District of Stewart

Avalanche Development Guidelines Review

Final Report

6 Point Engineering & Avalanche Consulting Ltd.
202c-330 Baker St. Nelson, BC V1L 4H5 CANADA
Tel: 250-777-1254 email: info@6pointeng.com
www.6pointeng.com

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1 Introduction

6 Point Engineering (6PT) was contracted by the District of Stewart to provide a review and recommendations in support of the development of guidelines for avalanche hazard development permit areas located within the townsite. This report summarizes the scope of work including:

- A review of the inputs and recommendations outlined in the District of Stewart Townsite Avalanche Hazard and Risk Assessment (Alpine Solutions Avalanche Services, 2019).
- A review of land use policies for avalanche hazard in other North American communities.
- Review and recommendations for updated Avalanche Hazard Development Permit Area guidelines.

The intention of this work is to provide the District of Stewart with additional information and recommendations with respect to the implementation of land use planning guidelines for the specific avalanche hazard context of the municipality.

2 Background

2.1 District of Stewart

The District of Stewart is a municipality situated in northwest coast mountain range of British Columbia within the Regional District of Kitimat-Stikine (Figure 2-1). The community has a population of 517, including 337 private dwellings, located within a land area of 552 km^2 (Statistics Canada, 2022). The townsite area is located at the head of the Portland Canal located at valley bottom near sea level elevation.

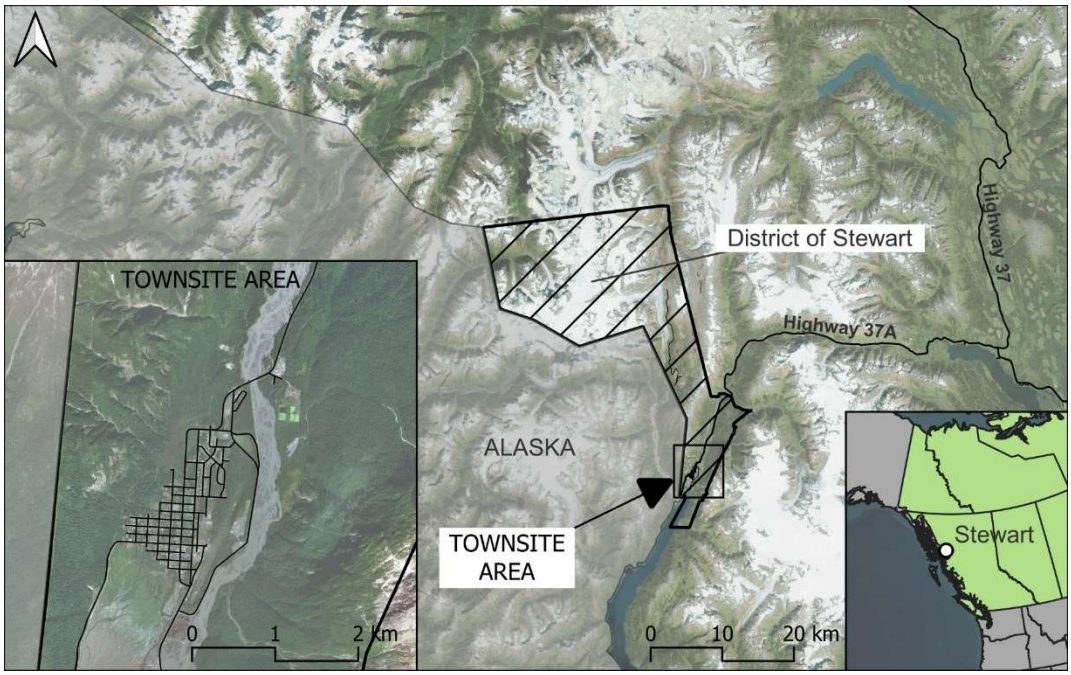

Figure 2-1: District of Stewart Location

The townsite is confined within an approximately 1.7 km wide north-north-east to south-south-west-oriented valley. Steep mountainous terrain exists on both sides of the valley above the townsite reaching elevations up to approximately 1900 m above sea level. Avalanche hazard originates from large and small avalanche paths on both sides of the valley affecting both eastern and western sides of the townsite.

An operational avalanche forecasting and control program is managed the British Columbia Ministry of Transportation and Infrastructure (MOTI) to mitigate avalanche risk to the Highway 37A transportation corridor and the bypass road within the District of Stewart. This includes avalanche paths located in Bear Pass to the east, as well as some paths located within the boundaries of the District of Stewart. The mandate of the MOTI avalanche forecast and control program is to mitigate risk for elements-at-risk associated with transportation corridor (e.g., highway users), this does not include residential or municipal elements-at-risk (e.g., residential or commercial structures, residents when they are not traveling on a highway).

2.2 Relevant regulations and guidelines

Acceptable risk levels associated with avalanche hazard for residential areas within Canada is not federally legislated or provincially legislated in British Columbia. However, zoning guidelines have been developed by the Canadian Avalanche Association to provide best practices for communities subject to avalanche hazard. The Technical Aspects of Snow Avalanche Risk Management (TASARM) (Canadian Avalanche Association, 2016) provides guidelines for this purpose.

