

SITE NUMBER AND NAME: NC018 – Pembina River Bridge (North of Cherhill)	LOCATION: On Highway 764, 12 km north of Cherhill	HIGHWAY: 764:02	KM: 12.052
LEGAL DESCRIPTION: NW-15-57-5-W5	NAD83 COORDINATES: UTM11U 5978069 N, 652940 E		
AVERAGE ANNUAL DAILY TRAFFIC (AADT): 410 (2022)		CONTRACTOR MAINTENANCE AREA (CMA): 509	

	DATE	PF	CF	TOTAL
PREVIOUS INSPECTION:	June 6, 2016	3	4	12
CURRENT INSPECTION:	July 31, 2023	9	10	90
INSPECTED BY:	Stantec: Leslie Cho TEC: Gary Lee, Caroline Watt, Amy Driessen, Jeniifer Morton, Uzair Qasmi, Rishi Adhikari, Pramaya Kannel, Brian Adams			
REPORT ATTACHMENTS:	Figure 1 – Overall Site Plan Figure 2 – 2023 Precipitation Data from Barrhead Weather Station Figure 3 – 2019 to 2023 Precipitation Data from Barrhead Weather Station Figure 4 – 2022 and 2023 River Level Data from Pembina River near Entwistle Hydrometric Station Site Photographs Drawing No. 17-550-103-1 – Site Plan Showing Test Hole & Instrumentation Locations Drawing No. 17-550-103-2 – Stratigraphic Cross Section A-A South Abutment Borehole Records TH96-1 to TH96-8 Slope Inclinator Plots for SI-7, SI-8, SI-9, SI-22, and SI-24 Plot of Groundwater Level vs Time			

PRIMARY SITE ISSUE: Washed out head slope at north abutment of BF9333
APPROXIMATE DIMENSIONS: 35 m wide by 13 m long
SITE BACKGROUND AND HISTORY: <u>Thurber Engineering Ltd. (Thurber, 1996) Bridge File #9333 Geotechnical Review of Proposed Rehabilitation Work:</u> <ul style="list-style-type: none"> • Field observations indicate distress at south abutment concrete face (H-piles forced out of abutment concrete). Soil under the west side of the south abutment had settled by about 300 mm. Distress to the north abutment was also observed but to a lesser extent than the south abutment. No indication of distress to the north head slope was observed although some cracking along the lower slope was noted. Settlement was observed within the north abutment fill prior to the 1996 review by Thurber. • TEC's files indicate bolts on piers have undergone shear related deformation in the north direction by about 10 to 15 mm suggesting the south H-piles are being pushed out of the abutment face by slope movements. Thurber theorized that movement at the north abutment may be caused by bridge movements due to slope movement at the south abutment and may not be due to slope instability at the north abutment. • Air photo review for the years 1951, 1968, 1977, 1986, and 1995 showed no evidence of slope movement. • The margin of a large area of known artesian flow conditions is located 1 km south and east of the site. There is also evidence of artesian flow at the site observed from pipe installed beside a test H-pile in 1968. Top of pipe elevation was at approximately 649 m; therefore, artesian head elevation would be higher than 649 m. • Recommended a facing of free draining granular fill on the north head slope to assist in draining the abutment fill. Removal and replacement of the entire north head slope was not considered sufficiently beneficial at the

time. The south abutment could be unloaded to increase the stability of the slope. However, further studying of the artesian conditions is required to determine whether a subdrain system is required.

Thurber (1996) Supplementary Geotechnical Investigation:

- Soil conditions at the south abutment generally consisted of a stiff high plastic lacustrine clay layer overlying stiff to very stiff medium plastic clay till deposits. The clay till was underlain by soft to very stiff clay and compact sand to the borehole termination depth.
- Soil conditions at the north abutment generally consisted of 4.4 m of stiff clay fill overlying loose to compact silt to 8.2 m. The silt was underlain by dense water bearing gravel and sand over stiff to very stiff clay till to the borehole termination depth. Previous test holes by others suggest varying stratigraphy at the north abutment and may consist of sand zones and rafted bedrock intervals.
- Two potential failure surfaces were identified at the south abutment with both surfaces failing through the layered sand and clay deposits as deep as 15 m below ground level at mid-slope of the abutment.
- Slope movement at the north abutment appears to coincide with the fill/native silt interface indicating that the fill may be moving in the silt. However, movement towards the river was very small; instead, more significant lateral movement to the east was observed.
- Stability analyses suggests the high piezometric pressures are the primary factor for slope instability at the south abutment. This coupled with over steepening due to abutment fill placement at the crest of the slope likely caused the ongoing slope movements since construction.
- Slope stability analyses indicated unloading the south slope provided little increase (10%) to the stability of the south slope. However, a 45% increase to the factor of safety was gained from lowering the groundwater level at the south abutment.
- Thurber recommended depressurization of sand layers from elevation 642 m to 645 m along with unloading the head slope at the south abutment. Riprap was also recommended to protect the lower slope against river erosion.
- It was recommended that buttress fill be placed along the east side of the north approach to improve slope stability at the north abutment.

Thurber (2004) Geotechnical File Review for NC018:

- Site is located south of the thalweg of a pre-glacial buried channel where it follows the north side of the meanders of the Pembina River. Bedrock is expected at depths of >30m.
- In 1997, major bridge and slope repairs were undertaken including:
 - Constructing a buttress fill along the east side of the north approach fill to address roadway settlement.
 - Placing a facing of free-draining coarse granular material on the north abutment head slope to assist in draining the existing fill.
 - Unloading the south abutment which required the installation of another bridge pier and extending the bridge deck south.
 - Installing horizontal and vertical subdrain system to relieve artesian pressures.
- Significant flow volume was observed at the drain outlets since installation with no buildup of sediment noted in the clean-out points.
- A shallow slump was observed on the backslope on the west side of the south abutment in 2002. It was recommended that the slump be cut back to flatten and then regraded to close cracks.

ITEM	CONDITIONS EXIST		DESCRIPTION AND LOCATION	NOTICEABLE CHANGE FROM LAST INSPECTION	
	YES	NO		YES	NO
Pavement Distress		X			X
Slope Movement		X			X
Erosion	X		North abutment head slope washed out. Riprap channel collapsed east of north abutment.	X	
Seepage		X			X
Bridge/Culvert Distress	X		North abutment head slope washed out.	X	
Other		X			X

ASSESSMENT

- The site is located on the meander of the Pembina River with the south abutment on the outside bank.
- Recent flooding of the Pembina River appears to have resulted in washing out of the north abutment bridge head slope.
- Weather station data from the Barrhead CS weather station located 24 km northeast of the site indicates two significant rainfall periods in mid-June and late July (Figure 2). During this period, approximately 100 mm of rainfall was received within a few days. The cumulative precipitation for 2022 is comparable to 2023, as shown on Figure 3, however, higher intensity rainfall was experienced in 2023. Due to the rainfall received in mid-June 2023 the Pembina River water level increased by more than 3 m (Figure 4) as recorded at the Entwistle Hydrometric Station approximately 40 km southwest (upstream) from NC018. Despite comparable cumulative precipitation in 2022, river levels only risen about 1 m given the lower intensity.
- The highway surface currently does not appear to be affected by the loss of the north embankment head slope (Photos 1 to 4).
- Significant drift accumulation was observed on the upstream side of the bridge (Photo 5). Stantec was informed that some of the drift accumulated up to the north bank of the river and was recently removed using an excavator. TEC also indicated that the remaining drift will be removed via crane in early August.
- The current crest of the head slope is about 2.4 m away from the concrete north abutment wall (Photo 6).
- A collapsed riprap channel wrapped in geotextile was observed at the east extent of the washed out head slope (Photo 7).
- Erosion and slumping were observed along the riverbank west of the north bridge abutment (Photo 8).
- The south abutment did not appear to be affected by recent flooding. (Photos 9 and 10). A small slump along the riverbank was observed about 15 m to 20 m west of the south abutment. It is unlikely this slump is affecting the bridge.
- A small erosion channel was developing along the south head slope (Photo 11). Water appears to be pooling between the head slope and drainage galleries (Photo 12).
- TEC indicated on-site that the river levels were up to the 17 feet mark on the river level gauge at Pier 3 (Photo 13).
- All three drains in the west drainage gallery (collection point) were slowly trickling water. Only the east most drain was slowly draining in the east drainage gallery. Siltation within both drainage galleries was apparent.
- The existing functional instrumentation include five slope inclinometers and two standpipes. No instruments appear to be damaged due to the current washout.
- All instruments were monitored as part of the call-out inspection. The slope inclinometers do not show signs of slope movement related to the recent washout. Piezometers SP2 and SP96-1 show an increase in piezometric level of 1.2 m and 1.3 m, respectively. The increase in water level is likely related to recent flooding of the Pembina River.
- A Probability Factor of 9 was assessed since the bridge embankment slopes contain erodible soils with little vegetation cover. In addition, it is anticipated that loss of riverbank and bridge embankment slopes will continue with each high precipitation event or freshet from rapid snowmelt. Given that significant loss of infrastructure has already occurred, and the eroded material is directly flowing into a fish bearing river, a Consequence Factor of 10 was assessed.

RECOMMENDATIONS

- The bridge should be monitored regularly (in the spring following freshet, fall and following high precipitation events) for adverse impacts due to significant loss of the north head slope.
- The accumulation of driftwood should be removed.
- A periodic subdrain cleaning program should be implemented to reduce risk of potential siltation and clogging of subdrains. The cleaning method may consist of pressure washing the insides of the subdrains and removing the dirty water and sediment from the collection points with a hydrovac. The outlet pipes to the river should be temporarily plugged until the collection points have been cleaned out to reduce migration of dirty water into the river. The outlet should also be flushed by forcing water out from the drainage galleries. The anticipated cost for subdrain cleaning is \$6,000 excluding any consulting effort.
- For long-term remediation, Stantec recommends the following for high-level consideration:
 - Rebuilding the bridge head slope to its original configuration with concrete slope protection.
 - The north riverbank should be regraded to remove existing erosion and slumping areas.
 - Riprap should be placed for erosion protection 20 m upstream and downstream of the north abutment up to the 1:100 year water level.

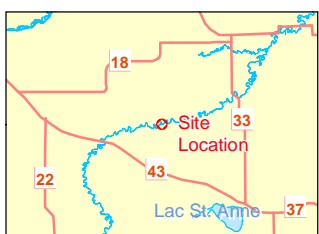
- The high-level cost for the above remediation is \$700,000 to \$1,000,000 excluding engineering and environmental permitting and/or assessment. The estimated high-level cost assumes stream isolation cost of \$300,000.
- Final design details should be confirmed by a hydrotechnical and/or bridge engineer.
- The site did not return any records of historic resources based on a search of the Listing of Historic Resources. However, Historical Resources Act approval will be required since the remediation options are not included under its Land Use Bulletin.
- The washed-out head slope may be a reportable incident to the Alberta Environment hotline due to release of a deleterious substance that may have caused, is causing, or may continue to cause an adverse effect.
- *Public Lands Act* approvals may also be required, however, given this is TEC property, requirements may vary depending on how the land is titled and if there is a disposition for the bridge.
- Work below the ordinary high-water mark (i.e., 1:2-year flood elevation) will require notification/approvals under the *Water Act*, *Fisheries Act*, and *Canadian Navigable Waters Act*.
- The site inspection frequency should return to annually with the next site visit in 2024.

PREPARED BY: Leslie Cho, M.Eng., P.Eng.	REVIEWED BY: Carrie Murray, M.Eng., P.Eng.	PERMIT TO PRACTICE:

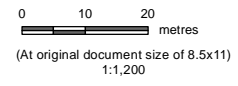
653000



653000



- Approximate Location of Slope Inclinometer (SI)
- Approximate Location of Stand Piezometer (SP)
- Piers
- Previous Observation
- 2023 Observation
- Photos and Direction



Project Location: Hwy 764:02, km 12.052
 Prepared by CL on 2023-08-10
 TR by LC on 2023-08-10
 IR by CM on 2023-08-10

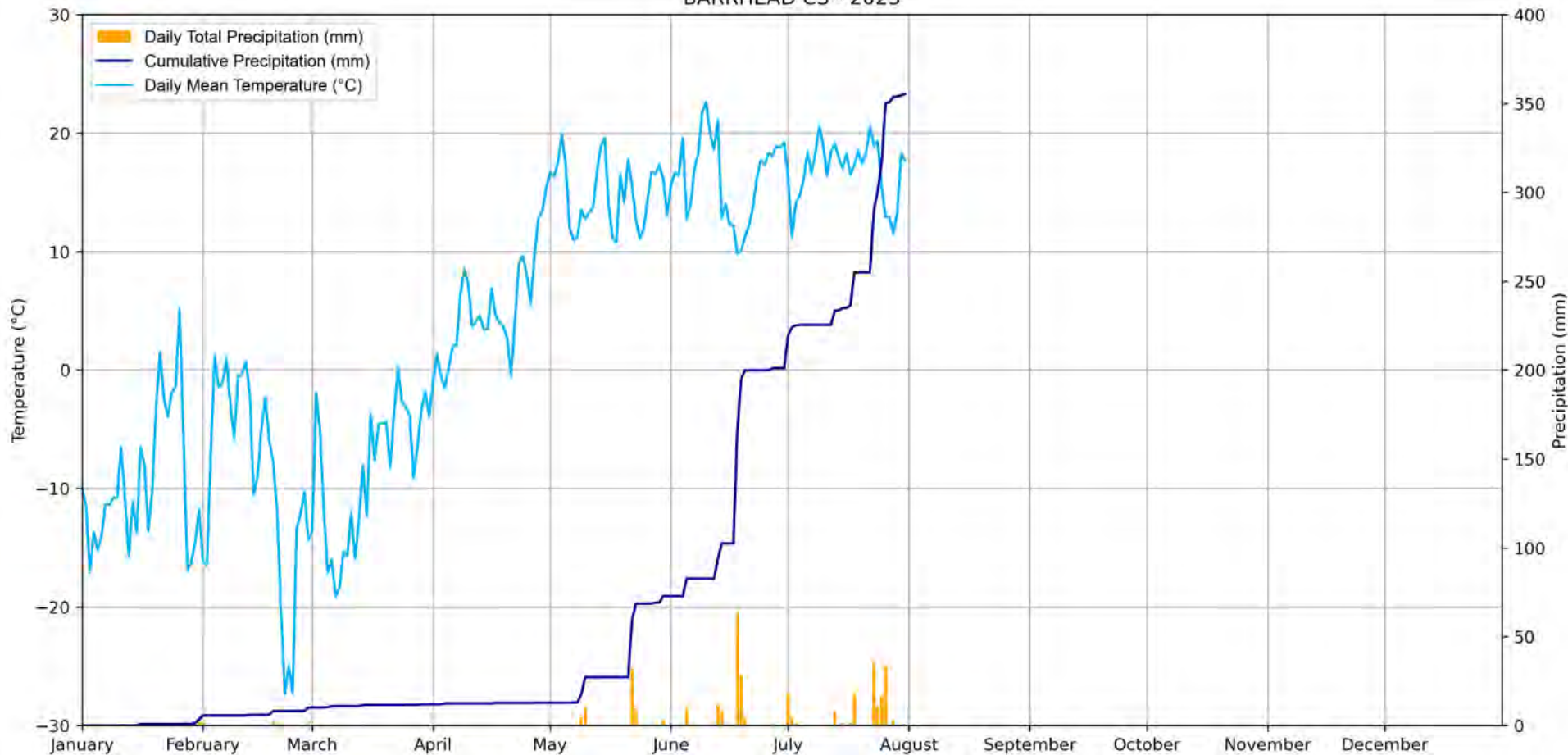
Client/Project: Alberta Transportation and Economic Corridors Geohazard Monitoring Program, Hwy 764:02, km 12.052
 123315222

Figure No. 1
 Title Site Plan

Notes
 1. Coordinate System: NAD 1983 UTM Zone 11N
 2. Data Sources: Geogratis, ©Department of Natural Resources Canada, All rights reserved.
 3. Background: © 2023 Microsoft Corporation © 2023 Maxar ©CNES (2023) Distribution Airbus DS

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BARRHEAD CS - 2023

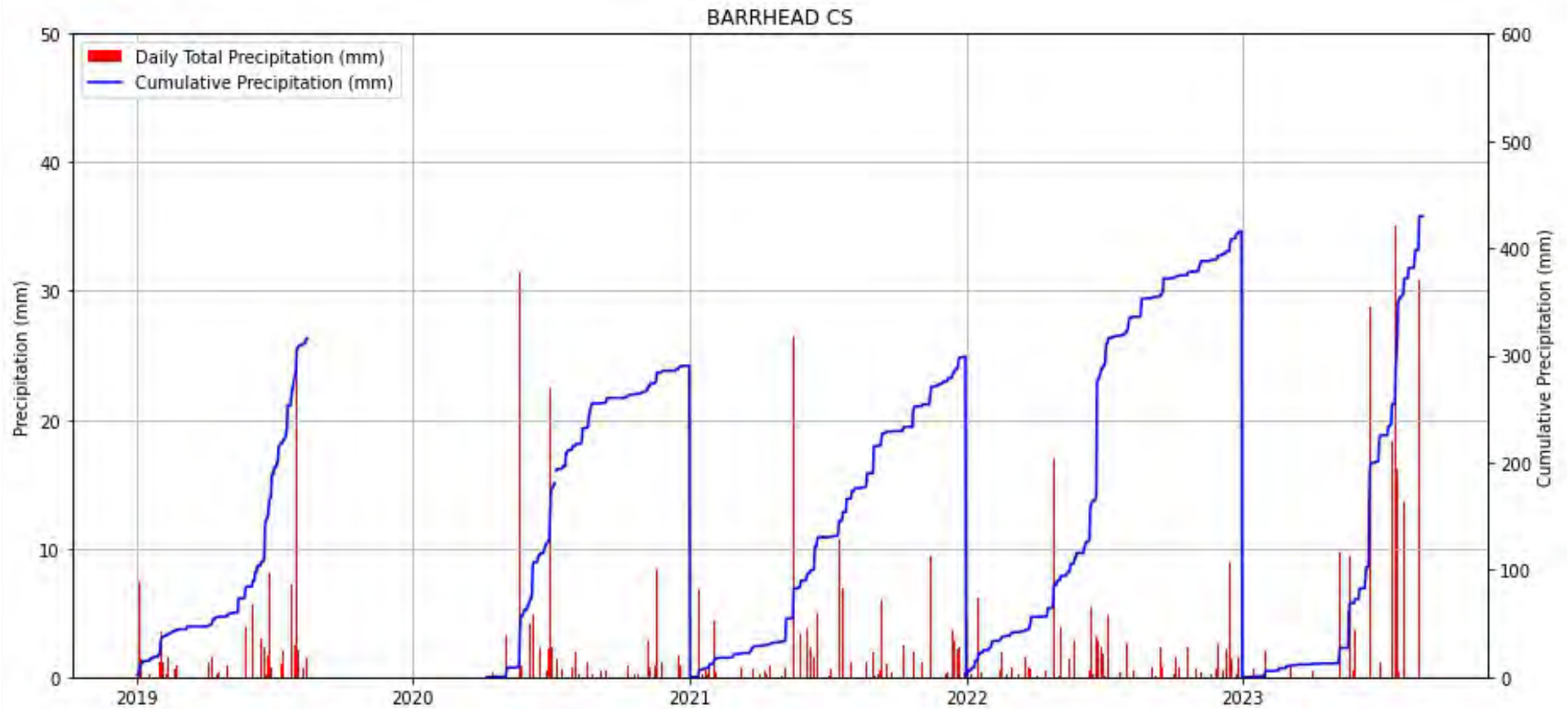


Project No.: 123315222
 Scale: ---
 Date: August 2023
 Prepared by: LC
 Checked by: CM

Client/Project
 Alberta Transportation and
 Economic Corridors
 NC018 Call-Out Inspection

Title
 2023 Precipitation Data from Barrhead Weather Station

Figure No.



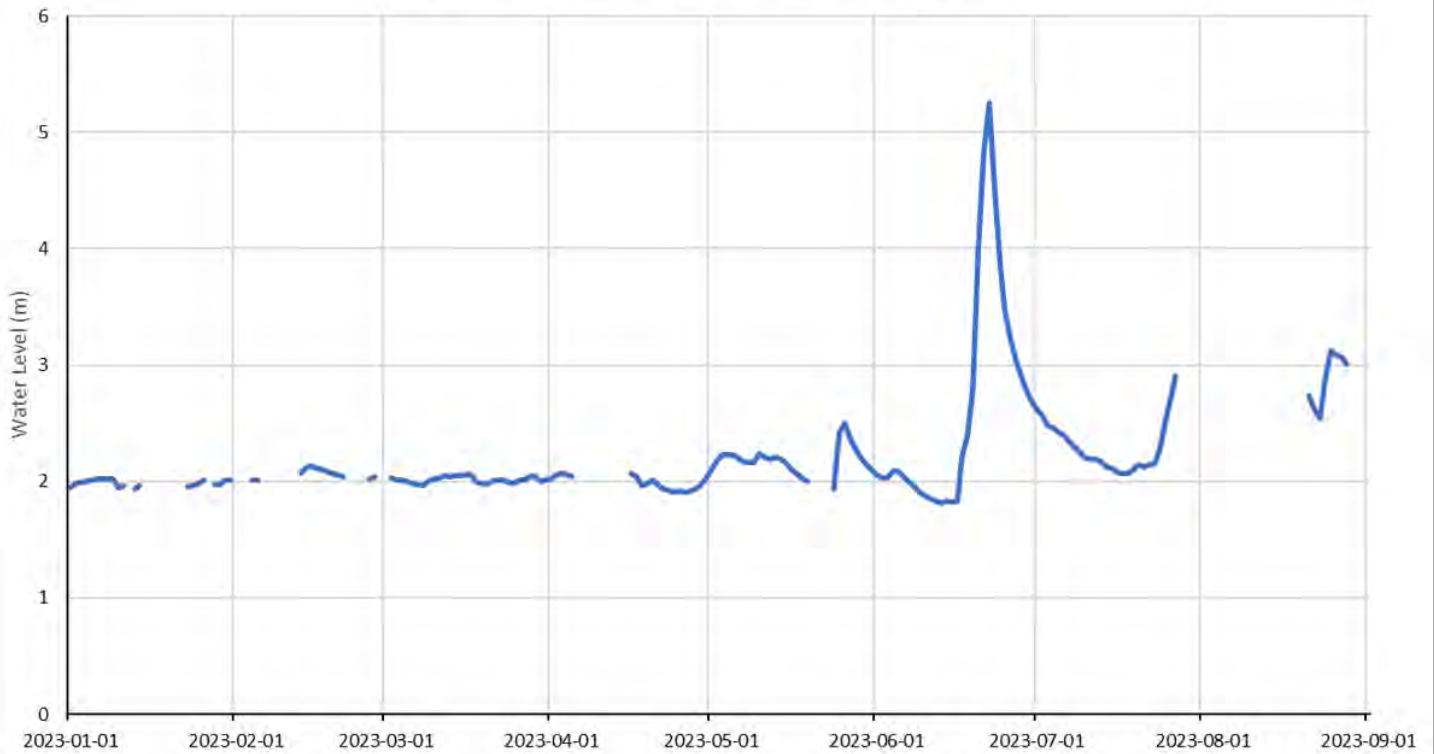
Project No.: 123315222
 Scale: ---
 Date: August 2023
 Prepared by: LC
 Checked by: CM

Client/Project
 Alberta Transportation and
 Economic Corridors
 NC018 Call-Out Inspection

Title
 2019 to 2023 Precipitation Data from Barrhead Weather
 Station

Figure No.
3

River Level - Pembina River Near Entwistle - 2023



River Level - Pembina River Near Entwistle - 2022



Project No.: 123315222
 Scale: ---
 Date: August 2023
 Prepared by: LC
 Checked by: CM

Client/Project
 Alberta Transportation and
 Economic Corridors
 NC018 Call-Out Inspection

Title
 2022 and 2023 River Level Data from Pembina River near
 Entwistle Hydrometric Station

Figure No.

