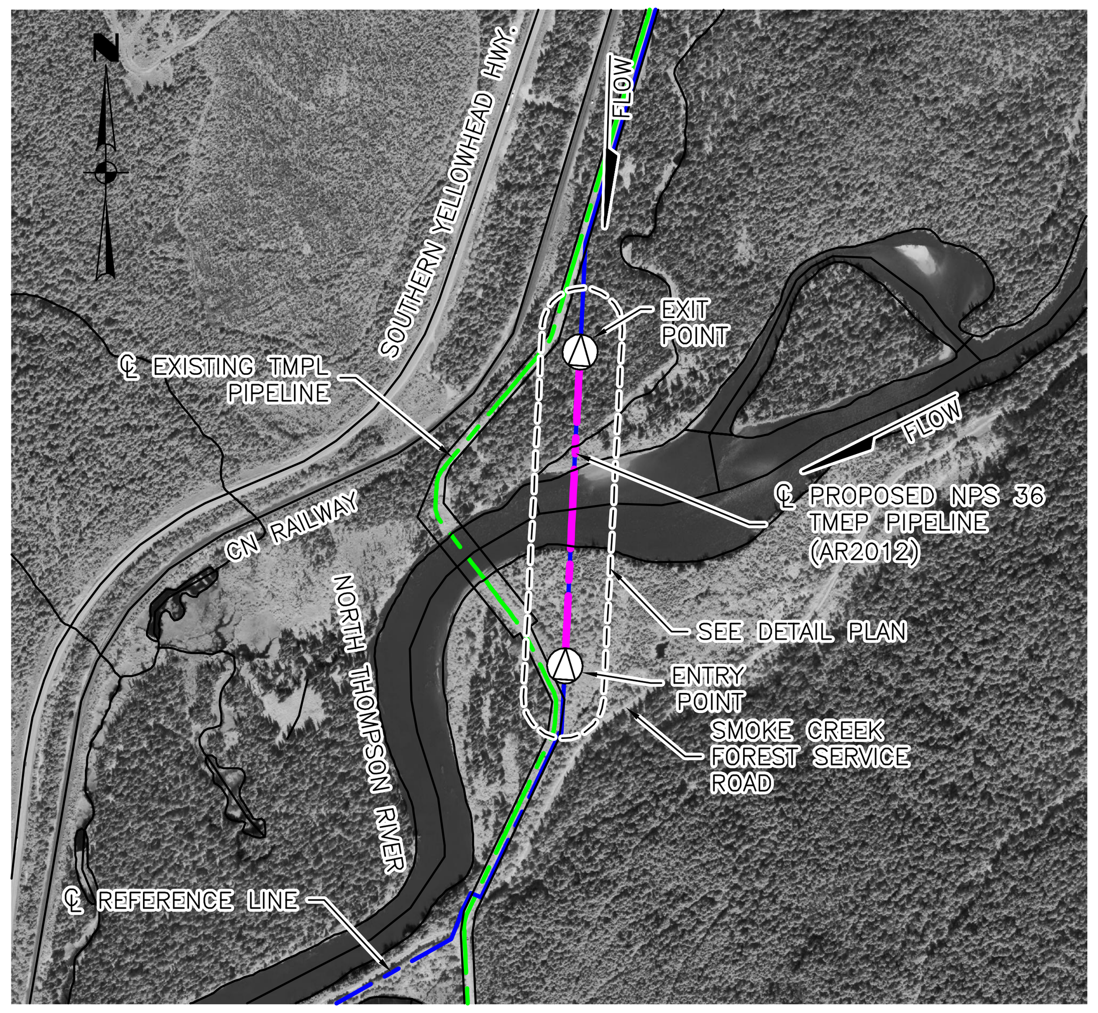
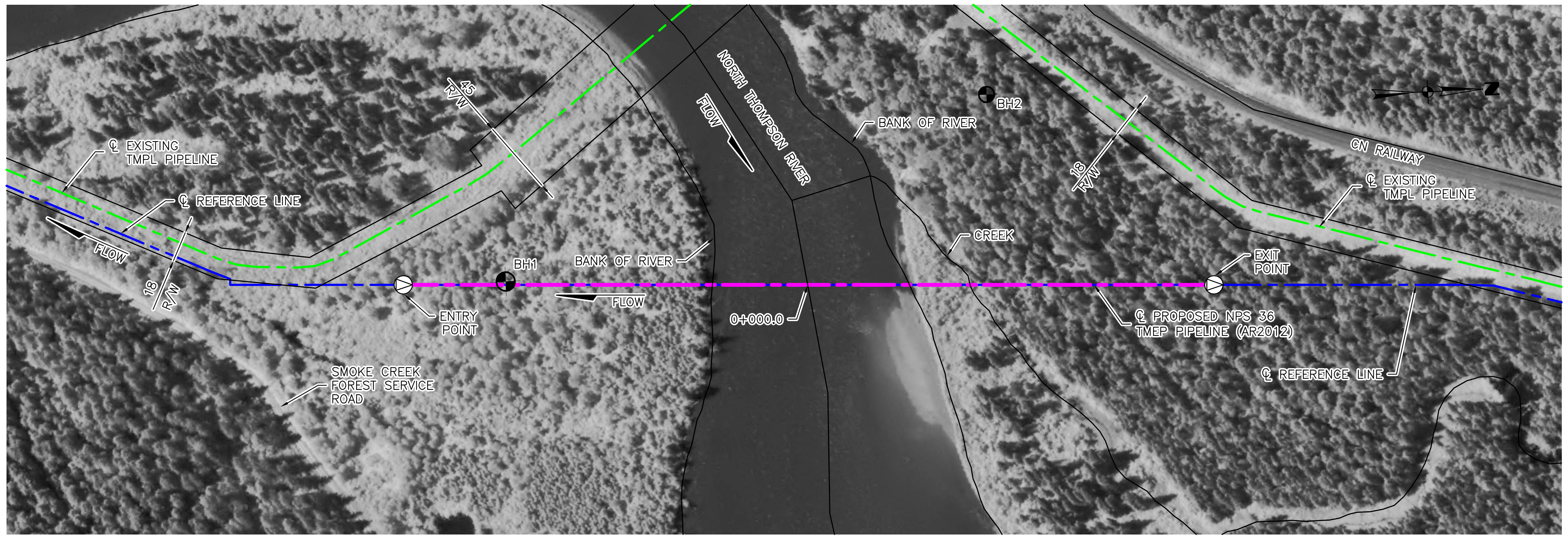


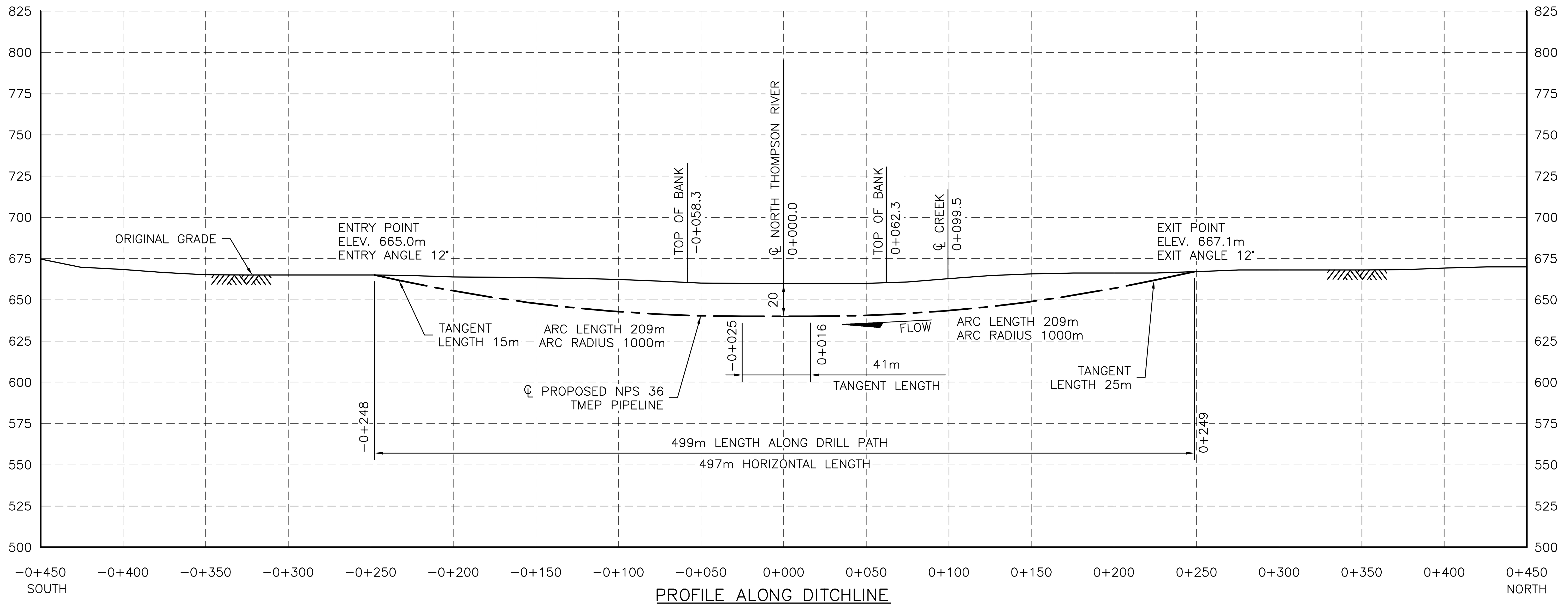
LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 083D004



PLAN
SCALE: 1:2000

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662–11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE–UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

PIPE SPECIFICATIONS

OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 – ZONE 11)

	EASTING	NORTHING
ENTRY POINT	341249.7	5770457.1
0+000 POINT	341261.7	5770704.6
EXIT POINT	341273.8	5770953.1

PROPOSED GEOTECHNICAL BOREHOLE LOCATION
(UTM NAD 83 – ZONE 11)

BOREHOLE	EASTING	NORTHING
BH1	341250.8	5770519.9
BH2	341150.7	5770819.6

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE
- BOREHOLE

NOT FOR CONSTRUCTION

PRELIMINARY
FOR DISCUSSION ONLY

RK 619.9 = SSEID 2002

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10565

Integrated Pipeline Projects Canada Ltd.
UPI DWG. No.: 19731–505–PPW–00594

KINDER MORGAN CANADA — TRANS MOUNTAIN

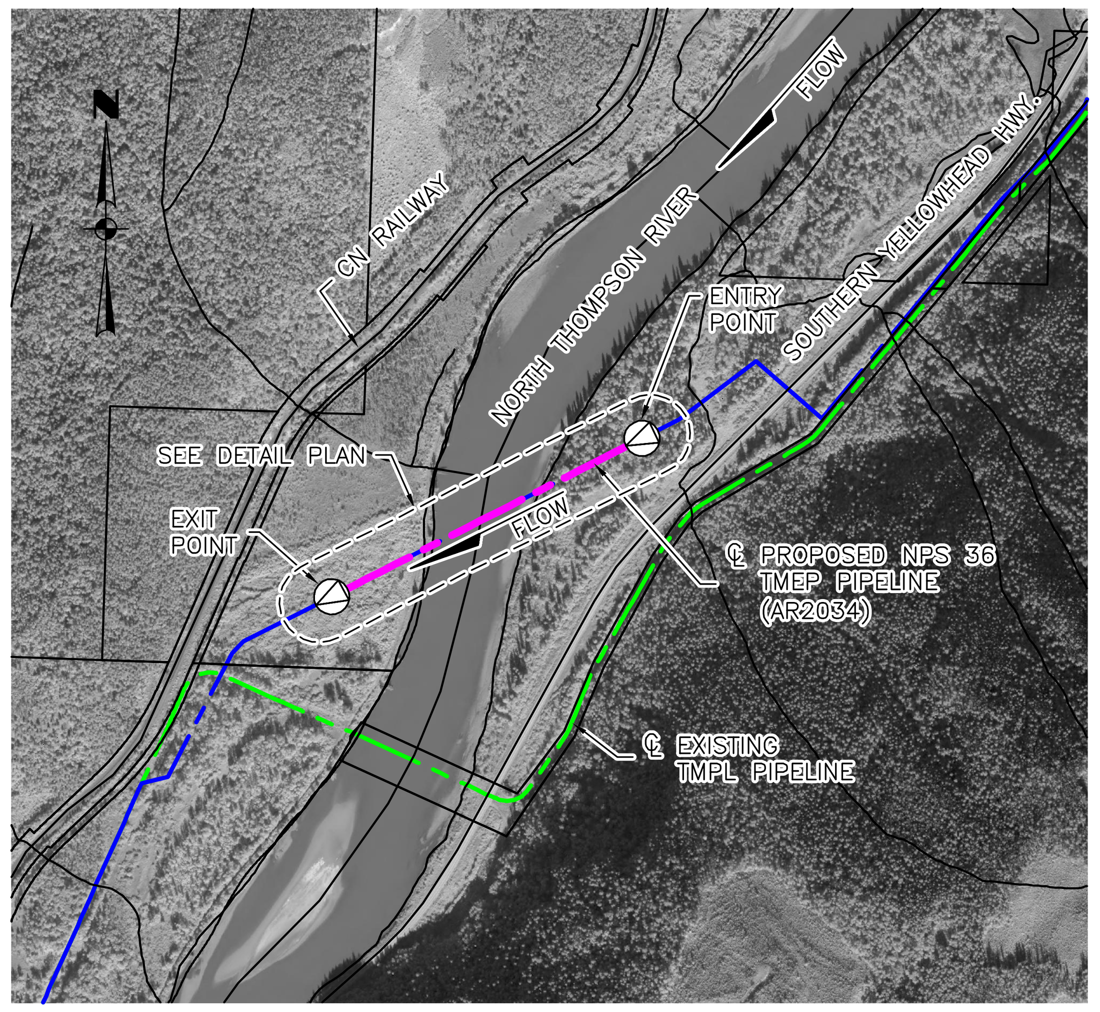
NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			C	2013–11–18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			B	2013–07–29	RE–ISSUED FOR REVIEW	RGR	PL	JPM	
			A	2013–05–29	ISSUED FOR REVIEW	RGR	FS	PL	JPM

DRAWN BY	RGR
CHECKED BY	WGS
APPROVED BY	JPM

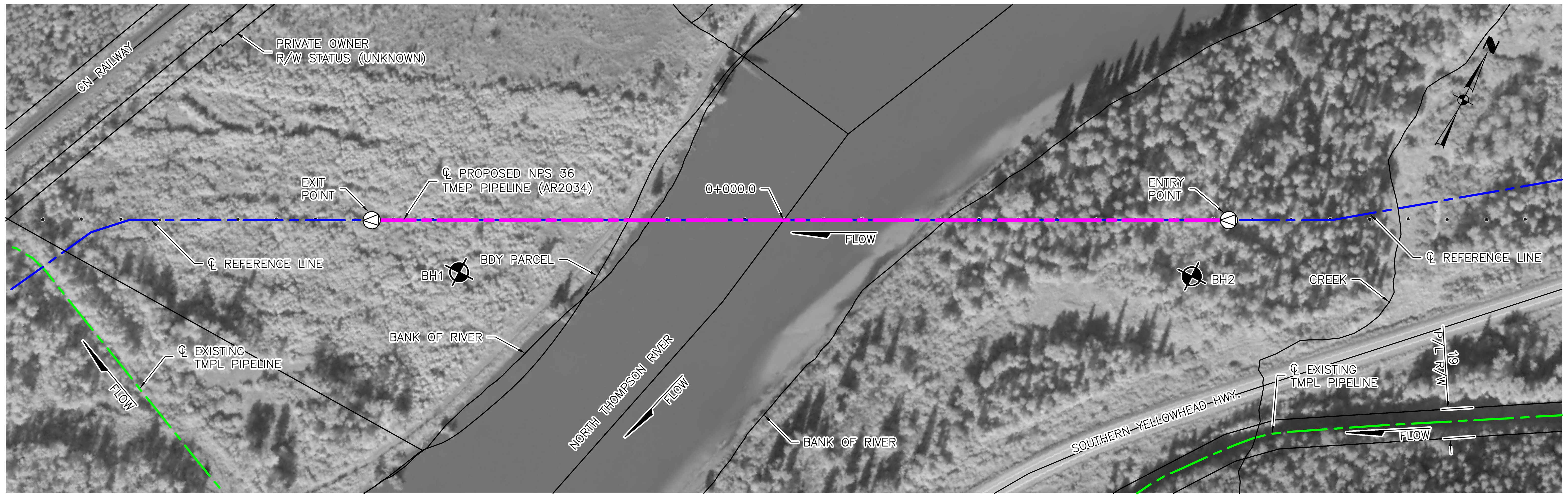
TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
NORTH THOMPSON RIVER 6 KP 594.3
UTM 83–11

SHEET SIZE	A1
SCALE	AS SHOWN
DATE	2013–04–23

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR–594		C



LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 082M084



PLAN
SCALE: 1:2000

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662–11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE–UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.

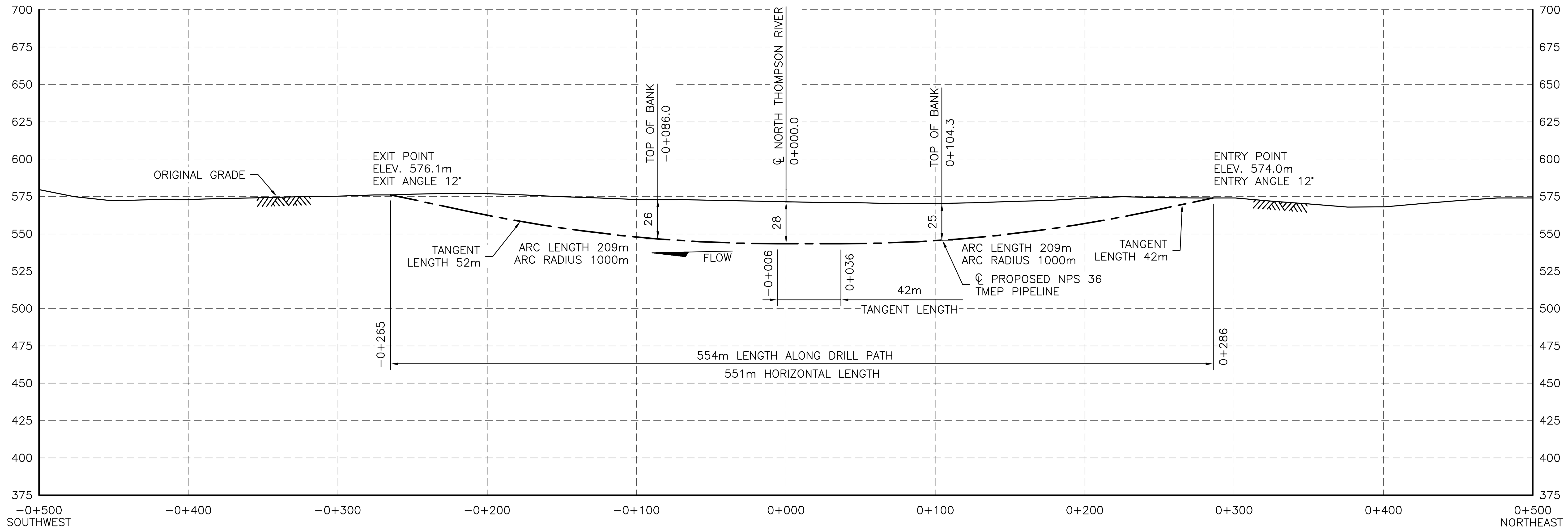
PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 – ZONE 11)

	EASTING	NORTHING
ENTRY POINT	341564.2	5742929.1
0+000 POINT	341309.6	5742799.1
EXIT POINT	341073.8	5742678.8

PROPOSED GEOTECHNICAL BOREHOLE LOCATION
(UTM NAD 83 – ZONE 11)

BOREHOLE	EASTING	NORTHING
BH1	341139.0	5742674.5
BH2	341559.4	5742886.1



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE
- BOREHOLE

NOT FOR CONSTRUCTION

PRELIMINARY FOR DISCUSSION ONLY

RK 651.6 = SSEID 2002

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10565

Integrated Pipeline Projects Canada Ltd.

