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Vista Naramata Subdivision
Naramata, BC

Natural Hazards Assessment

June 28, 2021

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1. Introduction

At the request of Randy Kowalchuk of Vista Naramata, SNT Geotechnical Ltd. (SNTG) undertook a Natural Hazards Assessment of a property located 1.5 km east of Naramata, BC on Arawana Road (the Subject Property – see Figure 1).

The property is currently referenced as PID 029-929-857 and 029-929-865, Lot 3, District Lot 3474, SDYD, Plan EPP60812 and Lot 4, District Lots 2711 & 3474, SDYD, Plan EPP60812.

The subdivision is presently proposed to comprise the division of the land into 41 Fee Simple lots. A layout of the proposed subdivision was presented by CJD Consulting Ltd. in the drawing "*DP 1*" dated June 11, 2021.

In the terms outlined by the Ministry of Transportation and Infrastructure (MoTI) Subdivision Preliminary Layout Review (PLR) letter dated January 15, 2021, the Ministry indicated in Condition 1, "*The Approving Officer considers that the land within your proposal may be subject to natural hazard(s) such as, but not limited to, flooding, erosion, land slip or avalanche*".

Given the setting of the Property, the primary focus of the assessment was directed towards the evaluation of the geotechnical slope hazards above the site and the potential for flood hazards associated with Arawana Creek located immediately south of the property.

To perform the assessment, the following terms of reference were utilized:

Field Assessment

- Perform thorough site review to establish surficial drainage patterns, drainage characteristics, stream characteristics, geologic & geomorphologic conditions and establish the extent, type and history of natural hazards (if any) on the Property and within the adjacent section of Arawana Creek;
- Review the stream characteristics of Arawana creek;
- Review available aerial photos and local geological mapping in context of site conditions and;
- Liaise with provincial government and Regional District of Okanagan Similkameen (RDOS) staff to obtain and review historic reports & information.

Office Analysis & Report

- Summarize geologic and geomorphologic conditions with any observed history of recent natural hazard events;
- Calculate and summarize volumes and extent of perceived natural hazards;
- Calculate the 200 year flood on Arawana Creek;
- Review potential flood routing to establish level of hazard to the proposed development with respect to flood hazard impacts;
- Analyze natural hazard potential with estimates for magnitude, frequency and extent;

- Compile a report for submission to MoTI Development Approvals outlining the site investigation, analysis and the determination of the potential for natural hazards to impact the proposed development, if any.
- Liaise with client's consultant(s), RDOS and MoTI development approvals & engineering staff to ensure fulfillment of required assessments.

The report was compiled following the guidelines and terms of references outlined in the following documents:

- EGBC Guidelines for Legislated Flood Assessments in a Changing Climate in BC, Version 2.1, Published August 28, 2018
- EGBC Guidelines for Legislated Landslide Assessments for Residential Developments in BC, Revised May 2010.

The following report outlines the results of the assessment and details our conclusions.

2. Site Description

The property is located along Arawana Road approximately 1.5 kilometres southeast of Naramata, BC (see Figure 1&2). The Property is located along the east side of the Okanagan Lake valley directly adjacent to Arawana Creek. The general co-ordinate of the property is UTM 11N: 314,385 E, 5,496,190m N.

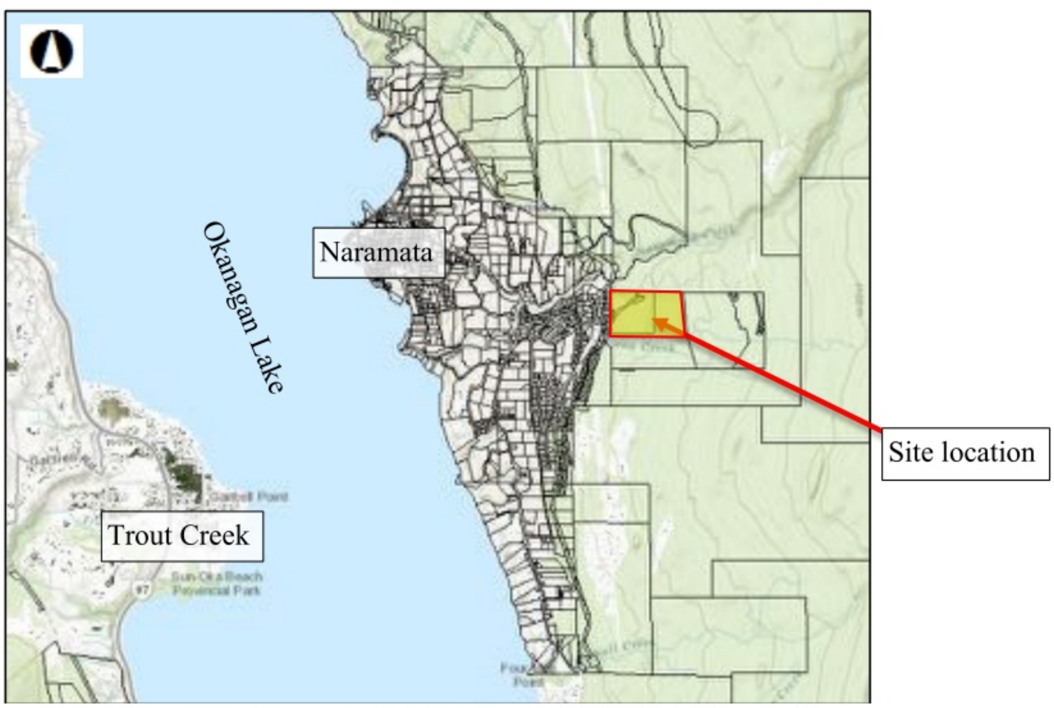

Figure 1: Vista Naramata Subdivision (RDOS Web Mapping)

