



September 15, 2026

Project 1358013

Rev. 0

Squamish Lillooet Regional District
1350 Aster St
Pemberton, BC, V0N 2L0

Attention: Edward Witwicki, Manager of Infrastructure and Utility Services

Whitecap Berm Emergency Geotechnical Assessment

1.0 INTRODUCTION

In the early hours of August 23, 2026, an intense, localized thunderstorm triggered debris flows in the Bear and Pete's creek watershed near Seton Portage, BC (Figure 01). During this event, debris filled and overtopped a portion of the Whitecap berm (the "berm"), inundating downstream properties and depositing debris and mud around an occupied residence at 8332 Seton Portage Road (PID 025-389-882).

The Squamish Lillooet Regional District (SLRD) retained BGC Engineering Inc. (BGC) to conduct an emergency geotechnical assessment to:

- Assess the short-term stability of the berm under its debris-filled condition
- Identify any imminent hazards to downstream residents associated with the current condition of the berm.

The scope of work, defined during correspondence with SLRD on August 25, 2026, was limited to:

- A one-day site visit and helicopter overflight to collect observations of the berm condition and debris-flow hazards
- Documentation of observations, findings, and recommendations for SLRD's immediate consideration.

BGC understands that SLRD will use the findings of this assessment to inform emergency response and decisions regarding berm repairs.

This work was carried out under the emergency response service agreement between SLRD and BGC dated September 9, 2026. BGC submitted a draft version of this document to SLRD on August 31, 2026 in advance of the contract execution to support the emergency response.

2.0 BACKGROUND

2.1 Bear and Pete's Creeks

Bear and Pete's Creeks are ephemeral creeks that drain steep, rugged terrain on the north flank of Seton Portage Mountain with a peak elevation of approximately 2,300 m. The creeks drain two sub-catchments of a common watershed and flow in parallel to one another before discharging onto a shared alluvial fan at the base of the mountain (Figure 01). Although the creeks presently drain separate catchment areas, the poorly-defined channels on the fan are subject to frequent avulsions and channel shifts, such that flow from one creek may be diverted into channels historically associated with the other. Both creeks are susceptible to debris-flow activity and have a long history of debris flows affecting the fan and the downstream community. Detailed descriptions of the local geology, geomorphology, and geohazards are provided by others, including assessments completed by BGC (BGC, January 31, 2017; April 6, 2018).

2.2 Whitecap Development and Mitigation Works

The Whitecap Development consists of 5 lots surrounded by a 913 m long U-shaped berm, part of the Whitecap Development mitigation works (Figure 02). Only one of those lots is currently developed and presently occupied. The property at 8332 Seton Portage Road contains a single-family residence constructed in 2010 according to BC Assessment. The residence is located approximately 30 m downslope of the berm toe on a cut building pad, excavated approximately 2 to 2.5 m below the surrounding original fan surface. The building itself is elevated approximately 1 m above the pad grade with stone-armoured foundation walls.

BGC understands that the Whitecap Development mitigation works were constructed sometime in the early 2000s to allow for subdivision of the Whitecap Development and that SLRD subsequently assumed responsibility for operation and maintenance of the works.

The mitigation works consist of a training berm and channel along the southeast corner and southern boundary of the development, a perimeter berm and ditch along the eastern and northern boundaries of the development, and culverts and swales crossing Seton Portage Road (Figure 02). The works were designed by LaCas Consultants Inc. (LaCas) and EBA Engineering Consultants Ltd. (EBA) (July, 2000) based on the following key design criteria:

- The southern training berm and channel were designed to direct debris flows and floods entering from the east and south toward Anderson Lake. These works were sized for debris flows with estimated instantaneous peak discharges of approximately 10 to 20 m³/s, equivalent to roughly 2 to 5 times the estimated 200-year clearwater flood from the combined Bear/Pete's creek watershed.
- The perimeter berm and ditch along the eastern and northern boundaries were designed to intercept and contain "partial overland flows" associated with the 200-year return period flood.

LaCas & EBA (July, 2000) specified a berm top width of 3.7 m to accommodate maintenance vehicle access, side slopes of 1.5H:1V on the development side and at least 2H:1V on the channel side, and construction using compacted sand and gravel from local channel excavation.