2023 Call-Out Inspection Photos at Highway 764:02



Photo 1: Highway surface at north abutment. Looking southwest.



Photo 2: Highway surface at north abutment. Looking northeast.

2023 Call-Out Inspection Photos at Highway 764:02



Photo 3: Highway surface at south abutment. Looking northeast.



Photo 4: Highway surface at south abutment. Looking southwest.

2023 Call-Out Inspection Photos at Highway 764:02



Photo 5: Drift accumulation upstream of bridge. Looking southeast.



Photo 6: North abutment head slope washed away. Looking northwest.

2023 Call-Out Inspection Photos at Highway 764:02



Photo 7: East extent of washout at north abutment. Note collapsed riprap channel wrapped in geotextile. Looking east.



Photo 8: West extent of washout at north abutment. Looking north.

2023 Call-Out Inspection Photos at Highway 764:02



Photo 9: Downstream side of south abutment. Looking southeast.



Photo 10: Upstream side of south abutment. Looking southwest.

2023 Call-Out Inspection Photos at Highway 764:02



Photo 11: South abutment head slope. Looking west.

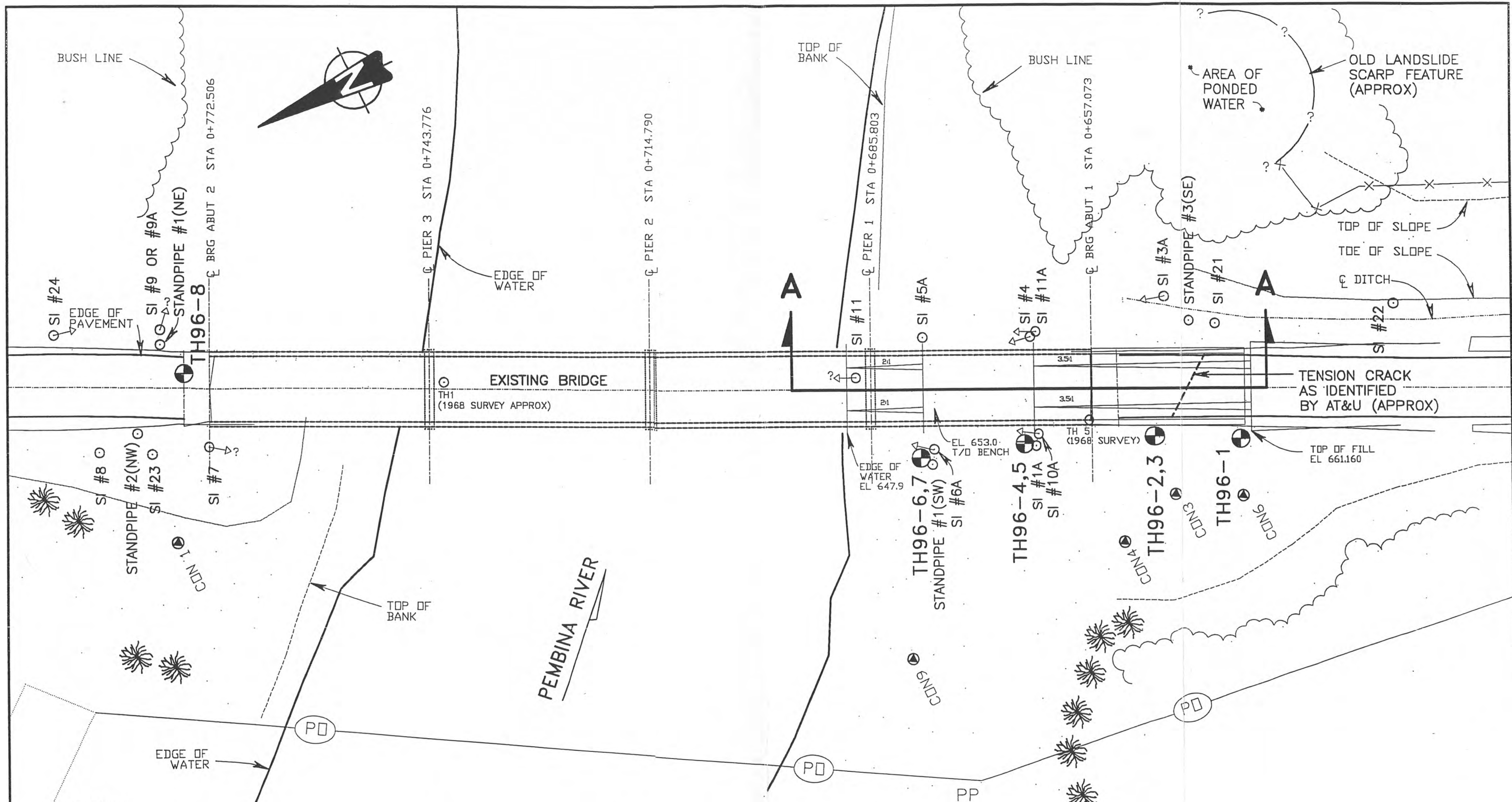


Photo 12: Saturated ground between drainage galleries and Pier 1. Looking northeast.

2023 Call-Out Inspection Photos at Highway 764:02



Photo 13: Drift accumulation upstream of bridge up to about 20 ft mark. River level up to 17 ft mark during flooding. Looking northeast.



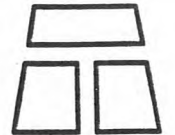
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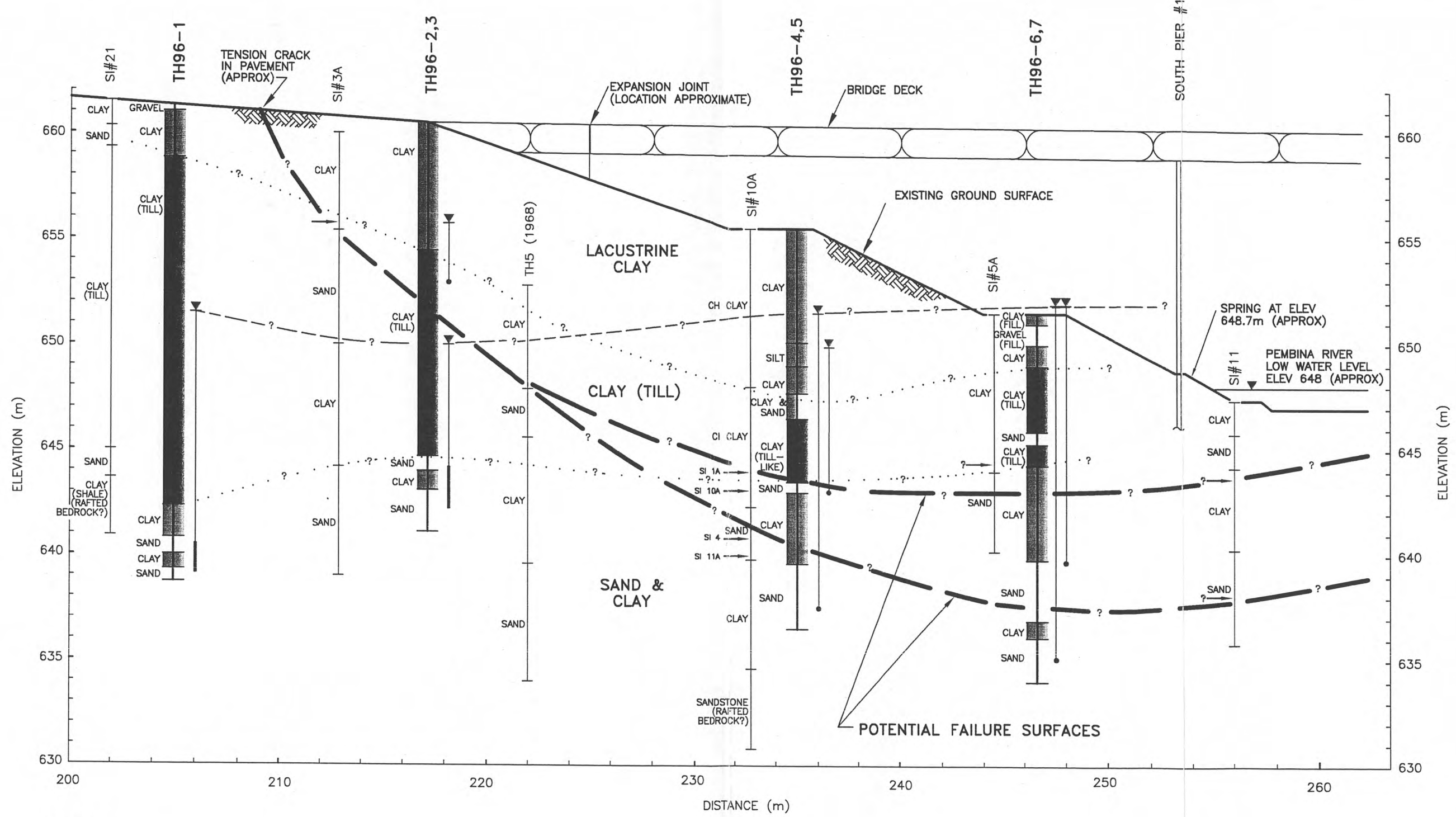
- ⊕ APPROXIMATE LOCATION OF THURBER TEST HOLE
- ⊙ APPROXIMATE LOCATION OF AT&U TEST HOLE
- ⊙ SURVEY CONTROL POINT (UMA)
- ← INCLINOMETER MOVEMENT DIRECTION

SITE PLAN SUPPLIED BY CLIENT

ENGINEER	DJL
DRAWN	MM
DATE	DEC 1996
APPROVED	<i>[Signature]</i>
SCALE	1 : 500

UMA ENGINEERING LTD.	
SITE PLAN SHOWING TEST HOLE & INSTRUMENTATION LOCATIONS	
PEMBINA RIVER BRIDGE	SH 764 NORTH OF CHERHILL, AB

 THURBER
DRAWING No. 17-550-103-1



LEGEND

- SAND OR GRAVEL
- SILT
- CLAY (LACUSTRINE)
- CLAY (TILL)
- TH96-1 THURBER TEST HOLES
- SI#3A SELECTED AT&U TEST HOLES
- MOVEMENT IN INCLINOMETER
- - - ▽ PIEZOMETRIC LEVEL

SEE DRAWING 17-550-103-1 FOR CROSS SECTION LOCATION

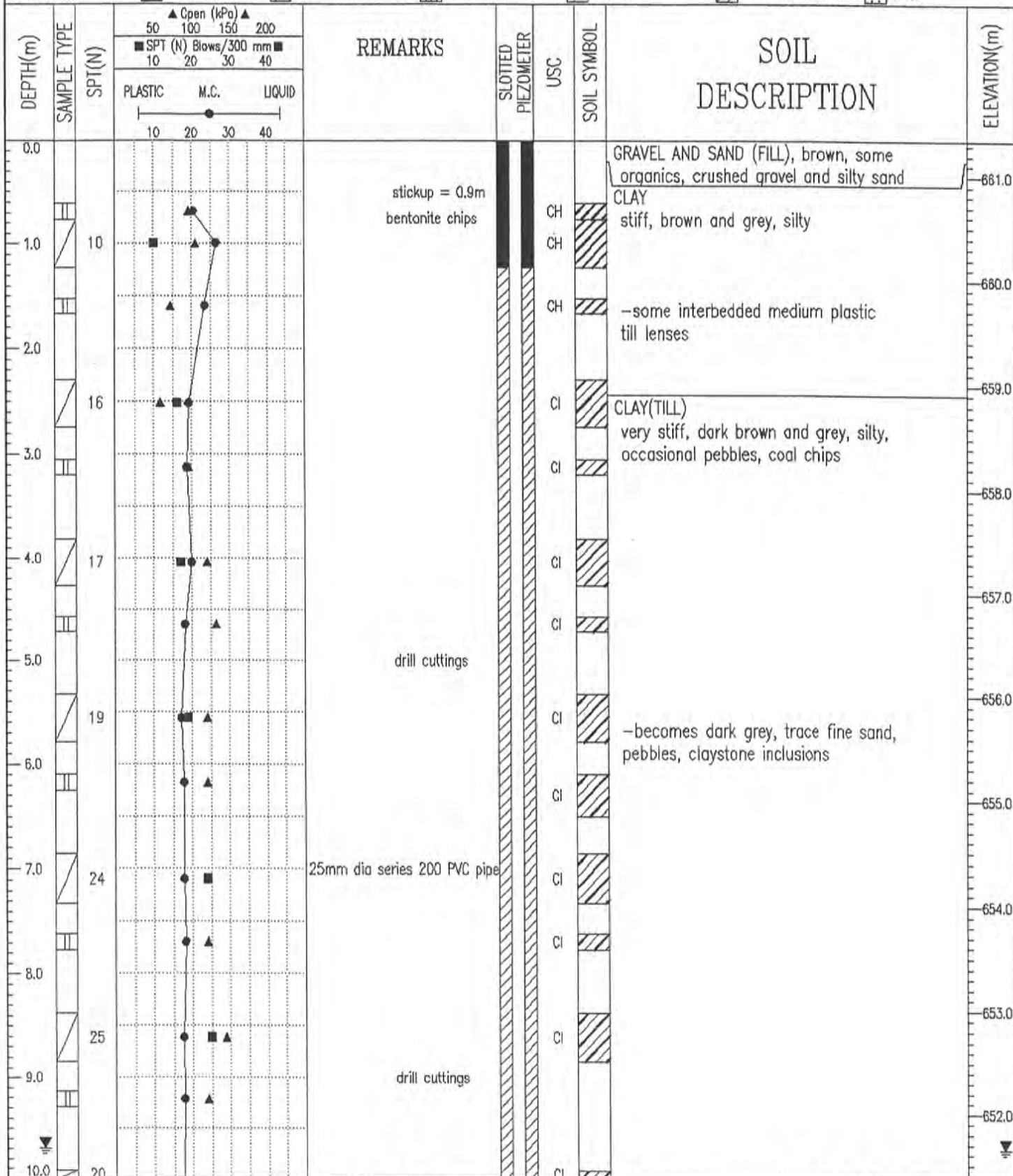
ENGINEER	DJL
DRAWN	MM
DATE	NOV 1996
APPROVED	
SCALE	1 : 200

UMA ENGINEERING LTD.	
STRATIGRAPHIC CROSS SECTION A-A	
SOUTH ABUTMENT	
PEMBINA RIVER BRIDGE	SH 764 NORTH OF CHERHILL, AB



DRAWING No.
17-550-103-2

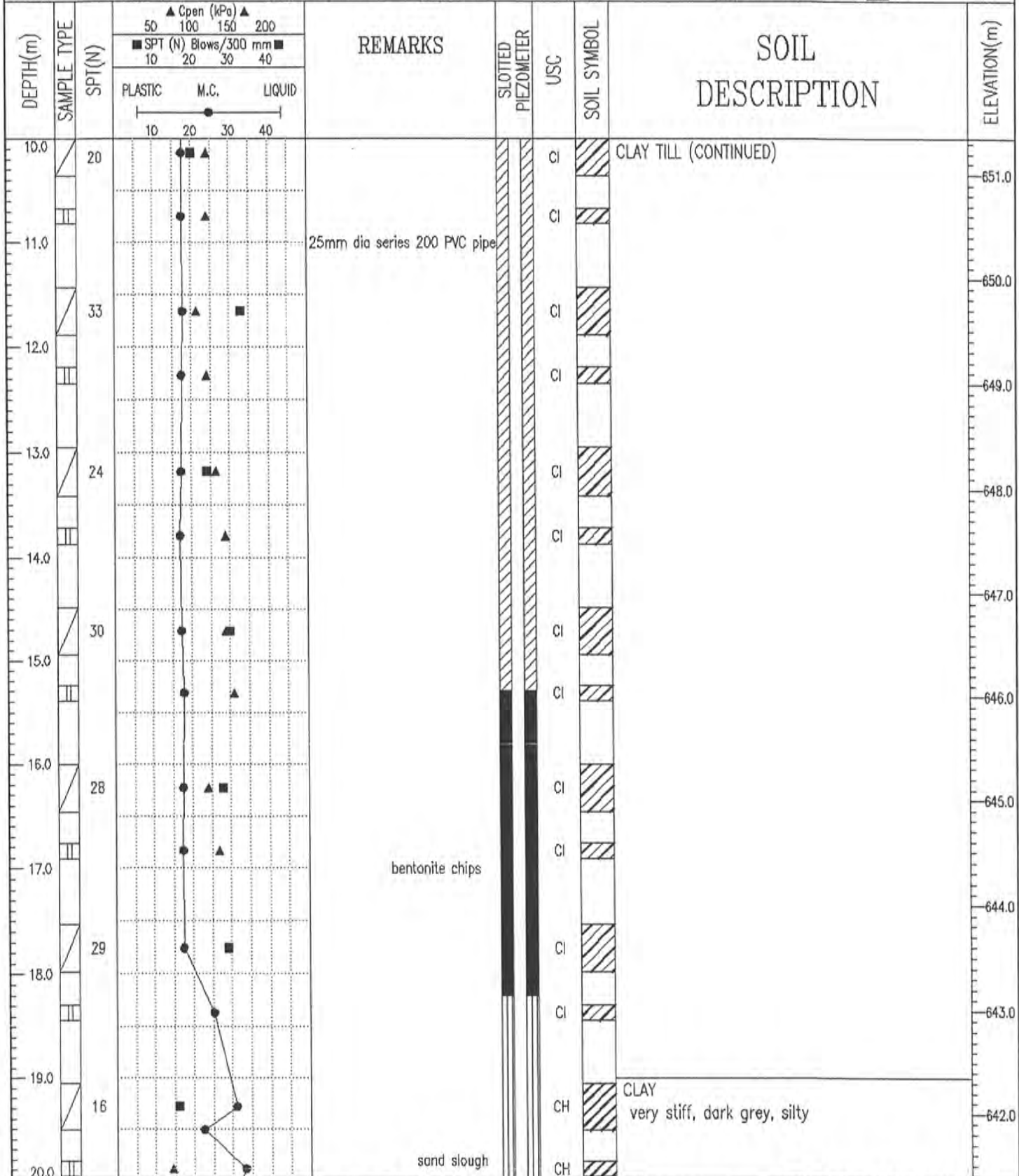
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Thurber Engineering Ltd.
Edmonton, Alberta.

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REVIEWED BY: DJL	COMPLETE:
Fig. No:	Page 1 of 3

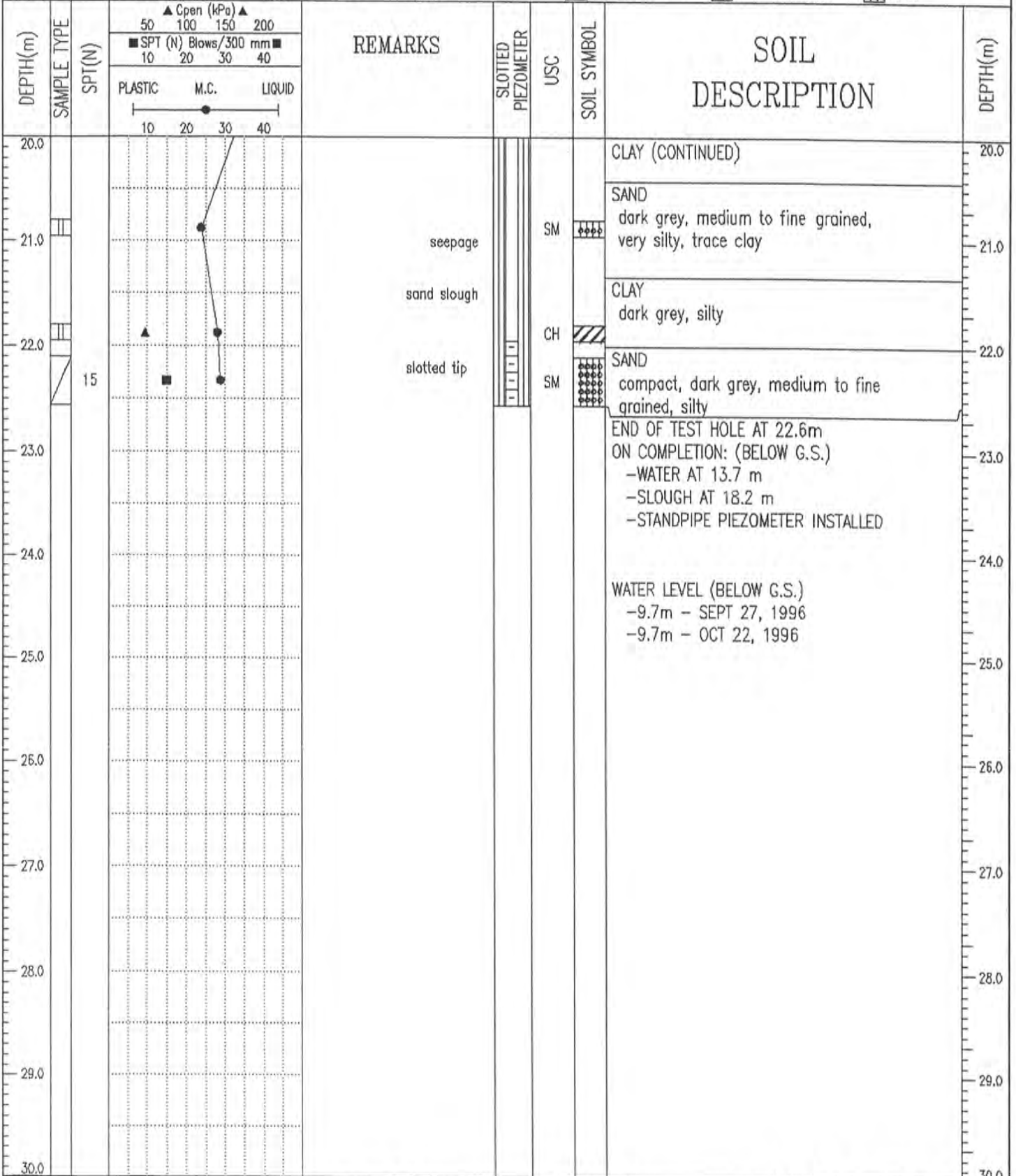
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Fig. No:	Page 2 of 3