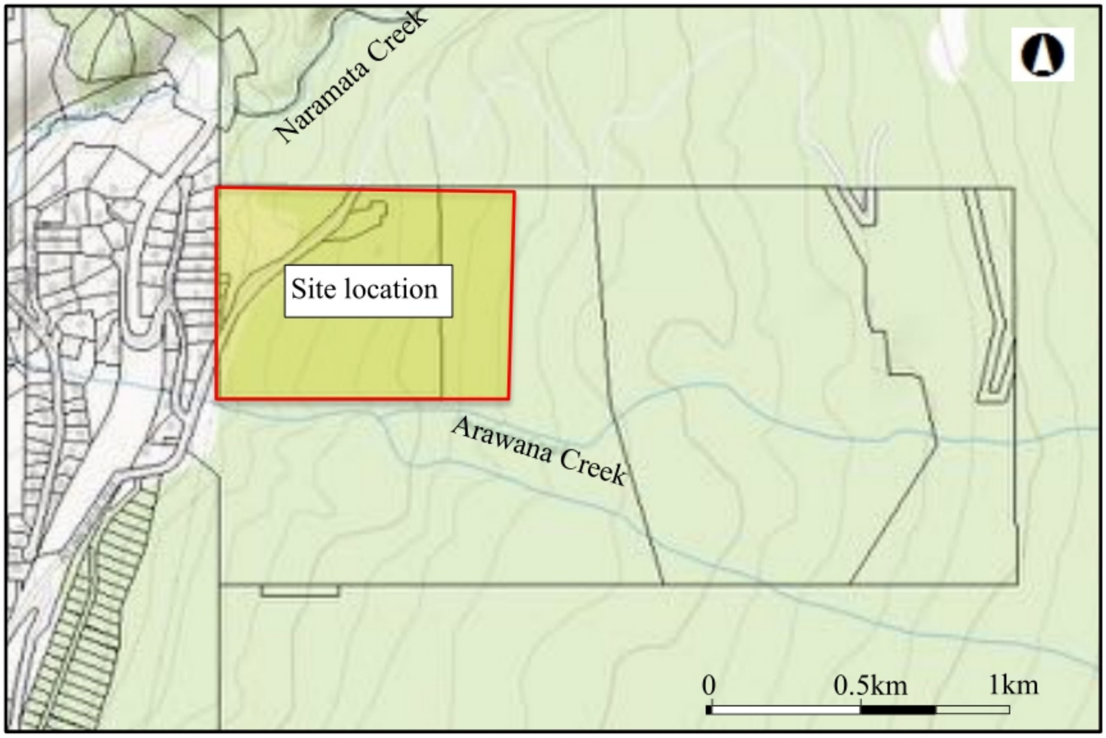

Figure 2: Vista Naramata Subdivision (RDOS Web Mapping)

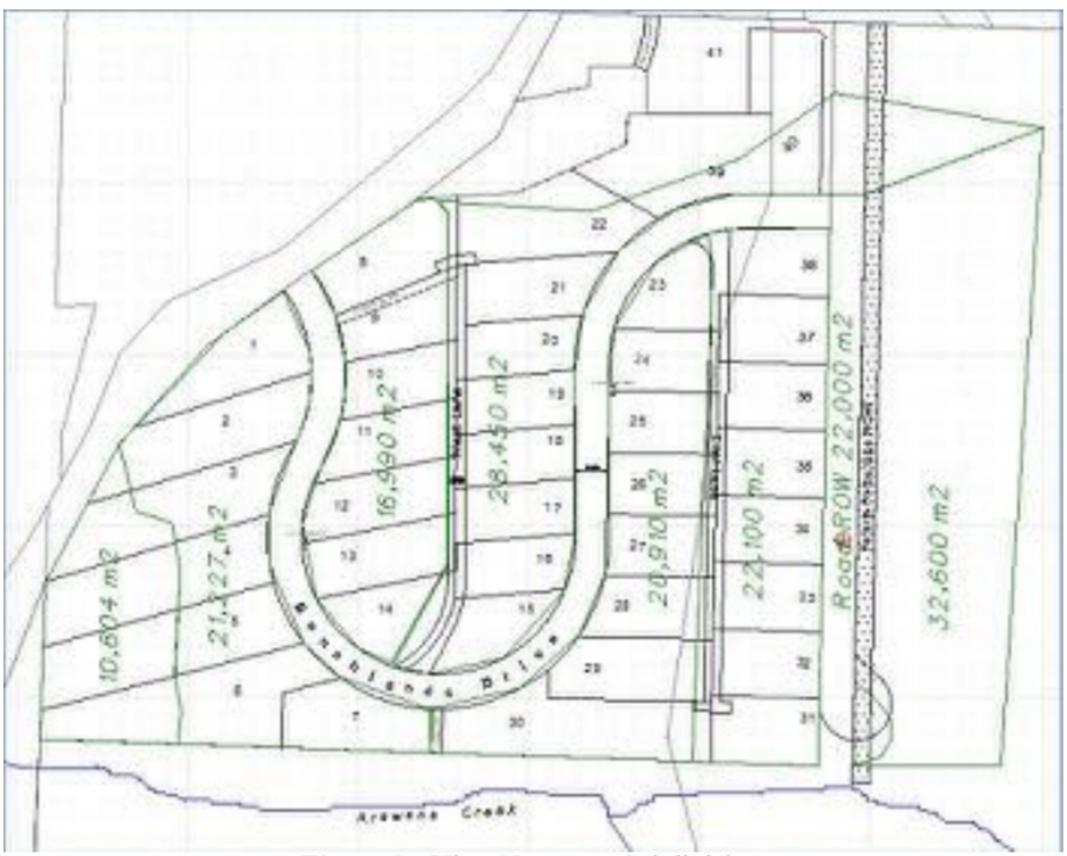

Figure 3: Vista Naramata Subdivision

3. Background Information

The hazard assessment involved the collection and review of available hydrologic, geologic and geotechnical information, the review of available historical government air photos, a subsurface investigation and, a site reconnaissance walkover review of the study site area.

Background information available and reviewed included:

- Recent Google Earth Imagery
- Historical Airphotos (1963 to 2007)
- Geological Mapping (P. Schiarizza and N. Church 2005)
- Test pit and Auger hole data gathered for the project geotechnical investigation
- RDOS Web Mapping
- IMAPS BC Mapping
- BC Watershed and BC Freshwater Atlas
- CJD Consulting Ltd. Drawings dated June 07, 2019

3.1. Bedrock Geology

Information provided in the Geologic Survey of Canada Map 1736A (Tempelman-Kluit, 1989) indicates that the development area is predominated by bedrock from the Shuswap Assemblage. Rock from this formation is described as consisting of highly weather resistant material primarily of Proterozoic to Paleozoic aged metamorphic rocks. Locally, the outcrop is described as “Okanagan Gneiss" which is comprised of massive, medium grey, hornblende·biotite granodiorite orthogneiss.

An excerpt from the bedrock geology mapping is shown in Figure 4.

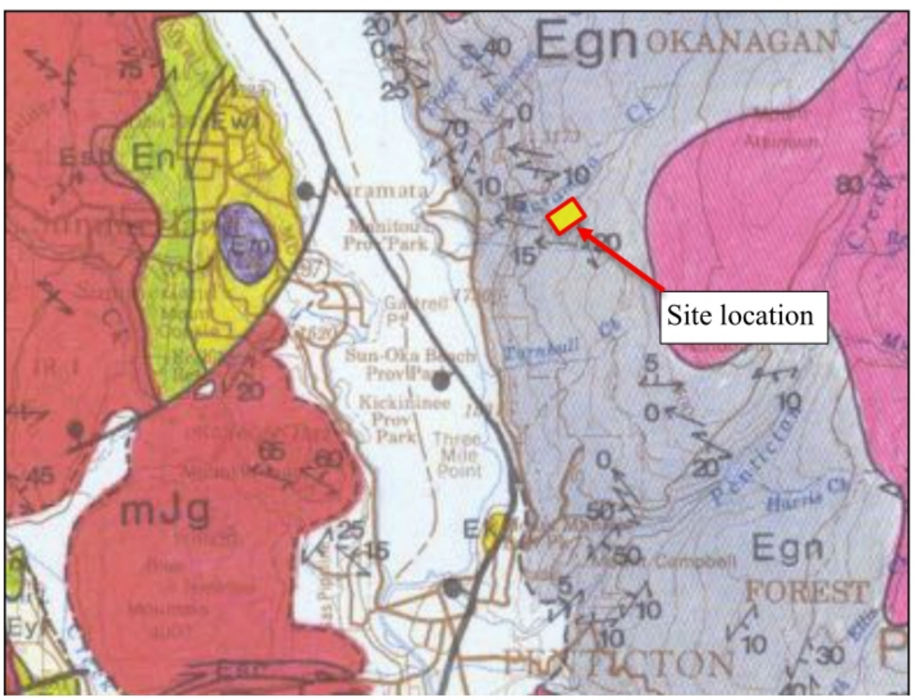

Figure 4: Bedrock Geology (Tempelman-Kluit, 1989)

The gneiss is considered the sheared and thermally overprinted equivalent of the Okanagan Batholith that underlies much of the eastern terrain.