UPI DWG. No.: 19731–505–PPW–00624

KINDER MORGAN CANADA — TRANS MOUNTAIN

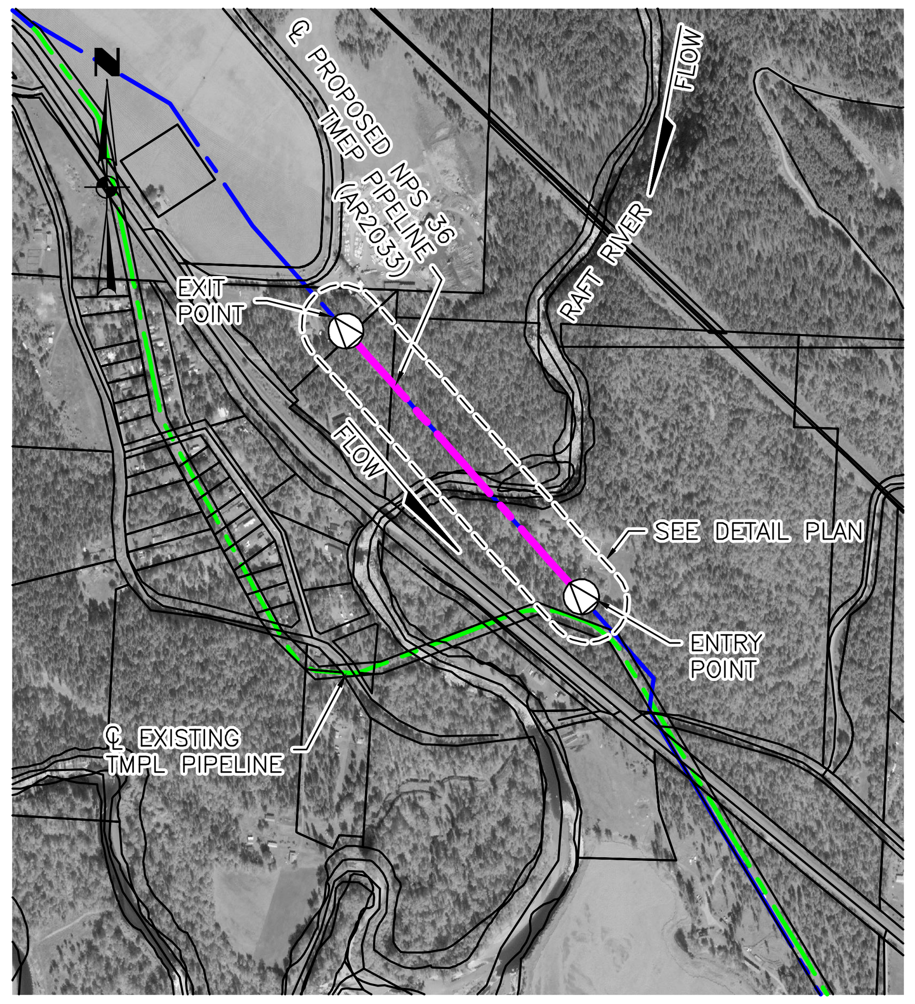
NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			C	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			B	2013-07-29	RE-ISSUED FOR REVIEW	RGR	PL	JPM	
			A	2013-05-29	ISSUED FOR REVIEW	RGR	FS	PL	JPM

DRAWN BY RGR
CHECKED BY WGS
APPROVED BY JPM

TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
NORTH THOMPSON RIVER 7 KP 625
UTM 83–11

SHEET SIZE A1
SCALE AS SHOWN
DATE 2013-03-29

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR-624		C

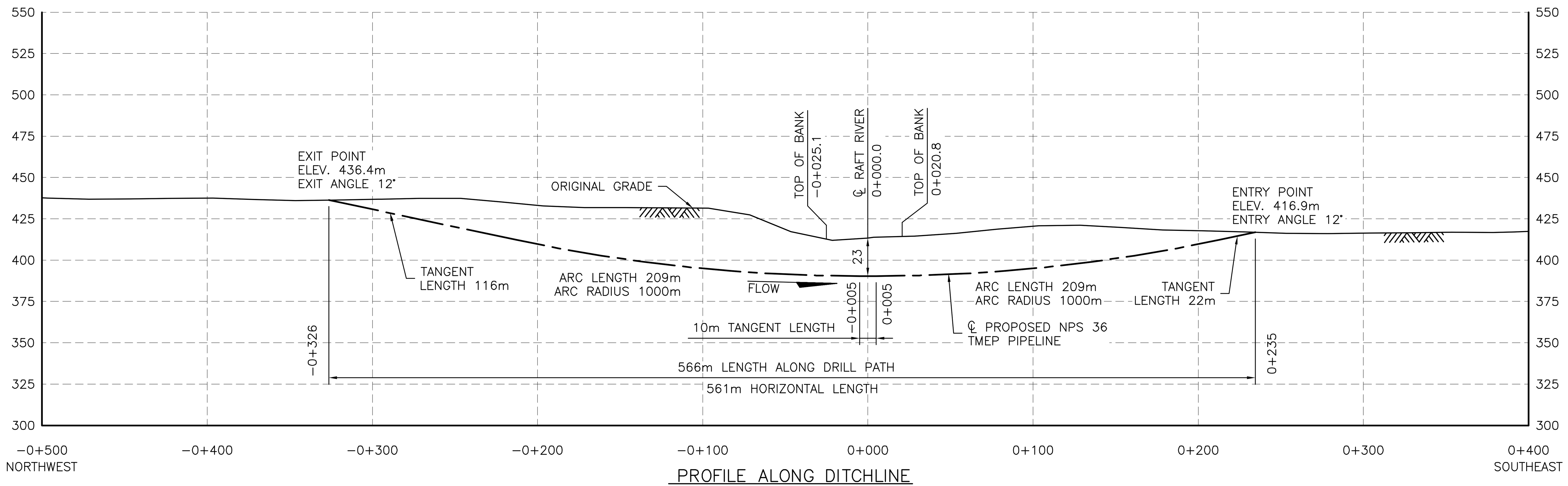


LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 082M061

PLAN
SCALE: 1:2000

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662-11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE-UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES (UTM NAD 83 – ZONE 11)

	EASTING	NORTHING
ENTRY POINT	294332.3	5725017.9
0+000 POINT	294176.8	5725193.5
EXIT POINT	293960.4	5725437.9

PROPOSED GEOTECHNICAL BOREHOLE LOCATION (UTM NAD 83 – ZONE 11)

BOREHOLE	EASTING	NORTHING
BH1	294106.6	5725314.4
BH2	294219.8	5725122.6

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE
- BOREHOLE

NOT FOR CONSTRUCTION

PRELIMINARY FOR DISCUSSION ONLY

RK 717.7 = SSEID 2002

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10565

Integrated Pipeline Projects Canada Ltd. — UPI DWG. No.: 19731-505-PPW-00691

KINDER MORGAN CANADA — TRANS MOUNTAIN

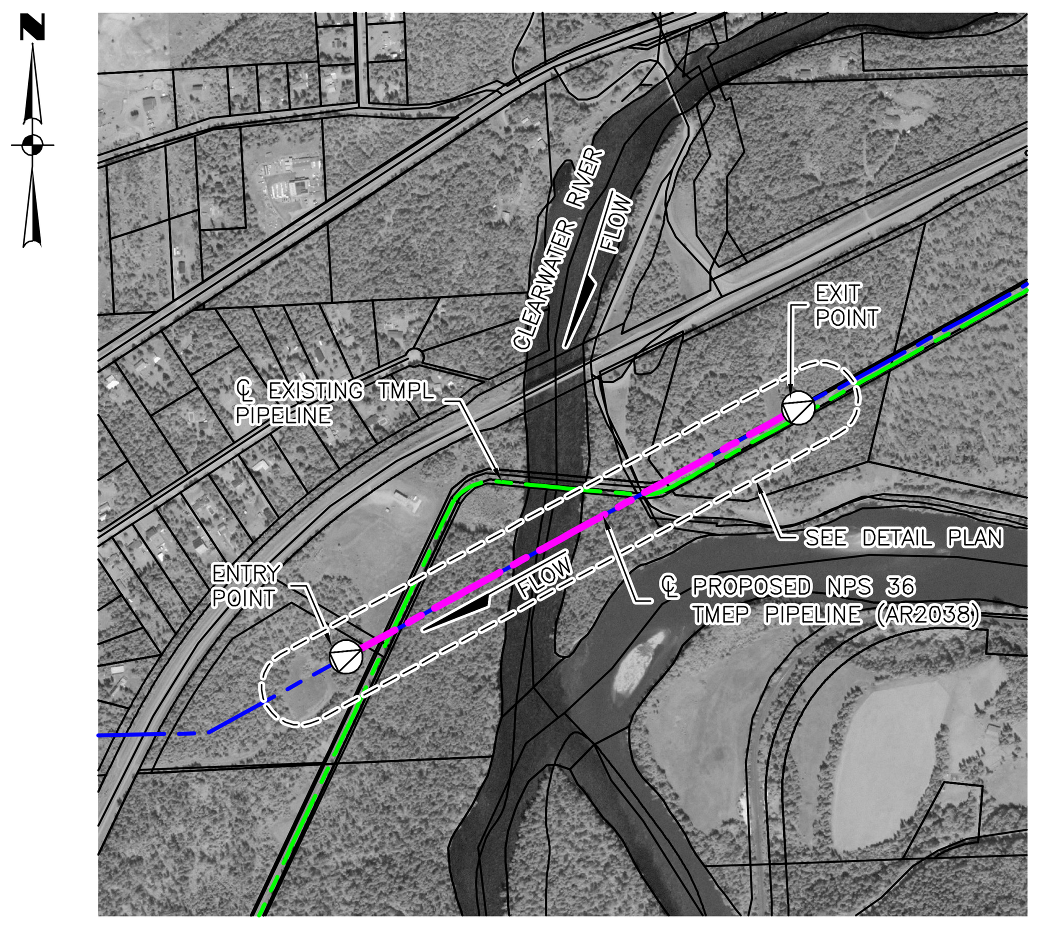
NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			C	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			B	2013-07-29	RE-ISSUED FOR REVIEW	RGR	PL	JPM	
			A	2013-05-29	ISSUED FOR REVIEW	SAH	FS	PL	JPM

DRAWN BY: SAH
CHECKED BY: WGS
APPROVED BY: JPM

TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
RAFT RIVER KP 691
UTM 83-11

SHEET SIZE: A1
SCALE: AS SHOWN
DATE: 2013-02-08

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR-691		C



LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092P070

PLAN
SCALE: 1:2000

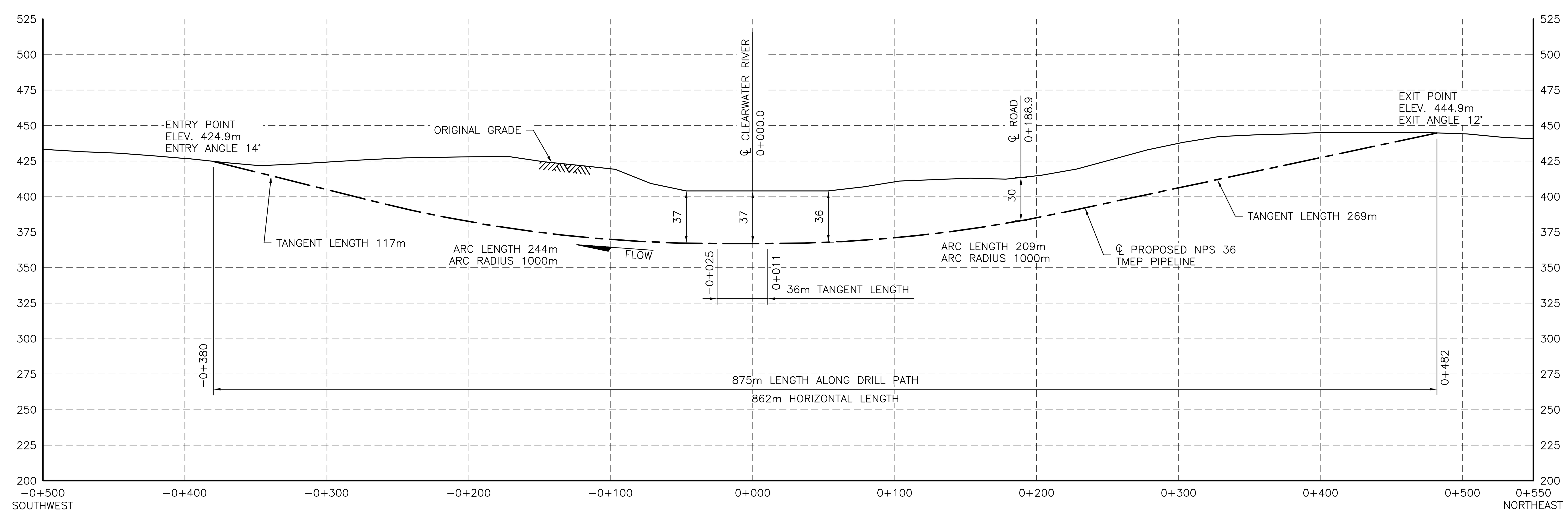
GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662-11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE-UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.

PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 - ZONE 10)

	EASTING	NORTHING
ENTRY POINT	701712.5	5724320.0
0+000 POINT	702045.4	5724503.3
EXIT POINT	702467.7	5724735.7



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

NOT FOR CONSTRUCTION

PRELIMINARY
FOR DISCUSSION ONLY

RK 725.6 = SSEID 2002

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE

Integrated Pipeline Projects Canada Ltd.

KINDER MORGAN CANADA — TRANS MOUNTAIN

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10585

UPI DWG. No.: 19731-505-PPW-00699

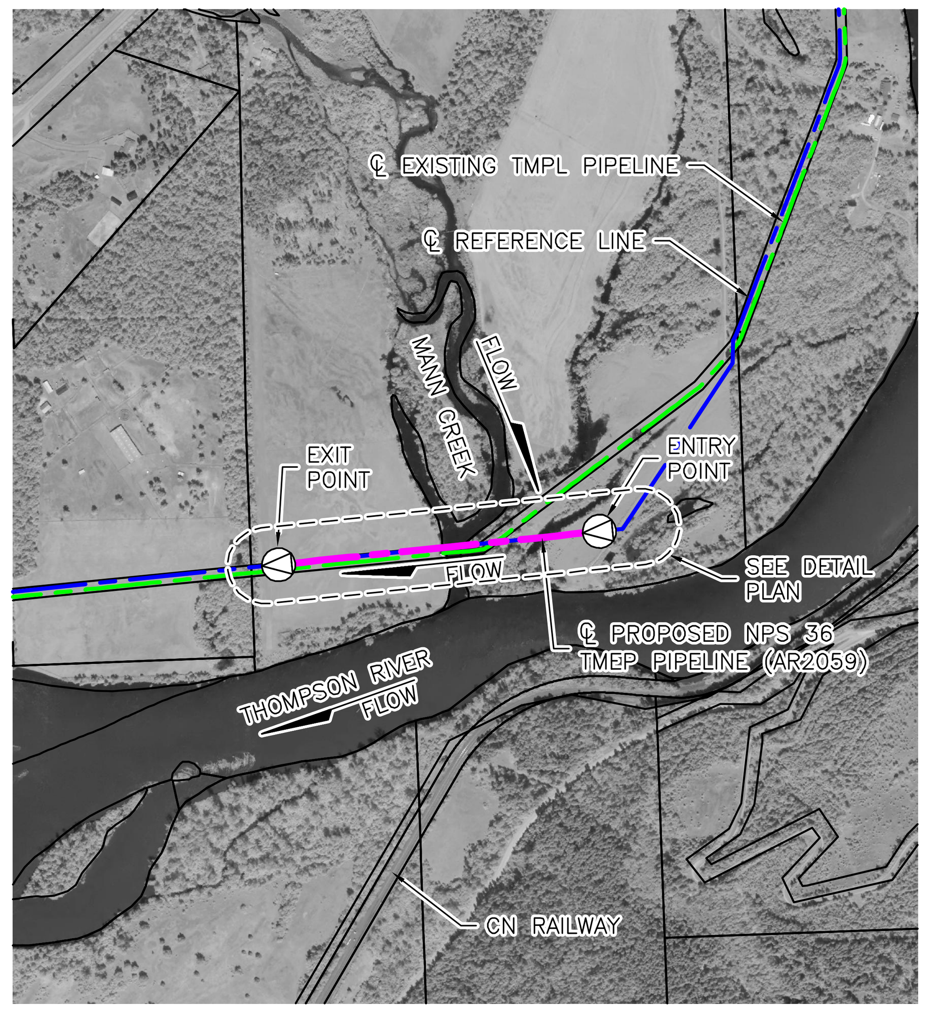
NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			B	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			A	2013-08-09	ISSUED FOR REVIEW	RGR	PL	JPM	

DRAWN BY: RGR
CHECKED BY: WGS
APPROVED BY: JPM

TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
CLEARWATER RIVER KP 699.2
UTM 83-10

SHEET SIZE: A1
SCALE: AS SHOWN
DATE: 2013-04-10

PROJECT CODING (AFE)	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR-699		B



LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092P060

PLAN
SCALE: 1:2000

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662-11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE-UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.

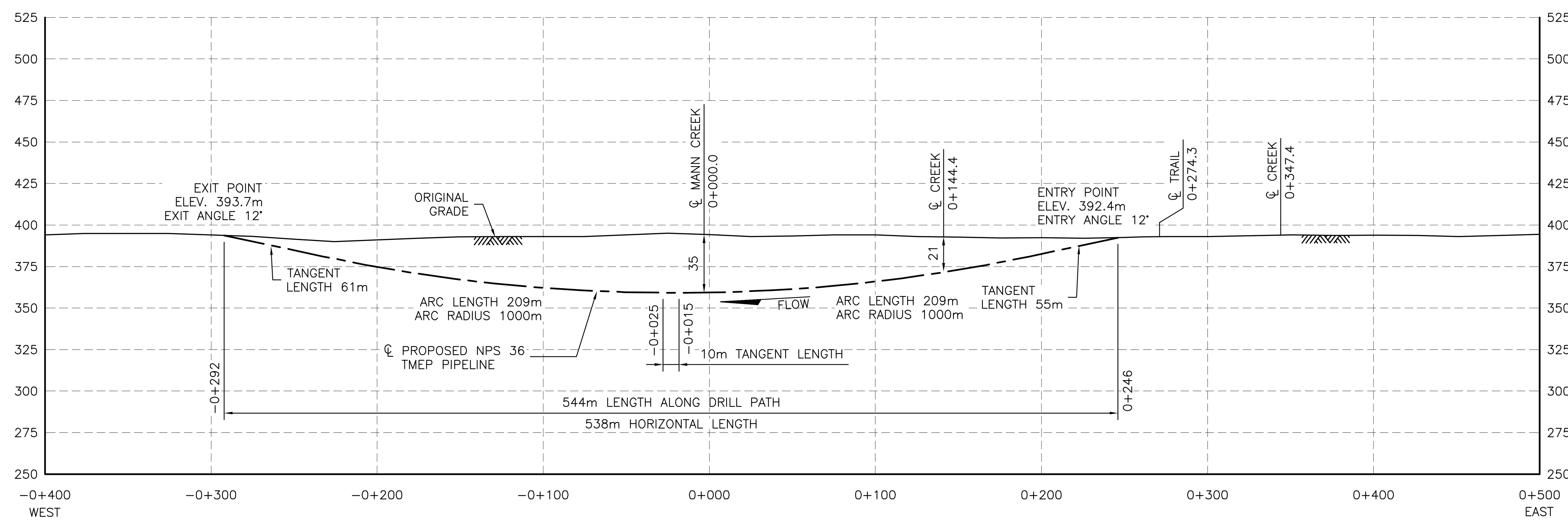
PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 – ZONE 10)

	EASTING	NORTHING
ENTRY POINT	698712.2	5716818.7
0+000 POINT	698467.3	5716793.3
EXIT POINT	698176.8	5716763.1

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

NOT FOR CONSTRUCTION

PRELIMINARY
FOR DISCUSSION ONLY

RK 735.1 = SSEID 2002

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10565

UPI DWG. No.: 19731-505-PPW-00708

Integrated Pipeline Projects Canada Ltd.

KINDER MORGAN CANADA — TRANS MOUNTAIN

NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.

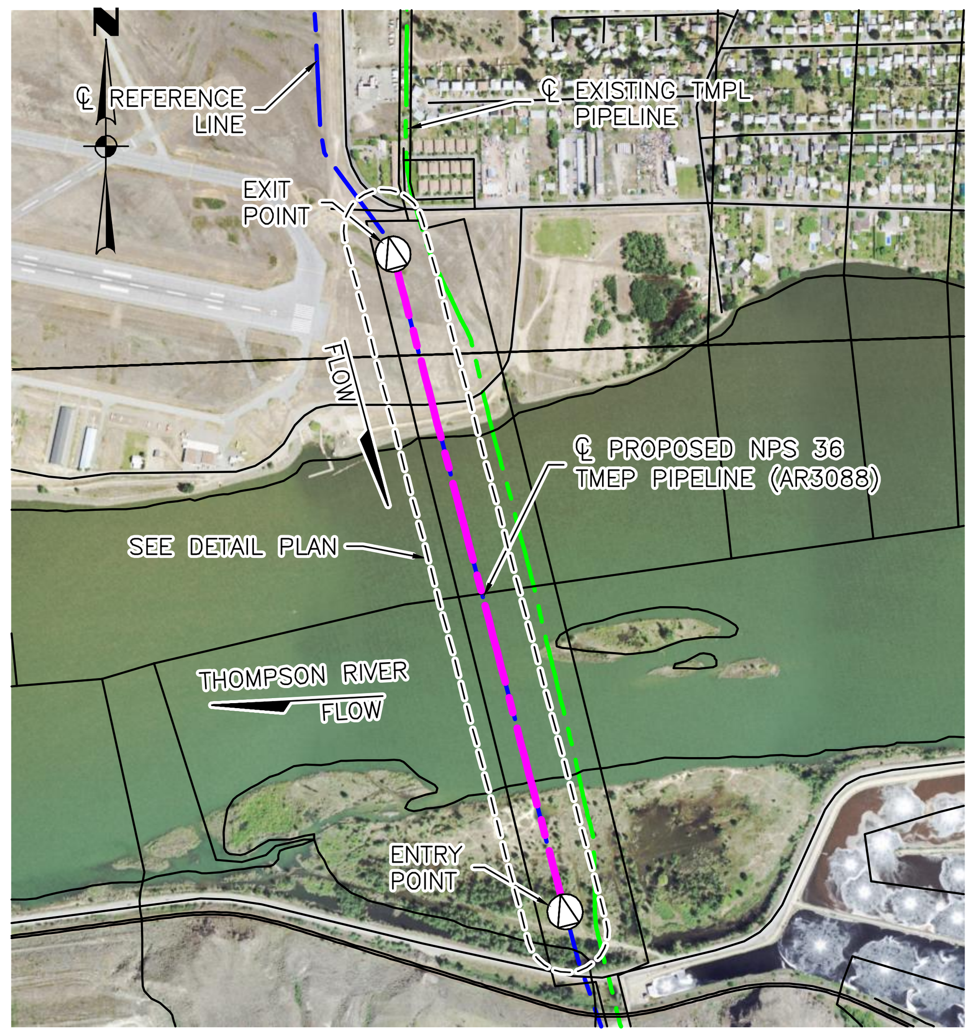
NO	DATE	REVISION	DRN	CHK	ENG	APPR
B	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
A	2013-08-12	ISSUED FOR REVIEW	SAH	PL	JPM	

DRAWN BY	SAH
CHECKED BY	WGS
APPROVED BY	JPM

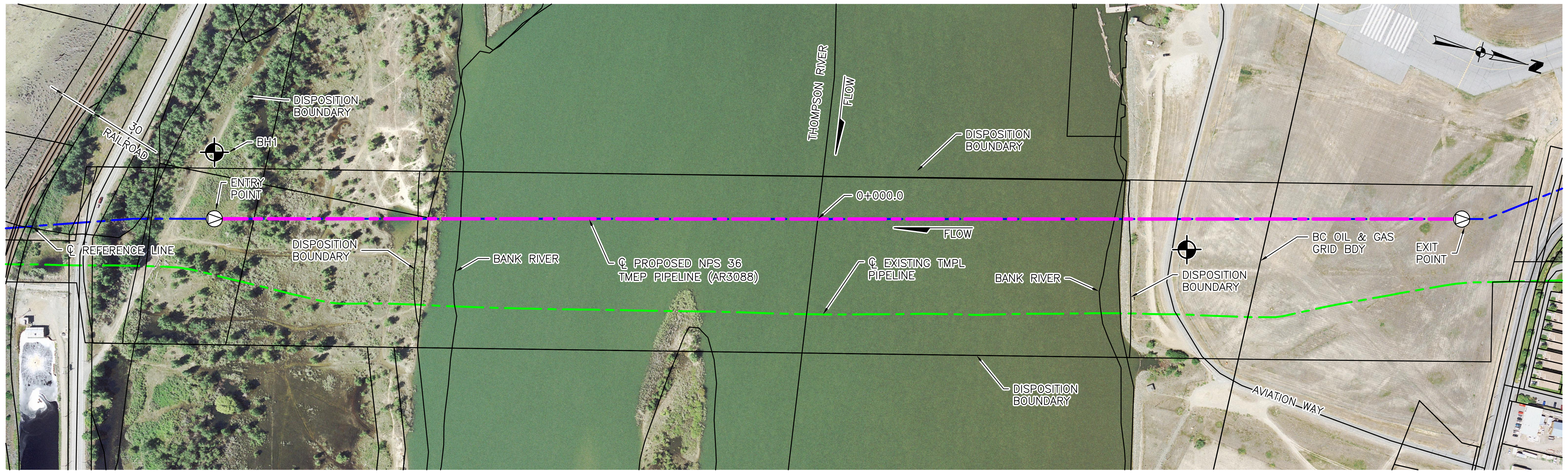
TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
MANN CREEK KP 708.2
UTM 83-10

SHEET SIZE	SCALE	DATE
A1	AS SHOWN	2013-05-22

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR-708		B



LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092I068



PLAN
SCALE: 1:2500

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662–11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE–UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.