The dimensions of the berm and channel vary around the development perimeter. The southern channel and training berm are substantially larger, with a maximum elevation difference of approximately 5.4 m between the channel invert and berm crest, whereas the perimeter berm and ditch along the eastern and northern boundaries generally range from approximately 1 to 1.5 m in height.

LaCas & EBA (July, 2000) also specified the following additional protective measures within the development:

- A 10 m wide vegetation/tree belt (no-build zone) be planted and maintained inside of the berm
- Buildings were to be elevated a minimum of 1 m above finished grade, with foundations and earthworks protected against erosion and scour.

2.3 Previous Events

The eastern berm has been impacted or overtopped by debris flows on multiple past occasions at approximately similar locations:

- A small debris flow on Pete's Creek, likely during a storm in October 2003, deposited debris behind the berm (KWL, November 24, 2005).
- On September 20, 2015, a long-duration rainfall event triggered a debris flow on Pete's Creek that overtopped the berm and flowed across two lots of the Whitecap Development to Seton Portage Road. The overtopping caused significant erosion on the downhill face of the berm requiring repair. Debris also deposited behind the berm to the south of the overtopping location from an avulsion channel, and flow along the southern channel blocked the 600 mm culvert on Seton Portage Road, resulting in minor flooding and sedimentation of a downstream property. BGC (April 6, 2018) estimated the debris flow had a volume at approximately 3,000 to 4,600 m³.
- On July 30, 2016, a short-duration, high-intensity thunderstorm triggered a debris flow on Pete's Creek that overtopped and eroded the berm and flowed across two lots of the Whitecap Development to Seton Portage Road, similar to the 2015 event. Reported volume estimates range from approximately 1,000 to 5,000 m³.

A number of comparatively larger debris flows have also occurred on Bear Creek, impacting the eastern side of the fan. During the July 30, 2016 storm, an approximately 67,000 m³ debris flow spread across the fan and past the fan edge, reaching residential areas.

2.4 August 23, 2026 Storm

Precise rainfall amounts associated with the August 23, 2026 storm are uncertain. There are no active Environment and Climate Change Canada (ECCC) precipitation gauges near Seton Portage, and precipitation likely varied substantially with elevation and location within the watershed, as the storm appears to have been highly localized.

Preliminary hydrometric data from BC Hydro's Shalalth climate station (50.7281°N, 122.242°W; elevation 290 m), located approximately 5.1 km northeast of the Whitecap Development, indicate intense rainfall between approximately August 22 23:45 PST and August 23 01:30 PST,

with approximately 62 mm of precipitation recorded over this period. The dataset also includes a maximum 15-minute rainfall of 24 mm and a maximum 1-hour rainfall of 54 mm. These short-duration intensities appear anomalously high, and should be interpreted with caution, as BC Hydro advises that the data are derived from automated measurements that may contain inaccuracies.

Unaudited data from personal weather stations accessed through Weather Underground similarly indicate a peak in precipitation between approximately 00:00 and 02:00 PST. The ISETON1 (50.729°N, 122.244°W; elevation 77 m) station in Shalalth recorded approximately 62 mm of precipitation over this period, which is consistent with the BC Hydro gauge. In contrast, the ISETON2 (50.702°N, 122.3°W; elevation 92 m) station, located on the Bear/Pete Creek alluvial fan immediately north of the Whitecap Development, recorded approximately 12 mm over the same two-hour period.

In summary, the available data indicates that the majority of rainfall occurred over a relatively short period of approximately two hours during the early morning of August 23, 2026. Antecedent conditions were dry, with minimal precipitation recorded in the weeks preceding the storm.

