Furry Creek
Master Drainage Plan

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1. INTRODUCTION

The Furry Creek lands are an assembly of private lands that were created in the early part of the last century and assembled together and sold to Tanac Lands in 1990. The lands are within the SLRD in Area D located approximately 30 km's North of West Vancouver and 15 km's south of Squamish. The original subject property comprises approximately 1036 acres and is just south of Britannia Beach along the Howe Sound. The project extents are shown in Figure 1 which is also contained in Appendix 1:

Planning for the Furry Creek community began in 1990 following the purchase of the property by Tanabe Corporation of Japan under the Canadian company, Tanac Land Development Corporation. Since the lands are in an unincorporated area, an application was submitted to the Ministry of Transportation and Highways, and in 1991 a Preliminary Layout Approval (PLA) was granted for a complete community comprising a golf course, up to 920 residential units, a 300-room resort or hotel, marina, commercial and community facilities. The PLA was based on a number of studies including geotechnical studies by Thurber Engineering, Water studies by Thurber and Brown Erdman, road designs, sewage treatment studies, archeological reviews and foreshore and upland environmental assessments. The development areas were identified as Marina, Waterfront, Benchlands, Uplands, Northwest, Northeast, Mountain and Highlands. This PLA was reissued a number of times. Currently there are 56 townhouse units in Oliver's Landing strata, an 8,000 ft^2 community building with 4 duplex lots (1 duplex built) and 90 single family lots and the Golf Course above the highway. These single family and duplex are freehold other than single family strata at Oceans Crest at the south entrance

In 2017 Fine Peace Furry Creek Developments Ltd (FPFCD), the Canadian subsidiary of an international company active in the development of golf course and resort oriented residential communities, purchased the holdings of Burrard Group. In 2018, it acquired the Tanac Lands from Parklane Homes. FPFCD is determined to realize the original vision of a complete recreational/residential community at Furry Creek, with a variety of housing choices, neighborhood village retail space, resort facilities, a residents'-only marina, community facilities and an extensive open space and trail network.

Creus Engineering Ltd. has been retained by FPFCD to provide a review of the civil servicing requirements for the above project which includes site access, water works, sanitary collection and treatment, stormwater, outside utilities, Canada post and solid waste management. One of the Principals of Creus had previously been an employee of Tanac during the development stages and had worked as a consultant for Tanac, Burrard Group and Parklane on the project.

The lands are part of an overall zoning proposal. Creus prepared a design brief in support of the zoning and submitted that to the SLRD originally in September of 2019. This report formed part of that submission but has been segregated for convenience. The Appendix numbers have been maintained from the original reports.

Each subdivision requires approval of the Provincial Approving officer. The subdivision process would include referrals to all relevant regulatory authorities including: CN rail when work adjacent to rail; Ministry of Transportation and Infrastructure (MOTI) roads division for any public roads or roads accessing public road as well as associated drainage; BC Hydro when adjacent to BC Hydro Right-of-Way (ROW); Department of Fisheries and Oceans Canada (DFO) and Forests, Lands, Natural Resource Operations and Rural Development (FLNRO) in relation to environmental concerns; Vancouver Coastal Health (VCH) to confirm that the water system

expansion is permitted for expansion and that the operating permit is in good standing and can accommodate the additional demand; and Waste Management Branch to ensure that the WWTP permit is in good standing and that the additional flows can be accommodated by the permit. The SLRD has always played a significant role in any subdivision as the local governing authority but also as it related to SLRD being the agency that owns and manages the water system, the sanitary sewer system, streetlights, diking, public open space and fire protection. As such each subdivision will have to gain a significant number of permits and approvals from all levels of government including geotechnical sign offs, environmental approvals and confirmation of water and sewer servicing. It is a reality that all roads, services and subdivision will have to meet all provincial and federal regulation and be designed and constructed in accordance with the most recent version of the Electoral Area D subdivision and Development Servicing (Planned Communities) Bylaw No. 741, 2002.

Flood protection work relating to Furry Creek and foreshore has previously been completed by Delcan based on earlier works by CH2M Hill and Reid Crowther Partners Limited (RCPL) and the flood protection works have been constructed and turned over to the SLRD. This design brief will provide a review of the general drainage patterns on site and provide commentary on the original Reid Crowther Master Drainage Study. It will also give general direction on the Stormwater Management goals and potential treatment systems. Detailed sizing of culverts will be done as the development proceeds.