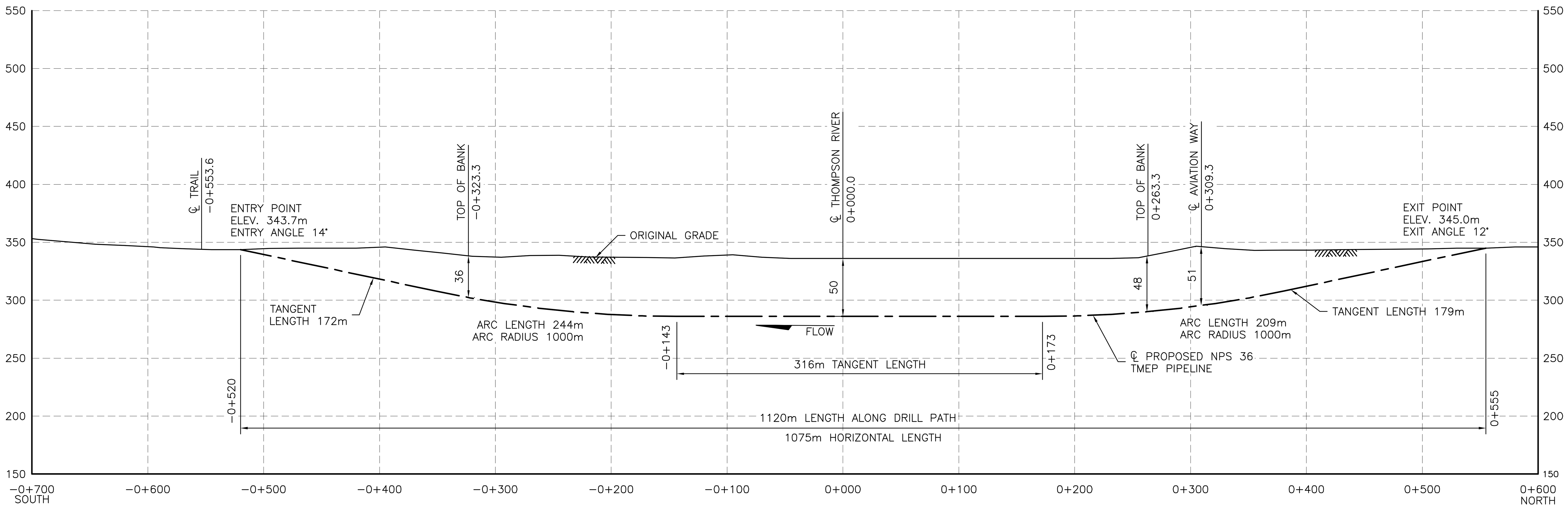
PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 – ZONE 10)

	EASTING	NORTHING
ENTRY POINT	681749.5	5618736.5
0+000 POINT	681617.9	5619239.6
EXIT POINT	681477.5	5619776.5

PROPOSED GEOTECHNICAL BOREHOLE LOCATION
(UTM NAD 83 – ZONE 10)

BOREHOLE	EASTING	NORTHING
BH1	681694.0	5618722.1
BH2	681563.0	5619554.0



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2500 VERTICAL 1:2500

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE
- BOREHOLE

NOT FOR CONSTRUCTION

PRELIMINARY FOR DISCUSSION ONLY

RK 846.7 = SSEID 3003

THIS DRAWING IS PREPARED SOLELY FOR THE USE OF TRANS MOUNTAIN PIPELINE ULC. UPI PROJECTS CANADA LTD. ASSUMES NO LIABILITY TO ANY OTHER PARTY FOR ANY REPRESENTATIONS CONTAINED IN THIS DRAWING.

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10585

UPI DWG. No.: 19731–505–PPW–00819

Integrated Pipeline Projects Canada Ltd.

KINDER MORGAN CANADA

TRANS MOUNTAIN

NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.

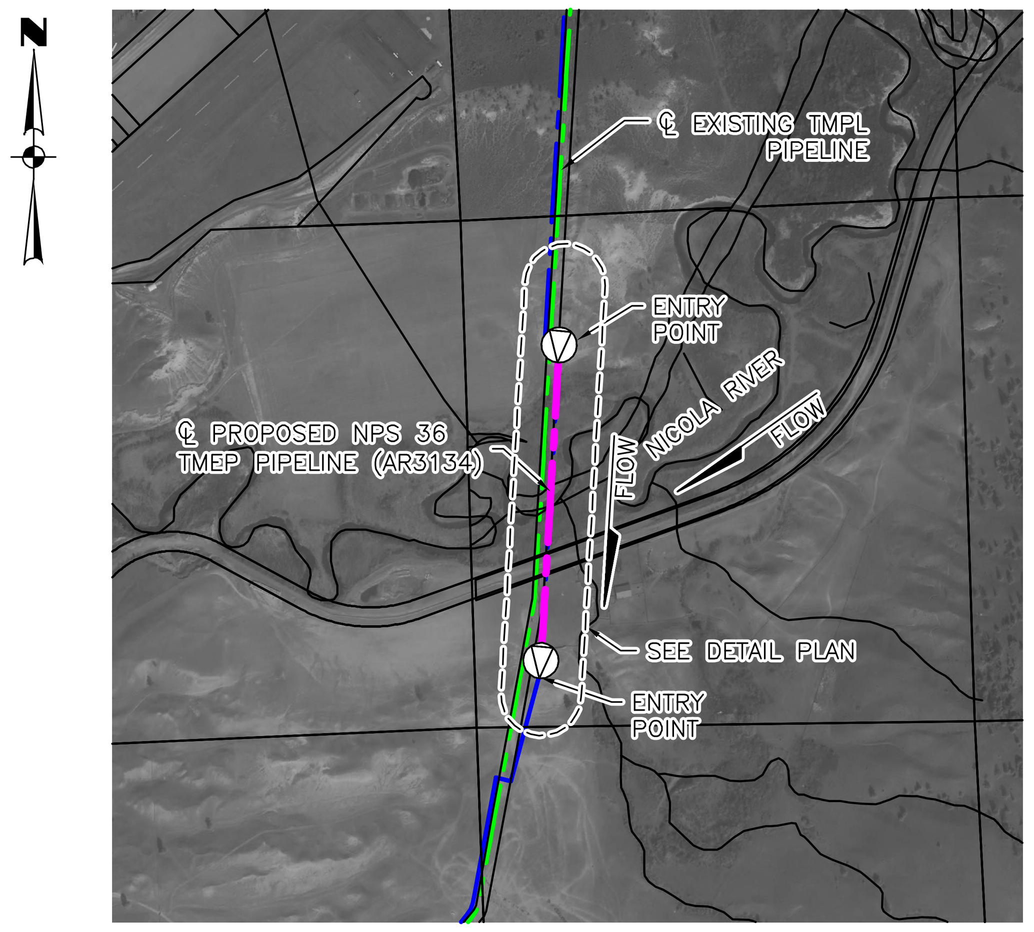
NO	DATE	REVISION	DRN	CHK	ENG	APPR
C	2013–11–18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
B	2013–07–29	RE–ISSUED FOR REVIEW	RGR	PL	JPM	
A	2013–05–29	ISSUED FOR REVIEW	RGR	FS	PL	JPM

DRAWN BY RGR
CHECKED BY WGS
APPROVED BY JPM

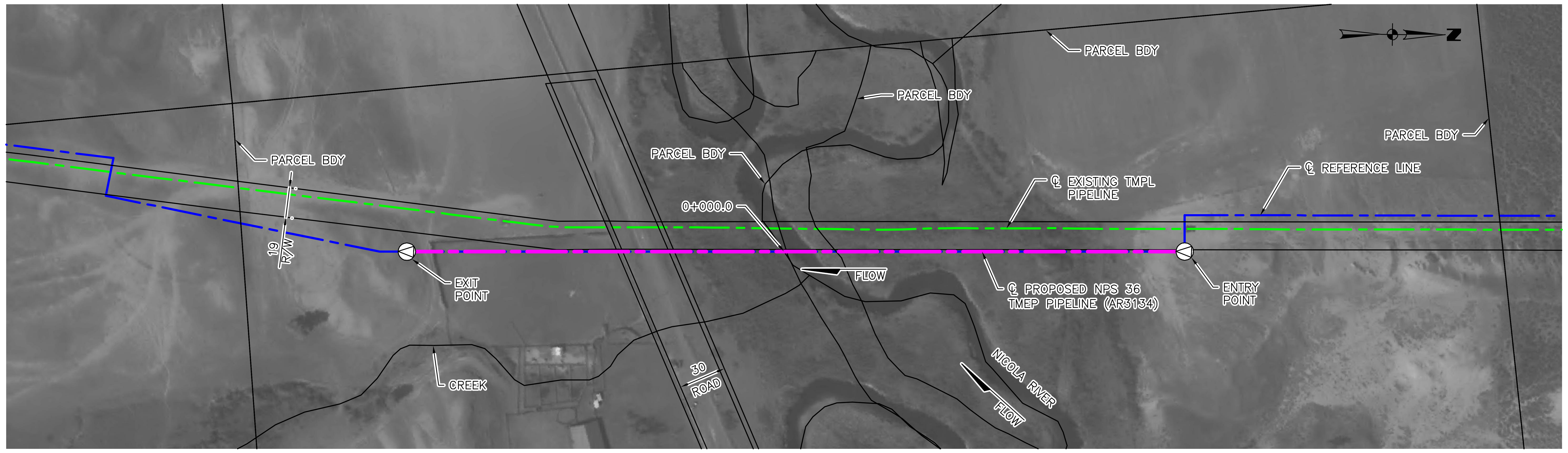
TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
THOMPSON RIVER KP 818.9
UTM 83–10

SHEET SIZE A1
SCALE AS SHOWN
DATE 2013–02–11

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR–819		C



LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092I017



PLAN
SCALE: 1:2000

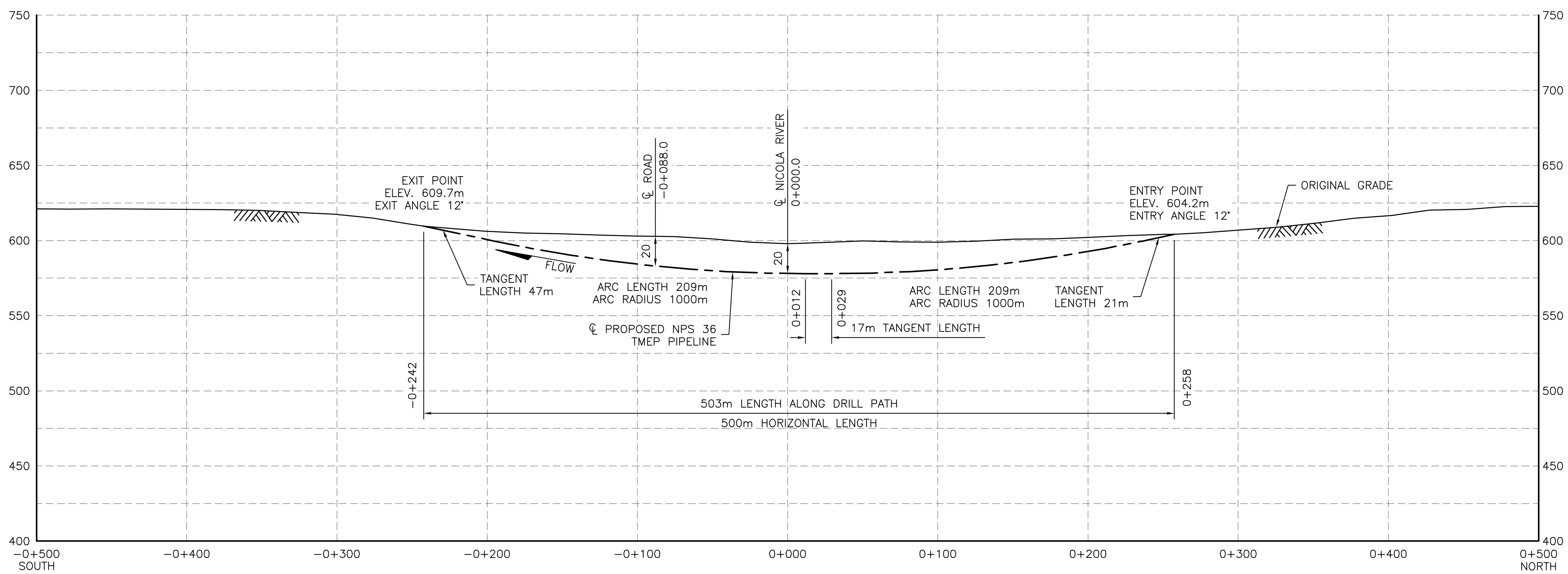
GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662-11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE-UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.

PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 – ZONE 10)

	EASTING	NORTHING
ENTRY POINT	661637.9	5554250.7
0+000 POINT	661622.9	5553993.6
EXIT POINT	661608.9	5553751.7



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

LEGEND:

PROPOSED NPS 36 TMEP PIPELINE
EXISTING TMPL PIPELINE
REFERENCE LINE

NOT FOR CONSTRUCTION

PRELIMINARY FOR DISCUSSION ONLY

RK 928.4 = SSEID 3003

THIS DRAWING IS PREPARED SOLELY FOR THE USE OF TRANS MOUNTAIN PIPELINE ULC. UPI PROJECTS CANADA LTD. ASSUMES NO LIABILITY TO ANY OTHER PARTY FOR ANY REPRESENTATIONS CONTAINED IN THIS DRAWING.

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10585

Integrated Pipeline Projects Canada Ltd.

UPI DWG. No.: 19731-505-PPW-00899

KINDER MORGAN CANADA

TRANS MOUNTAIN

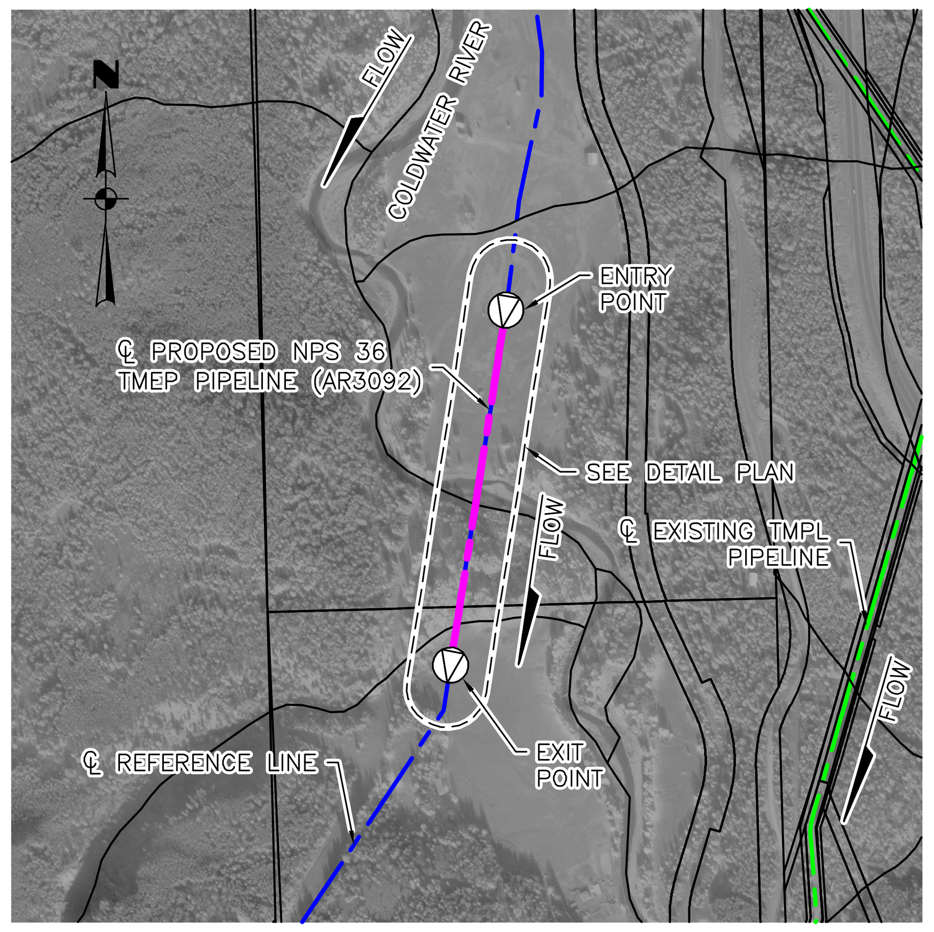
NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			B	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			A	2013-08-12	ISSUED FOR REVIEW	SAH	PL	JPM	

DRAWN BY: SAH
CHECKED BY: WGS
APPROVED BY: JPM

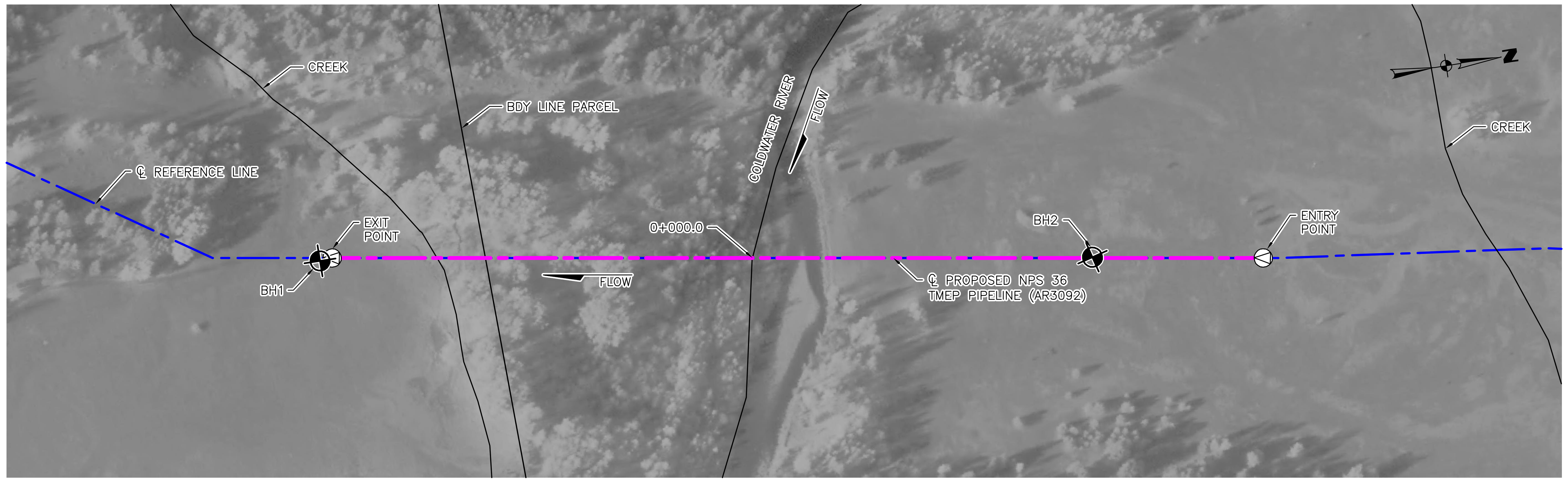
TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
NICOLA RIVER KP 898.6
UTM 83-10

SHEET SIZE: A1
SCALE: AS SHOWN
DATE: 2013-03-05

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR-899		B



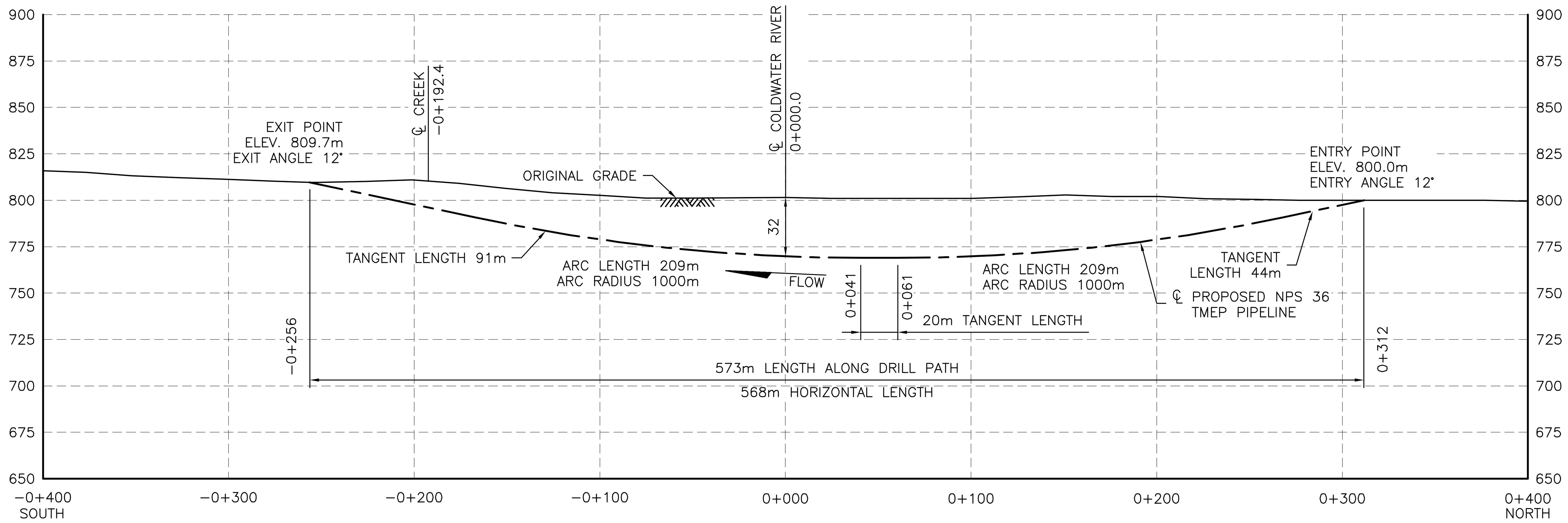
LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092H096



PLAN
SCALE: 1:2000

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662-11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE-UP SECTION WILL PROBABLY BE PLACED ON THE ENTRY SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 - ZONE 10)

	EASTING	NORTHING
ENTRY POINT	649394.7	5531526.8
0+000 POINT	649346.6	5531218.9
EXIT POINT	649307.1	5530965.6

PROPOSED GEOTECHNICAL BOREHOLE LOCATION
(UTM NAD 83 - ZONE 10)

BOREHOLE	EASTING	NORTHING
BH1	649307.7	5530958.0
BH2	649378.2	5531423.9

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE
- BOREHOLE

NOT FOR CONSTRUCTION

PRELIMINARY
FOR DISCUSSION ONLY

RK 958.3 = SSEID 3003

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10585

Integrated Pipeline Projects Canada Ltd.

