ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION (PEACE RIVER DISTRICT)
2023 INSPECTION

THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
PH042	Daishowa East Hill	Pumping Well	986:01	33.2
Legal Description		**UTM Co-ordinates**		
NE7-85-20 W5M		11V E 491155	N 6246175	

	Date	PF	CF	Total
Previous Inspection:	05-Jul-2021 (Highway)	3	6	18
	05-Jul-2021 (South Ditch)	13	2	26
Current Inspection:	18-May-2023 (Highway)	3	6	18
	18-May-2023 (South Ditch)	13	2	26
Road WAADT:	890		**Year:**	2022
Inspected By:	Tyler Clay, TEL Max Shannon, TRANS		Don Proudfoot, TEL Rocky Wang, TRANS Pramaya Kannel, TRANS	
Report Attachments:	☑ Photographs ☑ Plans		☐ Maintenance Items	

Primary Site Issue:	Roadway and embankment have a history of active landslide movement. Head scarp extended across both driving lanes. Site was remediated once (successfully in short-term) with a series of pumping wells installed on upslope side of roadway. The pumps required ongoing maintenance that was impractical to sustain and eventually the pumps were no longer effective at reducing the rate of landslide movement. Mitigation work was completed between the fall of 2016 to the summer of 2018 involving construction of a 98 m long, tied-back tangent pile wall to mitigate a landslide affecting the highway. A callout in August 2020 was requested due to a rapid landslide that developed in the valley slope uphill/south of the highway whose toe had heaved the gabion mattress in the south ditch.
Dimensions:	The original landslide is 100 m wide and extends from east bound driving lane to (presumably) creek approximately 150 m downslope of roadway. Recent valley slope slide on south side of highway is approximately 85 m wide parallel to highway, extends 70 m uphill from the ditch and toe roll extends into middle of south ditch.

Maintenance:	Road overlaid in 2017.	
Observations:	**Description**	**Worsened?**
☑ Pavement Distress	ACP was in good condition at the time of the inspection with no signs of cracking or subsidence along previously observed extents of pavement damage due to landslide movement (Photos 42-01 and 42-03).	☐
☑ Slope Movement	No observations of slope movement were evident at the road surface or below the pile wall along or outside the previous landslide extents (Photos 42-02). Backslope failure that occurred in 2020 near 33+125 has ongoing movement. The toe roll has lifted and deformed approximately 75 m of the gabion mattress in the south ditch, with a vertical displacement up to 1.1 m. The gabion was slightly more heaved at the slide toe but there was no significant change from the 2021 condition (Photo 42-06).	☑
☑ Erosion	Minor rill erosion was noted between the road edge and the edge of the gabion mattress but has not significantly changed since the previous inspection. (Photo 42-05)). An erosion gully (up to 0.2 m deep and 0.5 m wide) is developing near km 33+150 between the south road shoulder and heaved gabion mattress (Photo 42-06).	☑
☑ Seepage	Drain outlets between the piles were dripping at the west end of the wall and area at the base of the wall was wet. Subdrain outlet at the end of the riprap swale was dripping. (Photo 42-04)	☐
☐ Bridge/Culvert Distress		☐
☐ Other		☐

Instrumentation:

Legacy SI instrumentation (installed in 2009):
SI09-1 - Upslope of roadway; sheared at 2.6 m after September 2013
SI09-2 - Downslope of roadway; sheared at 16.8 m after June 2011
SI09-3 - Downslope of roadway; sheared at 11.0 m after May 2010
SI09-4 - Downslope of roadway; sheared at 9.8 m after September 2010

Instrumentation has been installed to monitor performance of the pile wall and includes the following: 9 vibrating wire (VW) piezometers,1 slope inclinometer (SI), 3 shape accelerometer arrays (SAA), 14 vibrating wire strain gauges (SG), and 9 load cells. After the spring of 2020 readings, the batteries for both dataloggers were stolen. Prior to the spring of 2022 readings, batteries were replaced, and several upgrades were completed by Thurber to the pile wall datalogger station to allow for automated readings of the pile wall instruments.