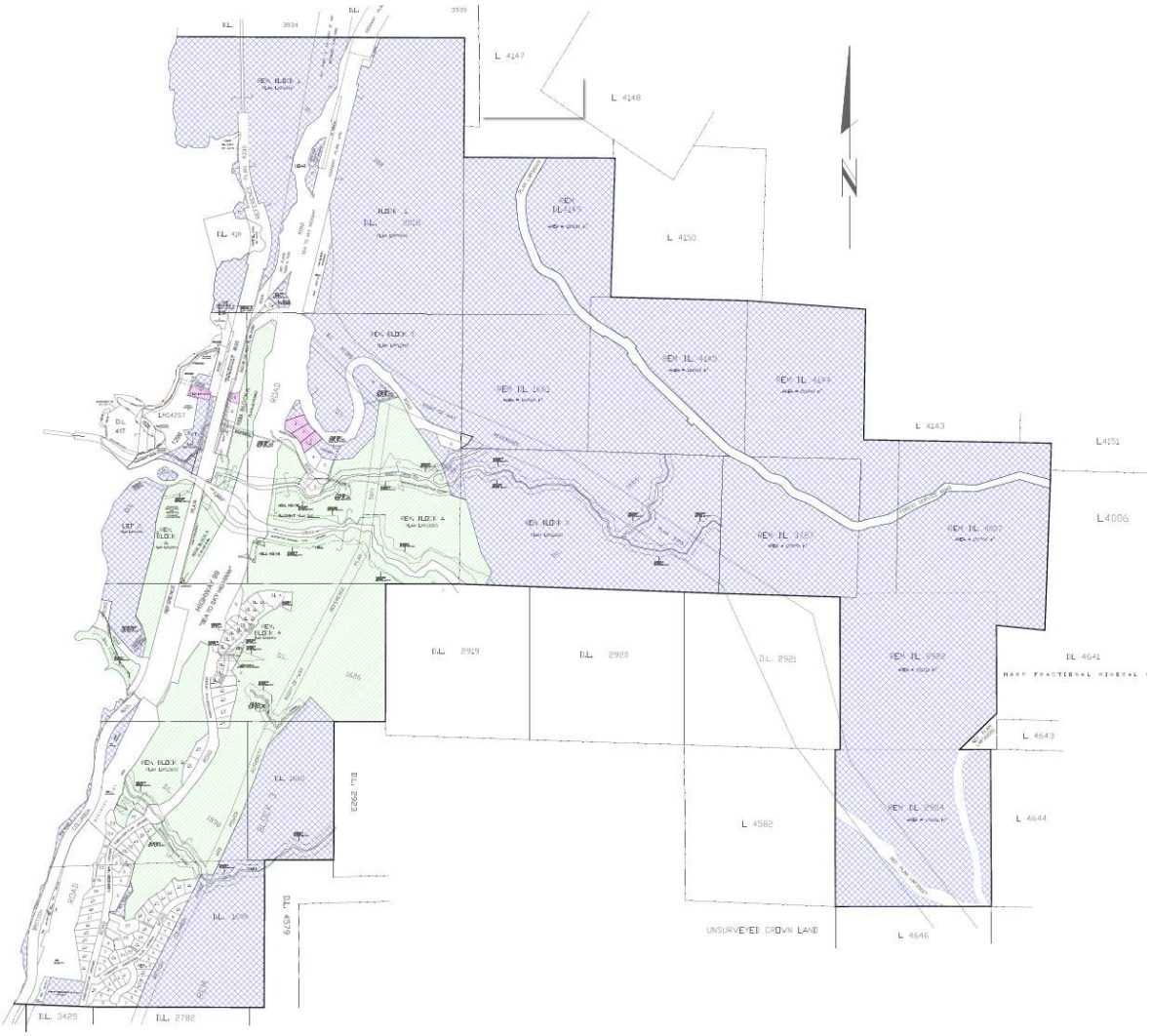

Figure 1: Context Legal plan from Bennett

2. DESIGN CRITERIA

Design criteria is laid out in SLRDs Electoral Area D Subdivision and Development Servicing (Planned Communities) Bylaw No. 741, 2002 as updated and consolidated as of March 2015. We have also reviewed MOTI design criteria. MOTI is solely responsible for drainage from lands under their jurisdiction. MOTI is the subdivision approving authority within the SLRD and is responsible for the drainage works within the public road ROWs. The minor or piped drainage systems must include run-off controls to limit post-development peak discharge rates to the pre-development rates for 5-year return period storms. The major or overland system which comes into operation once the minor system's capacity is exceeded, which includes streets and receiving ditch shall be designed to convey a peak discharge flow for a 100-year return period. All designs will include Erosion and Sediment Control features for construction reflecting the latest version of Construction Site Erosion and Sediment Control Guide of "Best Management Practices Guide for Stormwater", Greater Vancouver Sewerage and Drainage District. This would be submitted with each construction project. As well Riparian areas, special environment zones and trees to remain would be protected during construction. Permitting from DFO and FLNRO would be required for any works triggered under the water act for creek crossings and discharging outlets.

MOTI design criteria is to convey the 1:100 year flow, to check the 1:200 year flood routing, and to meet MOTI and SLRD Stormwater requirements. MOTI is not generally supportive of stormwater features that require significant maintenance although bioswales and simple ponds are considered acceptable. As per Bylaw requirements, drawings would detail flows and capacity of existing structures that would be tied into. The design would detail the piped system including the hydraulic grade line and would show the 100-year major storm routing and overland flow direction. A Stormwater Management Plan would be included to detail pre and post development grading, soil and vegetation types and drainage systems, both permanent and temporary.

SLRD Bylaw No. 741 indicates the Minor System consists of pipes, culverts, open channels, water courses and flow control facilities designed to carry runoff caused by storm events up to a return period of 1 in 10 years. The Major System consists of overland flow routes, swales, channels, watercourses, roadways, walkways, pathways, flow control facilities or other publicly owned property at the discretion of the Manager of Utilities, designed to accommodate runoff from storm events of a return period of 1 in 100 years with the maximum hydraulic grade line below the elevation of the lowest existing or proposed adjacent buildings. In special conditions, where surface flood paths cannot be established, pipes and culverts of the existing or proposed Minor System may be enlarged to accommodate the major flow. Emergency overflow routes may be required by the Manager of Utilities. The Rational Method may be used for drainage basins of less than 10 ha which do not include detention systems. For catchments greater than 10 ha USDA SCS TR-55 (Curve number method - high level, ground cover, soil types) can be used. Rainfall intensity-duration-frequency curves will be based on Atmospheric Environment Service data where such are available for the vicinity of the development or on curves established for use in the closest municipality. Previously RCPL used IDF curves from Port Melon and Squamish, these are currently the most relevant and nearby data that is available. It is acknowledged that Port Melon reflects the Furry Creek development in terms of topology and location. At the time when the Integrated Stormwater Management Plan (ISWMP) is required, further detailing of design criteria will be addressed.

It is understood that the actual design work would be triggered by each phase of work. In discussion with the SLRD and their consultants, a primary concern was the risk of overland flow from one neighborhood to another during significant storms that may overwhelm stormwater management systems and/or downstream developments. This Master Plan identifies and discusses each of these risks in a general manner below.

3. STORMWATER MANAGEMENT OBJECTIVES AND FEATURES

Stormwater management guidelines in the SLRD bylaw No.741, 2002 applies to this area. The guideline in the bylaw are general and there is no specific reference to Furry Creek. There is reference to the Electoral Area D Official Community Plan which sets out policies and Stormwater Management Guidelines for the Britannia Beach Planned Community. It is assumed that the same or similar guidelines would apply for the Furry Creek Development. The guidelines include a selection of Best Management Practices (BMPs). BMPs vary in their applicability to different objectives (e.g. protection against flooding and erosion or protection of fish habitat) and in their suitability for different levels of development and for different site conditions.

The SLRD bylaw does not include design parameters as it states. “Because site and climatic conditions vary considerably over Electoral Area D and there is a lack of data, design parameters for hydrological calculations are also excluded from this schedule.” Key objectives of the BMP

guide for stormwater are: anti-degradation which is to avoid deterioration of a resource; Enhancement - to improve or enhance a degraded resource to some degree; Restoration - return a degraded resource to a state similar to what likely existing before extensive, permanent human occupancy; and Preservation – to retain a resource in its current state. Some combination of the above levels of application may be appropriate, depending on the specific situation. Various measures are in place to preserve and protect fish habitat for example. Buffer zones and environmental setbacks have been determined by Cascade Environmental Resource Group Ltd.

Although specific design criteria have not been prescribed for Furry Creek within the bylaw, the following report will discuss various drainage practices and measures in accordance with the general bylaw objectives. These measures are aimed to address key criteria stipulated within the BMP. Below is an extract of some key considerations:

"Groundwater Recharge - The most significant impact of urban development on the hydrology of streams is the decrease in pervious area caused by the construction of impervious surfaces (roads, buildings, etc.) This results in an increase in the amount of surface runoff, with a resulting decrease in the amount of precipitation infiltrating into the ground. This in turn results in decreased groundwater recharge and lower dry season base flows in streams. Low base flows during the dry season can damage or eliminate spawning beds and fish habitat. This can be mitigated by promoting groundwater recharge. The groundwater recharge with be supported through the use of infiltration tanks, perforated pipes, and minimising the use of impervious surfaces where applicable." (Best Management Practices Guide for Stormwater, 1999, p.2-10). It should be noted that only Middle Creek has fish population within the subject lands, however the approach will be applied generally. The local ground conditions will restrict this ability in many areas as it is bedrock controlled. The construction activity will generally increase rock fracture in the immediate construction zone; however, it is expected the constructed detention may be required in some zones. The Middle Creek drainage has the best opportunity for infiltration due to the sand and gravel soil conditions and an extensive bioswale project is proposed there. Additionally, as indicated in the Waterworks Master plan the development will be relying on wells for water supply. The use of these infiltration structures will ensure that the water is treated before percolating to the groundwater, which will be further discussed below.

"Water Quality – Urban surface runoff is known to carry a variety of materials that have potential negative impacts on water quality, including sediment, excess nutrients, metals and trace elements, organic contaminants, floatable materials such as plastics, oxygen-demanding materials, oil and grease, and harmful bacteria and viruses." (BMP, 1999, p.2-11.) As mentioned above this will be addressed with the use bioremediation ponds, natural filters and vegetation. No industrial activity is allowed for in the community zoning and as such the primary risk is potential hydrocarbon release from road traffic. The existing golf course already tests for herbicides and pesticides and is part of the Audubon Cooperative Sanctuary Program for Golf.

"Turbidity and Sedimentation – Discharges of urban surface runoff often contain suspended solids or other contaminants that increase the turbidity of the water in receiving streams." (BMP, 1999, p.2-9). This will be prevented via the use of Erosion and Sedimentation Control measures during construction but also permanent ponds and stilling areas prior to discharge back to creeks. This is a requirement under the SLRD bylaw.

