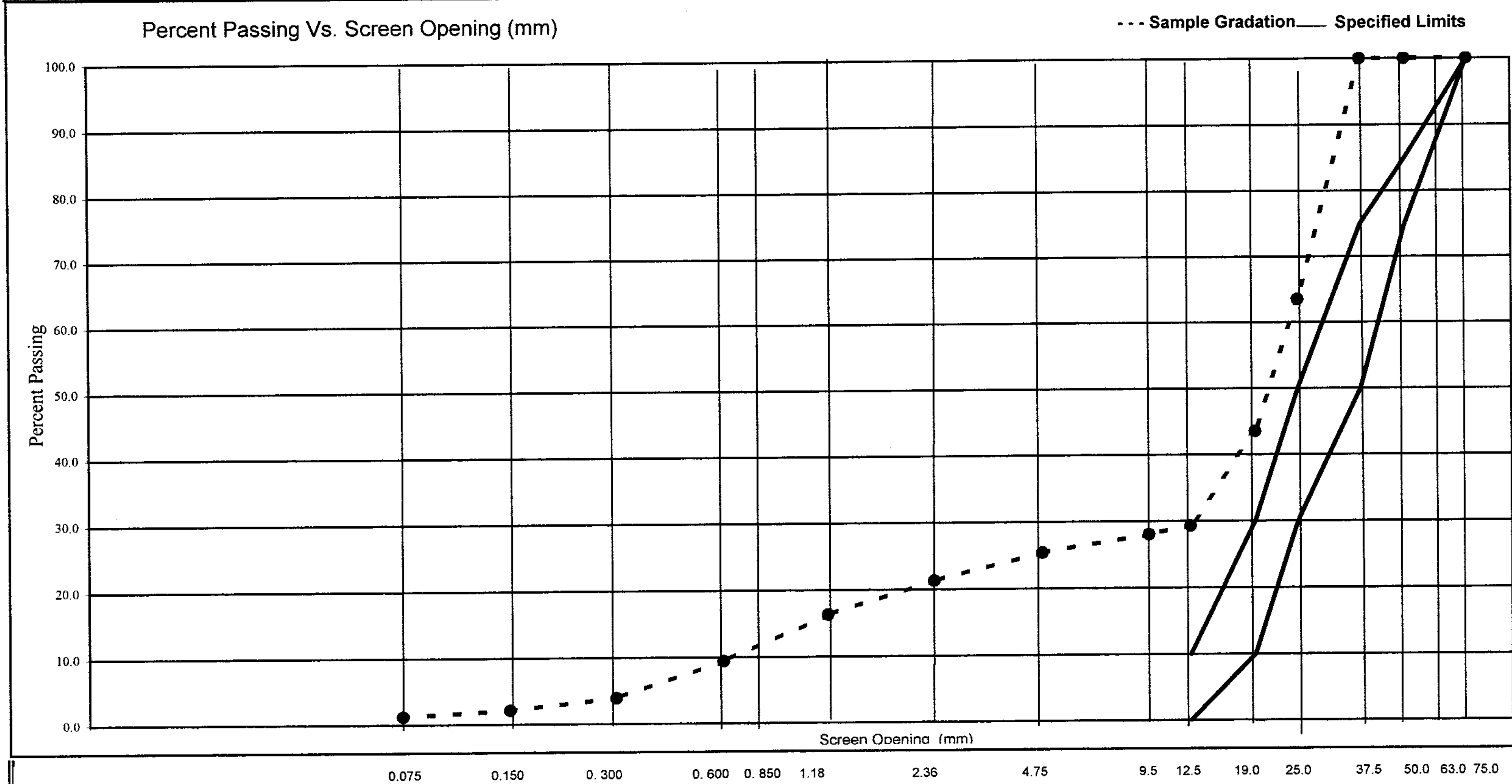
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 15
Source: Mid-channel, 0-0.25m
Specified Limits: As Shown

Sampled by: Client Date: 6-Apr-09 Washed Analysis X
Tested by: VW Date: 6-Apr-09 Dry Analysis

MATERIAL: Native Fill Native
Imported Fill

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	63.5	30.0	50.0
19.0	43.5	10.0	30.0
12.5	29.3	0.0	10.0
9.50	28.0		
4.75	25.4		
2.36	21.3		
1.180	16.3		
0.600	9.4		
0.300	3.9		
0.150	2.1		
0.075	1.2		

