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Rehabilitation Strategy: Summary Table
Updated: November 5, 2015

Purpose Statement:
This table outlines a high level summary of the rehabilitation actions underway or being contemplated in regards to the tailings dam breach of August 4, 2014. It is written with the purpose of being a living document that helps others understand the steps that we are taking and to enable regulators to provide feedback on direction. The rehabilitation works are adaptive; specifically, this means that they are subject to change as decisions are made or new data become available. Some items may be added, amended or removed and the reader should consult the most recent version. The table cells should not be read in isolation of the intended purpose and context.

Rehab Plan Area ID and Topic		Issue/ Consequence Stressor	Rehabilitation Objectives	Information Needs	Short Term		Status	Long Term		Status	Uncertainty	Contingency	Monitoring
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1) TSF	Discharge cessation (Completed)	Will turbid flows hamper recovery of HC once repaired? Will continued inputs to QL impair clearing of water? Does the flow volume through un-rehabilitated HC increase bank erosion?	Cease discharge of turbid waters to HC and QL.	Completed.	Collection sump, pump, piping and conveyance to Springer pit; flow control from PL.	Containment of discharge from TSF to HC.	Sumps and pumps to collect TSF drainage. Completed as of Sept. 4, 2014 and upgraded to address surrounding work; see PL plug for flow control; Springer Pit water elevation to be controlled using permitted discharge [1]. (awaiting permit). *There is no further discharge from the TSF*	TSF rebuilt, function restored, discharge treated as needed and discharged under permit (mid term conveyance; long term treatment and conveyance).	Rebuild of dam, permit issued.	The breach repair is complete. Drilling program and engineering design of other portions of TSF dam, together with perimeter embankment buttressing work complete. Main embankment buttress permit applied for (MEM); Application for return to full operation pending.	Low. The breach is now repaired and the dam is holding water.	Storage in TSF (Requires a rebuilt TSF dam). Redundant equipment; equipment has been overhauled so that it is in good repair and with improved mechanical tolerances. Permit to be applied for to use TSF For 2016 freshet.	Visual monitoring of interception works. Climate monitoring for advance planning of temporary measures for early thaw; requires a permit for TSF use for 2016 freshet.

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1) TSF cont'd	Breach repair	Breach has been repaired to +950 m elevation.	Eliminate discharge of turbid waters to HC; contain tailings; contain water	Forensic reports from Independent Panel and MEM (KCB); Design incorporates an adaptive management plan such that the findings of the forensic investigations will be reviewed and adjustments made to the design if needed; modifications if any await reports being provided to MPMC.	"Plastic" concrete CSM wall and rockfill to construct dam breach repair to +950m	Breach is repaired in time to use the TSF as storage for freshet flows; Associated pumps and pipes concurrently in place to take advantage of capacity	Earthworks to design level complete. CSM work is complete and quality control work has confirmed success; spring thaw was early and punctuated. A large spring thaw volume was not experienced. TSF was not used for 2015 freshet; MPMC will be applying for use of TSF for freshet water management.	Final phases of dam repair construction to be engineered and dam breach repaired to pre-breach levels.	TSF fully functional		Findings from the Independent Panel Engineering for 2015. Freshet repair is well advanced.	Place additional rockfill buttress (perimeter embankment done) and/or flatten downstream slope.	Monitor progress; Facilitate permitting; Geotechnical instrumentation (installed).
	Windblown dust	Is there potential for health impacts due to inhalation of particulate material (regardless of metals content) for on-site and off-site receptors? Is dispersion of particulate material limited to nuisance and visual impacts?	No unacceptable windblown dust is caused	Preferred approach is to prevent rather than to risk assess/risk manage; Tailings are well characterized in terms of chemistry.	Water cannons (already on site) to be deployed; existing and added AQ monitoring was carried out summer 2015; TSF seeded Sept. 2014.; dust palliatives as contingency.	Tailings are not eroded by wind and blown away (remain in TSF) in unacceptable amounts.	Dust management plan [2] submitted and implemented during summer 2015. Monitoring results and recommendations submitted to MoE [3]; PM levels were less than ambient air quality guidelines during monitoring period. [3]	TSF reconstructed	No tailings eroded by wind PM levels acceptable for occupational (on site) and offsite exposure, no worse than in operation.	PM levels were less than ambient air quality guidelines during monitoring period. [3]	Low. AQ results collected in 2015 were less than ambient AQ guidelines and comparable with results at the nearby Williams Lake and Quesnel AQ monitoring stations [3]	Continued management of fugitive dust emissions as per dust management plan, as amended based on 2015 experience.	Continued monitoring at dust fall stations as required by permit conditions.

