August 16, 2023

Alberta Transportation and Economic Corridors
Main Floor, Provincial Building
9621 96 Avenue
Peace River, Alberta
T8S 1T4

Max Shannon
Construction Technologist

Dear Mr. Shannon:

CON0022166 Peace Region (Grande Prairie District – South) GRMP
Hwy 40:36, km 13.700 Debris Flow
Section D – Call-Out Report
Draft

1 INTRODUCTION

As part of the Geohazard Risk Management Program (GRMP) contract for the Peace Region (Grande Prairie District – South) (GP South) region, Klohn Crippen Berger Ltd. (KCB) was requested by Alberta Transportation and Economic Corridors (TEC) to conduct a call-out inspection at km 13.700 of Hwy 40:36 (the site), near McIntyre Mine (or Smoky River Coal Mine) approximately 21 km north of Grande Cache, Alberta. The approximate UTM coordinates of the site are 5985608 N, 361022 E (UTM Zone 11, NAD 83) and the legal land description is NE 09-58-08-W6M.

The site has not been previously inspected by KCB, but KCB has seen the general area of the site while completing inspections at other nearby sites. The site is located adjacent to an unnumbered rockfall site at km 13.820, and north of the GP036 and GP049 rockfall sites at km 12.061 and km 8.395 and the GP054 debris flow corridor site, which consists of multiple debris flow sites between km 8.119 to km 12.262. It is noted that prior to 2022, some of the debris flow sites now included in the GP054 site were previously included in the GP036 and GP049 sites which are now rockfall-only sites. A site location plan for the debris flow sites, the rockfall sites, and the site is shown on Figure 1, and a site plan for the subject site is shown on Figure 2.

On June 19, 2023, TEC notified KCB that a debris flow at the site had reached the highway during a heavy precipitation event (see daily precipitation data on Figure 3). It is our understanding based on an e-mail received from TEC on June 19, 2023, that during the debris flow, the Highway Maintenance Contractor (HMC) was struggling to keep the highway clear with a front-end loader. TEC requested KCB to complete a call-out inspection once the precipitation stopped so an Unmanned-Aerial Vehicle (UAV) flight of the site could be conducted.

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On June 22, 2023, the call-out inspection and UAV flight were completed by Courtney Mulhall, M.Sc., P.Eng. and Jacques Bernier, E.I.T. of KCB. Select photographs taken during the inspection (Photos 4 through 26), including photographs taken with our UAV, are presented in Appendix I with one photograph (Photo 1) taken by the HMC on June 19, 2023 during the debris flow event and two photos taken during our May 2023 fieldwork at the adjacent unnumbered rockfall site (Photos 2 and 3) (see Section 3). Waypoints (WPs) taken with a handheld global-positioning system (GPS) during the inspection are presented on Figure 2.

This call-out report was prepared for TEC under the existing Consulting Services Contract CON0022166 for the Peace Region (Grande Prairie District – South) GRMP. KCB's site observations, assessments, and recommendations for short-term and long-term remedial actions are presented in this report.

To assist with your review of this report, requests for information or clarification are identified with ***red, bolded, and italicized text***.

2 SITE DESCRIPTION

The site is located within Contract Maintenance Area (CMA) 504 on the north valley slope of the Smoky River valley approximately 50 m upslope of Canadian National Railway Company's (CN's) railway tracks and 70 m upslope of the Smoky River (a fish-bearing Class C water body). The 2022 Average Annual Daily Traffic (AADT) from Traffic Count Station No. 25592 for this section of Hwy 40:36 is 780 vehicles northbound and 980 vehicles southbound (TEC 2022).

A TransCanada Pipelines Ltd. high-pressure natural-gas pipeline is located below the west highway ditch. We understood from previous discussions with TEC that the pipeline is shallow and that any excavation of debris flow material from the ditch must be undertaken with a pipeline representative present.

The area upslope of the site includes mine-waste dumps and mine (haul and access) roads developed on the mountain side. The mine-waste dumps and mine roads appear to be composed of varying mixtures of fine-grained and coarse-grained materials, including some boulders. We understand from previous discussions with TEC that a rockfall fence was previously installed at the adjacent unnumbered rockfall site in 2011 or 2012 to protect the public using the highway from fly rock during blasting and rockfall from waste-dump construction.

According to the Alberta Geological Survey (AGS 2013a), the surficial geology along the subject section of the Smoky River valley is composed of fluvial deposits on the lower section of the valley and riverbanks; these deposited sediments include poorly to well sorted, stratified layers of sand, gravel, silt, clay, and organics. The surficial geology in the upper hills of the valley is composed mainly of colluvial deposits which are sediments from gravity induce movements that include bedrock and surficial material from fluvial deposits. Moraine deposits (i.e., till) are found between the upper hills and lower section of the valley, these deposits include a mixture of clay, silt, and sand, with the presence of pebbles, cobbles, and boulders.

The bedrock along the the subject section of the Smoky River valley is part of the Bullhead Group and Fort St. John Group in the Foothills region of Alberta (Prior et al. 2013). The Bullhead Group is composed of the Gething and the Cadomin formations of the lower Cretaceous. The Fort St. John Group is composed of multiple formations including the Shaftesbury of the upper and lower Cretaceous, and the Boulder Creek, Hulcross, Gates, and Moosebar of the lower Cretaceous (Prior et al. 2013). The detailed geology description of the Smoky River Coal mine by Forgeron (2016) indicates that the bedrock near the site belongs to the Gates Formation, which is composed mainly of interbedded layers of sedimentary rock, including fine-grained and medium-grained sandstone, conglomerate, mudstone, carbonaceous mudstone, and thick coal seams (Prior et al 2013).

3 BACKGROUND INFORMATION

KCB reviewed the available background information, which included:

- Two call-out reports prepared by Karl Engineering Consultants Ltd. (KEC) in 2012 and 2013 for a mine/haul road extension at the GP025 mudslide site (KEC 2012 and 2013). No km or coordinates were provided for the site, but it was described as near the mine access road which is located approximately 330 m north of the subject site. The call-out reports indicate:
  - a debris flow happened at the GP025 site in either 2005 or 2006;
  - the drainage topography of the catchment area would be substantially modified by the earthworks undertaken for the new mine road, which were understood to include a roll-out berm and rock traps, a dyke, ponds for sedimentation, road embankments and drainage measures including rock drainage layers and culverts, etc.; and
  - the waste-rock dump was being monitored using radar prisms, slope inclinometers, and piezometers.
- A call-out report prepared by Thurber Engineering Ltd. (TEL) in 2020 for a rockfall event at km 8.55 and two debris flow events at km 10.9 and 11.2 (Thurber 2020). The call-out report indicated debris flow events have occurred at debris flow sites south of the subject site in June 2017, 2019, and 2020.
- The aerial imagery available on AT Maps (date unknown but assumed to be pre-2022) (TEC 2023), which is shown on Figure 4, shows an approximate 35-m-long erosion gully on the side of a mine road bench above the mine-waste dump and an approximate 120-m-long erosion gully between the north flank of the mine-waste dump and natural slope. There is a debris fan at the base of the lower erosion gully that extends into a body of water impounded by a mine road at the toe of the mine-waste dump.
- As mentioned in Section 1, KCB has not previously inspected the subject site but has inspected other nearby sites, including the adjacent unnumbered rockfall site at km 13.820 during a Section D call-out inspection on July 14, 2022 (KCB 2022a) and some of the other debris flow sites at km 8.1, 8.8, 10.9, 11.2, 12.1 during previous Section B inspections on July 21, 2021, June 14, 2022, and June 12, 2023 (KCB 2021 and 2022b – the 2023 report has

not yet been prepared). KCB also recently completed our field work for the Hwy 40:36 rockfall hazard mitigation project in May 2023, which included the unnumbered rockfall site adjacent to the subject site.

