TSOLUM RIVER RECOVERY PLAN:

TSOLUM RIVER WATERSHED

"A Healthy, Diverse and Productive Tsolum River"

(Version: AUGUST 2016)

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Executive Summary

Recovery Plans are 'living document' tools developed to aid in the recovery of aquatic habitats. The purpose of the Recovery Plan is to identify and set priorities for activities that intend to achieve the recovery goals for the watershed and its fish stocks. There are many factors associated with declines of anadromous salmonids such as stream habitat loss and degradation, over exploitation in sport and commercial fisheries and ocean survival. This Recovery Plan measures the impacts on the ecosystem of the freshwater habitat through the components of upslope activities, riparian areas, and streams and their inter-connection or connectivity. It does not address management issues associated with fisheries harvest, global climate change or variable ocean conditions.

Pink salmon production in the Tsolum River declined from an historical high of 100,000 pink salmon adults returning per year in 1935-36 to a record low of ten pink salmon returning to spawn in 1984. Other salmon and trout stocks followed this same trend. In view of declining returns, the Tsolum River Task Force was formed to address the probable causes linked to problems of: mine site pollution, low summer water flows in the river and restore fisheries habitat throughout the watershed. The 2015 return was a record count of approximately 129 000 pink salmon. A cautious success resulting from all work done to date since this population remains vulnerable due to many variables including: sediment loading, channel instability, continued low flow levels, summer water temperature, food availability and marine survivability.

The Mount Washington Copper Mine, which only operated between 1960 and 1969, had long term impacts on water quality in the Tsolum River due to acid rock drainage; resulting in the decimation of these once-strong salmonid populations. Early remediation efforts began in the 1980s, eventually leading to the installation of a geotextile cover over the abandoned mine site in the summer of 2009. This remediation has led to vast improvements in water quality and levels are now measuring above federal government water quality targets, allowing current restoration efforts to shift focus on other factors supressing watershed health and limiting salmon and trout production.

The Tsolum River Restoration Society and its partners in the Tsolum River Partnership (an interagency and multi-stakeholder partnership) have been working on the Tsolum River Watershed Assessment Strategy since 2010 when monitoring showed that the Ministry of Environment water quality copper objectives were being met consistently.

The Tsolum River Recovery Plan (TRRP) represents the culmination of a series of technical assessments, recommended and overseen by the TRRP, outlining a comprehensive watershed recovery plan that systematically prioritizes the key watershed restoration and monitoring initiatives. The development of an

Action Plan was founded on core principles that served to focus and clarify the Partnership's goals and approach to watershed recovery. The Action Plan links determined impairments supressing watershed health to habitat availability and function and ultimately fisheries productivity. Continued loss of habitat, in particular spawning and summer rearing habitats due largely to worsening summer low flow conditions, and excessive bedload transport are considered the most significant threats. These impacts appear to be directly related to land use development - in particular historic deforestation, increased drainage and road development, and the degradation and loss of riparian areas. The assessment basis for the TRRP include both the physical and biological attributes (characteristics, impairment, diversity, etc.) of the entire watershed as expressed through the response of endemic fish populations to restorative efforts over time.

Major recovery plan objectives are to:

- Monitor acid rock drainage from an abandoned copper mine (which has been addressed)
- Reduce sedimentation from upland sources
- Reduce bank erosion along watershed length
- Restore riparian areas and function – develop watershed riparian prescription
- Manage / monitor low summer flow and wetted areas
- Enhance channel stability and increase channel complexity
- Improve and protect fish rearing areas
- Increase spawning gravel areas

The specific habitat objectives of the TRRP and its supporting assessments are formulated around the critical requirements of five salmonid species that collectively act as the barometer of the health of the Tsolum River ecosystem and are of critical socio-economic and cultural importance in the region. These species include:

a. Chum Salmon (*Oncorhynchus keta*): spawning and holding habitat;
b. Coho Salmon (*Oncorhynchus kisutch*): spawning, rearing, holding, overwintering and refuge habitat;
c. Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*): spawning, rearing, holding, overwintering and refuge habitat;
d. Pink Salmon (*Oncorhynchus gorbuscha*): spawning and holding habitat;
e. Rainbow/Steelhead Trout (*Oncorhynchus mykiss*): spawning, rearing, holding, overwintering and refuge habitat.

Based on the work to date, TRRS recovery efforts have had a perceived focus or emphasis on pink salmon stocks. However, it is recognized that the Tsolum River also supported once viable populations of both Steelhead and coho salmon (and resident trout); with pink returns serving as a significant nutrient foundation for the watershed. Although chinook salmon were also present, their numbers have historically been low, primarily due to basin characteristics and an absence of suitable spawning habitats. Now that The Tsolum River has experienced recent and significant increases in pink returns - a highly positive indicator - there is a cautious optimism for a full and sustained watershed recovery. The TRRS will continue to have a restoration focus moving forward, with emphasis on channel condition and substrate stability, riparian health and function, as well as, integrated stock assessment monitoring. The results of the supporting assessment reports and the TRP will additionally serve as valuable tools to inform and support discussion with local government and other response agencies concerning land use planning, development and application of best management practices that support watershed sustainability and resiliency.

Acknowledgements

The completion of The Tsolum River Recovery Plan, biophysical report, The Tsolum River Habitat Status Report, The Tsolum River Fish Habitat Assessment Procedures (FHAP) Report, The Tsolum River Channel Morphology and Base Load Assessment and the Tsolum River GIS Mapping System could not have been accomplished without the support of the following funding agencies:

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This Recovery Plan is the final stage of the Tsolum River Assessment Framework, as described in the Tsolum River Recovery Strategy (TRRS, 2014). The authors of the following documents are credited for their supporting reports and studies:

1. The Tsolum River Habitat Status Report (Remillard & Clough, 2015),
2. The Tsolum River Fish Habitat Assessment Report (FHAP) (Clough, 2015),
3. Tsolum Watershed Habitat Restoration Planning (Clough, 2015),
4. Channel Morphology and Bedload Assessment (Gooding, 2015),
5. Tsolum River Overview Assessment (Gooding, 2013),
6. Tsolum River Biophysical Assessment Hydrology and Channel Assessment (Gooding, 2010),
7. Tsolum River Limiting Factors to Pink Salmon Production (Campbell, 2010).

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1.0 Introduction to Watershed Recovery Planning

The Tsolum River Restoration Society (TRRS) was established in 1998 as the business agent of the Tsolum River Taskforce, a multi-stakeholder organization established to bring back the Tsolum River after it had been declared biologically dead due to long term mine pollution. After the TRTF dissolved the TRRS went on to organize the Tsolum River Partnership (TRP) to address the impacts from an abandoned copper mine in the headwaters. The old copper mine was covered with a geotextile membrane in 2009 and re-vegetated in 2010.

Once the mine site was successfully restored the TRP moved on to the other issues facing the recovery of fish stocks in the Tsolum. The TRP now includes representation from the K'ómoks First Nation, Timberwest, Comox Valley Farmers' Institute, the City of Courtenay, the Comox Valley Regional District, the BC Ministry of Forest, Lands and Natural Resources Operations, the BC Ministry of Agriculture, Fisheries and Oceans Canada, the BC Conservation Foundation and the TRRS.

The TRP works on a consensus model to share information, identify communities of interest, rank projects at a watershed scale, pool resources, attract partners, seek funders, and enable a new way of conducting stewardship business in the Tsolum River watershed. Its primary interests include salmonid stock and habitat assessment, public education and outreach.

This living document, the Tsolum River Recovery Plan, is the final stage of the Tsolum River Assessment Framework, as described in the Tsolum River Recovery Strategy (TRRS, 2014). This plan has been based on fieldwork and outcomes from the following supporting assessments and planning documents:

1. The Tsolum River Habitat Status Report (Remillard & Clough, 2015),
2. The Tsolum River Fish Habitat Assessment Report (FHAP) (Clough, 2015),
3. Tsolum Watershed Habitat Restoration Planning (Clough, 2015),
4. Channel Morphology and Bedload Assessment (Gooding, 2015),
5. Tsolum River Overview Assessment (Gooding, 2013),
6. Tsolum River Biophysical Assessment Hydrology and Channel Assessment (Gooding, 2010),
7. Tsolum River Limiting Factors to Pink Salmon Production (Campbell, 2010).

The first four of the reports listed above are supported by a GIS database which is displayed on the Tsolum River GIS Mapping system which will be available from the TRRS website: www.tsolumriver.org.

Recovery Plans are a 'living document' tool developed to aid in the recovery of aquatic habitats. The purpose of this Recovery Plan is to identify and set priorities for activities that intend to achieve the recovery goals for the watershed and its fish stocks. In order for the plan to be effective, all relevant factors must be considered. There are many factors associated with declines of anadromous salmonids such as stream habitat loss and degradation, over exploitation in sport and commercial fisheries and ocean survival (Nehlsen et al., 1991; Frissell, 1993). This Recovery Plan measures the impacts on the ecosystem of the freshwater habitat through the components of upslope activities, riparian areas, and streams and their inter-connection or connectivity. It does not address management issues associated with fisheries harvest, global climate change or variable ocean conditions.

Stream recovery should be planned and managed at a watershed scale. Relationships between habitat condition and individual salmonid response has been well documented within the habitat unit (Nickelson et al., 1992; Bisson et al., 1982), stream reach (Murphy et al., 1989) and at the watershed unit levels (Schlosser, 1991). Consideration and restoration of upslope and fluvial processes that create and maintain habitats should be integral components of a recovery program (Thomas et al., 1993) and as such, the entire watershed should be managed for recovery. Biologically based restoration goal efforts will be more effective with a basic understanding of the morphological processes occurring in each reach. This being understood, there is still the need to distinguish between physical/natural process restoration and the restoration of habitat/biologically limiting factors. While these attributes are linked (the former being a result of land use/climate change and the latter a symptom and response) both contribute to variation in observed productivity. Therefore, in prioritizing resources, effectiveness and effort the Recovery Plan may hold off on some habitat-based projects when the risk of stability and failure are greater due to broader physical situations that may not be feasibly addressed (pers. communication, Nick Leone, April, 2015).

The Tsolum River Recovery Plan (TRRP) is intended to identify a prioritized list of restoration projects and monitoring requirements that are specific to recovery of the river and its salmonids based on historical and recently collected field data. The plan will present; a summary of detailed studies on priority reaches to determine prescriptions and recommendations on the resources necessary to achieve the restoration objectives. This plan will be updated as projects are completed, resources are secured and in response to the ever changing conditions in the watershed.

1.1 Guiding Principles for Watershed Recovery Planning

The TRRP is a sum of the parts of all other Tsolum River Watershed assessments done to date and as such, sets the foundation for the direction of the Tsolum River Restoration Society and the Tsolum River Partners. Following the components and guiding principles adopted by the Pacific Salmon Endowment Fund and the Wild Salmon Policy, in order to determine and assess watershed recovery successes, the core values and objectives approach to the Tsolum River Recovery Planning is defined by the following Guiding Principles:

Principle 1 - Use of evidence-based approaches that maintains information and data integrity;

Principle 2 - Knowledge of watershed land-use history and influence;

Principle 3 - Knowledge of watershed natural/physical processes and temporal shifts linked to Climate Change;

Principle 4 - Knowledge of impacts of land-use on changes to natural/physical processes including water quality;

Principle 5 - Knowledge of physical process changes in watershed natural processes as they influence channel condition/integrity, habitat diversity and ultimately, productive capacity;

Principle 6 - Identification of factors limiting the productivity of fish populations and supporting habitats including: assessments of key factors such as hydrology/flow, riparian health/function, channel morphology and bedload, habitat diversity and stock abundance;

Principle 7 – Development of key planning elements: Monitoring, Restoration, Public Awareness and Outreach, Land-use Governance, Adaptive Management, and Stewardship.

1.2 Study Area - Tsolum River Watershed

1.2.1 Physical Features

The Tsolum River (watershed code 920-553200-94100) is the largest tributary of the Courtenay/Puntledge River Watershed. It is located on the eastern coast of Vancouver Island in the traditional lands of the K'ómoks First Nation in the Comox Valley Regional District at the northwest limit of the City of Courtenay, British Columbia (Figure 1). The mainstem drains the east side of Mount Washington (elevation 1585 m) while other low gradient branches are spread across the lower lying, approximately 20 km wide, glacio-marine floodplain from Courtenay to Black Creek (Figures 2 & 3). The Tsolum Watershed area is 248 km^2 within the 859 km^2 area of the Courtenay/Puntledge watershed. The mainstem Tsolum River is approximately 40 km long originating from Mount Washington and joining the Puntledge River to form the Courtenay River which enters the Comox estuary 1.0 km downstream.

The Tsolum Watershed includes many significant (3^{rd} order or greater) salmon bearing tributaries; Dove, Murex, Headquarters, Hell Diver, Constitution and Portuguese. There are many other smaller stream channels in the watershed which are identified on the community stream atlas (Project Watershed SHIM, 1999-2005). The Tsolum watershed consists of a long low gradient mainstem along the base of Mount Washington from Helldiver Lake to the Puntledge confluence, with the steeper headwaters (upper Tsolum) and tributaries (Murex Creek, Headquarters Creek, and Dove Creek) entering the low gradient Tsolum off of the side of the mountain. Downstream on the floodplain, Portuguese Creek brings in flow from the flatter, low elevation agricultural land on the east side of the river (Figure 4).

Headquarters Creek, due to Wolf Lake moderating peak flows and cutting off bedload flow from upstream of the lake, and Portuguese Creek, due to its lower gradient, have limited coarse bedload transportation capacity. The Upper Tsolum (Blue Grouse), Murex Creek, and Dove Creek are the major sources of bedload being carried off the mountain and into the low gradient Tsolum mainstem. Some additional bedload is added in the lower floodplain from bank erosion in the agricultural and residential areas.

Figure 1 – Courtenay BC and the Tsolum Watershed location on Vancouver Island, BC