TASARM suggests acceptable frequency and magnitudes of avalanche hazards for various land uses (e.g., residential) and common elements-at-risk. Typical avalanche planning and operational measures are also provided in these guidelines. These guidelines for municipal, residential, commercial, and industrial avalanche terrain land use in Canada for structures (occupied and unoccupied) and recognised pedestrian areas are outlined in Table 2-1 below. Structures are considered to be occupied if people gather in or around them for portions of the day or night, if they provide essential services, or otherwise attract people during the seasonal avalanche hazard periods.

Table 2-1: Guidelines for municipal, residential, commercial, and industrial avalanche terrain land use in Canada (adapted from Canadian Avalanche Association, 2016)

Element at Risk	Avalanche Size or Impact Pressure	Return Period	Typical planning
Occupied Structures	≥ Size 1 ≥ 1 kPa	≤ 300 years	• Considered at a path-scale exposed over decades. • Identified using path profile mapping and frequency-magnitude analysis. Typically developed using ground surveys by foot traverse. • Assessed using quantitative procedures and impact-based classification. • Supported by hazard zone and avalanche path maps. • Mitigated using location planning, reinforcement and design of structures, start zone snowpack support structures, track and runout zone long-term measures. Short-term operational measures are used where long-term mitigation does not achieve tolerable risk.

Element at Risk	Avalanche Size or Impact Pressure	Return Period	Typical planning
Unoccupied structures and other infrastructure	> Size 2	≤ 30 years	• Considered at a path-scale exposed over years to decades. • Identified using frequency-magnitude analysis. Typically developed using ground surveys by foot traverses, supported by vehicle and/or flying. • Assessed using qualitative or quantitative procedures and impact-based classification. • Supported by hazard zone maps. • Mitigated using location planning, reinforcement and design of structures, starting zone snowpack support structures, and track and runout zone long-term measures. Specification of short-term operational measures.
Recognised pedestrian areas	> Size 1	≤ 100 years	• Considered at a path-scale exposed over hours to days. • Typically identified using ground surveys by foot traverse. • Assessed using quantitative procedures and terrain exposure classification • Supported by hazard zone mapping. • Mitigated using location planning, seasonal closures, and specification of short-term operational measures.

For the case of occupied structures, an impact-based terrain classification system provides the basis for hazard zoning maps in Canada. The system defined by TASARM (Canadian Avalanche Association, 2016) delineates three hazard zones based on impact pressures and return periods as is illustrated in Figure 2-2 and described in Table 2-2 below.

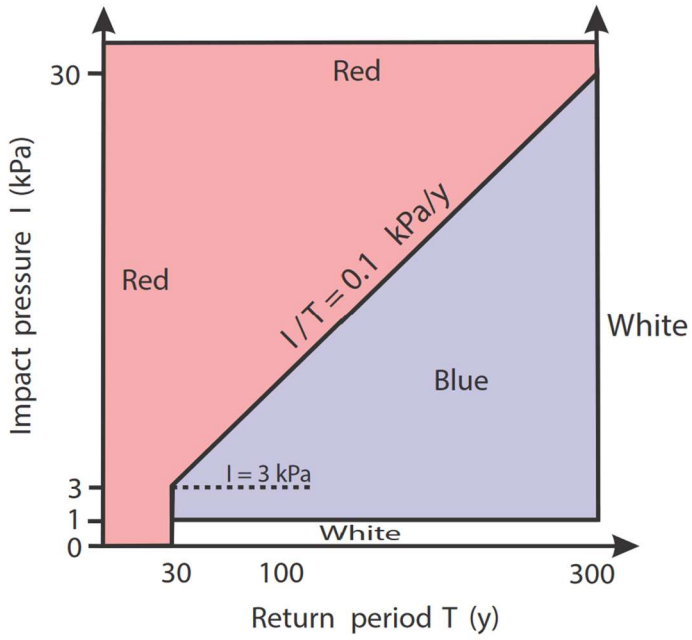

Figure 2-2: Impact based hazard zoning recommended for occupied structures in Canada (Canadian Avalanche Association, 2016)

Table 2-2: Definitions of the impact based zones recommended for occupied structures in Canada as illustrated in Figure 2-2 (Canadian Avalanche Association, 2016)

Zone Colour	Definition	Recommended Activities
White (low hazard)	An area with an estimated avalanche return period of > 300 years, or impact pressures < 1 kPa with a return period of > 30 years.	Construction of occupied structures is normally permitted.
Blue (moderate hazard)	An area which lies between the red and white zones where the impact pressure divided by the return period is < 0.1 kPa/year for return periods between 30 and 300 years, and impact pressures ≥ 3 kPa. The blue zone also includes areas where impact pressures are between 1 and 3 kPa with return periods of > 30 years.	Construction of occupied structures may be permitted with specified conditions.
Red (high hazard)	An area where the return period is < 30 years and/or impact pressures are ≥ 30 kPa, or where the impact pressure divided by the return period is > 0.1 kPa/year for return periods between 30 and 300 years.	Construction of occupied structures should not be permitted.