UPI DWG. No.: 19731-505-PPW-00927

KINDER MORGAN CANADA · TRANS MOUNTAIN

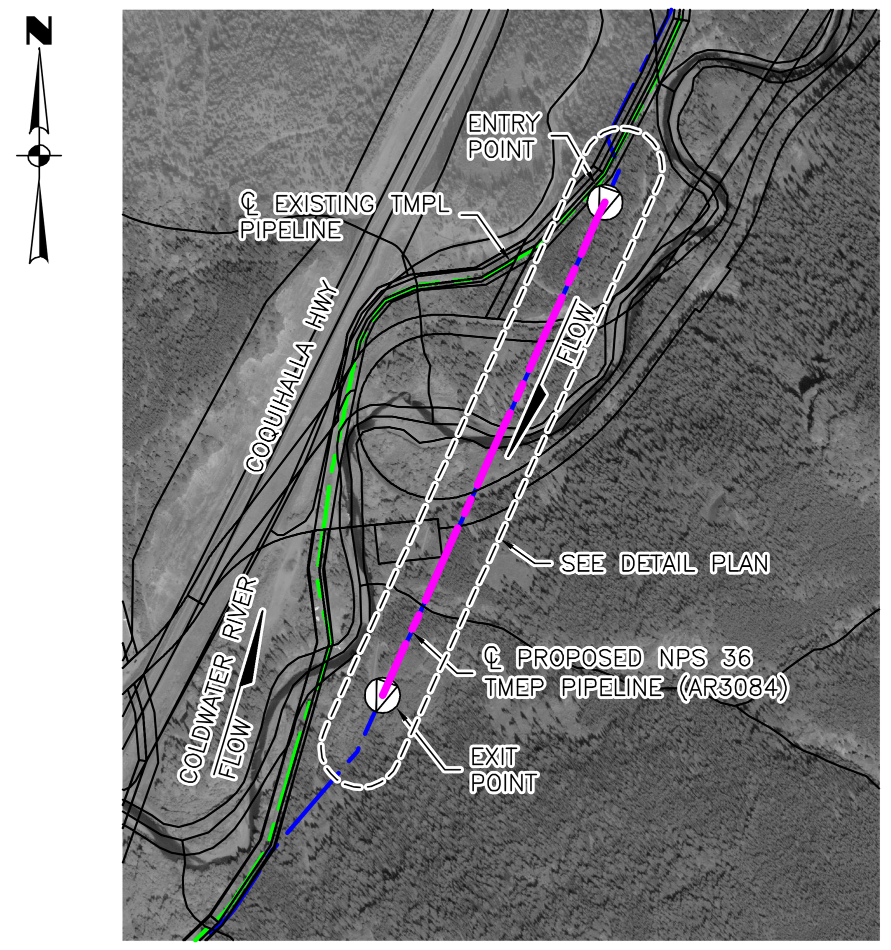
TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
COLDWATER RIVER 1 KP 927
UTM 83-10

NO.	DATE	REVISION	DRN	CHK	ENG	APPR
C	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
B	2013-07-29	RE-ISSUED FOR REVIEW	RGR	PL	JPM	
A	2013-05-29	ISSUED FOR REVIEW	SAH	FS	PL	JPM

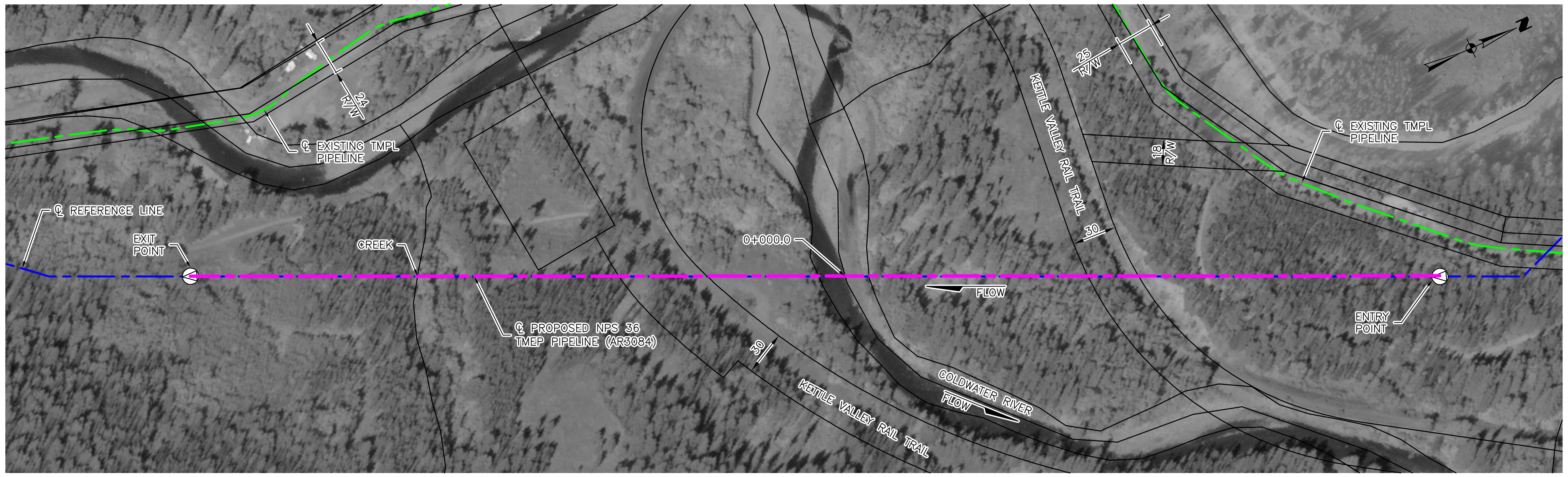
NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.

DRAWN BY	SAH
CHECKED BY	WGS
APPROVED BY	JPM
SHEET SIZE	A1
SCALE	AS SHOWN
DATE	2013-04-30

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR-927		C



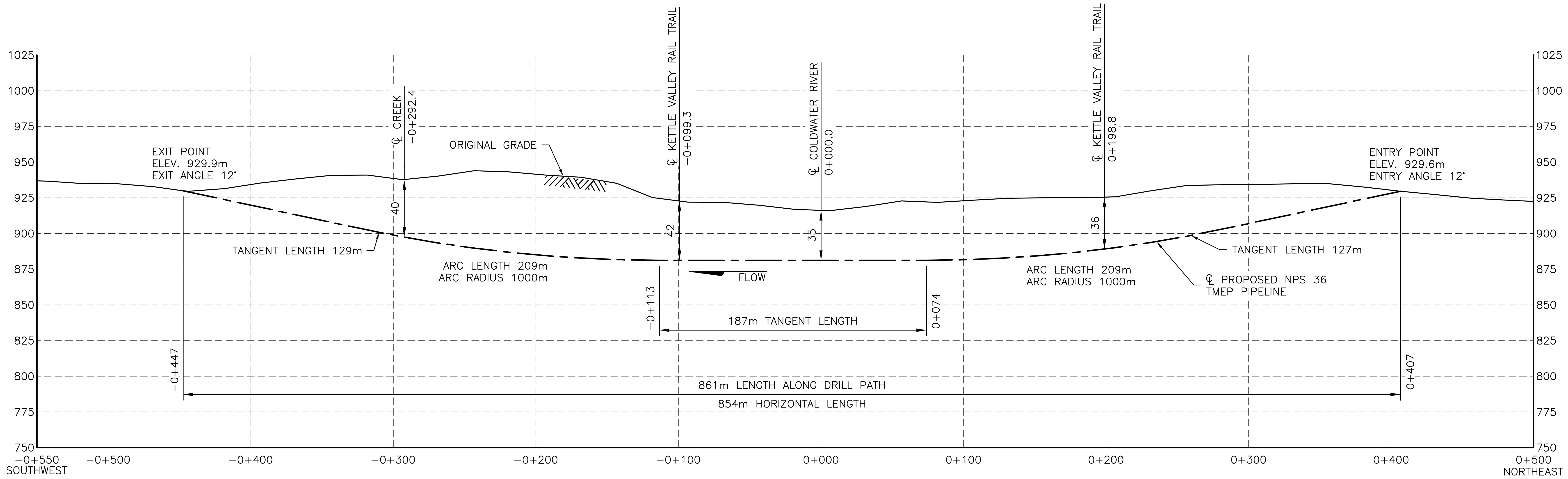
LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092H075



PLAN
SCALE: 1:2000

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662-11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE-UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES (UTM NAD 83 – ZONE 10)

	EASTING	NORTHING
ENTRY POINT	648408.3	5520440.1
0+000 POINT	648240.7	5520069.6
EXIT POINT	648056.8	5519661.7

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE

NOT FOR CONSTRUCTION

PRELIMINARY FOR DISCUSSION ONLY

RK 970.7 = SSEID 3003

THIS DRAWING IS PREPARED SOLELY FOR THE USE OF TRANS MOUNTAIN PIPELINE ULC. UPI PROJECTS CANADA LTD. ASSUMES NO LIABILITY TO ANY OTHER PARTY FOR ANY REPRESENTATIONS CONTAINED IN THIS DRAWING.

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10585

Integrated Pipeline Projects Canada Ltd.

UPI DWG. No.: 19731-505-PPW-00940

KINDER MORGAN CANADA

TRANS MOUNTAIN

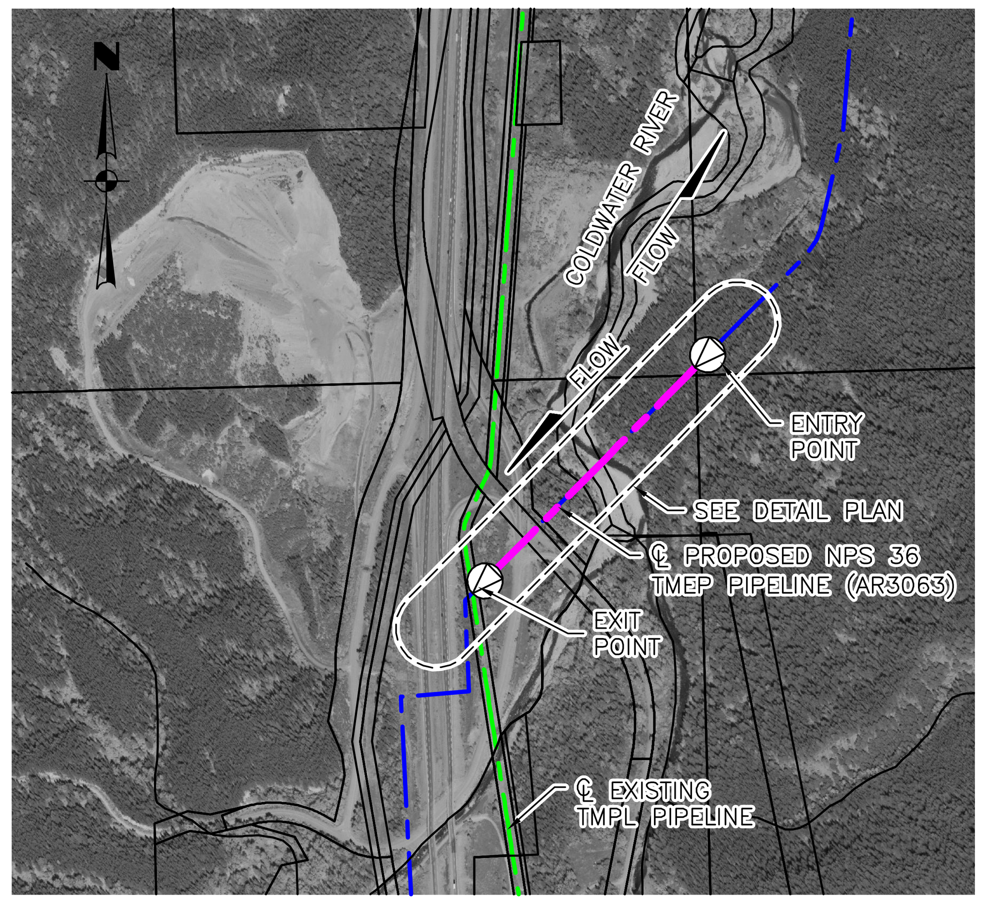
NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			B	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			A	2013-08-12	ISSUED FOR REVIEW	SAH	PL	JPM	

DRAWN BY: SAH
CHECKED BY: WGS
APPROVED BY: JPM

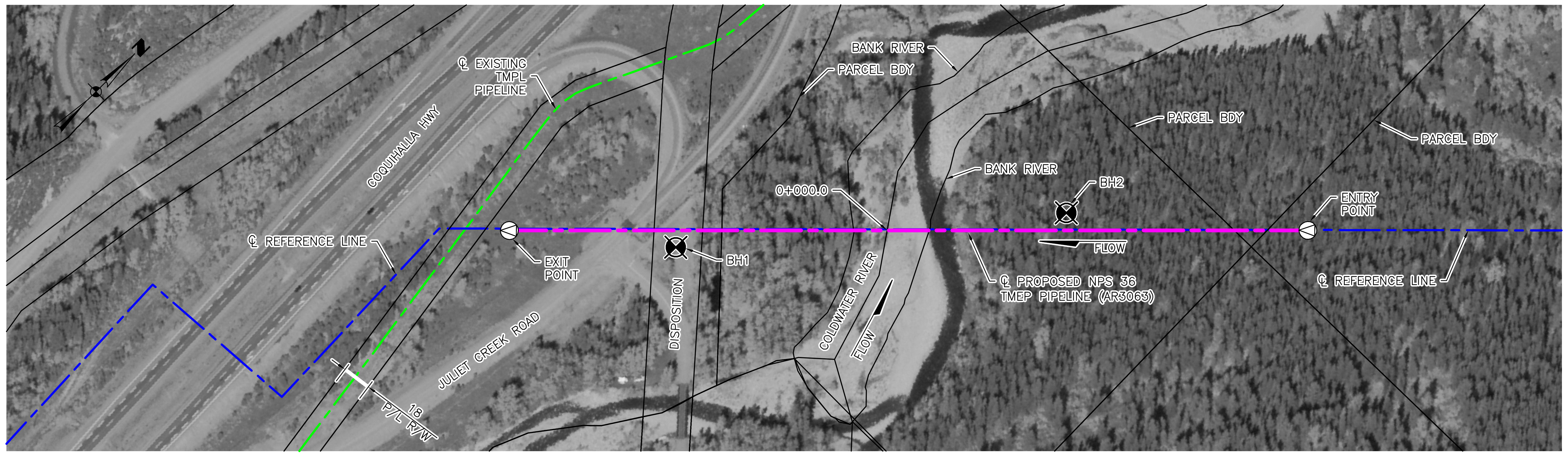
TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
COLDWATER RIVER 2 KP 939.4
UTM 83-10

SHEET SIZE: A1
SCALE: AS SHOWN
DATE: 2013-04-10

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR-940		B



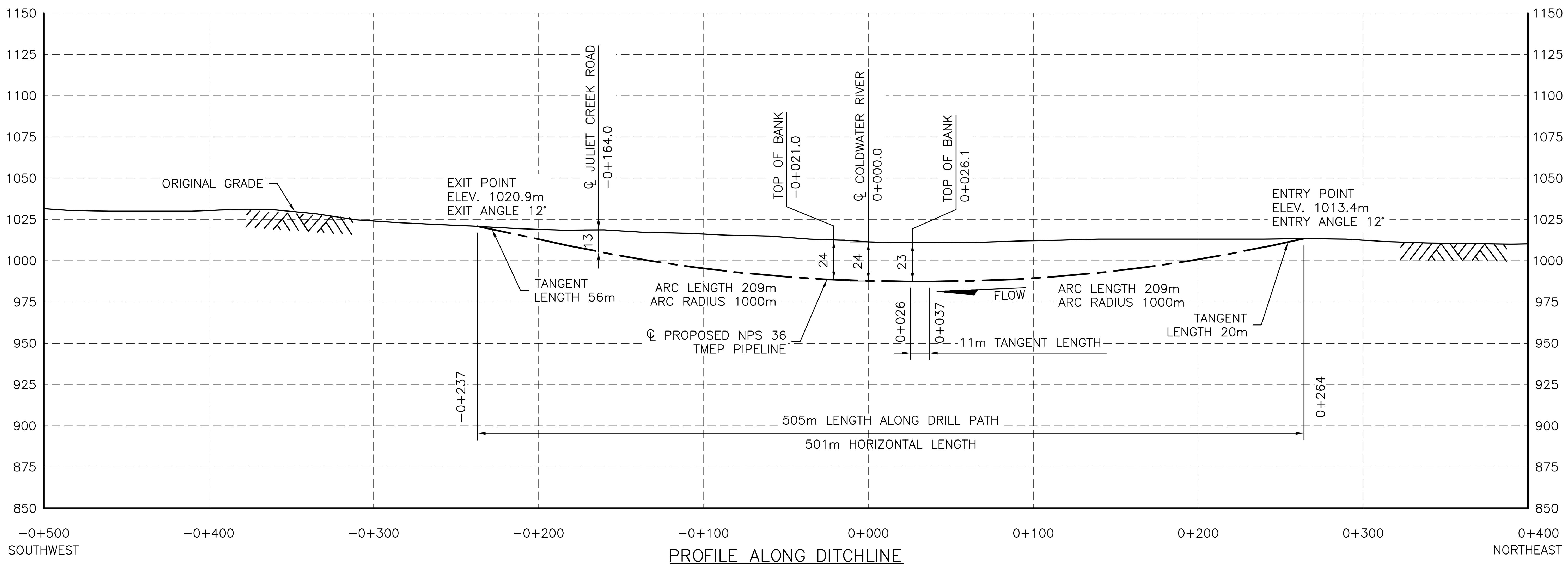
LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092H075



PLAN
SCALE: 1:2000

GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662–11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE–UP SECTION WILL PROBABLY BE PLACED ON THE ENTRY SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 – ZONE 10)

	EASTING	NORTHING
ENTRY POINT	643620.8	5512346.1
0+000 POINT	643435.6	5512157.8
EXIT POINT	643269.2	5511988.8

PROPOSED GEOTECHNICAL BOREHOLE LOCATION
(UTM NAD 83 – ZONE 10)

BOREHOLE	EASTING	NORTHING
BH1	643350.0	5512055.9
BH2	643506.6	5512245.8

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE
- BOREHOLE

NOT FOR CONSTRUCTION

PRELIMINARY
FOR DISCUSSION ONLY

RK 980.4 = SSEID 3003

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10585

Integrated Pipeline Projects Canada Ltd.