Remarks:
Sample #3, Spawning Platform #2, Freeze Core, Stn 0+527 - 0+570
Note: Ran out of C02 during the test (smaller sample).
Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

Client: DFO
cc:
cc:

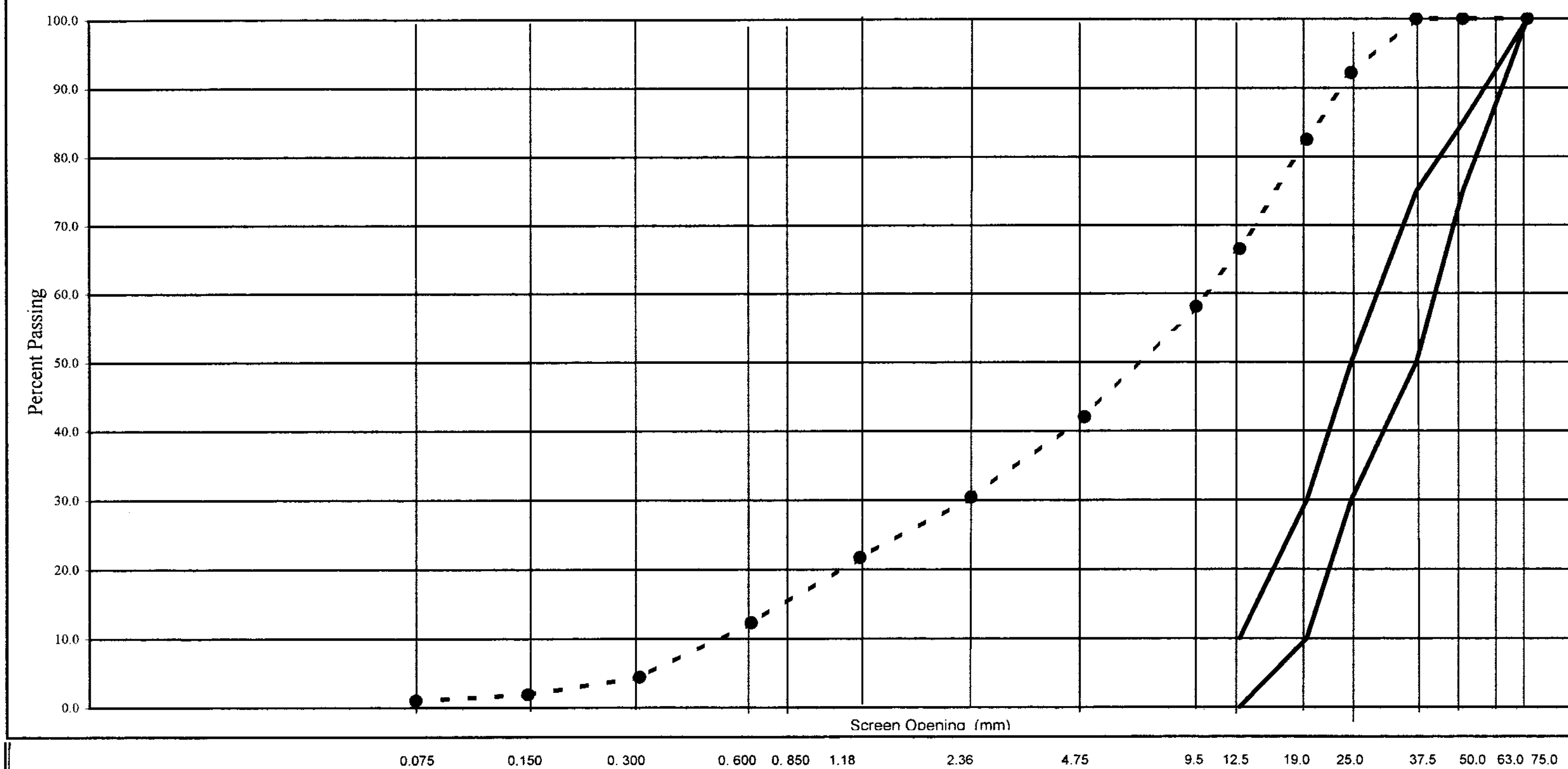
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 16
Source: Mid-channel, 0-0.2m
Specified Limits: As Shown