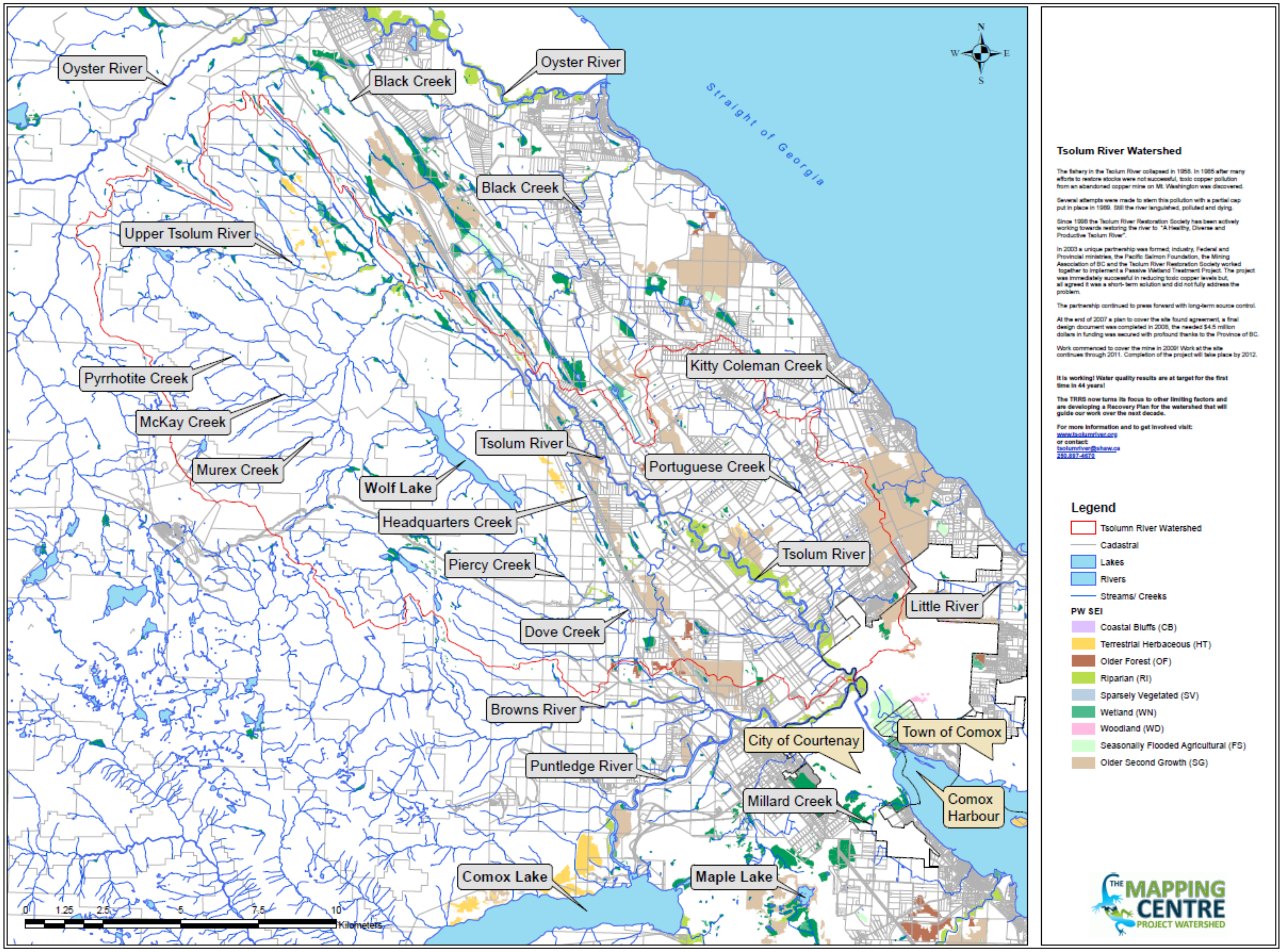

Figure 2 - Tsolum River Watershed Survey Area

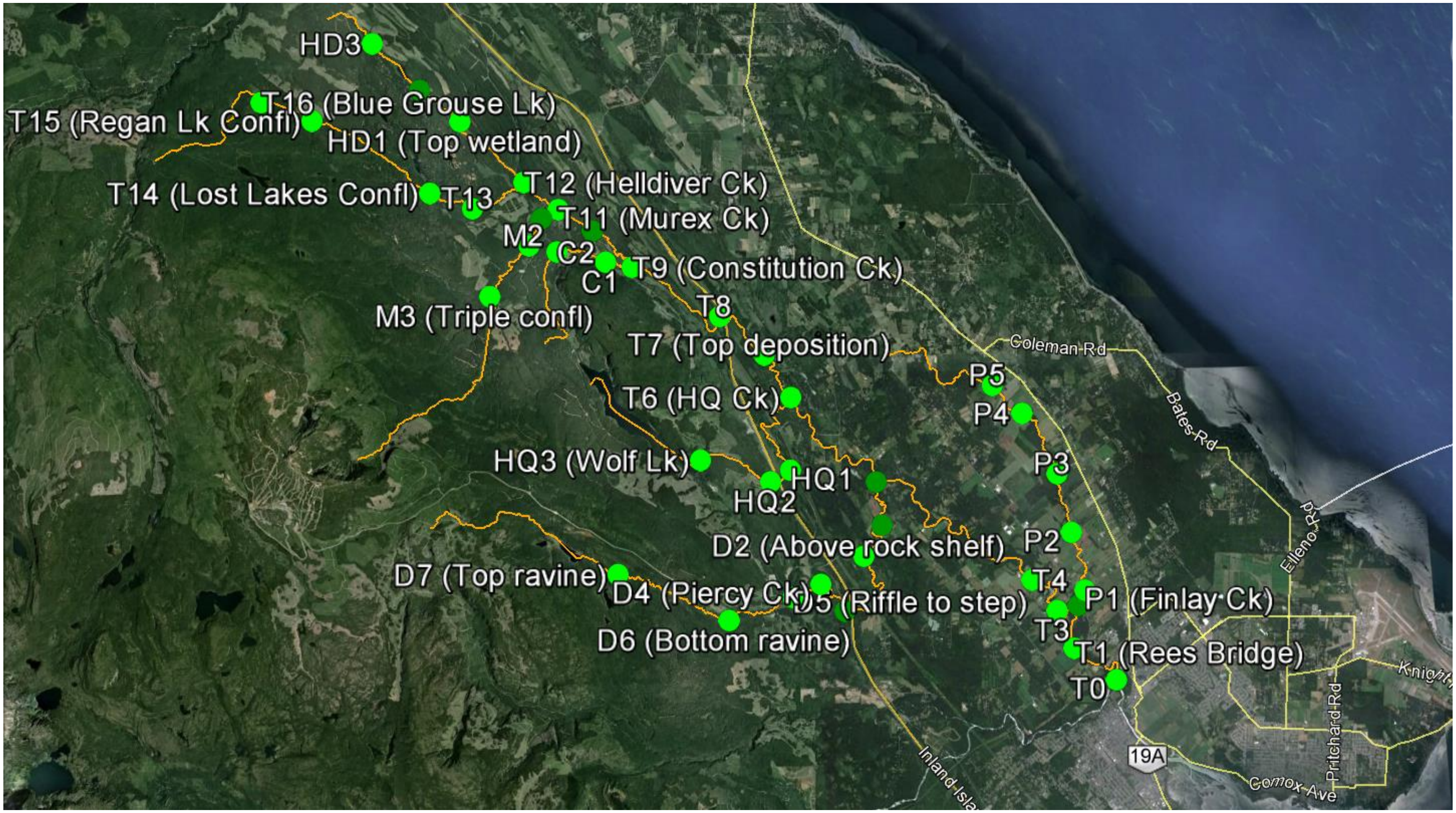

Figure 3 – Tsolum Watershed showing Reach Designations (from the TRRS Mapping Tool at www.tsolumriver.org)

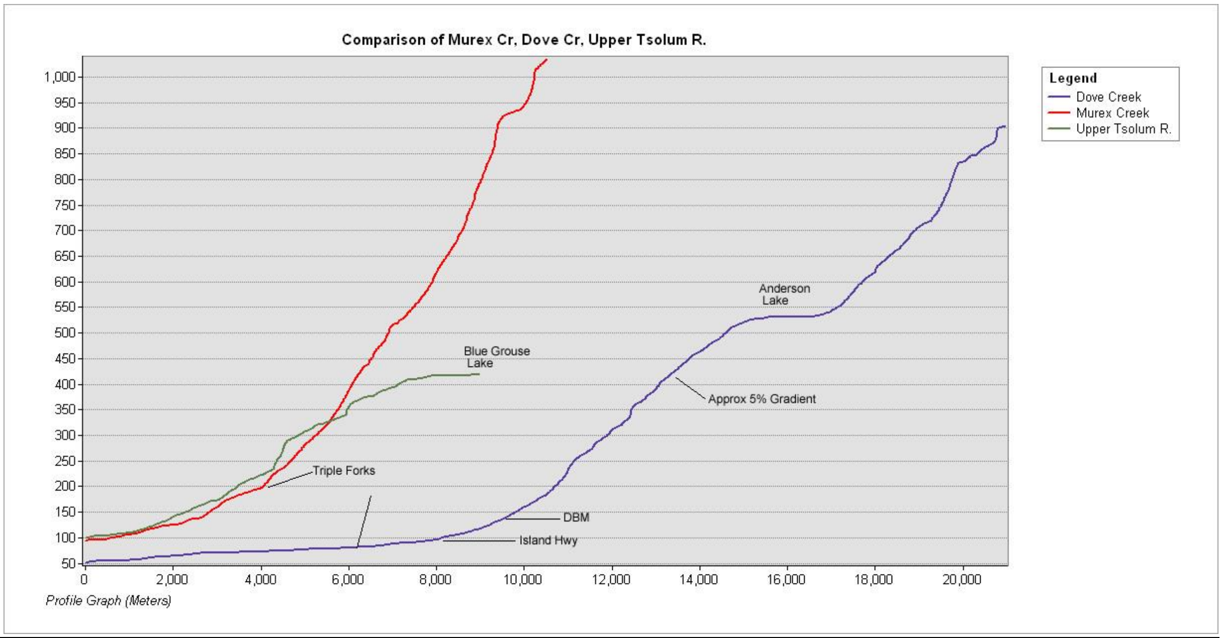

Figure 4 – Gradient profiles of Dove Creek, Murex Creek and the Upper Tsolum

1.2.2 Fish Species

It is assumed that the target fish species include those species that were historically present. Salmon populations of the Tsolum River are part of larger Conservation Units (CUs) for chinook, coho, pink, chum, and river sockeye and include resident fish stocks of cutthroat and rainbow / steelhead trout. Using the database available with DFO Mapster (www.pac.dfo-mpo.gc.ca/gis-sig/maps-cartes-eng.htm), in the Tsolum River watershed there are six identified CUs; the most in the East Coast Vancouver Island area:

1. ECVI Qualicum-Puntledge Fall Chinook Salmon
2. Georgia Strait Chum Salmon
3. ECVI –Georgia Strait Coho Salmon
4. Georgia Strait Even Year Pink Salmon
5. Georgia Strait Odd Year Pink Salmon
6. ECVI –Georgia Strait River Sockeye Salmon

This diversity results in a broad range of spawning, rearing, and migratory habitat requirements throughout much of the watershed. Spawning gravel, pool habitat, plentiful large woody debris (LWD), and healthy riparian buffers, are all required along all of the lower gradient mainstem Tsolum River and its low elevation tributaries, as well as up the higher gradient tributaries, to accommodate all the life stages of these species. The work of Labelle et al. (1997) demonstrating variability in marine survival rates among East Coast Vancouver Island streams emphasizes the need to have stock specific monitoring of recovery efforts.

1.2.3 Salmon Stock Status

The river has salmon access from the Puntledge River upstream at least 31 km where it enters a canyon at the base of Mt. Washington (Clough, 2015). The Tsolum River was a significant salmonid producer until the late 1940s. Peak historical opening runs have recorded +100,000 pink, 15,000 coho, and 11,000 chum salmon. Also, 3,500 steelhead were reported (the productive capacity of the entire Puntledge watershed was estimated at 2,500 smolts by Ptolemy, 2002), and populations of chinook and cutthroat trout have been recorded in this waterway. There are resident trout populations further 7 km to the headwater lakes; Blue Grouse/Regan/Lost (Freshwater Fisheries Society B.C. archives). Anderson Lake on upper Dove Cr, Wolf Lake on upper Headquarters and Helldiver Lake at the top of Helldiver Creek also have known resident trout.

Today, pink salmon are the dominant salmonid species in the Tsolum Watershed and both even and odd year pink salmon can be found in the watershed (Figure 5). The next most common species are coho and chum (Figure 5). Currently, all five species of pacific salmon are found in the Tsolum River watershed (Table 1). From Fisheries and Oceans escapement records (Mapster v3: http://pacgis01.dfo-mpo.gc.ca), pink salmon are the most abundant species with runs cycling below 1,000 up to over 40,000 until 2012. In 2015, the largest run single day count was approximately 129 000 fish in the Tsolum Watershed. Not only was this the largest run since the water quality remediation but the largest day count ever registered for the Tsolum with records going back to 1935 and the first non-enhanced (non-hatchery) run since pre-copper mine days - the last fry release from the Tsolum Hatchery was in 2012. A cautious victory since this population remains vulnerable due to many variables including: low flow levels, high summer water temperature, high fall/winter flows effect on bedload movement and riparian health and diversity resulting in loss of large woody debris recruitment, food availability and marine survivability.

Coho Salmon populations have been on a steady increase since the lowest record of only 86 in 1986. There have been small counts of stream-type Sockeye in some years in the Tsolum River. Additional data on this species should continue to be obtained while assessing other target species. There should be an awareness that recovery efforts on coho or steelhead do not negatively impact on sockeye.

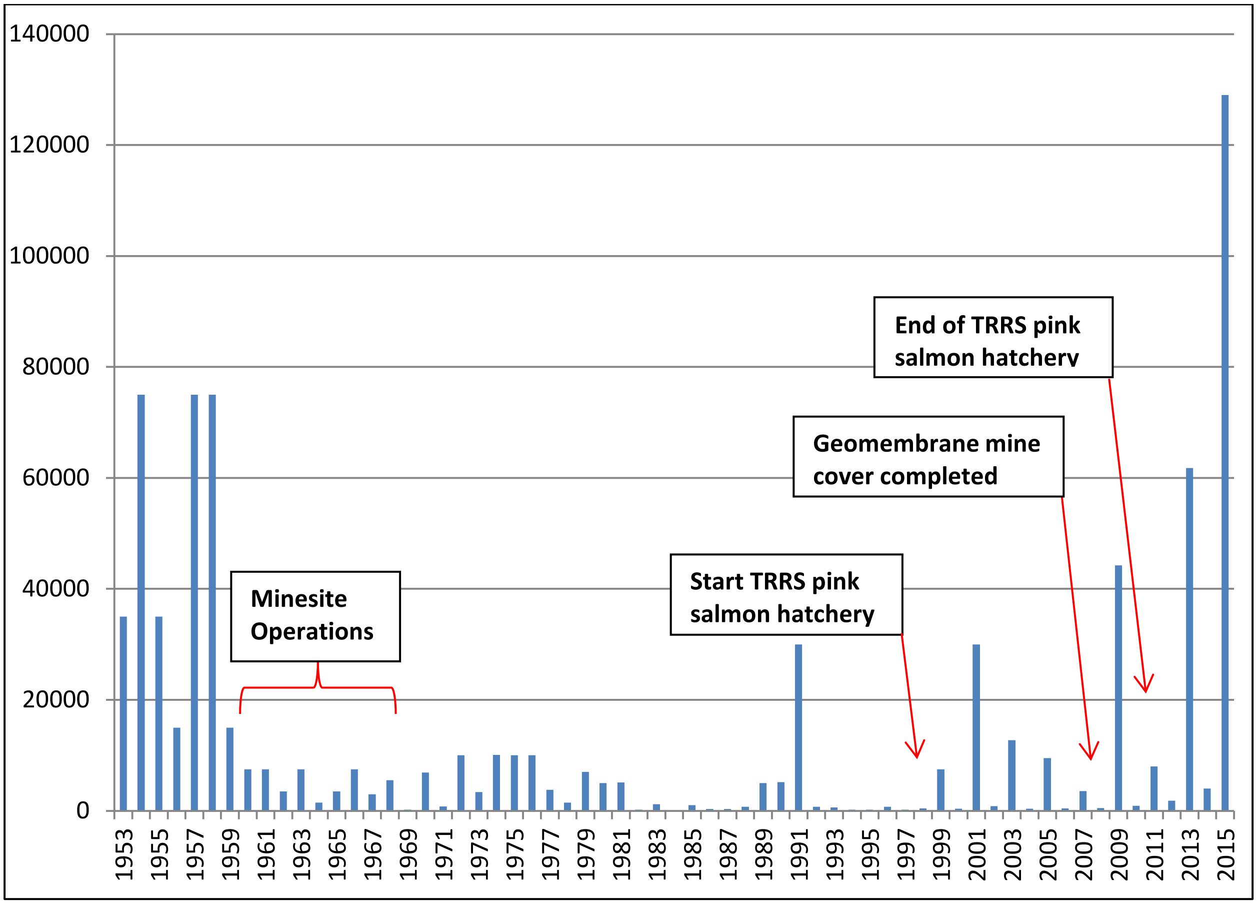

Figure 5 - Tsolum River Pink Salmon Escapements 1952 – 2015.

Table 1 – Tsolum Salmon Escapes (spawning adult numbers) 2000-2015 (adapted from Clough, 2015).

	Pink Fall Run	Chum Fall Run	Coho Fall Run	Chinook Run 1	Sockeye Run 1
2015	129 000	Not Inspected	Present	No Data	No Data
2012	1200	1200	Present	Not Inspected	No Data
2011	8000	Not Inspected	Not Inspected	Not Inspected	No Data
2010	900	1500	1000	Not Inspected	No Data
2009	50 000	5000	500	Not Inspected	No Data
2008	500	550	250	None observed	No Data
2007	3550	12000	100	None observed	No Data
2006	Not Inspected	Not Inspected	Not Inspected	None observed	No Data
2005	12 500	Not Inspected	Not Inspected	None observed	No Data
2004	350	18000	600	None observed	No Data
2003	12 718	10000	Not Inspected	Present	No Data
2002	840	1700	None observed	None observed	No Data
2001	19 000	7500	Present	None observed	None observed
2000	400	735	present	None observed	None observed

1.2.4 Trout Status and Abundance

Cutthroat

Cutthroat trout critical rearing habitats are composed of first, second and smaller third order sub-basins that remain wetted year round. The habitat capacity is estimated to be 400 g/100m2 of suitable habitat. Within the Tsolum watershed, given the relatively long anadromous length of several qualifying tributaries the potential anadromous cutthroat smolt production is estimated at more than 1000 smolts at capacity. Yet, the most recent standing stock assessments of Dove creek (Craig and Eastman, 2006) showed that standing stocks were only a small fraction of predicted biomass with habitats producing cutthroat at well below optimum levels.