Surficial bedrock was not observed on the property, however, bedrock surface exposures are abundant in the terrain above the property. These exposures tended to comprise of massive structure smoothed from glacial action and demonstrated very little apparent structure or active structural erosion.

3.2. Surficial Geology

The physiography of the area is well studied and documented by Nasmith (1962) and Geoterrain Consultants (1995). These studies indicate the general area contains a variety of surficial materials sourced from morainal, glaciofluvial, colluvial and, fluvial actions.

The lower elevations of the southern Okanagan Lake Valley are predominated by lacustrine silt terraces deposited when glacial action blocked the Okanagan valley south of Penticton, forming what is referenced as "Penticton Lake". Sediment laden inflow from glacial melt settled along the lake valley bottom causing a thick layer of silt deposition. Once the valley blockage receded, the draining lake downcut through the sediment, stranding the remaining deposition on the valley walls and creating the terraces. The maximum elevation of the silt terraces on the Okanagan Valley walls around Penticton is found to be 455m (1500 feet). As the lower area of the subdivision is above this elevation, silt deposits were not observed on the property.

At elevations above the silt terraces of the Penticton-Naramata area, lobes and thin mantles of granular material overlying bedrock are observed. These materials are sourced from glacial outwash along the margins of the receding or stagnant ice deposits and lateral moraine deposits from active glacial movement.

A subsurface auger investigation performed on the property indicates the morainal material is up to 15m in thickness overlying bedrock.

Abundant surficial boulders varying from 300mm to over 3m in diameter were observed throughout the property. Given the generally sub-angular to rounded appearance of the boulders and the lack of an identifiable colluvial source, it is speculated they are erratics that have been transported and deposited on site through glacial actions.

3.3. Surface Water

Based on a review of the stream centerline network mapping compiled and produced by the BC Government, there are no documented surficial water courses directly on the subdivision property. However, Arawana Creek runs parallel to the property's southern boundary, offset between 20 and 75m. On the section paralleling the property, the creek is conveyed in a 25 to 75m wide incised channel eroded through the morainal mantle deposits over bedrock. The banks of the channel vary from 5 to 20 m high at slopes from 50 to 90%.

Arawana Creek is a relatively small drainage with a catchment of 3.97 km^2 (above the property) which extends 3760m up to an elevation of approximately 1180m. The overall creek has an average gradient of 15.4% above the property; mainly comprised of bedrock channel and step-pool morphology. Figure 5 presents the elevation profile of the creek adjacent to and above the property.

Most of the surface drainage from upslope of the property is directed through overland flow to Arawana Creek to the south or to a small unnamed possibly ephemeral creek on its northern boundary.

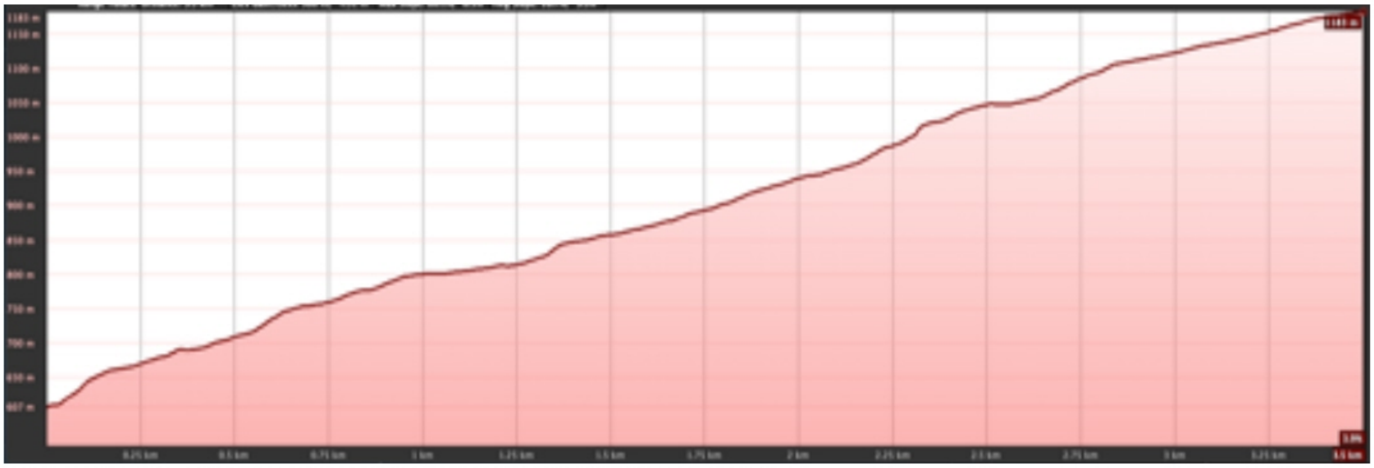

Figure 5: Arawana Creek Elevation Profile (Google Earth, 2021)

3.4. Local Topography

The proposed subdivision is located between approximately 620m and 740m elevation, part way up the east wall of the Okanagan valley.

The local ground topography peaks at 1220m, approximately 2.8km east of the property. The average upslope grade to the height of land above the property is 17% (9.8 degrees). The ground profile is generally uniform. Figure 6 & 7 present the elevation profile of the topography above the property.