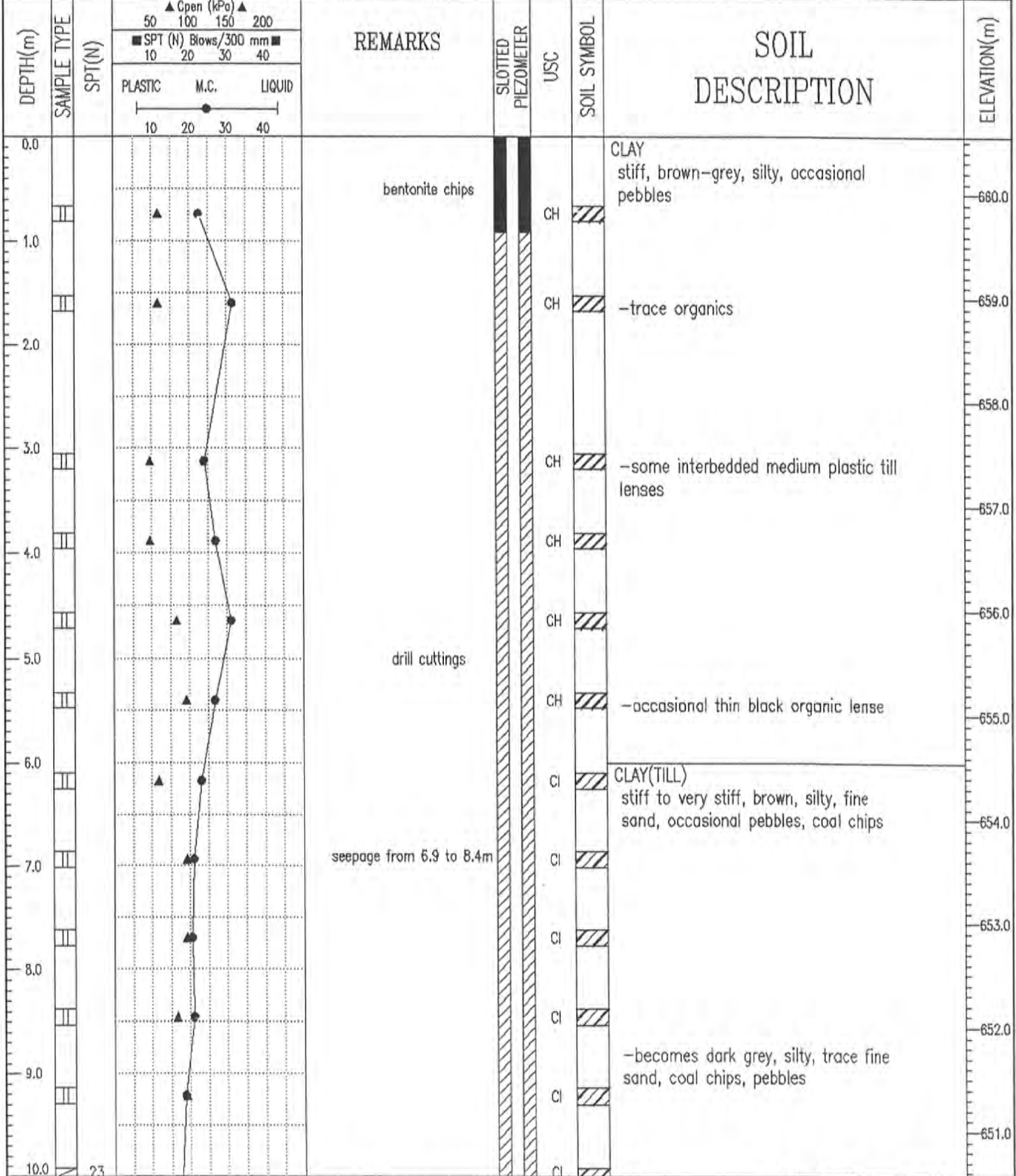
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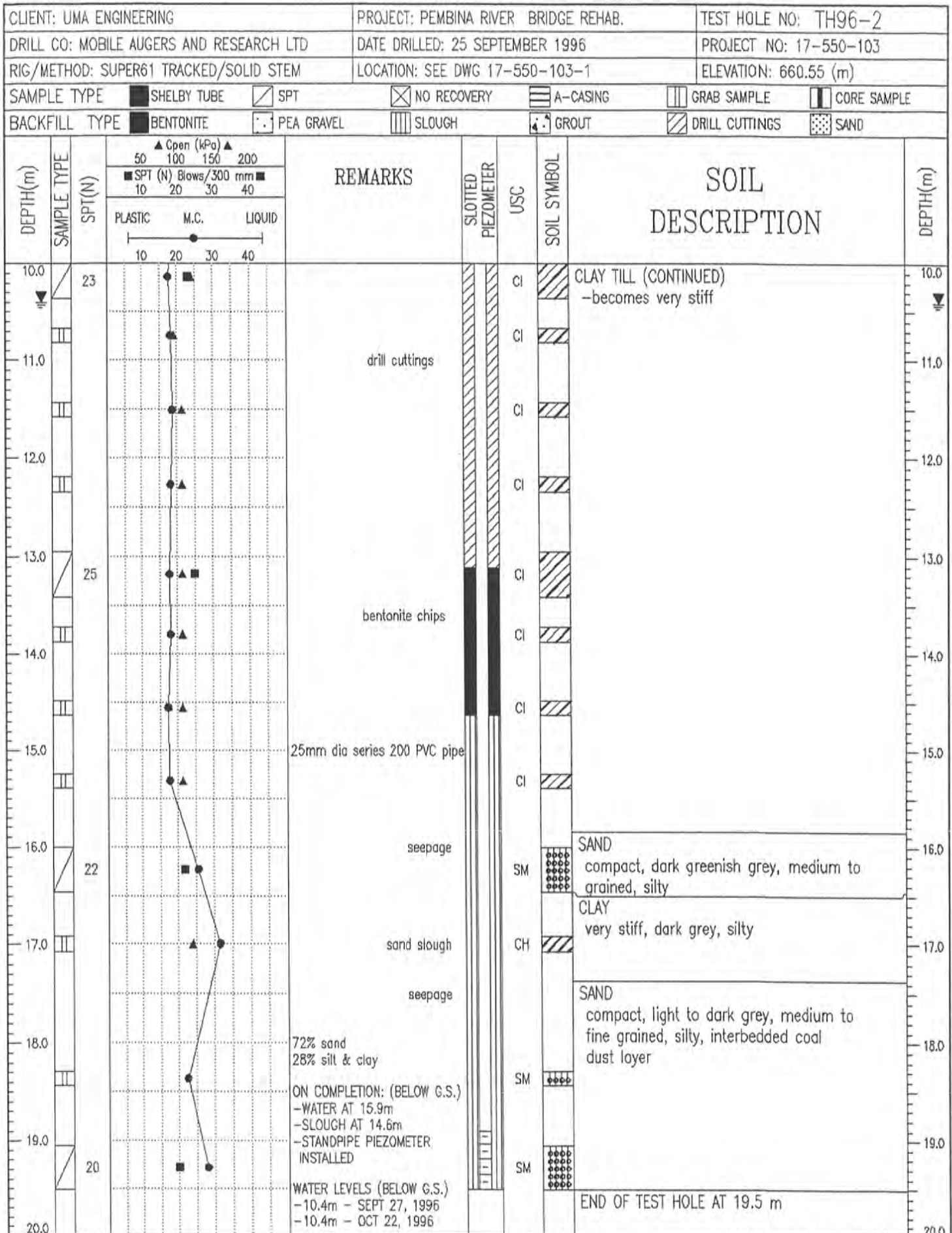
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Fig. No:	Page 3 of 3

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Fig. No:	Page 1 of 2



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REVIEWED BY: DJL
Fig. No:

COMPLETION DEPTH: 19.5 m
COMPLETE:

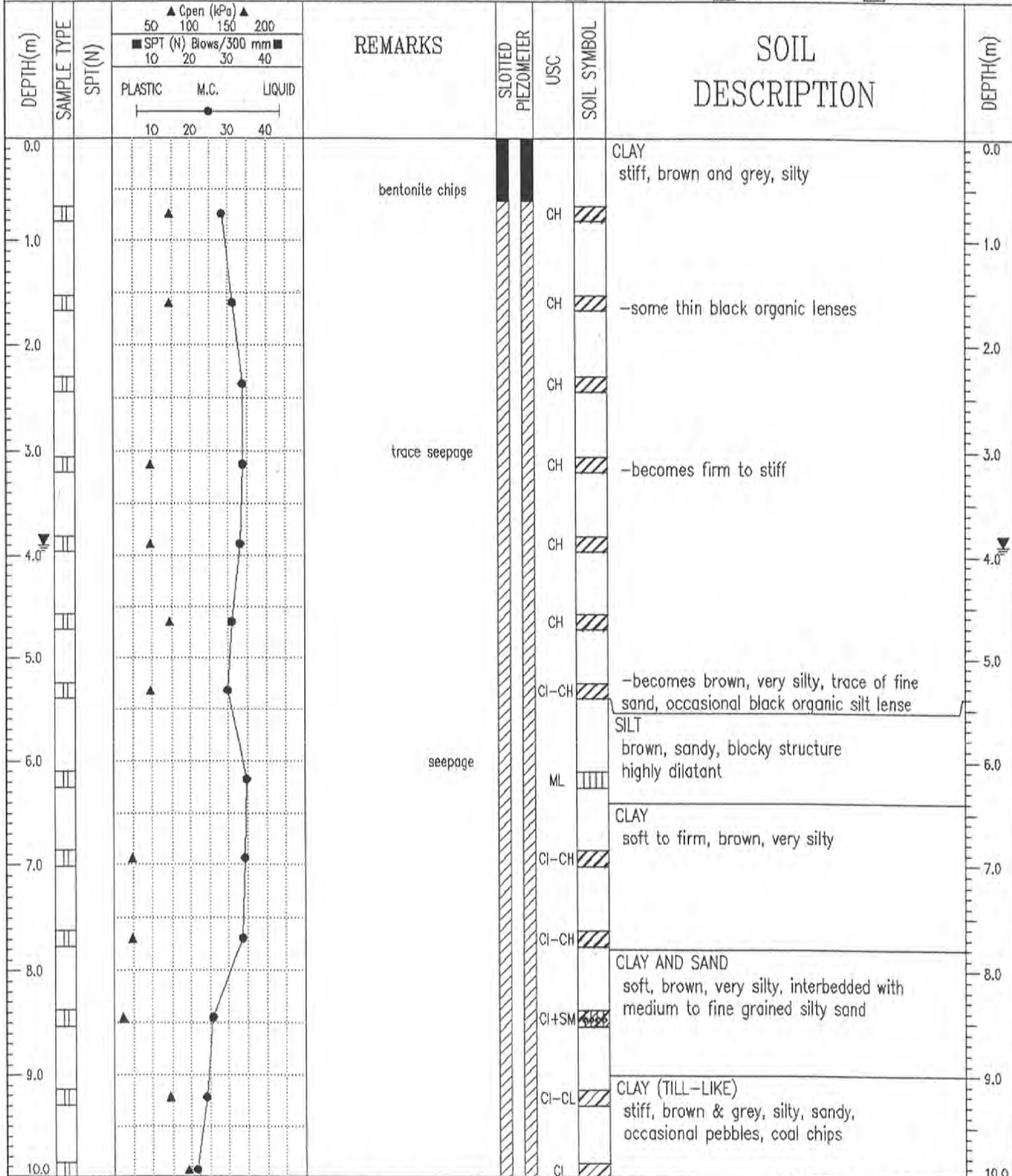
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DEPTH(m)	SAMPLE TYPE	SPT(N)	REMARKS			SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION(m)
			50	100	150					
			▲ C _{pen} (kPa) ▲							
			■ SPT (N) Blows/300 mm ■							
			10	20	30	40				
			PLASTIC	M.C.	LIQUID					
			10	20	30	40				
0.0			Drilled adjacent to TH96-2 stick-up = 0.9m bentonite chips					CLAY	stiff, brown-grey, silty, occasional pebbles	660.0
1.0								-trace organics	659.0	
2.0			25mm dia series 200 PVC pipe							658.0
3.0								-some interbedded medium plastic till lenses	657.0	
4.0			drill cuttings							656.0
5.0								-occasional thin black organic lense	655.0	
6.0								CLAY (TILL)		654.0
7.0			sand slough					stiff to very stiff, brown, silty, fine sand, occasional pebbles, coal chips		653.0
8.0			slotted tip							652.0
9.0			END OF TEST HOLE AT 7.9m ON COMPLETION: STANDPIPE PIEZOMETER INSTALLED TO 7.9m							651.0
10.0			WATER LEVEL (BELOW G.S.) - DRY - SEPT 27, 1996 - 4.6m - OCT 22, 1996							

Thurber Engineering Ltd.
Edmonton, Alberta.

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REVIEWED BY: DJL
Fig. No:

COMPLETION DEPTH: 7.9 m
COMPLETE:

CLIENT: UMA ENGINEERING	PROJECT: PEMBINA RIVER BRIDGE REHAB.	TEST HOLE NO: TH96-4
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Thurber Engineering Ltd.
Edmonton, Alberta.

LOGGED BY: TC

REVIEWED BY: DJL

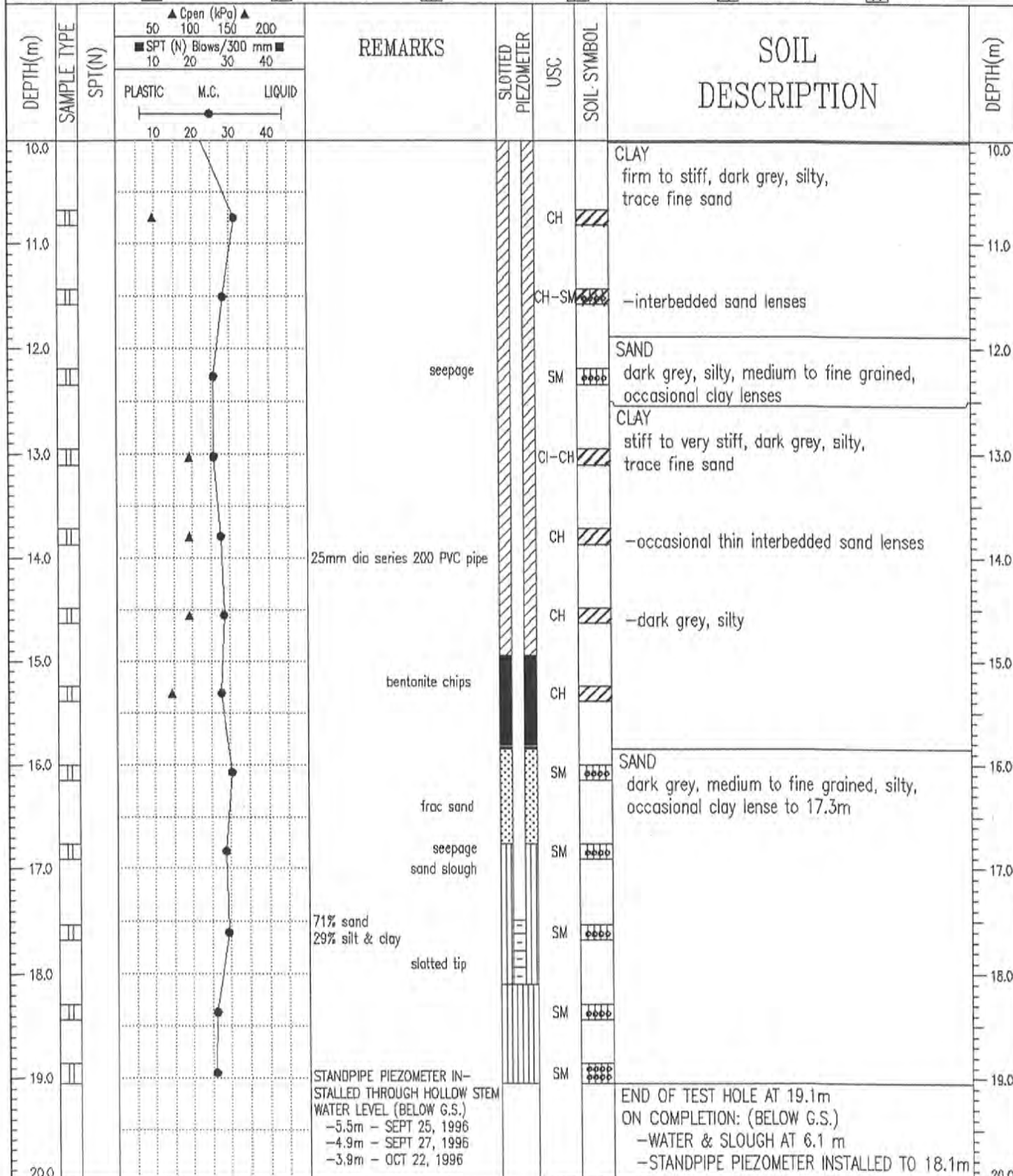
Fig. No:

COMPLETION DEPTH: 19.1 m

COMPLETE:

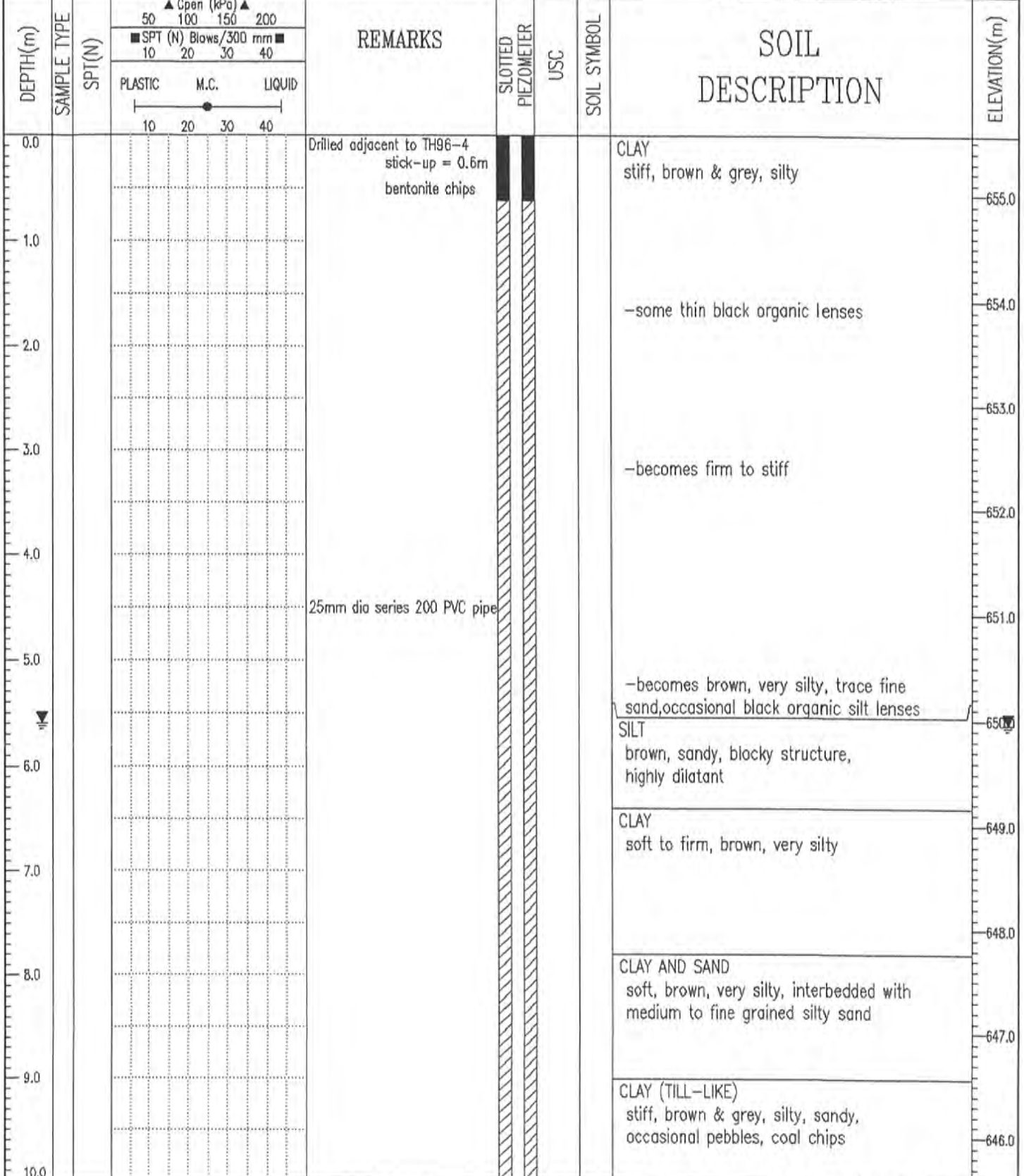
Page 1 of 2

CLIENT: UMA ENGINEERING	PROJECT: PEMBINA RIVER BRIDGE REHAB.	TEST HOLE NO: TH96-4
DRILL CO: MOBILE AUGERS AND RESEARCH LTD	DATE DRILLED: 25 SEPTEMBER 1996	PROJECT NO: 17-550-103
RIG/METHOD: SUPER61 TRACKED/SOLID+HOLLOW	LOCATION: SEE DWG 17-550-103-1	ELEVATION: 655.56 (m)
SAMPLE TYPE	<input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> A-CASING <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> CORE SAMPLE	
BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input checked="" type="checkbox"/> SLOUGH <input checked="" type="checkbox"/> GROUT <input checked="" type="checkbox"/> DRILL CUTTINGS <input checked="" type="checkbox"/> SAND	



Thurber Engineering Ltd. Edmonton, Alberta.		LOGGED BY: TC	COMPLETION DEPTH: 19.1 m
		REVIEWED BY: DJL	COMPLETE:
		Fig. No:	Page 2 of 2

CLIENT: UMA ENGINEERING	PROJECT: PEMBINA RIVER BRIDGE REHAB.	TEST HOLE NO: TH96-5
DRILL CO: MOBILE AUGERS AND RESEARCH LTD	DATE DRILLED: 26 SEPTEMBER 1996	PROJECT NO: 17-550-103
DRILL/METHOD: SUPER61 TRACKED/SOLID STEM	LOCATION: SEE DWG 17-550-103-2	ELEVATION: 655.56 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input type="checkbox"/> A-CASING <input type="checkbox"/> GRAB SAMPLE <input type="checkbox"/> CORE SAMPLE		
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input checked="" type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND		



Thurber Engineering Ltd. Edmonton, Alberta.	LOGGED BY: TC	COMPLETION DEPTH: 12.8 m
	REVIEWED BY: DJL	COMPLETE:
	Fig. No:	Page 1 of 2

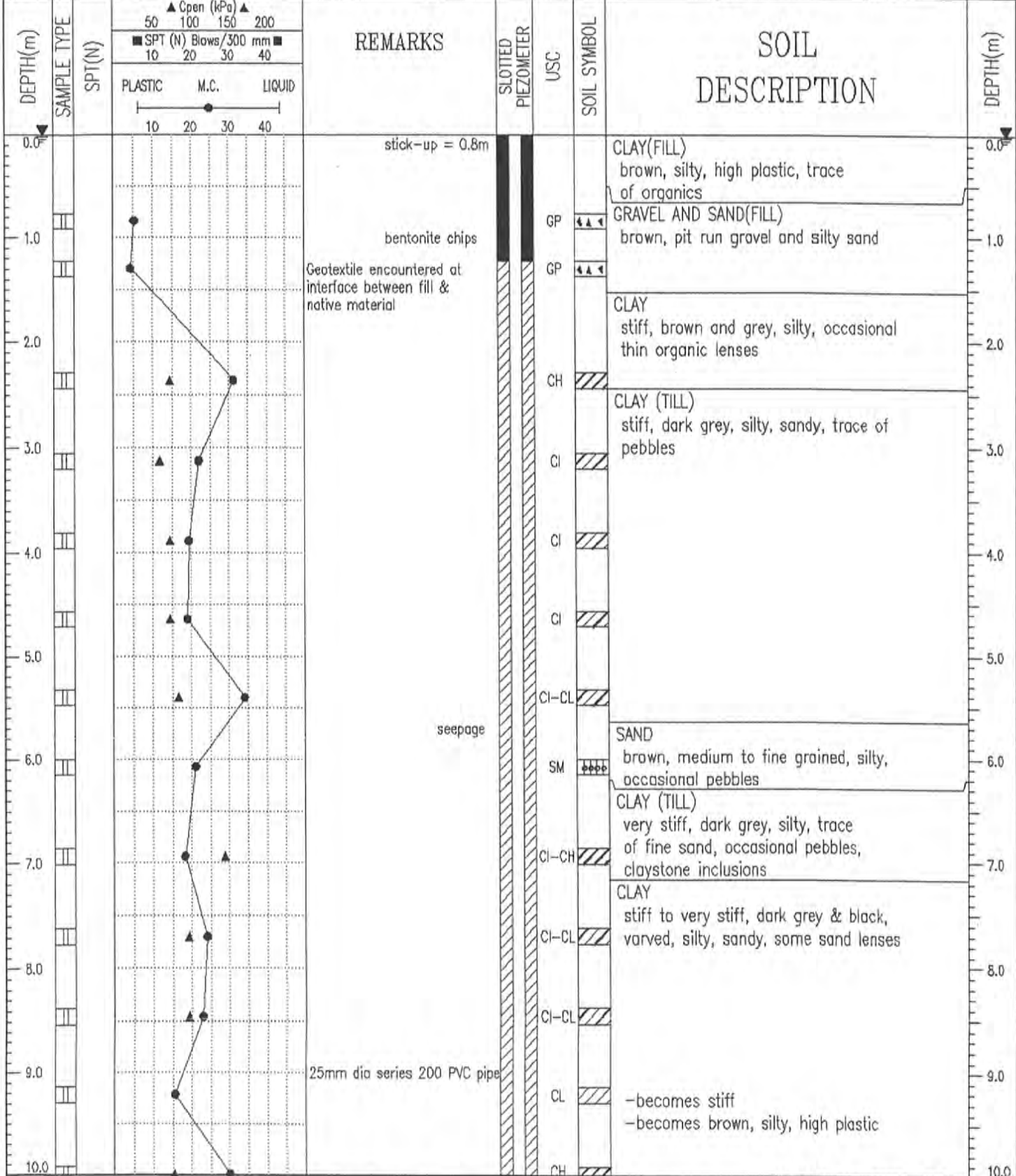
CLIENT: UMA ENGINEERING	PROJECT: PEMBINA RIVER BRIDGE REHAB.	TEST HOLE NO: TH96-5
DRILL CO: MOBILE AUGERS AND RESEARCH LTD	DATE DRILLED: 26 SEPTEMBER 1996	PROJECT NO: 17-550-103
DRILL/METHOD: SUPER61 TRACKED/SOLID STEM	LOCATION: SEE DWG 17-550-103-2	ELEVATION: 655.56 (m)
SAMPLE TYPE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input type="checkbox"/> A-CASING <input type="checkbox"/> GRAB SAMPLE <input type="checkbox"/> CORE SAMPLE		
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND		