"Control Flooding Frequency – Development generally increases the risk of flooding downstream, due to greater runoff volumes and flow rates caused by the increase in impervious area that accompanies development. Control of peak runoff flow rates will be used to prevent or mitigate major and minor flooding events that might result in extreme damage to property and significant

risk to life. Methods of reducing peak runoff flow rates include temporarily detaining collected runoff water in storage structures with subsequent release at controlled rates, minimizing the impervious area associated with development, and promoting infiltration of precipitation into the soil. Infiltration reduces the volume of runoff as well as the peak flow rate, while detention reduces only the peak flow rate." (BMP, 1999, p 2-8) This will be achieved with onsite and offsite features. Overland flooding routes will also be studied to determine if any residential zones lie within the overland flood routes. The existing main drainage of Furry Creek, Middle Creek, South Creek and North Creek are deeply incised through the developed portion of the site and do not subject residential areas to flooding. The existing major drainages isolate each of the significant development pods such that each neighbourhood drains fairly directly to the major drainages or to Howe Sound such that overland flow from one neighbourhood to another is generally not a risk.

"Minimize Streambank Erosion – Development often results in increased stream bank erosion, due to the greater frequency and duration of highly erosive bankfull flows caused by increased runoff volumes. Streambank erosion can be controlled by reducing the frequency and/or duration of bankfull flows through similar measures to those described above for controlling peak runoff rates, and by stabilizing streambanks with vegetation or non-erodible material." (BMP, 1999, p 2-8,9)

As per the bylaw, "At the time of subdivision an Integrated Stormwater Management Plan (ISWMP) will be required. The process will follow that described in the GVRD (now Metro Vancouver) publication "*Integrated Stormwater Management Planning – Terms of Reference Template*" amended appropriately to the requirements of the SLRD." The ISWMP will be generated for that drainage catchment zone based on the more detailed development plan that would be available at that time. As such there will in fact be a separate ISWMP for Upper Benchlands (the South Creek drainage), Northwest (largely foreshore catchment), Northeast (the North Creek drainage), Collector and likely a combined plan for Uplands and Mountain (for the Middle Creek Catchment). The Waterfront Lands will trigger an ISWMP for Furry Creek drainage. These will be triggered by the first subdivision within the watershed. These will be able to more definitively identify location of the specific types of stormwater features, identify and quantify routing of major drainage system flows, pipe flows, and outfalls and detail design criteria and operational and maintenance requirements for BMP's according to their purpose and location and establish appropriate intensity-duration-frequency curves and other design parameters. Design criteria will include aesthetic considerations for all above ground works.

The Metro Vancouver *Integrated Stormwater Management Planning – Terms of Reference Template states, "The* ISWMP process involves comprehensive data collection and technical analysis to develop an understanding of the subject watershed and its issues. The stakeholder process ensures that community values are clearly identified, and that the study is being guided in the proper direction. It would be tremendous if every municipality could adopt the criteria listed in Table 3-2, but that is unrealistic. Many land uses, and development conditions simply can not meet that criteria. Therefore, it is likely that watershed specific criteria relating to a variety of land uses within the watershed will be developed during an ISMWP. This will be guided by no-net-loss objective and trade-offs between land development and environmental protection will be balanced." This will be detailed with calculation of detention, flow, low flow release rates etc.

The current stormwater management objectives are to maintain stormwater flow from the lands at pre-development levels and store volumes with a low flow release system and encourage infiltration such that the flow leaving development sites is similar to pre-development conditions and maintain normalized flow into the creeks and drainage courses. This will be accomplished by a combination of rain gardens, some underground piping, surface bioswales, infiltration fields,

ponds and structural storage. There has also been enhancement work on both South Creek and Middle Creek and this work would be continued. The golf course has incorporated stormwater management features, including ponds, to mimic pre development flow and drainage.

Stormwater requirements would be subject to the MOTI review and approval as a required part of the subdivision process. The works will also be subject to the Department of Fisheries and Oceans Canada (DFO) Urban Stormwater Guidelines for the Protection of Fish and Fish Habitat (draft, April 2001). MMCD Guidelines are used extensively throughout the Lower Mainland and areas of BC. As Furry Creek does not have specific criteria, the MMCD will be viewed as the guiding document in this regard.

Within the MMCD, section 8.14.1, it outlines the intentions of the traditional stormwater quantity control design approach, which is to limit the post-development release rate of the site to pre-development levels for a specific storm event. This method of approach has design flaws including excess shear developing in a watercourse which can result in streambed erosion as well as by delaying peak flows from some catchments can lead to simultaneous peaks withing other catchments and ultimately leading to an overall increase in the receiving watercourse. This can be overcome by specifying post-development targets for a wider range of return periods and not just for a single return period. The following is an excerpt of the tiered stormwater design approach and is outlined in the (*Stormwater planning: A guidebook for British Columbia, Ministry of Environment, 2004*).

"A key parameter for describing the rainfall spectrum is the size of the Mean Annual Rainfall (MAR), the rainfall event that occurs once per year, on average. The distribution of rainfall events relative to the MAR is fairly constant throughout British Columbia. The following rainfall tiers are the building blocks of an integrated strategy for managing the complete spectrum of rainfall events:"

- ***Tier A*** *Events* – The small rainfall events that are less than half the size of a MAR. About 90% of all rainfall events are Tier A events.*
- ***Tier B*** *Events* – The large rainfall events that are greater than half the size of a MAR, but smaller than a MAR. About 10% of all rainfall events are Tier B events.*
- ***Tier C*** *Events* – The extreme rainfall events exceeding a MAR. An extreme event may or may not occur in any given year.*

**For the purpose of setting performance targets, a rainfall event is defined as total daily rainfall (i.e. mm of rainfall accumulated over 24 hours). This assumption results in conservative site design criteria, which can be optimized over time through continuous simulation modeling, and by monitoring the performance of demonstration projects (as discussed in Section 6.5).*

These three rainfall tiers correspond to three components of an integrated strategy for managing the complete spectrum of rainfall events and below rainfall data are in reference to Vancouver, North Shore statistical analyses using 30+ years of rainfall data;

- Rainfall Capture, Tier A (Source Control) – Capture the first 40mm of rainfall per day and store it to natural hydrologic pathways where possible by promoting infiltration, evapotranspiration or rainwater reuse. This is the small storm runoff, rainfall events from rooftops and paved surfaces and roadways. The roadways must also be able to convey Tier C flood events.
- Runoff Control, Tier B (Detention) – Detain the next 40mm to 80mm of rainfall per day and release it to drainage system of watercourses at natural interflow rate. The large tier B rainfall event runoff cause the most significant peak flows in downstream watercourses

and is achieved by control and release features such as detention or infiltration tanks/ basins.

- Flood risk management, Tier C (Conveyance) – ensure that the storm water plan can safely convey storms greater than 80mm (up to the 100-year rainfall). This is the extreme rainfall event and the development must ensure adequate escape routes for overland flow via stream channels, bridge and culvert crossings.

A variety of source control system will be implemented on the site including rain gardens, biofiltration swales, infiltration and detention ponds. Runoff from the impervious and pervious surfaces will first be directed to these features. The systems are designed to capture runoff, slow flow rate which then results in promoting infiltration and allowing for increased evaporation time. Check dams built into the bioswales will store volumes of runoff such that the post development flow is equal to or less than the pre development flow. The bioswales and rain gardens will be fitted with exfiltration piping to augment the infiltration into the underlying sand layers. The detention features also aid by allowing for settling of sediments and particulate matter carried by the flows that would otherwise be directed to the adjoining creeks.

The vegetation elements of the stormwater features serve to remove pollutants carried by the overland flows by detention, filtering elements of the plants and biological breakdown. The vegetative element also helps with flow control through absorption as part of the plant growth process, evaporation and transpiration. These will be designed in consultation with the Environmental Monitor to maximize potential for environmental enhancement.

The stormwater features would be designed in a manner to mimic existing surface and subsurface flow regimes. A series of discharge points would be designed to provide exfiltration and surface flow to pre-existing creeks and foreshore outlets spread along the length of the creek interface with the site. Detention sizing would enable slow release of flows after significant rain events.