Steelhead

Steelhead trout critical rearing habitats are composed of larger third and fourth order streams with a relatively high gradient (riffles) with course bed material (cobbles and boulders). Qualifying habitats include the mainstem Tsolum and the lower reaches of select tributaries including Dove Creek.

The Steelhead smolt capacity for the entire Puntledge watershed is estimated at 2500 smolts (Ptolemy 2002), with only a fraction of those smolts, perhaps one quarter to one third, derived from the Tsolum River sub-basin based on a pro rata habitat basis (based on data collected with the Steelhead Harvest Analysis (SHA) historic catches between 1968 and 2007 that included years where almost 400 steelhead were harvested) (Figure 6) (personal communication, Mike McCulloch (BC MLFNR)). These data tend to have a positive response bias, particularly in the latter years, but do strongly support a smolt capacity and watershed production that is greater than our current estimate.

Based on a marine survival range of 5-10%, current steelhead abundance would be in the magnitude of 40 – 75 steelhead at capacity. Given the cyclically observed rates of marine survival of between ~2 and 25%, historic abundance could have ranged from 20 to 200 steelhead with peak estimates of four to five hundred steelhead in years with above average recruitment and marine survival. No recent estimates of stock size, juvenile saturation or local marine survival have been collected.

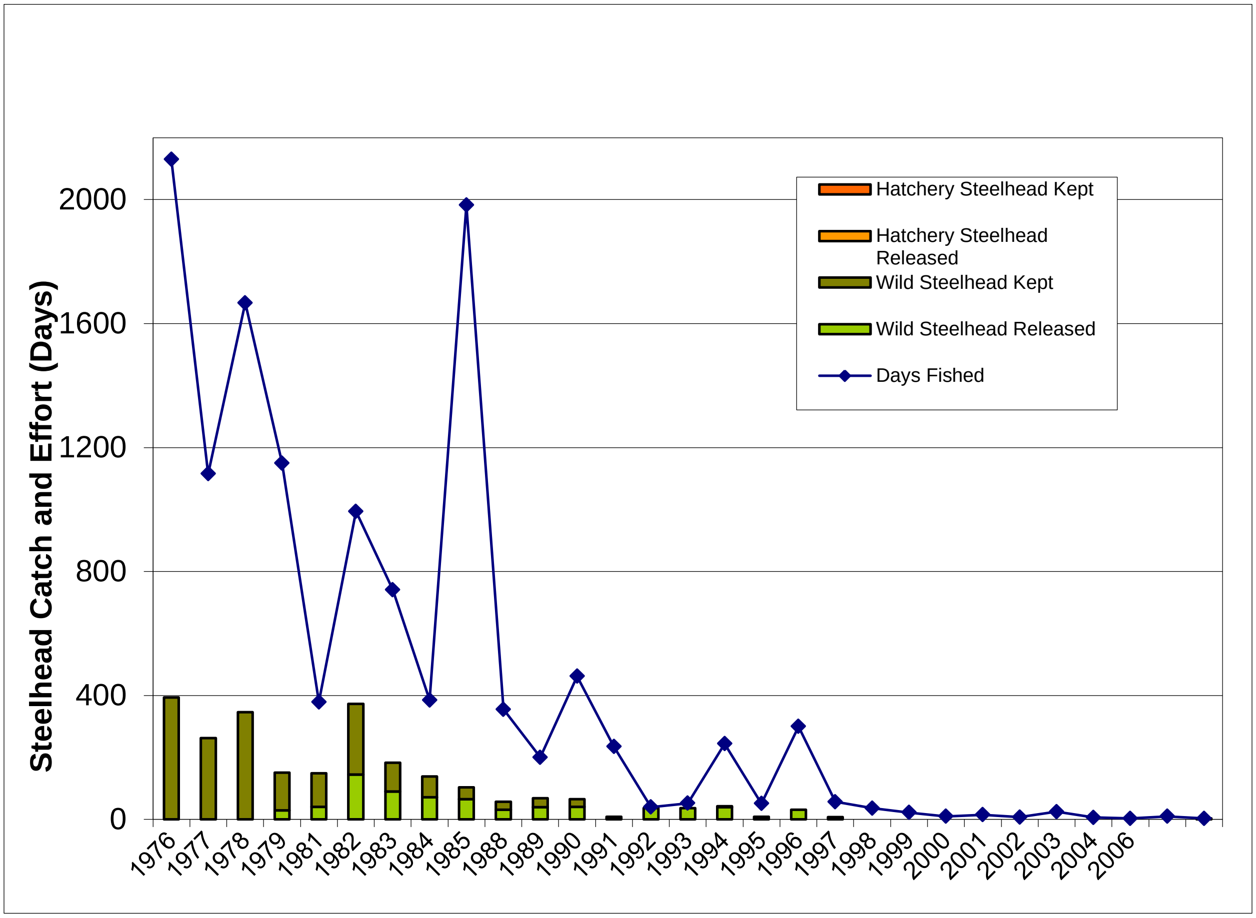

Figure 6 - Tsolum River Steelhead Catch and Effort, 1968-2008 (figure provided by BC Ministry of LNRO)

1.2.5 Stock Enhancement

According to the BC Ministry of Environment, no stocking has occurred in the last 6 years. However, prior to that annually up to 15,000 late winter coho, cutthroat and steelhead smolts were released with records dating as far back as 1939. These releases were during the period when the Tsolum was rehabilitating from historical logging impacts and prior to the water quality issues.

The Tsolum River Restoration Society (and it preceding versions) had continually enhanced pink stocks since re-opening the Tsolum Facility on Headquarters Creek in 1999, releasing one million fry each year through 2012. The Puntledge Hatchery has also released a million pinks over several of these years in addition to the fry the TRRS released. However, even with all this effort there were still small responses in pink salmon escapement until the mine site was remediated in 2009/2010.

1.2.5 Vegetation

Depending on elevation, the watershed is located in variants of the Coastal Western Hemlock (CWH) Biogeoclimatic Zone, (Meidinger and Pojar, 1991). The low lying areas where the majority of salmon habitat is found are in CWHxm1; "Very Dry Maritime sub zone, eastern variant". Common vegetative species in the CWHxm are Douglas Fir *(Pseudotsuga menziesii*), Western Hemlock (*Tsuga heterophylla),* Western Red Cedar (*Thuja plicata*), with common understory of Salal (*Gaultheria shallon*), Step moss (*Hylocomium splendens*), Bracken fern (*Pteridium aquilinum*) and Vanilla leaf (*Achlys trifilla*).

In the Tsolum watershed riparian areas have been significantly altered and reduced. Historic logging practices took no account of the riparian areas and much of the river was logged to its banks. Non-functioning (or impaired) riparian ecosystems offer poor bank protection and are a poor supply of large woody debris, which provides many important components of a healthy stream ecosystem such as cover, scour, hydrologic function and habitat. This type of impaired ecosystem will eventually recover, but over an extended period time (Prichard, 1993).

1.2.6 Human Activity – Historic and Current Land Use

The Tsolum Watershed forests have been important resources to humans. The watershed has been home to the people of the K'ómoks First Nation for thousands of years. Oral history describes the food supply in the watershed as so abundant that it was referred to as the 'land of plenty". Some forested areas may have been historically cleared by First Nations to tend crops of bulbs and berries through burning of over story trees (Turner & Jones, 2000).

The European settlers arrived in the 1860's and the watershed has been logged extensively since that time. Logging up the valley at lower elevations along the Tsolum mainstem had reached Helldiver Creek by the late 1930s. Through the 1940s and 1950s the entire mountainside, including all riparian areas, was logged progressively up to the higher elevation, more difficult terrain of Mount Washington. By the early 1960s, stream banks of the lower and mid-slope tributaries were weakened from yarding disturbances, removal and loss of LWD and log drives during logging, and from the subsequent decomposition of root structures.

A copper mine which operated for a few years in the early 1960s had long term impacts on water quality in the Tsolum River because of acid drainage, resulting in the decimation of these once-strong salmonid populations. Early history of remediation work began in the 1980s with the work of the local chapter of the Steelhead Society who struck a committee whose mandate was the reclamation of the Old mine site and the enhancement of the Tsolum River. Their efforts culminated in a 50% reduction of copper in the Tsolum in 1997 (Personal communication, Charles Brandt and MOELP, 1995). The reformation of this group, the Tsolum River Task Force, raised funds and awareness until in the summer of 2009 when a geotextile cover was placed over the abandoned Mount Washington Copper mine site. This remediation has led to vast improvements in water quality and levels are now measuring above TRRS targets, allowing current restoration efforts to focus on other factors limiting salmon and trout production. All of these efforts paved the way for the ultimate success of the final cover on the mine site and the return of some 129,000 pinks in 2015.

These historic impacts resulted in a combination of weak banks and increased bedload from landslides, caused by logging of unstable slopes in the upper watersheds. This destabilized the boulder lines of the mid and upper slopes' cascade-pool and step pool morphologies, resulting in a massive movement of bedload down the mountain channels, consisting of landslide input and the destabilized boulder, cobble and gravel of the step and cascade pool structures. All of the excess bedload entering the low gradient mainstem Tsolum over the years has reduced flood capacity (and pool depths), and has caused stress to the river's banks, causing erosion where banks are weak, and further bedload input. An analysis comparing pink salmon returns with the number of days of bankfull flow during their incubation season in the gravel suggests that the highly mobility of the excess gravel component of bedload in the Tsolum is a major contributing factor limiting fisheries productivity.

Currently, forestry and agriculture are the primary land uses in the watershed. Combined, urban and rural development has a relatively minor land area but a not insignificant effect on the watershed (Figure 7). Forestry has been the predominant land use by area and continues to be a significant activity within the watershed. Today, Timberwest is the primary forestry operator in the watershed. However, agricultural land use also covers a substantial portion of the low lying areas. Urban development is concentrated at the bottom of the watershed, where the Tsolum River ends in the town of Courtenay at the Puntledge River. Both urban and agricultural use adjacent to the river has resulted in much of the lower Tsolum having bank armouring and other floodplain constraints including removal of riparian vegetation. All use types should be considered as having a responsibility towards actions, plans and development effects on the Tsolum watershed channel function and habitat conditions.

1.2.7 Water Use

Water Use along the Tsolum is a complicated situation to monitor. Due to differences in historic and current title regulations, there are properties that are bounded by the wetted bank or to the center of the channel, and some include the entire river or creek beds. These differences affect the approach the TRRS must take regarding restoration of riparian areas and bank access. Surface water (versus ground water withdrawal which is largely an unknown) allocation in the Tsolum River is approximately 400 Acre-feet and largely reflects historical use. The withdrawal or use varies relative to land use where higher withdrawal rates are often associated with commercial or agricultural lands. Since 1996 there has been a policy that limits water licences when flows are less than 10 percent of mean annual discharge (typically August through October in the Tsolum Watershed). Nonetheless, this surface water withdrawal on the mainstem is relatively small in the context of flow volume even in low flow periods and is non-detectable during high flow. Water withdrawals from tributaries such as Portuguese Creek are much more pronounced especially during low flow periods when refuge habitat pool availability is critical. Restrictions on use vary with the type of licence e.g. older irrigation permits have been grandfathered in and are not monitored. The new provincial Water Sustainability Act should allow a better handle on use and improve monitoring.

Efforts have been made by TRRS to make the public aware of water use. This is particularly appropriate in the light of marked fluctuations in high and low seasonal flows in recent years with the attendant flooding and drying of the river, especially in the lower tributary sub basins.

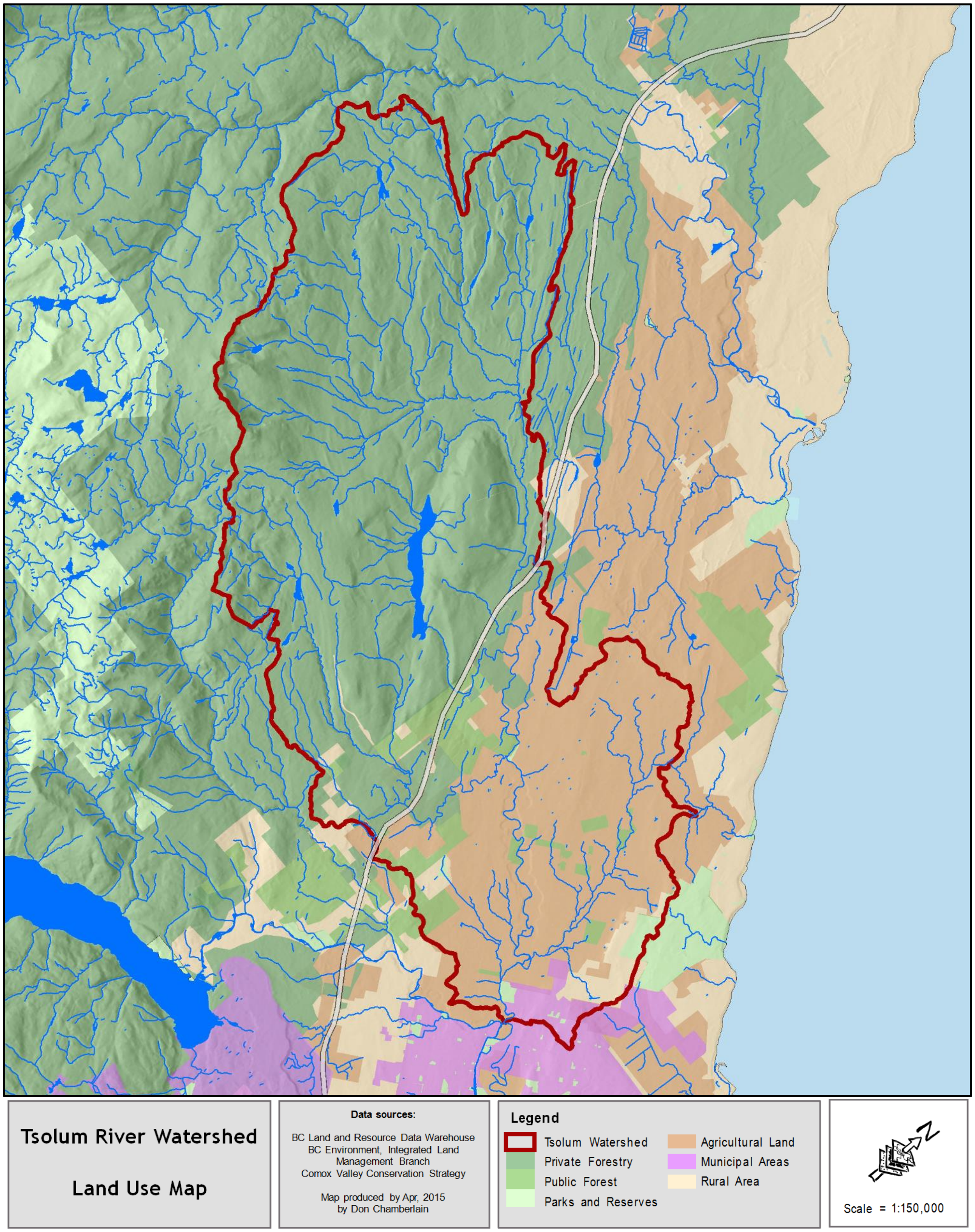

Figure 7 – Land Use within the Tsolum River Watershed

1.2.8 Water Flow - Hydrology

East Coast of Vancouver Island watersheds experience extreme fluctuations in flow, primarily resulting from rain events (Figure 8). There is a Water Services Canada (WSC) flow station on the lower Tsolum with real time results. Unfortunately a second station below Murex Creek is closing. The TRRS, under the guidance of BCCF, also does manual flow monitoring on the Tsolum River below the Dove Creek confluence, there is also a WSC flow monitoring site on Dove Creek. Data can be found in the *Tsolum River, Vancouver Island, BC Hydrometric & Water Temperature Data Report, 2012-2015* (BC Conservation Foundation, 2016). The Tsolum River was captured under the Water Allocation Plan (Riddell & Bryden, 1996). This plan was to summarize the current and historical flows and allow for proper management. The goal was to conserve the quality, quantity and timing of water flow or prevent cumulative hydrological effects.