- Some UAV photos (Photos 2 and 3) taken of the subject site during our May 2023 fieldwork at the adjacent rockfall site are included in Appendix I. In the photos, the two erosion gullies shown in Figure 4 appear to have connected and eroded further downslope below the rockfall fence and through the mine road along the toe of the waste-rock dump. There also appears to be some pond water and debris in the west highway ditch.

KCB reviewed the available precipitation data for the site from 1967 to 2023. The record is discontinuous before 1990, but the available daily precipitation data from 1990 to 2023 is shown on Figure 3. The data was recorded at the Grande Cache S.T.P. and Kakwa weather stations located approximately 15 km southwest and 26.5 km northeast of the site, respectively (ACIS 2023 and GoC 2023). As previously mentioned in KCB (2022a and 2022b) it is noted that since 1990, the five highest daily precipitation events have occurred since 2017 with daily precipitation between approximately 69 mm to 111 mm. Based on the available data the intensity frequency of heavy precipitation events appears to be increasing in recent years.

A summary of documented debris flows events by kilometer (km) and year are summarized in Table 1. Most of these events appear to correlate to the heavy precipitation years as shown on Figure 3 for the Kakwa weather station.

Table 1 Debris flow events by highway km and year

Year[1]	Site and Highway km							
	GP054 Debris Flow Corridor						Subject Site (Unnumbered)	GP025
	8.1	8.8	10.9	11.2	11.6	12.0	13.7	14.0
2005/2006								X
2017	X	X			X	X		
2019				X				
2020			X	X				
2023							X	

Notes:
[1] Debris flow events prior to 2023 summarized from KEC (2012 and 2013) and Thurber (2020).

4 SITE OBSERVATIONS

KCB's visual observations made during the June 2023 call-out inspection are listed below. Select photographs taken during the inspection (Photos 4 and 26), including photographs taken with our UAV, are provided in Appendix I.

- The weather was approximately 10° C to 15° C, overcast and rainy.
- Upslope and southwest of the site, there are two mine roads developed on the mountain side and what appears to be a unvegetated mine-waste dump (Photos 4 through 6).

One mine road switchbacks across the mine-waste dump before joining with a mine road that connects with another portion of the mine to the northeast, and the other lower mine road transverses along the bottom of the waste-rock dump towards the subject site and rockfall fence.

- A pond of water is located at the northeast corner of the mine-waste dump (Photo 4).

- Debris from the highway removed during/following the June 19, 2023 flow event was temporarily stockpiled along the west side of the highway creating an approximate 60-m long berm between WP003 and WP009 and a smaller 50-m long berm extending south of WP009 (Photo 4 through 13). The width and height of the berms varies, but near WP008 where it is largest it is up to approximately 3 m to 4 m wide and 3 m to 4 m high. ***TEC to confirm if the stockpiled material has already been removed.***
  - Along the temporary stockpile of debris, a row of survey stakes marks the location of a high-pressure natural-gas line (photos 9 and 12).

- Behind the temporary stockpile of debris, a debris fan extends back through the trees approximately 60 m to the toe of the lower mine road and northeast corner of the mine-waste dump where it is approximately 20 m wide (Photos 4 through 6, and 14 through 17). The material in the debris fan mainly consisted of coarse-grained material, including some cobbles and a few boulders, in a matrix of fine-grained material. The coarse-grained material varied from angular to subrounded. Generally, the material in the debris fan appeared coarser than the material removed from the highway. ***TEC to confirm if coarser material from the debris flow was removed and stockpiled elsewhere.***
- An approximate 275-m long erosion gully extends from an upper bench of the mine road down between the north flank and toe of the mine-waste dump and natural ground.
  - The erosion gully cuts through some material located on the outside corner of a mine road switchback, below the rockfall fence, and through the lower mine road (Photos 4 through 6, 17, and 18) where it joins the apex of the debris fan (Photos 17).
    - The width and depth of the erosion gully along the waste-rock dump varies, but at its widest it appears to be up to approximately 15 m wide and 10 m deep.
    - The entire length of rockfall fence undercut was not visible (obscured by trees and outside TEC's right-of-way), but an approximate 5-m high near-vertical face has been eroded below one of the visible rockfall fence posts (Photo 18). The section of rockfall fence to the north appeared to be in good condition with little to no debris retained behind it (Photo 19).
    - An approximate 20-m wide by 15-m high section of the lower access road has been eroded at the northeast corner of the mine-waste dump (photos 17 and 18).
  - The bottom of the erosion gully is located approximately 150 m upslope and west of the Smoky River.

- Water was observed flowing from the highway backslope near WP009 (Photos 4, 5, and 8) and through and along either side of the debris fan into the west highway ditch (Photo 13).
  - The water flowing from the highway backslope near WP009 accounts for approximately 50% of the ditch flow and appears to be flowing from a leakage point located at the downstream toe of the mine slope at WP010 (Photos 20 and 21). Based on the 2012 and 2013 call-out reports prepared by KEC, this maybe the location of a possible drain below the mine-waste dump.
  - The water flowing through and along either side of the debris fan appears to be flowing from further upslope, including the erosion gully and the pond of water located at the northeast corner of the mine-waste dump (Photos 4 and 18).
- Water in the west highway ditch flows through a centerline culvert below the highway to discharge downslope adjacent to the railway tracks. The culvert inlet (WP003) (Photos 4, 5, and 22) consists of an approximate 900-mm-diameter piece of corrugated-steel-pipe (CSP), which is dented at the obvert, and the culvert outlet (WP004) (Photo 23) consists of an approximate 900-mm-diameter piece of corrugated-plastic-pipe. Both the culvert inlet and outlet were clear and open.
- Surface water overflow across the highway has resulted in erosion gullies along the east side of the highway over an approximate 35-m long section between WP001 and WP002 (Photos 6, 24, and 25). Some of the erosion gullies were up to approximately 2 m wide by 1 m deep. In some locations the pavement subgrade consisting of sand and gravel was exposed, and some of the w-beam guardrail posts were partially undermined up to approximately 0.3 m (Photos24 and 25). ***TEC to confirm if the erosion gullies have already been backfilled.***
- Debris washed downslope of the site was observed along the CN tracks where a train was parked at the time of the inspection (Photos 4 and 24). A small berm up to 0.3 m high was observed along the track indicating CN has done some clean-up.
- KCB was unable to cross the railway tracks to assess if material or turbid water from the debris flow had reached the Smoky River but based on photos taken with our UAV (Photo 6) it does not appear that it did.

KCB also briefly stopped at a few other debris flow sites and at a couple other locations where watercourses along the mountain side flow into the west highway ditch, including sites and watercourses at km 8.1, 8.8, 10.4, 10.9, 11.2, 11.5, 11.6, 12.1, or 12.4. No obvious changes were observed at this sites or water courses since the June 14, 2022 and June 12, 2023 Section B inspections.

5 ASSESSMENT

Site Conditions

KCB's assessment of the conditions at the site is as follows:

- Material (mainly mine-road and waste-dump material) was eroded and transported downslope through an existing erosion gully onto the highway and railway tracks during a period of heavy precipitation (the largest precipitation event recorded at the Kakwa station since it was installed in 1990).
  - Based on the available aerial imagery and UAV photos (see Figures 2 and 4, and Photos 2 and 3):
    - two smaller erosion gullies, one on the side of a mine road bench and the other between the north flank of the mine-waste dump and natural ground, appear to have connected and eroded further downslope below the rockfall fence and through the mine road along the toe of the waste-rock dump prior to our May 2023 fieldwork at the adjacent unnumbered rockfall site and our June 2023 inspection of the subject site; and
    - the erosion gullies observed on the east side of the highway during our June 2023 inspection of the subject site were not visible during our May 2023 fieldwork at the adjacent unnumbered rockfall site.