3.0 FIELD VISIT OBSERVATIONS

On August 26, 2026, Sophia Zubrycky, P.Eng., and Brandon On, E.I.T., of BGC completed a ground-based site visit to the Whitecap Development, the berm, Pete's Creek, and Bear Creek near the fan apex. A helicopter overflight of the fan and watershed area was completed the following day on August 27, 2026 at approximately 09:30 PST. The following summarizes observations from these site visits, with references to figures attached:

- A debris flow originating from Pete's Creek overtopped an approximately 70 m section of the eastern berm directly upslope of the 8332 Seton Portage Road residence, immediately south of the previous overtopping locations. Some of the flow was conveyed north along the eastern and northern berm perimeter ditch (Photo 5).
- BGC observed splash marks on trees upslope of the berm, but no splash marks on the residence itself, suggesting the berm reduced the velocity of the debris flow reaching the residence. BGC estimates the ditch and berm retained up to approximately 1,000 m³ of debris.
- The debris flow was fines-rich (muddy-type debris flow), comprised of clay to cobble-sized sediment, some woody debris, and the occasional boulder up to 1.5 m diameter transported to the fan. Most of the material transported downstream of the berm was fine-grained.
- Flows that overtopped the berm caused erosion and gullying at approximately four locations on the downhill slope of the berm (Photo 8). Gullies were up to approximately 1 m wide and scoured up to approximately 0.5 m into the berm crest and slope.
- BGC did not observe signs of berm instability, such as cracking or settlement at the crest, bulging at the berm toe, or active seepage through the berm.

- The overtopping location appeared to coincide with a localized low point (dip) in the berm crest of approximately 0.5 to 1 m relative to the berm grade along an approximately 100 m section of berm upslope of the residence.
- Flows that overtopped the berm deposited on the upslope and northern sides of the 8332 Seton Portage Road residence, and continued downslope along the driveway and a gully to Seton Portage Road (Figure 02). Deposit depths around the residence varied but appeared to be approximately 0.3 m to 0.5 m deep (Photo 7). Debris that overtopped the berm did not enter the residence as the structure is elevated above the surrounding pad grade. However, debris pooled between the building and the pad cut into the original fan surface, which limited the ability of water and debris to drain away from the residence.
- Based on field estimates of deposit thicknesses and approximate inundation extents, BGC estimates a total sediment volume of approximately 5,000 to 7,000 m³. On the upper fan, a narrow V-shaped channel conveyed the flows through a cross-section of approximately 6 m². Assuming a debris-flow velocity of approximately 3 to 5 m/s, this corresponds to an estimated peak discharge of approximately 18 to 30 m³/s. According to BGC's (April 6, 2018) frequency-magnitude relationship, this magnitude estimate corresponds to a return period of less than 10 years for the combined Bear Creek and Pete's Creek watershed.
- BGC also observed evidence of a fresh debris flow originating from the Bear Creek watershed, which appeared substantially larger than the Pete's Creek event. It impacted an area similar to the July 30, 2016 Bear Creek debris flow, except BGC did not observe evidence of the runout extending past the fan margin from the helicopter (Photo 1), and there were no reports of downstream impacts. The Bear Creek debris flow appeared to be a distinct event from the Pete's Creek debris flow, in that it did not avulse into the Pete's Creek channel.
- From the helicopter, the Pete's Creek debris flow appeared to have initiated from two or three tributaries in the upper watershed at an elevation of approximately 1,600 m (Photo 3, 4). BGC did not observe a single, large initiating source, such as a landslide scar, and interprets the debris flow was likely triggered through in-channel sediment entrainment during high runoff. BGC observed that most of the Pete's Creek mainstem scoured to bedrock in the watershed, with water flowing in the tributary at the time of inspection, indicating limited remaining sediment supply along the mainstem. Some sediment sources remain in the upper watershed, but appear to be more limited than observed in the Bear Creek watershed, described below.
- Similar to Pete's Creek, BGC did not observe a single large initiating source in the Bear Creek watershed from the helicopter overflight, rather, fresh debris-flow tracks on the three main tributaries and multiple sub-tributaries (Photo 3). Unlike Pete's Creek, the Bear Creek watershed contains numerous, extensive debris sources associated with material accumulated within tributaries and talus cones. BGC observed a few isolated locations that may have been scoured to bedrock, but most of the debris tracks and surrounding slopes appeared to retain substantial remaining debris supply.

4.0 FINDINGS AND RECOMMENDATIONS

4.1 Berm Stability

BGC's opinion is that a berm failure resulting in a sudden release of debris from behind the berm is very unlikely. As described in Section 3.0, BGC did not observe any signs of active berm deformation or evidence of a developing failure mechanism. Although BGC observed erosional gullies on the downhill slope of the berm, these were relatively limited in extent and are not expected to compromise the overall stability of the berm. Furthermore, the debris deposit behind the berm is expected to stabilize over time as excess water drains and the material consolidates. Therefore, the filled berm does not pose an imminent threat to downstream residents from its failure.