Late in the summer, flows often reach critically low levels for salmonids rearing (coho, steelhead, cutthroat, and chinook). With the excess bedload through much of the lower gradient mainstem Tsolum, a higher proportion of flow, especially during low flow periods, will be travelling sub-surface through the gravel. This decreases the surface flow levels and worsens low flow impacts on habitat availability. As for many East Coast Vancouver Island streams, there is potential for water withdrawals from some of the sub-basins within the Tsolum watershed that would compound low flow periods and negatively impact rearing fish. The river dries significantly in summer with water flow below 10% of the Mean Annual Discharge in August resulting in no water available for extraction in the months of June to September (Riddell & Bryden, 1996).

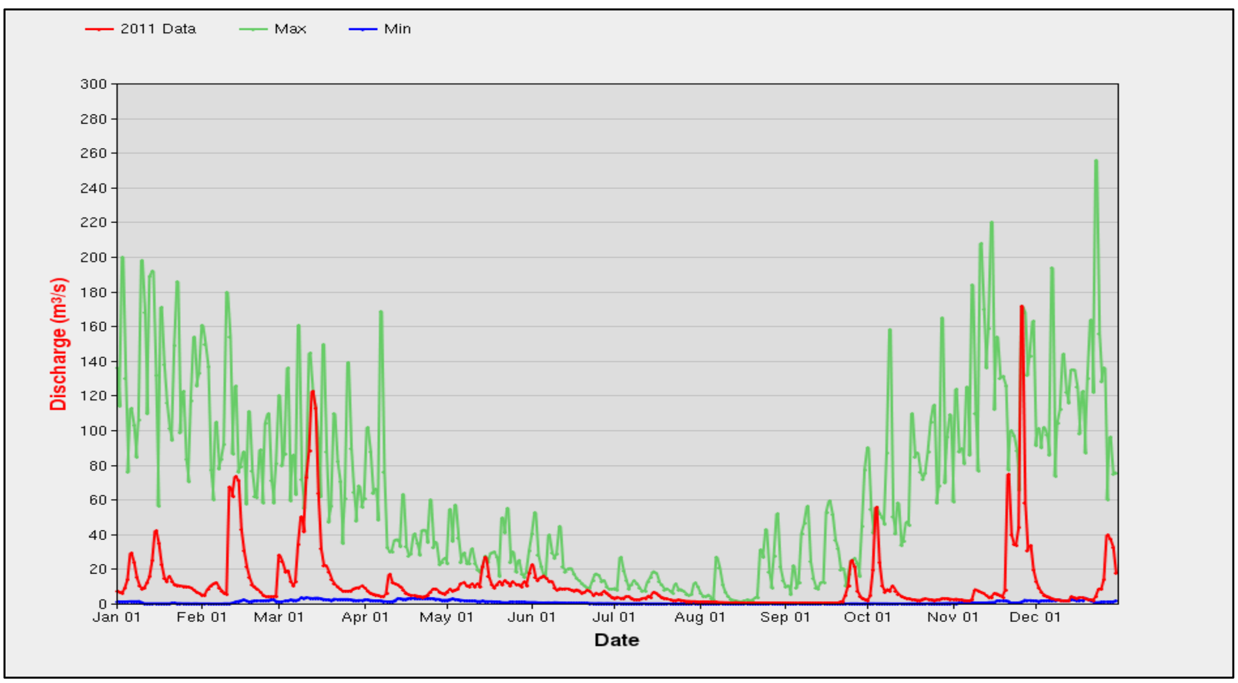

Figure 8 – Daily Flows at the Tsolum River Water Station - 2011

Incubating eggs and pre-emergent fry are vulnerable to the combination of high flows and unstable mobile bedload. Gooding (2015) reports if there are more than five days of greater than 50 cfs water flow rate days in a winter; the pink fry emergence will be severely, negatively affected (Figure 9). As a potential impact of climate change, frequent extreme weather events will make monitoring and recovery planning more challenging in the future.

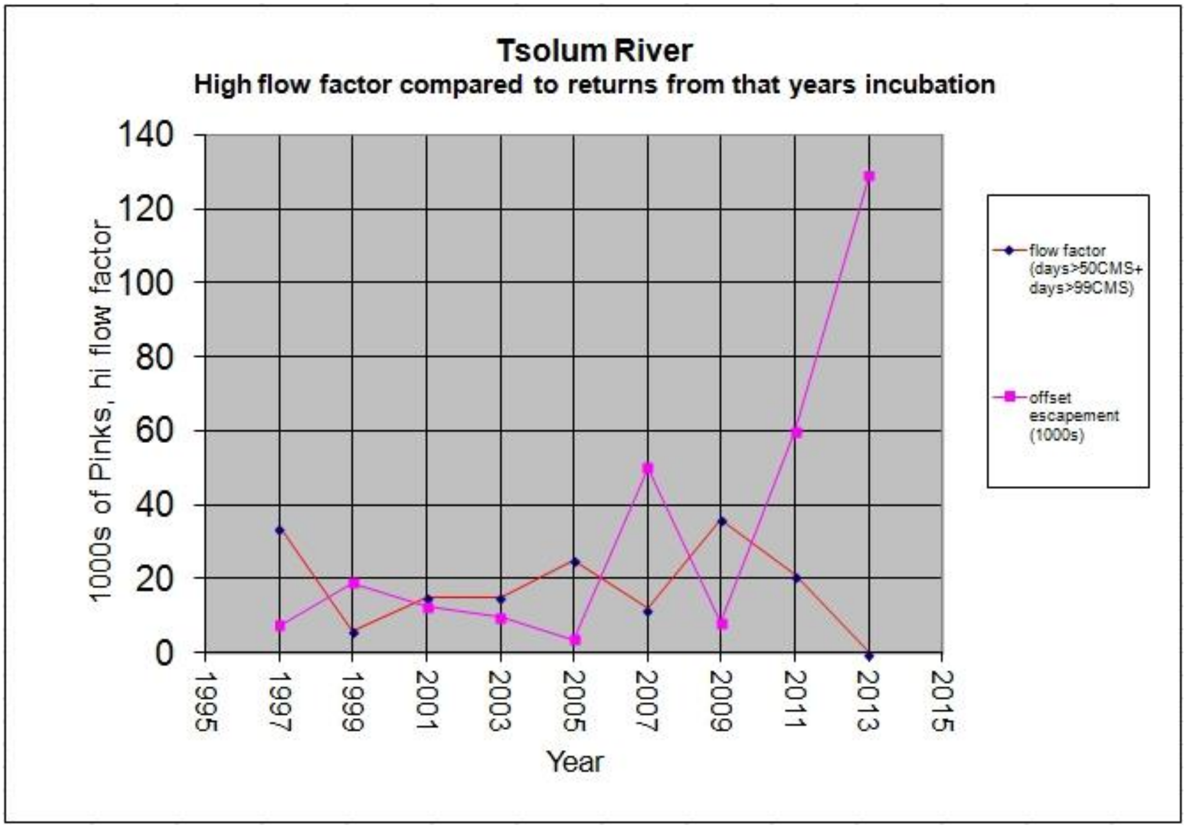

Figure 9 – High Flow Factor versus Pink Escapement Curve, 1997-2013

2.0 Habitat Restoration Objectives

2.1 Channel Restoration Assessment

Fifty years after the major breakdown of the channel structures of the mountainside tributaries, and forty years after the peak of the resulting bedload flush down the mountain and into the Tsolum mainstem, the majority of the river system (with the exception of new impacts to middle Dove Creek) is recovering. However, bedload from this flush is still moving through the system, and it will be several decades until pools are deeper, gravel spawning beds are relatively stable, and LWD is plentiful. Restoration efforts can reduce significantly the remaining period of recovery, and increase fisheries productivity.

While there are many sources of bedload in any dynamic river system, the mainstem Tsolum River can be divided into three main sections and associated major bedload flows, which influence the channel morphology through the mainstem.

2.1.1 Upper Tsolum River

Length from the Murex Creek confluence upstream to Blue Grouse Lake and includes Helldiver Lake, Lost (Twin) Lakes, and Regan Lake tributaries. All of the tributaries originate from the lower elevations of the divide to the Oyster River, from the Tsolum valley bottom up along the northeast shoulder of Mount Washington.

All tributaries have significant lakes which have acted as bedload traps for substrate flow from their upper basins. By the 1960s, weakened banks allowed bank erosion and created wider, shallower channels. This de-stabilized the boulder line structures in semi-confined reaches T14 to T16 and a large flush of boulder, cobble, and gravel moved down towards the valley bottom. Boulders from this flush have settled out in the top end of unconfined reach T13, which then have cobble and gravel as the gradient drops. Boulder deposition now appears to be fairly stable, with little downstream movement in high flows. Cobble continues to move through mid-reach T13, although slugs of it are being settled out by fallen alder cross channel LWD resulting in flow shifting to and enlarging old flood channels. This is also occurring to the gravel, as much of the gravel remnants of the original flush of bedload, with added material from still eroding banks upstream, is being captured in large bars around cross channel alder LWD, with beneficial local scour. Little excess bedload in recent years appears to be moving past the Helldiver confluence into reach T12, which has improved significantly to a near stable morphology, though lacking some pool depth and sufficient LWD.

These upper reaches, though remaining boulder lines are sparse, now appear stable, with some LWD from the successional stage alder that have begun to strengthen the banks and to erode into the system. All the above mainstem reaches have sections which are lacking in mature conifer regeneration. Trend is definitely improving. Riparian areas should be strengthened for the long term with conifer planting where needed. LWD is needed in reach T12.

2.1.2 Middle Tsolum River

The Middle Tsolum goes from the Murex Creek confluence down to the Dove Creek confluence, and includes the Murex, Constitution, and Headquarters tributaries.

This section of the Tsolum River mainstem begins with excess bed load entering the mainstem from Murex Creek, with its dominant influence gradually becoming less visible by the Headquarters Creek confluence. As in the upper Tsolum, a large flush of boulder, cobble, and gravel was released from the upper Murex Creek and tributaries in the 1960s from bank erosion and channel structure break-up. In the upper Murex, specifically above M3, slope failures along a ravine continued to input excess bedload through confined M3 into the lower unconfined reaches M2 and M1. As these failures have gradually stabilized, bedload moving downstream under the DBM to the Tsolum confluence has decreased significantly in the last decade. However, only the larger boulders at the top end of M2 appear stable in high flows, and some cobble continues to move as far as the Tsolum confluence, with little gravel in the bed upstream of the DBM. Murex is at an earlier stage of physical recovery than the upper Tsolum.

Log jams, not just single cross channel LWD, are required to capture cobble flow in the higher gradients of Murex. It will continue to improve unless the fragile recovering slope failures on upper Murex are disturbed. Spawning fish access into lower Murex and the upper Tsolum has improved significantly in the last decade. The gravel from the 1960s bedload flush, with subsequent bank erosion, has largely moved out of Murex and through the confined mainstem T11, to form large bars in unconfined reaches T10 and T9. This gravel will continue to feed downstream to move through what should be a major spawning reach T7, upstream of HQ, where gravel is very mobile. A major objective for recovery of the mainstem Tsolum, in order to reduce aggradation, bank erosion, and gravel mobility, and increase pool depths from T10 to the Puntledge, should be the stabilization/capture of the gravel bars in T9 and T10. Any short term LWD input opportunities, and planting of riparian conifers where needed to increase long term riparian strength and provide quality LWD input, would benefit fish habitat.

2.1.3 Lower Tsolum River

The lower Tsolum River is the section between the Dove Creek and Puntledge River confluences, including the Dove, Portuguese, and other small low elevation tributaries.

Excess bedload from the middle Tsolum and Dove Creek enters at the upstream end of this section of the Tsolum. This bedload, plus input from agricultural and residential bank erosion along the lower river, both have a dominant influence downstream to the Puntledge confluence. Dove Creek, like the upper Tsolum and Murex Creek, released a flush of bedload in the 1960s. Multiple slope failures along the ravine reach D7 below Anderson Lake continued to input bedload to Dove Creek for decades, decreasing as more of the failures stabilized. When assessed in 2009, and revisited in 2014, the reaches from DBM to the confluence were progressing well in their recovery, being rated as stable to partially aggraded though lacking in LWD. However, conditions observed in March 2015, after extreme peak flows in the previous winter, had deteriorated. A large slug of bedload, from accumulated and new material out of partially healed slope failures in ravine reach D7, (including a larger recent slide), has been deposited through reaches D6 and D5 down to Piercy Creek, overwhelming the recovering cascade-pools and creating heavy bank erosion and erosion of riparian trees, which are large enough to span the channel. Gravel bedload, moving ahead of the slug, is aggrading in reach D4 and D3, upstream and downstream of the Island Highway, also increasing bank erosion and dropping riparian trees.

The large gravel deposits in the Tsolum channel upstream of the Maple and Puntledge Campgrounds, and downstream of the Comox water pipeline crossing, appeared to be significantly backwatering flood flows in 2014, and creating a significant potential for a new channel to be cut through the Puntledge Campground to a new confluence with the Puntledge.

2.2 Potential Delays to Recovery

Today, there is often great public and private concern around issues of 'responsibility' and 'liability'. Appreciating this mood while remaining forward looking, we must not focus on the historic timber management practices and their effect on the Tsolum River. Any future land use effect must be examined from the forestry, local municipal and agricultural impacts and prescription responsibility as consistently as possible. The *BC Riparian Areas Regulation* (RAR), under the *Fish Protection Act,* can be applied to all new development. There is a distinct approach for agricultural lands under the *Farm Practices Protection (Right to Farm) Act;* however a RAR farm practices guide is being developed. Activities such as hydroelectric facilities and forestry activities are also not subject to RAR but are regulated by other provincial/federal legislation. Finally, Federal lands and First Nations reserve lands are also not exempt from the RAR. However, activities on reserve lands are still subject to the federal *Fisheries Act* and any negotiated local agreements with local government (Government of British Columbia, n.d.).

Upper Murex (between around 580 m to 800 m elevation) and Dove Creek D7 below Anderson Lake both have ravines where many slope failures, feeding directly into the stream, occurred in the decades following the first pass of logging. Many of these slope failures are in only the early stages of recovery, with very young alder re-growth. These slides are very easily re-triggered, as seen in recent activity on Dove Creek, and can set back tributary recovery by decades. Field assessments and cautious drainage design are recommended in cut block planning and layout in those locations.

Overland flooding in light of extreme weather events, watershed management and property protection along the lower Tsolum are equally important under both agricultural and CVRD land planning and watershed management. Vegetation management at four BC Hydro power line crossings has allowed bank erosion, shifting the thalweg and triggering further bank erosion downstream. Some discussion with BC Hydro should be initiated regarding guidance and partnership in riparian management activities.

While no single restoration project will address the larger overreaching physical morphology issues identified by Gooding (2015) due to scope and resource limitations; aspects of his thorough assessment are considered within each of the biophysical restoration priorities identified in the following sections.

2.3 Biological Restoration Assessment

Successful riparian recovery strategies would address the bed load problem by re-contouring the streambed. In order to achieve this, instream restoration of LWD is the most critical component. Restoration of up-slopes, roads and riparian zones diminish flood effects, cut off most sediment loads and strengthen stream banks leading to opportunities for recovery of instream LWD function. An aggraded thalweg is the legacy of upslope impacts. This is visually apparent in the lower alluvial and anadromous reaches. Additionally, bed loads result in the loss of pool-riffle complexity and much of the surface water may be transported as shallow glides (subsurface) through an impacted reach. Thus, recovery strategies should address the bed load problem to re-contour the streambed. In these circumstances, instream restoration of LWD is the most critical component.

Riparian restoration is necessary for ensuring a future source of LWD recruitment, as well as ensuring bank integrity, litter fall input, and shading. The riparian area is an important source of LWD and also has very high value for wildlife habitat. LWD is a keystone element in coastal low gradient streams, not only for hydraulic processes but also as habitat for fish, mammals, birds, amphibians and invertebrates. It offers cover, feeding, and protection from predators and access in the riparian zone.