  These observations indicate erosion at the site is active, and increased erosion and more frequent debris flows of a higher severity may be occurring.
- The source of the debris flow material appears to consist of erodible soils (mainly mine road and waste dump materials) with little to no vegetation soil cover, and erosion is likely to occur during most precipitation events.
- The volume of eroded material and surface water overflow is influenced by operations within the mine and increased erosion and more frequent debris flows of a higher severity may be occurring than in a natural state (i.e., before the mine).
  - The volume of material transported was likely exacerbated by the volume of material located on the outside corner of the mine road switchback, the existing debris fan at the northeast corner of the mine-waste dump, and erosion below the rockfall and through the mine road at the toe of the mine-waste dump. As well as surface water flowing from the mine, including the pond of water located at the northeast corner of the mine-waste dump.
- Unless revisions to mine surface water drainage are undertaken, erosion and subsequent debris flow/deposition of materials in and across the highway right of way is likely to occur again under similar heavy precipitation events.

The development of mine infrastructure above the highway and the subject debris flow site (and adjacent unnumbered rockfall site) represents a change in site drainage conditions since the highway was constructed. To further our understanding of site conditions, TEC should contact the mine regarding:

- the answers to the questions previously asked by KCB in an e-mail to TEC on June 19, 2023 (***TEC to confirm if they have already received a response from the mine to these questions***), which include:
  - was the waste-rock dump inspected after the heavy rainfall on June 19, 2023 and is the waste-rock dump stable from the perspective of sliding stability;
  - where is the source of the debris that is being eroded and transported to the highway;
  - has gullying of the waste-rock dump occurred due to surface water flow, and if so, is the gullying creating any risks of increased rate of erosion or material transport (e.g., are there unstable gully slopes that could collapse with a surge of additional materials to the channel for transport downslope to the highway) and what steps are being taken by the mine to divert surface water away from the erosion site; and
  - is the rockfall fence retaining material, if yes, will the rockfall fence remain stable and what steps are being taken to address the risk of the rockfall fence falling and releasing material onto the highway.
- whether or not drainage patterns on mine property have been altered (e.g., diverting drainage from one area to another) resulting in concentrated drainage discharging towards the highway;
- how the mine infrastructure above the highway is being monitored, and whether or not TARPs (trigger action response plans) have been developed for the mine infrastructure above the highway and how and when the mine would notify TEC of events that could impact the highway; and
- if erosion and sediment controls have been implemented on mine property since the debris flow event, including backfilling gullies and diverting drainage away from the highway.

It is noted that the 2012 and 2013 call-out reports prepared by KEC indicated cooperation between TEC and the mine; however, based on our recent experience in the GP South GRMP region, it appears communications have not continued.

Climate Triggers

KCB's assessment of the climatic trigger for debris flows at this site are as follows:

- Based on Figure 3 the intensity and frequency of heavy precipitation events appears to be increasing in recent years.

- The debris flow and rock fall events that occurred along this section of Hwy 40:36 between 2017 and 2023, including the debris flow at the subject site in 2023, are likely to occur again in the future.

TEC should assess the potential impacts of increased precipitation on debris flows, not only originating at the mine site but also along the subject section of Hwy 40:36

6 RISK LEVEL

Risk levels for TEC GRMP sites are determined according to the following:

Risk Level = Probability Factor X Consequence Factor

where the TEC's Risk Level is defined as follows:

- For earth slide and debris flow sites:
  - Probability Factor varies from 1 (inactive, very low probability of debris flow occurrence) to 20 (catastrophic debris flow is occurring).
  - Consequence Factor varies from 1 (debris flow may spill into ditches or fills where debris flow does not impact pavement, minor consequence of failure, no immediate impact to driver safety, maintenance issue) to 10 (Sites where the safety of public and significant list of infrastructure facilities or privately owned structure will occur if a debris flow occurs, and where rapid mobilization of large-scale debris flow is possible).
- For erosion sites:
  - Probability Factor varies from 1 (inactive, very low probability of erosion, non-erodible soils or bedrock, physical or structural limitations to erosion expansion; and flat slopes, well vegetated) to 20 (mass wasting of great volumes of soil is occurring, gullies 10-m wide and 4-m deep formed).
  - Consequence Factor varies from 1 (relatively small area of erosion involved confined to ditch or backslope. Less than 25 m of ditch of 100 m^2 or slope affected) to 10 (sites where the eroded material could directly flow into fish bearing rivers of affect water quality and aquatic resources).

We considered both the risk ranking guidelines for earth slides and debris flows and for erosion sites when we developed the risk ranking for the subject site.

The risk level was determined using TEC's risk level system and is presented as follows:

- Probability factor – A rating of 11 was selected as the source of the debris flow material appears to consist of erodible soils (mainly mine road and waste dump materials) with little to no vegetation soil cover, and erosion is likely to occur during most precipitation events. Also, based on the available aerial imagery and UAV photos, the upslope erosion gully is enlarging and greater than 5 m wide by 2 m deep and surface water overflow across the

highway is eroding gullies on the east side of the highway. It is also noted that the volume of eroded material and surface water overflow is influenced by mine operations and increased erosion and more frequent debris flows of a higher severity maybe occurring as a function of how mine drainage is being managed.

- Consequence Factor – A rating of 6 was selected for the site because debris flows reaching the highway affect the use of the highway and the safety of motorists and could result in a temporary full closure of the highway until heavy equipment is available to clear the debris. Detours, if required, would be significant because there is no viable local detour route. There is also the potential for debris flow/eroded material or turbid water to reach the Smoky River which is less than 500 m away from the point of origin of the debris flow.

A total **Risk Level of 66** was assigned for the site.

7 RECOMMENDATIONS

Recommended short-term and long-term remedial actions for the site are discussed in the following subsections.

7.1 Short-Term

KCB recommends the following short-term actions:

- Debris should be removed from the highway right-of-way, including the debris in the west highway ditch stockpiled overtop the high-pressure natural-gas line, to improve storage volume for future debris flow events and remove load/weight from the pipeline. As discussed in Section 0, the pipeline is shallow and any excavation of debris flow material from the ditch must be undertaken with a pipeline representative present. The estimated cost for the HMC to complete this work is between $40,000 and $60,000. ***As discussed in Section 4, TEC to confirm if the stockpiled material has already been removed.***
- The erosion gullies on the east side of the highway should be backfilled to provide support to the highway pavement, subgrade, and guardrail posts where exposed. The estimated cost for the HMC to complete this work is between $20,000 and $40,000. ***As discussed in Section 4, TEC to confirm if the erosion gullies have already been backfilled.***
- TEC should contact the mine regarding the items and questions summarized in Section 5.
- Debris flow reporting could be improved by maintaining a record of debris flows that reach the highway, including the date of event, approximate location, volume of particles, and maximum particle size. It appears that TEC may already be doing this, but a formal record could be prepared by the HMC or MCI based on e-mails to TEC and the regional geotechnical consultant.

7.2 Long-Term

KCB recommendations the following long-term actions:

- If no action is taken by the mine to divert drainage and reduce erosion on their site that may affect the highway and the safety of motorists, TEC should conduct a debris flow risk assessment to verify the cause of the debris flows, assess the risk of future debris flows, and assess how the public could be protected (e.g., debris flow barrier, increased debris flow storage capacity, or improved drainage measures, including how much maintenance and removal of material is needed).
- An assessment should be completed on the potential impacts of increased precipitation on debris flows, not only originating at the mine site but also along the subject section of Hwy 40:36.

8 CLOSURE

This is a draft report only and we solicit your review and comments within four weeks of submission. This draft report must not be relied upon for design, implementation and/or construction.

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Alberta Transportation and Economic Corridors (Client) for the specific application to the Peace Region (Grande Prairie South) Geohazard Risk Management Program (Contract No. CON0022166), and it may not be relied upon by any other party without KCB's written consent.

KCB 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. KCB 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 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.
4. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or

accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.

5. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

Please contact the undersigned if you have any questions or comments regarding this report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Courtney Mulhall, M.Sc., P.Eng.
Geotechnical Engineer

Reviewed by:
Chris Gräpel, M.Eng., P.Eng.
Senior Civil Engineer, Associate

CM&JB:bb

ATTACHMENTS
Figures
Appendix I Site Photographs

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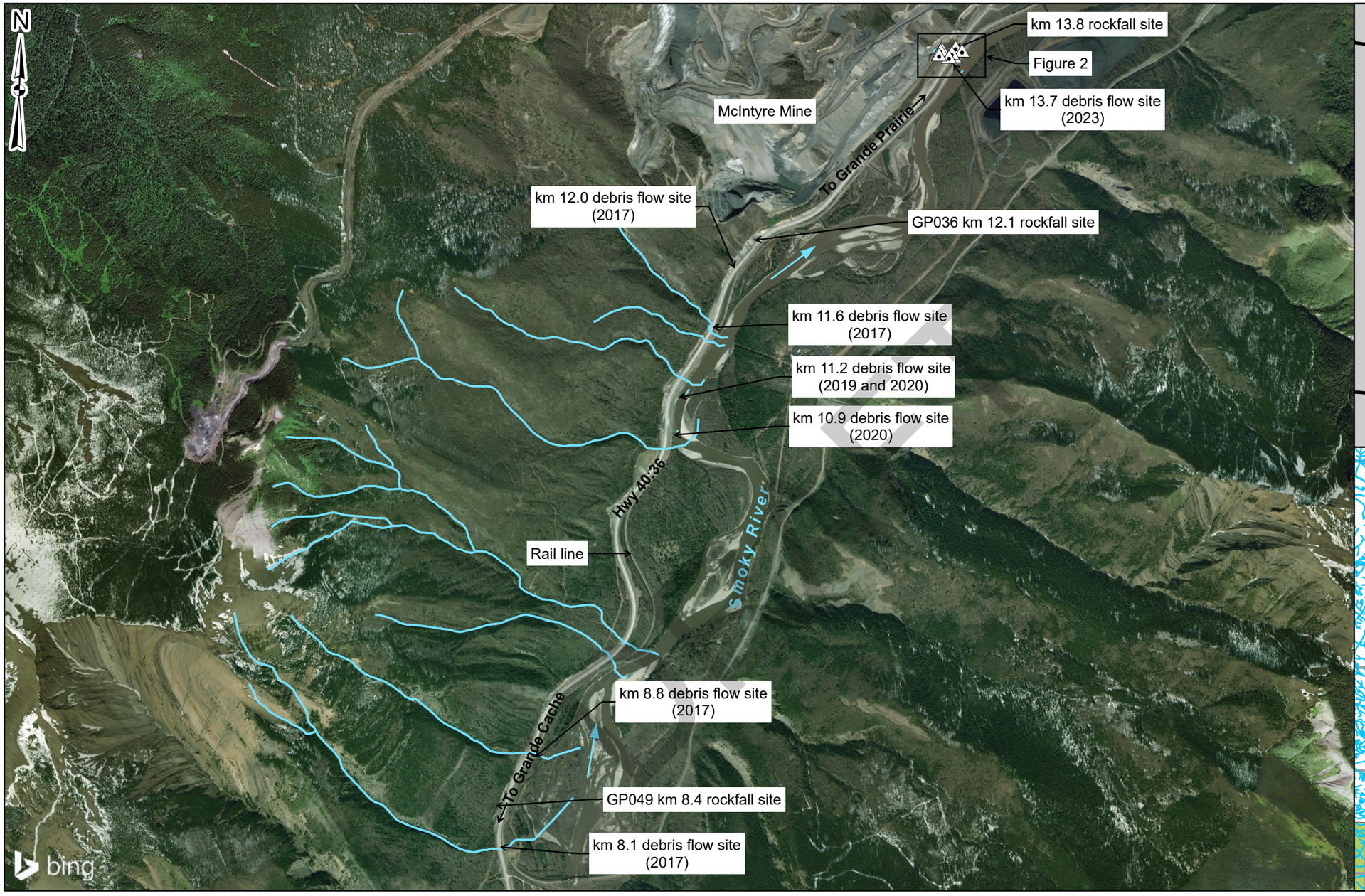
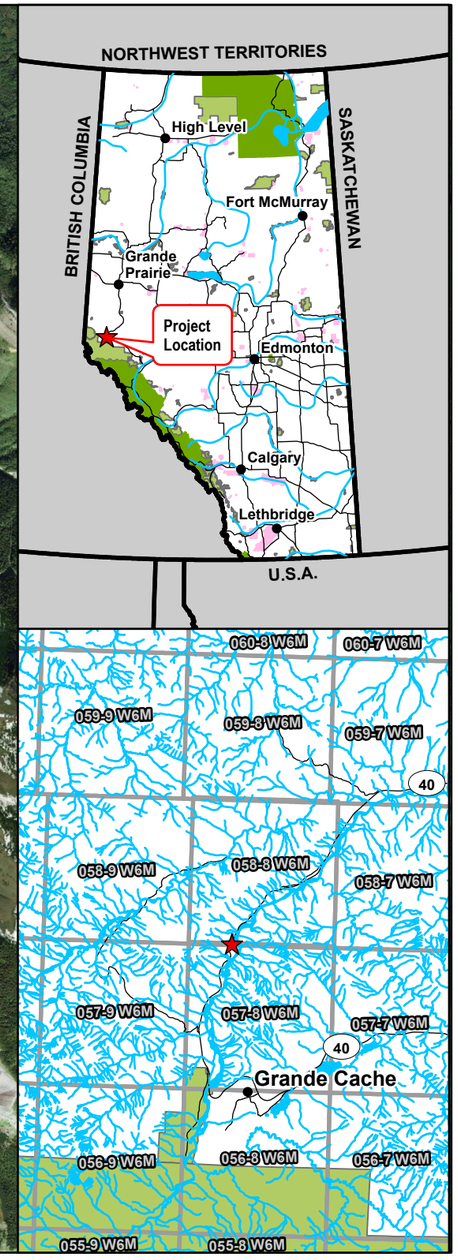
FIGURES





Legend

- Flow Direction
- Watercourse

0 1 Kilometres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: 2022 MICROSOFT CORPORATION, 2022 MAXAR CNES, DISTRIBUTION AIRBUS DS

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: PEACE REGION (GRANDE PRAIRIE DISTRICT-SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
Debris Flow and Rockfall Sites
Hwy 40:36, km 8.1 to 13.7

SCALE	PROJECT No.	FIG No.
1:24,000	A05116A01	1

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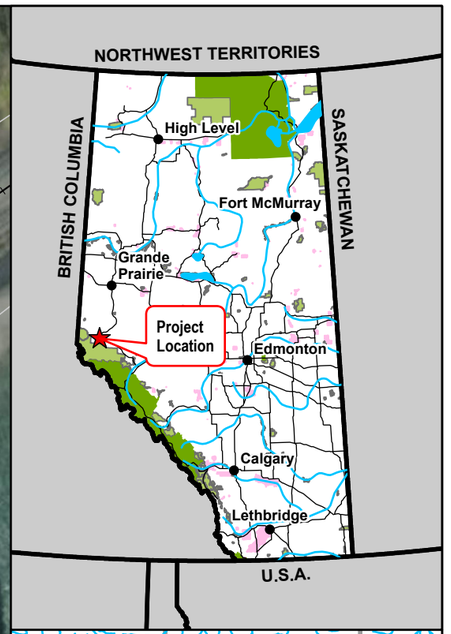

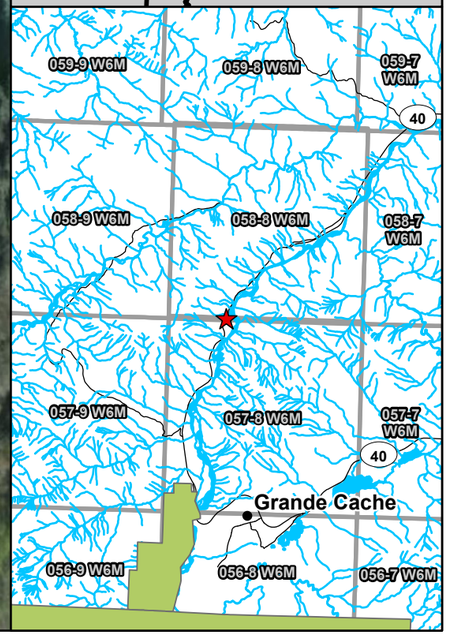

Legend

- GPS Waypoint (June 22, 2023)
- Rail Line
- Flow Direction
- Rockfall Fence
- Culvert
- Guardrail
- Right-of-way