Any disturbed areas not required for parking or circulation would be amended with soils and planting to aid in the stormwater management and improving biodiversity of the site. The vast majority of the site will remain undisturbed with approximately only 57.0 ha (+/- 14%) of the total 419 ha being developed with hard surfaces. The developed lands will include large portions of landscaped area including the golf course which is approximately 61.0 ha and as such will constitute 15% of the lands. Approximately 124.5 ha is zoned public open space with a further 18.3 ha of land zoned park which will see very limited disturbance other than landscaping and largely gravel trails. Disturbed areas outside of the hard surfaces will be revegetated to tie into the surrounding forests.

Some standard features to be used in the Stormwater Management designs are shown in Figure 2 and also included in Appendix 10:. These are features that can be fit throughout the development to further mitigate changes to stormwater flows.

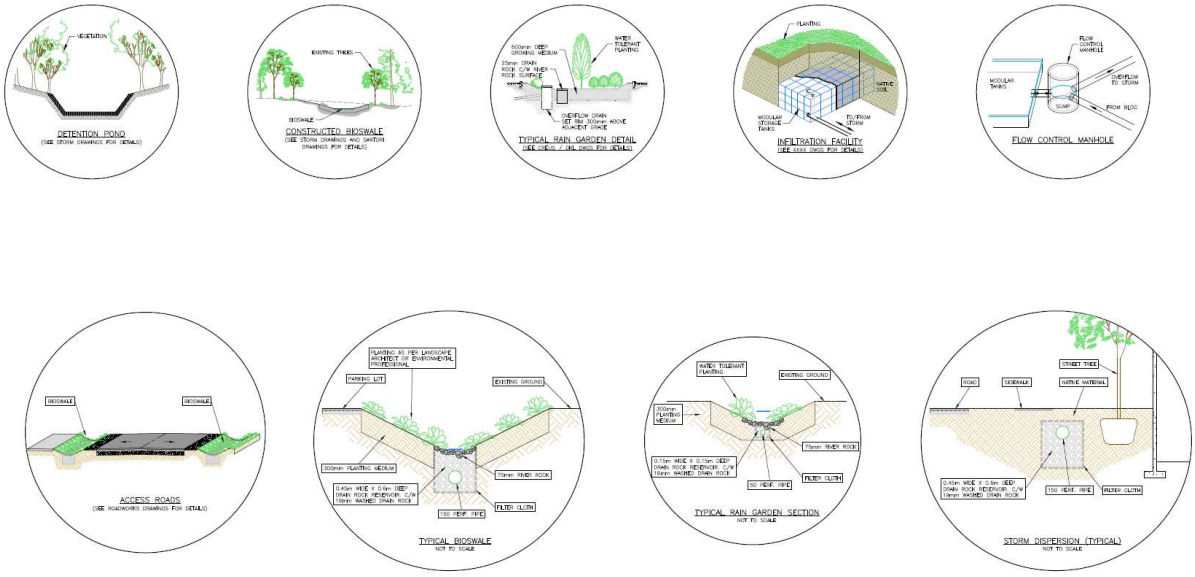

Figure 2: Sample Stormwater Management Features

There is a permitted stormwater outlet into the Marina to serve the north side of Furry Creek and a 900 mm outlet into Howe Sound adjacent to the 14th Hole tee box. Within the Uplands area there were initial concerns brought forward by DFO regarding discharge of stormwater into Middle Creek. However, this creek has now been enhanced such that it is fish bearing. It is therefore beneficial to maintain the stormwater feeding the Middle Creek system. It was agreed with DFO at the time to provide bio treatment wetlands within the BC Hydro ROW to treat the stormwater prior to discharging back to Middle Creek. This will reduce the reliance on piping, maintain flow in Middle Creek and enhance the community use of the BC Hydro ROW by providing ground cover planting and trails in the area. There are existing outfalls to South Creek and further tie in was envisioned during the initial works.

4. DRAINAGE CATCHMENT AREAS

The Community of Furry Creek totals just over 1,000 acres. It is generally within the Furry Creek drainage catchment area but also includes South Creek and North Creek catchments. There is a significant sub-catchment of Furry Creek that is named Middle Creek which ties into Furry Creek just below the highway. The surrounding lands are Crown Lands and are undeveloped other than a run of the river power project that ties back into Furry Creek above the proposed development area and periodic logging operations. The area is generally tree covered and lies within the South Coast Mountain Range and is underlain by granitic bedrock of the Coast Plutonic Complex. The area of the subject site is underlain by quartz dioritic intrusive rocks of the Upper Jurassic Period (157 - 145 million years ago) of the Mesozoic Era (Data BC, 2019). Resting on this granitic bedrock are deposits of surficial material that are mostly colluvial and fluvial in origin. The general soil type for the Coast Mountain and Islands physiographic region is of the Podzolic Order, residing in the Humo-Ferric Great Group. These soils overlay igneous intrusive rock which is resistant to weathering, thus retarding soil development. The soils of the subject site area were generally found to be shallow in nature due to the numerous rocky outcrops and steep slopes to cliffs. Elevations of proposed lands range from sea level to approximately 700m. On the higher

topography of the steep valley walls, there are frequent bedrock outcrops throughout the subject lands with shallow soils on parent bedrock material.

The total development under the original PLA was 920 units in single and multifamily set up, 300 room resort, golf course and commercial Marina. The current rezoning application indicates 920 market housing in single family as well as ground orientated and apartment style multi family, 120 non market units in multi family format, golf course and 120-unit resort with supporting commercial and community amenities.

Reid Crowther & Partners Ltd (RCPL) had modelled the site in 1992 based on the original PLA using IDF curves from Port Mellon and Squamish for 1:10 and 1:100 year events. They used HYDSY modelling software to calculate the flows and sized the drainage infrastructure to accommodate the future development of the lands.

The current expectation is that the total number of units is fixed at 920 market plus 120 non market along with resort, golf and commercial. The actual distribution between neighbourhoods may adjust over time but the overall total units will be fixed. It is understood that each phase will require passing through a process of Development Permit, Subdivision and Building Permit. This will require sign off from DFO, FLNRO, SLRD and MOTI. Each development lands will have to go through a process to prove out there is adequate drainage measures and that the existing networks and lands are safe for their intended purpose. Final distribution and SMP features would be done at the time of development when the building densities are known.

Creus have prepared pre and post drainage conceptual plans based on the updated zoning densities, refer MDP-1 and MDP-2 shown in Figure 3 and Figure 4. The general intent is to demonstrate that the pre and post development total catchment areas from initial reporting by RCPL have had minor changes. Also, that the proposed impervious areas from the building roofs and proposed roads account for a very small fraction of the overall catchment area. As the final layout of the roads and amount of buildings that will ultimately be constructed on the lands are unclear, detailed analysis is not necessary until such a time when ISWMPs are required. The general drainage intent of this report presents various measures as options which can and will be utilised to manage increased flows as a result of paved surfaces, as well as dispersing concentrated flows via various SMP features such as bioswales. This is further discussed in detail in the following section and broken up into the major catchment areas and the associated creeks. Creus pre and post master drainage plans label where potential existing culverts may be overwhelmed. However, it is understood that the existing culverts were sized to accommodate the future development of the lands.

Currently the SLRD does not address climate change within the bylaw, however an IDF curve adjusted for climate change is available from the Squamish municipality records. Creus has used the design criteria from SLRD Bylaw No. 741 and has allowed for climate change per MOTI requirements. MOTI is solely responsible for drainage from lands under their jurisdiction and is the subdivision approving authority within the SLRD and is responsible for the drainage works within the road ROWs. The MOTI supplement to TAC Design Guide Section 1010. A provides a *“Design Criteria Sheet for Climate Change Resilience”*. It is a requirement that this sheet be completed and submitted to the Chief Engineer’s Office at BCMoTI. Below is a breakdown of the major catchment areas as laid out in Figure 3 and Figure 4.