SI18-1 (installed in the bench downslope of the pile wall) has not shown any discernible movement since it was reinitialized in the spring of 2019.

Wall deflections have been measured in SAA17-P20 and SAA17-P40 over the length of the piles. The rate of movement ranges from 1 to 5 mm/yr with a maximum total resultant pile head movement in the downslope direction of 25 to 60 mm. These deflections are within expected design limits.

SAA18-1 (installed in the bench downslope of the pile wall) showed an average rate of movement of approximately 4 mm/yr over 0.5 m to 12.5 m depth since July 2020 with a total cumulative movement of 13.5 mm. SAA17-P40 has shown a total cumulative movement of 9.1 mm over the same depth zone since June 2018, indicating that the bench below the pile wall has moved 4.4 mm in the downslope direction relative to the pile wall during this time span. On this basis there is not significant separation, and the soil bench is still providing support to the wall.

Strain Gauge Summary: The strain gauges showed changes in strain ranging from an increase in positive (tension) strain of 35.5 at 18.5 m depth on the upslope pile face to an increase in negative (compressive) strain of 7.7 at 2.5 m depth on the downslope pile face.

VW Summary (at pile wall): Vibrating wire piezometers VW17-1A and VW17-1B showed decreases in groundwater level of 0.20 m and 0.04 m, respectively, since the spring of 2022 readings. VW17-2B, VW17-3A and VW17-3B showed increases in groundwater level of 0.01 m, 0.01 m and 0.32 m, respectively. VW17-3A measured an all-time high groundwater level on March 8, 2023. VW17-2A continued to be dry. The piezometers at the pile wall show relatively stable groundwater levels, with the exception of VW17-3B, which is showing a trend of slowly increasing groundwater level over time.

VW Summary (at upslope ditch): VW18-1, VW18-2, and VW18-3, installed in the south highway ditch to the east of the pile wall, showed decreases in groundwater level of 0.02 m, 0.10 m, and 0.10 m, respectively, since the spring of 2022 readings.

Load Cell Summary: The anchors all measured all-time high loads between March 20, 2023 to April 3, 2023. It should be noted that VC2011 (anchor P40A) is measuring a current load that is above its design load. Overall, the load cells show steady to slowly increasing anchor loads, with the highest loads measured in late winter to early spring, when the depth of frost penetration is greatest.

Assessment:

The anchored retaining wall is designed to support the roadway and relies on passive support of the downslope bench. Future readings should check if the bench exhibits faster downslope movement relative to the pile wall. The wall relies on lateral support from the bench and if significant downslope movement is measured another row of tie-back soil anchors would be required below the existing anchors. Based on observations since construction completion the wall appears effective in supporting the highway and the risk of embankment failure due to landslide movement at this site is expected to be significantly reduced. The site should be monitored to assess the wall performance and potential expansion of the slide area laterally and upslope of the wall.

It is recommended to create a post-construction monitoring and design performance review plan (i.e., Asset Management Plan) to provide recommendations for ongoing monitoring and for future pass-off from construction / design to operations. Currently, as part of TEC's innovation work, the design parameters of the wall are currently being reviewed so that warning thresholds can be developed with regard to the pile wall deflections and load cell readings. This information can be used to determine if more tie-back anchors are required to support the pile wall or if other temporary measures need to be implemented.

The hillside upslope/south of the highway has been affected by historic landslide movements and has always appeared hummocky during previous inspections. However, higher than usual precipitation and groundwater levels over the last few years (up to 2020) have triggered the recent new more aggressive movements. The toe roll of the landslide is clearly marked by the near-vertical heaving of the gabion

mattress lining in the ditch. The west flank is also clearly marked by shearing and displacement of the bush covered ground surface. However, the uphill backscarp and east flank were not as well defined. The toe heave has impacted the gabion mattress ditch lining and constricted ditch drainage causing erosion near the shoulder. The ditch restriction could result in overflowing of water onto the highway under high runoff conditions.