Riparian restoration generally consists of silviculture treatments (gap and dispersed thinning) to accelerate the natural recovery process towards old growth attributes. Treatments are planned to enhance the development of old-growth attributes in the stand, e.g., by creating snags and gaps to enhance structural diversity, and may be carried out concurrently with instream restoration. The goal of riparian restoration is to accelerate the recovery of the riparian ecosystem.

2.4 Habitat Assessment Methodology

2.4.1 River and Fish Habitat Status Assessments

Both In-stream and Riparian habitat assessments was conducted using an assessment procedure developed by the Urban Salmonid Habitat Program (USHP). The survey methodology is described in detail in the *Vancouver Island Urban Salmonid Habitat Program (USHP) Assessment and Mapping Procedures Manual (*Michalski, et al., 2000). It was developed by the B.C. Ministry of Environment on Vancouver Island to guide watershed stewardship groups on a standard inventory process. Riparian restoration generally consists of silviculture treatments (gap and dispersed thinning) to accelerate the natural recovery process towards old growth attributes. Treatments are planned to enhance the development of old-growth attributes in the stand, e.g., by creating snags and gaps to enhance structural diversity, and may be carried out concurrently with instream restoration.

The survey method collects data on a number of in-stream parameters. In-stream cover includes in-stream vegetation, undercut banks, boulders and LWD, bankfull channel width, substrate (percentage of fines, gravels, cobbles, boulders, and bedrock), percentage of reach eroded and percentage of wetted area throughout the streams length. Riparian conditions such as plant community type, bank slope and depth were also sampled.

The USHP survey method collected this information at habitat units identified as pools (areas with residual depth) or riffles (exposed substrates at low flow and no residual depth). Due to the extensive waterway, with over 19km of identified reach segment length, 100% sampling of habitat was not feasible in the timeframe or budget for the current program. The target was to sample a minimum of 10 habitat units in each reach. Dave Clough, RPBio (Fisheries Resource Consultant) provided a summary of the assessment in his *Tsolum River Habitat Status Report* (Remillard & Clough, 2015), and *Tsolum River Fish Habitat Assessment Report* (FHAP) (Clough, 2015) documents.

2.4.2 Channel Morphology

Dave Gooding, P.Eng. (Gooding Hydrology) provided the reach segments based on hydraulic and riparian characteristics. The Tsolum River Overview Channel and Riparian Assessment (2013) used air photo analysis (2007 ortho-photos and 2011, 3D air-photo pairs of the watershed), a time-series air-photo analysis, and previous field observations during the fieldwork for the reconnaissance level channel assessment done as part of the biophysical report of 2010. The 2015, detailed channel morphology and bedload assessment was also based on observations during the low flow augmentation report completed in 2008, a canoe survey by the hydrologist and biologist of the mid and lower mainstem Tsolum (from Helldiver confluence to the Puntledge in June 2013), and a photo reconnaissance flight over the watershed in August 2013. Extensive walking of the tributaries was done in the spring of 2015 to determine the upper extent and source of impacts which had been observed in previous lower elevation assessment.

For channel morphology discussions through this report, the Tsolum River was divided into three main sections:

1. Upper Tsolum River, from the Murex Creek confluence upstream to Blue Grouse Lake, including the Helldiver Lake, Lost (Twin) Lakes, and Regan Lake tributaries. All of the tributaries originate from along the lower elevations of the divide to the Oyster River, from the Tsolum valley bottom up along the NE shoulder of Mount Washington, and all have significant lakes which have acted as bedload traps for substrate flow from their upper basins.
2. Middle Tsolum River, between the Murex Creek down to the Dove Creek confluences, including the Murex, Constitution, and Headquarters tributaries. This section of the Tsolum River mainstem begins with the excess bed load entering the mainstem from Murex Creek, with its dominant influence gradually become less visible by the Headquarters Creek confluence.
3. Lower Tsolum River, between the Dove Creek and Puntledge River confluences, including the Dove, Portuguese, and other small low elevation tributaries. The excess bedload from Dove Creek enters at the upstream end of this section of the Tsolum, and with bedload from agricultural and residential bank erosion is a dominant influence downstream to the Puntledge confluence.

In fall of 2015, the TRRS had a thalweg survey completed by D. Gooding and volunteers to access impacts to the channel morphology, whether from excess bedload, increases in peak flows, eroded banks or widened channels and whether the channel is aggraded or degraded, always result in a loss of pool depth and extent of deep residual depth. Thalwag depth frequency is a measure of depths along a single line down the deepest part of the stream (thalwag). At 14 sites, depths were measured through a series of at least three riffle-pool, cascade-pool, or step-pool cycles or units. Approximately 100 data points were gathered for each monitoring reach, between a fixed top and bottom of the reach. Distance between data points varied depending on the size of the stream, and the distance which 3 cycles covered e.g. on a large stream, distance between data points may be 3 to 5 m, while in a small creek the distance between points may be only 1 m.

2.4.3 GIS Mapping

Don Chamberlain (contract GIS Specialist), produced on-line maps for the watershed, including field survey data and photos to be used for planning purposes. The data was provided by the past community stream mapping inventories from Project Watershed, Tsolum River Restoration Society and Timber

West. The mapping tool can be accessed via the TRRS website link: www.tsolumriver.org/recovery-plan.html.

2.5 Reach Summaries

There were seven streams surveyed. The 29 reaches were the Tsolum mainstem (T1-T13), Portuguese Creek (T1-3, P5), Dove Creek (D1, D3, D5/D6), Headquarters Creek (H1 & H2), Murex Creek (M1-3), Constitution Creek (C1,C2) and Hell Diver Creek (HD1, HD2).

Reach T1 (0.0 -2.0km):

The 2032m long reach begins at the confluence with the Puntledge River upstream to the Dove Creek Road (Rees) bridge. This reach has been described as an unconfined, low gradient (<1%) channel with braided and historic channels. The dominant substrate types in this reach were gravel and sand. Gooding (2010) noted this reach was developed by 1938 noted limited base flows, bed loading causing poor access and incubation success within reach and the banks had been developed by agriculture/logging practices which left narrow riparian stripes. Campbell (2010) compiled a reach 1 description summary noting it is wide and shallow, lacking pools. The report identifies gravel accumulation of gravels and fines in the few pools that are present.

Reach T2 (2.0-3.3km):

This 1316m long reach extends from Rees Bridge upstream to the confluence with Portuguese Creek. It is similar in habitat to reach T1. Gooding (2010) noted this reach was developed by 1938 with the banks cleared by agriculture/logging practices which left narrow riparian stripes. Gooding (2010) noted limited base flows and bed loading causing poor access and incubation success within reach.

Reach T3 (3.3-4.3km):

This 941m long reach is similar to the lower two reaches which ends at Chillie Creek confluence. Gooding, (2010) noted that this reach has suffered from bank erosion and was significantly wider than the lower reaches. Campbell 2010 noted low summer flows, poor adult holding, inadequate pool frequency and poor spawning substrates being limited in this reach.

Reach T4 (4.3-6.6km):

A wider less confined segment that runs from Chillie Creek confluence upstream approximately 1445m where the channel becomes confined again. Clough (2014) identified that this reach with a maximum channel width of 8.4m. It is similar to the lower reaches as it is sensitive to low flow and limiting in refuge and cover habitat.

Reach T5 (6.6-13.5km):

This nearly 7km reach end at the Dove Creek confluence. It has an average gradient of 2.1%. The channel is frequently confined characterized by a change to a narrower valley and steeper bank slope and according to Gooding (2010) has received significant volumes of sediment.

Reach T6 (13.5-17.8km):

This 4.3km long reach ends at Headquarters Creek confluence. It features Farnham Road Bridge and the channel has an average of 2.9% gradient. It has average channel width 15m. Gooding (2010) noted an area of heavy deposition near the top of the reach and changes of an increase in average width.

Reach T7 (17.8-19.7):

This reach extends from Headquarters Creek to above the inland highway crossing; the 1.9km long reach has an average gradient of 3.7%.

Reach T8 (19.7–23.6km):

This reach ends at Constitution Creek confluence and located nearly entirely on private forestry lands. It is noted by Gooding (2010) to have areas of deposition on 2.6% average gradient.

Reach T9 (23.6–25.3km)

This reach is 1.66km long on a 3.3% gradient extending from Constitution confluence upstream to what is locally known as the canyon. Gooding (2010) described this reach as moderately to severely aggrading and observed significant channel shifting from 1938 to present. Google Earth shows unstable log jams within this reach.

Reach T10:

This well confined forested reach ends at the Murex Creek confluence. It is 1.09km long and has an average gradient of 7.0%. Gooding (2010) identified the upper most portion of this reach as moderately to severely aggrading from the heavy bed loading from Murex Creek.

Reach T11:

Running between Murex and Helldivers Creeks this reach features a forestry road crossing. This reach is 1.19km long with an average gradient of 2.5%. Gooding (2010) described this reach as moderately to severe aggrading. This reach is actively logged.

Reach T12:

The upper most anadromous reach running from Murex Creek to the gradient break located at approximately 142m elevation. This reach is 1.65km long on a 5.4% gradient. Gooding (2010) described this reach as moderately to severely aggrading and observed significant channel morphology changes from 1938 to present.

Headwater Reaches T13- T16:

Not high value salmon reaches with a potential barrier at the top of Reach 12. These reaches are still important to downstream accessible salmon habitat as described in Gooding (2010 & 2013).

Portuguese Creek P1-P5:

Portuguese Creek is the most significant lowest tributary enters on river left bank at the reach 1 reach 2 break. It flows through the original farm lands of Merville which were cleared during the first European settlements. Campbell (2010) and Gooding (2010) reported that this watershed was nearly completely developed by 1937. The agricultural development included the channelization of streams and draining and wetlands. Campbell (2010) documented it as a seasonal channel with a few artificially created ponds. Clough (2014) reported 5 anadromous reaches over 11km during his survey with excellent Coho spawning habitat throughout the lowest portion. However, the stream is typically dry until the fall rains which limits adult migration access for pink and chum.

Dove Creek D1-D6:
Dove Creek offers an anadromous length of 10,895m. Clough (2014) reported on six anadromous reaches (D1-D6). The mainstem Dove Creek is over 20km long and has Anderson Lake in the headwaters below Mt. Washington. A large slug of gravel has been identified in the upper Dove Creek (Gooding, 2014). In 2014, Clough surveyed three reaches D1, D3 and D6 and found during late summer the flow is a trickle with few perennial pools. The accessible reaches offer spawning areas for Pink and Coho salmon. Removal of bedload by means of bedload traps should be considered, before this long slug of material moves further downstream.

Headquarters Creek H1, H2:
Headquarters Creek is anadromous from the Tsolum River up past the Hatchery through to just above the Island Highway (4024m). It drains from Wolf Lake approximately 2.2 km further upstream that has resident trout. The lower reaches offer adequate rearing pools and spawning areas for pink salmon and Coho but there is limited riparian canopy within Hydro right of way (Clough, 2015).

Murex Creek M1-M3:
Murex Creek is anadromous from the Tsolum River up under the Duncan Bay Mainline (DBM) to Triple Falls after a distance of 4073m. It drains from Wolf Lake approximately 2.2 km further upstream that has resident trout. This tributary offers limited high value habitats due to lack of deep pools, cover and limited spawning habitat associated with the channel aggradation described by Gooding (2010).

Constitution Creek C1, C2:
The creek originates above the DMB and drains around the north side of Wolf Mountain and enters the upper Tsolum downstream of Murex Creek. Reach C1 goes 419m from the Tsolum upstream to the top of a long wetland. This wetland offers winter off channel habitat. However, numerous beaver dams were observed by Clough (2014) that may impair access/exit to the refuge areas.

Helldiver Creek H1, H2:
Hell Diver Creek originates from the north side of the Tsolum Watershed and drains down a long flat bench over a bedrock escarpment and into the Tsolum River above the Murex Creek confluence. This waterway is a series of interconnected waterbodies (wetlands and lakes) which offers high value rearing habitats (Gooding, 2013) however, access may be limited based on a low rock waterfall downstream of the lake that may create a passage blockage into the lake and its wetlands (Gooding, 2014).

2.6 Stock Assessment

2.6.1 Out-Migration Counts
One method of counting juvenile salmonids and other small fish is the use of a rotary screw trap (RST) (Figure 10). RSTs are used to take a subsample of the fry and smolt population on rivers that are too large to use a full-spanning fence. The traps consist of a large metal cone kept afloat by pontoons

attached on either side. The cone is situated in the river such that the narrow end points downstream. Inside the cone are a series of angled baffles that spiral down the central shaft and cause the cone to rotate in the current of the river. As the cone rotates fish enter the trap and are guided into a holding box located at the downstream end. DFO contributes to maintenance costs of the TRRS owned RST. TRRS members and volunteers identify, count, measure and release the trapped fish each day. The TRRS RST is placed in the Tsolum River at T3 – Stephens Rd. from late March through early June.

Because RSTs only take a subsample of the total population, it is important to know what percent of the population the subsample represents. In order to estimate this, mark/recapture studies are commonly performed while the trap is running. A known number of fish are marked by colour dye and released upstream of the trap, and the number of marked fish subsequently caught downstream by the RST is recorded. The ratio of recaptured fish to number of individuals marked indicates the trap efficiency. Using the trap efficiency and the number of fish caught by the RST fishing days all can be expanded and a total population estimate can be made.

Figure 10 – RST at Reach T3 - Tsolum River 2015. Photo credit A. Spooner, 2015.

A common and effective method utilized for smolt enumeration is the full-spanning fence. A full-spanning fence is essentially a V-shaped weir that points downstream and funnels fish into a holding box where they can be identified, counted, measured, and released each day. The “V” is constructed with panels made of a 4’ x 8’ wood frame panel covered in hardware cloth. The size of the hardware cloth is such that water and most fry are able to pass through, but the smolts cannot pass though and are funnelled into a tube at the base of the “V”. Once the smolts enter the tube they travel downstream to a holding box for counting.

Full-spanning fences are desirable because they count every fish that migrates downstream. 2015 was the first year that the TRRS and it was found to be successful in terms of effort, volunteer resources and counting techniques (Figure 11). The TRRS reinstalled the fence on Portuguese Creek again in 2016 and added a second fence on Finlay Creek. After 4-5 years, the fences will be moved to other tributary locations in order to get a better understanding of smolt use in more creeks in the system. It is also possible to mark the smolts caught in the fence by caudal cut prior to release in order to get a better idea of RST count efficiency and proportion of smolts (expansion factor) that enter the mainstem versus staying in the tributaries.

Figure 11 – Fish Fence Reach P1 – Portuguese Creek 2015. Photo credit S. Marcoux, 2015.

Gee traps (Figure 12) are used to sample fish use in the river and off channel habitats such as wetlands and side channels. They are a small basket trap that are baited with salmon roe and allowed to soak overnight to establish the fish use of different habitat features. The TRRS often uses these traps in their fry salvage efforts in low flow periods.

Figure 12 – Gee Trap in a Stream (www.byrnecreek.org)

2.6.2 Spawner Counts

For the past number of years, the TRRS volunteers have conducted river walks and swims to enumerate the pink salmon spawning run return. The methods are derived from the Streamkeepers Module 12, spawner survey and DFO Stream Inspection Logs (SIL) method of bank and stream walks and pool swims. The method was adapted in that the fish counters walk downstream counting fish moving upstream as they are encountered and observed. The information gathered can then fit directly into both Federal and Provincial stream information databases as well as into the DFO/Streamkeepers Data Entry Tool.

The Tsolum mainstem is divided into survey segments that should take a team of 3-4 volunteers (one swimmer) no more than 4 hours to complete. All segment surveys are started at the same time on one day so a total number of fish (holding, spawning and dead) can be enumerated. In 2015, there was a record number of non-hatchery raised fish returning, so Dove and Headquarters Creeks were also counted. Counts are repeated weekly from a time when the fish have entered the river until after the fish have stopped entering the river. Some weeks, counts are not possible due to rain and murky water. Counts are also stopped if the water levels rise due to rain, making it unsafe for the volunteers. Other information is recorded as well including, other salmonid species, predator and scavenger activity, food insects and other interesting observations.

In certain reaches or extents of the watershed, walking counts are not feasible. In these cases, estimates were used by doing density counts at specific locations and then multiplying that number based on the length of suitable biological and physical habitat (pools, run, spawning riffles) as assessed and reported by Clough (2015) and Gooding (2015) in the FHAP and Channel Morphology Reports.