UPI DWG. No.: 19731–505–PPW–00949

KINDER MORGAN CANADA

TRANS MOUNTAIN

TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
COLDWATER RIVER 3 (EAST) (P1) KP 949.4
UTM 83–10

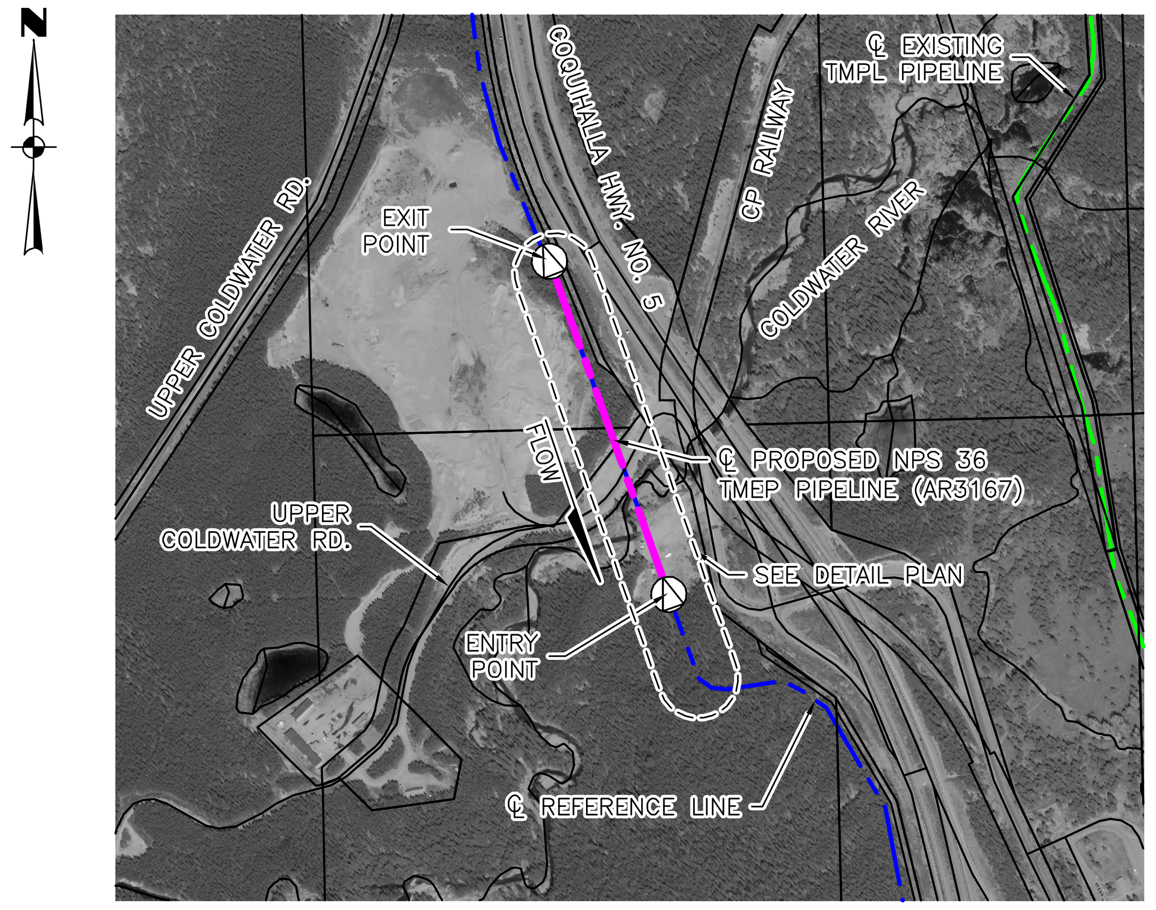
NO	DATE	REVISION	DRN	CHK	ENG	APPR
C	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
B	2013-07-29	RE–ISSUED FOR REVIEW	RGR	PL	JPM	
A	2013-05-29	ISSUED FOR REVIEW	RGR	FS	PL	JPM

NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.

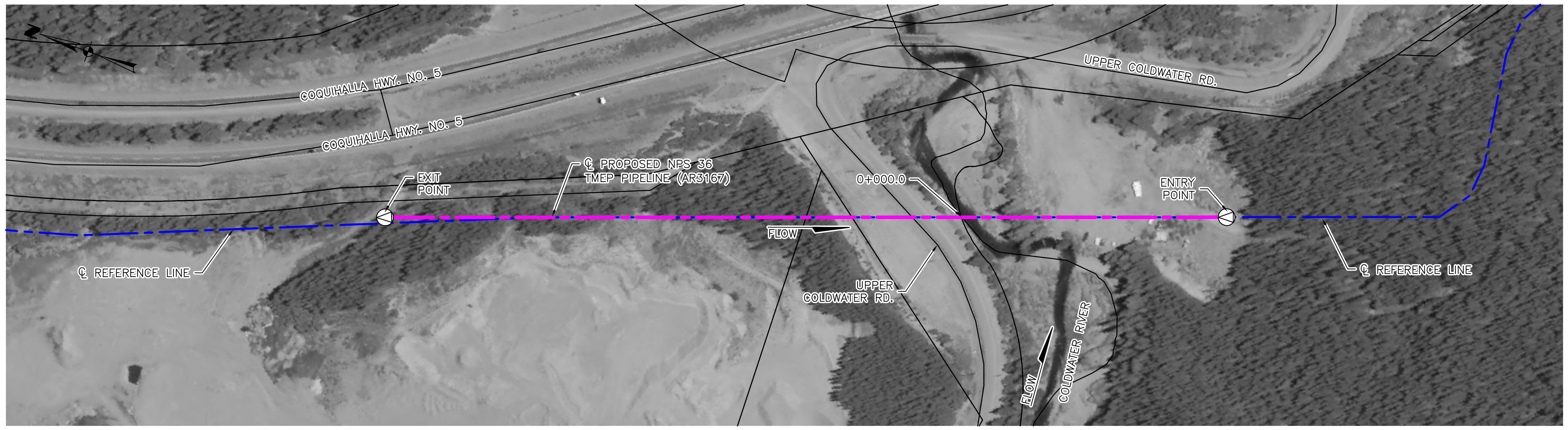
DRAWN BY: RGR
CHECKED BY: WGS
APPROVED BY: JPM

SHEET SIZE: A1
SCALE: AS SHOWN
DATE: 2013-03-29

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR–949		C



LOCATION PLAN
SCALE 1:10000
LEGAL DESCRIPTION: 092H065



PLAN
SCALE: 1:2000

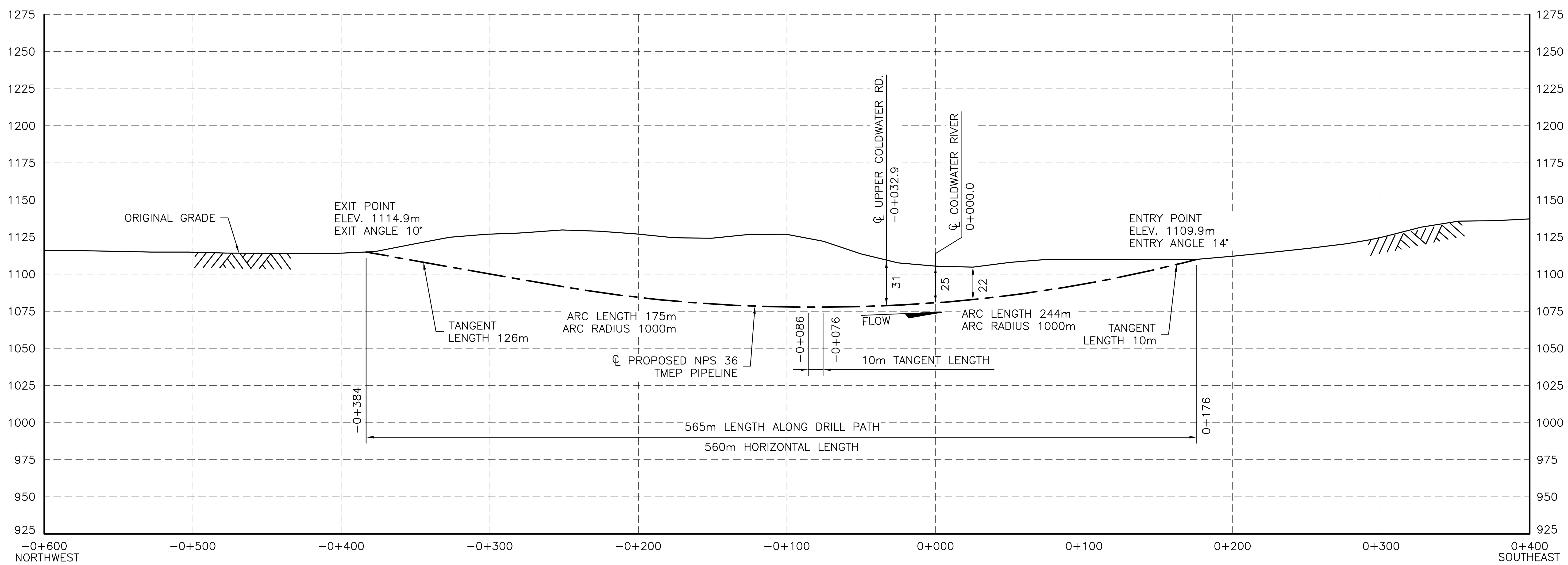
GENERAL NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
2. CONSTRUCT METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD.
3. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662–11, AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
4. THE MAKE–UP SECTION WILL BE PLACED ON THE EXIT SIDE.
5. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE APPROVED DRILLING EXECUTION PLAN.
6. ORIGINAL GRADE HAS BEEN TAKEN FROM CDED 50K DEM.

PIPE SPECIFICATIONS	
OUTSIDE DIA.	914.4mm (NPS 36)
CLASS LOCATION DESIGNATION	CLASS 1 (TO BE CONFIRMED)
WALL THICKNESS	TBD
PIPE MATERIAL SPECIFICATION	CSA Z245.1 GR. 483, CAT. II
MAXIMUM OPERATING PRESSURE	9930 kPa
MAXIMUM OPERATING TEMPERATURE	50°C
MINIMUM TEST PRESSURE	12,412 kPa
MINIMUM YIELD STRENGTH	483 MPa
CORROSION TREATMENT	FUSION BOND EPOXY (ABRASION RESISTANT COATING)
CATHODIC PROTECTION	IMPRESSED CURRENT
PRODUCT	PETROLEUM PRODUCTS (LVP)

HDD FEATURE COORDINATES
(UTM NAD 83 – ZONE 10)

	EASTING	NORTHING
ENTRY POINT	643607.7	5502325.7
0+000 POINT	643548.5	5502491.4
EXIT POINT	643419.4	5502852.4



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

NOT FOR CONSTRUCTION

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE

PRELIMINARY
FOR DISCUSSION ONLY

RK 990.4 = SSEID 3003

THIS DRAWING IS PREPARED SOLELY FOR THE USE OF TRANS MOUNTAIN PIPELINE ULC. UPI PROJECTS CANADA LTD. ASSUMES NO LIABILITY TO ANY OTHER PARTY FOR ANY REPRESENTATIONS CONTAINED IN THIS DRAWING.

Integrated Pipeline Projects Canada Ltd.

KINDER MORGAN CANADA — TRANS MOUNTAIN

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10585

UPI DWG. No.: 19731–505–PPW–00959

DRAWN BY: RGR
CHECKED BY: WGS
APPROVED BY: JPM

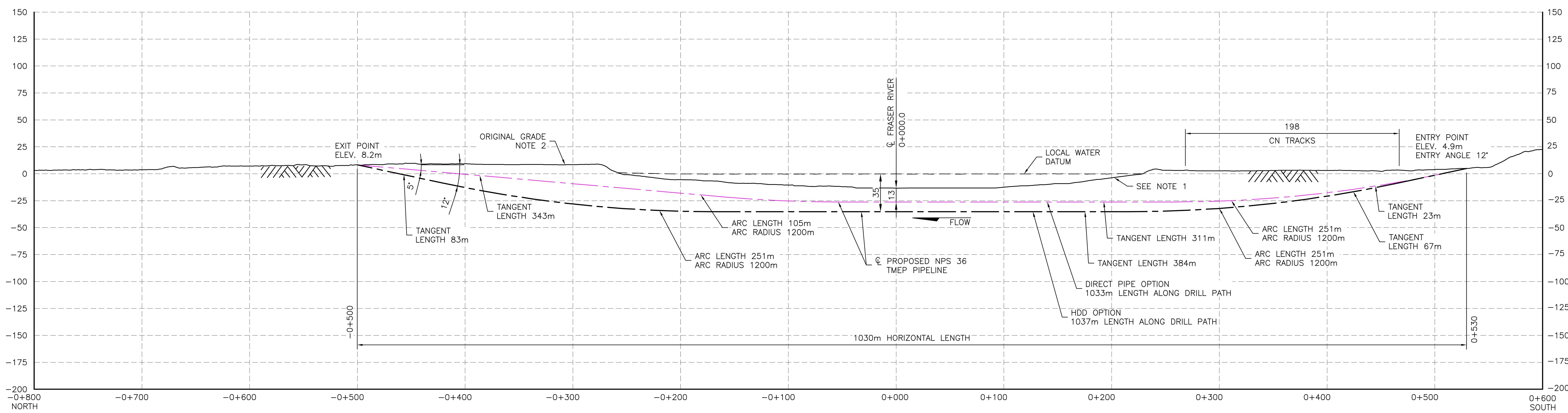
TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
COLDWATER RIVER 4 (P1) KP 959
UTM 83–10

SHEET SIZE: A1
SCALE: AS SHOWN
DATE: 2013–06–28

NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			B	2013–11–18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			A	2013–08–12	ISSUED FOR REVIEW	RGR	PL	JPM	

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PR–959		B

PLAN
SCALE: 1:2000



PROFILE ALONG DITCHLINE
SCALE: HORIZONTAL 1:2000 VERTICAL 1:2000

PRELIMINARY
FOR DISCUSSION ONLY

RK 1169.3 = SSEID 3003

NOTES:

1. RIVER BED PROFILE IS ASSUMED.
2. ORIGINAL GRADE HAS BEEN TAKEN FROM LIDAR DEM DATASET.

NOT FOR CONSTRUCTION

LEGEND:

- PROPOSED NPS 36 TMEP PIPELINE
- EXISTING TMPL PIPELINE
- REFERENCE LINE

Integrated Pipeline Projects Canada Ltd.

KINDER MORGAN CANADA — TRANS MOUNTAIN

APEGA PERMIT TO PRACTICE UPI PROJECTS CANADA LTD. PERMIT NUMBER P10565

UPI DWG. No.: 19731-505-SKT-00006

NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
			B	2013-11-18	ISSUED FOR INFORMATION	RGR	WGS	PL	JPM
			A	2013-04-15	ISSUED FOR REVIEW	RGR			

DRAWN BY: RGR
CHECKED BY: WGS
APPROVED BY: JPM

TRANS MOUNTAIN EXPANSION PROJECT
HDD CROSSING PLAN AND PROFILE
FRASER RIVER – OPTION 2
KP 1137 – UTM 83-10

SHEET SIZE: A1
SCALE: AS SHOWN
DATE: 2013-04-15

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
	TMEP	PS-0006		B

Appendix H Terrain Mapping and Geohazard Inventory Report

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

TRANS MOUNTAIN PIPELINE ULC

TRANS MOUNTAIN EXPANSION PROJECT

TERRAIN MAPPING AND GEOHAZARD INVENTORY

PROJECT NO.: 0095-150-02
DATE: November 28, 2013

DISTRIBUTION:
TMP ULC: e-copy
BGC: e-copy

EXECUTIVE SUMMARY

Trans Mountain Pipeline ULC is developing the Trans Mountain Expansion Project (TMEP) and proposes to undertake the looping of the existing TMPL system with the exception of the Hinton, AB to Hargreaves, BC and the Darfield, BC to Black Pines, BC pipeline segments. BGC Engineering Inc. was retained by Trans Mountain Pipeline ULC to undertake terrain stability and natural hazard mapping for the proposed TMEP along the route from Edmonton, Alberta to Burnaby, British Columbia. Terrain stability and hazard mapping were completed for the pipeline corridor at a scale of 1:20,000. The area mapped included all slopes above the pipeline route where hazards could originate. Glaciofluvial, fluvial, glacial till, colluvial, glaciolacustrine, glaciomarine, eolian and organic surficial materials and bedrock were identified along the pipeline route. The mapping was developed using office techniques including airphoto interpretation and review of satellite imagery, and was verified with observations in the field.

Geohazards (a subset of natural hazards) were reviewed with respect to their ability to impact the pipeline, and an inventory of geohazard sites was developed. From the assessment, a total of 434 geohazards were identified. Typical hazards seen along the pipeline corridor include: flooding, watercourse channel scour and bank erosion, rock fall and debris flows.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIMITATIONS

BGC Engineering Inc. (BGC) prepared this document for Trans Mountain Pipeline ULC (Trans Mountain). The material in this report reflects the judgment of BGC staff based upon the information made available to BGC at the time of preparation of the report, including that information provided to it by Trans Mountain. Any use which a third party makes of this report or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility whatsoever for damages, loss, expenses, loss of profit or revenues, if any, suffered by any third party as a result of decisions made or actions based on this report.

As a mutual protection to our client, the public and BGC, the report, and its drawings are submitted to Trans Mountain as confidential information for a specific project. Authorization for any use and/or publication of the report or any data, statements, conclusions or abstracts from or regarding the report and its drawings, through any form of print or electronic media, including without limitation, posting or reproductions of same on any website, is reserved by BGC, and is subject to BGC's prior written approval. Provided however, if the report is prepared for the purposes of inclusion in an application for a specific permit or other government process, as specifically set forth in the report, then the applicable regulatory, municipal, or other governmental authority may use the report only for the specific and identified purpose of the specific permit application or other government process as identified in the report. If the report or any portion or extracts thereof is/are issued in electronic format, the original copy of the report retained by BGC will be regarded as the only copy to be relied on for any purpose and will take precedence over any electronic copy of the report, or any portion or extracts thereof which may be used or published by others in accordance with the terms of this disclaimer.

1.0 INTRODUCTION

1.1. Project Description

Trans Mountain Pipeline ULC (Trans Mountain) is a Canadian corporation with its head office located in Calgary, Alberta. Trans Mountain is a general partner of Trans Mountain Pipeline L.P., which is operated by Kinder Morgan Canada Inc. (KMC), and is fully owned by Kinder Morgan Energy Partners, L.P. Trans Mountain is the holder of the National Energy Board (NEB) certificates for the Trans Mountain pipeline system (TMPL system).

The TMPL system commenced operations 60 years ago and now transports a range of crude oil and petroleum products from Western Canada to locations in central and southwestern British Columbia (BC), Washington State and offshore. The TMPL system currently supplies much of the crude oil and refined products used in BC. The TMPL system is operated and maintained by staff located at Trans Mountain's regional and local offices in Alberta (Edmonton, Edson, and Jasper) and BC (Clearwater, Kamloops, Hope, Abbotsford, and Burnaby).

The TMPL system has an operating capacity of approximately 47,690 m^3/d (300,000 bbl/d) using 23 active pump stations and 40 petroleum storage tanks. The expansion will increase the capacity to 141,500 m^3/d (890,000 bbl/d).

The proposed expansion will comprise the following:

- Pipeline segments that complete a twinning (or "looping") of the pipeline in Alberta and BC with about 987 km of new buried pipeline.
- New and modified facilities, including pump stations and tanks.
- Three new berths at the Westridge Marine Terminal in Burnaby, BC, each capable of handling Aframax class vessels.

The expansion has been developed in response to requests for service from Western Canadian oil producers and West Coast refiners for increased pipeline capacity in support of growing oil production and access to growing West Coast and offshore markets. NEB decision RH-001-2012 reinforces market support for the expansion and provides Trans Mountain the necessary economic conditions to proceed with design, consultation, and regulatory applications.

Application is being made pursuant to Section 52 of the *National Energy Board Act* (*NEB Act*) for the proposed Trans Mountain Expansion Project (referred to as "TMEP" or "the Project"). The NEB will undertake a detailed review and hold a Public Hearing to determine if it is in the public interest to recommend a Certificate of Public Convenience and Necessity (CPCN) for construction and operation of the Project. Subject to the outcome of the NEB Hearing process, Trans Mountain plans to begin construction in 2016 and go into service in 2017.

Trans Mountain has embarked on an extensive program to engage Aboriginal communities and to consult with landowners, government agencies (*e.g.*, regulators and municipalities), stakeholders, and the general public. Information on the Project is also available at www.transmountain.com.

The scope of the Project will involve:

- using existing active 610 mm (NPS 24) and 762 mm (NPS 30) OD buried pipeline segments;
- constructing three new 914 mm (NPS 36) OD buried pipeline segments totalling approximately 987 km:
  - Edmonton to Hinton – 339.4 km
  - Hargreaves to Darfield – 279.4 km
  - Black Pines to Burnaby – 367.9 km;
- reactivating two 610 mm (NPS 24) OD buried pipeline segments that have been maintained in a deactivated state:
  - Hinton to Hargreaves – 150 km
  - Darfield to Black Pines – 43 km;
- constructing two, 3.6 km long 762 mm (NPS 30) OD buried delivery lines from Burnaby Terminal to Westridge Marine Terminal (the Westridge delivery lines).
- installing 23 new sending or receiving traps (16 on the Edmonton-Burnaby mainlines), for in-line inspection tools, at nine existing sites and one new site;
- adding 35 new pumping units at 12 locations (*i.e.*, 11 existing and one new pump station site);
- reactivating the existing Niton Pump Station that has been maintained in a deactivated state;
- four existing pump stations at; Albreda, Stump, Hope, and Wahleach, may be deactivated if further studies indicate that these stations are not required;
- constructing 20 new tanks located at the Edmonton (5), Sumas (1) and Burnaby (14) Terminals, preceded by demolition of 2 existing tanks at Edmonton (1) and Burnaby (1), for a net total of 18 tanks to be added to the system; and
- constructing one new dock complex, with a total of three Aframax-capable berths, as well as a utility dock (for tugs, boom deployment vessels, and emergency response vessels and equipment) at Westridge Marine Terminal, followed by the deactivation and demolition of the existing berth.

1.2. Scope

BGC was retained by Trans Mountain to undertake terrain stability and natural hazard mapping as well as the development of a geohazard inventory for the proposed TMEP corridor from Edmonton to Burnaby (Figure 1-1). As looping of the pipeline from Hinton to Mt. Robson and Darfield to Black Pines has been completed, no mapping was undertaken in these areas.

Terrain stability and hazard mapping were completed for the pipeline corridor at a scale of 1:20,000. The area mapped included all slopes above the pipeline route on both sides of valleys where hazards could originate. In areas where gentle slopes occur on the upper valley walls, these were viewed on the aerial photographs but not mapped. Where the pipeline crosses plateau areas or is located in broad valleys, approximately 500 to 1,000 m on each side of the route were mapped. Slopes further than 1 km from a proposed pipeline route were not mapped. Where the pipeline parallels large rivers, such as the Fraser River, mapping was completed only on the side of the river on which the pipeline is located.

Known reference points along the existing Trans Mountain pipeline system are commonly referred to as a Kilometre Post or “KP”. KP 0.0 is located at the Edmonton Terminal where the existing Trans Mountain system originates. KPs are approximately 1 km apart and are primarily used to describe features along the pipeline for operations and maintenance purposes. To delineate features along the Proposed Route (i.e., applied-for route), the symbol “RK” or Reference Kilometre has been applied throughout the document.

1.3. Physiographic Areas

The terrain and natural hazard mapping have been separated into the segments shown in Table 1-1 for the purpose of this report. This is also shown in Figure 1-1. For more information on the physiographic regions please refer to the report titled Route Physiography and Hydrology (BGC, 2013a).