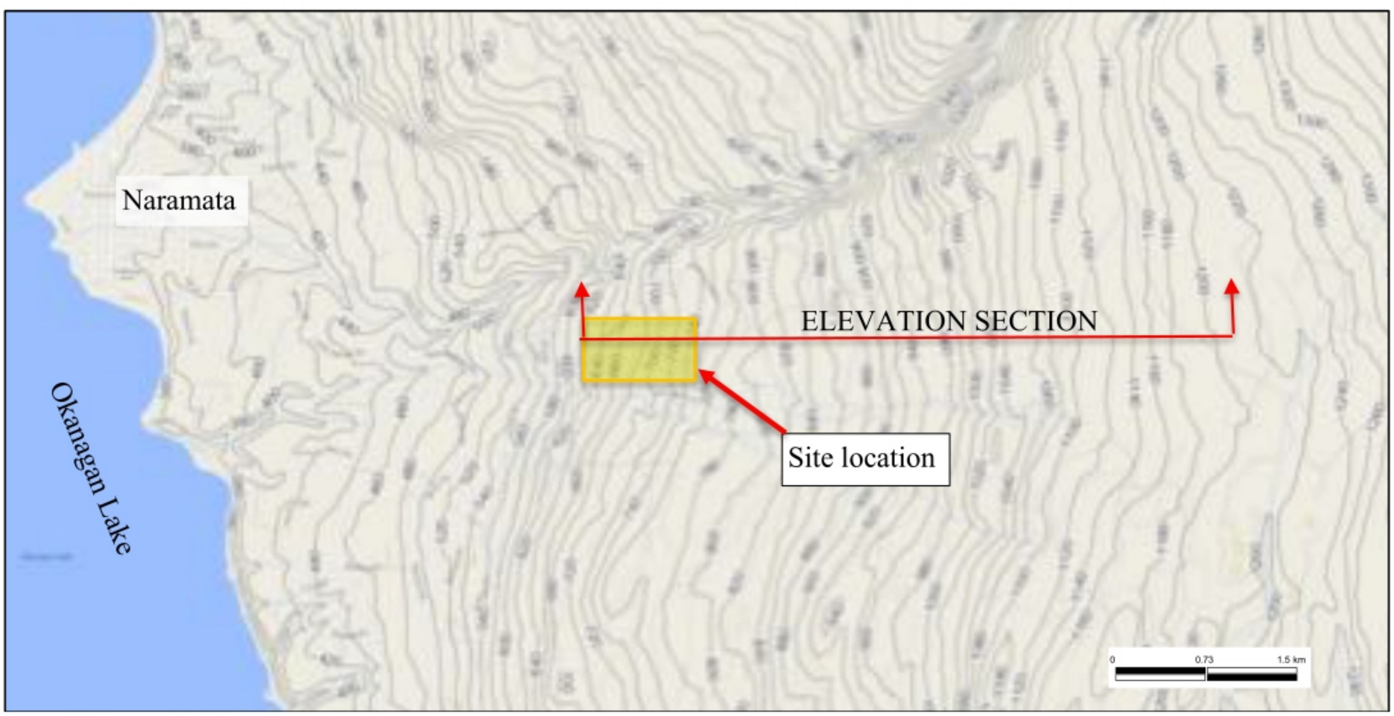

Figure 6: Terrain Map (iMap BC, 2021)

Figure 7: Terrain Elevation Profile (Google Earth, 2021)

Based on the contour maps (TRIM Contour Data) the steepest extended slope within the local topography is located within the property where the ground slope ranges between 50% and 70% over a 300m segment of bench features formed in the morainal deposits at the lower elevations of the property. Beyond the steeper segment, topography on the property is gently sloping (5-15%) with three prominent level benches.

4. Airphoto and Watershed Review

A review of historical government air photos (see list below) was available for each decade and dating back to 1963:

1963: BC 4193 / 16-17
1975: BC 5654 / 88-90
1985: BCC 372 / 170
1990: BCB 901004 / 62-63
2007: BCC 07034 / 129 - 131

Available historical Google Imagery was also reviewed: 1985, 2004, 2008, 2010, 2015 and 2018.

Little development of the property or watershed above was observed over the time frame of the imagery. Some land clearing was noted between 1990 and 2004 for forestry work and the initial clearing for an undeveloped golf course on the project property, however, very little terrain development was noted.

Obvious visible features and/or tones to indicate past or incipient slope movements were not observed within the project or in the above watershed during the 1963 to 2018 time frame.

Figure 8-10 illustrate the history of the area.

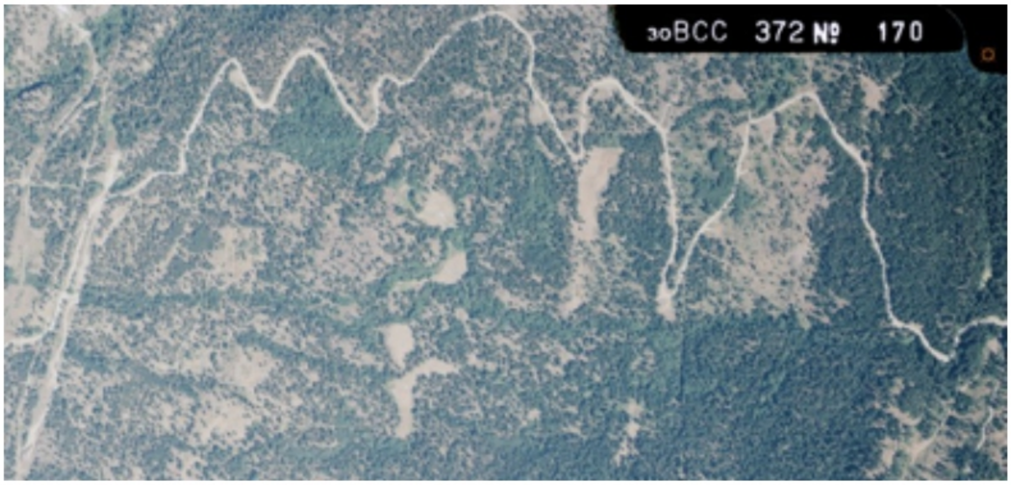

Figure 8: 1985 Aerial Photo

Figure 9: 2007 Aerial Photo

Figure 10: 2018 Google Earth Image

5. Field Reviews

Field reviews of the project site were performed on April 26th, 2021, May 20, 2021 and June 8, 2021 to assess the subsurface conditions and review the creek and offsite/upslope areas for evidence of past geohazard events or incipient soil movements.

On April 26th and May 20th test pits and auger holes were performed as part of the SNTG geotechnical investigation for the subdivision.

On June 8th an extensive foot traverse and visual field assessment of the property and watershed was performed. During the field reconnaissance, the soil and bedrock slopes and drainage were examined with respect to the presence of historic natural hazard depositions as well as the potential geomorphologic settings that may trigger or contribute to these. Basic measurements were made using an inclinometer and GPS. Local soil types were determined by inspection of slope exposures, open test pits and road cuts.

The generalized observations of the terrain and creek channel from the field review are summarized in section 3.3 and 3.4.

5.1. Surface Soils

Prior to the site review, a test pit investigation had been performed on the property indicating the granular deposits vary from silty coarse sand and gravel to coarse sandy gravel with cobbles and boulders. These materials are suspected to be sourced from glacial morainal and/or higher energy fluvial sources. The auger hole information indicated these deposits were found to vary from approximately 5m thickness in the southwest corner of the project area to greater than 15m in the center of the property.

5.2. Bedrock

The bedrock observed along the creek channel and within the terrain of the watershed above the property tended to confirm the granodiorite gneiss rock type outlined in the geologic mapping for the area. Much of the exposed surfaces displayed slight weathering and/or glacial eroded surfaces. The massive nature of the rock and the glacial surficial erosion tended to obscure any major structure in the rock.

Several shallow cliff faces observed along the creek channel had only minor history of rockfall activity as evidenced by the minimal colluvial deposits at their base. Furthermore, there is no evidence in the aerial photos or from the field review that indicates an history of recent significant zones of rockfall activity.

6. Geotechnical Hazard Assessment

As there is a lack of a comprehensive, long-term record of terrain hazards in the project area, the hazard occurrence cannot be predicted by formal statistical analysis. Consequently, a subjective assessment based on experience and judgment was used to assess the potential, type and magnitude of any significant natural hazards, its ability of impacting the proposed development and their probability of occurrence.

The hazard interpretation is based on information review, interpretation of air photos, a field review of the site, observations of the presence or absence of geologic activity in similar terrain in nearby areas, and professional experience with hazard assessments in mountainous terrain in British Columbia.

The following is a summary of the potential for differing natural hazards that are typically assessed for within subdivisions in British Columbia.

6.1. Adopted Level of Safety

As per the MoTI's Natural Hazard Assessment Terms of Reference outlined in the subdivision PLR, the following criteria was adopted when considering the safety of the proposed subdivision area with respect to geotechnical hazards:

For damaging events a probability of occurrence of 1 in 475 years (10% probability in 50 years) for individual hazards will be considered.

For life-threatening catastrophic events reaching the subject property a probability of occurrence of 1 in 10,000 years will be considered.