Recommendations:	**Cost**
Continue to visually monitor as part of annual inspections. Instrumentation should have bi-annual readings / data collected regularly to monitor the mitigation performance.	-
South Ditch Repairs: Short term remedial measures could consist of removing the eastmost 30 m of gabion mattress (and salvaging the stones), excavating the heaved ground back to the pre-disturbance level and replacing a new gabion mattress over this section. The risk with this method is that further ground movements might heave the mattress again.	$75,000
Longer term remedial measures could consist of removing the gabion mattress (and salvaging the stones) over the disturbed zone, strengthening the subsurface foundation soil, trimming the ditch smooth and then relaying new gabion mattress. The subsurface strengthening could consist of either of the following methods: • Sub-excavating the slide material under the ditch to a depth below the slip surface and constructing a well compacted granular shear key zone to force the slip surface to toe out uphill of the ditch. The shear key would likely need to be at least 2.5 m deep and 5 m wide; or • Installing spaced H piles parallel to, and offset about 1 m south, of the uphill edge of the ditch lining. The piles would likely need to be at about 6 m long/deep.	$250,000 to $400,000

CLOSURE

It is a condition of this letter report that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

Tarek Abdelaziz, Ph.D., P.Eng.
Partner | Senior Geotechnical Engineer

PROFESSIONAL ENGINEER ALBERTA
TYLER T. CLAY
ID: 120965
October 16, 2023

PROFESSIONAL ENGINEER ALBERTA
TAREK ABDELAZIZ
ID 91085
October 16, 2023

PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
RM SIGNATURE: _____
RM APEGA ID #: 91085
DATE: October 16, 2023
PERMIT NUMBER: P005186
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

Tyler Clay, P.Eng.
Geological Engineer

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

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5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

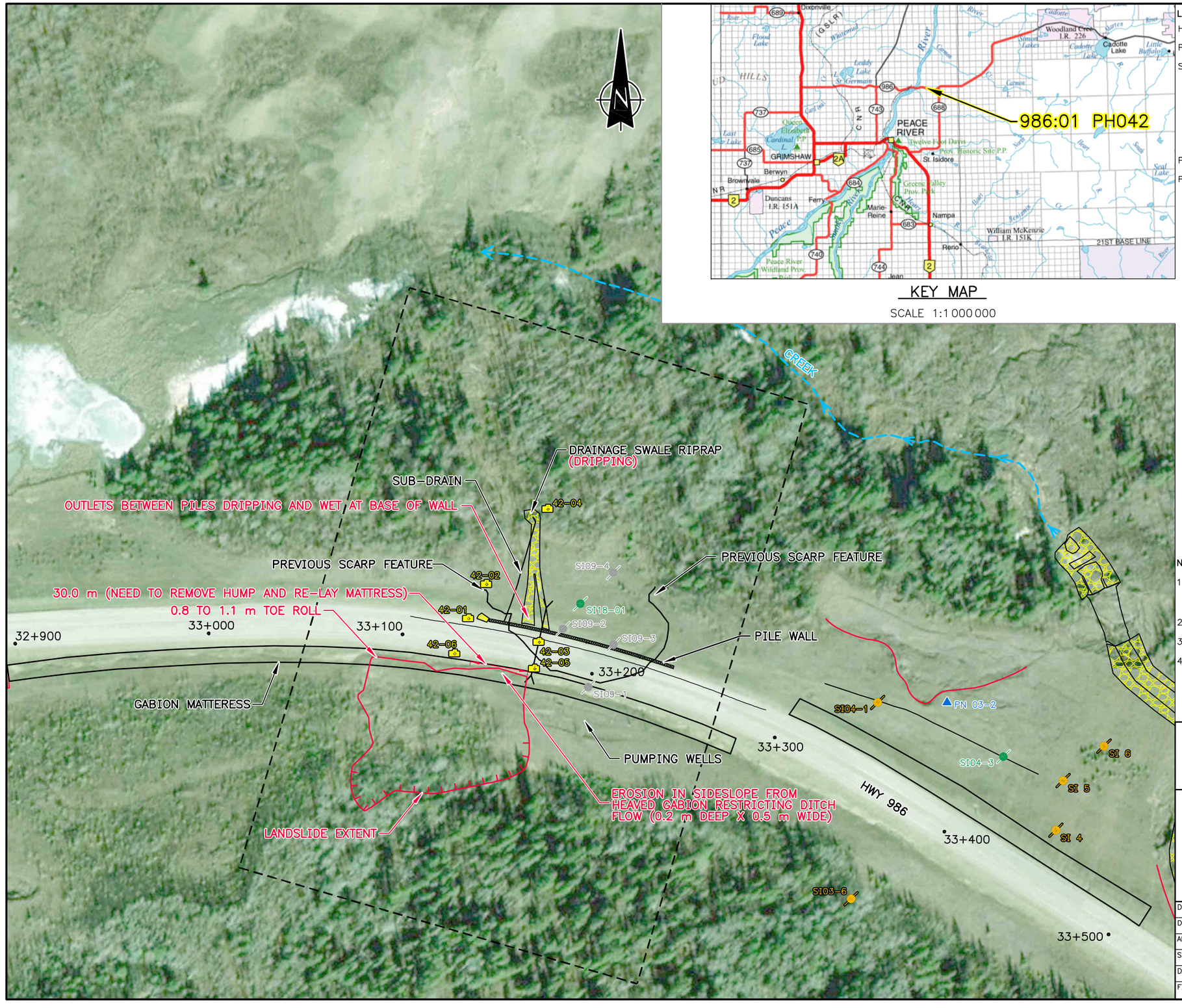
d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