Sampled by: Client **Date:** 6-Apr-09 **Washed Analysis** X
Tested by: VW **Date:** 7-Apr-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill / Native

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	92.2	30.0	50.0
19.0	82.5	10.0	30.0
12.5	66.5	0.0	10.0
9.50	58.1		
4.75	42.0		
2.36	30.4		
1.180	21.7		
0.600	12.3		
0.300	4.4		
0.150	1.9		
0.075	1.0		

Remarks:
Sample #1, Natural Spawning Platform, Freeze Core, Stn 0+286 - 0+316

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

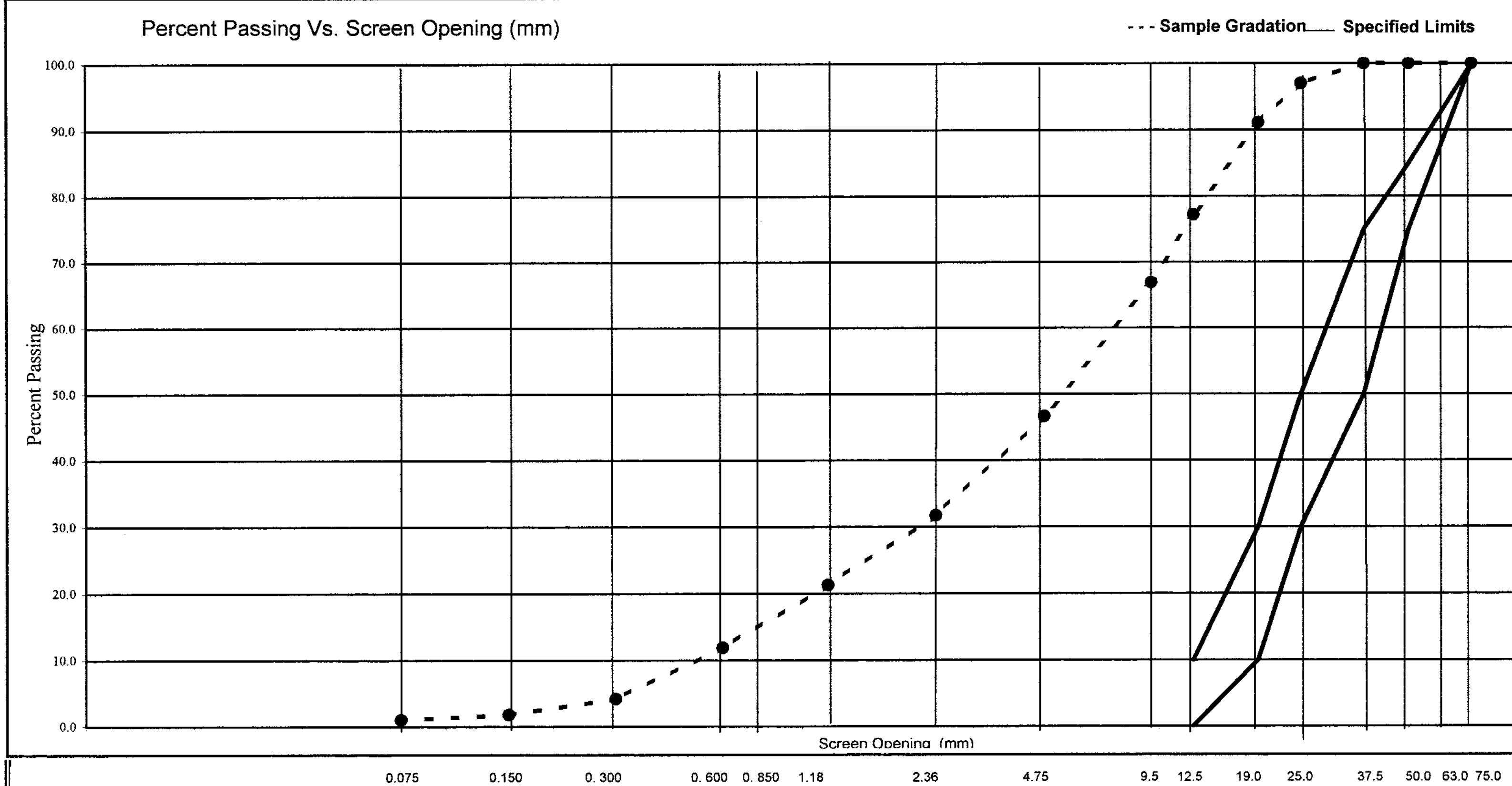
Client: DFO
cc:
cc:

Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 17
Source: Mid-channel, 0-0.2m
Specified Limits: As Shown

Sampled by: Client **Date:** 6-Apr-09 **Washed Analysis** X
Tested by: VW **Date:** 7-Apr-09 **Dry Analysis**

MATERIAL: Native Fill Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	97.0	30.0	50.0
19.0	91.1	10.0	30.0
12.5	77.2	0.0	10.0
9.50	66.9		
4.75	46.6		
2.36	31.7		
1.180	21.3		
0.600	11.9		
0.300	4.2		
0.150	1.8		
0.075	1.0		

Remarks:
Sample #2, Natural Spawning Platform, Freeze Core, Stn 0+286 - 0+316

Reviewed by: G. Maltin CTech

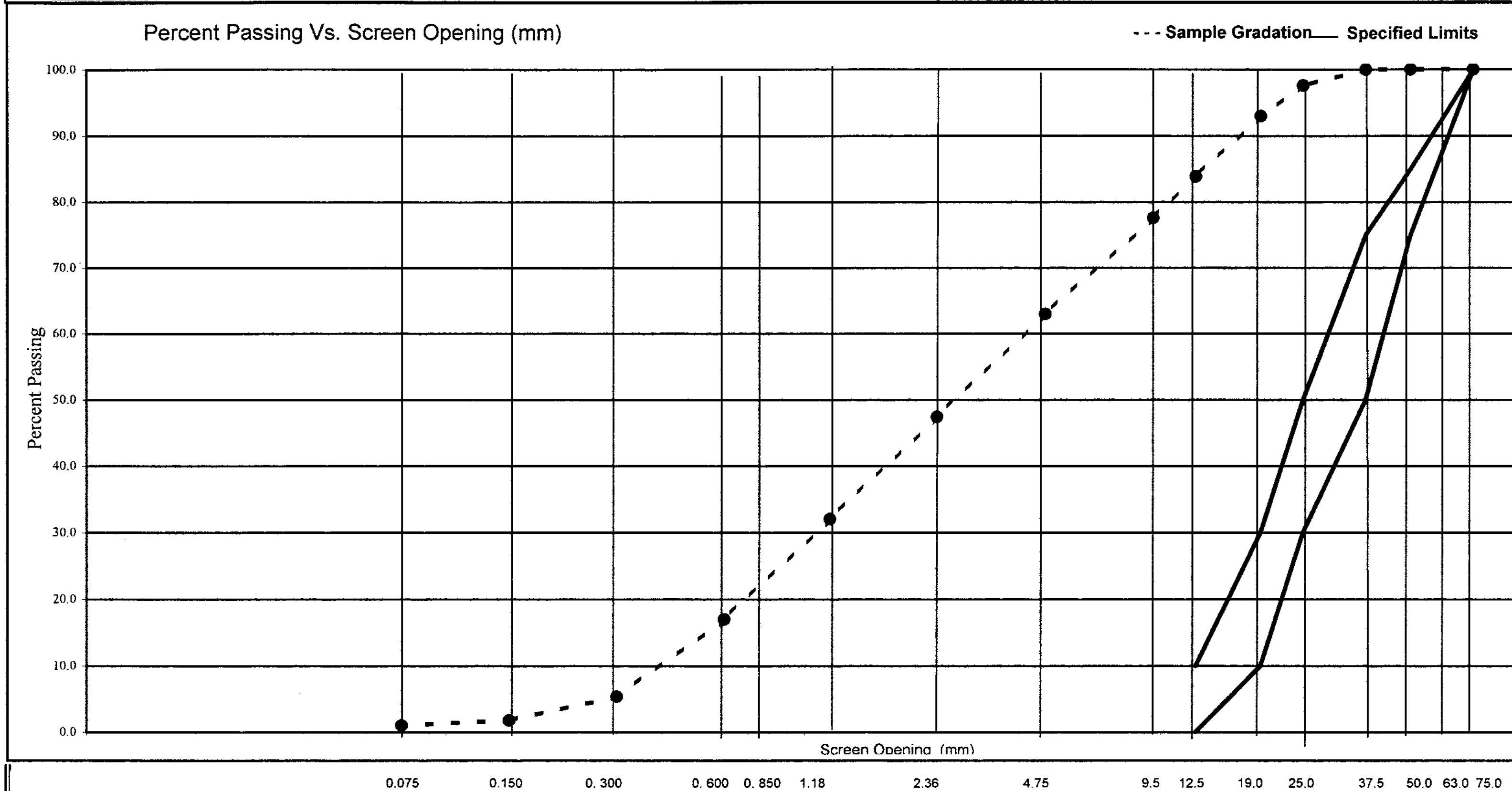
Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Client:	DFO	Project:	DFO Sieve Analysis
cc:		Project No:	2321-22240-0
cc:		Location:	Scully Creek
		Date of Report:	1-Apr-09