3.0 Watershed Targets and Strategies

Based on Gooding & Chambers 2013 *Tsolum River Overview Assessment* and Gooding's 2010 *Tsolum River Biophysical Assessment and Hydrology Channel Assessment*, reach segments were identified on a GIS base map (Chamberlain, 2014) for the 2015 *FHAP* (Clough) and the 2015 *Tsolum River Channel Morphology and Bedload Assessment* (Gooding). The 29 reaches were: Tsolum mainstem (T1-T13), Portuguese Creek (P1, P3, P5), Dove Creek (D1, D3, D6), Headquarters Creek (H1, H2), Murex Creek (M1-M3), Constitution Creek (C1, C2) and Hell Diver Creek (HD1, HD2).

The assessments and recommendations in the 2015 FHAP (Clough), 2015 *Tsolum River Watershed Habitat Restoration Planning* (Clough) and 2010 *Reconnaissance Channel Assessment* (Gooding), 2013 *Tsolum River Overview Assessment* (Gooding & Chambers)and 2015 *Tsolum River Channel Morphology and Bedload Assessment*, were all considered collectively at the February 2015 TRRS Technical Committee meeting. At a subsequent March 2015 meeting, TRRS Technical Committee representatives, together with Clough and Gooding, developed an initial list of priority sites and reaches to re-visit for focused assessments, and for completion of detailed channel and bedload assessment. From this assessment document (*Tsolum River Watershed Habitat Restoration Planning* (Clough, 2015)), and all other documents, recommendations were made for a final priority list and initial prescriptions detailed in this Recovery Plan. The various restoration and monitoring projects recommended in the Recovery Plan will establish a Strategic Action Plan for the Tsolum River Restoration Society and its partners in the Tsolum River Partnership.

3.1 Function and Habitat Restoration Priorities for Recovery Plans

The following list is a summary of the function and habitat restoration priorities for Recovery Plan from the implementation plan projects in this report. These are listed in geographical order from upstream to downstream, and process and habitat based – not in order of priority.

- Newbury weir or other cross channel gravel stabilization weirs would increase successful incubation in the mobile gravel in reach T12 around the Helldiver confluence (upstream of DBM bridge) and upstream of the Headquarters confluence in lower reach T7. Reach T7 is narrow enough that multiple partially buried (notched) logs could be considered.
- The historic logging impacts on the river morphology are such that even with current sediment sources stabilized and mitigated through good partnership and stewardship practices, there is significant stockpiled sediment in the channel still available for transport and deposition in the lower river (Gooding 2010). Stabilization through bar planting of the large high gravel bars in reaches T9 and T10, which contain a massive amount of gravel which can be mobilized in flood flows. Riparian planting and LWD placement will further enhance these reaches.
- Mitigation of impacts of further movement downstream of the large new bedload slug currently massed mainly in Dove Creek's D5 and D6, and its related bank erosion through gravel traps and bar planting. Short term plans includes an emphasis on gravel bar staking and potentially, constructing a gravel trap.

- Impacts increase the priority of the proposed bank protection project at the Hydro crossing of Dove Creek, in reach D3.
- Dove Creek D1 bank stabilization with high benefits to pools and spawning gravels and enhancement of fish habitat and cover, including riparian areas.
- Various bank erosion sites in the lower floodplain reaches T1 to T4 have varying levels of priority. Highest priority would be the long eroding banks along the fields in reach T4, with associated bar planting/stabilization after the erosion is dealt with. Next would be the erosion along a couple of smaller sites in lower T4 and T3.
- Portuguese Creek P1, rehabilitate spawning gravel conditions and secure perennial winter flood refuge pools and P2 bank stabilization.
- Removal of gravel from the large bar and use bar planting to stabilize: upstream of the Puntledge and Maple Pool campgrounds in T1.

Process

- More hydrological information is needed on groundwater and surface water to understand specific flow requirements and the watershed's vulnerability to climate change. Continued hydrological assessments in the mid to upper reaches have been contracted as part of the Tsolum River Assessment Strategy.

- Nearly the Entire system is lacking in LWD, from a combination of first-pass riparian logging, farm and residential historic riparian clearing, and historic log-driving which would have cleared any cross channel LWD. Any project which installs or retains LWD would benefit the stream system.
- Riparian prescription for the entire system with site specific process focus.

Habitat

- Riparian prescription for the entire system with site specific habitat focus.
- Side channels are an effective tool in habitat restoration for many species of fish. There are only two documented side channels within the Tsolum River (State of the Tsolum Report). Expansion of these channels and creation of new ones would provide a valuable much needed limited habitat.
- Stable instream fish habitat in the mainstem is significantly lacking and needed (Campbell, 2010 & Clough, 2015). However, over the years this has been addressed in several applications but is expensive to install and requires maintenance (Gooding, 2010 & Clough, 2015).
- Instream fish habitat in tributaries addresses similar issues of LWD, bank stabilization and off channel habitat (State of the Tsolum).
- Up to date fish habitat information is needed for areas not surveyed on the mainstem and many tributaries. Critical rearing habitat must be measured and monitored using a comparable habitat assessment methodology (i.e. USHP/RIC) to provide an overall habitat status that provides direction on management.

3.2 Impacts and Achievements

This report considers most of the past and present impacts and the recovery activities on the Tsolum River since the mid 1980's. Most of the TRRS project activities have been in response to past or current impacts, however many of these impacts have not yet been addressed. The various TRRS assessment reports previously mentioned have identified the remaining significant challenges. The following is a short summary of achievements to date:

- Perhaps the most important positive action in the recent history of the watershed is the successful capping and water treatment of the Mt Washington mine site.
- Several bank stabilization / habitat enhancement projects as well as spawning bed habitat restoration on Headquarters Creek.
- Riparian tree planting is ongoing primarily associated with individual restoration projects. A full prescription is recommended.
- Bank stabilization with scour pool and LWD enhancement at the Babcock site in reach T1.
- Full trees spanning river were swung and anchored to protect bank and offer refuge and scour pool development while preventing risk to property and assets from flooding in reach T1.
- There is significant low flow in summer months and while this is still a concern, it has been improved considerably with water releases from Wolf Lake (Gooding 2007).

4.0 Uncertainties and Information Needs

4.1 Changing Climate Conditions

This section serves only to highlight the dynamic nature of the conditions we will be facing in the future. Specific to the Tsolum River Recovery Plan, there is the need to consider priority projects from a forward looking viewpoint. Consideration should be given to monitoring changes and recovery planning in the face of unknown effects. It is certain that there will be unknown changes that could include: increased in-season and/or annual precipitation variability, increased storm and flow runoff intensities, shifts in annual and seasonal precipitation, reduced snowpack, increased seasonal temperatures and length of warming season, reduced or extended base flow periods, and shifts in seasonal hydrological response flows. These are all factors that can affect fish species, particularly salmonids due to their complex life cycles.

The following is simply a projection of possible future changes in the local environment and was taken from the University of Victoria's Pacific Climate Impacts Consortium Website publication for the West Coast Region of BC (n.d.).

> *Climate models project warming throughout the 21st century for all seasons that is large compared to historical variability. Projected warming is quite uniform across the seasons, with an annual warming of 1.4 °C (0.8 °C to 2.2 °C) by the 2050s and 2.3 °C (1.2 °C to 3.5 °C) by the 2080s. Projected precipitation changes are relatively modest*

> *compared to historical variability, By the 2080s the median projection indicates an increase of about 10 %, relative to the 1961-1990 baseline, in all seasons but summer when a 10 % decrease is projected.*

By the 2050s, there are substantial projected decreases in spring snowfall and a decrease in heating degree days (an energy measure of days that require heating our homes above ambient temperatures). Along with these changes, an increase in frost-free days and growing degree days (measure of heat accumulation used by horticulturists, gardeners, and farmers to predict plant and animal development rates) is indicated. Warming will decrease snowpack. Increases to high intensity precipitation and seasonal moisture variability could affect ecosystems and disturbance regimes. A seasonal increase in hot and dry conditions could decrease water supply and lake productivity, and affect inland fisheries. Both river flooding and ocean storm surge events may increase in frequency and magnitude; stream bank erosion and strain on flood protection infrastructure may increase. Storm water design standards may no longer be adequate and seasonal water quality may be reduced. There could be a transition to rainfall-dominant watersheds, causing an increased need for water conservation and storage.

Extreme weather events associated with climate change can suddenly 'take out' recovery projects or condition gains in a single event or season. Events such as these can therefore hamper or impact recovery of pink salmon, riparian habitat and streambed restoration efforts. Planning for and mitigating such events are a challenge but perhaps is the new reality. Therefore, recovery plans need to be flexible and adapt to these events and changes.

4.2 Stock Condition

A current summary of surveys and trapping efforts, and a comprehensive review of fish stocks for each salmonid species are needed, specifically adult; coho, chum, and steelhead and steelhead parr / cutthroat trout counts. Adding multiple fish count swims of the reaches is an option, although fall and winter higher water levels are a concern that must be considered. Adult steelhead and Redd counts may be more achievable in April by volunteers using a boat in mainstem habitats as an effective tool to access presence/absence and get a sense of relative reach abundance.

Juvenile stock assessment efforts with the RST and fish fence are effective methods, however additional information could be attained through future stock assessment of summer coho fry density through pole seine studies. As mentioned previously, the fish fences can be moved to assess different tributaries in future years. In all fry handling, consideration must be given to value of the results weighed against the handling stress placed on the fish. Recognizing the limitations DFO has on their resources; it should be reviewed to determine if the capacity of the TRRS in undertaking the burden of stock assessment perennially is realistic.

It has been recommended that a survey of the headwaters of Helldiver and Constitution wetlands should be completed in order to get a sense of abundance and presence / absence of fish at all life stages in these important refuge habitats. Refuges are critical to the survivability of resident fish and salmonid fry and smolts as they provide habitat during months with low water levels and high water temperature conditions experienced by in the mainstem and tributaries.

A performance review of restoration activities is needed. The performance review should focus on stock condition, productivity and spawning/rearing success. A single library of information on fish habitat restoration and enhancement for this watershed is needed. An interactive web based file using an application such as Google Earth or Dropbox could permit partners to contribute their project location information to the TRRS. The TRRS has also developed a mapping tool that could catalogue this sort of information. The TRP has agreed that all reports on the Tsolum should be housed on EcoCat, a provincial government searchable database.

4.3 Marine Survival

Since the 1990s, low marine survival is possibly one of the most important factors affecting returns for all anadromous species. Not all the reasons are clear why. However, there is now an understanding of the role and effects the different cyclic patterns can play, based on pacific oscillation, climate and productivity, for each species. In the meantime, rehabilitating and protecting anadromous systems such as the Tsolum River will offer the best spawning opportunity for the returning stocks and optimum freshwater rearing conditions to support more robust, larger smolts for marine entry. While the focus of this Recovery Plan is the Tsolum River, which is freshwater, it is worth mentioning that associated recovery efforts in the marine nearshore environment are also key and for this reason the TRRS is a member of the K’ómoks Estuary Working Group.

4.4 Influence of Fisheries

The Tsolum River is, at the time of writing, not open to fishing for recovering stock protection. Stock aggregate data information assessments regarding the marine fisheries status that impact the Tsolum River salmonid population are needed. In the future, DNA analysis may provide better understanding of the impact of marine fishing; this fishery information would include commercial, sport and First Nation traditional harvesting. The TRRS may consider using stock aggregate data from Black Creek as a surrogate index for the Tsolum River.

4.5 Stewardship and Education

Ongoing stewardship and education activities for TRRS are a priority. However, public opportunities have historically, not been well attended. The Outreach group of the TRRS has been working hard at bringing a higher profile to the TRRS and the Tsolum Watershed as a whole. Traditional activities are ongoing (open AGM, booths at public events, school education programs, hosted river walks, etc.) while also seeking alternative means of engaging the community in awareness and Recovery Planning. The summer intern has completed an interactive, scale model that shows water flow of the river. The TRRS outreach group has coordinated with other Not-for-Profit groups for a fall volunteer appreciation dinner and media releases have been submitted regularly on various topics resulting in both television and radio interviews locally and with the major networks.

Recently the TRRS website has been updated and links to all assessment documents and this plan will be available. On the website, there is also a link to the new mapping tool which allows users to view the Tsolum River Watershed, the FHAP and thalweg sections and the associated data. Photos are also linked to the map, and restoration projects are documented on it. This year, the use of social media has been revitalised and is being kept current, showing not only ongoing activities and photos but also links to other watershed and salmonid recovery success and related current media issues.

4.6 Responding to Unplanned Natural Events

Unplanned natural events have the potential to have different consequences on the river; possibly benign, a nuisance, a concern, or a hazard. However, these events can also become an enhancement feature or improve the function of the river depending on the response plan. Actions such as the following example situation demonstrate how trees that may have dammed the river, flooding property, has become an improved biological and physical feature in the watershed.

As a result of the unprecedented 2014 floods and a subsequent high wind event, several large trees fell across the Tsolum River in the bottom reach in spring of 2015. These trees are spanning the river near agriculture and private land, a K'ómoks Reserve land campground, BC Hydro line crossings and the main Comox water supply pipe crossing. While, events such as these are deemed a natural event and do enhance watershed habitat by providing LWD and cover, the location potentially put assets and property at risk. A multi-partner response between the TRRS, the CVRD, BC Hydro, the K'ómoks First Nation and the landowner quickly came together and a response strategy and plan for mitigating the very serious risk of these trees damming the river and causing overland flooding was developed. DFO provided guidance and feedback on the plan, which was developed by a contracted Hydrology Engineer. The plan will keep the majority of the downed trees in the river but pivoted towards the bank so river flow is not impaired.

A response such as this should be considered a template towards similar future events, based on our best understanding. The preferred functioning condition of the river is naturally variable and process complex.

4.7 Future Development

The TRRS will work with partners, including the CVRD, to monitoring watershed/land use development as a means to assess/interpret future channel conditions, channel and biological response. The population of the CVRD is predicted to increase steadily into the future, making this a key pressure indicator relative to river health and fish stocks.

5.0 Recovery Plan Objectives

5.1 Riparian Restoration Work Plan

Riparian restoration cannot proceed far without buy in and permission from the various stakeholders in the watershed. Timberwest, private landowners, BC Hydro, the K'ómoks First Nation, and the CVRD all have a vested interest and will have the opportunity for feedback into the Recovery Plan before finalization of the priorities and projects set out in this plan.

The riparian reserve zone and riparian management is assumed (and recommended) in this report to follow the BC provincial riparian assessment and prescription procedures (RAPP) techniques to restore aquatic and terrestrial functions of the riparian zone as well as the Forest Practices Code (FPC) Guidelines for recommended riparian width. That is, under the FPC classification the Tsolum River falls within the S2 stream classification (>5 m < 20 m bank full width), which requires a minimum of a 30 m riparian reserve zone (RRZ), and an additional 20 m management zone.

When implementing the prioritized projects (Table 2) the following forest harvest management practices for riparian management are recommended:

- Follow the Riparian Management Area Guidebook from the FPC
- Minimum 30 m Riparian Reserve Zones on all S2 and S3 streams
- Low and medium bench flood plains should not be considered for harvest even if they are outside the 30m RRZ
- Assume fish bearing status on all streams (i.e. all streams > 1.5 m should have an RRZ)
- Careful consideration should be made for possible sediment sources on headwater streams when planning active Riparian Reserve Zones.
- Riparian Zones for all sizes of streams, channels and drainages should reflect consideration for natural channel processes and function including downstream transport of sediments.

Priority order of riparian objectives will however, also depend on coordination with in-stream restoration activities. A major consideration is that riparian land is primarily in private ownership so developing education programs and building on established relationships is imperative. The TRRS has access to donated tree plugs and has made them available to private landowners as well as included planting in all restoration projects to date. Impacts on the riparian also need to consider the upslope water and land use. Land use and development can also have far reaching negative effects on a watershed if not planned properly including, blow downs, erosion, water flow diversion and runoff impacts.

