

**ALBERTA TRANSPORTATION
GEOHAZARD ASSESSMENT PROGRAM
PEACE REGION–GRANDE PRAIRIE
2020 INSPECTION**



THURBER ENGINEERING LTD.

Site Number	Location	Name	Hwy	km
GP16	Hwy 666:02 S. of Grande Prairie (Wapiti River Valley Slides)	Mid-Valley/Old Major (Site 1)	666:02	34+773
		Lower Valley (Site 2)		34+837
		Valley Top (Site 3)		34+250
Legal Description (Site 1)		UTM Co-ordinates (Site 1)		
NE¼ 15-070-06 W6M		11U E 383370		N 6103058

	Date	PF	CF	Total
Previous Inspection:	30-Aug-2019	13	6	78 (Site 1)
		14	6	84 (Site 2)
		14	5	70 (Site 3)
Current Inspection:	27-May-2020	14	6	84 (Site 1)
		15	7	105 (Site 2)
		14	5	70 (Site 3)
Road AADT:	2680	Year:	2019	
Inspected by:	Ed Szmata, TRANS Dwayne Loewen, TRANS Rishi Adhikari, TRANS		Nicole Wilder, Thurber Don Proudfoot, Thurber	
Report Attachments:	<input checked="" type="checkbox"/> Photographs <input checked="" type="checkbox"/> Plans <input checked="" type="checkbox"/> Maintenance Items			

Primary Site Issue:	Three landslide features are affecting the embankment of Hwy 666:02 along the Wapiti River Valley south slope. Additional activity was evident since the last call out inspection.		
Dimensions:	Site 1: 300 m wide backscarp, (65 m wide at guardrail) and extends to the centerline. Landslide depth is assessed to be about 20 m near the roadway. Site 2: 300 m wide backscarp at guardrail, extending 300 m in length to the river valley floor with backscarp extending across roadway into the EBL ditch. Landslide depth is assessed to be at about 10 m depth along the roadway and about 20 m in depth at 150 m downslope towards the river. Site 3: 250 m wide backscarp and extends 1.5 m past edge of shoulder. The Landslide depth is assessed to be about 7 m to 11 m at the roadway.		
Maintenance:	Patching was done in June 2019 at all three sites. Asphalt was also placed in October 2019 and then where the scarp dropped significantly the ACP had been milled to smooth the drop off.		
Observations:	Description	Worsened?	
<input checked="" type="checkbox"/> Pavement Distress	Cracks and drops in pavement along the landslide backscarps are showing signs of significant activity since the last call out inspection in August of 2019. The cracks have shown through the recent patching in the same locations as observed in previous inspections and have increased in width and drop in most locations. Site 1 now has the crack open to 100 mm wide with a 70 mm drop. Site 2 scarp crack is now open to 120 mm wide with a 90 mm drop and at Site 3 the asphalt slab has now dropped 400 mm.	<input checked="" type="checkbox"/>	

<input checked="" type="checkbox"/> Slope Movement	Significant increases in the drops were observed along the backscarps at Sites 1, 2 and 3 as they have been patched over and are still deeper and wider than previously noted with increased rate of movement. At Site 3 the backscarp has continued to retrogress, the ACP patch is failing, and the scarp is now cutting into the WBL.	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Erosion	Several sections of the SBL/EBL ditch bottom are eroded outside of the area that was protected with TRM at Site 3 which continues to worsen. There is now erosion at Site 1 at the 600 mm diameter SWSP culvert inlet and further east within the ditch and the erosion that was typically observed at the same culvert outlet has worsened. The culvert may have froze and sediment built up on the inlet side and when thawed the build up likely blew through causing further erosion on both ends.	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Seepage	Springs were noted in the EBL ditch at Site 1, 2 and Site 3 and were wet during the recent inspection.	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/> Bridge/Culvert Distress	The inlet to a centerline culvert at Site 3 is still obstructed by silt. Erosion of the valley slope below centerline culvert outlets were not inspected; however, are likely in similar or slightly worse condition.	<input checked="" type="checkbox"/>
<input type="checkbox"/> Other		<input type="checkbox"/>
Instrumentation: (from the Fall 2020 Geohazard Instrument Readings)		
SI-1 SI-2	Installed at the crest of the Wapiti River Valley slope in the Landry Heights residential subdivision between Site 1 and Site 3. No discernable movement.	
SI-13	Installed downslope of the highway embankment within the Mid-Valley/Old Major Slide (Site 1). Showed a rate of 30.0 mm/yr over 1.3 to 5.0 m depth.	
SI-41	Installed in the upslope ditch at the Lower Valley (Site 2). Showed no discernable movement since last readings.	
SI-52	Installed near the toe of the Wapiti River Valley slope below the Lower Valley (Site 2). Sheared after the fall of 2015 readings at a depth of 18.9 m.	
SI-53	Installed near the toe of the Wapiti River Valley slope below the Lower Valley (Site 2). Sheared after the fall of 2019 readings at a depth of 4.9 m.	
PN-13A/B	Installed below the highway embankment at the Mid-Valley/Old Major Slide (Site 1). PN-13A showed no increase in water level while PN-13B showed a decrease in water level of 0.10 m since the spring 2020 readings.	
PN-51A/B	Installed near the toe of the Wapiti River Valley slope below the Lower Valley/Adjacent Recent Slide (Site2). PN-51A showed a decrease in the water level of 0.45 m while PN-51B showed an increase of 0.49 m since the spring 2020 readings.	
PN-52A/B	PN-52A showed a decrease of 0.03 m while PN-52B showed a decrease in water levels of 0.33 m since the spring 2020 readings.	
	The following piezometers were installed downslope of the highway embankment in 2014 in the Valley top (Site 3) slide bowl.	
PN14-51	This piezometer was damaged after the spring 2020 readings.	
PN14-52	This piezometer was not functioning during the fall 2020 readings.	
VW14-55A	Showed a decrease in water level of 0.77 m since the spring 2020 readings.	