Table 1-1. Physiographic segments

Segment name	RK Start Chainage	RK End Chainage
Eastern Alberta Plains	0	128.3
Western Alberta Plains	128.3	262.4
Southern Alberta Uplands	262.4	339.4
Rocky Mountains	489.6	502.3
Rocky Mountain Trench	502.3	523.7
Columbia Mountains	523.7	612.1
Shuswap	612.1	768.8
Thompson	811.85	993.8
Cascade Mountains	993.8	1091.8
Georgia Depression	1091.8	1180.1

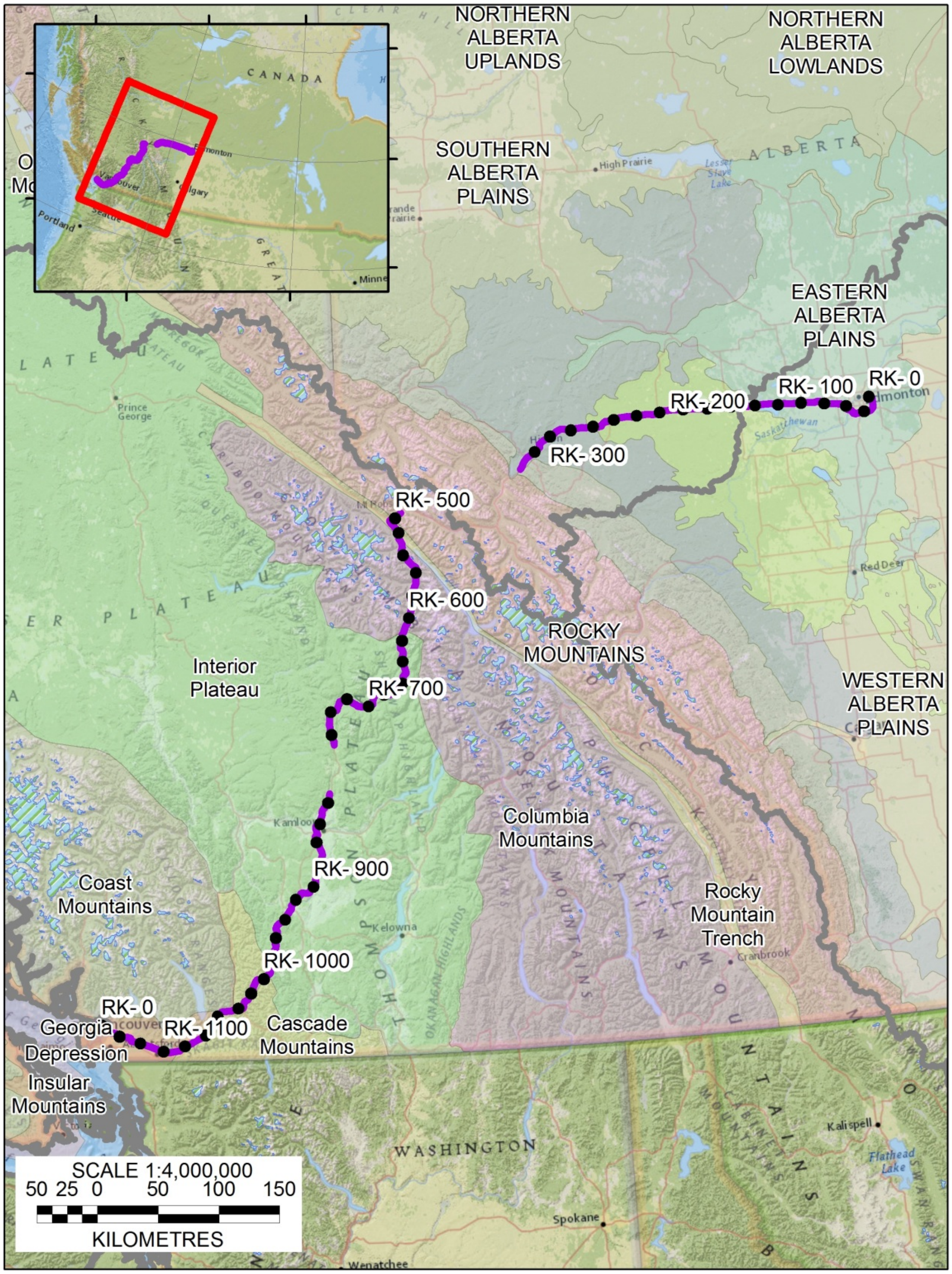


Figure 1-1. Location of the Proposed Trans Mountain Expansion Pipeline and Physiographic Regions.

2.0 TERRAIN STABILITY MAPPING

2.1. Terrain Stability Mapping Methods

Terrain stability mapping involves the subdivision of landscape into geomorphic units (i.e., terrain polygons), based on the criteria established for a particular study.

For the TMEP project, terrain mapping techniques were used to delineate areas with distinct surficial geology, landforms, terrain stability, and natural hazards. Areas of similar features and characteristics are delimited as polygons. Mapping methods were based on guidelines described by the Resources Inventory Committee (1996), using the terrain classification of Howes and Kenk (1997). The criteria used to differentiate the various features and characteristics of the terrain polygons are described in the following subsections.

Symbols describing material types, drainage, geomorphic processes, natural hazards and predicted slope stability following road construction or other ground disturbances were added to all terrain polygons. The presence of bedrock within an estimated 3 m of the surface was also noted for each polygon. Polygon attributes were entered into a data base with separate columns for each symbol. This will allow any mapped feature such as material type or presence of bedrock, to be rapidly identified for each polygon along the pipeline route.

Terrain mapping was based on stereoscopic interpretation of aerial photographs undertaken in 2012-2013. Digital aerial photos at approximately 1:20,000 scale were obtained for the entire route from either the Alberta or British Columbia governments. The digital aerial photos were georeferenced and set up in the Summit Evolution system, which allows viewing of the digital photos in 3D using polarized stereographic glasses. Mapping could then be completed in ArcGIS. The most recent available images were also ordered for each area; these ranged from 2000 to 2011. Where available, existing maps and reports were reviewed before mapping was started.

The completed terrain maps presented at 1:50,000 scale are provided in Appendix A.

2.2. Terrain Polygon Variability

The minimum size of terrain polygons that can be mapped at 1:20,000 scale terrain mapping is approximately 2 hectares. Thus local variations in terrain conditions over areas of 2 to 3 hectares, or over distances of less than approximately 150 metres, may not be identified in this scale of terrain mapping. As a result, within any polygon, variations in slope steepness and material characteristics can be expected. In addition, ratings for terrain stability and natural hazards are considered to be representative of an entire polygon. Consequently, small features may not be reflected in the evaluation. Examples include terrace scarps that may have active failures. The identification of smaller features within a polygon would require more detailed level field mapping. Terrain polygon boundaries are considered accurate to +/- 50 m.

2.3. Terrain Stability Interpretations

Terrain stability refers to the potential for slope instability or erosion within the polygon following disturbance by construction. The ratings assume appropriate surface water drainage management during the life span of the facility. Diversion of surface or groundwater by construction or blockage of culverts or ditches could result in slope instability on ground that is considered to be stable at present.

Terrain stability ratings range from Class I (stable) to Class V (unstable), as shown in Table 2-1, and were assigned to all terrain polygons. The classes are based primarily on slope angle, surficial material type, and observable geomorphological processes occurring within the polygon (e.g. gully erosion, existing active landslides), as shown in Table 2-2. For example, a slope morphology that includes irregular, near-surface bedrock would typically be rated as more stable than a similar slope with a smooth profile, because bedrock irregularities tend to stabilize soil against shallow instability caused by road construction or removal of forest cover.

There are some circumstances when Stability Class IV or V are automatically assigned to a polygon regardless of the soil or rock type or slope angle. Polygons with existing active landslides in bedrock or surficial soils are automatically assigned Class V ratings. For larger landslides, Stability Class V ratings are typically assigned to the headscarp areas, while the runout area is assigned a stability class based on its slope and morphology. Landslide headscarps that were active within the last 100 years or areas with visible shallow landslides were assigned Stability Class V. Areas comprising inactive or dormant deep-seated landslides were typically assigned Stability Class IV. Construction activities are more likely to trigger shallow landslides than deep-seated landslides.

Table 2-1. Terrain stability ratings for road construction (after Ministry of Forests, 1999)

Terrain Stability Class	Interpretation
I	Polygon is stable and no significant slope instability or erosion problems are present.
II	Polygon is stable and there is a very low likelihood of slope instability or erosion initiating in the polygon following cut and fill construction. Minor slumping is expected along soil cuts, especially for 1 or 2 years following construction.
III	Polygon is stable and there is a low to medium (<30%) likelihood of slope instability or erosion initiating in the polygon following cut and fill construction. Minor slumping is expected along soil cuts, especially for 1 or 2 years following construction.
IV	Polygon is marginally stable and it is expected to contain areas with a high (30% to 70%) likelihood of slope instability or erosion initiating in the polygon following cut and fill construction. Wet season construction will further increase the likelihood of construction-related slope instability or erosion.
V	Polygon is unstable and is expected to contain areas with a very high (>70%) likelihood of slope instability or erosion initiating in the polygon following cut and fill construction. Wet season construction will further increase the likelihood of construction-related instability or erosion.

Table 2-2. Criteria used to assign terrain stability classes (modified from Resource Inventory Committee, 1997)

<table>
<tr><th rowspan="3">TERRAIN STABILITY CLASS</th><th colspan="6">SLOPE CLASS</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th colspan="2">4</th><th>5</th></tr>
<tr><th>0.5%
(0-3°)</th><th>6-27%
(3-15°)</th><th>28-49%
(15-26°)</th><th>50-60%
(26-30°)</th><th>61-70%
(31-35°)</th><th>>70%
(>35°)</th></tr>
<tr><td rowspan="2">I</td><td>Mv, Mb; FGp, FGu; Fp; LGp, LGu; Rp, Ru</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Rj, Ru</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">II</td><td></td><td>Mv, Mb; FGf, FGu, FGj; Ff, Fj; Cf; Dv; L^Gj, L^Gu</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Ruh, Rum, Rur with Mw, Cv, Ra</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">III</td><td></td><td></td><td>FGa</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Mv, Mb; FGk, Cv, Cb</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">aCk, Rk</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">LGa, WGa</td><td></td><td></td></tr>
<tr><td rowspan="3">IV</td><td></td><td></td><td></td><td colspan="3">LGk, LGs, WGk</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Mb-V; Cb-V; (-V refers to dissected slopes)</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Mv, Mb; FGk, FGs; Cv; Cb, LGk, Uks, Us, WGk</td></tr>
<tr><td rowspan="2">V</td><td></td><td></td><td></td><td></td><td colspan="2">Mks-V; FGks-V; Cvb-V; WGs-V LGks-V, LGs-V</td></tr>
<tr><td colspan="6">all materials and landforms that are unstable (i.e. include the initiation zone of mass movements: -F”, -R”s, and/or –R”b*)</td></tr>
</table>

Note: Legends for the individual symbols can be found on each of the terrain map drawings located in Appendix A.

2.4. Natural Hazard Classes

For the purposes of this study, natural hazards are limited to slope and fluvial processes that may impact the polygon regardless of land use, and are synonymous with geohazards (which are a sub-set of natural hazards). These are naturally occurring processes such as rock fall, debris flows, debris floods, floods, channel changes, and rock avalanches. Polygons were assigned a rating from low (L) to high (H) based on the level of activity within the polygon (see Table 2-3).

Snow avalanches were not included in this classification. Snow avalanches are not likely to affect a buried pipeline, but could be a hazard during construction or inspection of the pipeline if these activities occur during avalanche season. The operational hazard related to snow avalanches will be covered under a separate report. Snow avalanches could also dam and divert creeks, causing erosion, flooding or avulsion. Where this scenario is deemed probable it is included as that hazard.

Natural hazards are shown in Appendix A on Drawings 1 to 54 as lines showing approximate initiation zones and runout distance. The lines should be regarded as an indicator of a hazard, not its extent, and show existing hazards only. They do not provide information on hazards risk.

Table 2-3. Criteria Used To Define Natural Hazard Classes

Likelihood of Occurrence of Hazard	Estimated Range of Annual Likelihood of Occurrence	Description of Activity of Geomorphic Processes	Terrain Attribute Criteria
High	>1/20	Hazard is currently or recently active; the occurrence of the terrain hazard(s) is imminent, and well within the lifetime of a person or typical structure.	Signs of recent or recurrent activity on photo imagery and/or in the field which is very significant, either through frequency of occurrence or spatial domination. Includes areas of landslide initiation, transportation, and deposition, unstable gullies, and active fans and floodplains.
Moderate	1/100 to 1/20	Hazard is inactive but there is potential for hazard to occur. It is currently not present but contributing factors and a trigger for a hazard are present. Terrain hazard(s) is probable within the approximate lifetime of a person or typical structure.	Evidence of historical activity and/or active, small-scale indicators; may also include areas of similar terrain attributes to nearby active areas. A more frequently active process may occur but will be spatially subordinate.
Low	< 1/100	Hazard is dormant or no hazard exists. Terrain hazard(s) is not likely, but is possible, within a given lifetime (i.e. ~ 1/100-1/500). Terrain hazard activity considered unlikely to nil would correspond to an annual likelihood of occurrence of ~<1/500.	Evidence of probable to possible relict activity and/or similar terrain attributes of areas of minor activity; no significant indications of activity for at least about 100 years. Areas where there is no evidence of geomorphic process activity are likely in a very low hazard class.

2.5. Drainage Classes

Drainage classes rate the potential for water to drain from a given polygon in relation to water supply (Table 2-4). These drainage classes assist with the design of drainage and erosion control structures.

Table 2-4. Example materials and locations for each drainage class (RIC 1996).

Drainage Class	Description	Example materials and locations
Rapid (r)	Water is removed rapidly in relation to supply	Exposed rock
Well (w)	Water is removed from the soil readily but not rapidly	Sand and coarser grained sediments, typically on upper slopes
Moderate (m)	Water is removed from the soil somewhat slowly in relation to supply	Coarser grained sediments, typically on mid-lower slopes
Imperfect (i)	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season	Coarser to finer grained sediments on lowermost slopes, gully bottoms, and in moist areas of floodplains
Poor (p) Very Poor (vp)	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen	Bogs in bedrock depressions, marshy or wet areas of floodplains

3.0 FIELD SURVEYS

Field inspection of the surficial geology, terrain, slope stability and natural hazards was completed in order to collect data to verify and update the terrain stability mapping. The field program consisted of three campaigns in June, August and September, 2013. Table 3-1 presents a breakdown of polygons mapped and verified in the field by physiographic region. Access to field sites was by vehicle or foot. At each site a natural cut was examined or a soil pit was hand dug. The following information was collected:

- Slope gradient and morphology
- Aspect
- Drainage
- Surficial material type and texture
- Coarse fragment lithology
- Presence and type of rock outcrops
- Presence of geomorphic processes
- Assessment of terrain stability

Table 3-1. Field Checking by Physiographic Area

Physiographic Region	Number of polygons mapped along corridor	Number of Polygons with ground observations	Number of Polygons with visual observations	Percent ground observations	Percent field checking total
Eastern Alberta Plains	160	19	11	12	19
Western Alberta Plains	207	33	12	15	22
Southern Alberta Plains	119	22	7	18	25
Rocky Mountains	26	12	6	46	64
Rocky Mountain Trench	34	10	6	29	47
Columbia Mountains	170	51	43	30	49
Interior Plateau	886	242	100	27	39
Cascade Mountains	262	60	100	23	61
Georgia Depression	105	18	17	17	33
Total	**1969**	**466**	**302**	**24**	**39**

4.0 SURFICIAL MATERIALS

4.1. Surficial Materials

In general, surficial materials can be considered to be of relatively young geological age. Other terms that are often used for surficial material are Quaternary sediments, unconsolidated materials, earth, and soil. Surficial materials are classified according to their mode of formation. Specific processes of erosion, transportation, deposition, mass wasting and weathering produce materials that have specific sets of physical characteristics (Howes and Kenk, 1997). Glaciofluvial, fluvial, till, colluvial, glaciolacustrine, glaciomarine, eolian and organic surficial materials and bedrock were identified along the pipeline corridor. Typical descriptions of each material, with their mapping codes, are given in the following sections.

4.1.1. Glaciofluvial (FG)

Glaciofluvial material is typically composed of coarse sands and gravels, deposited during the immediate post-glacial and earlier interglacial periods. It is commonly located in terraces above present river level.

4.1.2. Fluvial (F, FAp)

Fluvial material is deposited by the current river either in floodplains or low terraces and is typically composed of sand and gravel. Areas mapped as active floodplains (FAp) have little vegetation and are regularly flooded.

4.1.3. Colluvium (C)

Colluvium is material that has weathered and eroded from bedrock or other deposits and has been moved downslope by gravity. It is common as a thin veneer (< 1 m thick) on rocky slopes and as thicker deposits at the base of slopes which have experienced slumping or land sliding. The texture of colluvium reflects its source - where derived from bedrock, colluvium will typically be silt to gravel sized with some boulders and highly-disturbed bedrock.

4.1.4. Till (M)

Till is material that has been deposited by glacial ice. Typically, it is a highly consolidated deposit consisting of poorly sorted, usually matrix-supported subangular or subrounded clasts in a clayey-sandy-silt matrix. It is common as thick blankets or thin veneers throughout the study area.

4.1.5. Glaciolacustrine (LG)

Glaciolacustrine material was deposited into lakes that formed near the onset and end of the last glacial period. Typically this material consists of interbedded sand, silt and clay. Glaciolacustrine material is very common in the Thompson Valley near Kamloops, where it is exposed in scarp slopes and slump blocks.

4.1.6. Glaciomarine (WG)

Glaciomarine material was deposited in an offshore environment during a period of higher relative sea level. Typically it is composed of silt, clay and sand, and can be well-sorted and well-stratified to massive. Shells or other remains of marine organisms may be present. Glaciomarine material is found covering upland areas in the Fraser Valley west of Abbotsford at elevations below 200 m above sea level (asl).

4.1.7. Eolian (E)

Eolian material has been transported and deposited by wind. It typically consists of well-sorted fine sand and silt. Eolian material was mapped south of Tête Jaune Cache where dunes are present. Thin deposits may exist in other areas, overlying till or glaciofluvial material.

4.1.8. Organic (O)

Organic material is sediment that is composed largely of partially decomposed vegetative matter. It is common on floodplains of all major streams along the route. Organic material is also common and often extensive in low areas between Edmonton and Hinton.

4.1.9. Anthropogenic (A)

Anthropogenic is used where an area is sufficiently modified by human activity such that the original natural material, terrain stability and natural hazards are no longer relevant. This designation was used for features such as open pits and major highways where the slope has been built up or excavated, and when large debris flow control structures have been constructed.

5.0 DESCRIPTIONS OF TERRAIN BY PHYSIOGRAPHIC AREA

5.1. Geographic Setting

The proposed pipeline route covers approximately 1180 kilometers from Edmonton to Burnaby, passing through eight physiographic areas, including the Eastern and Western Alberta Plains, Southern Alberta Uplands, Rocky Mountains, Rocky Mountain Trench, Columbia Mountains, Interior Plateau, Cascade Mountains and the Fraser Lowland (Figure 1-1, Table 1-1). Each area contains distinct topographic features, surficial material, landforms and natural hazards (Holland, 1976; Pettapiece, 1986). For more information on the physiographic regions please refer to the report titled Route Physiography and Hydrology (BGC, 2013a).

5.1.1. Eastern Alberta Plains (RK 0 to 128.3)

This is a low relief area overlain by thick deposits of till and glaciolacustrine material. Topography is undulating to hummocky, and was formed by deposition of material either by ice or standing water. Bogs are common and often extensive in low-lying areas. Steep[1] slopes are present where larger streams have down cut through surficial materials and bedrock. Debris avalanches, rock fall and slumping may occur along steep slopes adjacent to Blackmud Creek, Whitemud Creek and North Saskatchewan River.

Table 5-1. Description of Material along the Pipeline Route- Eastern Alberta Plains

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Anthropogenic	1.4	1.0
Colluvium	0.2	0.1
Fluvial	1.9	1.4
Glaciofluvial	10.6	8.1
Glaciolacustrine	74.8	57.5
Lacustrine	0.7	0.5
Till	37.7	29
Organic	2.8	2.1
Total	**130**	

5.1.2. Western Alberta Plains (RK 128.3 to 262.4)

This is an area of low relief overlain by till and glaciolacustrine sediments with lesser amounts of fluvial, glaciofluvial, and organic material. Steep slopes are present where larger streams

[1] The following categories are used in this report to describe slope gradients: Gentle: 0-15º; Moderate: 15-35º; and Steep: >35º

have down cut through surficial materials and bedrock. Debris avalanches, rock fall and slumping may occur along steep slopes adjacent to the McLeod and Pembina Rivers.

Table 5-2. Description of Material along the Pipeline Route- Western Alberta Plains

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Fluvial	2.8	2.0
Glaciofluvial	15.6	11.5
Glaciolacustrine	44.1	32.4
Till	61.7	45.4
Organic	11.8	8.7
Total	**136**	

5.1.3. Southern Alberta Uplands (RK 262.4-339.4)

This is a low relief area mantled by thick till. Bedrock controls much of the topography, but few areas of bedrock exposure or shallow bedrock are present. Steep, gullied slopes are present at incised stream crossings. Shallow debris avalanches occur on steep gully sidewalls. Wetlands up to a size of 1 km long occur in low-lying areas.

Table 5-3. Description of Material along the Pipeline Route- Southern Alberta Uplands

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Colluvium	1.9	2.4
Fluvial	0.9	1.1
Glaciofluvial	9.1	11.7
Till	61.9	79.6
Organic	4.0	5.1
Total	**77.8**	

5.1.4. Rocky Mountains (RK 489.6-502.3)

The proposed pipeline route follows the Fraser River through the Rocky Mountains from Mt. Robson to Tête Jaune Cache. It is located on lower slopes or the valley floor. Glaciofluvial terraces, thick till and colluvial fans blanket the lower slopes. Where the Fraser River is incised into surficial material or bedrock, steep slopes with shallow debris avalanches are present. Debris flow or debris flood hazards are present on fans, particularly near their apex. Valley sides are steep and partially covered by thin deposits of till or colluvium. Rock outcrops are common. Rock fall and debris avalanches are present in places on mid and upper slopes, but few have travelled to the valley floor.