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1) TSF cont'd	Site-wide Water Management	Springer Pit is currently receiving all mine contact water but is approaching capacity. If water is not managed, Springer pit water will outflow via ground seepage (1030m elevation), at first and then overflow (1050m elevation)	Maintain collection of mine contact water; treat mine contact water and discharge treated contact water via permitted discharge.	Necessary information is available. A Goldsim model has been prepared for the site.	Springer Pit water levels are decreased by discharge of treated mine contact water to Hazeltine Creek channel, then to depth in Quesnel Lake via submerged outfall [1].	Permit conditions met; environmental monitoring demonstrates attainment of WQG.	Outfalls constructed and installed; Treatment plant delivered and installed; and tested Awaiting permit from Ministry of Environment to commence release of treated mine contact water; Springer Pit levels are rising in absence of a permit. Delays could result in outflow via gw.	Long Term water management plan to be developed. First step will be to revise conveyance from Hazeltine to a piped location either in Quesnel Lake or River. Possibility of distributed conveyance ("shared" across watersheds) to be explored as a longer term approach.	Water balance is effectively managed for remainder of mine life and into closure.	Long Term conveyance process to kick off upon issuance of MoE permit for short-term discharge. "Roadmap" document outlining process to get to long-term discharge options in prep.	Information obtained from external consultation; climate change effects on water balance; long term treatment methodology not yet identified.	Extension of short term treatment; review and revise long term Water Management during operations and closure; maintain updated Goldsim model to evaluate plans and changed conditions.	To be determined by permitting processes; short term monitoring plan in progress with MoE; Springer Pit levels monitored regularly.

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2) Polley-Lake Plug	Plug Area	Is the plug considered stable? Would loss of plug induce a risk of failure and risk to safety and life?	PL outlet maintains integrity and does not breach.	Geotechnical investigations of plug area are complete.	Pump down level of PL to reduce head and thus pressure on backside of plug.	No plug failure.	Work completed, geotechnical report completed [4]. Report findings indicate that plug is stable.	Densify PL plug area and install flow control structure [5].	Plug is stable and flow control structure has been built.	Complete. Geotechnical safety has been described in a memo by GAL [6]. Tailings removal from select portions of the plug area is in progress.	Low.	Resumption of safe work procedures (plug spotter, restricted access etc.).	As advised by Geotechnical engineers should conditions change.
	Flow Control	Will spring melt flows increase risk of erosion and turbid waters downstream? Does flow to HC need to be stopped to enable downstream work? Do flows need to be managed as part of discharge plan for short-term treated mine water discharge.	Dampen peak flows from PL to reduce risk of erosion of HC channel and sidewalls. Utilize storage in PL to manage freshet flow and to manage treated water discharge to HC.	No further information needs for structure; Verify that spawning habitat available is adequate because downstream fish passage will be prevented for ≈1-2 y; identify whether or not outlet spawners show behavioural plasticity, utilizing inlet streams.	Engineered flow control structure to dampen spring melt peaks in flow; stop flows to enable rehabilitation work in HC; manage HC treated water discharge in accordance with annual discharge plan.	Peak flows are dampened; erosion is prevented/ reduced; HC rehabilitation can continue on conclusion of short term plan. Riparian work to continue.	Flow control structure has been approved by MFLNRO [7]; Flow control structure is built and operational; MFLNRO supports restriction of fish passage (temporary) [8].	Once HC is deemed to be sufficiently stable, the flow control structure will be removed; previous flows restored and fish passage restored; consideration to retention of flow control structure for fishery flows if deemed appropriate (to be determined through consultation).	Erosion in HC is not occurring.	Designs approved [7]; flow control structure is completed and operational.	Uncertainty as to when it will be appropriate to remove vs suitability of spawning substrates d/s (consultation).	Fish ladder to provide passage; potential to retain flow control structure if it would have a beneficial effect on flows to enhance usability of HC by fish.	Turbidity measurement for erosion; inspection of suitability of constructed habitat in HC; visual checks of turbidity.