4.2 Berm Condition

The filled condition of the berm increases risk to life safety and properties from debris flows at 8332 Seton Portage Road. Although the level of debris-flow protection provided by this berm was already relatively low (described further in Section 4.5), the current filled condition further reduces this protection. If another debris flow were to occur on Pete's Creek, or from an avulsion on Bear Creek, it is very likely to overtop the berm, resulting in greater inundation extents and flow intensity at the 8332 Seton Portage Road property, compared to if the berm were empty. The filled berm crest also acts as a knickpoint, and further erosion and downcutting is likely to occur at the downhill side if high runoff or another debris flow reaches the overtopping location, possibly remobilizing the debris impounded behind it.

As for properties outside of the Whitecap Development, BGC considers that the filled condition of the berm would result in a negligible increase in flow intensity at other nearby properties from the mechanisms described above.

4.3 Berm Repair

BGC understands the SLRD is currently in the process of retaining a contractor to clean out and repair the berm. Per the Operations and Maintenance (O&M) Manual (SLRD, December 15, 2001), major repairs such as rebuilding, raising, or widening the works require guidance from a Qualified Professional (QP) and supporting documentation.

Although recommendations for berm repair are outside of BGC's current scope of work, BGC offers the following comments for SLRD's consideration, in response to questions raised by the SLRD representative during the site visit. These comments are based on field-level observations only. Decisions regarding major repair works should be made by the QP retained for that scope of work, in accordance with the O&M Manual.

General considerations raised in discussion with the SLRD representative included the following:

- Removing debris impounded behind the berm and in the ditch to restore capacity, consistent with the criteria set out in the O&M manual (SLRD, December 15, 2001).

- Repairing the downhill face of the berm by scraping loose debris from the berm face, filling the erosional gullies with compacted coarse granular material sourced from the debris-flow deposit, and restoring the downhill face to a maximum slope of 1.5H:1V.
- Where feasible, raising the berm crest elevation as much as practical upslope of the 8332 Seton Portage Road residence at the approximate location indicated on Figure 02. The berm raise should be completed with thin (e.g., less than 0.3 m) compacted (e.g., track-packed or roller-compacted) lifts of approved excavated material (e.g., workable moisture content and without significant organic content). In order to maintain the 3.7 m design crest width, the raise may require widening the berm on the downhill side or locally steepening the downhill face, to a maximum slope of 1.5H:1V. Widening the berm on the downhill side will require stripping vegetation and possibly removing trees within the vegetation/tree-belt zone specified by LaCas & EBA (July, 2000); however, it is BGC's opinion that raising the berm would provide more protection from debris flows than retaining the existing vegetation in this section.
- Where feasible, increasing the ditch capacity by widening the invert, cutting into the upslope side of the ditch at a slope of 2H:1V.
- Excavated debris may be suitable for use in raising and repairing the berm, at the discretion of the QP. If excess or deleterious material (e.g., fines- or organics-rich) cannot be disposed of off-site, BGC understands that material could potentially be placed and spread along the maintenance right-of-way on the interior side of the berm and seeded.
- Given the potential for further debris-flow activity, implementing weather-based planning and work-stoppage protocols for personnel involved in berm repairs, such as not scheduling work during forecast thunderstorms or heavy rain, and halting work and evacuating the fan area if such conditions develop while work is underway.

4.4 Evacuation

In discussion with the SLRD representative on August 27, 2026, BGC provided its professional opinion regarding the level of threat posed by the current condition of the berm, as described in Sections 4.1 and 4.2. Based on this input, the SLRD issued an evacuation alert on August 28, 2026 for the five lots within the Whitecap Development. BGC understands the main purpose of the alert is to prompt the current resident at 8332 Seton Portage Road to be prepared to evacuate during intense or prolonged rainfall, given the very high likelihood that the berm would be overtopped if another debris flow or flooding were to occur. The SLRD could consider upgrading the alert to an evacuation order in response to weather forecasts of heavy rain or thunderstorms. However, significant uncertainty would remain as to whether such conditions would trigger a debris flow, and implementing a forecast-based system would require ongoing monitoring by the SLRD. For this reason, BGC is not presently recommending that the SLRD supplement the evacuation alert with forecast-based evacuation orders, and instead recommends that the SLRD communicate potential debris-flow triggering conditions and emergency preparedness to the resident at 8332 Seton Portage Road.