Table 5-4. Description of Material along the Pipeline Route- Rocky Mountains

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Colluvium	3.0	23.6
Fluvial	3.0	23.6
Glaciofluvial	3.8	29.9
Till	2.9	22.8
Total	**12.7**	

5.1.5. Rocky Mountain Trench (RK 502.3-523.7)

This is a broad valley separating the Rocky Mountains on the east and the Columbia Mountains to the west. The pipeline is on the lower slopes or valley floor on the eastern side of the trench. Much of the pipeline route traverses thick deposits of glaciofluvial and till and lesser amounts of colluvium and eolian material. Slopes on the eastern side of the valley, above the pipeline route are moderately steep to steep and up to 1,500 m in relief. These slopes are mantled by till with lesser deposits of colluvium and occasional rock outcrops. Rock fall and debris avalanches are present on upper slopes, but none are likely to impact the pipeline route in the valley.

Table 5-5. Description of Material along the Pipeline Route- Rocky Mountain Trench

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Colluvium	3.9	17.7
Eolian	2.3	10.4
Fluvial	0.5	1.8
Glaciofluvial	7.6	34.5
Till	7.2	32.7
Organic	0.1	0.4
Total	**22**	

5.1.6. Columbia Mountains (RK 523.7-612.1)

The pipeline route follows the valleys of the Albreda and North Thompson Rivers through the Columbia Mountains. This part of the route is characterized by steep valley walls with up to 2,000 m of relief and a narrow valley floor. The steeper upper slopes are typically rock with a thin colluvial cover. Lower slopes are mantled by thick colluvial, till or glaciofluvial deposits. Glaciofluvial materials between approximately RK 567 and RK 576, are predominantly composed of medium sand with silt layers. This material is highly erodible. Surface erosion and shallow debris slides are common in this area (Photograph 5-1).

Photograph 5-1. Ditch erosion in fine sands near RK 571

Debris flow, debris flood and/or channel erosion hazards exist on many fans. Rock fall and debris avalanche hazards are present on many steep rock and colluvium covered slopes throughout the area. Valley fill deposits are commonly undercut by the North Thompson River creating unstable slopes. Several large rock avalanche and slump headscarps are present on mid to upper slopes in this region, although none are thought to be currently active. The lower slopes on the west side of the river between approximately RK 576 and RK 578 appear to have been actively deforming in the recent past. While no tension cracks were noted during a field visit, several split trees were observed (Photograph 5-2), possibly indicting slope movement.

Photograph 5-2. Split tree on West side of the North Thompson River opposite RK 577.

Table 5-6. Description of Material along the Pipeline Route- Columbia Mountains

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Colluvium	30.8	33.6
Fluvial	34.2	37.3
Glaciofluvial	13.2	14.4
Till	9.6	10.5
Organic	3.8	4.1
Total	**91.6**	

5.1.7. Interior Plateau (RK 612.1 to 768.8; 811.85 to 993.8)

Upland areas of the Interior Plateau are typically rolling, while major valleys such as the North Thompson are often steep sided with moderate to high relief. Upland areas are mantled by till of variable thickness from less than 1 m to several metres thick. Valley bottoms contain thick deposits of glaciofluvial and modern fluvial material. Glaciolacustrine silts occur in terraces and valley floor deposits near Kamloops and Merritt.

The pipeline corridor largely follows the North Thompson River Valley from Blue River at RK 614 to Kamloops at RK 846. Several debris avalanches are present on steep slopes near the valley bottom (Photograph 5-3). Debris flows and debris floods occur on several fans. There is potential river erosion and flooding where the pipeline is located on the floodplain of the North Thompson River.

Photograph 5-3. Shallow debris slide on gully sidewall near RK 686.4

From Kamloops to Merritt at RK 928 the route is largely on rolling upland terrain consisting of bedrock mantled by till of variable thickness with occasional pockets of glaciofluvial material and colluvium.

South of Merritt the route travels up the Coldwater Valley to Coquihalla Summit at RK 993. Terrain on both sides of the Coldwater River is gently to moderately sloping. Slopes are rock controlled with a thin, discontinuous cover of till. Pockets of fine textured glaciofluvial and glaciolacustrine material are present throughout the area. These materials are highly erodible and subject to gully and surface erosion (Photograph 5-4) and shallow debris slides and slumps. Steep slopes subject to shallow debris avalanches are present where down-cutting has occurred adjacent to streams.

Photograph 5-4. Surface erosion in fine textured glaciolacustrine sediments along the ROW at RK 982.7

Table 5-7. Description of Material along the Pipeline Route- Interior Plateau

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Anthropogenic	4.4	1.3
Colluvium	53.1	15.6
Fluvial	78.7	23.1
Glaciofluvial	65.2	19.2
Glaciolacustrine	13.6	4.0
Till	119.6	35.1
Organic	2.9	0.9
Bedrock	2.7	0.8
Total	**340.2**	

5.1.8. Cascade Mountains (RK 993.8 to 1,091.8)

The Cascade Mountains are an area of high relief featuring many interconnected, narrow, steep sided valleys.

The proposed pipeline corridor parallels the Coquihalla Highway along the valley floor of Boston Bar Creek. Steep upper slopes are rock-dominant with colluvium or till mantling the mid and lower slopes. Snow avalanches are common along much of this route. Debris flows occur on many of the fans that infill the rounded valley floor and diversion structures have been built at several of the fan channels that are crossed by the highway.

From RK 1,019.5 the route parallels the Coquihalla River to Hope at RK 1044. This is a large, but still relatively narrow, steep-sided valley with rocky slopes that are partially overlain by colluvium or till. Debris flows commonly occur in the steeper creek channels and on their fans that often over-run the valley-floor fluvial deposits.

Between Hope and Rosedale the pipeline corridor is bounded between steep, rocky slopes to the south and the Fraser River to the north. Debris flows occur in many of the steep creeks along this section and could impact the pipeline where it crosses the fans. Between RK 1,078.5 and RK 1,081 the route crosses the deposit of the Cheam Rock Avalanche, a very large catastrophic landslide which occurred approximately 5,000 years ago (Naumann and Savigny, 1992; Orwin et al., 2004).

Table 5-8. Description of Material along the Pipeline Route- Cascade Mountains

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Anthropogenic	1.0	1.0
Colluvium	46.3	46.7
Fluvial	30.6	30.9
Glaciofluvial	6.7	6.8
Till	11.3	11.4
Organic	2.8	2.8
Bedrock	0.4	0.4
Total	**99.1**	

5.1.9. Georgia Depression (1,091.8 -1,180.1 Km)

West of Rosedale the pipeline crosses the Fraser Lowland. This is a low relief area consisting of the Fraser River floodplain, and rolling upland areas mantled by thick deposits of till, glaciolacustrine and glaciomarine deposits. Lacustrine deposits are present between RK 1,075 and RK 1,083 where Sumas Lake was drained. Thin to thick organic deposits occur on floodplains throughout this area. Where creeks cut down through the uplands, steep ravines are formed that are subject to shallow debris avalanches.

Table 5-9. Description of Material along the Pipeline Route- Georgia Depression

Surficial Material	Intersected length (km)	Percent of Physiographic Region
Colluvium	1.1	1.3
Fluvial	31.5	37.3
Glaciofluvial	10.2	12.1
Glaciolacustrine	0.7	0.8
Lacustrine	7.2	8.5
Till	13.6	16.1
Organic	7.9	9.4
Glaciomarine	19.4	23.0
Total	**91.6**	

6.0 GEOHAZARD INVENTORY

A geohazard (a subset of natural hazards) is an event "caused by geological features and processes that present severe threats to humans, property and natural and built environments" (Geohazards, 2006). As such, geohazards pose potential threats to pipeline projects during construction, with respect to worker safety, and during operation with respect to potential damage to infrastructure and the safety of operating personnel. For the purposes of developing an inventory, hazards were considered solely on the basis of the potential to impact the proposed pipeline corridor. In development of the inventory, specifics related to vulnerability and likelihood of occurrence were not considered, and the corridor was assumed to exist without any mitigation design.

6.1. Scope

The geohazard inventory was developed using the Version 6 TMEP corridor (August 2013), and extended to slopes above the pipeline route on both sides of the corridor where hazards could originate. In cases where gentle slopes occur on the upper slopes, these were viewed on the air photos but hazards were not assessed unless clear indication of continuation down to the corridor was noted. Where the pipeline crosses plateau areas or is located in broad valleys, approximately 500 to 1,000 m on each side of the route were assessed. Where the pipeline parallels large rivers, such as the Fraser, as with the mapping, the geohazard inventory was completed only on the side of the river on which the pipeline is located. In addition to noting individual hazards, zones where similar hazards could occur were defined (e.g. areas of numerous rockfall or avalanche paths). The accuracy of the length over which the geohazard were considered to influence is +/- 50 m.

The inventory was restricted to include only geohazards with direct influence on the corridor, and did not include secondary or possible subsequently triggered events. Examples of secondary or subsequently triggered events would be flooding leading to bank erosion or stripped vegetation from a debris flow leading to soil erosion. In these examples, only flooding or debris flows would be indicated as the geohazard unless direct evidence of the secondary hazard historically occurring on site has been observed. Historic faults have been included in the hazards assessment based on approximate locations noted in publically available provincial geological databases and maps. However, as described above, seismically triggered hazards which may trigger secondary ground movement (such as liquefaction or lateral spreading) were not considered part of this inventory and are specifically discussed under separate filing in the BGC seismic report (BGC, 2013b).

6.2. Inventory Methodology

The inventory was developed based on an understanding of the geology, landform and hazard types, and of potential natural hazards triggers. Engineering judgment and experience in similar terrain and for similar infrastructure have been relied upon heavily in recognizing existing or potential geohazards in the development of this inventory.

The geohazards inventory was developed using several sources, including:

- Features identified from the terrain mapping;
- review of aerial imagery;
- observations undertaken during field verification of the terrain mapping;
- historic records of geohazards along the TMPL route; and,
- review of recent video flown along the TMEP route.

The initial inventory was developed from features identified in the terrain and slope mapping, as described in Sections 0 and 2.1, and was completed using 1:20,000 aerial photographs, and the Canadian Digital Elevation Data Set at a scale of 1:50,000. As discussed in Section 3.0, field review of the proposed pipeline route was completed to confirm the office-based terrain mapping. Where additional hazard sites or further information was noted, the new information was incorporated into the inventory.

In addition to the hazards identified though the terrain mapping process, the inventory was supplemented through records obtained from Kinder Morgan's geohazards database (Cambio™) for the existing TMPL pipeline corridor. This database provides regional and site specific hazard and mitigation information from annual field inspections conducted by KMC, BGC and other groups since 1998 at specific geohazard locations along the existing TMPL pipeline route.

Lastly, an immersive video (continuous 360° view) recording, conducted using a helicopter and live flight recording along the TMPL pipeline corridor in 2012, was reviewed by BGC for confirmation of hazards and their extents. The flight video provided the ability to review recent imagery from multiple directions, which included some near vertical slopes which are not easily assessed using air or satellite photos.

Some hazards that have been identified through this study may be subsequently discounted through further understanding of relevant site geology, geometry or other mitigating conditions.

6.3. Description of Geohazard Types

Geohazards can result in threats to people, property and natural and built environments. Threats may be activated by natural or anthropogenic means and have been separated into a subset of geological, hydrotechnical and geotechnical origination conditions. The following paragraphs provide an introduction to the classes of geohazards assessed as part of this study.

6.3.1. Hydrotechnical

Hydrologic and hydrotechnical hazards are those which involve water "occurrence, movement, and distribution" (Committee on U.S. Geological Survey Water Resources Research, 1999). Typically, these hazards involve water flows which are above or below normal flow conditions. For the purposes of this report, a stream is defined as a channelized, flowing body of water of sufficient size to capture and transport water across a surface.

6.3.1.1. Flooding

When a stream or body of water overflows its natural channel boundaries, this is termed a "flood". Upstream floods are those that occur in the upper reaches of a stream, and are typically the result of intense precipitation events. These types of floods can occur with little to no warning, but are typically short in duration. Downstream floods are those that occur in the lower reaches of a stream, and are the result of prolonged precipitation or rapid snowmelt. These floods are typically forecasted but are prolonged in duration. An outburst flood was classified under flooding for the purpose of this report. It is a sudden, high-volume flood surge caused by the break of a natural dam and rapid release of stored water.

6.3.1.2. Scour, Erosion and Bank Erosion

Scour is erosion of particles from a stream bed to produce downcutting of the material. This typically results in some loss of cover over buried pipelines, sometimes causing pipeline exposure. Flooding may cause water to occupy areas which do not typically retain water, increase erosion along river margins, landslides, and sediment deposition. Erosion is often associated with flood events and could result in exposure of a buried pipeline. Erosion due to flooding is possible at most stream and fan crossings and on floodplains throughout the pipeline route.

6.3.1.3. Debris Floods

Debris floods are flood events carrying large amounts of debris, but generally lower debris content than debris flows, that can result in channel avulsions and scour. These are common on fans in the Thompson Valley, Boston Bar Creek, Coquihalla Canyon and along the Fraser River south of Hope.

6.3.1.4. Debris Flows

Debris flows are the rapid downslope movement of saturated debris. These most often initiate in gullies and deposit on fans at the base of slopes. Scour is common along debris flow paths. Debris flows are common on fans in the Thompson Valley, Boston Bar Creek, Coquihalla Canyon and along the Fraser River west of Hope.

6.3.1.5. Avulsion

Avulsion is channel switching, erosion or formation of a new channel on an alluvial fan or flood plain. This is sometimes caused by peak flows and floods, but does not include changes occurring outside an alluvial fan or flood plain.

6.3.1.6. Tsunami

A Tsunami generally describes a fast moving, potentially high mass of water affecting coastal areas to some run-up height, often triggered by earthquakes.

6.3.2. Ground Movement and Geotechnical Hazards

Ground movement and geotechnical hazards are generally those in which the slope material, rock or soil, moves downward and outward as a result of the interaction between material strength and driving forces. The following section has been separated into rock and soil dominant hazards.

6.3.2.1. Rock Slope Hazards

6.3.2.1.1 Rockfall

Rockfalls are described as the rapid detachment of a rock from a slope face and falling under the influence of gravity with little to no lateral displacement. The movement is very rapid, and rocks can topple or roll to increase the distance travelled after detaching from the slope. Rockfalls are common on steep slopes and cliffs throughout the study area and can also happen along open rock-cut faces where exposed discontinuities within the rock create weak points along which failure can propagate. Water or freeze-thaw cycles may increase the possibility of a rock fall occurring on a slope.

6.3.2.1.2 Extremely Rapid Rockslides

An extremely rapid rockslide is a mass of rock (typically < 10,000 m^3) which detaches from a slope and slides rapidly downward. The sliding mass fragments rapidly and converts to granular flow-like motion if it progresses down a long enough slope.

6.3.2.1.3 Debris and Rock Avalanches

Debris and rock avalanches are the rapid descent of a mass of debris or rock down an open slope. Debris avalanches are common on gully side walls, terrace scarps, and steep open slopes throughout the study area. Rock avalanches typically originate on upper slopes and travel rapidly to the valley floor. No recent rock avalanches were mapped along the route.

6.3.2.1.4 Rock Slumps and Sakungen

Rock slumps are deep-seated, rotational failures in surficial material or bedrock that can move either slowly or rapidly. Several slumps were mapped along the pipeline route, most commonly along the valley walls bordering the North Thompson River. Most are believed to be currently inactive and are not expected to impact the corridor. Sakungen are slope sag features, having characteristic features such as lineaments near ridge tops and small bulges at the toe of movement. Toppling is commonly associated with sakungen and leads to planar rock slides. Several are mapped along the corridor, particularly along the North Thompson Valley. In general the features noted were too far up the valley slope or there were flat ridges between the feature and the corridor, thus they were not included in the hazards database.

6.3.2.2. Soil Slope Hazards

6.3.2.2.1 Slow Earth Slides

Slow earth slides are areas where translational or rotational slides in soil that move very slowly (< 1.6 m/year). Typically these are found on steep slopes which have been cleared and have weak foundation soil and/or a high groundwater.

6.3.2.2.2 Rapid Earth Slides

Rapid earth slides are slopes with translational or rotational slides in soil that move at a moderate to rapid speed (generally >13 m/month). Such slides are usually triggered by specific events such as strong or prolonged precipitation, undercutting, or seismicity.

6.3.2.2.3 Soil Raveling (cut slope)

Soil raveling is related to movement of topsoil and small debris, causing gullying and potentially result in stability issues in the surrounding ground.

6.3.2.2.4 Slow Earthflows

Slow earthflows are a slow-moving mass of cohesive soil (such as glaciolacustrine clay), peat, or very weak rock that moves through internal deformation (flow) rather than by shearing along a distinct basal surface. Can be initiated by a 3rd party through adjacent construction loading.

6.3.3. Seismic Hazards

Seismically triggered hazards are reviewed under separate BGC report cover titled "TMEP Seismic Assessment Screening Studies" (BGC, 2013b). Selected notable areas were included in the geohazards inventory specific to the processes below.

6.3.3.1. Liquefaction

Liquefaction is related to rapid strength loss and flow of unconsolidated sediments that are at or near saturation during seismic shaking. Liquefaction was included only at the Fraser River crossing near the Port Mann Bridge.

6.3.3.2. Fault Displacement

This hazard is related to potential rupture along a tectonic fault surface causing rapid displacement of adjacent ground and earthquake shaking.

6.3.3.3. Strong Shaking

Strong shaking is caused by earthquake ground motions, and is potentially amplified by thick layers of soft sediments. This could cause structural damage to bridges if not designed for seismic loads, including third party bridges used for construction and operational access. The entire Lower Mainland area has been noted as an area with this hazard present.

6.3.3.4. Historic Faults

Historic faults were noted from literature and provincial map databases, and are suggested to be pre-Holocene in age (older than 11,000 years) and considered inactive. These faults are indicated with approximate locations. At this stage the faults have been included to note potential need for further assessment during the detailed engineering design phase to confirm their location and activity.

6.3.4. Snow and Ice Hazards

6.3.4.1. Snow Avalanches

Snow avalanches are the rapid downslope movement of snow. Snow avalanches begin on unforested moderate to steep slopes in mountainous terrain. Failures occur when the strength of an underlying snow layer is overwhelmed by the weight of the overlying snow pack. Avalanches can entrain vegetation along their path, and can be very destructive due to their speed, high density, and travel distances. While these can be destructive for surface structures these are unlikely to impact a buried pipeline, but have the potential to impact construction activities.

Where present, snow avalanches are included in the terrain symbol, but are not generally reflected in natural hazard class rating. Only one area along the corridor near the Coquihalla Summit has been included in the assessment database; however further work related to avalanches is ongoing for construction and operational safety under a separate report cover.

6.3.5. Other Ground Hazards

6.3.5.1. Erosion and Sedimentation

Erosion is the loss and transport of soil by erosive power of surface water and wind potentially occurring as rill erosion or gullying, as examples, and potentially depositing in streams. Sedimentation is the deposition of material in a location after transportation. Erosion has been classified under soil slope hazards for the purpose of this report and has generally been noted separately to soil raveling, which is larger in scale and effect. Sedimentation has not been noted in this study.

6.3.5.2. Acid Rock Drainage and Metals Leaching

This hazard is related to environmental concerns and soil/rock management during construction and operations. It is from the development of low pH or metals-impacted runoff due to interaction between surface water or shallow groundwater and disturbed ARD/ML rocks. Only one known location is currently included in the inventory, near Vavenby, BC. However, this hazard is discussed in detail and further potential sites are noted in the BGC report titled: “Acid Rock Drainage and Metal Leaching Assessment” (BGC, 2013).

6.4. Summary of Geohazards

The following section provides a summary of the geohazards assessment by physiographic region and hazard type. Table 6-1 presents the results of the current hazards assessment by physiographic region and is shown graphically in Drawing B-01 in Appendix B, while Table 6-2 shows the breakdown by the dominant hazard type grouping.

In general the North Thompson and Coquihalla regions have a higher potential for large geohazard events, while Alberta and west of the Coquihalla are mainly dominated by hydrotechnical and seismic geohazards. A full list of the hazards by chainage and type is found in Appendix B. Locations of the geohazards identified in Appendix B are also shown corresponding to the specific geohazard number on the terrain maps in Appendix A.

Table 6-1. Summary of Geohazards by Physiographic Region

Segment name	RK Start Chainage (km)	RK End Chainage (km)	Number of Hydrotechnical	Number of Geotechnical	Number of Seismic and Others	Total
Eastern Alberta Plains	0	128.3	16	1	8	25
Western Alberta Plains	128.3	262.4	30	2	9	41
Southern Alberta Uplands	262.4	339.4	10	0	2	12
Rocky Mountains	489.6	502.3	6	1	1	8
Rocky Mountain Trench	502.3	523.7	4	0	3	7
Columbia Mountains	523.7	612.1	48	11	17	76
Interior Plateau (Shuswap)	612.1	768.8	72	9	18	99
Interior Plateau (Thompson)	811.85	993.8	28	15	18	61
Cascade Mountains	993.8	1,091.8	43	16	11	70
Georgia Depression	1,091.8	1,180.1	21	9	5	35
Total			**278**	**64**	**92**	**434**

The table above indicates that hydrotechnical hazards are present throughout the corridor length, while the geotechnical hazards are focused in several distinct mountainous regions where there are narrow valleys.

Table 6-2. Summary of Geohazards Types and Quantity

Type	Quantity
Hydrotechnical	
Scour and bank erosion	178
Flooding and floodplains	38
Debris floods	6
Debris flows	44
Avulsion	10
Other – Tsunami, outburst flooding	2
Ground Movement and Geotechnical	
Rock	
Rockfall (natural and cut slope)	24
Rapid rock slide	2
Debris and rock avalanches	1
Slumps and sakungen	2
Soil	
Slow earth slide	9
Rapid earth slide	4
Slow earthflow	1
Soil ravelling (cut slope)	2
Debris and debris slide	9
Soil erosion	10
Other	
Snow Avalanche zones	1
Seismic – including historic faults	90
Known ARD zones	1
Total	**434**

7.0 CLOSURE

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

Yours sincerely,

BGC ENGINEERING INC.
per:

ISSUED AS DIGITAL DOCUMENT.
SIGNED HARDCOPY ON FILE WITH
BGC ENGINEERING INC.