SP14-51	Showed a decrease in water level of 0.51 m since the spring 2020 readings.
SP14-54	Showed a decrease in water level of 0.88 m since the spring 2020 readings.

Assessment:

Conditions at all the 3 the sites have worsened since the last inspection in August 2019. Springs were noted in the bottom of the EBL ditch at Sites 1, 2 and 3. Old cracks have shown through the series of new ACP patches that were done in fall 2019 and are deeper and wider than previously observed. From discussions with AT, approximately 200 tons of asphalt was placed on June 17, 2019 and the road began to deform at the end of July and the scarp cracks showed through the new patches middle of August. Then more asphalt was placed in fall 2019 and milled down at the worst locations to lessen the severity of the drop. At Site 1 there is active backslope movement as well as existing scarp cracks have shown through recent ACP patch and have worsened from recent movement throughout. A graben is present near the middle of Site 1. At Site 2, the drop off next to the highway on the west side is extremely steep and the highway is now above the guardrail from several ACP patches. The crack in the highway adjacent to SI-41 has worsened and is now 100 mm wide and has a 90 mm drop. The cracks along Site 2 have significantly worsened since the last inspection. At Site 3 the backscarp has actively retrogressed into the ACP patch and is now cutting into the pavement into the WBL with a 400 m drop. and has a barricade placed as warning. In general, all three site have more differential settlements from the increased movement of the backscarps which poses greater hazard to the highway traffic.

Landslides are currently affecting the alignment of Hwy 666:02 at the following main locations:

Mid-Valley/"Old Major" Landslide (Site 1):

Deep seated landslide, believed to be rotational in nature at a depth of about 20 m to 25 m along the embankment sideslope, which corresponds to the top of the underlying bedrock and is affecting about 300 m of roadway. The toe of the landslide is believed to be at the bottom of the valley possibly within the limits of the Wapiti River bank itself. In addition, the backslope above the highway, which was offloaded and regraded in 1997-1998, has surficial slumps features above and below the intermediate level bench, which periodically cause slide debris to accumulate at the EBL ditch thus blocking the surface water flow.

Lower Valley Landslide (Site 2):

Deep seated rotational landslide assessed to be at 12m in depth along the embankment sideslope and 18 m in depth at mid slope and at 6 m in depth at the toe which is believed to be about 300 m downslope of the highway embankment, resulting in about 300 m of affected roadway.

Valley Top Landslide (Site 3):

Located near the top of the valley slope, assessed to be at about 7 m to 11 m depth along the highway embankment sideslope and is affecting about 250 m of roadway along the WBL shoulder.

Historically, except for the Valley Top Landslide (Site 3) from 2015 to 2016, these landslides have been relatively dormant or slowly creeping and as a result the affected sections of roadway have been maintained by milling and pavement overlays which were performed about every two years. However, the rate of movement at all three sites has increased in the last two years, likely in response to a period of prolonged rainfall and elevated groundwater levels both years.