Although acceptable avalanche risk levels are not defined, British Columbia legislation under the *Land Title Act* provides that "in considering an application for subdivision approval, the approving officer may […] at the cost of the subdivider, personally examine or have an examination and report made on the subdivision, […] refuse to approve the subdivision plan, if the approving officer considers that […] the land is subject, or could reasonably be expected to be subject, to flooding, erosion, land slip or avalanche." (Land Title Act, 1996).

Similarly, provisions under the British Columbia the *Local Government Act* specify that "For land within a development permit area designated under section 488 (1) (b) [protection from hazardous conditions], a development permit may […] specify areas of land that may be subject […] avalanche […] hazard […] as areas that must remain free of development, except in accordance with any conditions contained in the permit; […] may vary the use or density of land, but only as they relate to health, safety or protection of property from damage; […] may require the applicant to provide a report to assist the local government in determining what conditions or requirements […] provided by the applicant at the applicant's expense, and […] certified by a professional engineer with experience relevant to the applicable matter."

Similar to in Canada, the United States have not federally legislated acceptable avalanche hazard levels for occupied structures. Furthermore, 6PT is not aware of a set of national guidelines to provide consistency and best practices within the United States. As such, variation exists between the factors and the level of restrictions that exist between the communities who have implemented avalanche land use zoning.

However, Colorado Geological Survey Bulletin 49 *Snow-Avalanche Hazard Analysis for Land-Use Planning and Engineering* (Mears, 1992) provides an updated summary of additional county and municipal avalanche land use controls in the United States at the time as originally outlined by Niemczyk (1984). These factors include:

- Purpose
- Definitions
- Map(s)
- Avalanche studies
- Applicability
- Prohibitions
- Zoning districts
- Restricted uses
- Permitted uses
- Non-conforming uses
- Permit procedures
- Submittal requirements
- Review criteria
- Criteria for approval
- Mitigation
- Design standards
- Map amendments
- Amendments
- Variances
- Additional studies
- Consultant qualifications
- Referral procedures
- Disclaimers
- Public notice
- Suspension of services

2.3 Avalanche hazard zoning context

On average in Canada, ten avalanche fatalities occur annually (Avalanche Canada, 2022). Recently, these fatalities primarily result from recreational activities and rarely in the context of residential or commercial land use. However, historical fatalities and more recent non-fatal incidents provide examples of the critical role that planning, and land use zoning can play in avalanche risk reduction. Due to the involuntary nature of avalanche risk in townsites compared to recreational contexts, the acceptable risk level is generally considered to be lower.

Historically, 93 recorded avalanche fatalities have occurred between 21 incidents within Canadian towns since 1782 (Woods et al., 2014). The most recent of these incidents occurred in 1999 in Kangiqsualujjuaq in northern Quebec when a school was impacted by an avalanche during a new year's celebration resulting nine fatalities occurred including five children. This event triggered the implementation of risk reduction measures including land use planning in isolated northern communities that involved assessment, temporary community based forecasting and warning program, and the relocation of residents or structures in hazard zones (Germain, 2016). Non-fatal incidents of avalanches impacting residential structures have continued to occur in Canada for example in 2020 an avalanche damaged one home and resulted in the evacuation of others in the Battery neighborhood of St John's, NL (Davie, 2020).

In the United States, examples of avalanche incidents within a residential context also provide relevant considerations for land use planning. For example, the community of Ketchum, Idaho implemented avalanche hazard zoning in the 1970s following a 1971 incident that resulted in four fatalities and damage to seven structures. Subsequent urban avalanche occurrences in and around Ketchum have highlighted some of the additional challenges of managing avalanche hazard in these types of communities such as risk to private and city services, building contractors, real estate services, public transport, visitors, foot traffic (e.g. dog walkers and tobogganers), and curious spectators (Kellam, 2012).

3 Townsite Avalanche Hazard and Risk Assessment (Alpine Solutions, 2019)

Alpine Solutions Avalanche Services (Alpine Solutions, 2019) provided the District of Stewart with a detailed avalanche hazard assessment for the purposes of updating municipal hazard zoning within the community. This scope included the provision of hazard zoning maps identifying parcels of land exposed to moderate and high avalanche hazard. The report further provides mitigation approaches for the reduction of avalanche hazard in the community.

The study completed by Alpine Solutions to determine impact-based avalanche hazard zoning involved a desktop assessment (snow climate analysis, interpretation of imagery, historical records, and accounts), a field survey (ground and helicopter based), and numerical avalanche modeling. Numeric modeling methods used a confidence based weighted average based on the results of statistical (Alpha-Beta, Runout Ration Model, Alpha regression model for short slopes, and Alpha-Beta models for powder and air blasts) and physical dynamic models (PCM, RAMMS, and AVAL-1D). Delineation of red (high hazard) and blue (moderate hazard) zones were implemented at a path scale based on the impact-based terrain classification as defined in TASARM. Impact pressures were considered for both dense and powder flow components at a 300-year return period.