Type of Sample:	Spawning gravel	Sampled by:	Client	Date:	6-Apr-09	Washed Analysis	X
Sample No:	18	Tested by:	VW	Date:	7-Apr-09	Dry Analysis	
Source:	Mid-channel, 0-0.15m	MATERIAL:	Native Fill		Native		
Specified Limits:	As Shown		Imported Fill				



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	97.6	30.0	50.0
19.0	93.0	10.0	30.0
12.5	83.9	0.0	10.0
9.50	77.6		
4.75	63.0		
2.36	47.4		
1.180	32.0		
0.600	17.0		
0.300	5.4		
0.150	1.8		
0.075	1.0		

Remarks:

Sample #3, Natural Spawning Platform, Freeze Core, Stn 0+286 - 0+316

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

APPENDIX 5

Additional Project Photographs

Additional Photographs: Scully Creek Gravel Placement


Photo 1 – Collecting preliminary streambed shape.


Photo 2 – Project set-up.


Photo 3 – 6m offset stakes.


Photo 4 – Gravel added from the north bank only.


Photo 5 – Depth checked as gravel went in.


Photo 6 – Physical appearance at the time of construction.


Photo 7 – Post placement (typical)


Photo 8 – Rock added behind the log to strengthen the weir.


Photo 9 – Looking upstream, post placement


Photo 10 – Access road condition


Photo 11 – Creek downstream on the hot springs Property.


Photo 12 – Mouth of Scully – mid channel at the lake.

Additional Photographs: Scully Creek Gravel Sampling
(approx. 8 mo. after installation)

Photo 13 – Typical site conditions, flags still visible.

Photo 14 – Sediment (sands and silts) visible in the new gravel.

Photo 15 – (custom) Freeze core sampler in operation

Photo 16 – Sample being collected.

Photo 17 – A tripod used to lift the sample out.

Photo 18 – Size of sample collected using the larger pipes and triple probe system.

Additional Photographs: Scully Creek Incubation Study

PUTTING THE EGGS IN THE GRAVEL (OCT '08)

Photo 19 – Natural site at Scully South (u/s of hwy)

Photo 20 – Digging to install incubation boxes

Photo 21 – Checking piezometer installation

Photo 22 – Lakelse Sockeye eggs

Photo 23 - Eyed

Photo 24 – Loading the incubation boxes

Photo 25 – Installing the incubation boxes in the bed

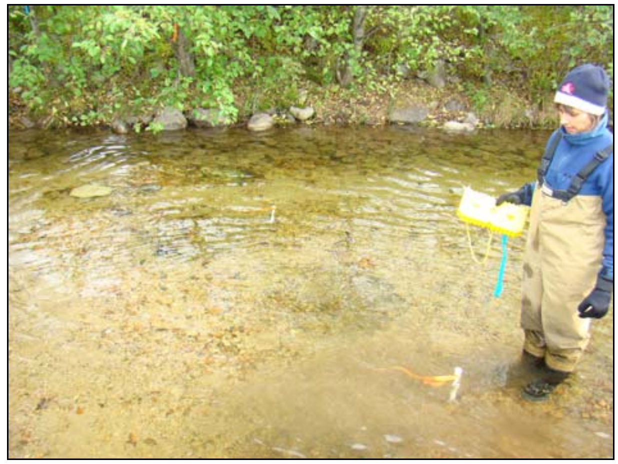


Photo 26 – A finished site.