KEY MAP

SCALE 1:1 000 000

LEGEND:

- HORIZONTAL CHAINAGE — 32+100
- PHOTOGRAPH LOCATION — 42-01
- SLOPE INCLINOMETER
  - NO MOVEMENT — SI 64
  - CREEP — SI 82
  - MEASURABLE MOVEMENT (OR RECENTLY SHEARED) — SI 82
  - NON OPERATIONAL — SI 82
- PIEZOMETER — PN 004
- PH042 BOUNDARY

NOTES:

1 DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 32121 DATED MAY 2023 AND IS SUBJECT TO THE STATEMENT OF LIMITATIONS AND CONDITIONS INCLUDED IN THE REPORT.

2 AIR PHOTO BASE FROM ESRI (DIGITAL GLOBE, 2016).

3 SLIDE FEATURES, PHOTOGRAPHS AND CHAINAGE ARE SHOWN APPROXIMATE ONLY.

4 BASED ON FIELD OBSERVATIONS ON MAY 17, 2023.

0 25 50 100 150 m

UTM 11N NAD83

Alberta Transportation

PEACE REGION (PEACE RIVER DISTRICT)

DAISHOWA
HWY 986:01 (PH042)
SITE PLAN

FIGURE PH042-1

DRAWN BY	ICB
DESIGNED BY	TTC
APPROVED BY	TSA
SCALE	1:2 000
DATE	SEPTEMBER 14, 2023
FILE No.	32121-A5B

THURBER ENGINEERING LTD.

	**Photo 42-01.** Looking east across the repaired slide area. Guardrail and pavement surface in good condition with no major change since previous inspection.
	**Photo 42-02.** Looking southeast at the pile wall and regraded slope below. Wall appears in a good condition and there has been no observable changes in the slope below since 2021.

	**Photo 42-03.** Looking east at the replaced highway segment that previously had cracking and settlement across the roadway due to landslide movement (33+210). Road surface was in a good condition at time of inspection and had no observable change from the 2021 condition.
	**Photo 42-04.** Looking at subdrain pipe outlet that was slowly dripping within the end of the armoured drainage swale from the west side of the wall.

	**Photo 42-05.** View looking east at the gabion mattress installed in the south ditch across the entire site extents to repair previous erosion damage. Minor rill erosion was noted between the road edge and edge of the gabion. No major change within the area east of 33+175 since 2021.
	**Photo 42-06.** View looking west at the gabion mattress installed in the south ditch near 33+125. The toe roll of a landslide that occurred in 2020 has encompassed and deformed the gabion pushing it upwards and towards the highway. The length of gabion affected is approximately 85 m. Gabion is slightly more heaved but no significant change since previous inspection. Erosion in sideslope due to restricted flow from gabion heave.