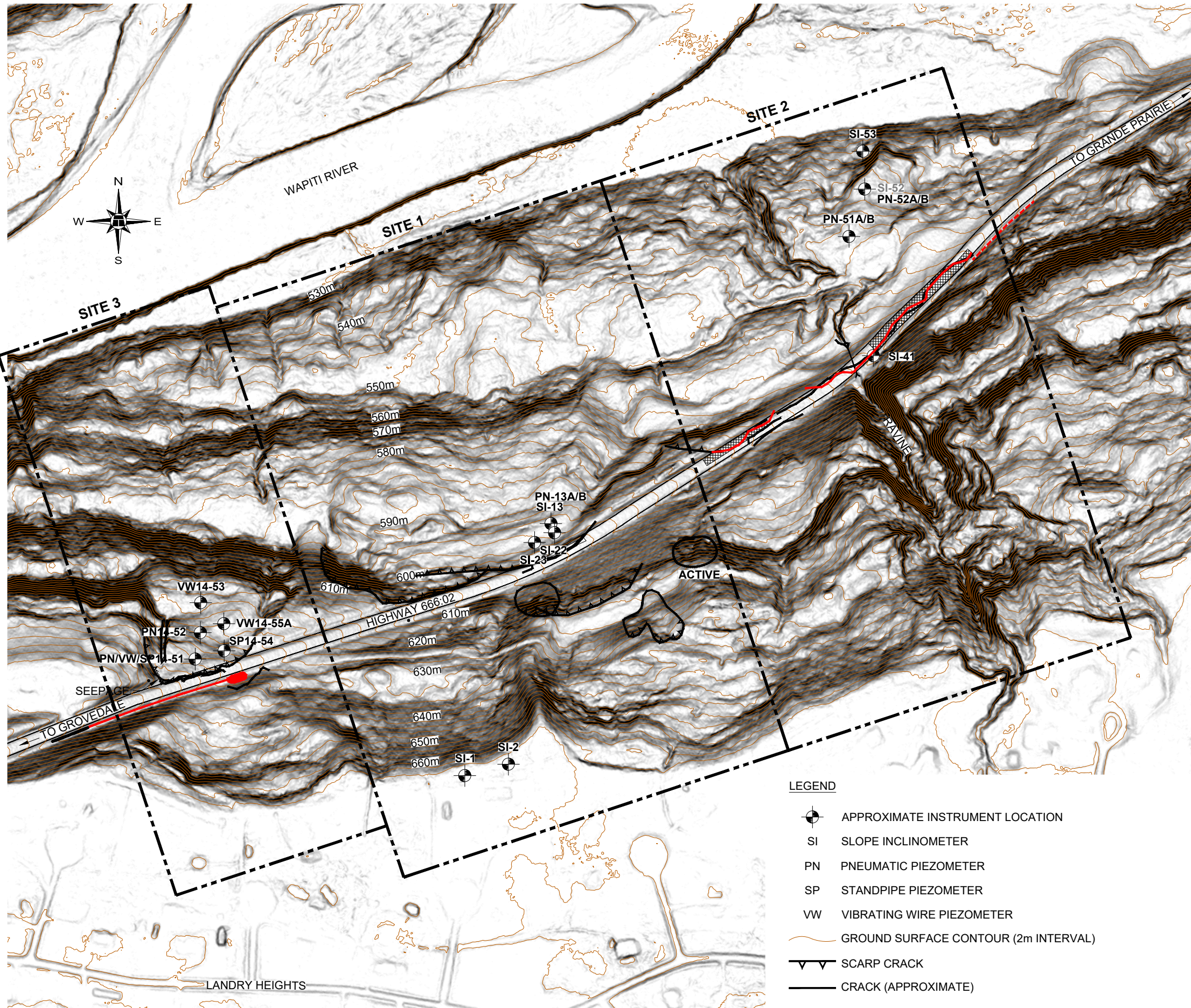
Permanent localized in-situ stabilization remedial measures allowing to maintain the current roadway alignment, such as cantilever pile walls or soil anchor supported concrete piles are typically limited to landslide depths in the order of 10 to 15 m as stand alone structures. Consideration could be given to tiered level retaining wall systems and shifting the highway into the backslope and cutting it back with a bench and French drains; however, a geotechnical investigation would be required to further explore the feasibility of this scenario.

Mid to long term remediation scenarios would necessarily involve realignment or partial realignments which would necessitate excavation/off-loading and flattening of the backslope possibly requiring the purchase of land in the residential subdivision at crest of the valley.