6.2. Landslide Hazard

6.2.1. Upslope Hazard

Landslide risk estimation entails estimating the potential landslide trigger mechanisms, type, size, and characteristics of potential landslides, and the likelihood of landslide occurrence and travel path based on terrain conditions, evidence of previous instability and proposed development activities (MFLNRORD 2010 LMH 66).

There is no known Terrain Stability Mapping for the project site or the watershed area above; however, based on our site investigation and observation in the watershed upslope, the surficial geology is inferred to comprise of glacial till, morainal soils and bedrock. The potential for landslide initiation in these materials at the 20-30% gradient of the terrain is considered very low.

Although the likelihood of landslide initiation is considered very low, with the combination of climate change, the increased prevalence of wildfire and the possibility of future upslope development (roads, trails, harvesting, etc.), the potential mechanisms imply the probability of landslide initiation is not negligible. Consequently, in the event that a landslide is initiated, it is likely more appropriate to assess its runout distance to assess the potential hazard such a circumstance would pose to the property.

Landslide runout distance can be estimated based on geomorphological assessment, geometrical assessment, or volume change method. There is no geomorphological evidence for landslide deposits at the project site. Consequently, a geometrical approach to estimating potential landslide travel distance (L) versus vertical drop (H) was used. In natural colluvial slopes (silty sands and sandy silts with gravel, cobbles and boulders), Hunter and Fell (2003) found that for unconfined landslides, the maximum travel distance is defined by and H/L ratio of 0.3. Moreover, in the work completed by Finley et al (1999) they found the H/L ratio for larger ($1000m^3$) landslides could be closer to 0.58.

Based on the site review and local mapping, the terrain above the project site averages approximately 18%; implying an H/L ratio of 0.18. This gradient is considerably shallower than the theoretical runout angles outlined above; therefore any landslide initiated in the terrain above the project site would have a minimal runout distance and have very low probability of impacting the project site.

6.2.2. Downslope Hazard

Based on our site review and the proposed subdivision layout, it is apparent that the southern boundary of the subdivision parallels the crest of the channel developed by Arawana Creek. The channel is incised through the prominent post glacial sediments in the area that are comprised of a variable mixture of silty sand and gravel with cobbles and boulders. The slopes along the northern side of the channel (parallel to the subdivision boundary) vary throughout from 30^0 to 40^0 and increase in height from 3m on the eastern end to 15m at the western end.

With the steeper slopes observed there is a recognized potential for the development of minor landslides and erosion. A review of the channel slope for historic or on-going movement did not reveal any significant issues. The slope is dominated by mature trees up to 600mm diameter and the creek appears to be relatively stable in a well developed channel controlled by bedrock and step pool boulder morphology.

Although evidence of historic slope instability was not observed, the relatively steep terrain of the channel slope in some places could theoretically experience localized instability due to erosion or extreme slope saturation. It is also well understand that such a circumstance could also be exacerbated by the loss of vegetation caused by wildfire

Lacking any specific mechanism or location for assessing specific instability along the slope, a precautionary passive approach is usually followed for determining slope crest offsets for structures to be developed in close proximity to slopes. In the relatively stronger soils present on site, a typical setback threshold of 2H:1V from the toe of the slope is usually employed. Using the LIDAR based digital elevation information from the survey performed for the development, the location of the theoretical setback along the southern boundary common with the channel was determined. From this assessment it was determined that the ground surface along the property boundary is outside the projected 2H:1V offset. Furthermore, it is understood that local zoning requirements demand all habitable structures be offset a minimum of 7.5m from an outside property line, further adding to the crest setback and providing an offset significantly greater than the minimum 2H:1V.

6.2.3. Probability of Occurrence

The soil and slope environment of the terrain above and adjacent to the project site does not produce a setting that would provide the potential for the development and/or transport of significant landslides. Based on this information and the lack of historic local occurrences, we believe there is a very low probability for a damaging landslide to impact the property; significantly less than 1 in 475 year.

6.3. Rockfall Hazard

Minor rock outcrops were observed intermittently along the margins of Arawana Creek , however, these sites were generally low outcrops at orientations and/or elevations that could not produce rockfall that would impact the property.

Bedrock was observed intermittently on the surface of the terrain upslope of the property. These exposures were generally rolling surface features without any prominent vertical faces or developed colluvial deposits. The closest significant bedrock exposure is a minimum of 450m upslope of the upper (eastern) property boundary. A review of the aerial imagery tends to reinforce this conclusions as no prominent bluffs or colluvial deposits are apparent upslope of the property.

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6.3.1. Probability of Occurrence

Based on the lack of terrain capable of producing any local rockfall, we believe there is a very low probability for a damaging rockfall to impact the property; significantly less than 1 in 475 year.

7. Flood Hazard Assessment

As with all natural creek channels, there exists a possibility of a flood as a consequence of increased flow. In the context of Arawana Creek, this increased flow is generally a consequence of rapid snow melt or intense and concentrated storm events. Flooding events as a consequence of such circumstances are generally caused by one or a combination of the following occurrences:

- Extreme flow causing water levels to exceed the natural confines of the creek channel and;
- Extreme flow triggering erosion/deposition and a subsequent avulsion event, causing the creek to deviate from its natural channel.

In assessing the flood hazard, an analysis generally considers the impacts of a certain magnitude of flow. In BC, the design level of flow considered has been established through provincial legislation as the 1 in 200 year flow event.

With respect to debris flow or debris flood hazards, based on the guidance from the PLR, a 1 in 475 year magnitude event was used as the acceptable level of risk.

The following presents the design flood event established for Arawana Creek and reviews the hazards produced with respect to the property.

7.1. Creek Channel Review

To assess the characteristics of the Arawana Creek channel from the bottom of the project site to the upper parts of the watershed, a visual review of the channel from 620m elevation to 1150m was performed on June 8th, 2021 in conjunction with the terrain assessment.

7.1.1. Reach 1

Upstream from the Arawana Forest Service Road, Arawana Creek is contained within a moderately steep sided wide V-shaped valley eroded through the moraine material from 620m elevation to approximately 740m. The stream gradient appears to be bedrock controlled in many locations; comprising cobbles and boulders with step-pool morphology. Channel gradient varied from 10% to 15% throughout the section. The banks of the creek varied in slope from 25^0 to 40^0, in top of bank width from 30m to 75m and in depth from 3m to 15m. Based on vegetation and creek erosion, at peak flow, the average channel width is estimated to be 1.5 m with an average channel depth is 0.20 m.

Vegetation ranged from thin soil and low brush to fully mature trees up to 600 mm in diameter. Numerous unscarred trees were present directly adjacent to the stream channel; implying a reasonably well established and stable channel with no recent history damaging flow events.

7.1.2. Reach 2

Above 740m elevation, the creek is contained in a wide valley following the rolling terrain up to the height of land at 1180m. The creek gradient is predominantly controlled by bedrock and varies from 5% to 15% with several minor drops or steep gradients (~25%) up to 1.5m in height at bedrock ledges.

The banks of the creek varied in slope from 25^0 to near vertical in bedrock areas, the top of bank width varied from 15m to 50m and, the height varied from 2.5m in some bedrock controlled areas to 20m in morainal deposits. Based on vegetation and creek erosion, at peak flow the average channel width is estimated to be 2.0 m with an average channel depth is 0.20 m.