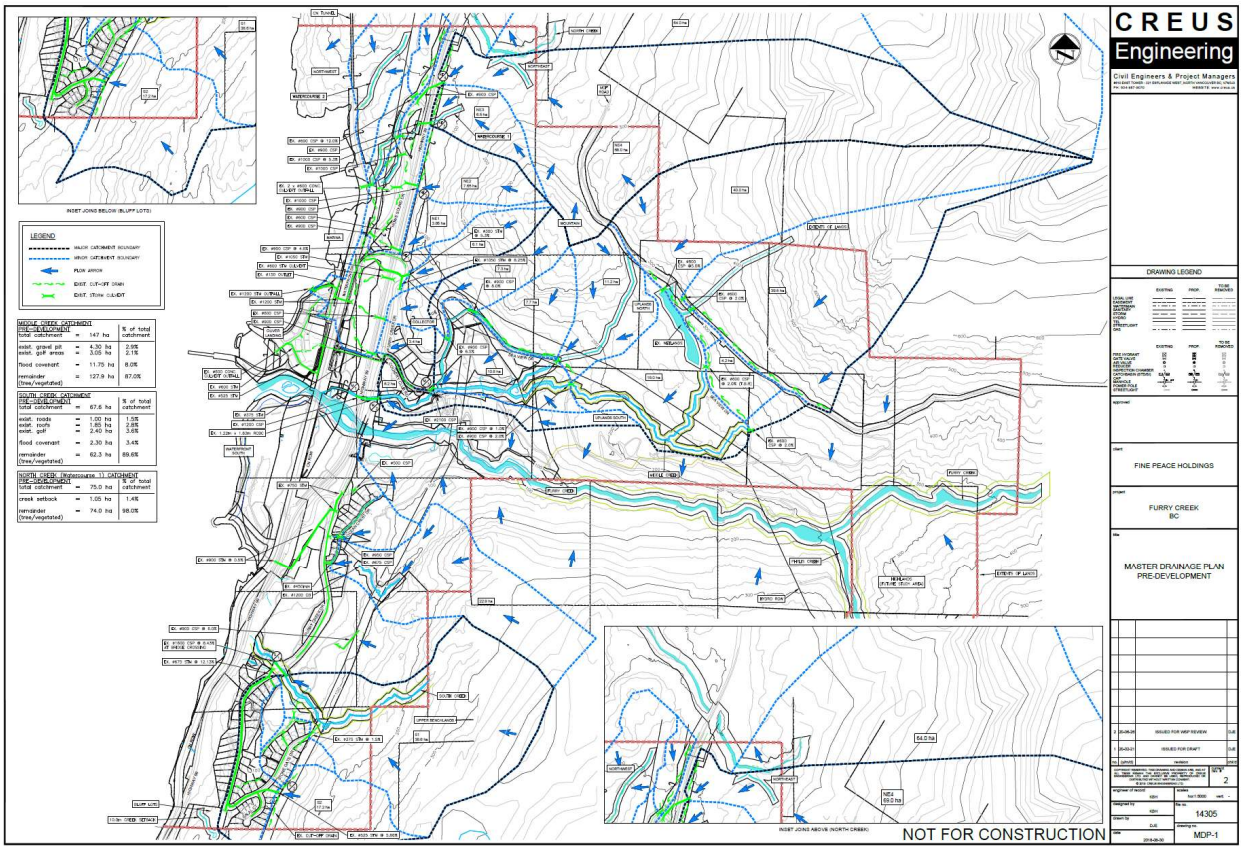

Figure 3: Pre Development Drainage Catchments

4.1. SOUTH CREEK

The South Creek Drainage Catchment totals an area of approximately 73.0 ha. The catchment ranges in elevation from 420m above the Upper Benchlands to sea level where it discharges to Howe Sound. The area is largely bedrock controlled in the upper and lower areas with some gravel deposits in the middle area that are primarily used as a golf course. The breakdown of land use is less than 3ha existing residential zoned single-family development area (+/- 4%), which includes undisturbed areas but did not require full stormwater management plan for each home at the time. There is approximately 2.4 ha golf course (+/- 3%) and 1.0ha of existing roads (just over 1%). It is expected that the actual development disturbed area of the residential zone would be around 10ha (+/- 14%), which includes just over 1.7% proposed roads, over 2 ha South Creek setback (+/-3%) with the remaining almost 63 ha (over 80%) largely tree covered and undisturbed. The terrain is steep with grades up to 60% and made up of rocky moss-covered outcrop containing a combination of young and mature forest. The forest is dominated by Douglas-fir and lodgepole pine with a layer of shrub.

South Creek enters the subject property from the east and flows through the Upper Benchlands proposed development and continues west through a culvert toward the golf course labelled as S/1 on the Post Development Drainage Catchment Plan before crossing under Highway 99, and then out to Howe Sound. Upstream of the golf course the creek gradient averages 36% and has an average bankfull width ranging from 6.37m to 7.99m, and an average wetted width of 4.55m per Cascade Environmental Resource Group Report March 15th 2019 and supporting documentation. The bed material is dominated by large cobbles and small boulders, with a step

pool and a cascade pool morphology. It is discussed within the Cascade environmental report that: no pertinent fish sampling records could be found on the MOE habitat wizard; South Creek itself is not fish bearing; fish passage is blocked by wood debris; and the gradient in the lower reaches of the watercourse near the golf course likely act as a barrier to any upstream fish passage. Passage is further restricted at Highway 99 by a trash rack and rock face above the culvert and a suspended culvert under the rail track. The creek is deeply incised below the Upper Benchlands and is not a flood risk to the existing homes on Furry Creek Drive.

RCPL modelled the lands and sized the existing culvert under Furry Creek Drive crossing as 1600mm culvert based on development zones that matched the current layout. They modelled the piped storm flow at discharge to South Creek from Upper Benchlands as 0.73 m3/s as 1.25 m3/s for lower Benchlands. South Creek discharges to Howe Sound via existing culverts under Highway 99 and CN Rail.

The South Creek drainage includes the existing Stonegate Drive, Salal Court, the southern half of Furry Creek Drive within it. These neighbourhoods currently discharge their stormwater to South Creek in three key locations all of which are collected in an open cut-off ditch above Stonegate to a series of pipes within the road corridor. The south side of Furry Creek Drive discharges to surface with flow routes towards the highway. The proposed developments in the South Creek drainage catchment is the Upper Benchlands which could be a mix of single-family and ground orientated multi-family of up to 40 buildings. The general intent is that SMP devices for overflow and overland flow would be directed back to South Creek within the road corridors. The actual development footprint is fairly small and will largely be on bedrock. The existing drainage had been designed with the expectation of developing Upper Benchlands. The stormwater features will ensure that minor storm flows will detain and release at pre-development flows. Actual discharge will be at the 3 road crossings locations above the existing golf course. South Creek within the golf course is highly incised and not subject to flooding. Overland flow would be to the golf course and not downstream residences.

The land type in the Upper Benchlands area is largely bedrock controlled. This will limit opportunities for infiltration however there may be opportunities to infiltrate at slow rates into the tree cover above Stonegate development and the golf course. The other stormwater features in this area will likely be more structural in the form of Brentwood Boxes etc. South Creek bisects the area and is crossed up to four times by the proposed road. During detailed design further review will be done to see if one culvert can be removed but this will depend on variances from MOTI/SLRD on road grades and maximum length of a cul-de-sac road. This has been reviewed with Cascade Environmental and standard culverts are envisioned here due to the fact the creek is in a bedrock channel. The development areas are raised significantly from the adjoining creek such that flooding is not a risk.