The resulting mapping identified occupied structures fully or partially located within blue and red zones as outlined in Table 3-1 below. Additionally, a transmission line, occupied vehicles on roads, facilities and infrastructure at the airport and industrial port (including occupied vessels, and vessels containing hazardous materials) were identified as partially located within the blue and red zones.

Table 3-1: Occupied structures in avalanche hazard zones as identified by Alpine Solutions (2019)

	Red Zone	Blue Zone
Single-family residence	133 lots*	494 lots
Multi-family residence	0 lots	1 lot
Schools and public use	0 lots	1 school; 1 recreation centre
Commercial	0 lots	152 lots

**No existing occupied structures were identified within these lots*

Mitigation options discussed included land use zoning policies, a forecast and evacuation plan, avalanche explosives control and remote avalanche control systems (RACS), and long-term measures (snow support, runout zone structures, and site-specific structural measures). More specifically:

- Expand the hazard forecast from the existing MOTI Bear Pass highway avalanche program for the Bypass Road to include the threatened areas of the Stewart townsite. Implementing an avalanche forecasting program and developing an evacuation plan. Requires active weather, snow, and avalanche observations with continual analysis.
- Revisions to land use zoning. Areas affected by avalanche hazard could include additional structural requirements, occupancy restrictions, evacuation plans, etc.
    - Site specific structural measures for areas within the blue zone, as directed by revised land use zoning.
- Long term measures, such as catchment berms or supporting structures may mitigate the avalanche risk however, the capital cost is significant.

The hazard assessment measures and recommendations are consistent with industry practices and the recommended practices identified in TASARM (Canadian Avalanche Association, 2016). While a detailed technical review of modeling is beyond the scope of the current study, the inputs, assumptions, and resulting recommendations are considered reasonable for the context of providing avalanche hazard zoning for the townsite area of the District of Stewart.

4 North American municipal avalanche development practices

A review of existing municipal avalanche development practices in North America included an examination of existing practices in municipalities that have acknowledged avalanche risk within their respective land use planning instruments. This review includes nine Canadian municipalities or regional districts, and nineteen municipalities or counties located in the United States (Table 4-1). While this is not a comprehensive review of all municipalities that may include avalanche land use planning within their zoning, it does provide a range of approaches to land use planning for avalanche risk. Notably, the context of the avalanche hazard within each community varies and will contribute to differences in appropriate land use planning approaches. Additionally, a community's resources including technical, administrative, and financial capacities will influence the appropriate hazard reduction tools for a given community.

Table 4-1: Sample of North American Communities with land use planning regulations for avalanche hazard

Community	Province/ State	Country	Identifier	Community	Province/ State	Country	Identifier
Fernie	BC	Canada	FBC	**Juneau**	AK	United States	JAK
Regional District of East Kootenay (RDEK) - Elk Valley	BC	Canada	EVB	**Ketchum**	ID	United States	KID
Regional District of East Kootenay (RDEK) - Island Lake Lodge	BC	Canada	ILL	**Missoula County**	MO	United States	MMO
Regional District of East Kootenay (RDEK) - Steeples	BC	Canada	STB	**Mono County**	CA	United States	MCA
Regional District of Central Kootenay (RDCK) - Area D	BC	Canada	ADB	**Town of Mammoth Lakes**	CA	United States	MLC
Regional District of Fraser-Fort George (RDFFG) - Robson Valley-Canoe Upstream	BC	Canada	RCB	**San Miguel County**	CO	United States	SMC
Fraser Valley Regional District (FVRD) - Hemlock Valley	BC	Canada	HVB	**Ophir**	CO	United States	OCO
Waterton (Improvement District 4)	AB	Canada	WAB	**Pitkin County**	CO	United States	PCO
Nain	NL	Canada	NNL	**Placer County**	CA	United States	PCA
Blaine County	ID	United States	BID	**Salt Lake County**	UT	United States	SLU

Community	Province/ State	Country	Identifier	Community	Province/ State	Country	Identifier
Breckenridge/Summit County	CO	United States	BSC	**San Juan County**	CO	United States	SJC
Chelan County	WA	United States	CWA	**Sun Valley**	ID	United States	SVI
Cordova	AK	United States	CAK	**Village of Taos Ski Valley**	NM	United States	TNM
Gunnison County	CO	United States	GCO	**Vail**	CO	United States	VCO

4.1 Application of land use policies

Due to the lack of legislation and/or guidelines defining acceptable avalanche hazard levels across jurisdictions, the application of land use restrictions is not uniform across municipalities. Three general strategies are observed between the communities examined. These strategies include applying avalanche land use policies using a graduated system where high, moderate, and low risk avalanche zones are delineated and handled differently by policy instruments; a two-level system where avalanche hazard zones are defined, but not further distinguished between high or moderate hazard levels for the implementation of land use requirements; and single leveled systems where avalanche design requirements are applied to all new occupied structures (one community).