5.2 In-Stream Restoration Work Plan

In-stream restoration cannot proceed without buy in and permission from the various stakeholders in the watershed. Fisheries and Oceans Canada's (DFO's) Request for Review process for projects near water under the *Fisheries Act*, and BC's Ministry of Forests, Lands, and Natural Resource Operations

Approval Application or Notification for Changes In and About a Stream under Section 9 of the *Water Act* and part 7 of the *Water Regulation* must be followed. Approvals should be obtained before proceeding with any in-stream restoration project. Timberwest, private landowners, BC Hydro, the K'ómoks First Nation, and the CVRD all have a vested interest and will have the opportunity for feedback into the Recovery Plan before implementation of projects set out in this plan.

All in-stream restoration work should be conducted in the stated operating window (July – September, depending on the salmonid species) as laid out under DFO's conditions found under www.env.gov.bc.ca/wsd/water_rights/cabinet/working_around_water.pdf and specified by the Ministry of Environment Habitat Officer for Vancouver Island. This time span presents the least risk of harm to fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed.

In-stream restoration work often cannot be successfully treated in isolation from the upslope processes they are connected to. Restoration projects should consider the whole watershed scale, generally proceeding sequentially from hillslopes to riparian areas to the stream channel (Johnston and Moore, 1995). Unless there can be exceptions, where channel instability is evident or at risk, also as in many of the objective priorities identified in this Recovery Plan, fisheries mitigation activities can often be implemented simultaneously with hillslope activities.

The operational principles in sequencing stream rehabilitation are:

1. As a general principle, undertake riparian stabilization first, but not exclusively;
2. Examine the biological need for off-channel mitigation before or simultaneously with riparian work to maintain or salvage fish stocks at risk from destabilized channels;
3. As a priority, focus restoration on sub-watersheds that are less highly impacted to ensure more rapid recovery and watershed-level benefits to fish stocks; and
4. Emulate nature by use of natural templates or analogues within undisturbed reaches of streams as the key to successful stream restoration strategy (Slaney and Zaldokas, 1997).

6.0 Monitoring and Evaluation of Recovery Plan

Proper design and implementation of monitoring is a prerequisite to determining the success or failure of watershed recovery. There has been a feedback and technical recommendation identifying a need to monitor and record all instream restoration sites on one shared record to assess for performance and maintenance (Clough, 2015). The TRRS will now use a modified version of Routine Effectiveness Evaluation Forms (BC Ministry of Environment, 2003) as a means of assessing projects and informing a strategy to achieve results which will be used to inform the public and agencies about the state of recovery of the Tsolum River. Geo-referenced photo points will be established at past and future project sites. Projects will be reported on via our developed TRRP Priority Projects map on our website (www.tsolumriver.org). This approach will provide further direction on the best monitoring strategy to follow as described in this Plan. With successes, Recovery Plan targets will adapt and change in response.

Monitoring and evaluation of the recovery of Tsolum River watershed and its salmonid populations will consist of:

- Recovery Stock Monitoring
- Thalweg Depth Monitoring
- Project / Activity Effectiveness Monitoring
- Water Quality Monitoring
- Water Flow Monitoring
- Watershed Recovery Evaluation
- Land Use monitoring
- Indices of Level of Response Evaluation

6.1 Recovery Stocks Monitoring

Once stock assessments are well in hand through RST, fish fence, gee traps, spawner counts, fry density monitoring and other survey methods, the stock levels will be used to formulate species specific target abundance goals using habitat based production capability models. Steelhead / rainbow trout redd surveys may be best achieved using volunteers to swim and boat the river. Now that the in-migration runs are rebounding, it is important to track habitat restoration efforts as a measurable improvement in spawning returns – as an indicator of survival of fry and parr. More information on marine survivability would also be valuable.

All past escapement and past stock survey data that has been gathered should be included / entered into the TRRS GIS database. This information is also available through government databases but is not always readily accessible. Once the baseline data on juvenile use of the numerous wetlands and riffles has been collected, effectiveness of restoration projects may be better assessed. Future and long-term monitoring decisions will be based on all known baseline data.

6.2 Thalweg Depth Monitoring

Impacts to the channel morphology, whether from excess bedload, increases in peak flows, eroded banks or widened channels and whether the channel is aggraded or degraded, always result in a loss of pool depth and extent of deep residual depth. A healthy channel, with a strong riparian, banks and a balanced bedload, will have deeper larger pools. Various assessment methods have used pool area, or estimated volume, however area misses out the factor of depth, and volume is difficult to repeat for different estimators and varied water levels. Therefore, the TRRS adopted the thalweg assessment method that D. Gooding developed as described previously. The data analysis was not yet complete at the time of this writing.

Now that these thalweg monitoring reaches are established, it is very easy for a volunteer to repeat the measurement process. If water levels are different than in previous measurements, it is still possible to compare sets of data, as the data will only differ by a simple offset, rather than by a square or cube, as is the case with area or volume.

Once monitoring data is gathered it can be compared to the baseline measurements of 2015, as well as the other monitoring runs. This may be done in a couple of ways; a profile of the stream bed can be drawn from the data directly, and compared to previous profiles, or the data can be graphed as a depth-frequency curve, the shape of which will vary as pool habitat either improves in depth and extent, or worsens.

6.3 Project / Activity Effectiveness Monitoring

Effectiveness monitoring in the Tsolum will involve two types or levels of monitoring: routine and intensive. A Monitoring Plan will be developed from the TRRP. Monitoring of restoration projects / activities main objectives are:

- Assess whether the works are functioning as intended using response indicators;
- Determine if remedial work is needed; and
- Identify specific areas which may warrant more detailed monitoring or specific investigation.

There are three types of monitoring needed:

1. Local performance monitoring of constructed in-stream works such as weirs and bank protection.
2. Riparian monitoring: there is still the need for baseline data, however as plantings occur, they will need local monitoring and care.
3. Overall habitat restoration trend monitoring in reaches of the Tsolum:
    - Monitoring quality of fish habitat in selected sample reaches. Using FHAP results as a baseline, habitat quality can be monitored by repeating measurements of selected FHAP parameters.
    - Monitoring channel morphology and bedload condition, using thalwag depth measurements as baseline data, the channel condition can be also monitored by repeat measurements.

6.4 Water Quality Monitoring

As noted in the B.C Ministry of Environment Water Allocation Plan (Riddell & Bryden,1996) the Tsolum River dries significantly in summer which then results in a critical period for surface run off contamination occurring with the first rains after the dry period. The heavy water flows of the winter result in significant re-allocation of all substrate materials and sediment input from eroding banks throughout.

The TRRS has monitored a site in the mainstem Tsolum River 500 metres below Murex Creek under a contract to Environment Canada. A broad range of water quality parameters are measured every two week, including field measurements of water temperature, dissolved oxygen and air temperature. This site was established to monitor the impact of the old copper mine on Mt. Washington.

The BC Ministry of Environment established new Water Quality Objectives for the Tsolum River Watershed in 2012 which monitored five sites along the Tsolum River and set objective for a wide variety of water quality parameters. The TRRS has been in discussion with Ministry of Environment and Environment Canada to move the sample location for the contracted biweekly sampling to the lowest site included in the Objectives, Tsolum River near Courtenay (at Rees bridge) which captures the entire watershed. The change in the regular sampling location would allow assessment of most water quality indicators for the watershed. The Ministry of Environment's policy was to assess the river in relation to their objectives every five years so the full watershed sampling should be due in 2016.

6.5 Water Flow Monitoring

In 2007 Gooding described the natural un-augmented hydrology of the Tsolum as less than 5% of maximum annual discharge (MAD) and had been observed at 1% of MAD (Figure 13). The reservoir at Wolf Lake has a summer release with the goal of providing at least 10% MAD in the lower 18 km of the Tsolum mainstem during the low flow periods. The current augmentation is designed from August 15 to September 30 and is released from Wolf Lake as required to provide 30 to 35cfs downstream at WSC gauge 08HB011. The Wolf Lake weir releases water into Headquarters Creek over the summer to augment low lows and is run by the Puntledge Hatchery (DFO) according to a rule curve decided by a committee that includes the TRRS. Gooding (2007) has described additional water storage options but these are likely too costly or not feasible due to other environmental impacts.

The TRRS flow monitoring is largely a low flow program as safety concerns preclude work in winter months. Our measurement sites are the mainstem just below the Dove Creek confluence (in its third year); and on Portuguese Creek (one year of results). The actual measurements are done by our trained volunteers. We hope to open a third station in 2016. This study allows us to monitor flows in more detail and to assess the effects of climate change, land use, extraction, etc. in specific reaches. This is a long term program.

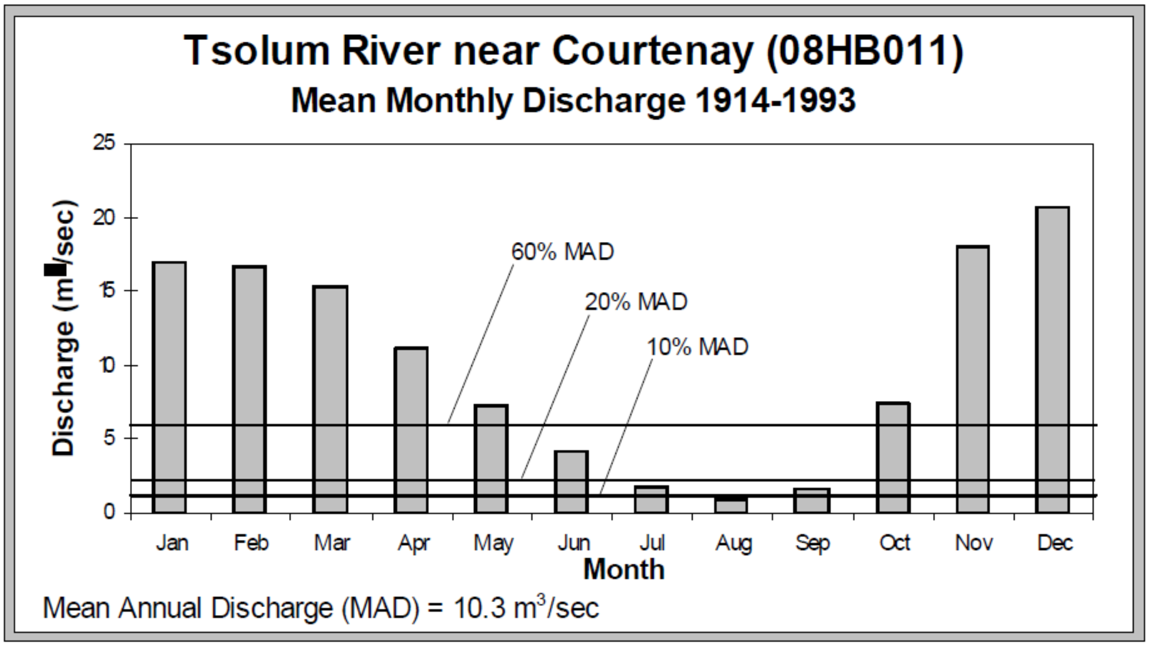

Figure 13 – Tsolum River Mean Monthly Discharge (from Water Allocation Study, Riddell & Bryden, 1996).

6.6 Watershed Recovery Evaluation

The overall success of implementing the priority activities in the Tsolum River Recovery Plan should be evaluated in terms of attaining salmonid species population targets and trends relative to improvements in habitat conditions, when identified. Rehabilitating watershed processes in concert with addressing the habitat limitations to fish production should also be assessed. These evaluations will best relate to the rate of recovery of watershed processes, and the combined effectiveness of watershed, riparian, stream, and site-scale restoration prescriptions on the recovery of limiting fish habitats and fish populations. These evaluations are best balanced against assessments and tracking of land use. Through partnership information sharing, monitoring indicators of development (type of use, density etc.) will indicate areas showing improvements, concerns and/or degradation.

6.7 Land Use Monitoring

Working with the community partners, agriculture and industry, to develop a watershed/floodplain map linked with current and projected development, storm water influx and potential watershed impacts would provide a useful monitoring tool.

6.8 Indices of Level of Response Evaluation

Indices of levels of response need to be clearly defined. This evaluation ties in with land use monitoring. An example of indices to measure can be found from the older forest management watershed assessment models. An inventory and impact rating (by percent and rate) of each river crossing, clearing, road, land use type, etc., can be expanded to other land use assessments and monitored or tracked as state of land use over time with categories or ratings. This tool is an excellent way to demonstrate complex issues such as tracking watershed improvements while faced with increased land use and pressures. Land use indicators (as described) can be linked to bio-physical indicators (such as changes in flow, water quality markers, reach-channel indices, benthic invertebrate assessments and/or stock assessment) can also be captured through monitoring.

7.0 Riparian Prescription

A reoccurring restoration and recovery activity is riparian planting within identified priority reaches. While the riparian activity remains assessed within the larger reach restoration activity of the Recovery Plan Projects (Table 2), it is also recommended that an individual riparian prescription be developed for the entire watershed.

Riparian planting has often been done on an opportunistic basis or tied in with past restoration activities. Ideally, the watershed riparian zones should be assessed and areas identified by separate priority and a prescription plan prepared so the ‘opportunistic’ planting opportunities are directed at reaches most in need of bank stabilization. Opportunistic planting is often when a group, such as schools or scouts, approaches the TRRS looking for a project and the TRRS is in possession of donated tree plugs. Monitoring needs to be part of the prescription. Also, some tree plugs need to be browse protected, others should be planted more carefully as saplings and often the preferred species has been overlooked in favour of what is on hand. Planting the riparian in the watershed is only a positive activity however; a developed riparian prescription would maximize the benefits and focus the efforts.

8.0 Recommended Recovery Plan Projects

The Fish Habitat Assessment (FHAP) (Clough, 2015), Tsolum River Channel Morphology and Bedload Assessment (Gooding, 2015), and the Tsolum Watershed Habitat Restoration Planning (Clough, 2015), examined each stream, channel and reach in the watershed. Through review of these documents the TRP Technical Committee, developed a focus list of reaches that presented restoration opportunities (Table 1). In March 2015, using established methods, these reaches were re-inspected by a TRP Technical Committee representative, Gooding (River Hydrologist) and Clough (Fisheries Biologist) with the focus of assessment by activity criteria for status (improving / stable / degrading), feasibility (factors such as ease of access, anchors possible, current strength, etc.) and benefit (priority of each activity within the reach).

The above criteria were each scored from low=1, moderate=2 and high=3 points then the totals combined (Table 2). The combined priority ‘score’ assessment will be the basis for prioritizing the TRRS’ future implementation of projects and project planning and will be reviewed and updated annually. All projects consider the feasibility of achieving secure funding. The priority assessment will also provide a sound basis and a comprehensive rationale that will support any requests for funding. It is important to understand that in some cases a higher priority project may be secondary to a lower one, if there are conditions upstream of the project site that would negate the intended benefits. In some cases, project priority assessments have included points for real or potential asset and property damage risk (denoted by 'red flag'). Each project was given a final total point score and a rating of Extreme, High, Moderate, or Low assigned.

As a living document, the Recovery Plan will also be reviewed by the Tsolum River Partnership group and through public consultation in fall 2015. The TRRP encompasses the overall goals of the TRRS by creating a plan and defining both future projects and information gaps. The criteria for prioritizing the projects are described below. This prioritization process has considered multiple factors including:

- **Feasibility**: technical/logistical feasibility, including accessibility, resources required and financial feasibility,
- **Benefits**: Ecological and biological values; including fish, river and habitat enhancement and enhancement of the physical processes of the river,
- **Benefits to salmonids**: specific species or all, and
- **Status**: the current watershed condition is: stable, declining or naturally (but slowly) improving.

The final priority (overall priority for the reach) was determined based on a cumulative rating scale that considered both benefit, status (risk), and feasibility then an Implementation Plan was developed (Table 2). Ideally all criteria must be measurable in some way: presence / absence of species, increase / decrease of stocks and returns, habitat area, diversity or habitat quality. Using the monitoring and evaluation objectives from Section 7.0, a monitoring plan will be developed and tracked using a TRRS managed database and GIS mapping output. The schedule of the individual monitoring tasks will be developed but should be on either an annual, three year or five year schedule depending on need.

Finally, the criteria approach to recovery evaluation was established to address biological benefit, physical process function, quantifiable criteria and standards by which priorities for action could be established and will be measured against each objective. The recovery plan includes actions to protect and restore habitat wherever habitat condition was a factor of decline, whether on private or public lands. The priority lists in the following tables have been reviewed by the TRRS Technical committee.