DEPTH(m)	SAMPLE TYPE	SPT(N)	REMARKS			SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION(m)
			PLASTIC	M.C.	LIQUID					
10.0								CLAY dark grey, silty, trace fine sand trace fine sand -some dark grey medium to fine	645.0	
11.0					bentonite chips			interbedded sand lenses	644.0	
12.0					sand slough			SAND dark grey, silty, medium to fine grained, occasional clay lenses	643.0	
13.0					slotted tip			CLAY dark grey, silty, trace of fine sand	642.0	
14.0								END OF TEST HOLE AT 12.8m ON COMPLETION: STANDPIPE PIEZOMETER INSTALLED	641.0	
15.0								WATER LEVEL (BELOW G.S.) -7.3m - SEPT 26, 1996 -5.6m - SEPT 27, 1996 -5.6m - OCT 22, 1996	640.0	
16.0									639.0	
17.0									638.0	
18.0									637.0	
19.0									636.0	
20.0										

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LOGGED BY: TC	COMPLETION DEPTH: 12.8 m
REVIEWED BY: DJL	COMPLETE:
Fig. No:	Page 2 of 2

CLIENT: UMA ENGINEERING	PROJECT: PEMBINA RIVER BRIDGE REHAB.	TEST HOLE NO: TH96-6
DRILL CO: MOBILE AUGERS AND RESEARCH LTD	DATE DRILLED: 26 SEPTEMBER 1996	PROJECT NO: 17-550-103
RIG/METHOD: SUPER61 TRACKED/SOLID+HOLLOW	LOCATION: SEE DWG 17-550-103-1	ELEVATION: 651.59 (m)
SAMPLE TYPE	<input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input type="checkbox"/> A-CASING <input type="checkbox"/> GRAB SAMPLE <input type="checkbox"/> CORE SAMPLE	
BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND	



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LOGGED BY: TC	COMPLETION DEPTH: 17.5 m
REVIEWED BY: DJL	COMPLETE:
Fig. No:	Page 1 of 2

CLIENT: UMA ENGINEERING		PROJECT: PEMBINA RIVER BRIDGE REHAB.		TEST HOLE NO: TH96-6						
DRILL CO: MOBILE AUGERS AND RESEARCH LTD		DATE DRILLED: 26 SEPTEMBER 1996		PROJECT NO: 17-550-103						
RIG/METHOD: SUPER61 TRACKED/SOLID+HOLLOW		LOCATION: SEE DWG 17-550-103-1		ELEVATION: 651.59 (m)						
SAMPLE TYPE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> A-CASING <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> CORE SAMPLE										
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input checked="" type="checkbox"/> SLOUGH <input checked="" type="checkbox"/> GROUT <input checked="" type="checkbox"/> DRILL CUTTINGS <input checked="" type="checkbox"/> SAND										
DEPTH(m)	SAMPLE TYPE	SPT(N)	REMARKS			SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	DEPTH(m)
			PLASTIC	M.C.	LIQUID					
			50	100	150	200				
			10	20	30	40				
10.0								CH	CLAY (CONTINUED)	10.0
11.0								CH	-wet sand lenses from 10.5m to 11.0m	11.0
12.0								CH	-becomes dark grey, silty	12.0
13.0								SM	SAND dark grey, medium to fine grained, silty,	13.0
14.0								SM		14.0
15.0								CH	CLAY stiff to very stiff, dark grey, silty, trace sand lenses, occasional organic inclusions	15.0
16.0								SM	SAND dark grey, medium to fine grained, silty	16.0
17.0								SM		17.0
18.0								SM		18.0
19.0										19.0
20.0										20.0

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LOGGED BY: TC

REVIEWED BY: DJL

Fig. No:

COMPLETION DEPTH: 17.5 m

COMPLETE:

Page 2 of 2

CLIENT: UMA ENGINEERING	PROJECT: PEMBINA RIVER BRIDGE REHAB.	TEST HOLE NO: TH96-7
DRILL CO: MOBILE AUGERS AND RESEARCH LTD	DATE DRILLED: 27 SEPTEMBER 1996	PROJECT NO: 17-550-103
DRILL/METHOD: SUPER61 TRACKED/SOLID STEM	LOCATION: SEE DWG 17-550-103-1	ELEVATION: 651.59 (m)
SAMPLE TYPE	<input checked="" type="checkbox"/> SHELBY TUBE <input type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input type="checkbox"/> A-CASING <input type="checkbox"/> GRAB SAMPLE <input type="checkbox"/> CORE SAMPLE	
BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND	

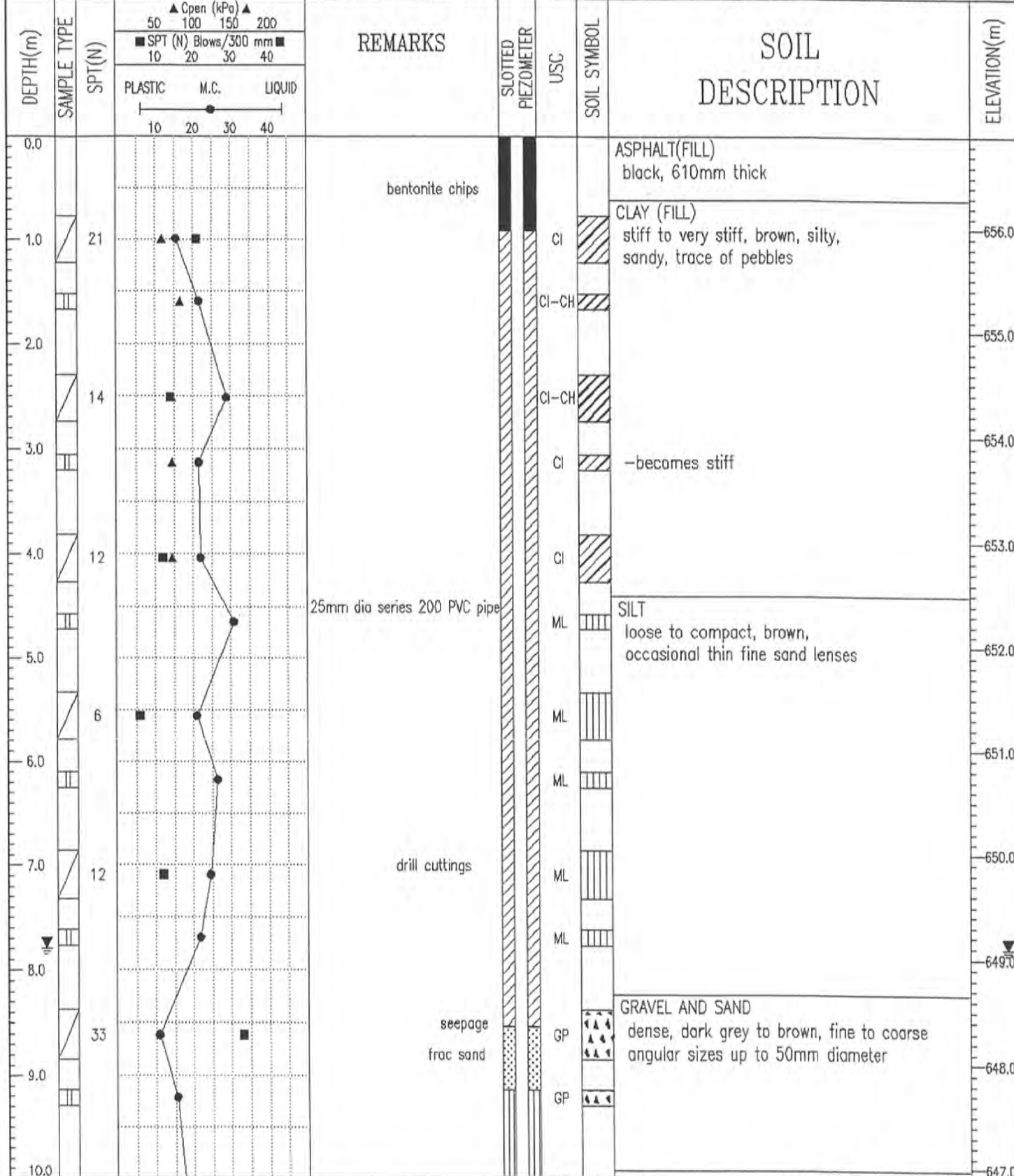
DEPTH(m)	SAMPLE TYPE	SPT(N)	REMARKS			SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION(m)
			PLASTIC	M.C.	LIQUID					
0.0					Drilled adjacent to TH96-6 stick-up = 0.8m			CLAY(FILL) brown, silty, high plastic, trace of organics	651.0	
1.0					bentonite chips			GRAVEL AND SAND(FILL) brown, pit run gravel and silty sand	650.0	
2.0					drill cuttings			CLAY stiff, brown and grey, silty, occasional thin organic lenses	649.0	
3.0					bentonite chips			CLAY (TILL) stiff, dark grey, silty, sandy, trace of pebbles	648.0	
4.0									647.0	
5.0					25mm dia series 200 PVC pipe				646.0	
6.0					drill cuttings			SAND brown, medium to fine grained, silty, occasional pebbles	645.0	
7.0								CLAY (TILL) very stiff, dark grey, silty, trace of fine sand, occasional pebbles, claystone inclusions	644.0	
8.0								CLAY stiff to very stiff, dark grey & black, varved, silty, sandy, some sand lenses	643.0	
9.0									642.0	
10.0								-becomes stiff -becomes brown, silty, high plastic		

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LOGGED BY: TC	COMPLETION DEPTH: 13.0 m
REVIEWED BY: DJL	COMPLETE:
Fig. No:	Page 1 of 2

CLIENT: UMA ENGINEERING		PROJECT: PEMBINA RIVER BRIDGE REHAB.		TEST HOLE NO: TH96-7				
DRILL CO: MOBILE AUGERS AND RESEARCH LTD		DATE DRILLED: 27 SEPTEMBER 1996		PROJECT NO: 17-550-103				
RIG/METHOD: SUPER61 TRACKED/SOLID STEM		LOCATION: SEE DWG 17-550-103-1		ELEVATION: 651.59 (m)				
SAMPLE TYPE <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> A-CASING <input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> CORE SAMPLE								
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input checked="" type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND								
DEPTH(m)	SAMPLE TYPE	SPT(N)	REMARKS	SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	DEPTH(m)
		▲ G _{pen} (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40						
10.0							CLAY (CONTINUED)	10.0
11.0			bentonite chips				-wet sand lenses from 10.5m to 11.0m -becomes dark grey, silty	11.0
12.0			sand slough slotted section				SAND dark grey, medium to fine grained, silty,	12.0
13.0							END OF TEST HOLE AT 13.00m ON COMPLETION: STANDPIPE PIEZOMETER INSTALLED TO 12.2m	13.0
14.0							WATER LEVEL -0.0m - SEPT 27, 1996 -0.3m (ABOVE G.S.) - OCT 22, 1996	14.0
15.0								15.0
16.0								16.0
17.0								17.0
18.0								18.0
19.0								19.0
20.0								20.0
Thurber Engineering Ltd. Edmonton, Alberta.				LOGGED BY: TC		COMPLETION DEPTH: 13.0 m		
				REVIEWED BY: DJL		COMPLETE:		
				Fig. No:				Page 2 of 2

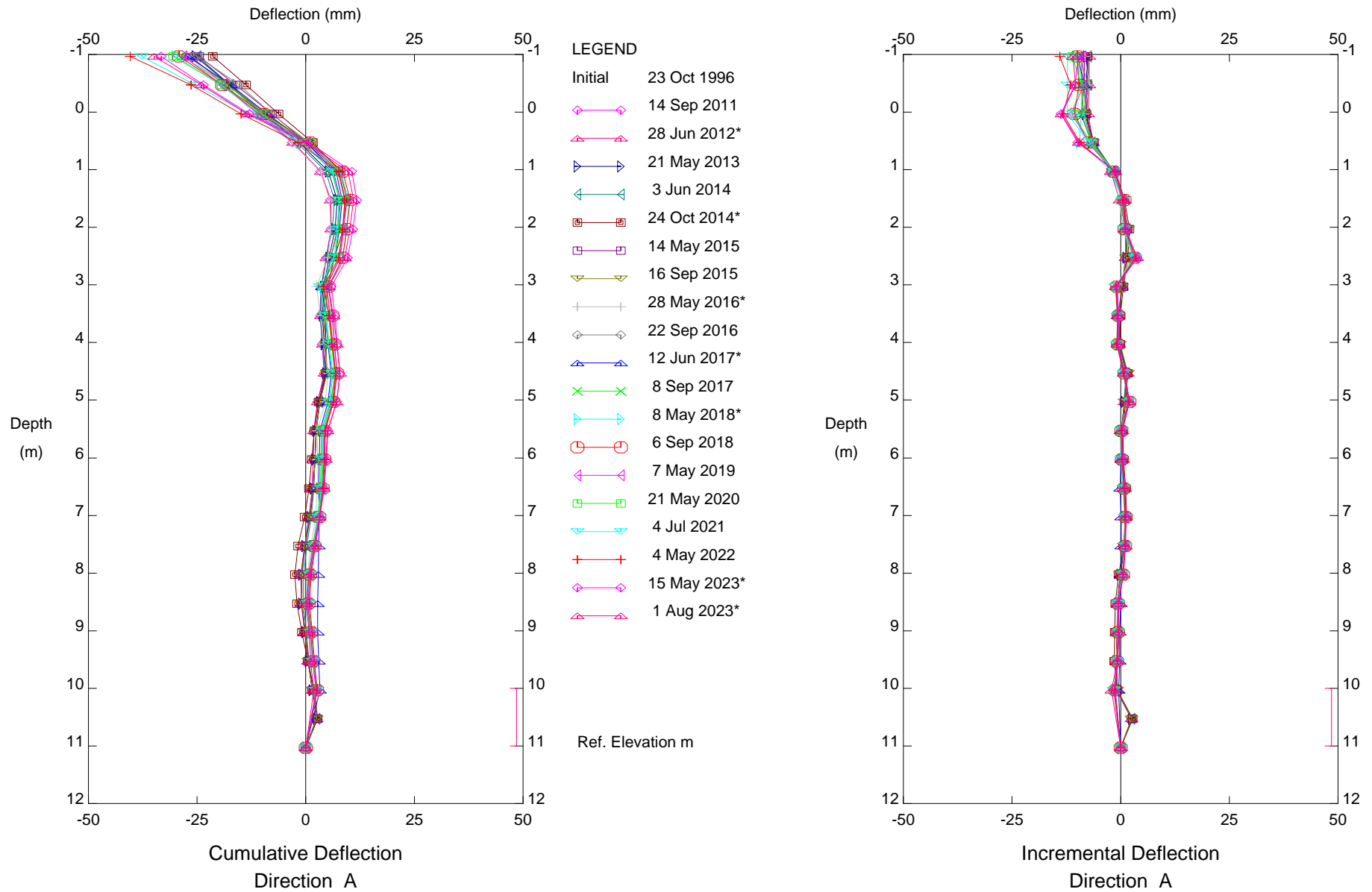
CLIENT: UMA ENGINEERING	PROJECT: PEMBINA RIVER BRIDGE REHAB.	TEST HOLE NO: TH96-8
DRILL CO: MOBILE AUGERS AND RESEARCH LTD	DATE DRILLED: 24 SEPTEMBER 1996	PROJECT NO: 17-550-103
RIG/METHOD: SUPER61 TRACKED/SOLID STEM	LOCATION: SEE DWG 17-550-103-1	ELEVATION: 656.89 (m)
SAMPLE TYPE	<input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> NO RECOVERY <input type="checkbox"/> A-CASING <input type="checkbox"/> GRAB SAMPLE <input type="checkbox"/> CORE SAMPLE	
BACKFILL TYPE	<input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND	



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LOGGED BY: TC	COMPLETION DEPTH: 14.9 m
REVIEWED BY: DJL	COMPLETE:
Fig. No:	Page 1 of 2

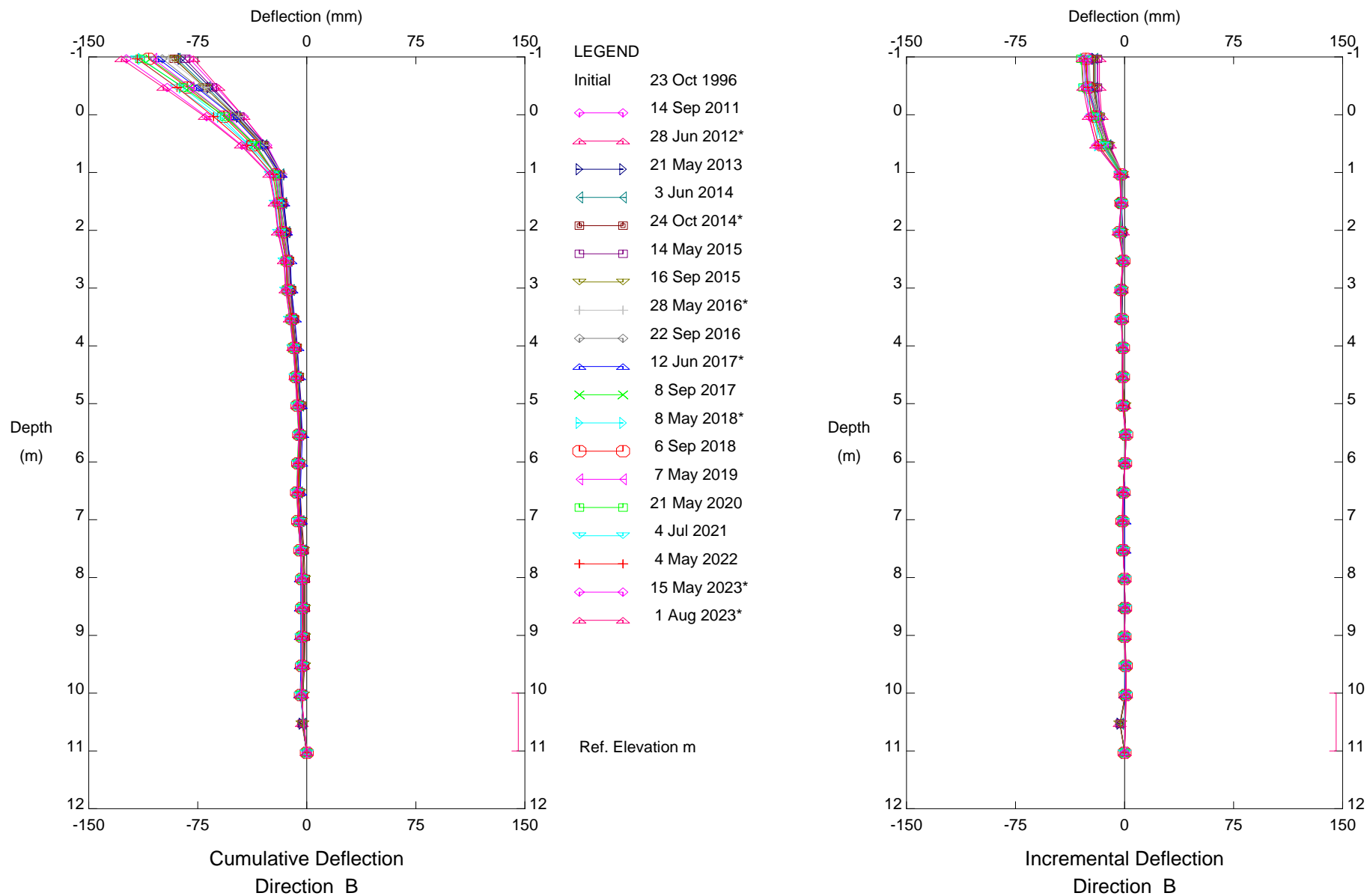
CLIENT: UMA ENGINEERING		PROJECT: PEMBINA RIVER BRIDGE REHAB.		TEST HOLE NO: TH96-8				
DRILL CO: MOBILE AUGERS AND RESEARCH LTD		DATE DRILLED: 24 SEPTEMBER 1996		PROJECT NO: 17-550-103				
DRILL/METHOD: SUPER61 TRACKED/SOLID STEM		LOCATION: SEE DWG 17-550-103-1		ELEVATION: 656.89 (m)				
SAMPLE TYPE <input checked="" type="checkbox"/> SHELBY TUBE <input type="checkbox"/> SPT		<input checked="" type="checkbox"/> NO RECOVERY		<input type="checkbox"/> A-CASING				
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL		<input type="checkbox"/> SLOUGH		<input type="checkbox"/> GROUT				
				<input type="checkbox"/> GRAB SAMPLE <input type="checkbox"/> CORE SAMPLE				
				<input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND				
DEPTH(m)	SAMPLE TYPE	SPT(N)	REMARKS	SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION(m)
							CLAY (TILL) stiff to very stiff, dark grey, silty, fine sand, trace pebbles, claystone inclusions	
10.0								
11.0			granular slough			Cl-CH		646.0
12.0		15				Cl-CH		645.0
13.0						Cl-CH		644.0
14.0						Cl-CH		643.0
15.0		29	slotted pipe			Cl-CH		642.0
16.0							END OF TEST HOLE AT 14.9m ON COMPLETION: (BELOW G.S.) -WATER & SLOUGH AT 9.1m STANDPIPE PIEZOMETER INSTALLED TO 14.9m	641.0
17.0							WATER LEVEL (BELOW G.S.) -7.8m - SEPT 27, 1996	640.0
18.0								639.0
19.0								638.0
20.0								637.0
Thurber Engineering Ltd. Edmonton, Alberta.				LOGGED BY: TC REVIEWED BY: DJL Fig. No:		COMPLETION DEPTH: 14.9 m COMPLETE:		Page 2 of 2