Notably where a multi-tiered system (either two or three levels) is applied, the definition of avalanche hazard levels delineating between these boundaries is not necessarily consistent between communities, or in some cases is not formally defined within the policies. While hazard zones aligning with the TASARM (Canadian Avalanche Association, 2016) document described in Section 0 are common, other examples include less conservative 25-year return period or 600 psf (29 kPa) lower threshold for high hazard zones, and 100-year return period lower thresholds for moderate hazard zones. One community (HVB) includes provision for changes to their hazard acceptability thresholds for development approvals as *'established and adopted by the local government or provincial government after considering a range of social values'* (Fraser Valley Regional District, 2020).

4.2 Land use policy components

The following subsections describe the range of land use controls observed within the documentation of the observed community policies. Land use policies range from very simple statements to more comprehensive approaches. Examples of communities who have taken a comprehensive approach see the Official Community Plan, Bylaws, or Land Use Codes of the Fraser Valley Regional District in Hemlock Valley, BC; Ketchum, Idaho; and Cordova, Alaska. While land use controls described below are best considered within the context of the individual community and their full policies, the intention of the subsections below is to provide a perspective on the range of tools that have been implemented in North America.

4.2.1 Prohibited uses

In general, the development of occupied structures was explicitly prohibited in municipalities who differentiated a red (high hazard) zone within their policies. Additional land uses that were prohibited within red zones in some municipalities included commercial occupancies, storage facilities, temporary structures, any seasonal uses open to the public during winter months, storage of vehicles, boats or equipment, hazardous materials including fuel, or junkyards (CAK).

Within blue (moderate hazard) zones and for two-leveled policies that do not specifically distinguish between blue and red zones language around development generally discourages or restricts development in hazard areas rather than explicitly prohibiting it.

4.2.2 Permitted uses (exemptions from policy)

Specifically permitted uses without restrictions are defined in some communities within red, blue, or general hazard zones. Water conservation and flood control, seasonal uses for parks, campgrounds, greenbelts, and land reserves outside of winter months; and utility installations are specifically permitted land uses within red zones identified by one municipality (CAK).

Within communities that specified permitted uses in red zones, those uses were also permitted in the moderate hazard blue zones. In addition, seasonal bed and breakfasts used outside of defined winter hazard period were permitted in blue zones for one community (CAK).

Similar land use permittance existed in some communities with general hazard area policies, for example, open space uses including nature trails for walking, hiking, and biking but not developed recreational uses (e.g., playfields, courts, permanent buildings) (OCO).

4.2.3 Restricted uses

Restricted land uses allowing for some development within hazard areas is common for moderate hazard blue zones, or within communities who define a single avalanche hazard zone. In one community (GCO) within red zones, subdivision roads and utilities are permitted given that roads avoid areas with return periods less than 10-years, and utilities are buried or otherwise designed to minimize exposure.

Many communities permit the development of occupied structures, including single-family residences, in blue zones given that additional requirements beyond the base land use case are met. Examples of additional requirements include:

- That **no alternate development areas exist** within the property because, the entire property area is within the moderate hazard zone, or the hazard cannot be avoided (HVB, GCO); or other possible development areas outside of the moderate hazard areas in a property are constrained (for example by other hazards) (PCO).
- Development is limited to the **lowest hazard areas** (e.g., as far away as possible from the base of steep slopes and ravines_.
- **Mitigation measures** are implemented to reduce the avalanche hazard or risk (VCO, GCO, PCO, JAK, SLU, BID, HVB, CAK, JAK).

- Avalanche **risk or hazard is not increased** by development actives on the subject property, another owner's property, or the personal safety of others.
- Specification that costs of avalanche control measures and mitigation are **at the owner's expense** (PCO).
- Avoidance of hazard areas and registration of a covenant for construction to only occur within the low hazard (white) zone for **properties partially located within a blue zone or avalanche hazard area**, in some communities this requires that a qualified professional identifies safe access and building zones.

4.2.4 Mitigation measures

Some communities specify the implementation of mitigation approaches including some combination of:

- **Structural protection** measures (e.g., direct protection through structural reinforcement, avalanche stopping or diversion structures, start zone support structures).
- Prohibition of removal of **natural barriers** (e.g., no large-scale removal of vegetation in avalanche path start zones).
- **Density restrictions or reductions** in the development area.
- Reducing hazard for access, such as requirements that **roads** avoid avalanche hazard if possible; secondary access provided; exposure limited and avalanche control practices in place in exposed road segments.
- **Seasonal restrictions** of the land use including for residential (e.g., rentals, and sublets), commercial, and extractive operations during the winter period (often between specified dates).
- **Public notice** including **signage** required in commonly traveled winter roads and trails crossing avalanche hazard zones, and **notice to any occupants** (e.g., tenants, subtenants, lessees, potential purchasers, short term rentals). The format of notice to occupants varies but may include written and signed documentation as part of an agreement, contract, or lease; posted warning signage at the property location; documentation in the form of deed restrictions, protective covenants, plat notes; and disclosure in all brochures and other printed materials advertising and/or soliciting reservations for rental or lease of living units during winter periods in red zones.
- Specific mitigation measures for **utilities** in avalanche hazard zones sometimes includes requirements that utilities are buried or otherwise protected (e.g., direct structural measures or deflection/diversion structures).