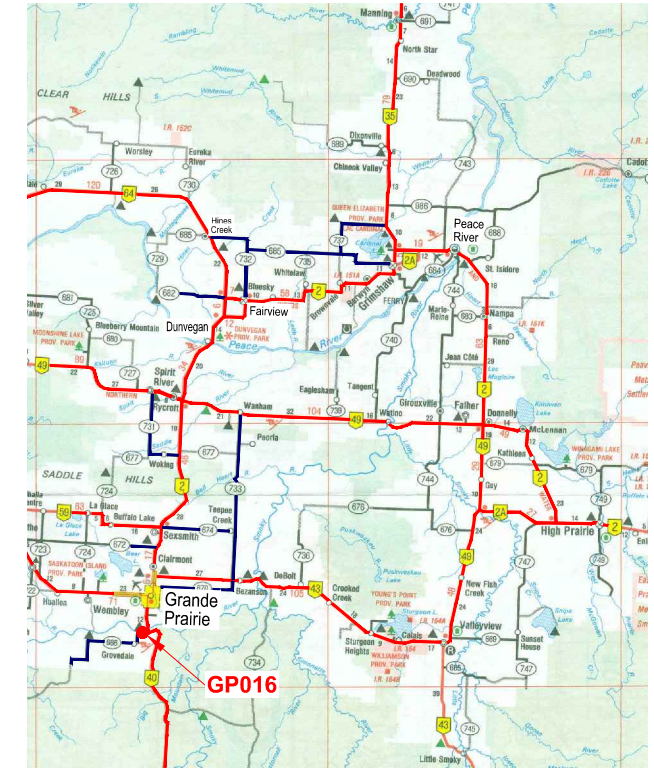
A combination of realignment, offloading of the backslope and stabilization at the toe of backslope to minimize the footprint of the offloading excavation activities may also provide a midterm remedial solution and would also require a geotechnical investigation to be further assessed.

All the remediation alternatives involve either costly regular maintenance measures or elaborate stabilization techniques. Due to the light usage (2680 AADT) a more pragmatic solution in the long term might be to close this section of the highway, or at least reduce its service rating to a secondary or emergency access road, implement gravel surfacing to avoid costly asphalt surface repairs and to provide access to the area either via Grovedale or a new access road connecting to Hwy 40 to the east from the upper plateau. Thurber is currently a part of a high-level feasibility study with CIMA to look at different options including re-routing traffic and from the findings of this study will be able to narrow down the options for remediation of this site.

Recommendations:	Ballpark Cost
<p>In the short term, it is recommended that the cracks in the pavement be sealed or overlain with an asphalt patch, that the drops along the backscarps be milled and that the area be closely monitored for future signs of movement.</p> <p>The ditch block at the inlet and outlet to the centerline culvert at Site 3 should be removed.</p> <p>The inlet of the centerline culvert at Site 2 should be cleaned out and erosion along the EBL ditch be filled in. The outlet should be re-established, and the channel lined with rip-rap with a dissipation bowl structure.</p> <p>The guardrail should be extended in the critical areas and installed above the highway as it is currently below due to several ACP patches. Traffic should also be slowed to 50 km/hr and signs for uneven pavement and sharp shoulders for 2 km should be installed to warn public.</p>	<p>Maintenance</p>
<p>A geotechnical investigation is required to assess the mechanisms of failure and to design repair measures for each of these landslide sites. A comparison of LIDAR from different years should also be performed. Due to the history of activity at these sites, it is recommended that the geotechnical investigation be implemented as soon as possible. Some economy could be made if all 3 sites were assessed by the same field investigation under a single mobilization of drilling equipment.</p>	<p>\$60,000 per site or \$150,000 (for all 3 sites)</p>
<p>In the mid term, a partial realignment at Site 1 could be performed with the support of a pile wall. The realignment alone might provide about 5 years of additional service life to the current alignment through the site. There is a possibility to extend the life span to about 10 years with the additional support of a pile wall on the upslope side.</p>	<p>\$5,000,000 (Realignment Only) \$10,000,000 (Realignment with Pile Wall)</p>
<p>For Site 3, a pile wall could be constructed to help preserve the current alignment for about 5 to 10 years.</p>	<p>\$3,000,000 to \$5,000,000</p>
<p>For Site 2, further geotechnical investigation would be required to propose an effective mid-term solution such as pile walls or realignment through this site. Consideration should be given to replacing the current 600 mm diameter SWSP culvert with a larger diameter pipe connected to a welded smooth wall steel drainpipe that would extend down the slope to the valley floor.</p>	
<p>The long-term solution for the sections of the roadway affected by the current landslide features would be a major realignment.</p>	<p>\$50,000,000</p>

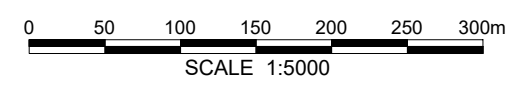


- LEGEND**
- APPROXIMATE INSTRUMENT LOCATION
 - SI SLOPE INCLINOMETER
 - PN PNEUMATIC PIEZOMETER
 - SP STANDPIPE PIEZOMETER
 - VW VIBRATING WIRE PIEZOMETER
 - GROUND SURFACE CONTOUR (2m INTERVAL)
 - SCARP CRACK
 - CRACK (APPROXIMATE)




SITE MAP
NOT TO SCALE

- NOTES:**
1. FEATURE LOCATIONS ARE APPROXIMATE.
 2. PREVIOUS OBSERVATIONS SHOWN IN BLACK.
 3. MAY 27, 2020 FEATURES SHOWN IN RED.