Table 2 – Prioritization Assessment of Identified Restoration Opportunities (in Watershed order)

Reach & Total Score	Restoration Activity	Feasibility	Benefit	Status	Benefit to Salmonids	Comments	Priority by Activity
Tsolum **T13** (11 pts)	Riparian Planting	Good	High	stable	All	Above Duncan Bay Main needs Red Cedar	High 8 pts
	LWD Placement	Poor	Low	improving	All	Lots of existing wood	MONITOR (3 pts)
Tsolum **T12** (12 pts)	Spawning Gravel/Crests	Moderate	Moderate	degrading	All	Successful spawning here benefits the rearing habitat	Moderate 7 pts
	Boulder and LWD Placement	Poor	Low	degrading	All	Low in wood but hard to anchor except for existing stumps – boulders would be easier	Low 5 pts
Tsolum **T10** (14 pts)	Riparian Planting	Good	High	stable	All	right bank planting would be a long term benefit	High 8 pts
	LWD Placement	Moderate	Moderate	stable	All	Some LWD could be attempted among riparian hand planting	Moderate 6 pts
Tsolum **T10 & T9** (18 pts)	Live Stake / Cottonwood Planting on extensive gravel bars	Good	High	degrading	All	Stabilizing 1000s of m^3 of gravel will impact this and downstream reaches. Include LWD placement while live staking.	**Extreme** 18 pts (9 pts per reach)
Tsolum **T9** (20 pts)	Riparian Planting	Good	High	degrading	All	Add more diversity in plant list, but Cedar still highest	High 9 pts
	LWD Placement	Moderate	Moderate	degrading	All	Improve existing LWD locations	Moderate 7 pts
	Spawning Gravel/Crests	Poor	Low	stable	All	Spawning habitat is already good	Low 4 pts
Tsolum **T8** (17 pts)	Riparian Planting	Good	High	stable	All	Some riparian on right bank oxbow is lacking in conifer	High 8 pts
	LWD Placement	Good	High	degrading	All	To initiate scour and diversity. Railway Ave provides good access – needs to be well anchored	High 9 pts

Reach & Total Score	Restoration Activity	Feasibility	Benefit	Status	Benefit to Salmonids	Comments	Priority by Activity
Tsolum **T7** (18 pts)	Riparian Planting	Good	High	degrading	All	Add more diversity in plant list, but Cedar still highest	High 9 pts
	LWD Placement	Poor	Moderate	declining	All	Hard to improve LWD due to difficult locations	Moderate 6 pts
	Spawning Gravel/Crests	Poor	Low	improving	All	Spawning habitat is good	MONITOR (3 pts)
Tsolum **T4** (24 pts)	Riparian (gravel bar) Planting	Good	High	degrading	All	Willow staking to stabilize bars	High 9 pts
	LWD Placement	Poor	Low	stable	All	Hard to improve LWD due to high energy locations	Low 4 pts
	Spawning Gravel/Crests	Poor	Low	improving	All	Spawning habitat fair	MONITOR (3 pts)
	Bank Stabilization	Moderate	High	degrading	All	Ongoing source of bedload and siltation to lower reaches along eroding fields	High 8 pts
Tsolum **T3** (21 pts)	Riparian Planting	Good	Moderate	declining	All	More conifers – Doug. Fir/Cedar	High 8 pts
	LWD & Rock Placement @ Dove Creek Rd / Formosa	Good	High	declining	All	Place Rip Rap to stabilize 2 banks existing LWD. Partial CVRD responsibility.	High 9 pts
	Spawning Gravel/Crests	Poor	Low	stable	All	No Spawning habitat opportunities	Low 4 pts
Tsolum **T2** (21 pts)	Riparian Planting	Good	Low	stable	All	Already planted, needs minor maintenance	Moderate 6 pts
	Rock Placement – Stephen Rd	Good	High	declining	All	preventative maintenance	High 9 pts
	LWD Placement – Formosa	Moderate	Low	declining	All	Site is easy access but benefit is low due to shallow site	Moderate 6 pts

Reach & Total Score	**Restoration Activity**	**Feasibility**	**Benefit**	**Status**	**Benefit to Salmonids**	**Comments**	**Priority by Activity**
Tsolum **T1** (12 pts)	Removal of gravel accumulation at KFN campground	Good	High	declining	All	Prevention of avulsion and flood damage as well as habitat enhancement **(+3 pts for asset protection)**	**Extreme** 12 pts
Murex **M1** (19 pts)	Riparian Planting	Good	High	declining	All	Needs Cedars and other conifers in many areas.	High 9 pts
	LWD	Low	Low	declining	All	No opportunities due to low banks and instability	Low 5 pts
	Spawning Gravel/Crests	Low	Low	declining	All	Channel stabilization required	Low 5 pts
Dove **D6/D5** (25 pts)	Riparian Planting	Moderate	Moderate	declining	All	Minor bank erosion & gravel bed staking as part of bedload removal	Moderate 7 pts
	Bedload Material Removal	Good	High	declining	All	By means of a bedload trap (2) to keep bedload from moving downstream	**Extreme** 18 pts (9 pts/reach)
Dove **D3** (27 pts)	Riparian Planting	Good	High	declining	All	Willow, Red osier, ninebark, salmonberry	High 9 pts
	Rock / LWD Placement	Good	High	declining	All	Along right bank 8-10 m sites (2)	High 9 pts
	Gravel bar / Pool depth	Good	High	declining	All	Stabilize erosion, open barrier to spawning	High 9 pts
Dove **D1** (25 pts)	Riparian Planting	Good	High	declining	All	Willow wattles on slumps, mixed trees on banks (100m)	High 9 pts
	Rock / LWD Placement	Good	High	declining	All	Along Day pool (40m)	High 9 pts
	Spawning Gravel Crests	Moderate	Moderate	declining	All	Possible at pool tail outs - improving perennial pools	Moderate 7 pts

Reach & Total Score	Restoration Activity	Feasibility	Benefit	Status	Benefit to Salmonids	Comments	Priority by Activity
Portuguese **P5** (4 pts)	Spawning Gravel / Pool Depth	Good	Low	stable	All	Shallow gravel beds at Smith Road	Low 4 pts
Portuguese **P2** (26 pts)	Riparian Planting	Good	High	degrading	All	More mixed shrubs and trees needed to stabilize banks	High 9 pts
	Spawning Gravel/Pools	Good	Moderate	degrading	All	Limited areas due to depth	High 8 pts
	Rock / LWD Placement	Good	High	degrading	All	Also wattles as bank protection and cover - LWD where possible in narrow areas	High 9 pts
Portuguese **P1** (25 pts)	Riparian Planting	Good	High	stable	All	More mixed shrubs and trees needed to stabilize both banks	Moderate 7 pts
	Spawning Gravel	Good	High	degrading	All	At Headquarters Bridge, H4 and H8 area, removal of fines recommended	High 9 pts
	LWD Placement	Good	High	degrading	All	At pool sites H4 & H8	High 9 pts

Note that riparian planting (green fill) is the most commonly recommended activity in all assessed reaches and mostly have priority assessments of High and High (Table 2). For this reason, riparian planting shall be considered a priority activity project in itself and is included as an over reaching project in the implementation plan (Table 3). When identified as a priority, monitoring was highlighted in orange fill.

9.0 Implementation Plan Summary

For each priority restoration plan and activity listed below (Table 3), there will be several components imbedded in the project including; stakeholder engagement, public information and education, stock assessment, habitat protection and monitoring. Tables 3 & 4 summarize the overall implementation plan for the next five years. This plan will evolve as new information is acquired through each year's projects and be reflected in the regular updates of the TRRP.

Table 3 – 5 Year Instream Restoration Activities Implementation Plan - Priority Projects (all are funding dependent)

Ranked Priority / Stream / Reach	Recovery Objective	Target Species	Activity – Project Description	Anticipated Timing
PRIORITY 1 Tsolum **T1**	Removal of mobile bedload, rehabilitation of bed and habitat.	All Species	Removal of bedload from deposits upstream of the maple and Puntledge campsites and downstream of the Babcock project. The K'ómoks First Nation may consider stockpiling and selling removed gravel from their adjacent lands. Work with CVRD, KFN, etc.	**2016 – Asset risks**
PRIORITY 2 Dove **D6/D5**	Enhancement of fish habitat and spawning, channel stabilization.	Juvenile and adult salmonids	Removal of bedload by means of a bedload trap (or 2) should be considered, before this long slug of material moves further downstream. **(Priority before D3/D1)**	**2016**
PRIORITY 3 Tsolum **T10/T9**	Stabilizing of mobile bedload.	All Species	Planting on the extensive high gravel bars of mobile bedload by live staking with cottonwood and an excavator. **(Priority over any following mainstem projects)**	**2017**
PRIORITY 4 Tsolum **T4**	Live stake planting - stabilization of gravel bar and bank stabilization	All Species	Willow staking to stabilize mobile bars. Ongoing source of bedload and siltation to lower reaches along eroding fields.	**2018** August salmon window
PRIORITY 5 Dove **D3**	Rehabilitation of channel and enhancement of LWD fish cover habitat: restore channel and floodplain path, open damming gravel bar and stabilize existing debris jam.	Juvenile and adult salmonids	Right bank (2.0m ht.) two erosion sites (8-10m long) between placed riprap require armour and LWD. Place logs in the floodplain to protect overland short cuts and help cut through the bar. Stabilize existing jam with wood and rock and tie it to the bank. This jam requires logs along with rock ballast. Bar to be scalped along thalweg to train first flows to assist cutting through the bar.	**Defer until bedload slug mitigation is determined; revert to high priority if mitigated.** August salmon window.
PRIORITY 6 Portuguese **P1** *Combine with P2 project	Rehabilitate spawning gravel conditions. Secure perennial winter flood refuge pools. Enhancement of fish habitat / cover and riparian areas.	Juvenile and adult salmonids	611m from Headquarters Rd downstream to the Tsolum. Spawning gravel imported to pool tail out areas. Removal of considerable sediment material prior. Installing 3-5 LWD pieces per pool (2 pool sites) buried into the banks with rock ballast would be an improvement. Planting shrubs & trees to improve bank stability and cover.	**2018**. August salmon window. September riparian planting.

Ranked Priority / Stream / Reach	Recovery Objective	Target Species	Activity – Project Description	Anticipated Timing
PRIORITY 7 Portuguese **P2** *Combine with P1 project	Bank stabilization – offers high benefits to pools and spawning gravel.	Juvenile and spawning salmonids	300m towards Carwithen Rd. Re-sloping the steep cut banks with an excavator where accessible and plant staking/wattles where no machine access is possible. The re-sloped banks can also receive LWD where it can fit in the confined area.	**2018**. August salmon window.
PRIORITY 8 Dove **D1** *D6/D5 bedload slug needs to be addressed before proceeding	Bank stabilization – offers high benefits to pools and spawning gravel. Enhancement of fish habitat / cover and riparian areas.	Juvenile and adult salmonids	At Day pool, 40-50m of left bank erosion requires rock and buried LWD and bank needs to be dug back from its vertical angle. Downstream in the next pool several cross logs require anchoring before they wash away. Downstream on left bank is a slump, stabilize with 15m by 3m of willow wattles. Upslope riparian planting is required after restoration on each site along approximately 100m of stream bank. Adding rock crests to increase the spawning gravel anchoring has potential.	**Defer until bedload slug mitigation is determined. 2019** August salmon window. September riparian planting.
PRIORITY 9 Tsolum **T3** (2 sites)	Bank and tree root wads stabilization, and enhancement of fish habitat.	Juvenile and adult salmonids	Dove Creek Rd site: Place Rip Rap to stabilize 2 banks existing LWD. Work with CVRD in 2015/16 to protect road bed. Formosa property: 50-75m rip rap at toe of slope with added LWD to anchor	CVRD – **2017**, Formosa – **2020** August salmon window
PRIORITY 10 Tsolum **T9**	Riparian planting and LWD replacement to enhance fish habitat.	Juvenile and adult salmonids	Diversify the riparian species diversity with an emphasis on cedar plantings. Improve existing LWD locations until new ones develop. This will improve spawning habitats.	**2020** and as part of riparian Rx

The top three priority projects (dark orange fill) have only a single activity and the single activity scored EXTREME while having an overall higher point score. Priority projects 4 through 8 (moderate orange fill) and 9 – 10 (light orange fill) were ranked based on their overall score *less the riparian point value* in an effort to equalize them. The riparian activities will be included in all projects and prioritized in a separate riparian prescription (Table 4).

Table 4 - Shelf Ready Project Plan(s) and Riparian Prescription – No priorities assigned

Priority / Site / Reach	Recovery Objective	Target Species	Activity – Project Description	Anticipated Timing
SHELF READY Tsolum **T2** (2 sites)	Bank stabilization and enhancement of fish habitat and cover.	Juvenile and adult salmonids	Wedaman Property: rock buttresses and bend-away weirs installed in 2010 need maintenance. The structures have successfully pushed the thalweg off the hard left bank into the middle of the channel. 2014 high floods eroded a 2 m hole where a few boulders were displaced. Formosa property: right bank, corner pool received two weirs with wood. The tail out of the pool has eroded 30m along the low right bank and offers a spot to add LWD.	**Shelf Ready**. August Salmon window. ***aim for early date in order to stop erosion on previous project which could impair biological function**
RIPARIAN PRESCRIPTION Tsolum - T13, T10, T9, T8, T7, T4, T3 & Murex – M3, M2, M1, etc.	Bank stabilization & future LWD and fish cover enhancement	Juvenile and adult salmonids	Riparian planting in all reaches, not necessarily linked to any specific assessed priority activity – **volunteer, school and community based**. Plant a variety of Doug Fir & Red cedar, willow, red osier dogwood, ninebark & salmonberry.	Opportunistically **2016 through 2019.**

Tsolum T2 did not score in the highest priority projects – however because the assessments are to protect 2 sites; a previous project and Dove Creek Rd infrastructure, and because they are ‘easy’ (feasible and cost-effective) to achieve, this project is recommended as a ‘shelf ready’ plan for when funding opportunities become available.

Table 5 - Monitoring Implementation Plan

Priority / Site / Reach	Monitoring Objective	Target Species	Activity – Project Description	Anticipated Timing
Tsolum River	Monitor out-migration - Increase salmonid populations	All fry salmonids	Using Rotary Screw Trap, estimate fry productivity; established as time series	Ongoing March – June
Targeted tributaries	Monitoring, stock population abundance	All smolt salmonids	Fish fence in targeted tributaries	Ongoing April – June
Tsolum Watershed	Monitoring water quality and quantity	All salmonids	Monitor water quality and levels, maintain quality and flow	Ongoing, monthly
Fry Salvage	Monitoring salmonid populations in low flow season – Tributaries and Mainstem pools	Coho fry and smolts	During low flow months, isolated fish cannot move up or downstream. Salvage smolts downstream and fry upstream – to increase salmon populations	Ongoing - July
Targeted reaches	Monitor Steelhead stocks	Steelhead and Rainbow Trout	Redds snorkel surveys in index reaches to estimate relative abundance	Ongoing - May
Reaches and Tsolum Mainstem	Monitor Salmonid stocks	Steelhead and Rainbow Trout	River swims / boating to id species and count fish	Proposed (moderate flow periods) – May / June
Tsolum Watershed	Monitor spawning populations	All adult salmonids	ID / Map and monitor/protect all spawning areas by creating baselines and comparing	Enter data, proposed 2016
Tsolum Watershed	Monitor channel characteristics for project decisions in improving salmonid habitat	All salmonids	Monitor through measurement changes to baseline data on depth to width ratio, and depth-frequency of thalweg at key locations in the system – baseline 2015	Repeat measurements every 5 years or as related to restoration project monitoring
Tsolum Watershed	Monitor fish habitat parameters of FHAP for project decisions in improving salmonid habitat	All salmonids	Repeat FHAP measurement and data collection at selected sub-reaches to determine changes in fish habitat – baseline data and reach selection 2014	Repeat measurements as related to restoration project monitoring
Tsolum Watershed (including lakes)	Monitor stocks, improve salmonid productivity and success, increase inventory understanding	All juvenile salmonids	ID / Map and monitor/protect all refuge areas, Helldiver Lake: fry trapping in wetlands to determine if spawning fish can access	Proposed 2016 to establish baseline. Repeat on 5 year cycle.

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