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3) Polley Lake	Tailings Deposit (chemical and biological)	Could metals be released from tailings at levels considered to be harmful?	Evaluate ability of tailings to release metals under conditions of PL	Geochemistry study [9]; monitoring data from actual measured water chemistry (not increasing thus far)	Tailings in subaqueous environments are not expected to leach metals, including under reducing conditions [9].	No unacceptable metals release into PL or downstream	Geochemical study has identified that release of metals from tailings is not expected in the lake [9].	Long term disposition of tailings to be determined but will be addressed based on scientific and regulatory criteria. Human Health and Ecological Risk Assessment is in progress.	Tailings do not release metals to an extent that harms environmental uses	Geochemistry program findings [9] indicate low potential for release of metals from subaqueous tailings.	Uncertainty in geochemistry is low. Potential for uptake via diet will be examined through monitoring of fish tissue and other mechanisms (see Monitoring).	TBD, depending on findings of environmental studies.	Monitoring of water chemistry to identify release of tailings; water and sediment toxicity testing; benthos; plankton; fish tissue.
	Tailings Deposit (physical)	Has deposition of tailings material in PL resulted in physical smothering of lake bed to a significant extent?	PL remains viable habitat for trout and other species occurring there.	Identify extent of materials deposition and ecological implications.	Terminate further deposition; evaluate impacts; identify feasible measures to address impacts.	Further erosion and deposition of tailings in PL has stopped; Impacts are quantified.	Bathymetric and sediment quality data evaluation to be done. Prior information to be compiled; estimates of impact to be developed.	TBD	Viable population of rainbow trout in PL.	Trout observed in Spring 2015 in Frypan and Polley Creeks and at fish fence at PL outlet. Impacts on fish habitat/ productivity are part of a “habitat objectives” working group”.	Low	TBD	TBD, in accordance with framework under development by the “habitat objectives” working group. Framework generally follows Bradford *et al.*, 2014 [10].
	Debris along Polley Lake shore	Physical presence of woody debris resulting from debris flow.	Physical material not harmful to the fish habitat or an issue for wildlife.	Interaction of fish and wildlife with the debris and whether the interaction is positive or negative. Some views that it may be beneficial based on observations of piscivorous birds.	Undertake evaluation by QP; report with findings to be prepared to verify observations.	TBD; successful outcome to be defined by findings of the study.	A study was undertaken in July. Surface water temperatures were such that trout in deeper waters. Study was re-done in September; data analysis and reporting in progress.	TBD based on study findings.	N/A	N/A	TBD	Physical removal of debris.	TBD

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3) Polley Lake cont'd	Water quality (DO_2)	DO_2 at depth was reduced but returned to normal with lake overturn. Will DO_2 remain in a normal range into spring and summer?	DO_2 is at levels suitable for aquatic life.	Monitoring (ongoing) data for DO_2 profiles.	DO_2 levels have returned to normal – none required.	DO_2 levels remain similar to those pre-impact.	DO_2 levels came back to normal following lake overturn. During summer of 2015, DO_2 levels at depth were observed to be low; to be monitored with lake overturn in 2015.	DO_2 levels have returned to normal; verification that this continues to be the case.	DO_2 levels remain similar to those pre-impact/ don't result in reduced lake productivity.	DO_2 levels back to normal following lake overturn.	Uncertainty as to whether the phenomenon will return upon lake stratification.	Lake aeration.	DO_2 profiling (when access is available).
	Water Quality (metals)	Have changes in water quality resulted in adverse impacts in PL?	Water quality and clarity is returned to pre-impact conditions.	Compilation of background water quality data; characterization of exposure conditions from MPMC monitoring program.	Comparison of exposure conditions to known effects levels.	Water quality conditions in PL are not harmful.	PL turbidity has decreased post-breach; dissolved copper remains low. Over the post breach period, increasing concentrations of copper have not been noted [11].	Comparison of exposure conditions to known effects levels.	Water quality conditions in PL are not harmful.	Copper concentrations remain low and are below the WQG; turbidity has decreased to less than the WQG [11].	Submerged tailings are expected to be geochemically stable and not leach metals [9].	Direct monitoring and data collection.	Water chemistry and limnological monitoring by MPMC.
	Spawning Habitat	Will loss of spawning habitat in upper HC result in reduced recruitment? Will there be a change in population structure (e.g., larger fish but less of them) since recruitment on PL was previously high will there be a lost year class?	Restore spawning habitat to near pre-impact extent or other objectives as defined via agency/FN consultation (see for example [12]).	Extent of recruitment needed until HC restoration is such that it can be re-opened to fish passage; Mark-recapture study to be carried out to identify if outlet spawners select inlet streams when access to outlet streams is blocked.	Objectives of MFLNRO have been discussed for trout recruitment; Mark-recapture study to be carried out next spawning season to identify if trout to go to other streams.	Recruitment over the short term is sufficient to maintain the fishery in PL.	A meeting was held with agency specialists (MNFLRO, MoE, DFO) and FN consultants on February 5, 2015. Subsequent email from MFLNRO advising that spawning habitat was adequate for the interim as HC undergoes repair [8].	Construction of new spawning habitat in HC (Reach 2, 3); resumption of fish passage from PL to HC when appropriate; removal of flow control structure or construct fish ladder.	PL fish are able to move to HC and spawn successfully in HC; provide recruitment to QL.	HC channel foundation is complete; fish habitat features not yet incorporated; HC to be used for short term effluent conveyance to QL [1].	Uncertainty in need to provide interim (and/or permanent) spawning habitat in the short term (under study).	Construct spawning channel in one or two influent creeks subject to flow and topography, if this is a desired fishery objective.	Fish population structure survey [13].