BASE PLAN PROVIDED BY ALBERTA TRANSPORTATION




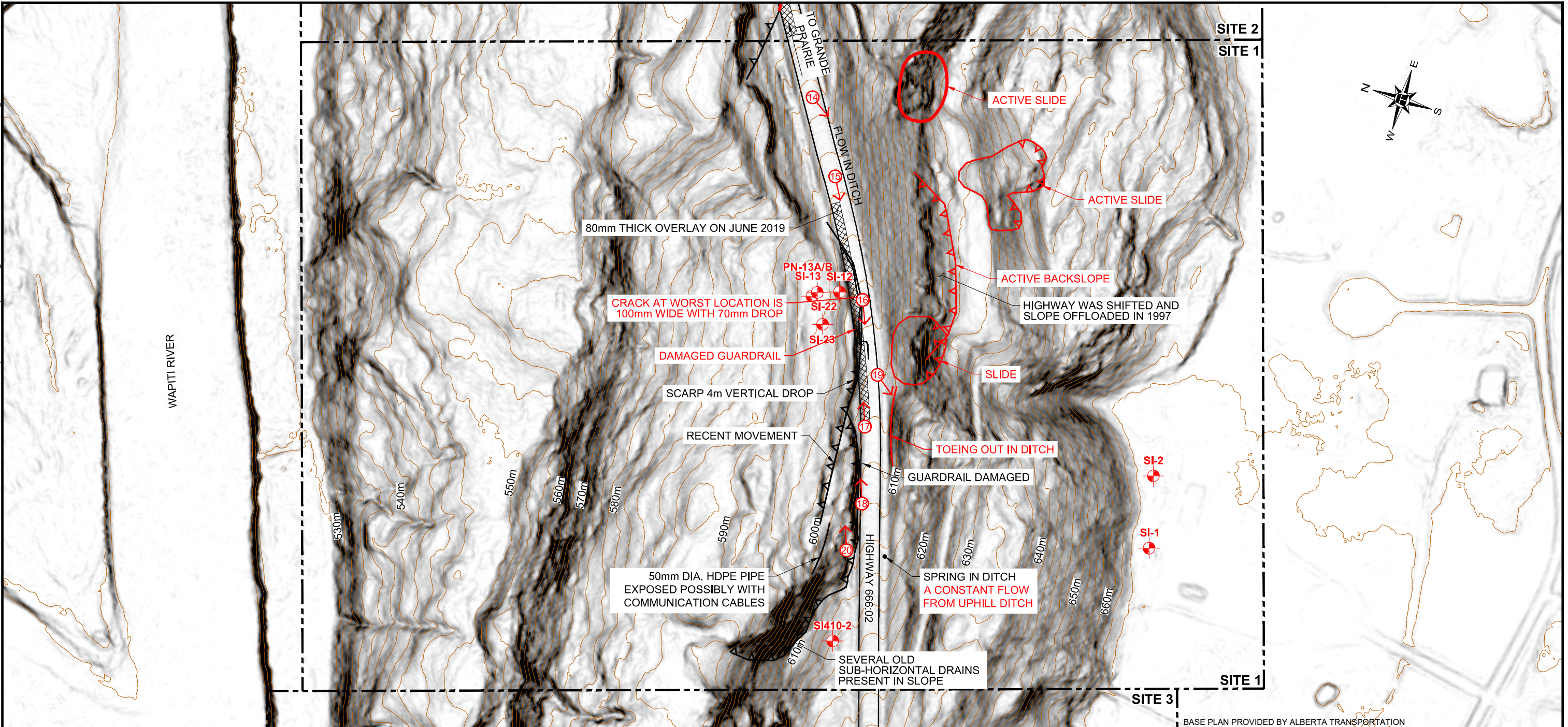
PEACE REGION (GRANDE PRAIRIE)