0 50 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 11N
3. IMAGE SOURCE: 2022 MICROSOFT CORPORATION, 2022 MAXAR CNES, DISTRIBUTION AIRBUS DS

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: PEACE REGION (GRANDE PRAIRIE DISTRICT-SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
Debris Flow
Hwy 40:36, km 13.7

SCALE	PROJECT No.	FIG No.
1:1,700	A05116A01	2

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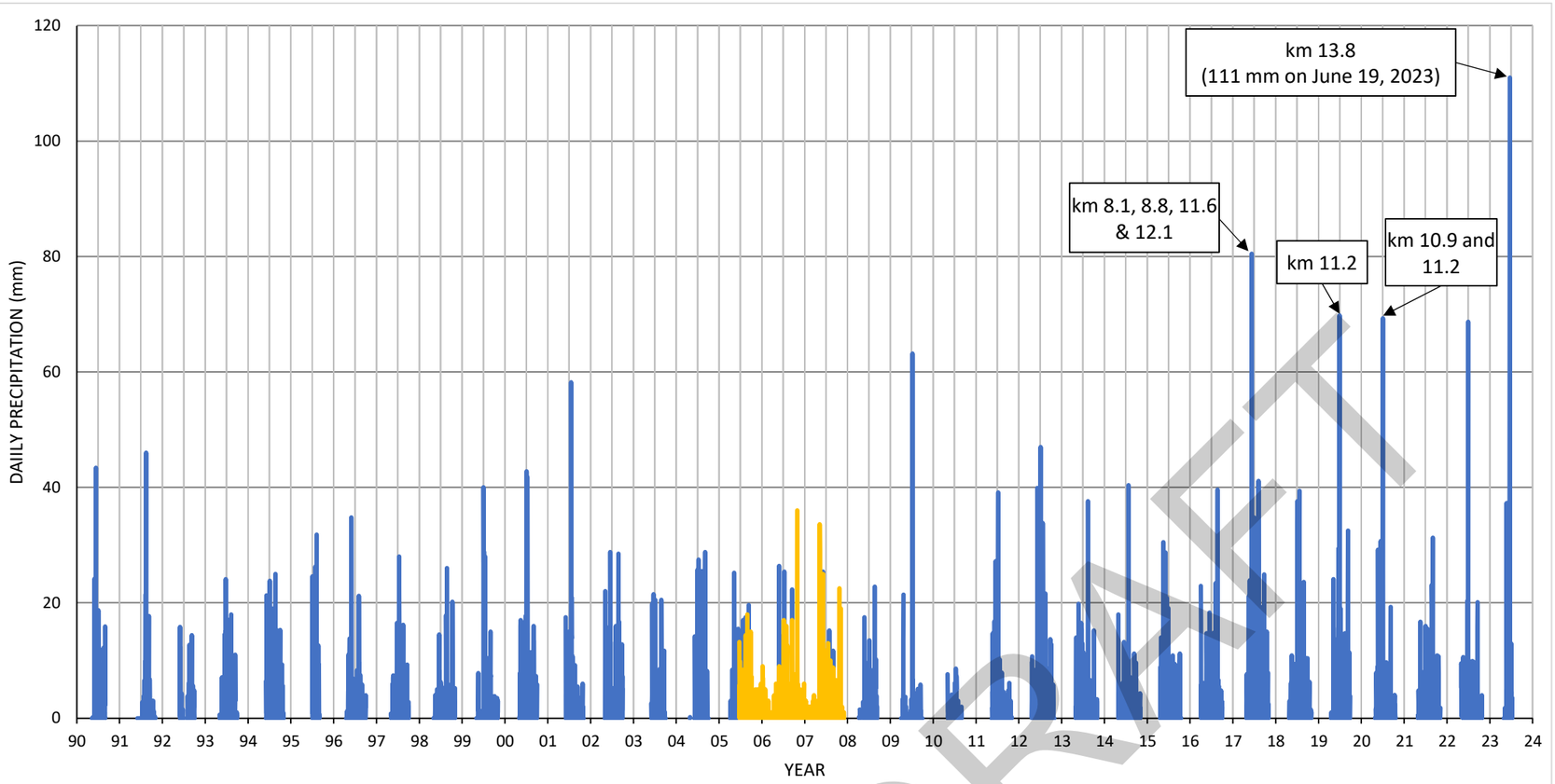
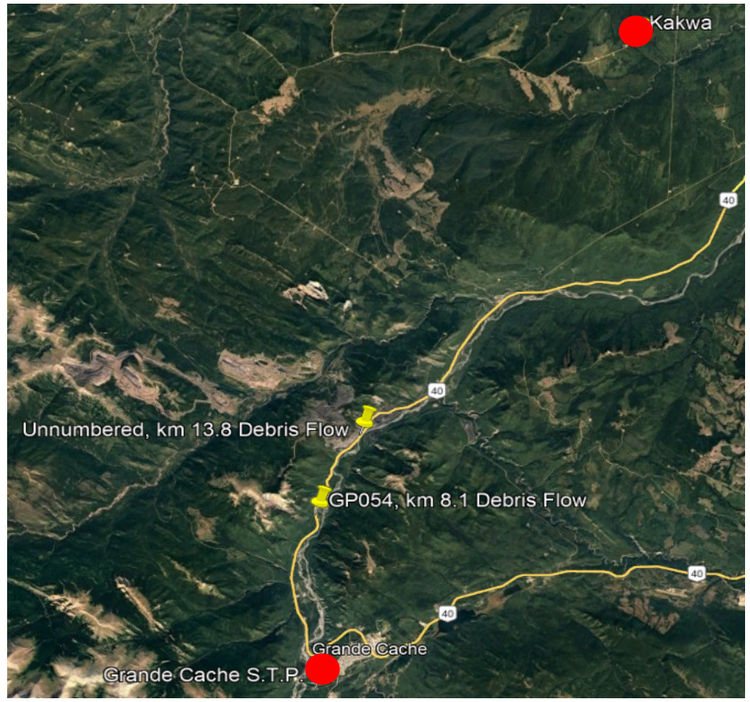




LEGEND:

- WEATHER STATION
- DEBRIS FLOW SITE
- WEATHER STATION DATA - KAKWA
- WEATHER STATION DATA - GRANDE CACHE S.T.P.
- km XX — DEBRIS FLOW EVENT LOCATION

NOTES:

1) DATA DOWNLOADED FROM GOVERNMENT OF CANADA (GoC) OR ALBERTA CLIMATE INFORMATION SERVICE (ACIS) WEBSITES.
2) KAKWA AND GRANGE CACHE S.T.P. STATIONS LOCATED APPROXIMATELY 15 KM AND 26.5 KM FROM SITE.
3) DATA DISCONTINIOUS BEFORE 1990 SO NOT INCLUDED.
4) KAKWA WEATHER STATION DATA INCLUDES DAILY RECORDS FROM GC BETWEEN 1990 AND 2011; AND, ACIS BETWEEN 2005 AND 2023.
5) GRANGE CACHE S.T.P. WEATHER STATION DATA INCLUDES DAILY RECORDS FROM GC BETWEEN 2005 AND 2007.
6) PLAN VIEW SOURCE FROM GOOGLE EARTH PRO.

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH) GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Daily Precipitation Data
Debris Flow Sites
Hwy 40:36

SCALE	PROJECT No.	FIG No
-	A05116A01	3

NOTES:
1) BACKGROUND AERIAL IMAGE TAKEN FROM AT MAPS (TEC 2023_ ACCESSED JULY 25, 2023 FROM: https://extranet.inftra.gov.ab.ca/inftra_portal.html#. DATE OF IMAGE UNKNOWN.