BGC recommends that the evacuation alert remain in place until debris behind the berm has been removed and the berm and ditch capacity has been re-established.

4.5 Long-Term Berm Functionality and Risk Management

As described in Section 2.3, the berm has been overtopped three times in the past 10 years by relatively small debris flows. Based on BGC's field observations, review of the Whitecap Development mitigation works design, and BGC's understanding of debris-flow hazards at this site, the mitigation does not effectively deflect, convey, or retain even relatively small-magnitude debris flows, such as those documented in Section 2.3. The southern training berm and channel were sized for debris flows with a peak discharge of approximately 10 to 20 m³/s, which is less than a 10-year return period event according to BGC's frequency-magnitude estimate (BGC, April 6, 2018). Moreover, debris flows originating from Pete's Creek are not presently directed toward this channel. Instead, they are directed perpendicular to the comparatively smaller-capacity eastern perimeter berm and ditch sized for overland flooding. The ditch gradient in this section is approximately 2 to 3° to the north, which is too gentle to effectively convey sediment. As a result, debris accumulates behind the berm and overtops rather than being deflected around the property.

Much larger debris flows than the previous events are possible on Pete's Creek, including from avulsions on Bear Creek, and could result in extensive damage and fatalities (BGC, April 6, 2018). BGC's April 6, 2018 risk assessment identified that life-safety risk to individuals in buildings on the Bear/Pete's fan is considered intolerable based on risk-tolerance criteria adopted in other Canadian jurisdictions (annual risk of fatality exceeding 1:10,000). Eleven of the residences on the fan, including 8332 Seton Portage Road, exceed an annual risk of fatality of 1:1,000.

Restoring the berm and ditch capacity and raising the berm will provide some risk reduction to the 8332 Seton Portage Road residence, but BGC estimates these measures will not reduce life-safety risk to tolerable levels. It is likely that the berm will be overtopped by debris flows again, posing ongoing life-safety risks to residents in the Whitecap Development, and recurring emergency response and maintenance costs to SLRD and the Province.

Therefore, BGC recommends that the SLRD explore funding mechanisms for debris-flow mitigation at the Whitecap Development and elsewhere on Bear/Pete's fan, such as the conceptual mitigation options presented in BGC's April 6, 2018 report. There may be interim risk-reduction measures to improve the functionality of the Whitecap Development mitigation works, which could offer a lower-cost alternative to fan-wide mitigation options presented in that report. Further assessment would be needed to confirm the feasibility and expected risk reduction of such measures.

5.0 CLOSURE

We trust the above satisfies your requirements. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Inc.
per:



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Reviewed by:

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EGBC Permit to Practice, BGC Engineering Inc. 1000944

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Attachment(s): Limitations
References
Figures 01 and 02

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REFERENCES

- BGC Engineering Inc. (BGC). (2017, January 31). *Bear Creek Fan, Preliminary Debris-Flow Hazard Assessment, Whitecap Development* [Report]. Prepared for Squamish-Lillooet Regional District.
- BGC Engineering Inc. (BGC). (2018, April 6). *Seton Portage Area Integrated Hydrogeomorphic Risk Assessment* [Report]. Prepared for Squamish-Lillooet Regional District.
- Kerr Wood Leidal Associates Ltd. (KWL). (2005, November 24). *Dike Inspection Report, Whitecap Development (Bear Creek)* [Report]. Prepared for Squamish-Lillooet Regional District.
- LaCas Consultants Inc. (LaCas) & EBA Engineering Consultants Ltd. (EBA). (2000, July). *The Whitecap Development, Flood and Debris Flow Mitigation Works* [Report]. Prepared for Mr. R. (Bob) Boyar of Seton Portage.
- Squamish-Lillooet Regional District (SLRD). (2001, December 15). *Seton Portage, B.C., Whitecap Development, Flood and Debris Flow Mitigation Works, Operation and Maintenance Manual*. Prepared by LaCas Consultants Inc. (LaCas) & EBA Engineering Consultants Ltd. (EBA) for Squamish-Lillooet Regional District.