**GP016: HWY 666:02, KM 34 SOUTH OF GRANDE PRAIRIE
2020 INSPECTION PLAN**

FIGURE 1







DRAWN BY	ML
DESIGNED BY	NPW
APPROVED BY	RVC
SCALE	1:5000
DATE	DECEMBER 2020
FILE No.	13353





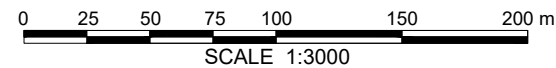
BASE PLAN PROVIDED BY ALBERTA TRANSPORTATION

LEGEND

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-  GROUND SURFACE CONTOUR (2m INTERVAL)
-  SCARP CRACK
-  CRACK (APPROXIMATE)
-  DIRECTION AND NUMBER OF PHOTO
-  ACP PATCH ON JUNE 2019

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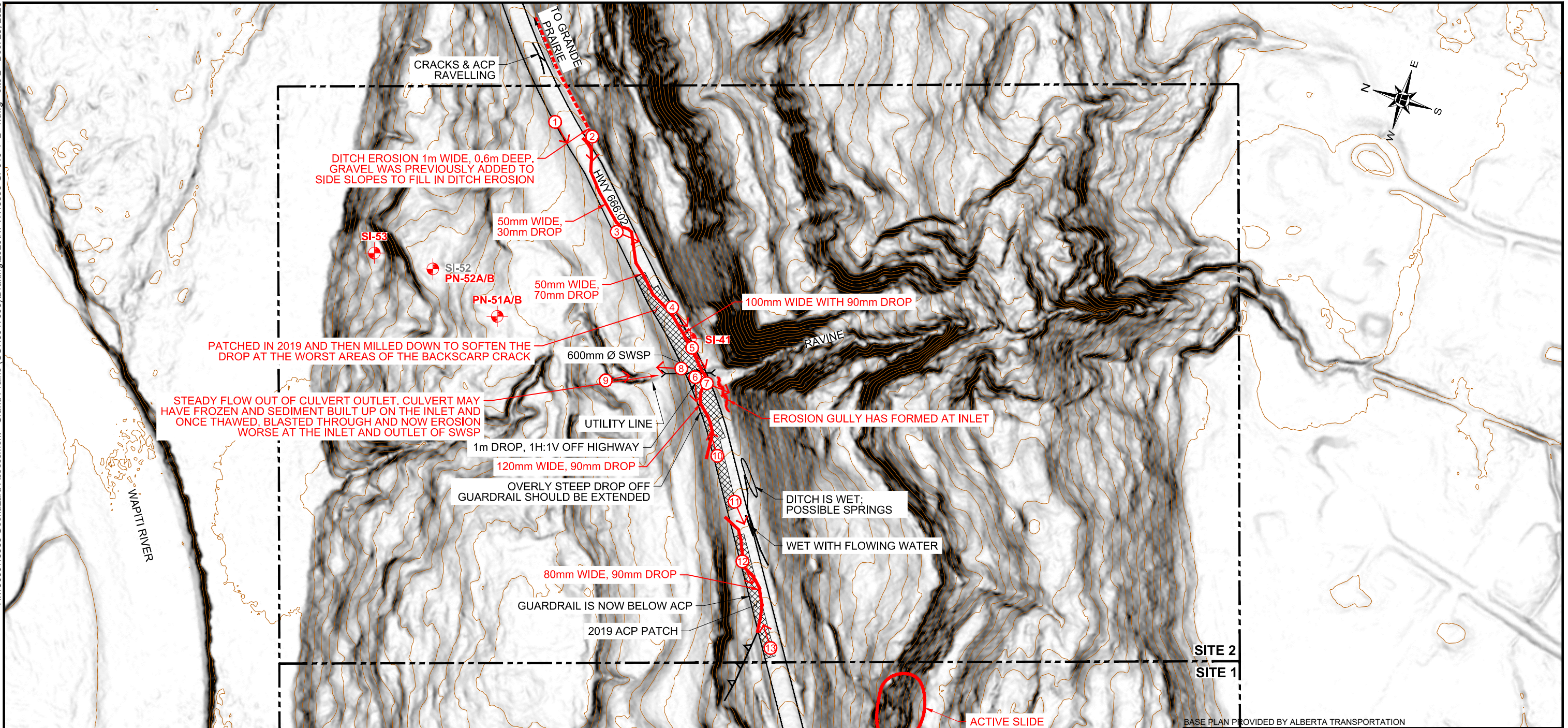
PEACE REGION (GRANDE PRAIRIE)