7.2. 200 year Flood Flow

Historic hydrometric information for Arawana Creek is not available; consequently, a direct statistical estimate of expected flood flows and return periods was not possible. However, the Water Survey of Canada (WSC) has historic flow information on numerous creeks and rivers within the vicinity of Arawana Creek. A review of the available sites indicated there is a limited selection of long duration local monitoring sites available; however, it was determined that the information from Penticton Creek above Dennis Creek (WSC #08NM168) would provide a reasonable proxy for the development of flood hydrology. The monitoring station on Penticton Creek is approximately 8km southeast of Arawana Creek and is considered to be in the same hydrologic subzone with identical aspect.

Table 1 presents the related information for the two creeks.

Table 1 – Creek Characteristics

Watershed	Watershed Size (ha)	Average Stream Gradient	Min Elev (m)	Max Elev (m)
Arawana Creek	397	15.4	620	1180
Penticton Creek	3,550	9.8	800	2000

Using the 29 year flow record for Penticton Creek, a Log-Pearson Type III statistical analysis was performed on the series of annual peak flows. Based on this analysis, the Q_{200} for Penticton Creek was determined to be 5.6 m^3/s.

To develop a proxy flow for Arawana Creek a ratio of the drainage areas was used to relate the two flows.

$$\text{Prorated Arawana } Q_{200} = \quad 5.61\ m^3/s \times \frac{(3.97\ km^2)}{(35.50\ km^2)} = 0.63\ m^3/s$$

However, recognizing the Penticton Creek drainage is an order of magnitude larger than Arawana Creek a multiplier of 1.25 was used to compensate for the fact that smaller drainages tend to exhibit higher unit peak flows. This multiplier was derived from an analysis of the local hydrologic zone data comparing peak unit flood flows relative to drainage area (Ahmed, 2020). Further to this an additional increase of 10% was used to account for the impacts of climate change on extreme flood flows, as recommended in Section 3.4 of Appendix G of EGBC Flood Assessment Guidelines (2018). Consequently, the instantaneous peak flood flow for Arawana Creek is:

$$\text{Estimated Arawana } Q_{200} = \quad 0.87\ m^3/s$$

7.3. Flood Flow Analysis

To establish the possible flow characteristics of Arawana Creek during design flood conditions, a basic hydraulic analysis was performed on a representative cross section of the creek reach adjacent to the property. The analysis used Manning's equation with the following range of assumptions:

Table 2 - Typical Channel Characteristics

Manning's 'n' value	0.05 - 0.07
Creek Gradient	12 - 15%
Bank Slope	1.5H:1V
Base width	1.5m

Based on this information, the analysis indicates a potential maximum flow depth of 0.27 m and a potential maximum velocity of 1.75 m/s.

7.4. Potential Flood Hazard

Based on the flood hazards potentially caused by the design flood flow, the following assessment and commentary is provided for the differing scenarios.

7.4.1. Loss of Confinement

Given the maximum flow depth of 0.27m determined for the flood flow, the creek will marginally exceed the typical freshet depth of flow of 0.20m observed along the creek channel. However, given the significant depth and width of the incised channel and the bedrock and cobble controlled morphology, it is unlikely the creek will lose confinement and develop a new flow path that could impact the property.

7.4.2. Avulsion & Blockages

As the creek is confined within a deep valley, it is unlikely that an avulsion event would develop causing the creek to lose confinement and impact the property. Furthermore, blockages due to woody debris and material deposition are also possible, however, the valley would likely still maintain general confinement of the creek channel.

7.4.3. Probability of Occurrence

Based on the watershed and channel and the lack of any identifiable path for flood water to reach the property, we believe there is a low probability for a damaging flood event impacting the property and conclude the probability of occurrence to be less than 1 in 200 year.

7.5. Potential Debris Flow/Flood Hazard

Debris flow/flood hazards are usually associated with mountainous drainages with well-developed gully systems and/or confined drainage paths. These drainages are typically characterized by steep, unstable sidewalls and/or headwalls with steep gradients. Drainages prone to debris flows generally have the following terrain characteristics (VanDine, 1985):

- An initiation zone with a channel gradient greater than 25º (47%);
- A transportation and erosion zone with a gradient greater than 15º (27%);
- A partial deposition zone, in the form of levees, at gradients less than 15º (27%) and;
- A deposition zone on the debris fan usually beginning as the gradient flattens to less than 10º (18%).

Further to the channel characterization of debris flow prone creeks another metric for evaluating drainages is offered by the Melton ratio (Melton, 1957) where a relationship between the watershed relief versus its area was developed to categorize the potential for debris flow/flood hazards. Wilford et al (2004) further refined the usage of the Melton ratio by including the watershed length in the assessment. Table 3 presents the watershed categorization criteria as developed by Wilford et al.

Table 3 - Watershed Categorization for Hydrogeomorphic Processes

Hydrogeomorphic Process	Watershed Attribute	Range
Water floods	Melton Ratio	< 0.30
Debris Floods	Melton Ration + Watershed length	Melton: 0.30 to 0.60 or, when Melton > 0.60 and Length > 2700m
Debris Flows	Melton Ration + Watershed length	Melton: > 0.60 and Length < 2700m

Reviewing the characteristics of the Arawana Creek drainage, the Melton ratio was determined to be 0.28; marginally lower than the lower bound for identifying debris flood potential. Moreover, comparing the creek channel to the VanDine criteria, Arawana Creek lacks sufficient gradient to provide sustained transportation of a debris flow mass needed to entrain additional material and develop momentum.

7.5.1. Probability of Occurrence

Based on the lack of watershed characteristics capable of producing a debris flow/flood, we believe there is a very low probability for a damaging event of this nature impacting the property and conclude the probability of occurrence to be significantly less than 1 in 475 year.

8. Catastrophic Events

It is understood that MoTI typically requests that natural hazards review also establish where life-threatening catastrophic events are known as a potential, the site should be reviewed to ensure the probability of such an event impacting the site is less than 1 in 10,000 years. Typically, events of such nature tend to be massive, rapid and generally unforeseen, making it difficult to mitigate their actions or avoid their path. Natural hazards of this nature and magnitude would tend to be limited to landslides, rock slides or debris flows.

There are several challenges in estimating a 1:10,000 year probability for a natural hazard event as identified by Jakob et al (2018) where it was noted that with long return period events, the accuracy of the estimate decreases. Vick (2002) proposed that subjective probability estimates are useful when based on sound engineering judgment to allow for an estimate of risk.

With respect to the proposed subdivision, as presented in Sections 6.2, Section 6.3 and Section 7.5, there are no indication of historic landslides, rockslides or debris flows in the general area that would tend to signify the site may be subject to a life-threatening catastrophic event from such a source.

As presented in Section 6.2.1, the likelihood of a landslide initiating directly upslope of the Property is estimated at less than 1 in 475 years (10% probability in 50 years) based on the historical airphoto review, regional attribute studies, local knowledge of the surficial and bedrock geology.

Furthermore, the likelihood of a landslide travelling the distance from initiation to the property is low considering the low gradient benched terrain, the lack of gullies for confinement and, the lack of observed historic landslide deposits. The combined low hazard of initiation and low likelihood of extended runout results in a very low risk to life. Consequently, it would be reasonable to conclude that there is less than a 1 in 10,000 year probability of occurrence for a life-threatening catastrophic event to impact the proposed subdivision.

9. Conclusions

In view of the above information and in accordance with the hazard acceptability criteria, the proposed development is considered safe for the proposed residential development, without requirement for building siting, restrictive covenants and/or the development of hazard-mitigating measures.