HWY764:02 Pembina River Bridge (NC18), Inclinometer SI-7

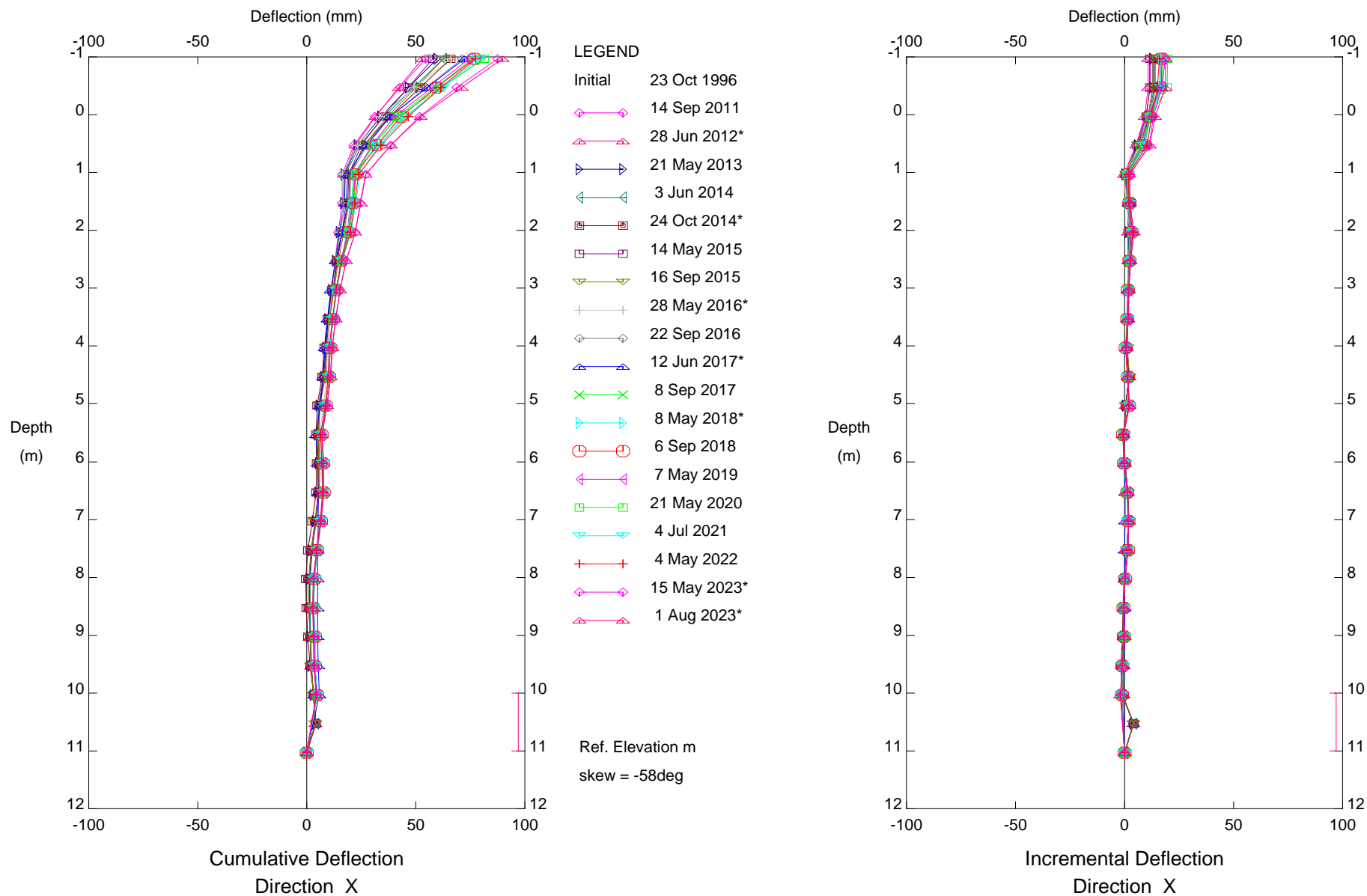
Transportation & Economic Corridors

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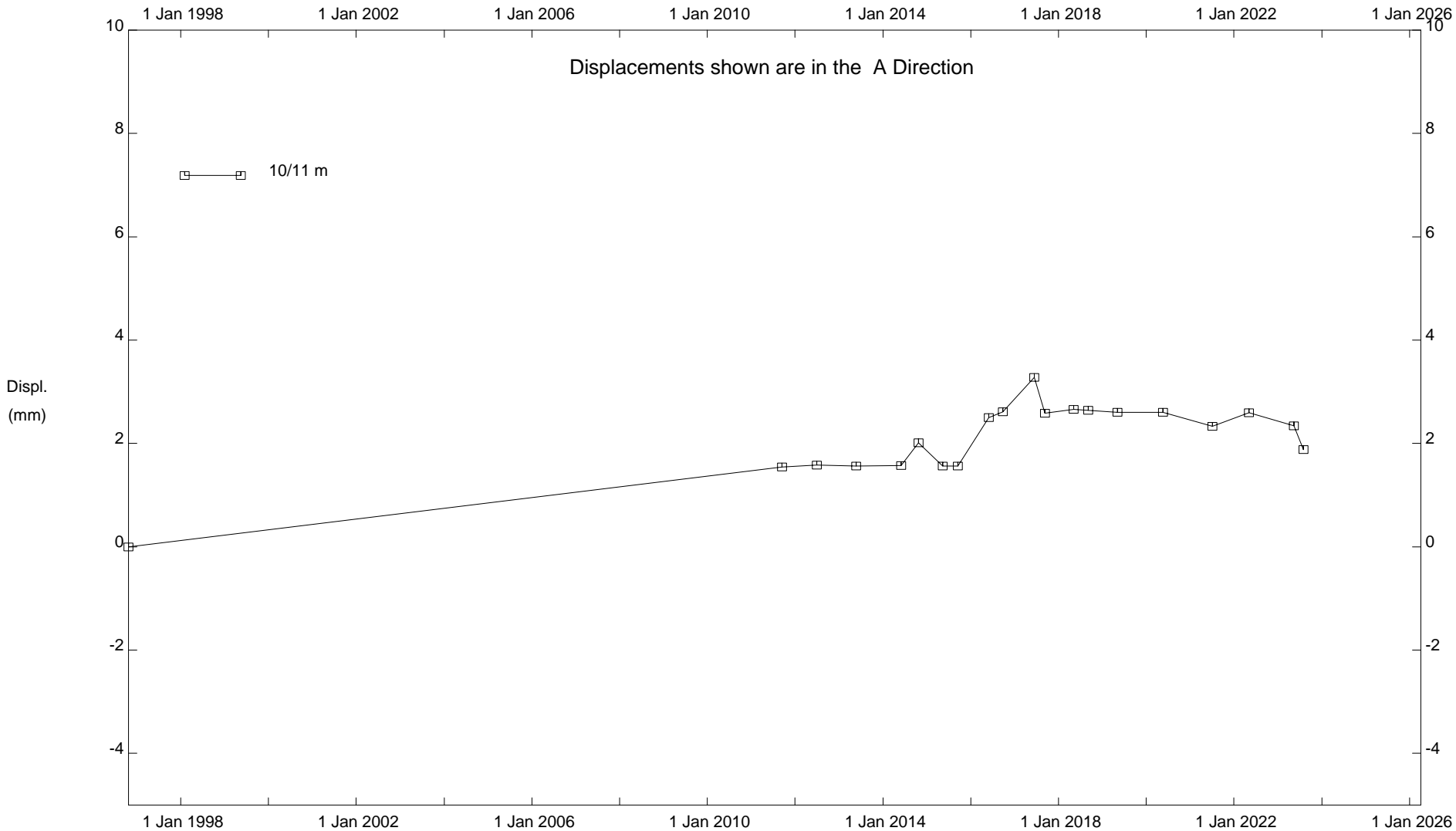
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Transportation & Economic Corridors

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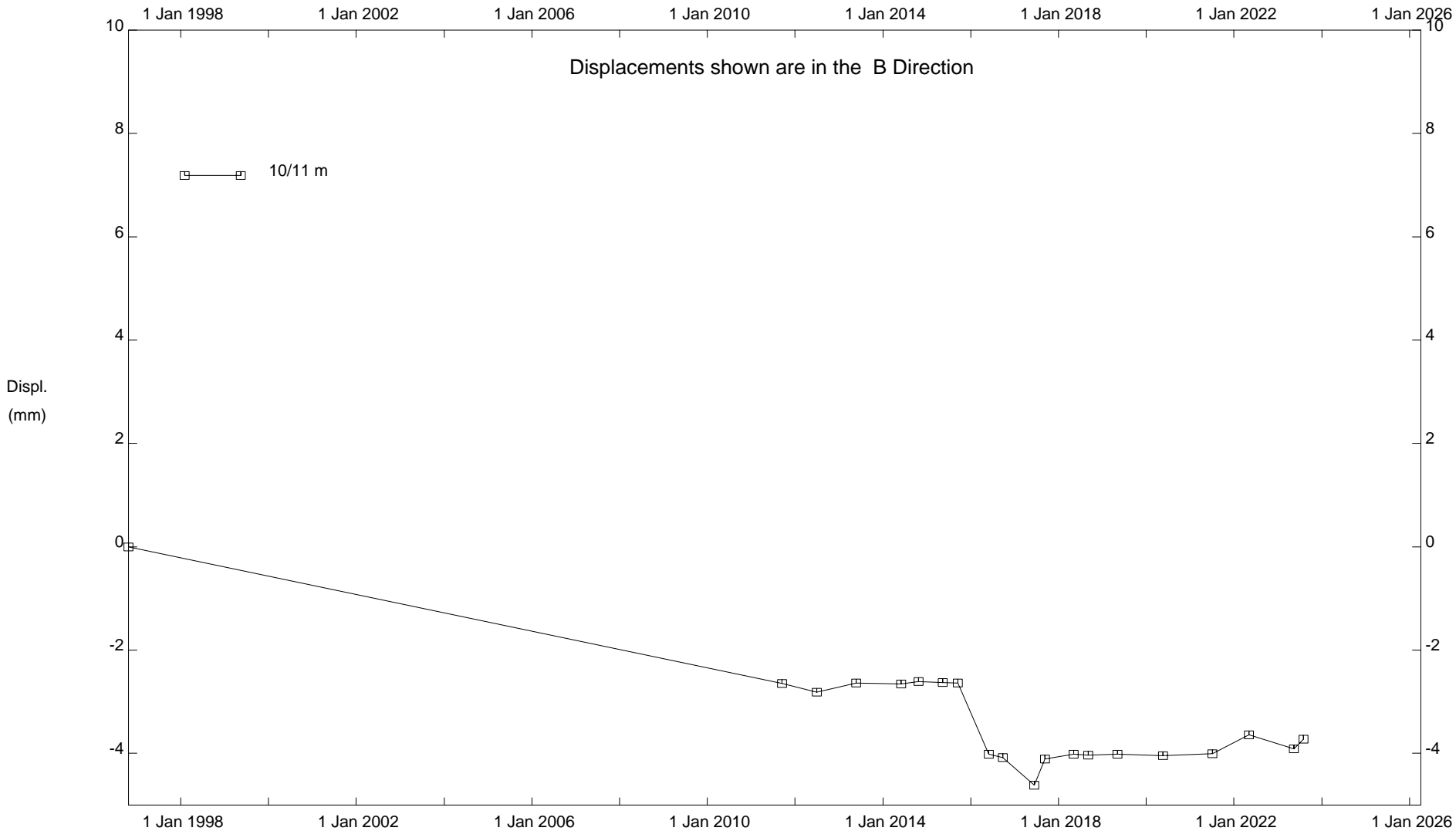


HWY764:02 Pembina River Bridge (NC18), Inclinator SI-7
Transportation & Economic Corridors

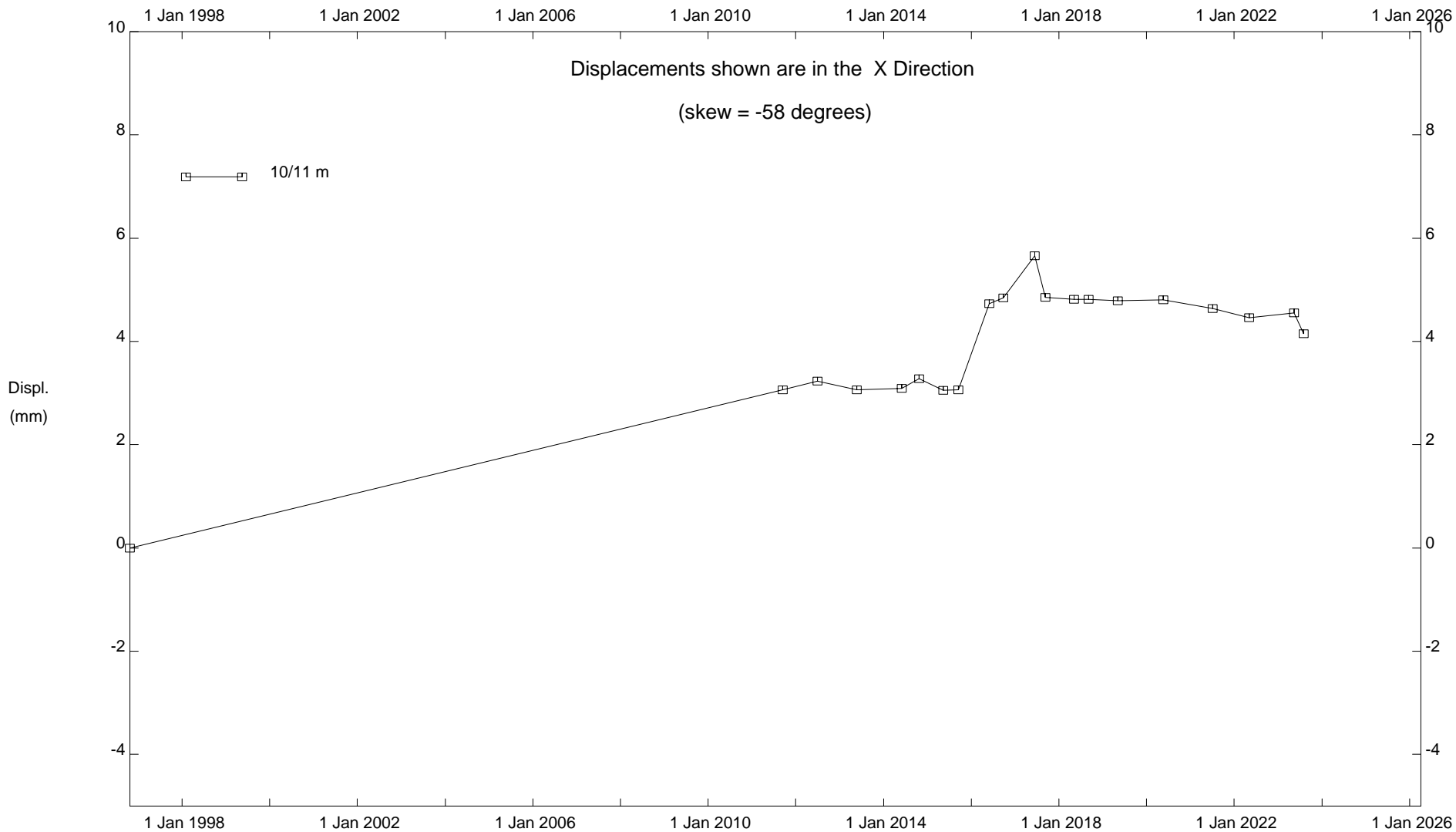
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HWY764:02 Pembina River Bridge (NC18), Inclinometer SI-7

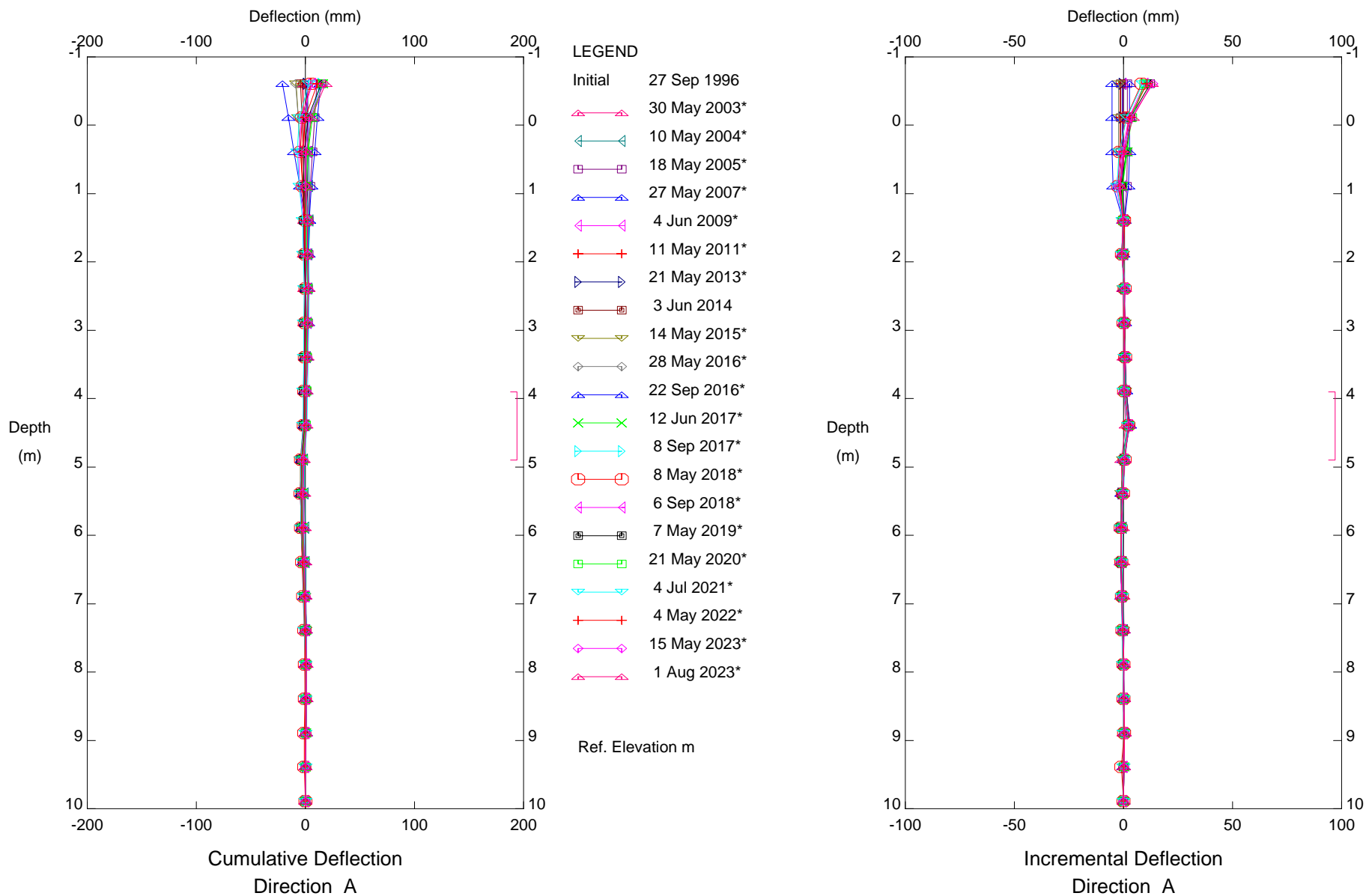


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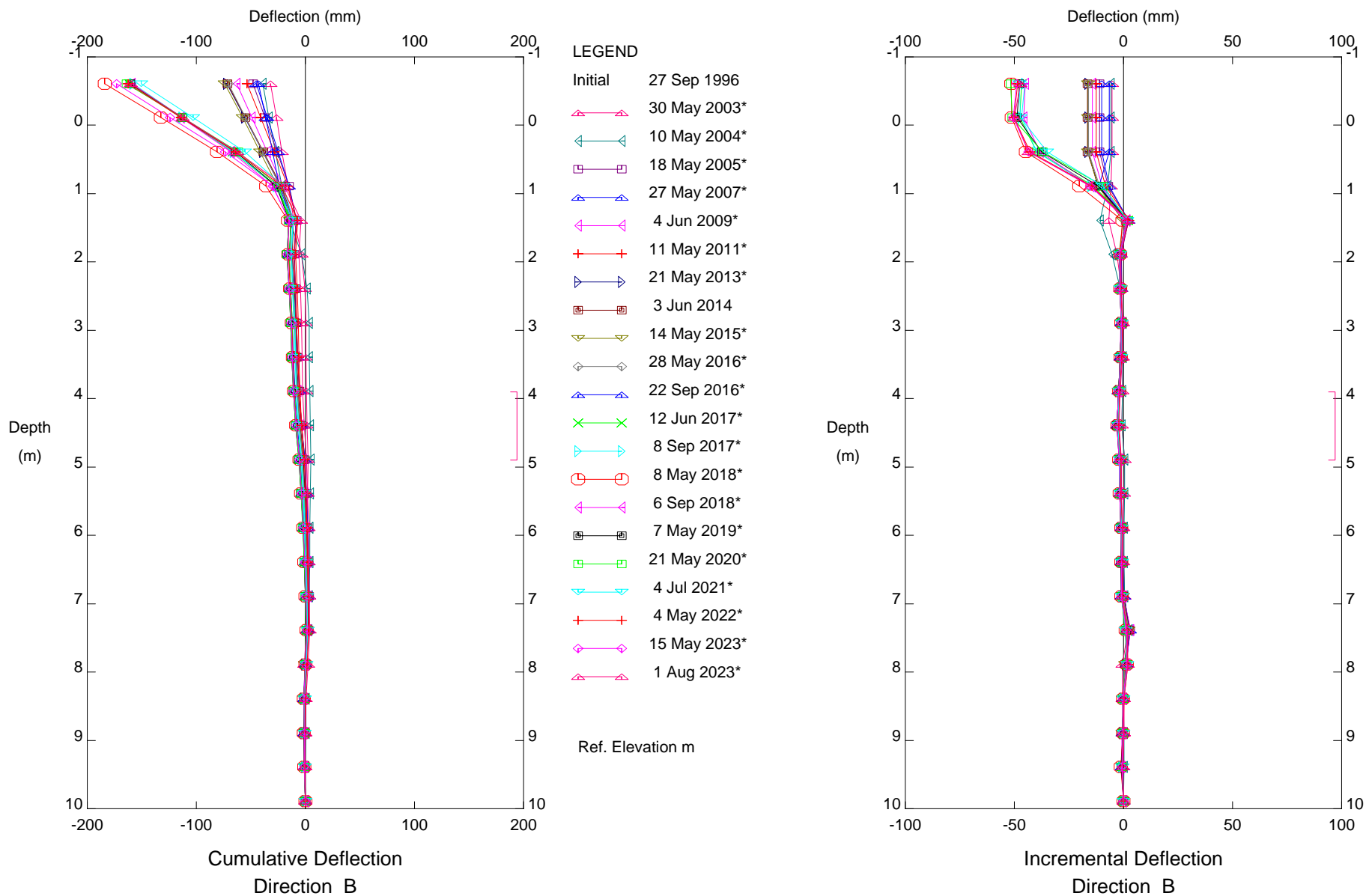
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Transportation & Economic Corridors