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4) Upper Hazeltine Creek	Erosion Control	Will high flows (spring freshet) further erode the base and banks of existing channel (if unarmoured); Will precipitation also erode exposed soils? Result is turbid waters. Main area at risk of erosion is in Reach 3 (Gavin Road bridge to Canyon).	Rehabilitate biophysical properties of HC to minimize erosion and reduce suspended solids in HC.	Done [14], [15];	Use of rock to establish a stable channel; channel design will consider erosion control concurrently with habitat design; Spring planting.	Erosion is not occurring.	Agency agreement in place [12]; Willow collection and spring planting (~50,000 cuttings) is completed. Channel construction work along all three reaches completed on May 11, 2015 [15]. Creek flowing clear after completion of erosion control works. Additional nursery plant stock sourced. Major fall planting program carried out in Reach 3 of Hazeltine and lower HC.	Long-term resilience against erosion of channel and floodplain is based on establishment of vegetation. Initially, fast-growing plants are established; subsequently, species of adjacent plant assemblages are recruited by the annual 'rain' of seeds from such assemblages; soil structure improves with leaf litter from early growth vegetation and mulch.	Vegetation is growing; plant roots and leaf/needle fall providing stability to soils and resilience against mobilization of soils from precipitation; species assemblage displays initial signs of succession.	Erosion control measures and channel construction works completed . Forest restoration works in progress. Considerable planting carried out.	Time lag for rehabilitation of vegetation within the HC flood plain. Spring freshet and/or extreme weather events.	Active program to address erosion; Replanting.	Turbidity monitoring to detect loss of material (erosion); visual monitoring for erosion; see also stream rehabilitation row.

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4) Upper Hazeltine Creek cont'd	Aquatic Habitat Rehabilitation	HC fish habitat features were eroded and lost in the debris flow following the breach. Does suitable habitat for productive spawning and rearing still exist?	Restore habitat functions to Upper HC for fish. Primarily, this consists of constructing features that facilitate spawning and rearing, concurrently with erosion control.	Past uses to inform objectives (MPMC have these); Agency and FN objectives; Overall, design will be prescribed by conditions as encountered with efforts to accommodate Agency and FN objectives.	Erosion control and concurrent construction of channel and floodplain (completed May 11, 2015 [15]); habitat complexing with boulders and other substrates summer 2016 or 2017: habitat complexing with woody debris; planting; timing will depend on water management needs for use of HC flows; Instream work requires low/no flow.	Stable channel established and associated habitat features established after two (2) freshets.	Erosion control measures in place but restoration of habitat features on hold pending use of HC for water management purposes [1].	Stream supports spawning and rearing habitat functions for fish; riparian vegetation is well established and displaying successional characteristics. Stream and riparian areas resist erosion.	Fish habitat functions typical of riparian vegetation (e.g., temperature control, particulate organic matter and nutrients, insect drop) are being provided.	Channel has been re-constructed. Habitat features not fully restored, pending use of HC for operational purposes.	Success of plant growth and recovery of riparian area. Temperatures observed in summer 2015 were above recommended range for trout habitat.	Plant growth to be monitored and performance managed as needed.	Surveys of use by fish and establishment and growth of plantings and recruited plants; turbidity monitoring; stream temperature monitoring; Record drawings to be produced of constructed habitat; aerial drone photomosaic of habitat.
	Tailings Remediation	Does upper HC represent a source of erodible material and possible source of copper or other elements?	Remove or risk assess; risk manage if necessary and feasible.	Geochemical stability report done [9].	Tailings have been removed under creek channel. Fate of tailings outside of the channel alignment will be based on HHERA.	No release of dissolved metals from tailings material to an extent that impairs environmental uses; tailings erosion is stopped.	Geochemical report [9] showed low potential for reactive tailings/metals release from tailings. Water chemistry does not indicate significant metals release in the post-breach period [16].	Long term disposition of tailings to be determined but will be addressed based on scientific and regulatory criteria. Considerable tailings removal underway in upper HC and surrounding plug area; Terrestrial impacts [17] under study.	Tailings do not release metals to an extent that harms environmental uses.	Geochemistry program shows tailings to be chemically stable with low potential for metals release [9]. These findings are supported by water and plant tissue chemistry.	Low	TBD	Water chemistry and water toxicity testing; biological monitoring.