Operational (short-term) mitigation programs are included in some communities as acceptable measures to reduce risk in avalanche hazard zones for extractive operations, for pre-existing occupied structures as an interim measure, or for roads that must cross hazard areas.

4.2.5 Design standards

In place of detailed design criteria, an assessment to determine design requirements by a qualified professional is frequently required. For example, structural reinforcement measures should withstand the anticipated avalanche forces determined by the consultant in a site-specific study or specified in previous engineering studies on file. In a British Columbian context on community (HVB) requires site specific reports are prepared in accordance with the appropriate EGBC Professional Practice Standards and TASARM (Canadian Avalanche Association, 2016). Other communities specify that widely accepted practices in avalanche theory should be used.

4.2.6 Qualifications of the consultant

Acceptable qualifications of the consultants for design and assessments commonly include a professional engineer licensed in the jurisdiction area (structural and geotechnical disciplines as appropriate to the mitigation measures is sometimes specified), and/or an avalanche professional. Some communities require that the consultant should be a recognized expert in the field of avalanche occurrence, force and behavior or have existing demonstrable recognition as an expert among the community of avalanche practitioners. One community further requires the consultant to demonstrate experience through examples such as submittal and approval of prior applications for development in red or blue avalanche zones, American Avalanche Association or Canadian Avalanche Association certification, proficiency in avalanche modeling software, receipt of specialized training or mentoring in avalanche hazard, snow science, and risk assessments.

4.2.7 Submittal requirements

Specified submittal requirements generally include a study or report completed and certified by a qualified professional detailing some or all:

- methods used to develop the criteria,
- forces including avalanche impact and deposition forces, air pressures, avalanche runout distance, velocity, flow depth, density, and impact pressure potential, forces associated with dense and powder flow avalanche components, and snow creep and vertical forces on mitigation structures.
- mapping that defines the limits of an avalanche runouts (including dense and powder flow components) and identifies the location and dimensions of mitigation measures, and anticipated paths of any diverted avalanche flows due to mitigation measures.
- sealed design plans for mitigation measures.
- and supporting modeling, analyses, and assumptions.

Additional documentation is also required in jurisdictions, for example the Fraser Valley Regional District in Hemlock Valley also requires a signed Letter of Assurance from the engineer and commitment completed by the Qualified Professional Engineer and Avalanche Professional to ensure that all works will be constructed in accordance with the recommendations and a statement that *‘the lands may be used safely for use intended’*.

4.2.8 Referral procedures

Referral procedures sometimes indicate that at the discretion of the municipality, independent third-party reviews of recommendations and studies provided by the applicant may be required at the applicant's expense.

4.2.9 Map amendments

Provisions are sometimes included to allow for amendments to avalanche hazard zone maps based on site specific studies.

4.2.10 Disclaimers

Many communities include a warning and disclaimer of liability. Various language is used to communicate this, for example *'granting a permit does not guarantee the safety of the development; that areas outside of the defined avalanche zoning areas do not imply that they are free of avalanche hazard'*; and a description that '*avalanches occur naturally, suddenly and unpredictably, and persons who develop or occupy real property within an avalanche hazard zone do so at their own risk*'.

4.2.11 Suspension of services

Suspension of city services during periods of avalanche hazard in some communities include emergency services, police, fire, rescue, utility, and snow removal services.

5 Avalanche Development Permit Area Discussion

The following section provides a discussion pertaining the District of Stewarts Avalanche Development Permit Area (ADPA) and Zoning Map drafts. The District of Stewart's Draft Avalanche Hazard Development Permit addresses the subdivision of land or the construction, the addition or alteration of a building or other structure. Land use controls currently include exemptions from the ADPA, prohibited uses in the Dahlie Avalanche Path and Red Zone, and restricted uses within the Blue Zone.

Considering the District of Stewarts specific context including the topographically constrained nature of the townsite, the small community size and associated administrative municipal capacity, and the closely situated MOTI Avalanche program, the District of Stewart may wish to consider the following items within the Avalanche Development Permit Area (ADPA) Zoning bylaw.

ADPA 1.1.6 EXEMPTIONS:

Any exemptions from the Avalanche Development Area process should not have the potential to increase avalanche hazard if they are developed without additional oversight. Currently, there are several items included in these exemptions that could potentially result in an increased avalanche risk including the following:

- Alteration to existing buildings includes the '*addition, replacement or alteration of doors, and windows*' (*1.1.6.1.)*. The addition of windows into the upslope side of structures in avalanche hazard zones can potentially result in an increased vulnerability of structures to avalanche damage. The District of Stewart should consider removing this from the list of exemptions,

allowing for the review of these installations by a qualified professional through the ADPA process.