**GP016: HWY 666:02, KM 34 SOUTH OF GRANDE PRAIRIE
2020 INSPECTION PLAN
SITE 1: MID VALLEY**

FIGURE 2







DRAWN BY	ML
DESIGNED BY	NPW
APPROVED BY	DWP
SCALE	1:3000
DATE	DECEMBER 2020
FILE No.	13353





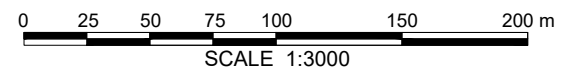
BASE PLAN PROVIDED BY ALBERTA TRANSPORTATION

LEGEND

-  APPROXIMATE INSTRUMENT LOCATION
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- PN PNEUMATIC PIEZOMETER
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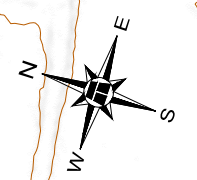
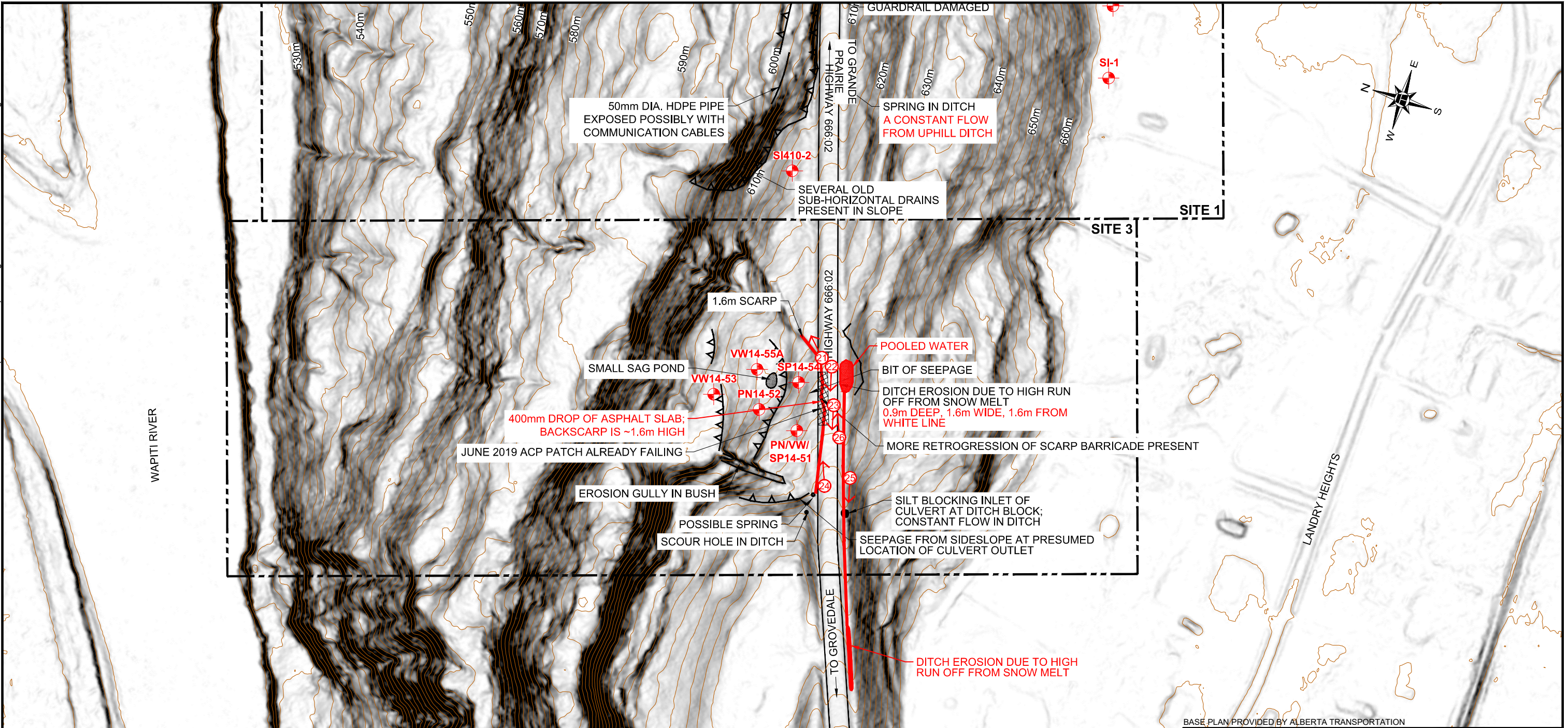
PEACE REGION (GRANDE PRAIRIE)