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4) Upper Hazeltine Creek cont'd	Soils	Are soils considered contaminated? Is soil function impaired from lack of soil structure (organic carbon)?	Soils, including spilled tailings are not leaching adverse metal concentrations	Geochemistry in oxidized environments; done [9].	Tailings are being removed from the stream channel where works are permanent; Dead trees being removed; tailings removal where thickness is deep.	Soil structure is such that plants can grow (and create continually improved structure); Residual tailings do not leach dissolved metals to the extent that environmental uses are impaired	Concurrent with creek rehabilitation work; Geochemistry report [9] shows low potential for reactive tailings; further geochemistry in progress. Water chemistry does not indicate significant metals release; some tailings removal in the upland.	Soil structure begins to restore and is aided by plant growth (nutrients in soils, organic matter via leaf litter); tailings to be addressed by risk assessment or through removal (if risk unacceptable); physical smothering effects are known [17]; Rehabilitation efforts have started.	Plant growth shows increasing improvement; species assemblage shows signs of succession.	In progress. Channel construction complete [15].	Soils do not develop organic layer	Organic material applied (mulching, adjacent forest soils, etc.)	Soil surveys; water chemistry and water toxicity testing; plant tissue chemistry

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5) Hazeltine Canyon		Has Hazeltine canyon been scoured to bedrock?	No erosion.	Unclear what rehabilitation is needed; the canyon was and still is a velocity barrier for fish migration.	TBD	TBD	Low priority for erosion control; difficult access; minimal deposition of tailings.	Completion of Detailed Site Investigation and Human Health and Ecological Risk Assessment.	Findings of HHERA do not identify unacceptable risks to receptors.	HHERA in progress.	Low, due to observation of minor tailings deposition.	TBD	TBD

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6) Lower Hazeltine Creek	Turbid water treatment	Does the flow of turbid water from erosion into QL result in cloudy water comprised of small particle size that is difficult to settle?	Reduce or remove turbid water entering QL.	None. Monitoring and corrective action is needed.	Sediment Pond construction and operation during HC channel construction [18]; HC armouring complete [15]; sediment ponds retained as contingency; decommission/replace ponds in future when HC stability confirmed.	HC channel erosion control works concluded May 11, 2015 [15].	Main turbidity reduction mechanism has been completion of Hazeltine Creek erosion control works and channel foundation construction, concluded May 11, 2015 [15]. Creek now running clear. Pond #1 now re-purposed as head pond to outfalls; pond 2 retained for flows exceeding outfall capacity.	Erosion to be prevented; treatment discontinued b/c unnecessary; Ponds decommissioned or repurposed for other environmental use (e.g., fish or wildlife habitat).	HC (non-storm flow) meets WQO (8 NTU 24h, 2 NTU 30d average); Clear water that can support egg incubation in lower reaches (some sockeye and possibly coho spawning in the past).	As of May 2015, TSS and turbidity in lower HC typically less than 24h – BC WQG for aquatic life and wildlife. [16].	Erosion control may not be effective; Freshet flow conditions may overwhelm hardened portions of channel; Time lag for vegetation to solidify banks.	SSWQO (long term); further erosion control; source investigation/ mitigation [19]. Flow control of Polley Lake outlet to ameliorate freshet flows to extent feasible.	Turbidity monitoring (automated); visual erosion survey; Biological monitoring.
	Erosion control	Does erosion in lower HC banks contribute to QL sediment load? Will erosion contribute to instability of stream channel and impair its use as spawning, food production habitat?	Rehabilitate ground so that rain/snow do not erode soils Restore creek morphology and plant riparian to prevent erosion of banks [18]	Channel foundation design was field fitted [12]; Habitat features to be installed after short term water management.	Armoring; Grass seeding; mulch cover; armoring; willow and other planting	Some armoring has taken place and more is in progress.	Sediment ponds used during construction of HC foundational channel; organic amendment/ treatment where further machine access is not required has started. Floodplain banks have been prepped for planting for slope stability and restoration or planting has already taken place.	Ponds decommissioned, bank erosion via revetment and logs, soil organics added, vegetative cover in place and self-sustaining. Creek habitat features installed.	Erosion in lower HC has stopped; upper HC erosion has stopped; channel water quality and substrate characteristics not harmful to spawning or rearing fish.	Channel construction completed but habitat features not yet constructed in HC until after short term water management use and low flow conditions allow in-stream work. Riparian planting underway.	Erosion control may not be effective; Freshet flow conditions may overwhelm ponds; Time lag for vegetation to solidify banks; soil structure may limit vegetative cover	F/C (short term) was investigated by not adopted [19]; SSWQO (long term); further erosion control; source investigation/ mitigation.	Turbidity monitoring (automated); Visual erosion survey; Biological monitoring to restoration components; Record drawings to be produced of constructed habitat; aerial drone photomosaic of habitat.