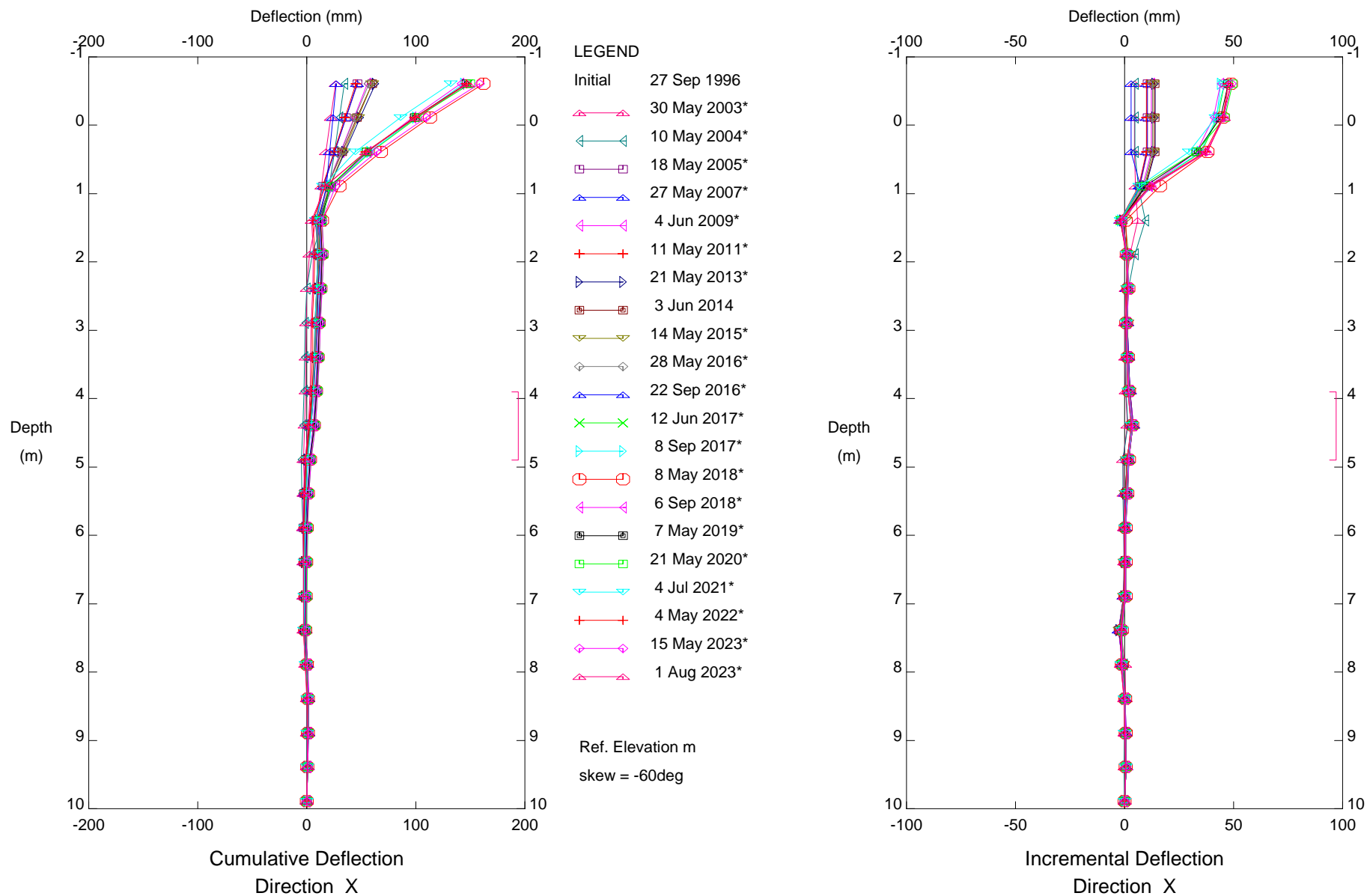
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Transportation & Economic Corridors

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HWY764:02 Pembina River Bridge (NC18), Inclinometer SI-8
 Transportation & Economic Corridors

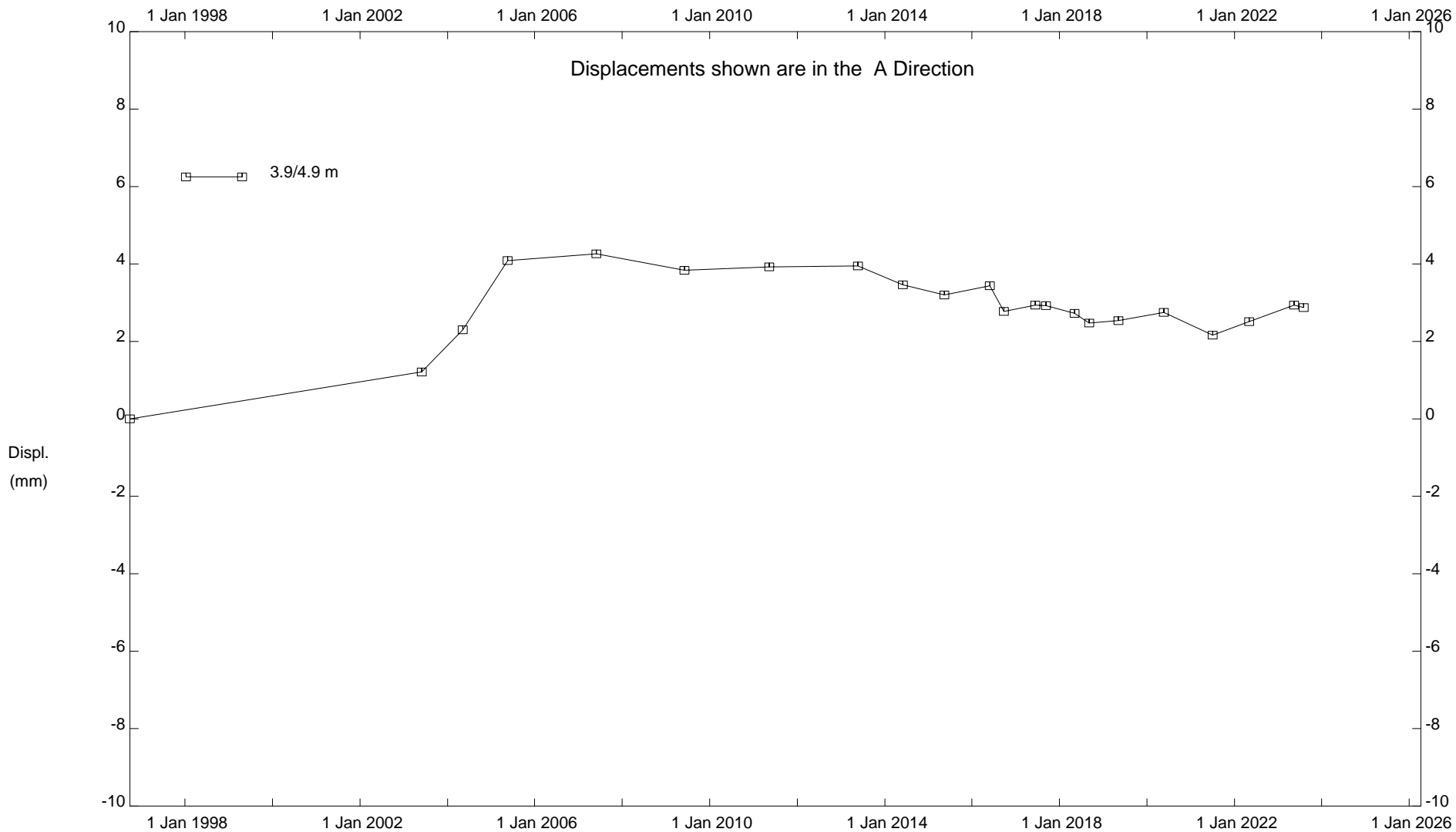
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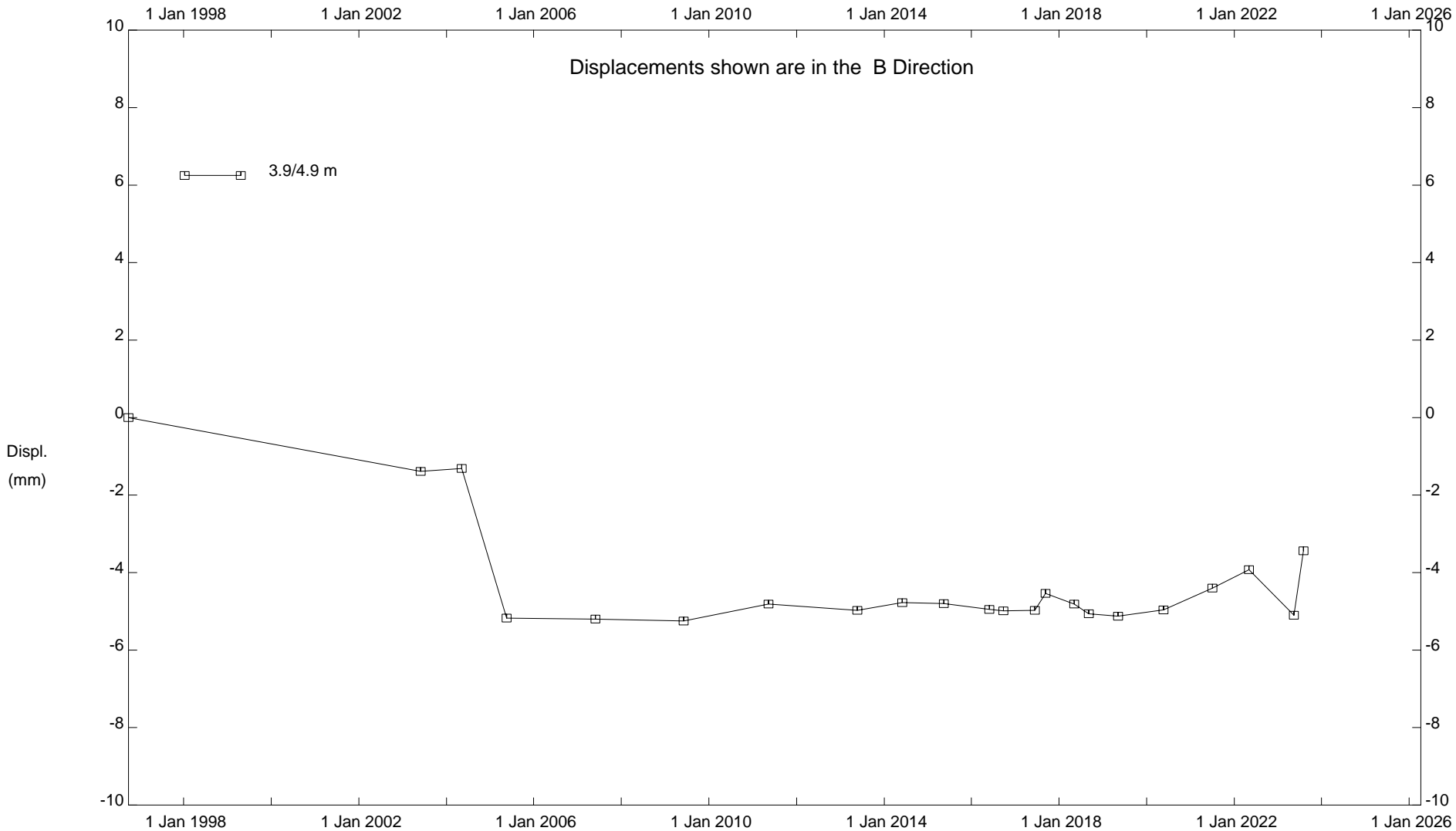
Transportation & Economic Corridors

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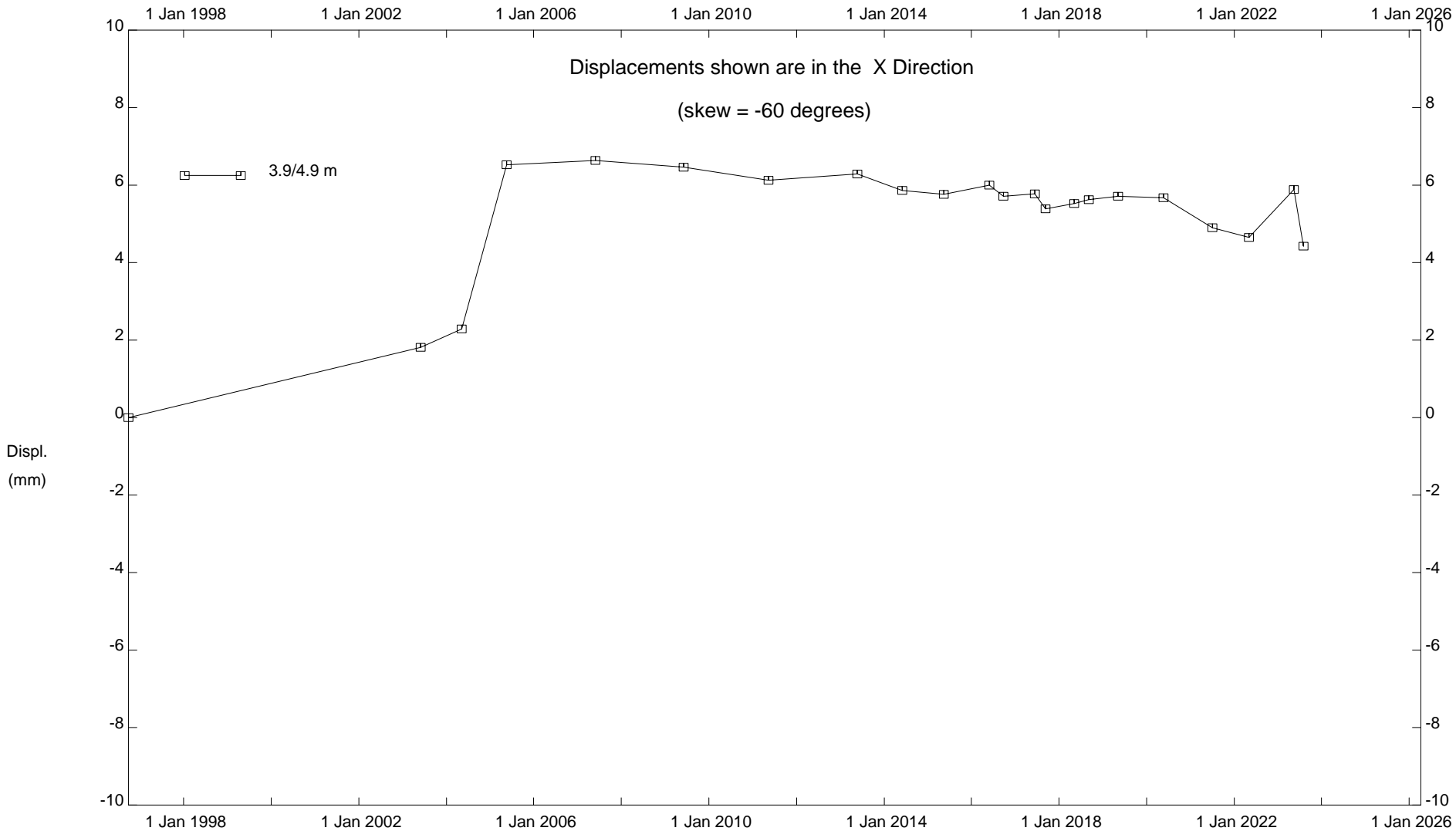


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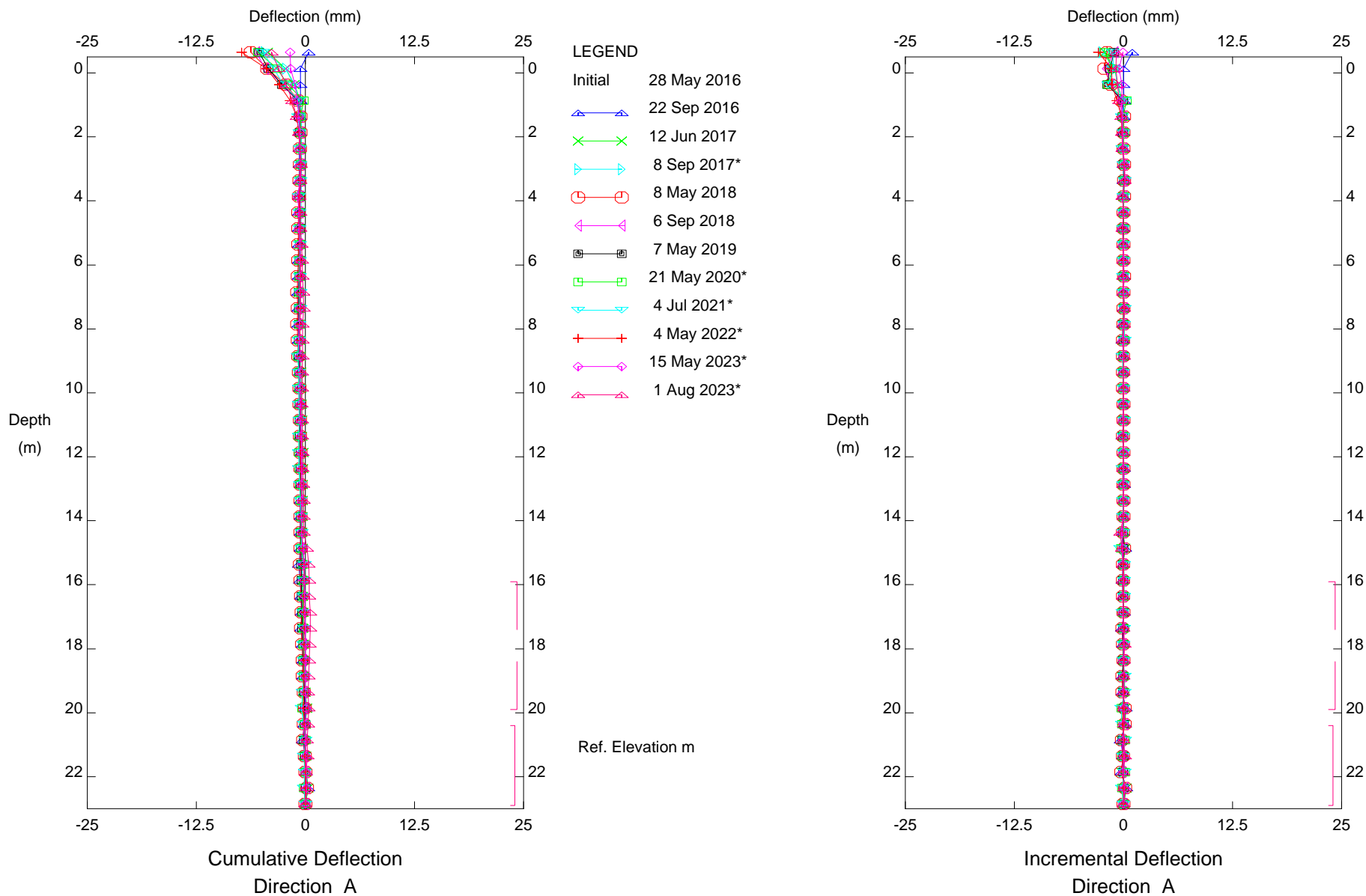
Transportation & Economic Corridors



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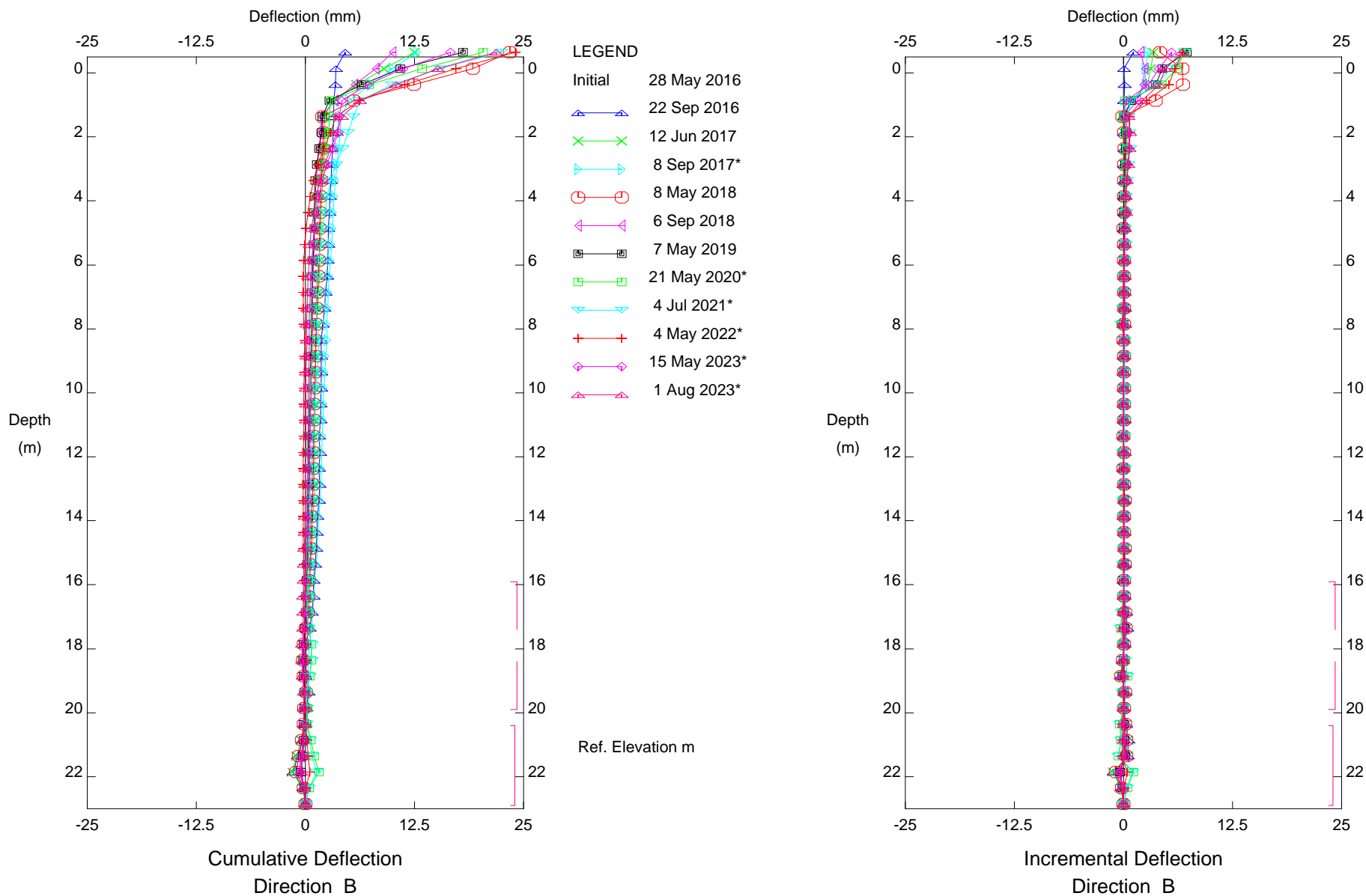


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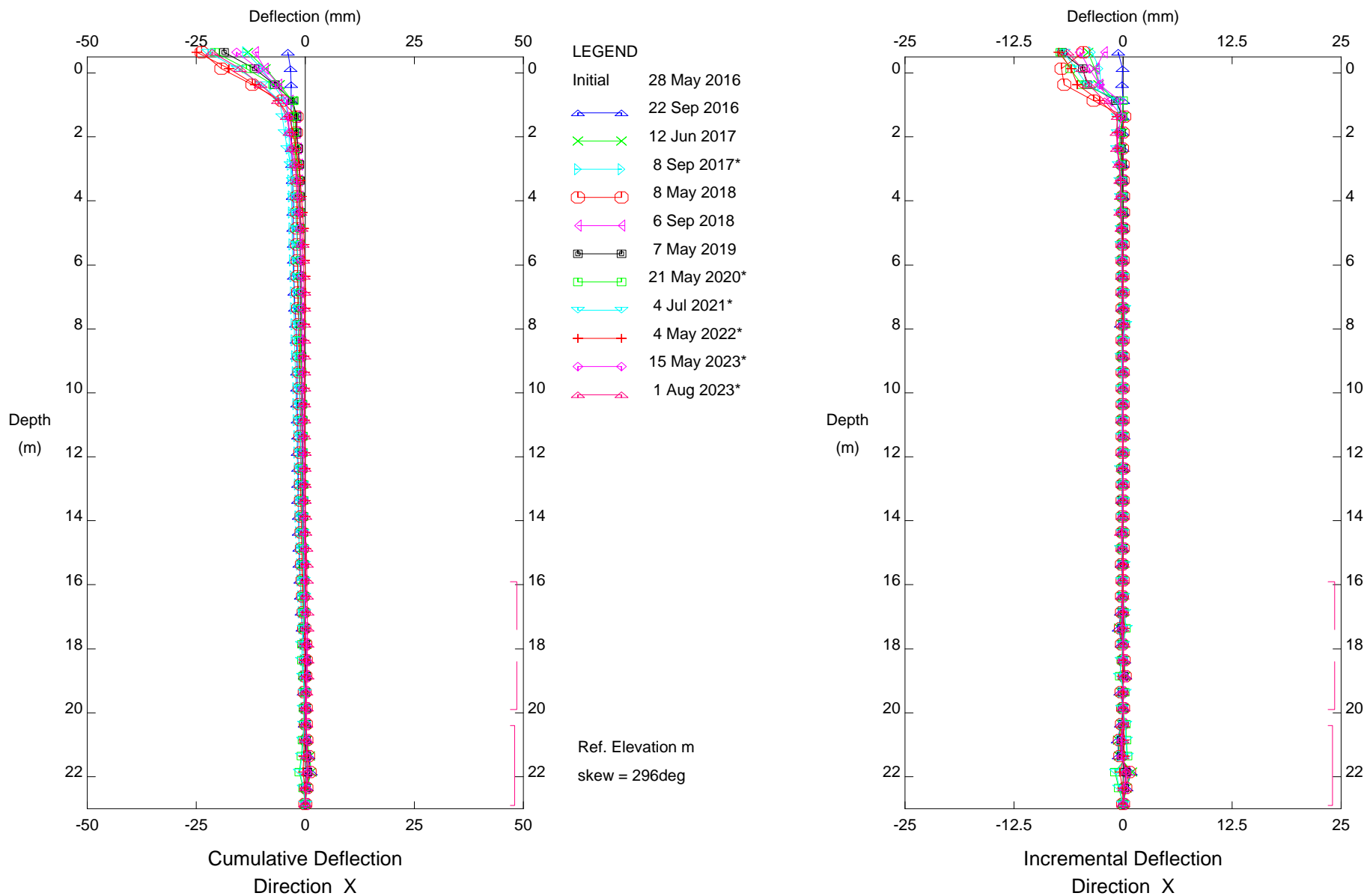
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Transportation & Economic Corridors