There is currently a cut-off ditch above the Stonegate development to restrict overland flow towards those houses, refer MDP-2 label S/2. The construction of the Upper Benchlands will control and restrict the amount of overland flow running towards the Stonegate homes via bioswales and infiltrations tanks and various other SMP features. As reflected in the master plans, the pre and post catchment is reduced from just over 17ha to approximately 13.0 ha due to the proposed road re-directing flows to discharge immediately to South Creek. The proposed development disturbed area reflects minimal change to pre-development conditions. The disturbed area which includes proposed road and developed area accounts for approximately 2ha (+/- 11%).

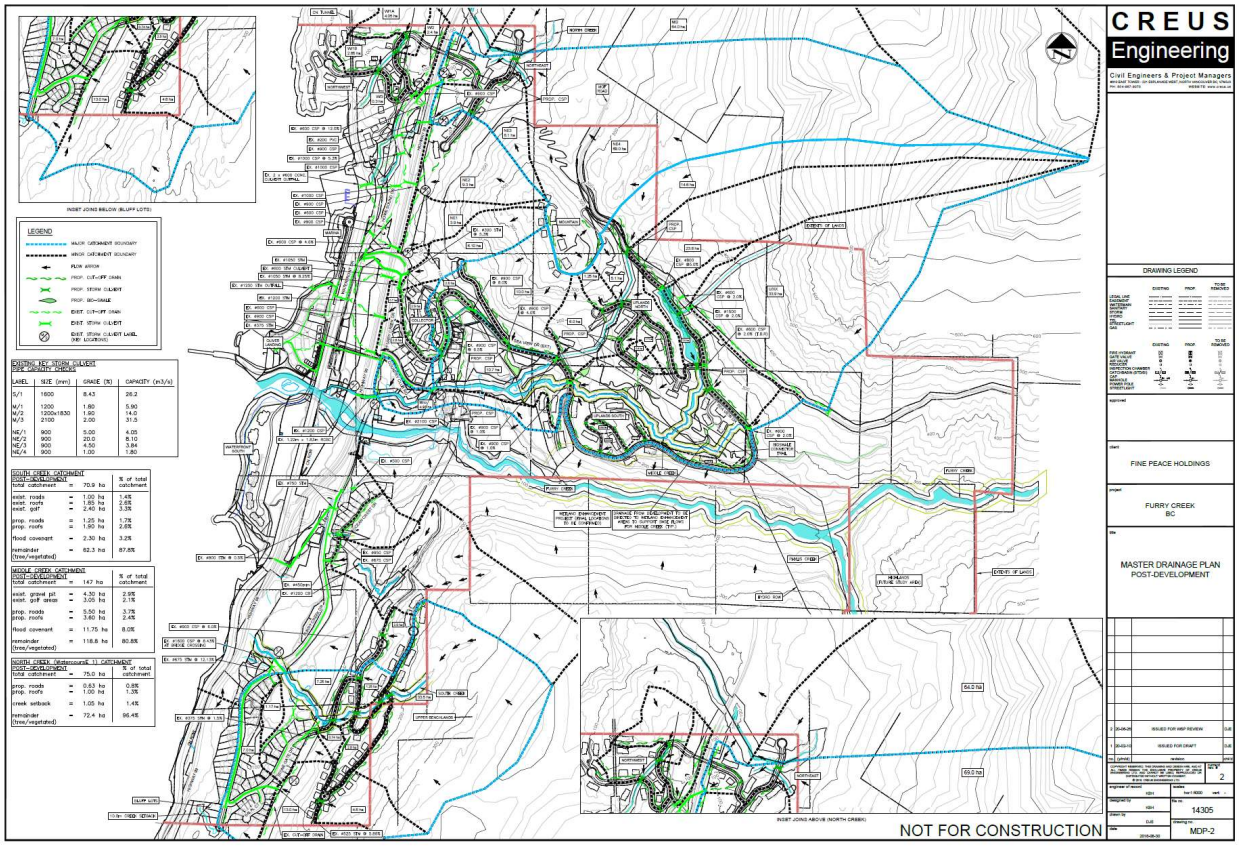

Figure 4: Post Development Drainage Catchments

4.2. MIDDLE CREEK (UPLANDS, MOUNTAIN AND COLLECTOR)

The Middle Creek Drainage Catchment totals an area of approximately 147ha. The catchment ranges in elevation from 1100 m above the Uplands and Mountain area to sea level where it discharges into Furry Creek and out to Howe Sound. The area is largely bedrock controlled in the upper and lower areas with some known significant gravel deposits in the pit area in Uplands South and the golf course. The existing breakdown of land use is 4.3ha existing gravel pit areas (+/-3%), 3ha golf course (2%), existing gravel roads of 4.4ha (+/-3%), low vegetation covered BC Hydro ROW of 9.7ha (+/-7%) with remainder forest regrowth and rock outcrops. The zoning anticipates 30.0ha of future development disturbed areas (+/-20%), which includes approximately 5-6 ha of future roads (less than 5%), 11.7ha of Middle Creek covenant BL333988 (8%) which will be largely undisturbed other than road crossings. The remaining +/-104ha is largely tree covered (+/-70%). The development footprint in the area is exceedingly small and managing stormwater will be readily achievable. The terrain is steep with a mix of cliffs and rocky outcrops with flatter sections of gravel and till overburden. The forest age ranges from young to mature throughout the Middle Creek catchment and is dominated by Douglas-fir, western red cedar and lodgepole pine. There are significant portions of this drainage that are under BC Hydro transmission rights of way. The lands vary from having shallow soil with a layer of shrub laying on mostly bedrock to portions of Uplands North and South area and golf course that have significant gravel deposits.

Middle Creek originates within the project extents from the east and flows through the Uplands and south of Collector and north of the existing Clubhouse where it enters a 2100mm culvert in

the clubhouse driveway and continues through the golf course and under Highway 99 via 1.22m x 1.83m concrete box culvert and into a 1200mm culvert and continues approximately 150m downstream and merges with Furry Creek before the CN rail crossing, which outlets to Howe Sound. Upstream of the Uplands the gradient averages 50%. From the golf course (hole 18) continuing about 370m upstream, the creek is confined to a ravine approximately 50m wide and the bed material is composed predominantly of boulder and bedrock. The channel morphology varied in this section exhibiting a step-pool morphology with an average slope of 27%, with field measurements of 37% in steeper sections, a bankfull width of 8.35 m and a wetted width of 5.21m. Canopy cover was approximately 40% and instream cover between 15% and 20% mainly consisted of overhanging vegetation. No pool larger than 0.25 m depth was noted in this section. Approximately 190m from the edge of the golf course are two distinct small waterfalls and is deemed as an impassible fish barrier for upstream fish passage.

RCPL modelled the lands and sized the existing culvert under clubhouse driveway as a 2100mm culvert, labelled as M/3 on the MDP-2 plan prepared by Creus. They also modelled the 1200mm culvert (M/1) and 1.22m x 1.83m box culvert (M/2). Middle Creek discharges to Furry Creek which outfalls to Howe Sound between Oliver's landing development and the proposed Waterfront Development. A bridge over Furry Creek from Oliver's Landing to the Waterfront was designed by Associated Engineering to a preliminary stage in consultation with Delcan as part of the flood protection works to provide adequate freeboard over the creek.

The proposed development areas are consistent with the original RCPL zones. The level of stormwater management is more stringent currently than during the original RCPL designs. The move towards more multi-family while maintaining a similar overall number of units will lead to lower percentage of introduced impervious surfaces. This is expected to lower the flows from the original analysis. This will be updated as part of the detailed ISWMP for the area.