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6) Lower Hazeltine Creek cont'd	Habitat Rehabilitation	Has the physical impact of debris flow damaged stream and riparian habitat?	Restore functional attributes (spawning, migration, rearing of lower HC	Previous uses; agency objectives.	Short term objectives are to develop habitat features; erosion control was first priority.	Channels are suitable in the short term as fish habitat (note that ponds anad use of HC channel for treated water conveyance will preclude realization of this function over the short term).	As per habitat rehabilitation in upper HC; erosion control work in HC Channel concluded May 11, 2015 [15].	Ponds decommissioned and rebuilt to provide desired functional attributes (TBD); revegetation program to provide channel integrity.	Fish are spawning successfully; fry emerge successfully; aquatic invertebrate production for fish food.	Pending short term actions in upper and lower HC. Aquatic invertabrates and periphyton present.	Ability to accommodate flows without erosion, especially in the short term; success of planting.	Monitor channel stability and repair/ revise as needed; plant growth to be monitored and managed as needed.	Turbidity monitoring; channel stability to be monitored by visual survey and drone photo mosaics; plant growth success to be monitored and managed as needed.
	Soils	Are soils considered contaminated? Is soil function impaired from lack of soil structure (organic carbon)?	Soils, including spilled tailings are not leaching adverse metal concentrations; Geochemical report has been prepared and published June 2015 [9].	Geochemistry in oxidized environments. Done [9].	Tailings removed from HC channel where works are permanent; HHERA to precede final remedial decisions.	Soil structure is such that plants can grow (and create continually improved structure); Residual tailings do not leach dissolved metals to the extent that environmental uses are impaired.	Geochemistry report shows low potential for reactive tailings [9]; Water chemistry does not indicate significant metals release [16]. Tree mortality observed – caused by physical smothering but not metals toxicity to trees [17].	Soil structure begins to restore and is aided by plant growth (nutrients in soils, organic matter via leaf litter); tailings to be addressed by risk assessment or through removal (if risk unacceptable). Tailings removal may also be carried out to address physical impacts.	Plant growth shows increasing improvement; species assemblage shows signs of succession.	Channel construction completed [15]. Tailings removed from creek as part of restoration works. Tailings removal in certain areas of HC underway, especially in Reach 1.	Soils do not develop organic layer.	Organic material applied (mulching, mixing, addition of adjacent forest soils, etc.)	Soil surveys; Geochemistry studies; water chemistry and water toxicity testing.

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7) Edney Creek mouth	Channel Connection to QL	Much of EC was unimpacted; Is migration of fish population of EC impaired because of altered elevations of EC and HC channel?	Restore fish passage between EC and QL [20].	None for EC – work has been approved and has been mostly finished except for temporary crossing.	"step down" EC to elevation of HC; divert flow to pond and construct temp crossing so that channel construction to QL can happen; planting in spring.	EC is passable for fish in both directions.	EC Channel constructed; Flow now goes through channel, necessitated by early thaw; Habitat features have been installed.	EC is "stepped down" in manner that is fish passable, all the way to QL; Habitat features are installed and are stable; planting with good riparian growth, providing stability, shade, insect drop.	Fish passage from EC to QL is possible, in both directions; habitat is suitable for spawning and/or rearing.	In-channel work is complete; riparian planting has been partly completed. Some aspects of riparian zone will be planted after roads are decommissioned.	Stability of channel.	Remedy as necessary	Fish movement monitored. Creek channel stability monitored visually and via drone survey.
	Tailings Remediation	Is mouth of EC a source of erodible material and possible source of copper or other elements because it was impacted by the debris flow?	Remove or risk assessment; Material left behind does not result in release of metals such that aquatic uses are impaired.	Geochemical report has been published [9].	Tailings have been removed under creek channel. Fate of tailings outside of the channel alignment requires geochemical data for decision; fate of tailings on upland will also take into account potential for physical impacts of tailings.	No release of dissolved metals from tailings material; tailings erosion is stopped.	Geochemistry report [9] shows low potential for reactive tailings; further geochemical investigations (results of humidity cell tests) will be reported in November (est.); Water chemistry does not indicate metals release at environmentally disruptive concentrations when compared to u/s EC chemistry.	Long term disposition of tailings to be determined but will be addressed based on scientific and regulatory criteria.	Tailings do not release metals to an extent that harms environmental uses.	Geochemistry results show low potential for release [9]. The geochemistry program is supported by water chemistry and toxicity testing.	Low, based on findings of preliminary geochemistry results [9].	For works that are permanent (stream channel), tailings are being removed.	Will be based on the findings of geochemistry and toxicity studies.