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HWY764:02 Pembina River Bridge (NC18), Inclinometer SI-9
Transportation & Economic Corridors

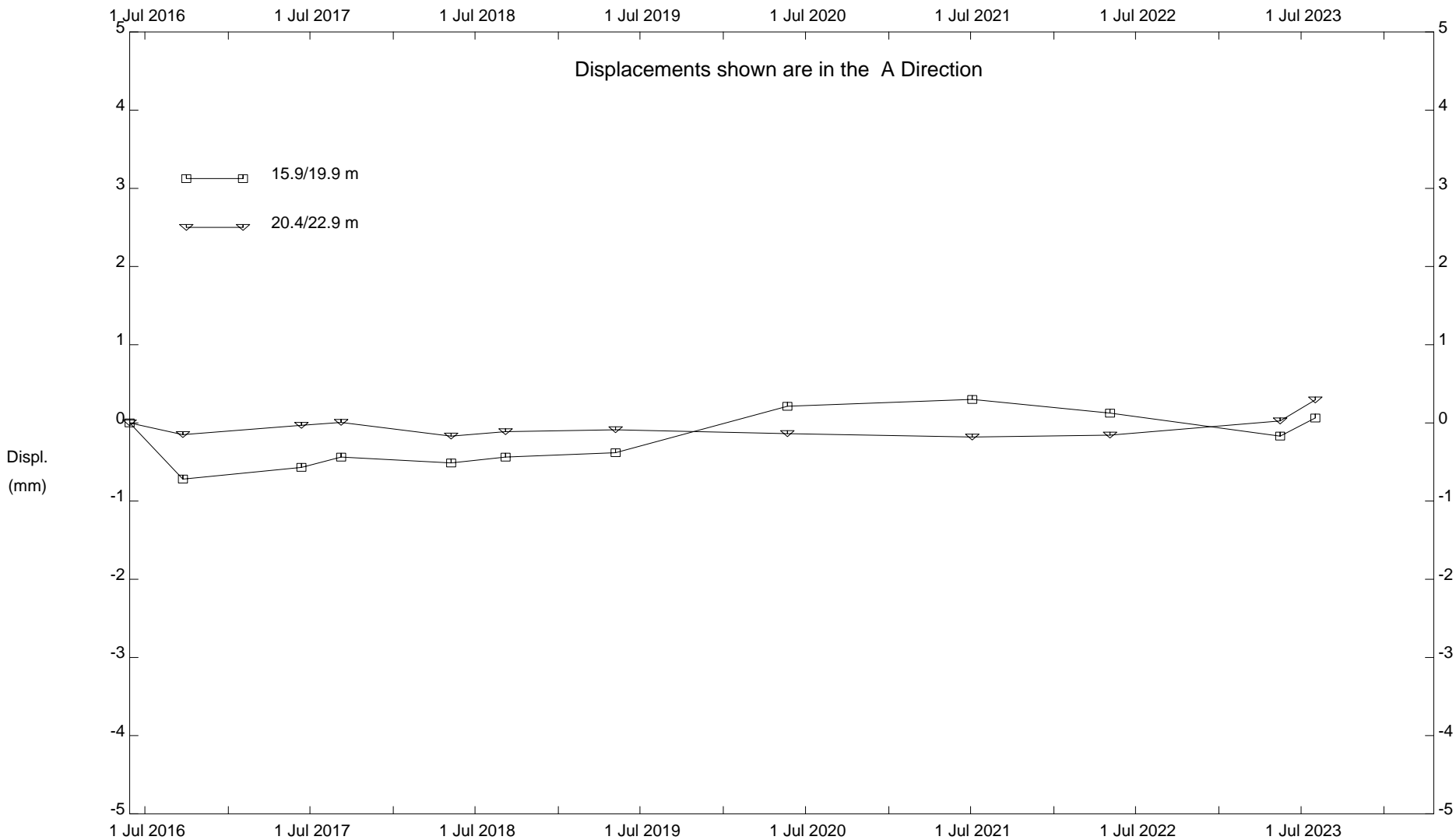
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Transportation & Economic Corridors

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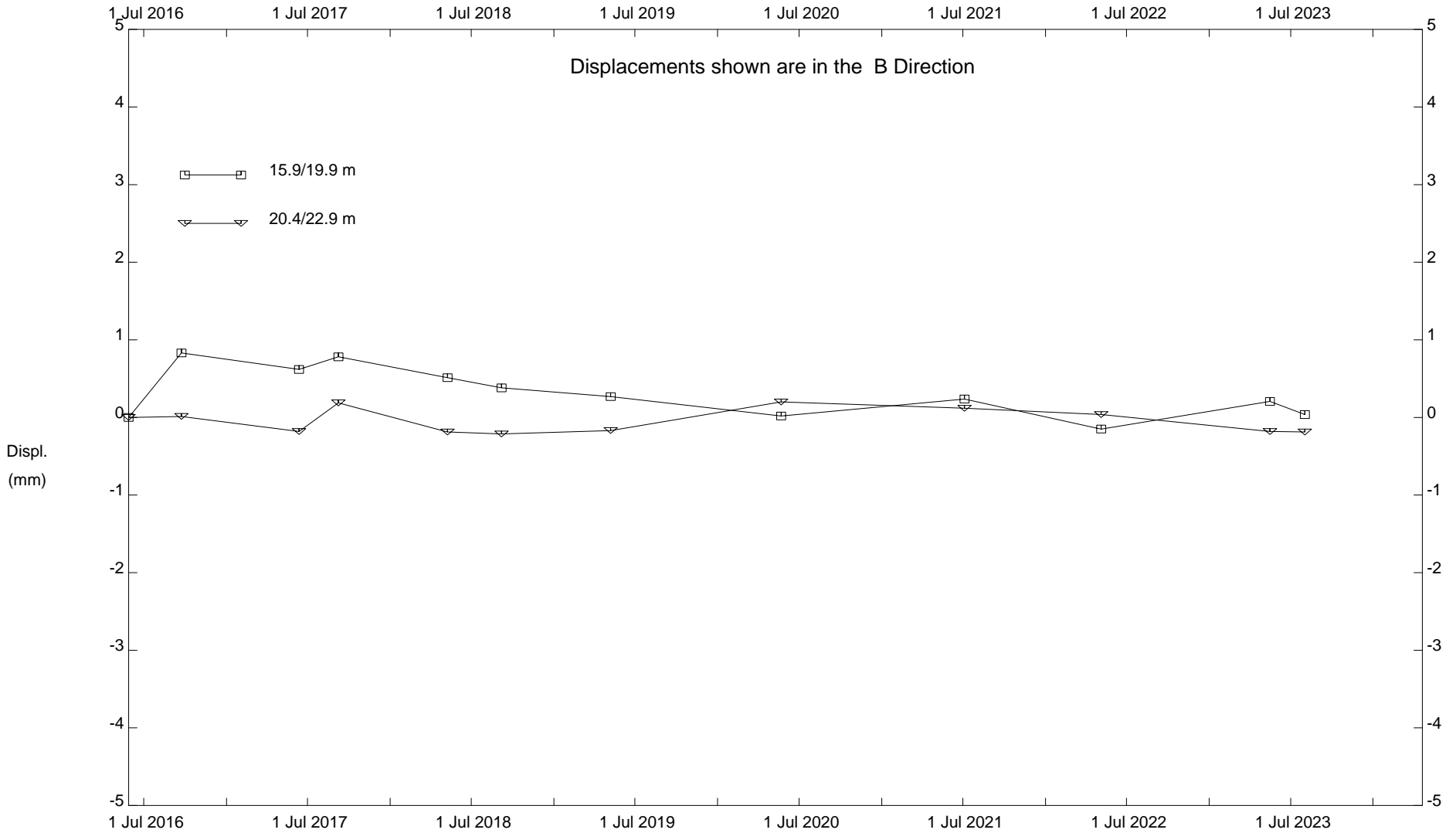
Stantec Consulting Ltd - Edmonton



HWY764:02 Pembina River Bridge (NC18), Inclinometer SI-9

Transportation & Economic Corridors

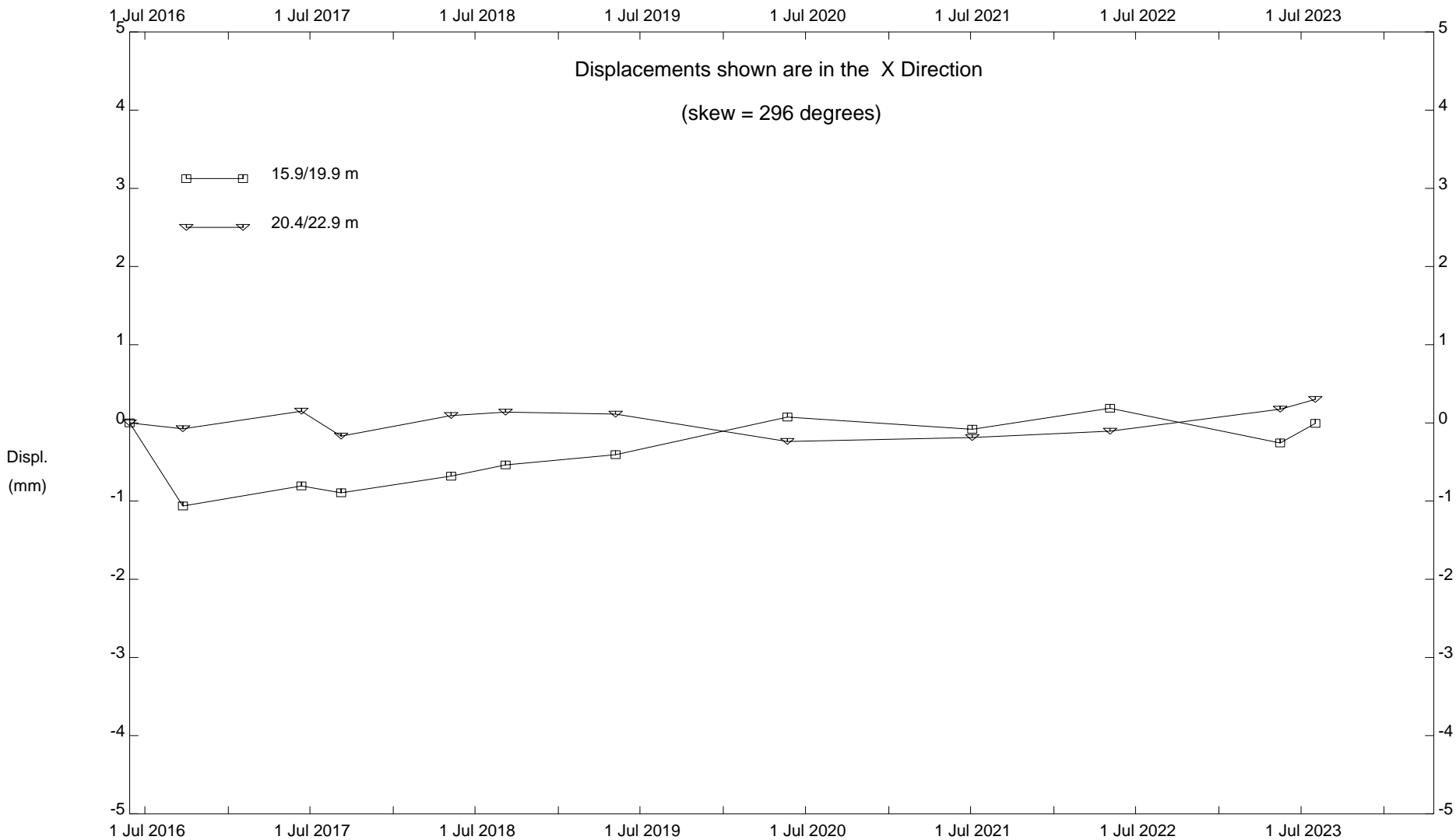
Stantec Consulting Ltd - Edmonton



HWY764:02 Pembina River Bridge (NC18), Inclinometer SI-9

Transportation & Economic Corridors

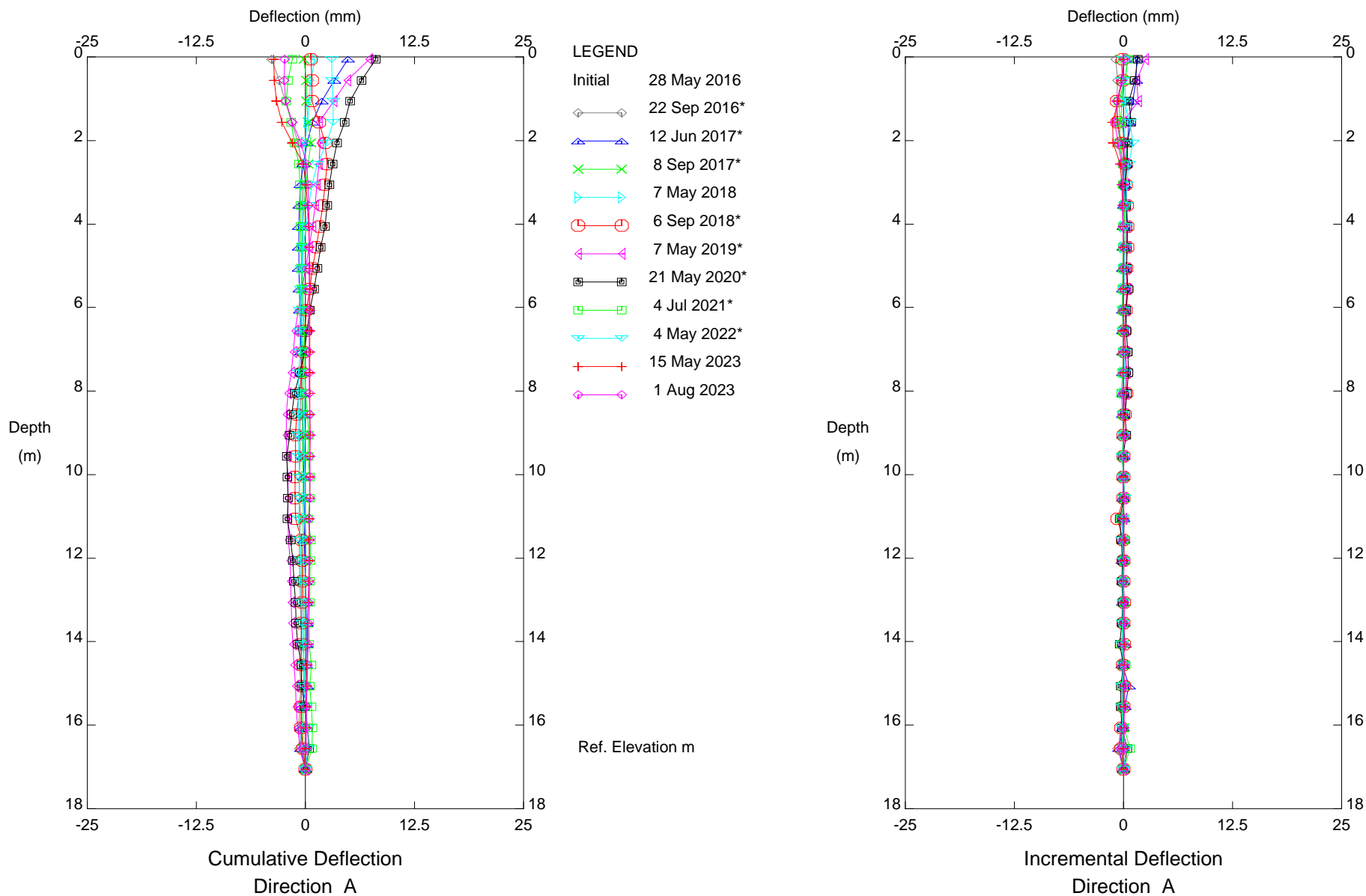
Stantec Consulting Ltd - Edmonton



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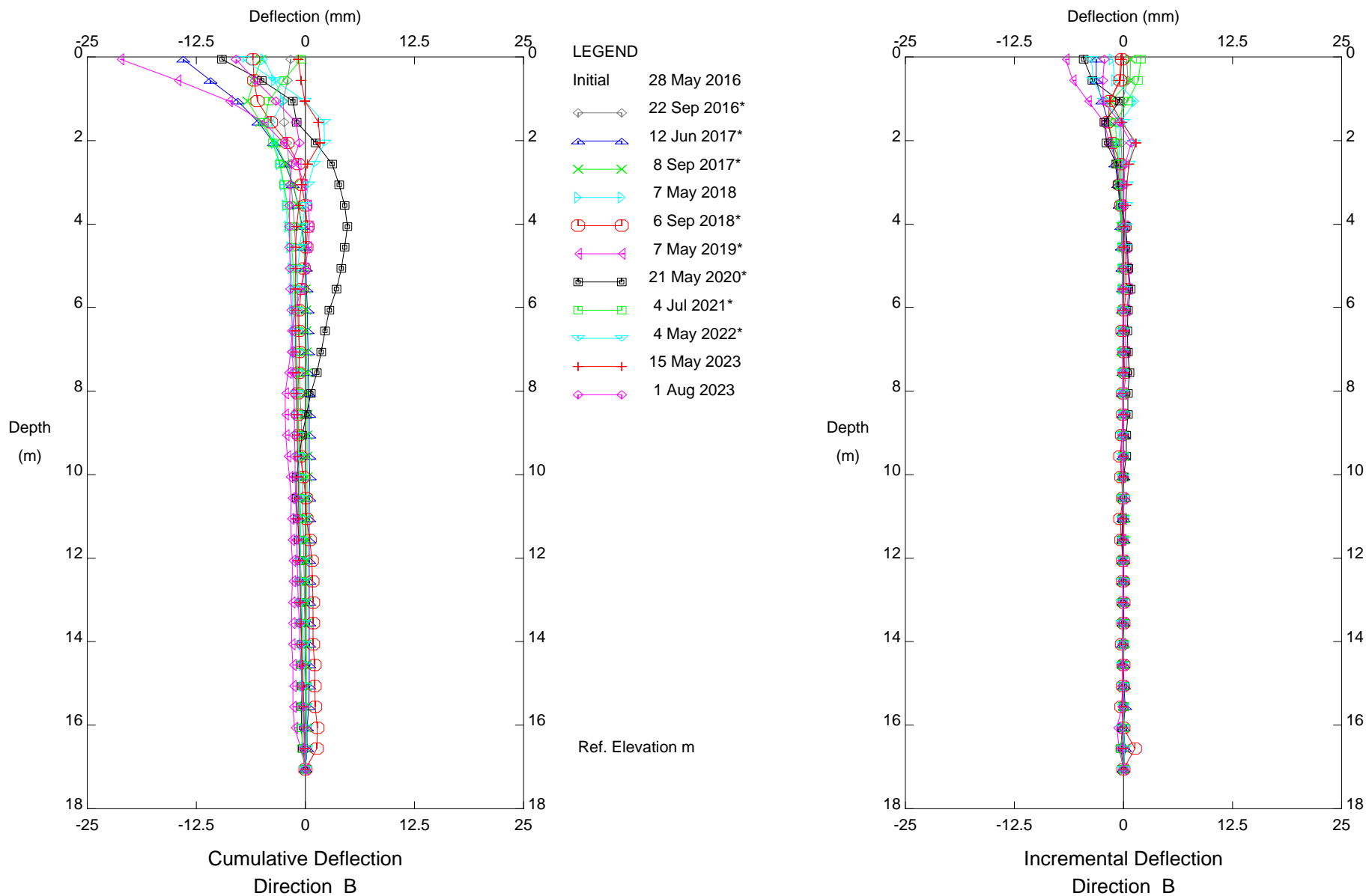
Transportation & Economic Corridors

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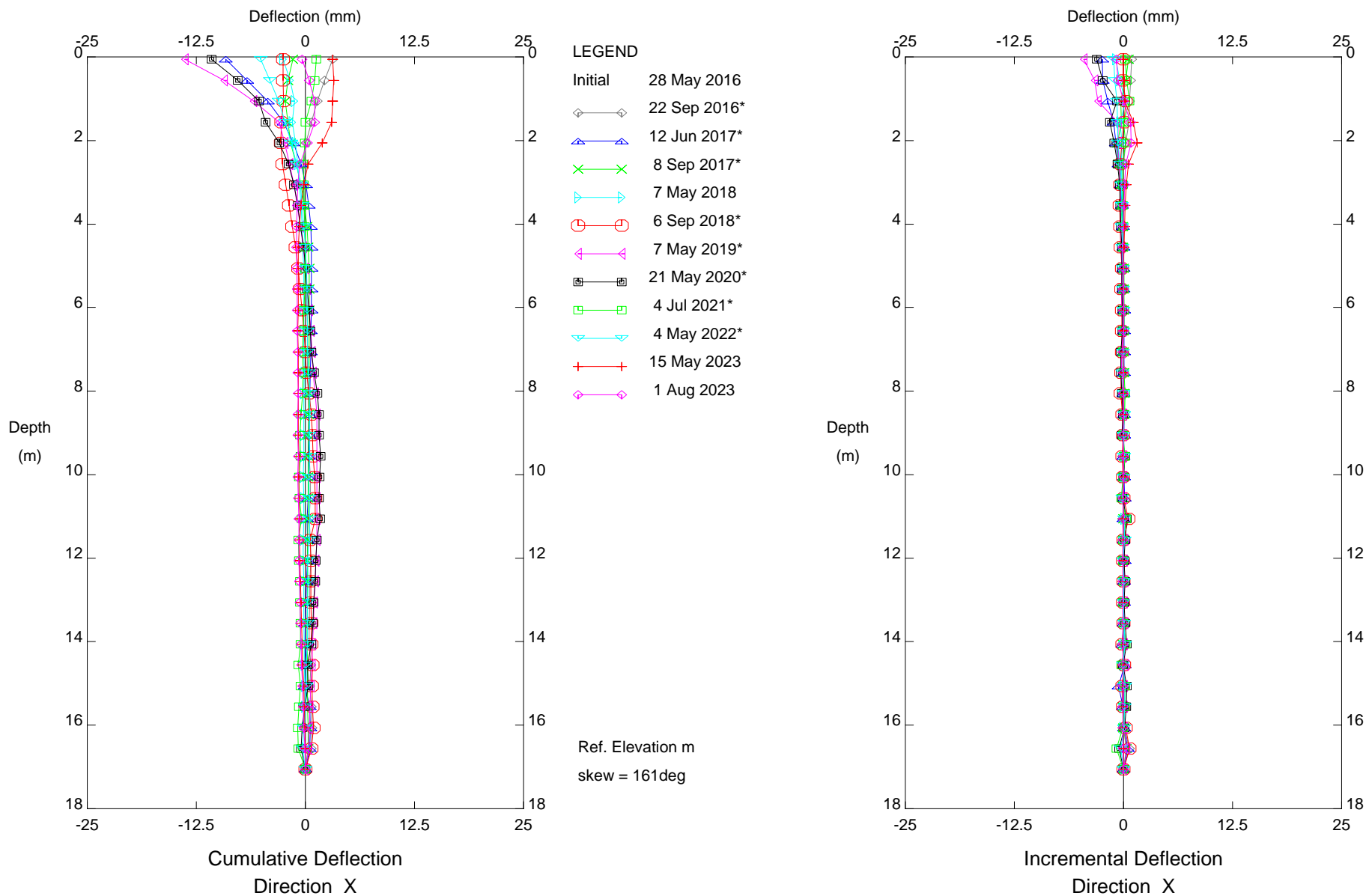
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Transportation & Economic Corridors