The Middle Creek drainage includes the existing Country Club Road the clubhouse, golf course, gravel pit and an existing dirt road. The future design of Sea View Drive (extension) has maintained a similar horizontal geometry to the existing dirt road. This road has a series of culverts and the road geometry currently cuts off the overland flow. It is expected that the proposed Sea View Drive (extension) will generally maintain the pre-development overland drainage flow path with minor changes. Future land to be developed within the Middle Creek catchment includes: Collector, Uplands South and North, Mountain and a Resort near the existing clubhouse. The majority of the dwellings will be a mix of stacked and ground orientated multi-family and the remainder being single-family. While the total amount of dwellings is yet to be determined, it is expected to be a mix of single-family houses and multi-family with approximately 40 buildings. The actual development disturbed area is approximately 30ha (+/-20% of Middle Creek catchment), with 7-8ha (+/-25% of the total disturbed area) being within the existing gravel pit deposits. A majority of the remaining lands will be founded on bedrock. In the original layout the footprint was significantly larger as the there were a similar number of single-family and townhouse dwelling units covering a much larger percentage of the lands.

There are three key existing drainage infrastructure culverts which are labelled on the MDP-2 as M/1 (Highway 99), M/2 (Furry Creek Drive) and M/3 (clubhouse entrance). M/2 and M/3 were previously sized by RCPL as mentioned in the paragraph above. M/1 was sized by Highway at the time of the Highway upgrade in 2008/09. M/2 and M/3 were oversized for fish passage. The adequacy of the existing culverts had been designed with the expectation of developing the Uplands, Collector and Mountain as single-family and townhouse. There are a series of existing culverts on the existing road that follows Sea View Drive (extension). It is expected that these will

all be replaced when detailed analysis and culvert sizing is done. The stormwater features will ensure that minor storm flows will reflect pre-development flows.

The land type in the Uplands, Mountain and Collector area is partially bedrock controlled and partially deep gravel deposits. This will direct where opportunities for infiltration will be. There will also be significant opportunities to detain in ponds and infiltrate at slow rates into the tree cover via bio-swales at various locations as seen in the MDP-2 plan. The much smaller development footprint frees up large areas of the site and especially areas in the existing BC Hydro transmission ROW. The introduction of bio step ponds in the area between Uplands North and South was initially discussed with DFO in the mid 1990s to avoid piping drainage directly to Howe Sound. There is a large park like setting there that will accommodate a significant amount of step ponds, bio-swales and other features. There has been a significant wetland identified in the Uplands North area that will be retained, protected and enhanced. Some onsite works may require stormwater features in a more structural form of Brentwood Boxes etc. Middle Creek crosses the future Sea View Drive and has watercourse crossings via culverts at eight locations. The storm drainage will be maintained in largely the same form with multiple locations where the drainage is returned to Middle Creek via bio-swales and step ponds. During detailed design the crossings will be reviewed with the Environmental Monitor to determine the optimal crossing mechanism, however open bottom culverts will be used where they provide enhanced benefit for the creek. The development areas are largely raised significantly from the adjoining creek such that flooding is not a risk and this will be reviewed in more detail at that time.

Currently the intent is to maintain the natural watercourse and existing overland flow route. In general, proposed roads will have a cut-off ditch on the high-side and where the flow is concentrated as a result, the design intent is to disperse these concentrated flows and re-enter the existing watercourse to minimise concentration to any specific area and resulting degradation. As discussed previously these key areas will discharge via bio-swales before entering Middle Creek. The current and future overland flow routing is such that the small development pods tend to discharge both minor and major storm systems to tributaries of Middle Creek and not to other development pods. There are portions of Uplands South that could, in an overland flow route, bypass the Sea View Drive drainage catchment and affect the development in the west edge of the Uplands South above the existing golf course. This will require some attention to design the uphill ditch of Sea View drive in a manner to safely convey the 200-year flows back to the Middle Creek channel and into the golf course. Majority of the Mountain neighbourhood is captured on the high-side of the proposed road via a cut-off drain and drains toward the Northeast catchment, with the remainder directed to Middle creek tributaries via wetlands which will mitigate peak flows. The Collector area is stepped such that only a small area drains to another catchment. The remainder of the area drains either to Tributaries of Middle Creek to the main channel through the golf course.

Figure 5: Drainage Bio-Swale, Middle Creek (Uplands)

4.3. FURRY CREEK

Furry Creek enters the subject property from the northeast and outlets to Howe Sound and is the main watercourse within the subject site. Phyliss Creek joins Furry Creek from the southeast near the top of the property with a future study area occurring between the two creeks. The environmental report completed by Cascade indicate that 700 m upstream from Howe Sound is an impassible waterfall adjacent to the clubhouse that is a barrier to fish passage. Downstream of the falls, Furry Creek supports coho salmon, coastal cutthroat trout, rainbow trout/steelhead, dolly varden char and sculpin. This area has already been developed as golf course and Oliver's Landing. The proposed Waterfront development sits on the south side of the outlet of Furry Creek on Howe Sound. The flood protection on the south side of the creek and along the Howe Sound foreshore is already in place.

The fan of Furry Creek has been the subject of a number of studies that were used to do the detailed design of the flood protection works. Kerr Wood Leidal (KWL) conducted previous inspections of the constructed flood protection works for the SLRD. In a 2005 inspection of Marina Phase flood protection and erosion protection works concluded that monitoring of Large-woody Debris (LWD) in the foreshore area was required as it had the potential to damage the riprap protection. In 2009 a review concluded that debris flood and coastal hazards may damage the private dock in the Marina Phase. The report again noted LWD in the foreshore embayed area but little evidence of erosion/ damage. In 2010 an inspection of Marina Phase erosion hazards notes an increase of LWD had plugged the drainage outfalls and erosion in the embayed area. The report recommends clearing of the drainage outfalls, removal of LWD and addressing erosion

through re-shaping/ planting or riprap construction. The SLRD is the operator of the dike system and will continue to fund dike inspection and repair as authorized under bylaw 481, 1992.

The Technical Memorandum issued on August 31st, 2020 by KWL details that two phases of flood protection works were constructed. Phase one at Marina was constructed in 2000 and a second phase at Waterfront in 2013. Since construction of the flood protection works SLRD has performed periodic inspection of the works. The Creek and Foreshore floodproofing works have been installed and the major components of the works included dike setback, foreshore and bank riprap protection and cobble shoreline erosion protection, mechanically stabilized earth (MSE) wall foreshore protection and overflow route/outlet are in place. Refer to the Delcan record drawings within Appendix 19:**Error! Reference source not found.**. The necessary flood covenants, environmental setbacks, development covenants, and SROW have been registered on title as detailed in the KWL memo. The SROW for operating the Waterfront Foreshore and Creek protection work will be registered at time of the Waterfront development. An overflow floodway has been protected by covenant on the 15th fairway to allow for Furry Creek to overflow in the event of a blockage of Furry Creek without negatively affecting the residences planned there. The Delcan drawings provide preliminary drawings and the details of that design will form part of the Development Permit drawings for that phase of works. The piles for the future bridge between Oliver's Landing and Waterfront South already have been driven in place through the creek flood protection. Currently there is minimal proposed works that directly discharges to Furry Creek. Middle Creek merges after crossing Highway 99 and had received environmental remediation at the time of golf course development. No further works are proposed in the Furry Creek wetted perimeter.

Thurber Engineering has created a report that denotes areas subject to various hazards including Fluvial and debris. These will fall within Development Permit Zones which will require further study at that time prior to Development Permit and Subdivision.

4.4. NORTH CREEK

North Creek crosses the subject lands within the proposed Northeast development and continues north-west under Highway 99 and out to Howe Sound outside of the subject lands. The contributing catchment to this creek is largely north and outside of the subject lands and therefore result in minimal change to pre-development site conditions. North Creek has minimal impact to the proposed development as the preliminary design anticipates to have one crossing to provide access to a possible multi storey high-rise. North Creek has a length within the subject lands of approximately 250 m. The creek leaves the site in a northwest direction and crosses under Highway 99 north of the subject property via a culvert and then runs approximately 670m where it discharges to Howe Sound.