10. Limitations, assumptions, and uncertainties

The estimation of natural hazard occurrence and travel distance is based on local topography, surficial and bedrock geology, local landslide attribute studies, and empirical landslide run-out studies, and the experience of the undersigned in collecting local landslide data and investigating the triggers and contributing causes of local landslides.

Although the empirical and attribute studies assist in estimating the landslide risk, there is significant judgment and opinion supported by extensive local experience or Subjective Probability (Vick 2002).

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11. Closure – Report Use and Limitations

This report was prepared for the exclusive use of the Naramata Vista developer and the Ministry of Transportation and Infrastructure and is the property of SNTG. The material in it reflects SNT Geotechnical Ltd.'s best judgment and professional opinion in light of the information available to it at the time of preparation. Any use which a third party makes of this report or any reliance on or decision to be made based on it are the responsibility of such third parties. SNT Geotechnical Engineering Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or action based, or lack thereof, on this report. No other warranty is made, either expressed or implied.

The report and assessment have been carried out in accordance with generally accepted professional practices in B.C. The discussion and recommendations presented are based on available information and limited field investigation and inferences from surficial features. No subsurface investigation was carried out as part of this assessment or development of conclusions or recommendations. Inherent variability in local precipitation, run-off conditions, soil and vegetation burn severity, surface and subsurface conditions may create unforeseen situations.

Prepared by:

July 26, 2021

Mike Walsh, P.Eng.
SNT Geotechnical Ltd.

Reviewed by:

Dwain Boyer, P.Eng.
SNT Geotechnical Ltd.

12. References

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13. Photos

Photo 1: Arawana Creek at 685m elev., 400mm pine tree adjacent to creek with no damage.

Photo 2: Road cut through creek channel bank showing typical material

Photo 3: Arawana Creek channel, 50m width at 680m elev, mature forest on slopes

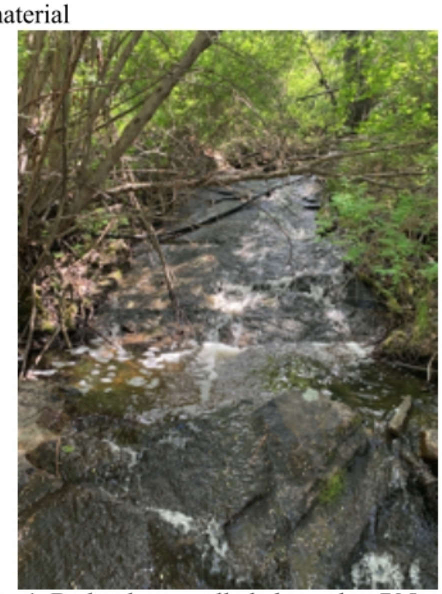

Photo 4: Bedrock controlled channel at 705m elev.

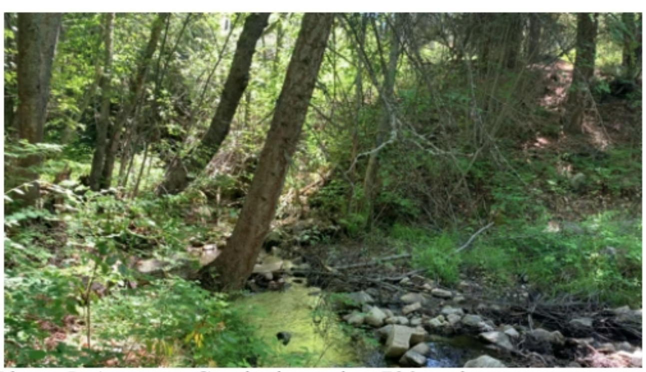

Photo 5: Arawana Creek channel at 730m elev.

Photo 6: Arawana Creek at 750m elev.


Photo 7: bedrock confined channel, elev 790m


Photo 8: shallow steep pool morphology, elev 820m


Photo 9: Test pit, typical morainal outwash soil over bedrock at 640m elev, SW corner of property


Photo 10: Test pit spoil pile with typical soils, elev 675m

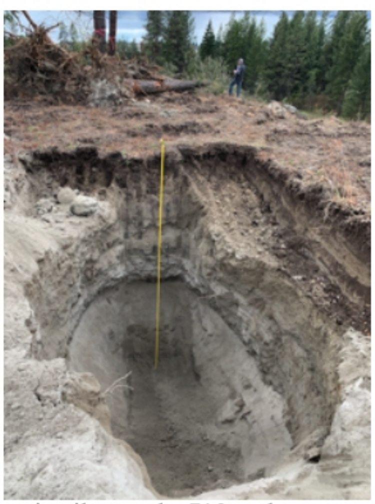
Photo 11: Test pit, silty sands, 710m elev


Photo 12: Typical drill probing for bedrock

APPENDIX D: *LANDSLIDE ASSESSMENT ASSURANCE STATEMENT*

Note: This Statement is to be read and completed in conjunction with the "*APEGBC Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia*", March 2006/Revised September 2008 ("*APEGBC* Guidelines") and the "2006 BC Building Code (BCBC 2006)" and is to be provided for *landslide assessments* (not floods or flood controls) for the purposes of the Land Title Act, Community Charter or the Local Government Act. Italicized words are defined in the *APEGBC* Guidelines.

To: The *Approving Authority* Date: July 28, 2021

Ministry of Transportation & Infrastructure

102 Industrial Place, Penticton, BC

Jurisdiction and address

With reference to (check one):

- ☑ Land Title Act (Section 86) – Subdivision Approval
- ☐ Local Government Act (Sections 919.1 and 920) – Development Permit
- ☐ Community Charter (Section 56) – Building Permit
- ☐ Local Government Act (Section 910) – Flood Plain Bylaw Variance
- ☐ Local Government Act (Section 910) – Flood Plain Bylaw Exemption
- ☐ British Columbia Building Code 2006 sentences 4.1.8.16 (8) and 9.4 4.4.(2) (Refer to BC Building and Safety Policy Branch Information Bulletin B10-01 issued January 18, 2010)

For the Property: Lot 3, District Lot 3474, SDYD, Plan EPP60812 and Lot 4, District Lots 2711 & 3474, SDYD, Plan EPP60812

Legal description and civic address of the Property

The undersigned hereby gives assurance that he/she is a *Qualified Professional* and is a *Professional Engineer* or *Professional Geoscientist.*

I have signed, sealed and dated, and thereby certified, the attached *landslide assessment* report on the Property in accordance with the *APEGBC Guidelines*. That report must be read in conjunction with this Statement. In preparing that report I have:

Check to the left of applicable items

✓ 1. Collected and reviewed appropriate background information

✓ 2. Reviewed the proposed *residential development* on the Property

✓ 3. Conducted field work on and, if required, beyond the Property

✓ 4. Reported on the results of the field work on and, if required, beyond the Property

✓ 5. Considered any changed conditions on and, if required, beyond the Property

6. For a *landslide hazard analysis* or *landslide risk analysis* I have:

  ✓ 6.1 reviewed and characterized, if appropriate, any *landslide* that may affect the Property

  ✓ 6.2 estimated the *landslide hazard*

  ✓ 6.3 identified existing and anticipated future *elements at risk* on and, if required, beyond the Property

  ✓ 6.4 estimated the potential *consequences* to those *elements at risk*

7. Where the *Approving Authority* has adopted a *level of landslide safety* I have:

  ___7.1 compared the *level of landslide safety* adopted by the *Approving Authority* with the findings of my investigation

  ___7.2 made a finding on the *level of landslide safety* on the Property based on the comparison

  ___7.3 made recommendations to reduce *landslide hazards* and/or *landslide risks*

8. Where the *Approving Authority* has **not** adopted a *level of landslide safety* I have:

✓ 8.1 described the method of *landslide hazard analysis* or *landslide risk analysis* used

✓ 8.2 referred to an appropriate and identified provincial, national or international guideline for *level of landslide safety*

✓ 8.3 compared this guideline with the findings of my investigation

✓ 8.4 made a finding on the *level of landslide safety* on the Property based on the comparison

✓ 8.5 made recommendations to reduce *landslide hazards* and/or *landslide risks*

✓ 9. Reported on the requirements for future inspections of the Property and recommended who should conduct those inspections.