FIGURES



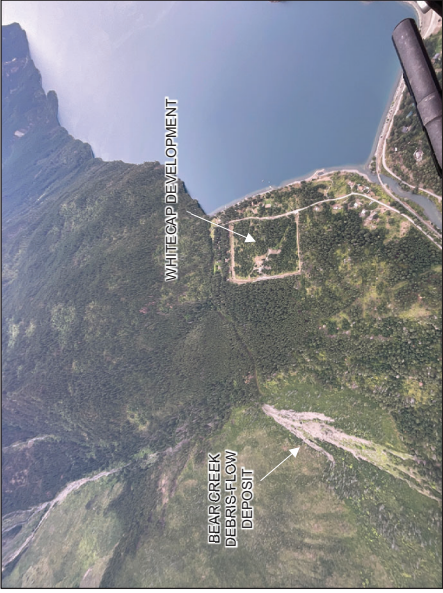
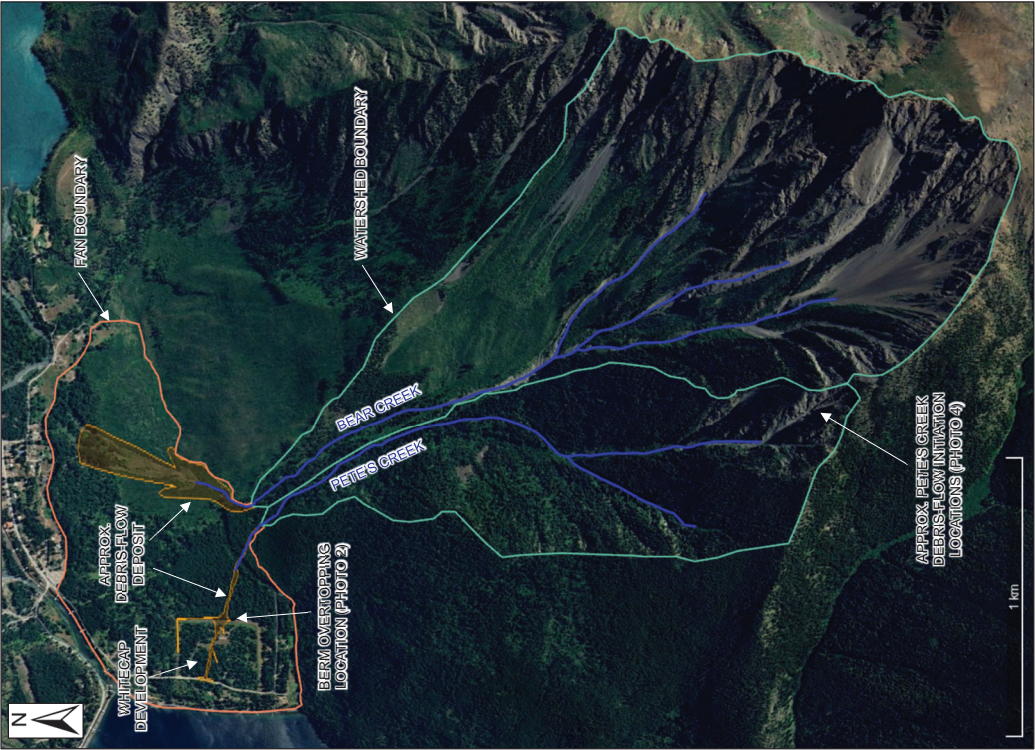


Photo 1. Overview of the Bear/Pete's fan area and lower watershed.



Photo 2. Berm overtopping location from debris flow on Pete's Creek.



Photo 3. Upper Bear/Pete's watershed. Yellow arrows indicate debris-flow initiation locations with fresh debris tracks.



Photo 4. Close-up of the upper tributaries in the Pete's Creek watershed where the debris flow initiated.