CLIENT
Alberta
Klohn Crippen Berger

PROJECT
PEACE REGION (GRANDE PRAIRIE DISTRICT - SOUTH)
GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Historic Aerial Image
Debris Flow
Hwy 40:36, km 13.700

SCALE	PROJECT No.	FIG No.
		4

APPENDIX I

Site Photographs

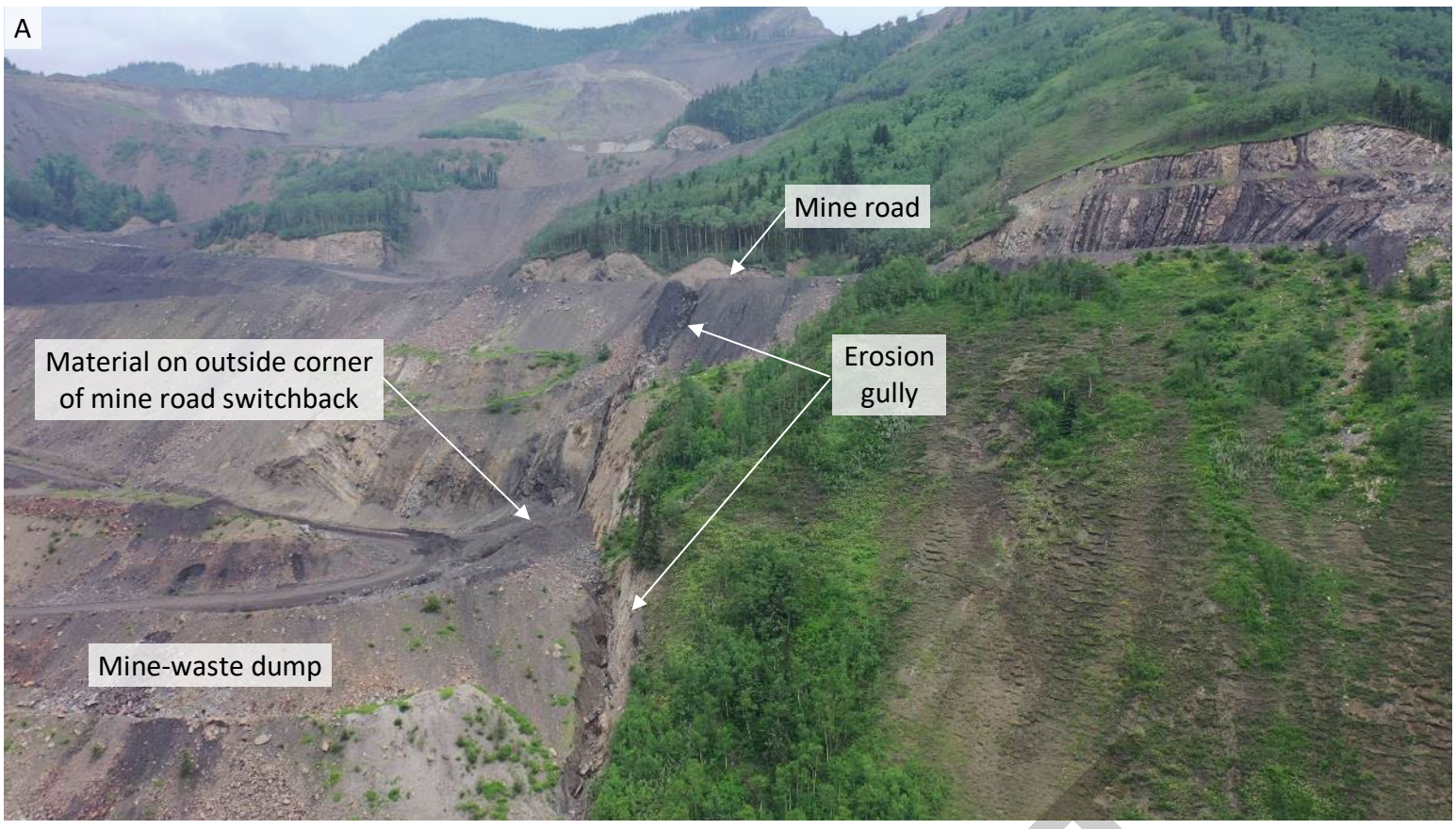
Appendix I
Site Photographs

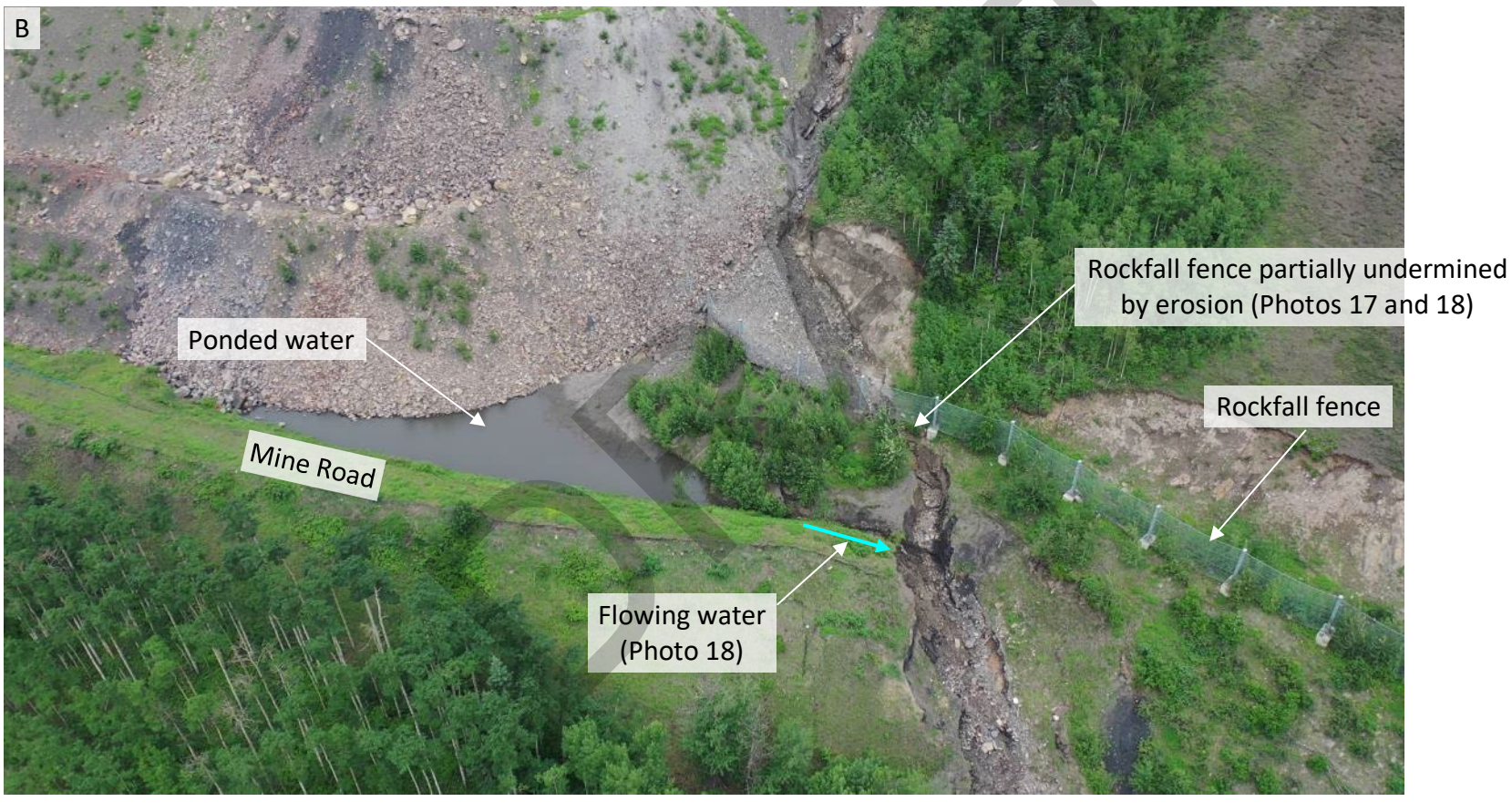
Photo 1 **Debris being cleared from highway by front-end loader. Photo taken by Highway Maintenance Contractor (MCI) on June 19, 2023, facing south.**