- The exemption for '*the construction of new buildings or structures less than 10 m^2*' (*1.1.6.3).* We recommend that this exemption to only apply specifically to unoccupied structures.

- Item *1.1.6.4* exempts from the ADPA process '*The placement of temporary construction site offices, structures used for short-term special events and emergency facilities during periods when MoTI designates the avalanche risk as low.*' This exemption assumes that the MOTI avalanche control program is providing an active avalanche forecasting program to the District of Stewart townsite, beyond their primary operational objective of mitigating avalanche risk for transportation corridors. 6PT is not aware of a formalized agreement in place for this purpose. We recommend an agreement is put in place with the MoTI before this item is included in the ADPA.

- *Section 1.1.6.6* provides an exemption for road widening. Road widening has the potential to encourage increased exposure in high hazard zones in particular if this provides additional parking or stopping areas in high hazard areas. Where an increase to avalanche risk exists, this can often be managed relatively easily, for example through signage specifying no stopping in avalanche hazard areas. However, the hazard should be considered within the scope of the ADPA process. We recommend appropriate alterations to existing roads consider discouraging additional parking or stopping areas.

ADPA 1.1.7 Interpretation:

The Avalanche Development Permit Area draft currently includes several definitions for occupied structures (Human Occupancy, Occupied Structure, and Permanently Occupied). Unless this maintains consistency with other municipal bylaws/zoning practices, the District of Stewart may consider simplifying these classifications to simply consider structures as occupied or unoccupied. While the type of occupancy will modify the risk (exposure) of the structure and appropriate mitigation measures, we recommend that the development of any occupied structure in the blue (moderate) hazard zone is reviewed by a Qualified Professional.

ADPA 1.1.8 Avalanche Hazard Area Development Permit Guidelines:

The draft guidelines (subsections *1.1.8.3* and *1.1.8.4*) currently prohibit construction of '*Permanently Occupied and with limited control over access, such as residences, hotels, lodges, and restaurants, within the 'Blue Zone – Moderate Hazard*' and allows for the consideration of *'private structures such as industrial plants, storage facilities, field offices and warehouses.'* Given several mitigating factors are met or the applicant provides *'a study undertaken by a Qualified Professional, that demonstrates that the land may be used safely for the intended use, with appropriate protection from the risk of avalanche'.*

While the mitigating factors listed for structures to be considered within blue zones are consistent with approaches and potentially acceptable risk levels, criteria such as structures being left unoccupied, and access control are generally only effective when implemented with some kind of forecasting and control (warning) program or a requirement for seasonal occupancy. Rather than meeting the selection of criteria outlined in *1.1.8.4.1* to *1.1.8.4.6* or provide a study as outlined in *1.1.8.4.7*, we recommend that the

District of Stewart requires a study be undertaken by a Qualified Professional for any development proposed within a blue zone. The additional mitigating measures outlined in sub-sections *1.1.8.4.1* to *1.1.8.4.6* such as occupancy limits may be included in the guidelines or left to the discretion of the Qualified Professional to provide defense and recommendations based on site specific considerations.

ADDITIONAL PROVISIONS:

In addition to the draft provisions and recommendations discussed above, the District of Stewart may also consider the following:

- **Public Notice:** Subsection *1.1.8.5* requires the registration *'as a priority on the title of the subject property, a covenant that addresses the avalanche risk and indemnifies and saves harmless the District of Stewart against liability.'* The registration of a covenant on the property may provide some communication to owners or developers of land located within the Avalanche Development Permit Area. Additionally, in subsection *1.1.8.4.2* specifies that occupants of private structures are made aware of and accept the risk associated with avalanches. The District of Stewart may consider providing a more specific method of public notice to account for potential occupants of any structure developed an avalanche hazard zone, for example written acknowledgements for long or short-term tenants.

- **Submittal requirements:** To provide the District of Stewart with pertinent information for review of the development permit, and adequate information for an external review if deemed necessary. Specification of addressed within the required studies by the Qualified Professional could either be outlined within the Development Permit Area Guidelines or a separate Assurance Statement to be provided by the Qualified Professional. Specific considerations include:

    - A description of methods used to complete the study.
    - Characterization of the hazard within the development area, including magnitude (forces/loading) and frequency.
    - Consideration of roads or access routes and utilities for the development site.
    - Mapping identifying hazard zones, structures, mitigation measures, and any changes to hazard levels as a result of the mitigation measures on the property and neighboring properties.

- **Suspension of Services:** The District of Stewart may also consider including a provision to allow for the suspension of some municipal services during high hazard periods in the Avalanche Development Permit Zones. During periods of high avalanche hazard, avalanche risk levels dictate that it is unsafe to provide these services. The District of Stewart or other private entities who provide these services during high-risk periods should assess and mitigate risk to workers as per the *B.C. Occupational Health and Safety Regulation Part 4 Section 4.1.1*.