GP016: HWY 666:02, KM 34 SOUTH OF GRANDE PRAIRIE
2020 INSPECTION PLAN
SITE 2: LOWER VALLEY

FIGURE 3

DRAWN BY	ML
DESIGNED BY	NPW
APPROVED BY	DWP
SCALE	1:3000
DATE	DECEMBER 2020
FILE No.	13353



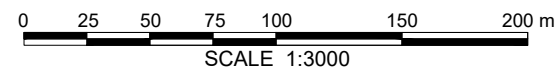


LEGEND

- APPROXIMATE INSTRUMENT LOCATION
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- CRACK (APPROXIMATE)
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PEACE REGION (GRANDE PRAIRIE)

GP016: HWY 666:02, KM 34 SOUTH OF GRANDE PRAIRIE
2020 INSPECTION PLAN
SITE 3: VALLEY TOP

FIGURE 4

DRAWN BY	ML
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SCALE	1:3000
DATE	DECEMBER 2020
FILE No.	13353

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Photo 1.
Looking southwest
towards the east
portion of the
Lower Valley
Landslide (Site 2).



Photo 2.
Looking southwest
towards the east
portion of Lower
Valley Landslide
(Site 2).



Photo 3.
Looking southwest along Hwy 666 at east portion Lower Valley Landslide (Site 2). The drops along the scarp in the ACP in this section in the roadway surface were about 70 mm.



Photo 4.
Looking southwest along Hwy 666 at middle portion Lower Valley Landslide (Site 2). The drop along the scarp in the ACP in this section in the roadway surface was up to about 80 mm.



Photo 5.
Looking southwest along Hwy 666 near the middle of the Lower Valley Landslide (Site 2). The scarp had asphalt placed and then milled in fall 2019.



Photo 6.
Looking southwest along WBL near middle of the Lower Valley Landslide (Site 2). The scarp has a 90 mm drop in the WBL shoulder.



Photo 7.
Looking southeast at erosion that has formed in sediment that had accumulating at the 600 mm diameter SWSP inlet, possibly due to the culvert being temporarily frozen.



Photo 8.
Looking northwest at erosion gully at 600 mm diameter SWSP outlet.



Photo 9.
Looking southeast
at erosion gully at
600 mm diameter
SWSP outlet.



Photo 10.
Looking east at
overly steep drop
off from several
layers of ACP
patching near the
east portion of the
Lower Valley
Landslide (Site 2).



Photo 11.
Looking southwest
along WBL at the
west extent of
Lower Valley
Landslide (Site 2).
The crack is open
to 80 mm and
drops 90 mm.



Photo 12.
Looking southwest
along WBL at the
west extent of
Lower Valley
Landslide (Site 2).
The crack is open
to 80 mm and
drops 90 mm.



Photo 13.
Looking northeast
along WBL at the
west extent of the
Lower Valley
Landslide (Site 2).



Photo 14.
Looking southwest
from the WBL
shoulder at the
slide in the
backslope in the
eastern portion off
the Mid-Valley/" Old
Major" Landslide
(Site 1).



Photo 15.
Looking west at the
ACP patch in outer
WBL at Mid-
Valley/" Old Major"
Landslide (Site 1).



Photo 16.
Looking west at the
ACP patch in outer
WBL at Mid-
Valley/" Old Major"
Landslide (Site 1).
There is a 70 mm
drop along the
scarp in the ACP
and it is open to
100 mm.



Photo 17.
Looking northeast at backscarp in the WBL at Mid-Valley/" Old Major" Landslide (Site 1). The scarp crack is now 100 m wide with a 70 mm drop in the ACP.



Photo 18.
Looking northeast at where guardrail is damaged, and erosion is occurring around the posts and below them.



Photo 19.
Looking southwest at part of the backslope toe showing recent movement near the Mid-Valley Landslide / "Old Major" (Site 1).



Photo 20.
Looking northeast at graben below the highway at the Mid-Valley Landslide / "Old Major" (Site 1) at scarp below the highway and exposed telecommunication cable.



Photo 21.
Looking northeast from the shoulder of the WBL at the scarp extending into the brush at the Valley Top Landslide (Site 3).



Photo 22.
Looking west along backscarp of Valley Top Landslide (Site 3). Backscarp drop in embankment side slope now about 1.6 m



Photo 23.
Looking west along backscarp in the west section of the Valley Top Landslide (Site 3). Site was patched in June 2019. Cracks extend past the white line in the WBL and the asphalt has dropped 400 mm.



Photo 24.
Looking northeast along backscarp near the middle of the Valley Top Landslide (Site 3).



Photo 25.
Looking west at erosion in south ditch near the Valley Top Landslide (Site 3).



Photo 26.
Looking northeast at ditch erosion along the south ditch near the Valley Top Landslide (Site 3).