4.5. NORTHWEST AND NORTHEAST DRAINAGE

The southern portion of the Northeast development lands is tied to the Northwest lands via a series of culverts under Highway 99 and Howe Sound Drive. The Northwest development lands sits on the foreshore of Howe Sound on a hill which ranges in height from sea level to approximately 160m in elevation with drainage directed to Howe Sound. Several ephemeral drainages have been flagged by Cascade Environmental as "unnamed watercourse 1" which can be seen on MDP-1. This watercourse course continues south-west where it crosses under Highway 99 via a 900mm culvert which can be seen on MDP-2 labelled as NE/4. The proposed lands are expected to contribute to the watercourse 1 but do not raise any concerns to the

downstream drainage pipes capacity, which is further detailed below. To the west is unnamed watercourse 2, which runs south-west and out to Howe Sound. The contributing catchment is relatively small and the proposed roads will have three crossings, the majority of the Northwest drainage is discharged directly to Howe Sound and will be further discussed below. The Northeast drainage catchment (watercourse 1) where it enters an existing 900mm culvert before Highway 99 totals an area of approximately 75 ha. The catchment ranges in elevation from 75m at the inlet location labelled NE/4, to 1100m above Uplands and Mountain area. The area is a combination of bedrock, cliff to tree covered and vegetated. The area is currently mostly tree covered with the remainder being the North Creek watercourse 1 setback.

The proposed development of Northeast poses minimal change to pre-development conditions and will have minimal impact to existing culverts. The proposed development area to be disturbed amounts to approximately 5.0ha (+/-7%), which includes less than 1 ha proposed roads (1%) with the remainder largely tree covered and undisturbed of over 90%. This is a very low level of impact. There are a series of culverts downstream of the NE/4 culvert. The design intent is to install a series of ponds and bioswales leading to each of the 900mm culverts under Highway 99. The large un-developed area allows for significant detention and infiltration. If the existing culverts were blocked, the flows would pond until they overflow to the next culvert, refer MDP-2 for reference to the culvert locations. This would not affect the highway embankment due to height differential nor the building which sit significantly above the culvert invert. In an event where the 900mm culvert (NE/4) were to reach maximum capacity or become blocked, flows would bypass to NE/3, NE/2 and NE/1. The master plan tabulates an approximate capacity of these culverts and it is noted that the 900mm culvert (NE/2) has a lot of capacity due to its grade and would allow for an inundation of flows in a major storm event. Downstream and east of Highway 99 the drainage outlets under the CN rail via 2 x 600mm culverts and out to Howe Sound.

The Northwest (NW) development lands have an existing watercourse 2 which branches off North Creek and heads south-west through the proposed lands where it crosses the proposed roads at three locations before continuing out to Howe Sound. The catchment that contributes to this watercourse is approximately 7ha, of which approximately 3ha will be disturbed accounting for about 45%. The remainder of NW catchment area discharges directly to Howe Sound via overland flow. There is currently one existing 600mm culvert that is within the lands and labelled as NW/1, MDP-2 plan clearly shows that the pre and post development catchment has very minor impact to this culvert. The NW lands range in elevation from 160m to sea level. The terrain generally consists of exposed bedrock which forms a series of irregular knolls and ridgelines separated by steep bluff of about 55% grade. The area is currently consisting of young to mature forest and shrub vegetated. The Northwest development raises little concern and overall a very low level of impact. The intent is to install various SMP features to maintain pre development condition when discharging to watercourse 2, the remainder of the catchment will be released directly to Howe Sound.

5. CONCLUSION

The proposed zoning of the lands is largely consistent with the original plans, engineering and the approved Preliminary Layout Approval. The development zones have not changed. The original vision for the community was 920 residential units in single and multi-family format, golf course, 300-unit Resort, Commercial amenities and a large Commercial Marina. This has evolved to 920 residential market units, 120 additional non-market units, a commercial village centre and resort facilities. The residential units are now largely stacked multi-family as opposed to the original single-family and ground orientated multi-family. The footprint of the development has

shrunk considerably given the total number of units is largely unchanged. The future roads and building footprint disturbed areas account for approximately 58ha (+/-14%) which is small fraction of the total 1036acre site (419ha). Of the developed area, pre-existing development was on the CN and Highway as well as gravel pit operations. There are non-residential landscaped areas of around 60ha as part of the golf course lands. CN rail is 10.96 ha, existing residential development is approximately 12ha, highway lands accounts for approximately 84.5ha within the site boundary, and the remaining area which includes the future development subdivision areas will remain largely pervious accounting for approximately 192 ha.

Existing drainage routes of North, Furry, Middle and South Creek divide the drainages into reasonably small catchments prior to discharge to Howe Sound.

Creus has reviewed the existing RCPL stormwater report. The proposed rezoning will not require any works that are beyond normal works required for development. None of the existing infrastructure appears to require upgrading. The Furry Creek development is consistent with the SLRD official community plan and regional growth strategy. As per the OCP, “The objective for the Furry Creek Neighborhood is to continue to recognize the Planned Community designation, and encourage adequate provision of community facilities and public open space as the development proceeds.” The proposed development fits well within this objective. The proposed development zones are consistent with the original planning and have the support of the environmental, geotechnical, traffic management, landscaping and civil infrastructure consultants in confirming they are suitable for their intended use.

The proposed development will have a small impact to the overall existing catchment areas. There will be the addition of impervious hardscape within the development. Typical methods of detaining and controlling the runoff have been proposed including roadside ditch, bio-swales, infiltration swales and rock pits. This will allow the development to meet the objectives of matching pre and post development flows. The existing drainage paths have almost exclusively been maintained and incorporated into the design. The existing drainage culverts installed in existing phases are largely independent of the proposed development. The exception is the existing culvert placed under Furry Creek Drive in South Creek which will accommodate the originally planned Upper Benchlands Development. The Middle Creek drainage will largely have all new crossings other than the existing crossing of the highway which were designed in anticipation of the development. Furry Creek will have one additional bridge crossing that has been sized by Delcan. North Creek will have one crossing. The majority of Upper Benchlands catchment will discharge directly to South Creek, with a small portion entering the network above Salal Court via an existing cut-off drain which was sized previously and will not negatively affect downstream residential units. The Uplands discharge to Middle Creek in numerous outlet locations via step ponds and bio-swales. The existing permanent culverts installed were largely oversized but will be analyzed at the time of ISWMP for the area. The Northwest area largely drains directly to Howe Sound. The existing permanent culverts installed were largely oversized but will be analyzed at the time of ISWMP for the area. The Northeast area has a small catchment tied to North Creek but the majority drains to a series of 900mm culverts under Highway 99. The developed area is very insignificant compared to the catchment area. The existing permanent culverts installed were largely oversized but will be analyzed at the time of ISWMP for the area.

All culverts and ditches will be designed using minimum 600mm culverts for ease of maintenance and to accommodate the 100-year flow including the effects of climate change. The ISWMP will also account for overland flood routing for 200-year storm to ensure residences and key infrastructure are not at risk. Stormwater design will be to meet the requirements of MMCD.

The development as shown is viable and can be designed and constructed using standard engineering design and construction standards. This was supported by WSP as SLRD's engineer in their review and confirmation email dated August 8th 2020. It was agreed that a full ISWMP for each watershed to be triggered by the first Subdivision or Development permit application within that watershed. If there are changes between subdivisions, that might require an update to the ISWMP or a technical memo depending on the impact of the change.

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6. APPENDICES

Appendix 1: CONTEXT PLAN
Appendix 9: REZONING PLANS
Appendix 10: INFRASTRUCTURE AND ROAD PLANS
Appendix 11: SUMMARY OF REPORTS ON WATER
Appendix 19: FLOOD PROTECTION WORKS
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