- **Uncertainty in Zoning Maps:** While the existing mapping has been implemented at a level of detail appropriate for land use planning, uncertainty exists with the estimation of large return period avalanche events. Additionally, the scope of the avalanche hazard mapping focuses specifically on

the townsite area, while the proposed zoning is applied to a larger area beyond the townsite extents. The District of Stewart may wish note that lands outside the defined hazard zoning areas do not guarantee they are free from avalanche hazard.

- **Dahlie Avalanche Zone:** The inclusion of the Dahlie Avalanche zone should carry the following considerations. Delineation of the avalanche hazard zone was outside the scope of the Alpine Solutions (2019) study and comes from a different risk assessment context (operational control for highway corridor). Avalanche hazard maps developed for zoning consider different elements-at-risk, including those beyond the extents of the highway, and require a more detailed level of assessment than would typically be considered for an operational level map. We recommend that the District of Stewart undertakes an avalanche hazard zoning study to determine the appropriate boundaries for these avalanche paths.

6 Recommendations

To summarize, 6PT has the following recommendations pertaining the Avalanche Development Permit Area draft and zoning map:

1. Remove the *'addition, replacement or alteration of doors, and windows'* from the list of exemptions in *Section 1.1.6.1.* Windows or doors may increase the avalanche risk to occupants if not designed to resist avalanche impact loads.

2. Rephrase the exemption in *Section 1.1.6.3.* to read: *'the construction of unoccupied new buildings or structures less than 10 m^2'*.

3. Remove *Section 1.1.6.4.* that refers to *'the placement of temporary construction site offices, structures used for short-term special events and emergency facilities during periods when MoTI designates the avalanche risk as low.'* from the list of exemptions. We recommend an agreement is in place with the MoTI before this section is included.

4. Reword *Section 1.1.6.6* pertaining to road widening to include that alterations to existing roads discourage parking or stopping.

5. Remove the references to Human Occupancy and Permanently Occupied as defined in *Section 1.1.7.* Replace references to these terms with Occupied Structure.

6. Adjust the definition of the Qualified Professional in *Section 1.1.7.* to *'Professional Engineer registered in the Province of British Columbia with training and experience in avalanche hazard assessment that is working within their discipline and area of practice as per the Bylaws of Engineers and Geoscientists BC pursuant to the Professional Governance Act.'*

7. Require that '*the applicant provides the District of Stewart with a study undertaken by a Qualified Professional, that demonstrates that the land may be used safely for the intended use, with appropriate protection from the risk of avalanche'* for any development located within a Blue Zone.

8. Add an item to specify a method of public notice for any potential occupants of a structure developed within the blue avalanche hazard zone, including provision for notice short or long-term tenants.

9. Specify minimum contents of the required study undertaken by the Qualified Professional, either within the Avalanche Development Permit Area Document, or through the implementation of a separate Assurance Statement. We recommend studies should require the following items:

    i. A description of the methods used to complete the study.

    ii. Characterization of the Hazard within the development area, including magnitude (forces/loading) and frequency.

    iii. Consideration of roads or access routes and utilities for the development site.

    iv. Mapping identifying hazard zones, structures, mitigation measures, and any changes to hazard levels as a result of the mitigation measures on the property and neighboring properties.

10. Consider adding a statement to allow for the suspension of some municipal services (e.g., emergency services, police, fire, rescue, utility, public transportation, and snow removal services), during high avalanche hazard periods. Evaluating services that remain during periods of elevated avalanche risk is the responsibility of the District of Stewart.

11. Add a statement noting the uncertainty associated with the hazard zoning maps including that lands outside the defined hazard zoning areas do not guarantee they are free from avalanche hazard.

12. Undertake an avalanche hazard study to provide an impact-based zoning map for the additional Dahlie Avalanche Path area using the methods described in TASARM (Canadian Avalanche Association, 2016). If development is required before a study is completed by the District of Stewart, landowners should be required to perform a risk assessment by a qualified professional.

13. Adopt the hazard mapping provided in the Alpine Solutions (2019) for zoning within the areas considered within their study.

7 Limitations

This report is an instrument of service of 6 Point Engineering. The report has been prepared for the exclusive use of the District of Stewart and it may not be relied upon by any other party with our 6 Point's consent.

6 Point has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. 6 Point Engineering makes no warranty, express or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
3. The report is based on information provided to 6 Point by the Client or by other parties on behalf of the client (Client-supplied information). 6 Point has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy.
4. 6 Point should be consulted regarding the interpretation or application of the findings and recommendations in the report.

The project site may be subject to a variety of other geohazards, including but not limited to, debris flows, rockfall, stream avulsions, and seismic events. Geohazard risk assessments are beyond the scope of this study and are the responsibility of others.

8 Closure

Please do not hesitate to contact 6 Point if you have any questions, comments, or concerns regarding this report.

Regards,

6 Point Engineering
Prepared by:

Reviewed and Approved by:

Permit to Practice
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Heather Hordowick, E.I.T. Greg Johnson, P.Eng.

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