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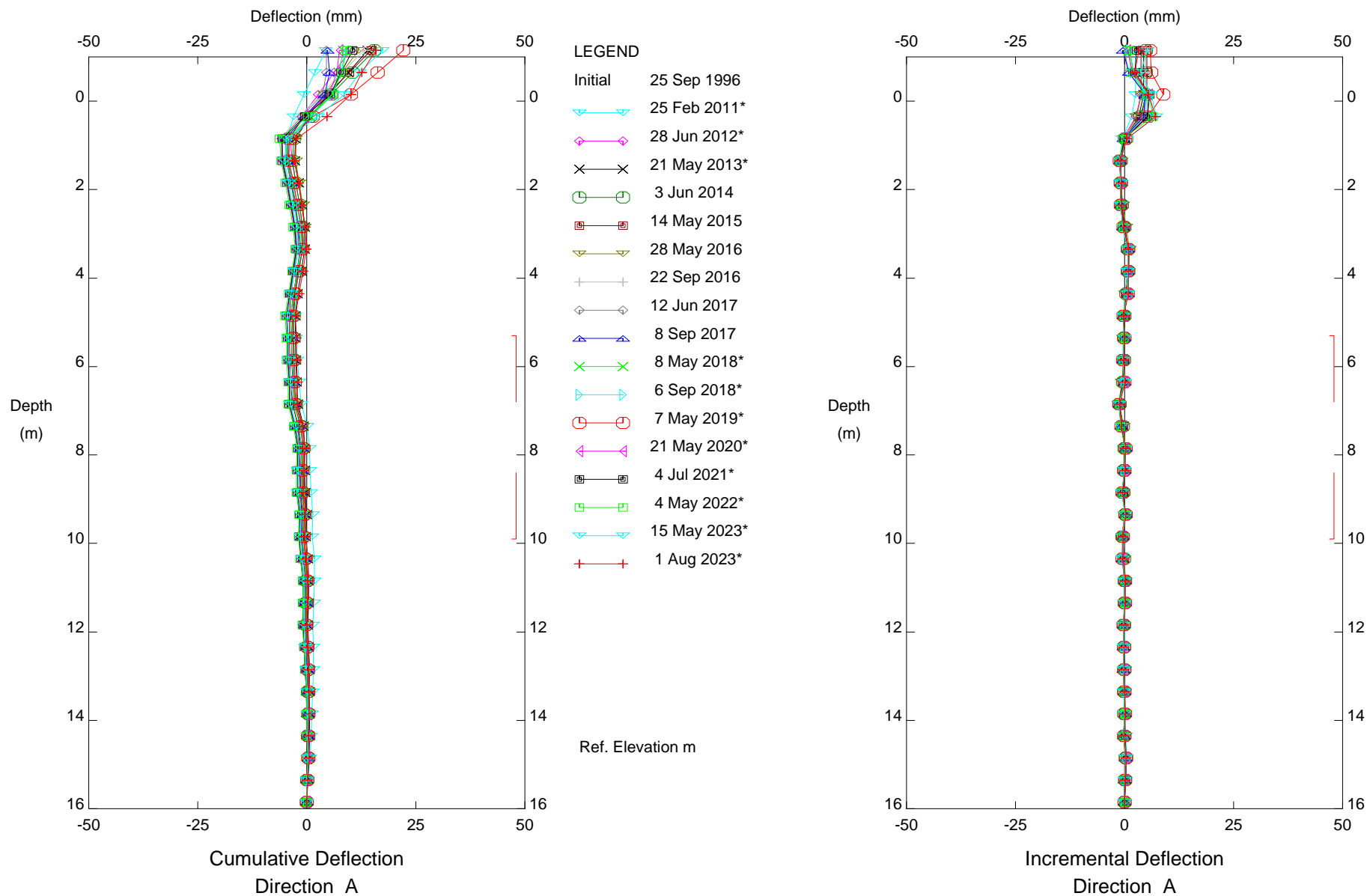
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 Transportation & Economic Corridors

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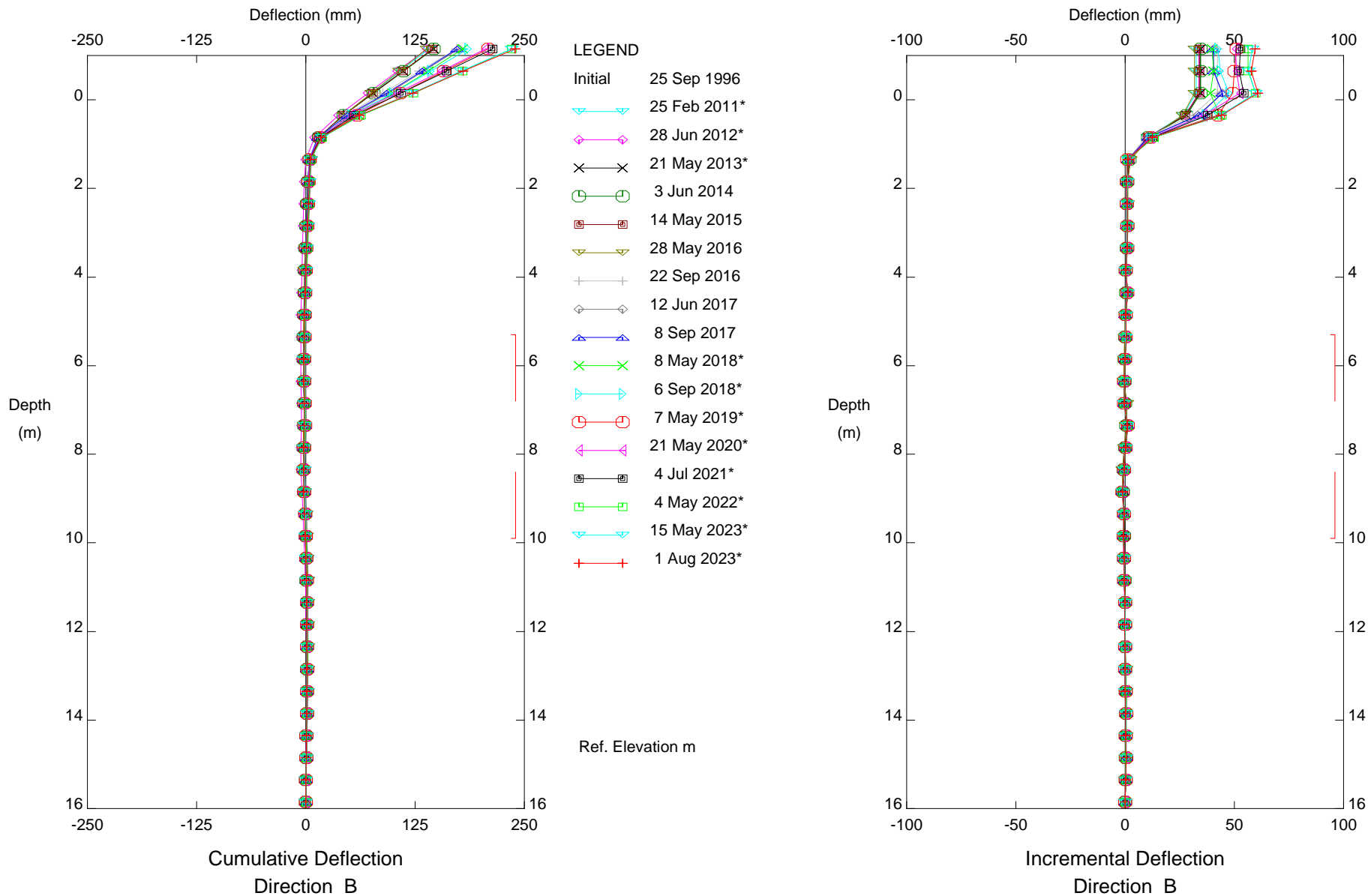
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Transportation & Economic Corridors

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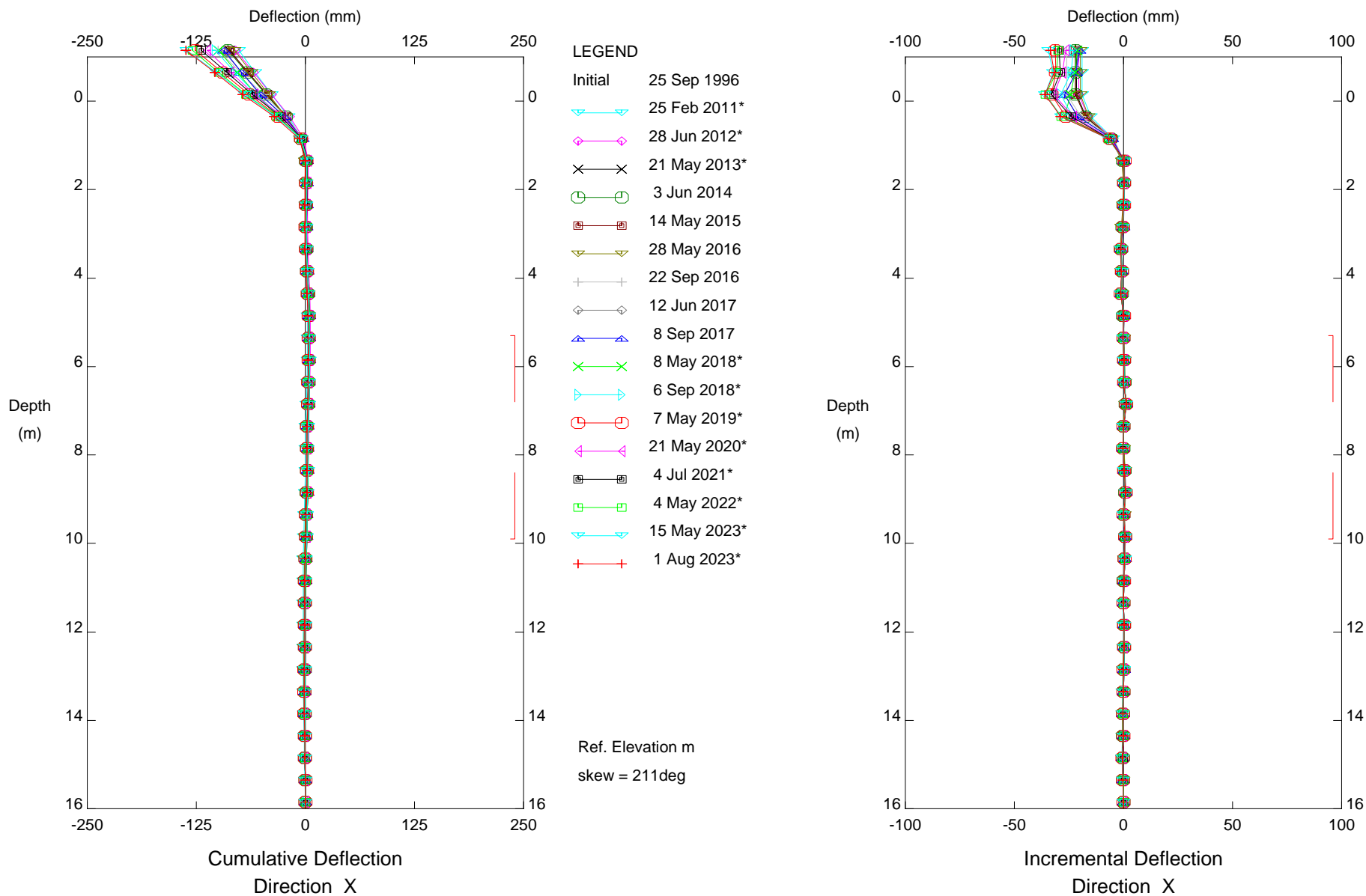
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Transportation & Economic Corridors

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HWY764:02 Pembina River (NC18), Inclinometer SI-24
 Transportation & Economic Corridors

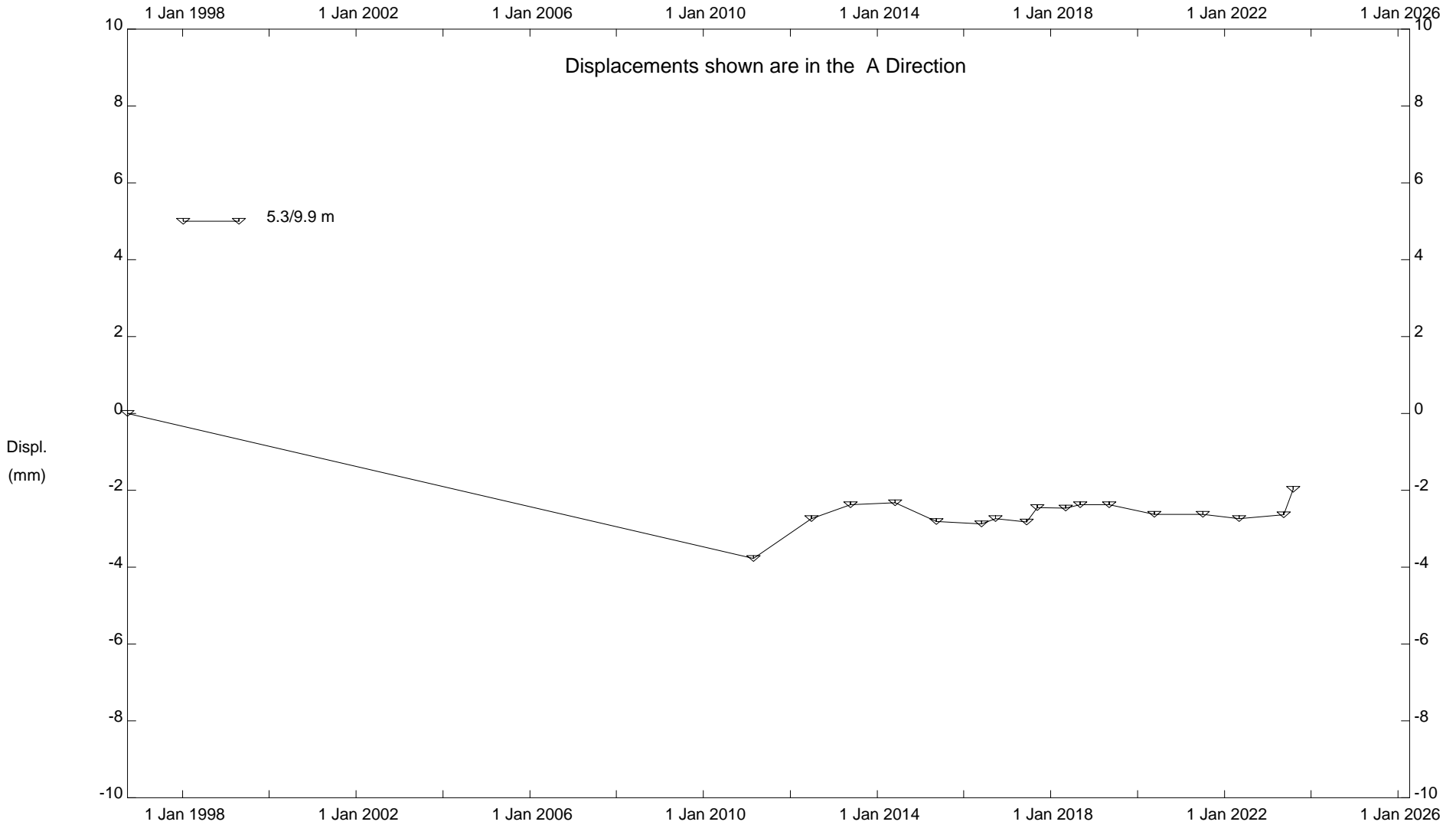
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Transportation & Economic Corridors

Sets marked * include zero shift and/or rotation corrections.

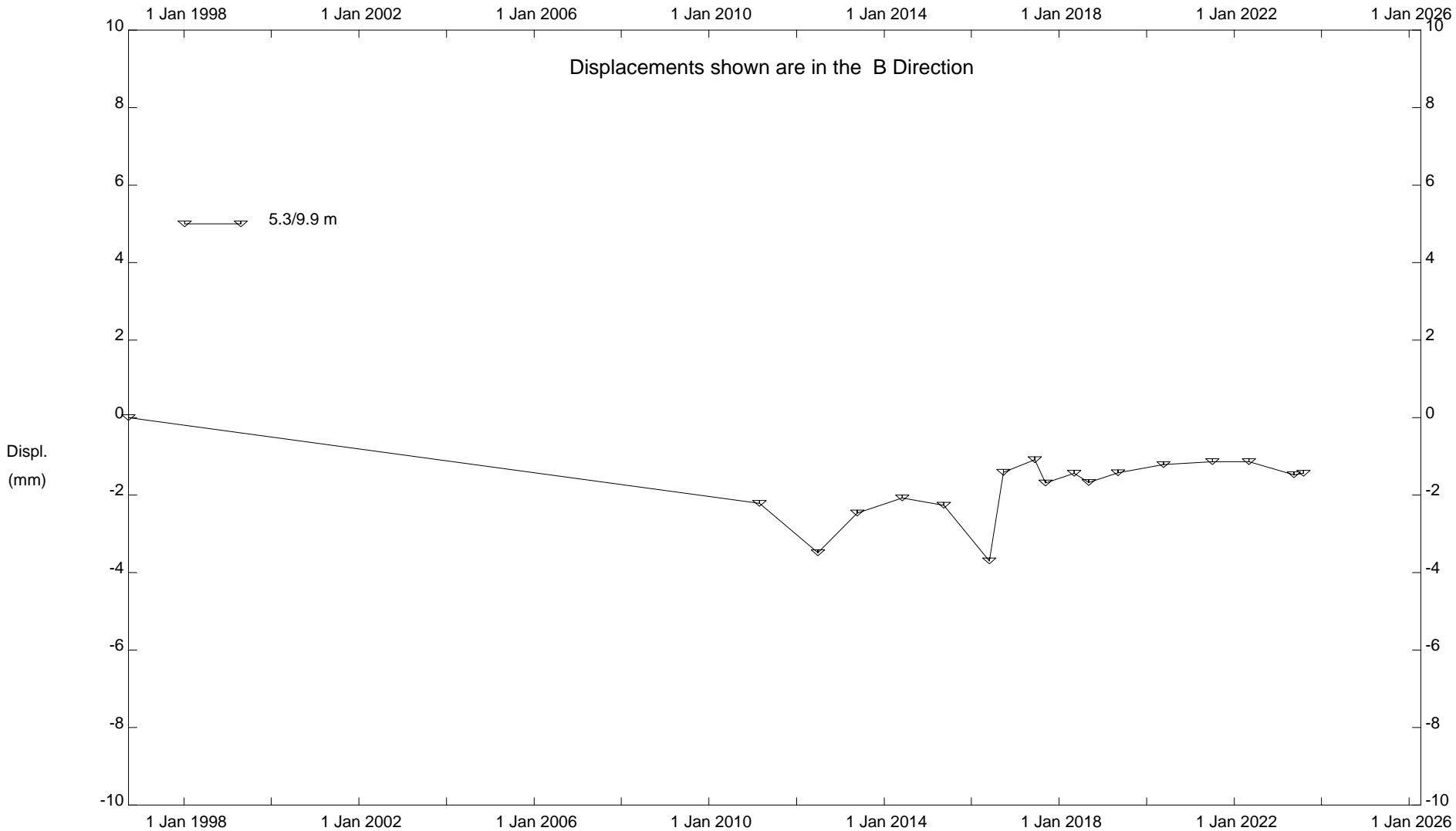
Stantec Consulting Ltd - Edmonton



HWY764:02 Pembina River (NC18), Inclinator SI-24

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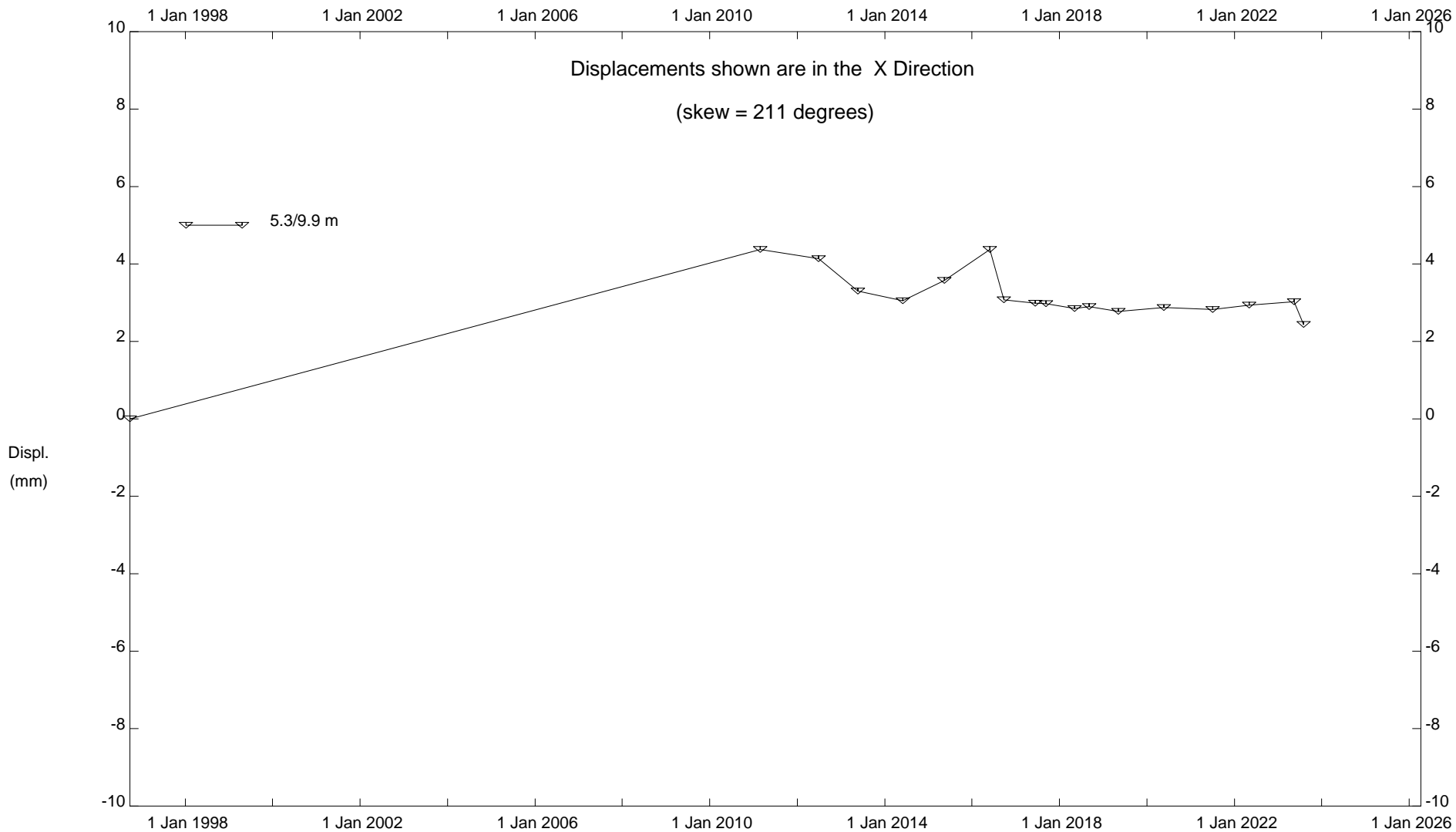
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STANDPIPE PIEZOMETER DATA NC18: HWY 764:02 Pembina River Bridge