Based on my comparison between

Check one

☐ the findings from the investigation and the adopted *level of landslide safety* (item 7.2 above)

☑ the appropriate and identified provincial, national or international guideline for *level of landslide safety* (item 8.4 above)

I hereby give my assurance that, based on the conditions[1] contained in the attached *landslide assessment* report,

Check one

☑ for subdivision approval, as required by the Land Title Act (Section 86), "that the land may be used safely for the use intended"

Check one

☐ with one or more recommended registered covenants.

☐ without any registered covenant.

☐ for a development permit, as required by the Local Government Act (Sections 919.1 and 920), my report will "assist the local government in determining what conditions or requirements under [Section 920] subsection (7.1) it will impose in the permit".

☐ for a building permit, as required by the Community Charter (Section 56), "the land may be used safely for the use intended"

Check one

☐ with one or more recommended registered covenants.

☐ without any registered covenant.

☐ for flood plain bylaw variance, as required by the "Flood Hazard Area Land Use Management Guidelines" associated with the Local Government Act (Section 910), "the development may occur safely".

☐ for flood plain bylaw exemption, as required by the Local Government Act (Section 910), "the land may be used safely for the use intended".

Michael Walsh, P.Eng.

Name (print)

[signature]

Signature

July 28, 2021

Date

[1] When seismic slope stability assessments are involved, *level of landslide safety* is considered to be a "life safety" criteria as described in the National Building Code of Canada (NBCC 2005*)*, Commentary on Design for Seismic Effects in the User's Guide, Structural Commentaries, Part 4 of Division B. This states:

"The primary objective of seismic design is to provide an acceptable level of safety for building occupants and the general public as the building responds to strong ground motion; in other words, to minimize loss of life. This implies that, although there will likely be extensive structural and non-structural damage, during the DGM (design ground motion), there is a reasonable degree of confidence that the building will not collapse nor will its attachments break off and fall on people near the building. This performance level is termed 'extensive damage' because, although the structure may be heavily damaged and may have lost a substantial amount of its initial strength and stiffness, it retains some margin of resistance against collapse".

#4 - 385 Baker St

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250-801-5325

Telephone

(Affix Professional seal here)

If the *Qualified Professional* is a member of a firm, complete the following.

I am a member of the firm SNT Geotechnical Ltd.
and I sign this letter on behalf of the firm. (Print name of firm)

From:	Bitte, Rob TRAN:EX(Rob.Bitte@gov.bc.ca)
To:	Sparkes, Bill TRAN:EX (Bill.Sparkes@gov.bc.ca)
Subject:	Vista Naramata (Formally NB3)
Sent:	09/24/2021 19:03:17
Attachments:	Vista Naramata - Natural Hazard Assessment.pdf, Vista Naramata - Appendix D (Hazard Report).pdf

Hi Bill,
MoT File: 2018-03237 – *Naramata Benchlands III has been re-branded as Vista Naramata*.
Regarding Brad's email below, I am attaching a copy of the Natural Hazards Assessment and the Appendix D for your review and comment. This Report was prepared to satisfy Condition 1 and 2 on the PLR dated June 24, 2021.
I read the Assessment and it appears satisfactory to me and therefore I recommend Condition 1 be concluded and Condition 2 is no longer required.
Regards,

Rob Bitte
DEVELOPMENT OFFICER
BC Ministry of Transportation and Infrastructure
102 industrial place penticton v2a 7c8
T: 778.622.7020| **C:** 250.809.6886| **E:** rob.bitte@gov.bc.ca
Permit Application Subdivision Application

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From: Brad Elenko <belenko@mcelhanney.com>
Sent: September 13, 2021 5:04 PM
To: Bitte, Rob TRAN:EX <Rob.Bitte@gov.bc.ca>
Cc: s. 22
Subject: Vista Naramata

[EXTERNAL] This email came from an external source. Only open attachments or links that you are expecting from a known sender.

Rob,
On August 10, while you were on holidays, Craig provided Mitch with a number of documents to be upload to our eDAS subdivision file. The documents included a Natural Hazards Assessment, Appendix D: Landslide Assessment Assurance Statement, and revised Vista Detailed Drainage Report.
The conclusions in the Natural Hazards Assessment indicated "… the proposed development is considered safe for the proposed residential development, without requirement for building siting, restrictive covenants and/or the development of hazard-mitigating measures." Based on the strength of this professional report, can you please confirm that requirements 1. and 2. in the PLR for the subdivision can be deemed satisfied, so we can "check that box" and not have to spend any more time on that matter.
In terms of the revised drainage report, can you please provide me with an update on when we can expect comments back on that report or confirmation that the drainage plan has be accepted / approved by the MoTI. If you are not sure of the status of that review, is it possible to provide me with the name of the engineer in Kamloops that is reviewing the report as I could contact that person directly to get an update on the review of that report.
Thanks Rob.
Cheers,

Brad Elenko, MCIP RPP
Senior Planner
Interior of B.C.
McElhanney
290 Nanaimo Ave. W | Penticton BC | V2A 1N5
D 250 495 0499 | **T** 250 492 7399 | **C** 250 485 7387
belenko@mcelhanney.com www.mcelhanney.com
McElhanney

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Ministry of Transportation & Infrastructure

102 Industrial Place, Penticton, BC

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Check one

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  - ☐ without any registered covenant.

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Name (print)

[signature]
Signature

July 28, 2021
Date

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Address

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(Affix Professional seal here)

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I am a member of the firm SNT Geotechnical Ltd.
(Print name of firm)
and I sign this letter on behalf of the firm.

From:	Sparkes, Bill TRAN:EX
To:	Bitte, Rob TRAN:EX
Subject:	RE: Vista Naramata (Formally NB3) - Natural hazard Assessment
Date:	October 18, 2021 11:36:53 AM
Attachments:	image002.png

Hi Rob, I have reviewed the Natural Hazards Assessment dated June 28, 2021 prepared by SNT Geotechnical Ltd. I find the report to be detailed and thorough. I have no questions about the report and accept it as satisfying PLR items 1 and 2 as per your recommended. Please advise the applicant.

Bill Sparkes
Provincial Approving Officer
Okanagan Shuswap District

From: Bitte, Rob TRAN:EX <Rob.Bitte@gov.bc.ca>
Sent: September 24, 2021 12:03 PM
To: Sparkes, Bill TRAN:EX <Bill.Sparkes@gov.bc.ca>
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Permit Application **Subdivision Application**

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Thanks Rob.

Cheers,

Brad Elenko, MCIP RPP
Senior Planner
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McElhanney

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