CHECKING CONDITIONS (NOV/DEC '08)

Photo 27 -

Photo 28 -

Photo 29 – measuring streamflow

Photo 30 – preparing for water quality measurements

Photo 31 – extracting subsurface flow from piezometer

Photo 32 -

REMOVE 1ST SET OF EGG TRAYS (Jan '09)

Photo 33 -

Photo 34 -

Photo 35 -

Photo 36 -

Photo 37 – some sediment starting to show in gravels

Photo 38 -

Photo 39 – removing the 1st set of incubation trays

Photo 40 -

Photo 41 -

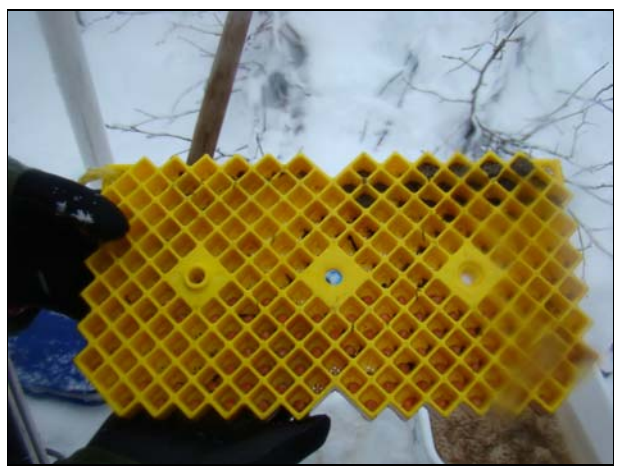


Photo 42 -

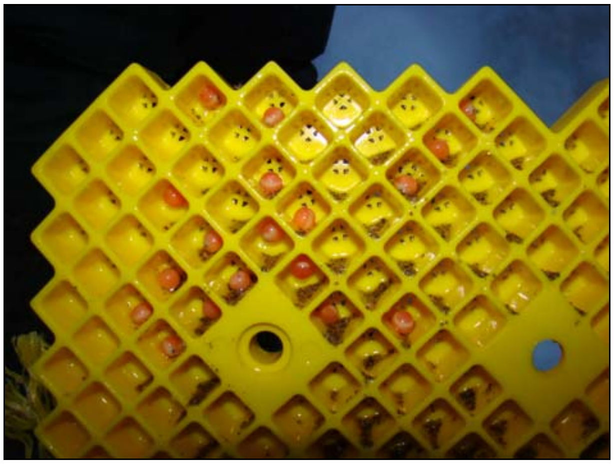


Photo 43 – some eggs did not hatch, sand in tray


Photo 44 – some survival

REMOVE REMAINING EGG TRAYS (APR '09)
- Work undertaken by consultants, no DFO participation required.
- Photos are in the Incubation Study report.

Additional Photographs: Williams Creek Test Ditch


Photo 45 – Test Wells installed in a previous project


Photo 46 –


Photo 47 – Test well at the top end of the project


Photo 48 - Site conditions prior to construction.

Photo 49 – Looking upstream at the top end of the site.

Photo 50 – Looking downstream near the bottom end.

Photo 51 – Installing sediment control

Photo 52 – Sediment control and groundwater

Photo 53 – Excavation worked from downstream to Upstream.

Photo 54 – Typical construction


Photo 55 -


Photo 56 -


Photo 57 -


Photo 58 -


Photo 59 -


Photo 60 -


Photo 61 – area downstream of the project


Photo 62 – taken 8 months later, Sept 09


Photo 63 – Sept 09


Photo 64 – Sept 09


Photo 65 – Sept 09


Photo 66 – Sept 09

Additional Photographs: Scully Creek Diversion Pipeline

Photo 67 – area where intake is proposed

Photo 68 – intake area, looking upstream

Photo 69 – Scully Creek near the apex of the fan

Photo 70 – typical ground cover near intake area.