NOTES:

1. This Figure should be read in conjunction with BGC's report title Whitecap Berm Emergency Geotechnical Assessment and dated September 15, 2026.
2. Satellite imagery basemap from Google Earth.
3. Debris-flow deposit delineations are approximate and do not include full extent of sedimentation and flooding.
4. Helicopter photos taken by BGC on August 27, 2026.

PREPARED BY:

SZ

FIGURE TITLE:

SITE OVERVIEW AND HELICOPTER PHOTOS

CHECKED BY:

ABS

CLIENT:

SQUAMISH LILLOOET REGIONAL DISTRICT

APPROVED BY:

SZ

SCALE:

AS SHOWN

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Photo 5. On eastern berm looking south at debris conveyed to the north by the perimeter ditch.



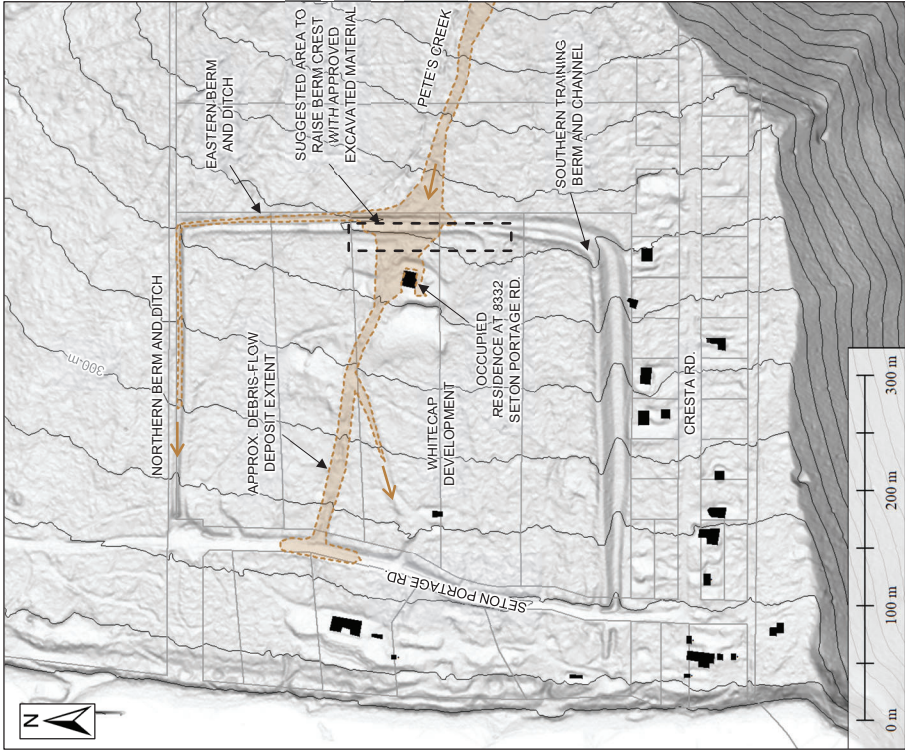
Photo 6. Looking south along downstream berm crest at overtopping location. Occupied residence approx. 30 m downslope of berm.



Photo 7. Upslope side of occupied residence at 8332 Seton Portage Road surrounded by debris.



Photo 8. At berm toe looking east at erosional gullies along downhill face of berm at overtopping location.



NOTES:

1. This Figure should be read in conjunction with BGC's report title Whitecap Berm Emergency Geotechnical Assessment and dated September 15, 2026.
2. Base topographic data based on lidar provided by FLNRO – Thompson Okanagan Region via UNBC, Dated October 10, 2017. Contour interval is 10 m.
3. Debris-flow deposit delineations are approximate and do not include full extent of sedimentation and flooding.
4. Field photos taken by BGC on August 26, 2026.
5. Parcel boundaries in grey from Parcel Map BC. Building footprints in black digitized by BGC from orthomagnery provided by FLNRO – Thompson Okanagan Region via UNBC, Dated October 10, 2017.

PREPARED BY:	SZ	FIGURE TITLE:	WHITECAP BERM OVERTOPPING
CHECKED BY:	ABS	CLIENT:	SQUAMISH LILLOET REGIONAL DISTRICT
APPROVED BY:	SZ	SCALE:	AS SHOWN
		PROJECT NO:	1358013
		FIGURE NO:	02