Photo 2 **UAV photo of the subject debris flow site taken during our field work at the adjacent unnumbered rockfall site in May 2023. Photo taken with UAV on May 17, 2023, facing west.**

Photo 3 **UAV photo of the subject debris flow site taken during our field work at the adjacent unnumbered rockfall site in May 2023. Photo taken with UAV on May 17, 2023, facing southwest.**

Photo 4 **Overview of site. Note erosion gully between north flank and toe of mine-waste dump through some material located on outside corner of mine road switchback, below rockfall fence, and through lower mine road. Also note water flowing from water ponded at northeast corner of waste-rock dump and along highway backslope (indicated with blue arrows), and stockpile of debris material along west highway ditch. Photo taken with UAV on June 22, 2023 facing west and down.**





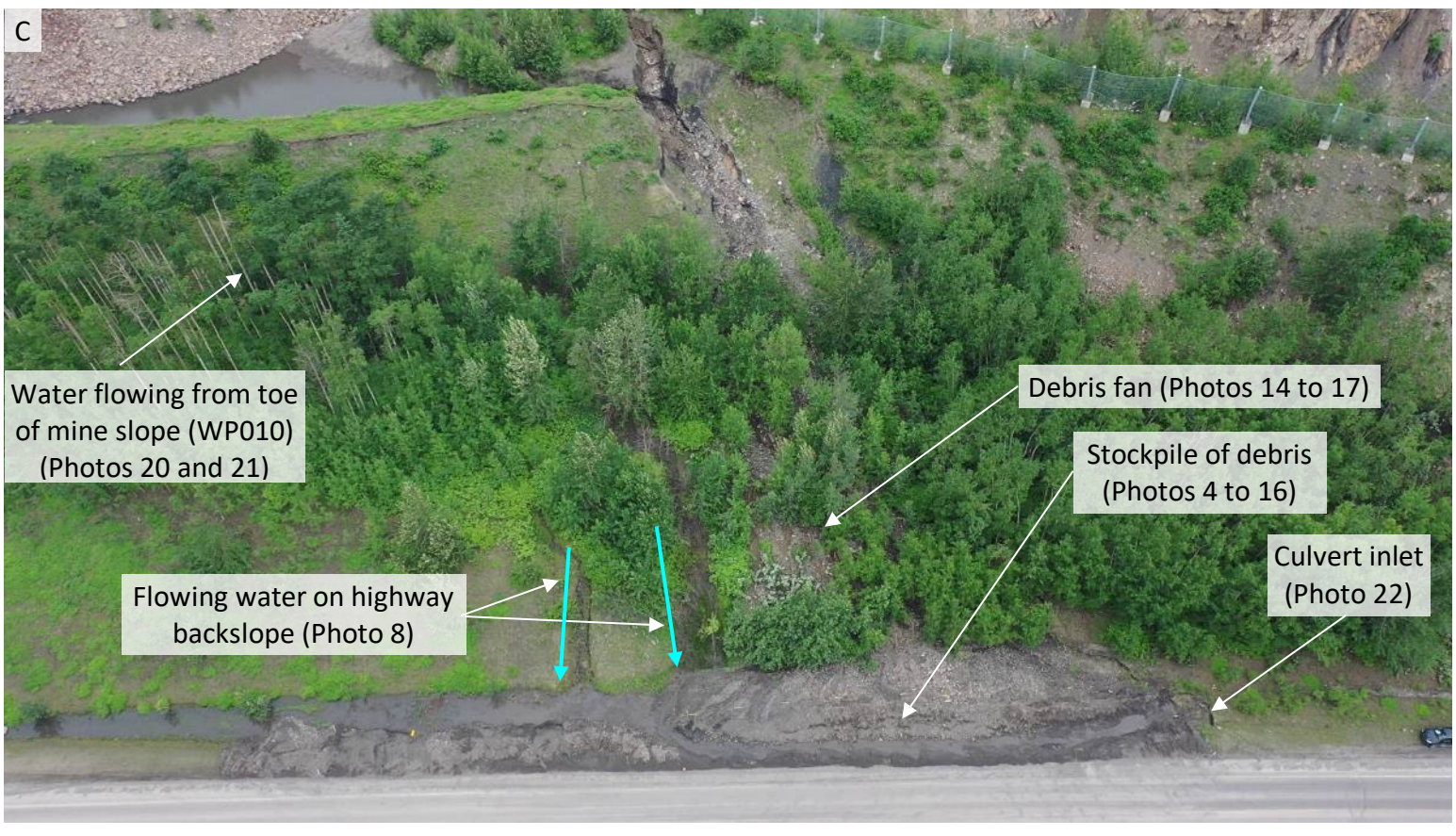


Photo 5 **Overview of site. Photo taken with Unmanned-Aerial Vehicle (UAV) on June 22, 2023, facing northwest.**

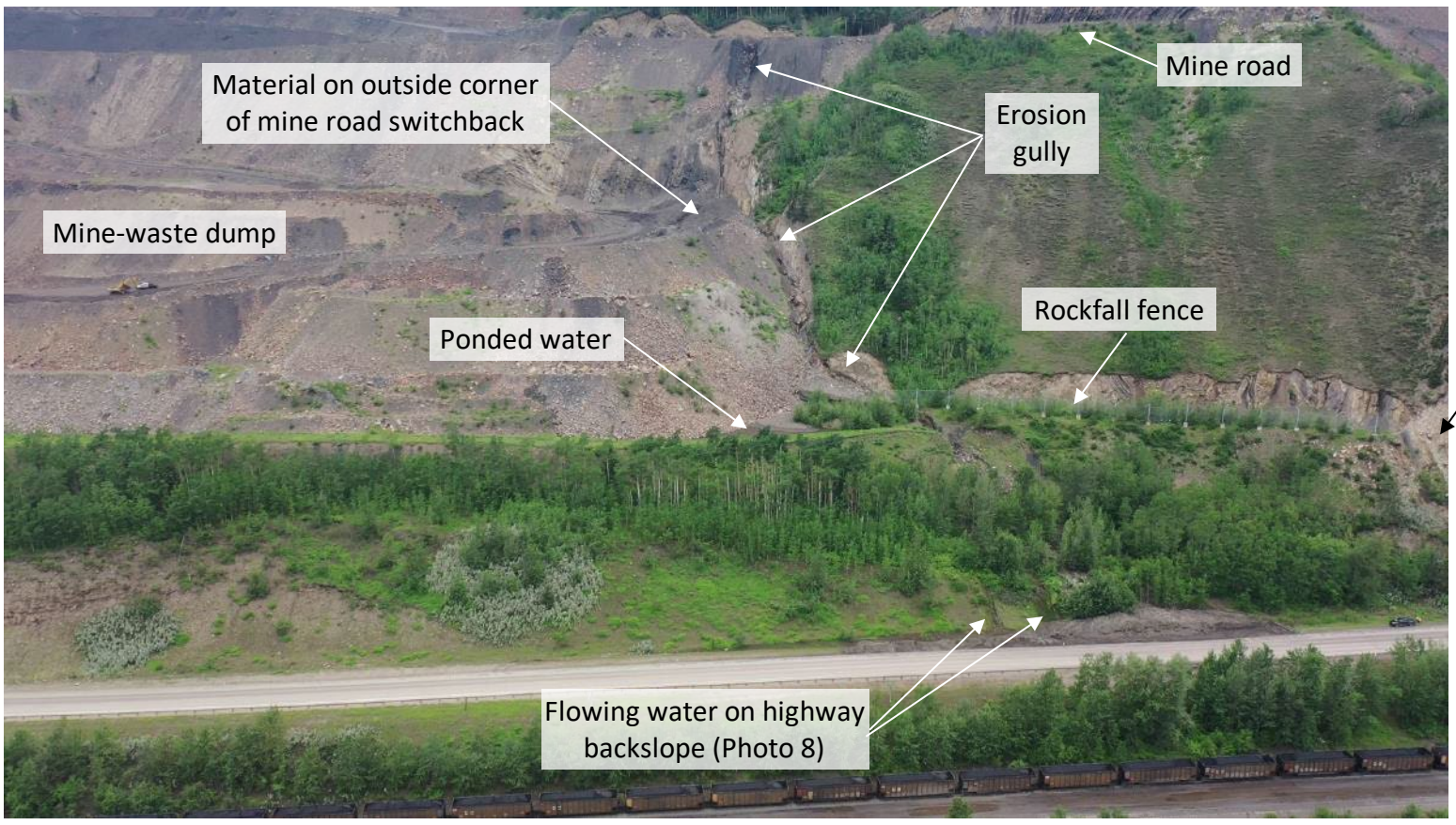


Photo 6 **Overview of site. Photo taken with UAV on June 22, 2023, facing southwest.**