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8) Quesnel Lake	Tailings Deposition	Are deposited tailings materials in QL a possible source of copper or other elements such as phosphorous and source of cloudy waters? (see also scoured HC sediments).	Tailings do not result in release of metals; increased phosphorous level (from apatite) does not result in eutrophication impacts.	Geochemical analysis shows metals release not likely [9]; studies underway re: benthos and food chain.	No release of dissolved metals from tailings material; tailings erosion is stopped.	Geochemistry report [9] shows low potential for reactive tailings; Water chemistry does not indicate metals release such that environmental uses would be impaired; no unacceptable impacts on benthos.	Geochemistry studies are completed, except for kinetic testing [9]; Sediment chemistry results indicate elevated concentrations of copper, however bioavailability is considered low. Benthic studies are in progress and are part of the HHERA [21], which is underway.	To be determined once HHERA [21] has been concluded.	Sediment quality supports colonization by benthic invertebrates; sediments do not release metals.	Studies in progress. HHERA to be completed in March 2016 per current schedule.	As above for tailings metal release.	TBD	Monitoring of benthos and metals in fish, invertebrate, sediment and water sampling; sediment toxicity testing; benthic community structure.
	Water Quality	Have changes in water quality resulted in adverse impacts in QL? (see also row on turbidity).	Water quality and clarity has returned to pre-impact conditions.	PEEIAR provides Water quality impact assessment, as well as an examination of available data for Quesnel Lake [11]. Monitoring data and data from follow-up studies (e.g., [21])	Comparison of exposure conditions to known effects levels; hydrodynamic modeling to predict returned water clarity (done; [22]).	Water quality conditions in QL return to pre-impact conditions.	Turbidity has returned to baseline; Modeling of turbidity predictions complete [22]; QL water meets drinking water quality [23].	Comparison of exposure conditions to known effects levels.	Water quality conditions in QL return to pre-impact conditions.	Turbidity has returned to baseline; Modeling of turbidity predictions complete [22]; QL meets drinking water quality [23].	Low, based on sampling results collected between March and August 2015.	Direct monitoring and data collection.	Water chemistry and limnological monitoring by MPMC and research partners (UNBC, DFO) with equipment funded by MPMC and MoE.

Rehab Plan Area ID and Topic		Issue/ Consequence Stressor	Rehabilitation Objectives	Information Needs	Short Term		Status	Long Term		Status	Uncertainty	Contingency	Monitoring
					Methods	Success Criteria		Methods	Success Criteria				
8) Quesnel Lake cont'd	Scoured HC sediments	Are scoured HC sediments deposited in QL a continued source of cloudy waters?	Water clarity (see turbidity section).	Monitoring data shows deposited material is stable and not expected to re-suspend at the next QL overturn (mid-Nov to Mid-Dec 2015) but monitoring should be done to confirm.	Terminate further deposition (done; [15]); evaluate impacts [24]; identify feasible measures to address impacts if found.	Further erosion has stopped; Impacts are quantified.	Erosion control in the channel concluded May 11, 2015 [15]; Bathymetric and underwater surveys [25] identified a change in lake bottom habitat and disruption to community of small organisms. Early sampling indicates some recovery of bottom-dwelling organisms may have begun [24]; benthos study is in progress [21].	TBD	TBD	TBD	Uncertainty in impacts and specific rehabilitation actions necessary.		Monitoring of TSS and turbidity.
	Turbidity	Has turbid waters caused a decrease in photosynthesis? Does turbidity preclude use for drinking water or is it limited to visual impacts? Are there direct impacts of turbid water on aquatic organisms.	Lake returns to previous water clarity	Detailed hydrodynamic model has been developed water quality monitoring has been undertaken; automated monitoring buoys in place.	Turbidity modeling to predict behaviour of cloudy lake water [26] [22]; Turbidity has returned to pre-impact background levels [16].	Turbidity meets BC WQG initially; Turbidity reduces to pre-impact conditions.	HC channel erosion control completed May 11, 2015 [15]. Findings of the PEEIAR indicate that turbidity levels have decreased in QL [24].	Lake has cleared of turbid waters.	Turbidity meets BC WQG initially; Turbidity reduces to pre-impact conditions.	Turbidity concentrations at monitoring stations in QL were below BC WQG by August 2015 [16] Water restrictions lifted by Interior Health Authority in May 2015 [23]; QL turbidity is at background [16]. Monitoring to be carried out during QL overturn to verify that sediments are not being re-suspended.	Low, based on current sampling results. Lake turnover in Fall 2015 unlikely to re-suspend sediments but spot monitoring of water column profile to confirm.	None currently, based on acceptance of water quality by Interior Health.	Turbidity and TSS monitoring.