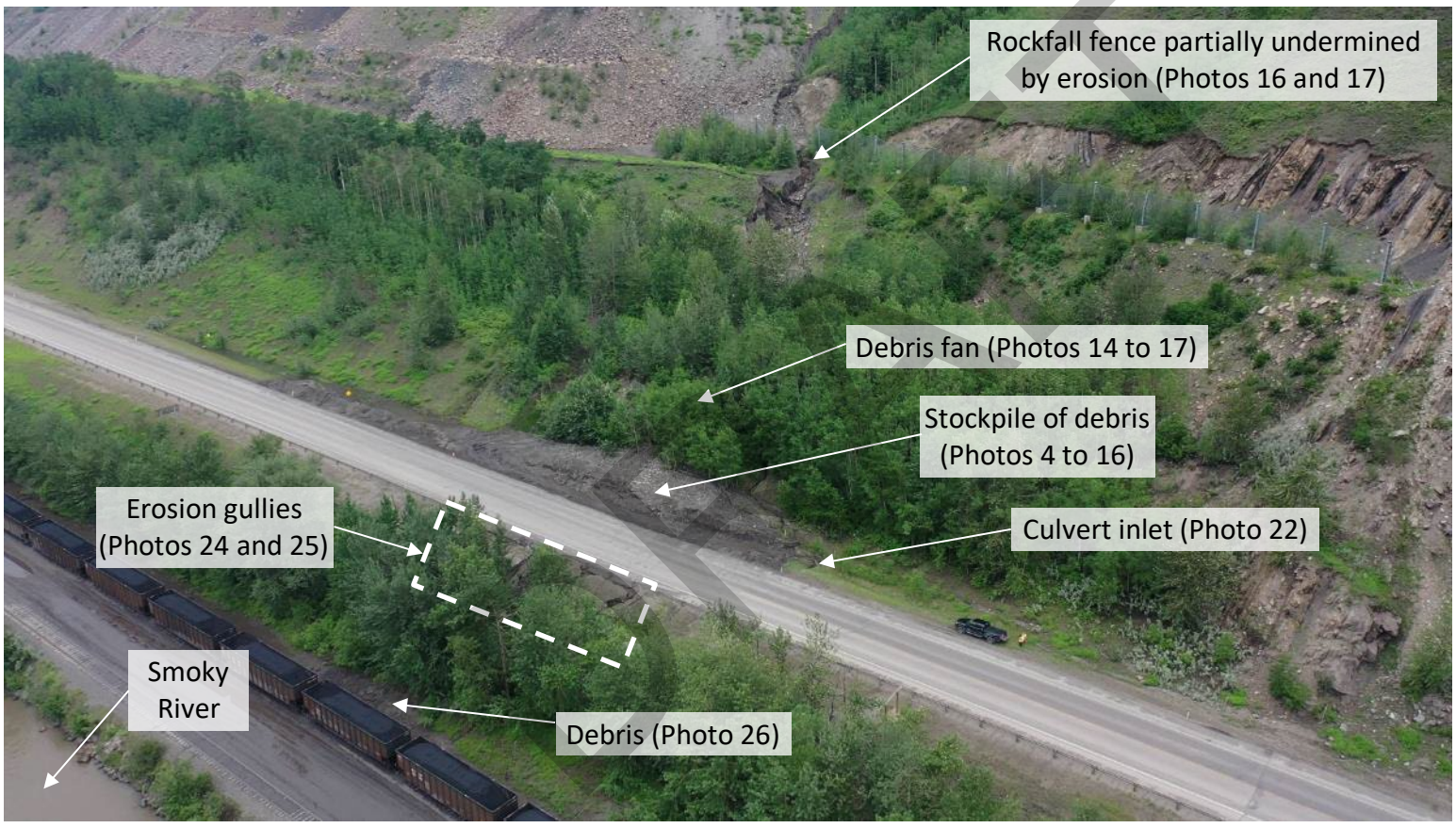


Photo 7 **Temporary stockpile of debris along west side of highway south of WP009. Photo taken on June 22, 2023, near WP009 facing southwest.**

Photo 8 **Flowing water on highway backslope (indicated with blue arrows). Photo taken on June 22, 2023, near WP009 facing west.**

Photo 9 **Temporary stockpile of debris along west side of highway between WP003 and WP009. Note survey stakes marking location of high-pressure natural-gas pipeline (indicated with red lines). Photo taken on June 22, 2023, near WP009 facing northwest.**

Photo 10 **Temporary stockpile of debris along west side of highway between WP003 and WP009 and erosion gullies along east side of highway. Note pavement subgrade exposed along west side of highway, and guardrail posts partially undermined. Photo taken on June 22, 2023, facing west.**

Photo 11 **Temporary stockpile of debris along west side of highway. Photo taken on June 22, 2023, facing southwest.**

Photo 12 **Temporary stockpile of debris along west side of highway. Note survey stakes marking location of high-pressure natural-gas pipeline (indicated with red line), water flowing in west highway ditch, and culvert inlet. Photo taken on June 22, 2023, near WP003 facing south.**

Photo 13 **Top of temporary stockpile of debris along west side of highway. Photo taken on June 22, 2023, facing south.**

Photo 14 **Debris fan behind temporary stockpile of debris along west side of highway. Photo taken on June 22, 2023, facing southwest.**

Photo 15 **Debris fan and flowing water in trees between WP008 and WP005. Photo taken on June 22, 2023, facing east.**

Photo 16 **Debris fan through trees. Panoramic photo taken on June 22, 2023, near WP006 facing southeast.**

Photo 17 **Transition between upslope erosion gully and debris fan on west side of highway. Panoramic photo taken June 22, 2023, near WP005 facing southwest.**

Photo 18 **Rockfall fence partially undermined by erosion. Note water flowing from ponded water at northeast corner of mine-waste dump (indicated with blue arrow). Photo taken June 22, 2023, near WP005 facing southwest.**

Photo 19 **Portion of rockfall fence to north unaffected by erosion gully. Photo taken June 22, 2023, near WP005 facing northwest.**

Photo 20 **Flowing water along downstream toe of mine slope at WP010. Photo taken June 22, 2023, facing southwest.**

Photo 21 **Flowing water exiting at downstream toe of mine slope at WP010. Photo taken June 22, 2023, facing southeast.**

Photo 22 Inlet of centreline culvert at WP003. Photo taken on June 22, 2023, facing southeast.

Photo 23 Outlet of centreline culvert at WP004. Photo taken on June 22, 2023, facing east.

Photo 24 **Erosion gullies along west side of highway between WP001 and WP002. Photo taken June 22, 2023, facing southwest.**

Photo 25 **Pavement subgrade exposed along west side of highway, and guardrail posts partially undermined. Photo taken June 22, 2023, between WP001 and WP002 facing southwest.**

Photo 26 Debris along railway tracks. Photo taken June 22, 2023, facing southeast.