Rehab Plan Area ID and Topic		Issue/ Consequence Stressor	Rehabilitation Objectives	Information Needs	Short Term		Status	Long Term		Status	Uncertainty	Contingency	Monitoring
					Methods	Success Criteria		Methods	Success Criteria				
8) Quesnel Lake cont'd	Habitat Impacts	Have deposited sediments resulted/resulting in smothering of benthos and possibly other habitat types?	Identify impacts and identify habitat rehabilitation or offset provisions (framework under development, based on methods of Bradford et al., 2014 [10].	Data on recolonization of benthos [21].	Identify through ROV or diver; quantify benthos smothering by bathymetry or other geophysical techniques (done; [25]).	Habitat recovers.	Bathymetric survey and sub-bottom profiling completed as part of PEEIAR [25].	Based on similar and/or follow up to short terms actions listed.	Benthos is productive; habitat impacts have recovered.	Early results indicate that some habitat may be recovering. Additional sampling has been carried out; sample processing and data analysis in progress.	Habitat impacts are identifiable.	TBD	TBD

Rehab Plan Area ID and Topic		Issue/ Consequence Stressor	Rehabilitation Objectives	Information Needs	Short Term		Status	Long Term		Status	Uncertainty	Contingency	Monitoring
					Methods	Success Criteria		Methods	Success Criteria				
9) Quesnel River	Water Quality	Has cloudy water caused a decrease in photosynthesis? Is the impact of turbidity on egg hatching success a concern since turbidity values have been lower than typical reports of egg survival? Is there toxicity to developing eggs?	Water clarity is returned to pre-impact conditions.	Literature review of possible effects of small particle size on egg survival; early life stage toxicity testing (done [27]).	Monitoring; direct exposure toxicity tests using fish eggs and QR water in progress (done [27], [28]).	No effect on egg survival.	In progress; QL and QR have been trending downwards in turbidity; toxicity tests show no effects [27], [28].	No further action once lake has cleared, provided that egg incubation in QR is not impaired.	River clarity is restored.	Turbidity concentrations in QR were below the 30-day BCWQG from mid-February through to end of August, 2015. Metals concentrations less than BCWQG [16].			Continuous turbidity monitoring at QUR-1; Federal /provincial monitoring site (weekly at Likely bridge). Sediment traps for settling of solids if waters remain turbid.
	Sediment accumulation	Is sediment deposition on river bed anticipated from materials flowing out of QL? Likelihood low given size and lack of settling out in lake.	No embedded-ness of gravels caused by cloudy water from QL .	Visual observations.	Monitoring only; considered unlikely that active rehabilitation would be required and may be more disruptive than warranted.	Lack of visible deposition of very fine materials.	Accumulation is not evident.	As per short term	As per short term	n/a	Expected to be low uncertainty. Solids that are now discharging out are those that have not settled after > 3 months at bottom of QL, therefore unlikely to settle in turbulent flow of QR.	Not identified	See information needs column entry.

Table of Abbreviations Used

AQ	Air Quality
CSM	Cutter Soil Mixing
d/s	Downstream
DFO	Fisheries and Oceans Canada
DO_2	Dissolved oxygen (O_2)
EC	Edney Creek
F/C	Flocculent and Coagulant
FN	First Nations
GAL	Golder Associates Ltd.
gw	Groundwater
HC	Hazeltine Creek

HHERA	Human Health and Ecological Risk Assessment
KCB	Klohn Crippen Berger
MFLRNO	Ministry of Forests, Lands and Natural Resource Operations
MoE	Ministry of Environment
NTU	Nephelometric Turbidity Unit
PEEIAR	Post Event Environmental Impact Assessment Report
PL	Polley Lake
PM	Particulate matter
QL	Quesnel Lake
QP	Qualified Professional
QR	Quesnel River

QRRC	Quesnel River Research Centre
ROV	Remote Operated Vehicle (unmanned submersible)
SSWQO	Site specific water quality objective
TBD	To be determined
TSF	Tailings Storage Facility
TSS	Total suspended solids
u/s	Upstream
u/w	Underwater
UNBC	University of British Columbia
WQG	Water Quality Guideline
WQO	Water quality objective

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