Betsy Waddington, M.Sc., P.Geo.
Senior Geoscientist

ISSUED AS DIGITAL DOCUMENT.
SIGNED HARDCOPY ON FILE WITH
BGC ENGINEERING INC.

Patrick Nolan, P.Eng.
Civil Engineer

Reviewed by:

ISSUED AS DIGITAL DOCUMENT.
SIGNED HARDCOPY ON FILE WITH
BGC ENGINEERING INC.

Dennis Maynard, M.Sc., P.Geo.
Senior Geoscientist
Denny Maynard & Associates Ltd.

ISSUED AS DIGITAL DOCUMENT.
SIGNED HARDCOPY ON FILE WITH
BGC ENGINEERING INC.

Dr. K. Wayne Savigny, P.Eng., P.Geo., F.E.I.C.
Senior Geotechnical Engineer / Engineering Geoscientist

BW/KWS/th

APEGGA Permit to Practice: 5366

REFERENCES

Alberta Geological Society. Bedrock geology compilation. 1:1,000,000 scale. Available from http://www.ags.gov.ab.ca/GIS/download_gis.htm [accessed June 16, 2013].

BGC Engineering Inc. 2013a. TMEP Route Physiography and Hydrology.

BGC Engineering Inc. 2013b. TMEP Seismic Screening Studies.

Holland, S.S., 1976. Landforms of British Columbia, A Physiographic Outline. Bulleting 48, BC Department of Mines and Petroleum Resources. 138 pp.

Howes, D.E. and Kenk, E. (eds.), 1997. Terrain Classification System for British Columbia, Version 2. A system for the classification of surficial materials, landforms and geological processes of British Columbia. Resource Inventory Branch, Ministry of Environment, Lands and Parks, Province of B.C. Victoria, B.C. 100pp.

Ministry of Energy and Mines, 2005. B.C. Digital Geology Maps. 1:250,000 scale. Available from http://www.mapplace.ca/ [accessed June 16, 2013].

Ministry of Forests, 1999. Mapping and Assessing Terrain stability Guidebook, Second Edition. Forest Practices Code Guidebook dated August 1999.

Naumann, C.M. and Savigny, K.W., 1992. Large rock avalanches and seismicity in Southwestern British Columbia. In, Proceedings of the 6th International Symposium on Landslides, held in Christchurch, New Zealand, February 10-14, 1992. David H. Bell (ed), pp. 1187-1192.

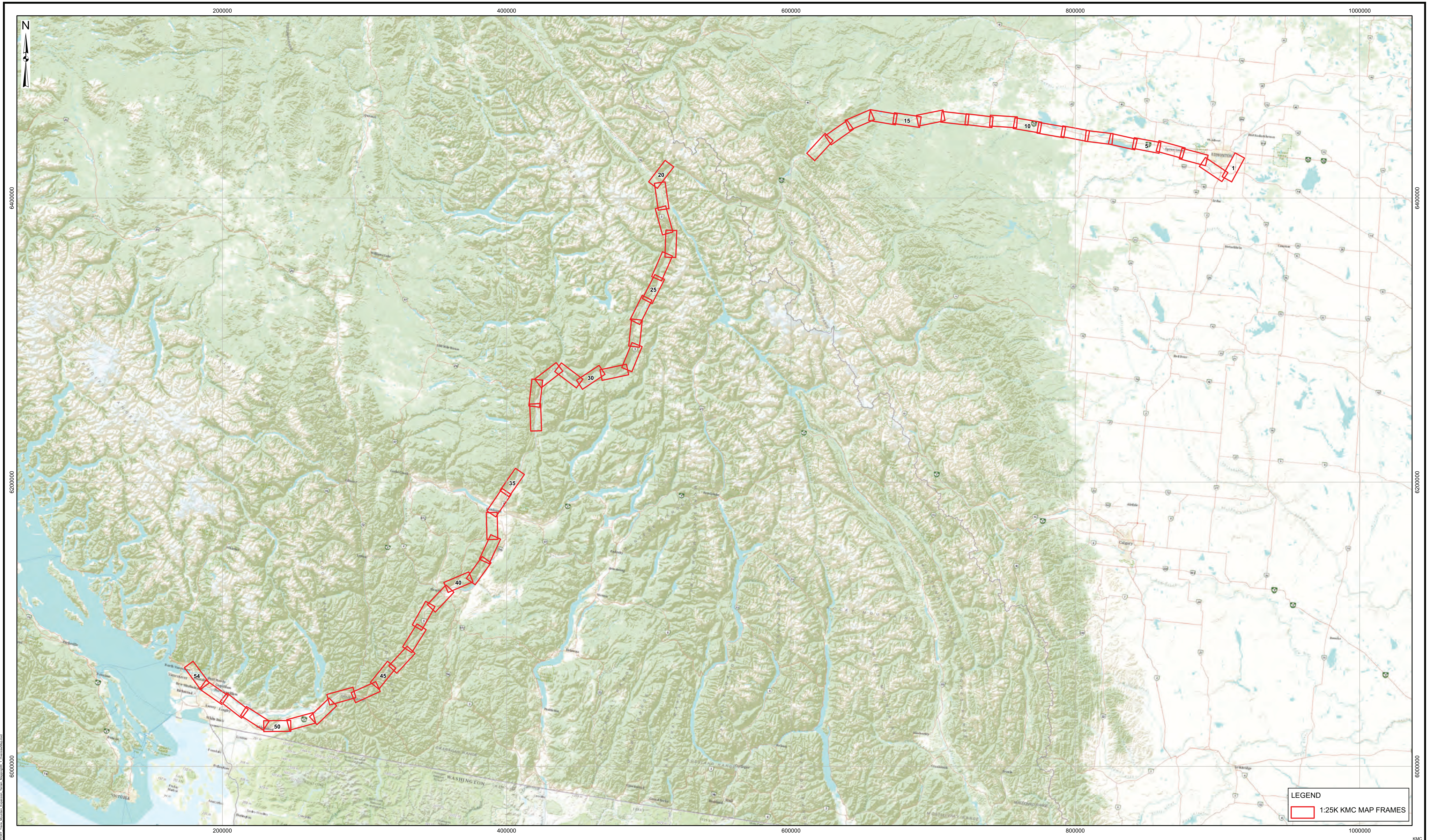
Orwin, J.F., Clague, J.J., Gerath, R.F., 2004. The Cheam Rock Avalanche, Fraser Valley, British Columbia, Canada. Landslides 1:289-298.

Pettapiece, W.W., 1986. Physiographic Subdivisions of Alberta. 1:1,500,000 scale. Land Resource Research Centre, Research Branch, Agriculture Canada.

Resource Inventory Committee, 1996. Guidelines and Standards to Terrain Mapping in British Columbia. Guidelines prepared by the Resource Inventory Committee Surficial Geology Task Group. 131 pp.

Resource Inventory Committee, 1997. Terrain Stability Mapping in British Columbia. Prepared by the Resource Inventory Committee Surficial Geology Task Group

APPENDIX A
TERRAIN MAPS



KMC

SCALE 1:2400000

50 25 0 50 100 150

KILOMETRES

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:2400000
DATE:	NOV 2013
DRAWN:	SMR
DESIGNED:	AB
CHECKED:	ML
APPROVED:	ML

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: TRANSMOUNTAIN

PROJECT: TRANS-MOUNTAIN EXPANSION PROJECT

TITLE: TERRAIN MAPS INDEX MAP

PROJECT No.:	DWG No.:	REV.:
0095150	00-1	

DWG TO BE READ WITH BGC REPORT TITLED "TRANS-MOUNTAIN EXPANSION PROJECT" DATED NOVEMBER 2013

TMEP Terrain Mapping Legend

Simple Terrain Symbols Used when one surficial material is present within a polygon

Example: zCb – Rb

- Material Texture (z)
- Surficial Material (C)
- Surface expression (b)
- Geomorphological process (up to 3 may be assigned) (R)
- Geomorphological process sub-type (b)

Composite Terrain Symbols Used when 2 or 3 terrain types are present within a polygon

Cv.Mv	indicates that 'C' and 'M' are roughly equal in extent
Cv/Mv	indicates that 'C' is greater in extent than 'M' (about 60:40)
Cv//Mv	indicates that 'C' is much greater in extent than 'M' (about 80:20)
Cv.Rs/Mv	indicates that 'C' and 'R' are roughly equal in extent and both are greater in extent than Mv (about 40:40:20)

Stratigraphic Terrain Symbols

Cv|Mj indicates that 'Cv' overlies 'Mj'

Surficial Material Types

C	Colluvium	R	Bedrock	LG	Glaciolacustrine
L	Lacustrine	M	Glacial Till	WG	Glaciomarine
F	Fluvial	O	Organic	U	Till, Glaciolacustrine, Glaciofluvial (interbedded)
E	Eolian	FG	Glaciofluvial	D	Weathered bedrock
A	Anthropogenic				

Surface Expressions

p	Plain (0-3°)	v	Veneer (0-2 m thick deposit)
j	Gentle Slope (4-14°)	b	Blanket (>2 m thick deposit)
a	Moderate Slope (15-26°)	w	Variable Thickness Deposit)
k	Moderately Steep Slope (27-35°)	m	Rolling
s	Steep Slope (>35°)	h	Hummocky
c	Cone (>15°)	f	Fan (<15°)
r	Ridge	u	Undulating
t	Terrace	d	Depression

Textural Terms and Symbols

a	blocks	b	boulders	k	cobbles
p	pebbles	s	sand	z	silt
c	clay	d	mixed fragments	x	angular fragments
g	gravel	m	mud		

Activity Level

FAp	'A' Indicates active floodplain (subject to channel changes)
CIf	'I' Indicates inactive fan

Geomorphologic Processes

R	Rapid landslide (runout zone)	V	Gully erosion
R"	Rapid landslide (initiation zone)	F"	Slow landslide (initiation zone)
H	Kettled	L	Seepage
U	Flooding	E	Melt water channels
A	Snow Avalanches	B	Braided Channel
M	Meandering Channel	I	Irregular Channel
J	Anastamosing Channel	K	Karst
N	Nivation	P	Piping
S	Solifluction	W	Washing
X	Permafrost	Z	Periglacial Processes

Geomorphological Process Subtypes

b	Rockfall	r	Rock slides	e	Earthflow
d	Debris flows	m	Bedrock slump	k	Tension cracks/sackung
s	Debris avalanches	u	Surficial material slump	Ud	Debris floods
a	Channel avulsion	c	Soil creep	g	Rock creep

Examples

Rs//Cv – VR"bd	Steep bedrock slope with <20% cover of a colluvial veneer; gullied with initiation zones for rockfall and debris flows.
FAp – U	Active floodplain potentially subject to flooding
Cj – F"g	Thick, gentle colluvium forming a rock glacier
Cf – Rd	Colluvial fan subject to debris flows
Ck – Rb	Colluvial slope subject to rockfall (talus slope)

Terrain Stability Class

I	No significant stability problems exist.
II	There is a very low likelihood of landslides following timber harvesting or road construction. Minor slumping is expected along road cuts, especially for 1 or 2 years following construction
III	There is a low (<30%) likelihood of landslide initiation following timber harvesting or road construction. Minor slumping is expected along road cuts, especially for 1 or 2 years following construction.
IV	Expected to contain areas with a moderate (30-70%) likelihood of landslide initiation following timber harvesting or road construction. Wet season construction will significantly increase the potential for road-related landslides.
V	Expected to contain areas with a high (>70%) likelihood of landslide initiation following timber harvesting or road construction. Wet season construction will significantly increase the potential for road-related landslides.

Natural Hazard Class

L	No existing hazard, or hazard is dormant, i.e. hazard has not been active in the last 100 to 1,000 years or it has developed under different climatic conditions.
M	Hazard is inactive. Vegetated tracks can be observed in airphotos. Smaller more frequent events, such as rock fall, may affect a small area of the polygon. No evidence that the hazard has been active within the 20 years but trigger is present. Hazard is unlikely to occur within the life of the project.
H	Hazard is currently active or shows evidence of activity in the last 20 years. Hazard likely to occur within life of project.

Soil Drainage Classes

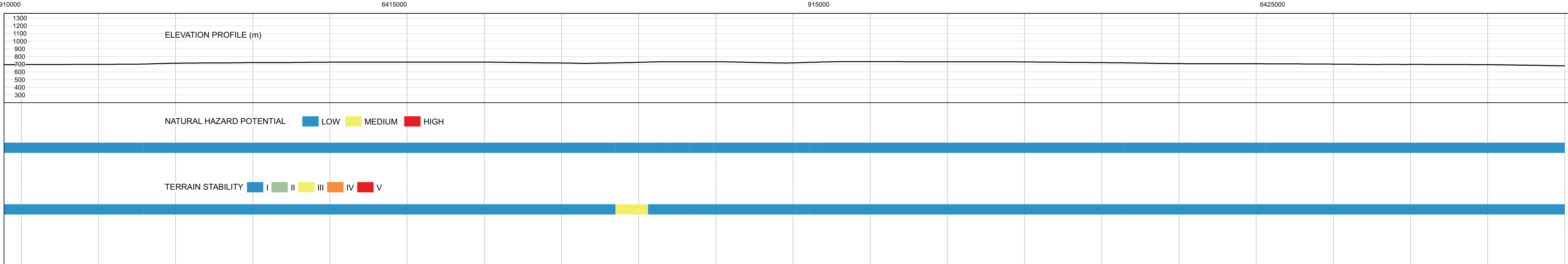
r	Rapidly drained:	Water is removed from the soil rapidly in relation to supply.
w	Well-drained:	Water is removed from the soil readily but not rapidly.
m	Moderately well-drained:	Water is removed from the soil somewhat slowly in relation to supply.
i	Imperfectly drained:	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season.
p	Poorly drained:	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen.
v	Very poorly drained:	Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen.

- SACKUNG
- LANDSLIDE SCARP
- DEBRIS FLOW

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:
DATE: NOV 2013
DRAWN: JVC, GLT
DESIGNED: AB
CHECKED:
APPROVED:
PROFESSIONAL SEAL:
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
CLIENT: TRANSMOUNTAIN
PROJECT: TRANS-MOUNTAIN EXPANSION PROJECT
TITLE: TERRAIN MAPS LEGEND
PROJECT No.: 0095150
DWG No.: 00-2
REV.:

DWG TO BE READ WITH BGC REPORT TITLED "TRANS-MOUNTAIN EXPANSION PROJECT" DATED NOVEMBER 2013



10 m CONTOUR INTERVAL
KMC

SCALE 1:50000

600 300 0 600 1200 1800

METERS

NOTES:

1. SMALL MAGNITUDE GEOHAZARDS EXIST (E.G. LOCALIZED ROCKFALL) THAT WERE TOO SMALL TO MAP
2. ARROWED LANDSLIDE PATHS SHOW GENERAL SLIDE TRAJECTORIES. THEY DO NOT SHOW HAZARD EXTENTS. PATH ARROWS EXTEND INTO THE GENERAL RUNOUT ZONE BUT DO NOT REPRESENT THE MAXIMUM RUNOUT LIMIT.
3. LANDSLIDE HAZARD EXTENTS ARE SHOWN BY SHADED POLYGONS. THEY SHOW EXISTING LANDSLIDE HAZARD INITIATION ZONE AND RUNOUT AREAS. POLYGON BOUNDARIES SHOULD BE REGARDED AS TRANSITIONS, NOT SHARP BOUNDARIES.
4. THIS MAP IS A SNAPSHOT IN TIME. CHANGES IN LAND USE (E.G. DEVELOPMENT, RIVER MIGRATION) MAY WARRANT RE-DRAWING OF CERTAIN AREAS.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:50000
DATE:	NOV 2013
DRAWN:	JVC, GLT
DESIGNED:	AB
CHECKED:	
APPROVED:	

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

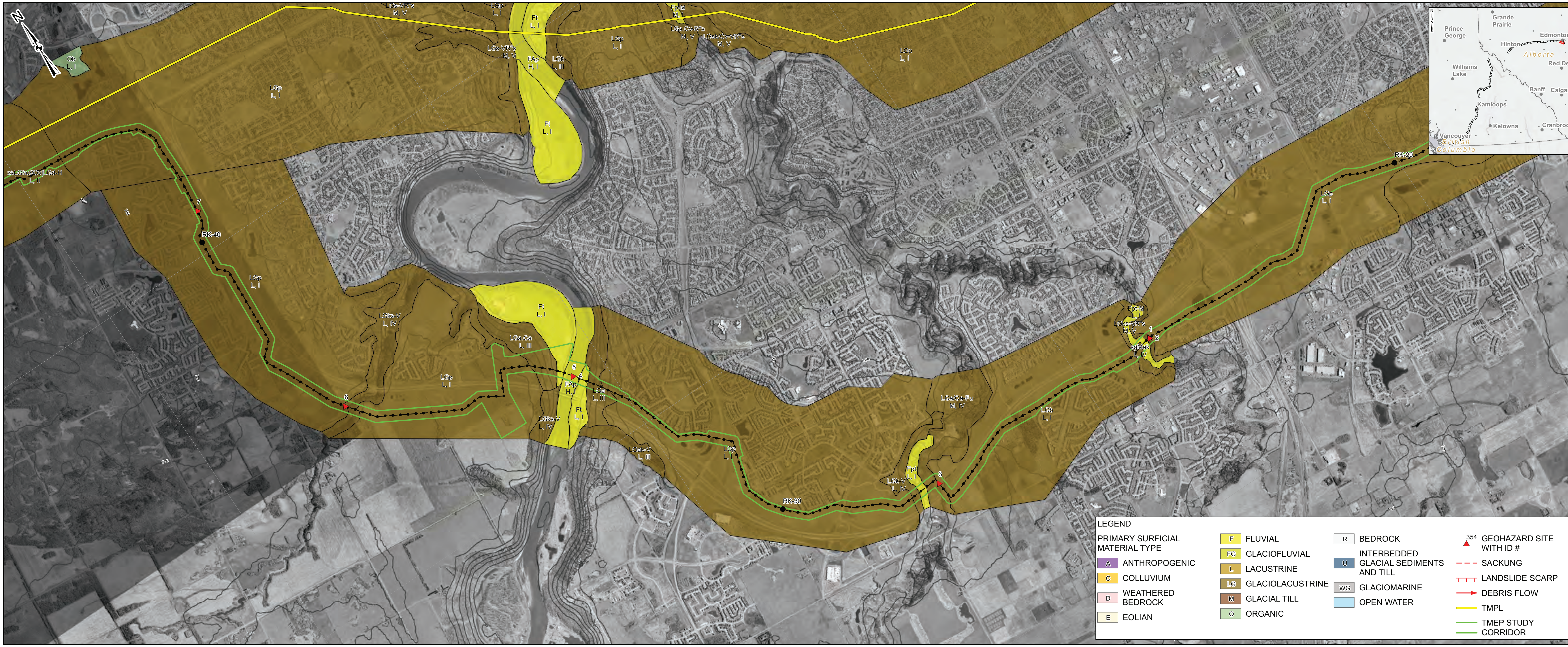
CLIENT: TRANSMOUNTAIN

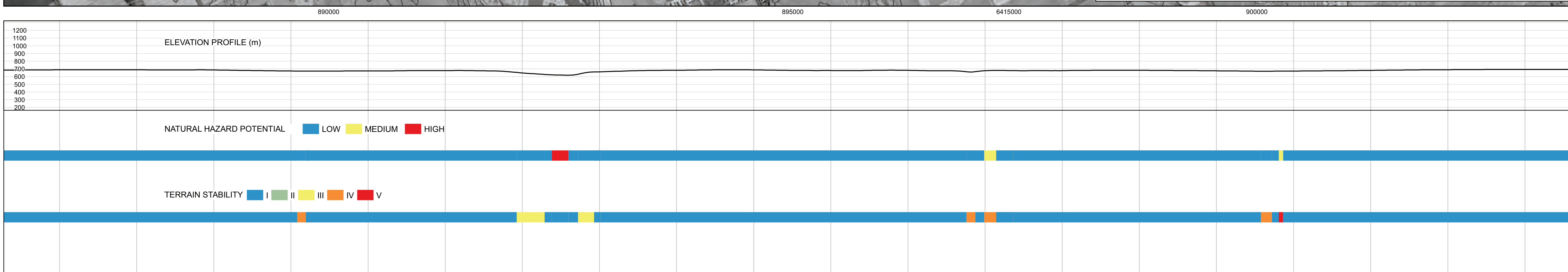
PROJECT: TRANS-MOUNTAIN EXPANSION PROJECT

TITLE: TERRAIN MAP
MAP NUMBER 1 OF 54

PROJECT No.:	DWG No.:	REV.:
0095150	1	

DWG TO BE READ WITH BGC REPORT TITLED "TRANS-MOUNTAIN EXPANSION PROJECT" DATED NOVEMBER 2013





10 m CONTOUR INTERVAL
KMC

SCALE 1:50000

600 300 0 600 1200 1800

METERS

NOTES:

1. SMALL MAGNITUDE GEOHAZARDS EXIST (E.G. LOCALIZED ROCKFALL) THAT WERE TOO SMALL TO MAP
2. ARROWED LANDSLIDE PATHS SHOW GENERAL SLIDE TRAJECTORIES. THEY DO NOT SHOW HAZARD EXTENTS. PATH ARROWS EXTEND INTO THE GENERAL RUNOUT ZONE BUT DO NOT REPRESENT THE MAXIMUM RUNOUT LIMIT.
3. LANDSLIDE HAZARD EXTENTS ARE SHOWN BY SHADED POLYGONS. THEY SHOW EXISTING LANDSLIDE HAZARD INITIATION ZONE AND RUNOUT AREAS. POLYGON BOUNDARIES SHOULD BE REGARDED AS TRANSITIONS, NOT SHARP BOUNDARIES.
4. THIS MAP IS A SNAPSHOT IN TIME. CHANGES IN LAND USE (E.G. DEVELOPMENT, RIVER MIGRATION) MAY WARRANT RE-DRAWING OF CERTAIN AREAS.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE: 1:50000
DATE: NOV 2013
DRAWN: JVC, GLT
DESIGNED: AB
CHECKED:
APPROVED:

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

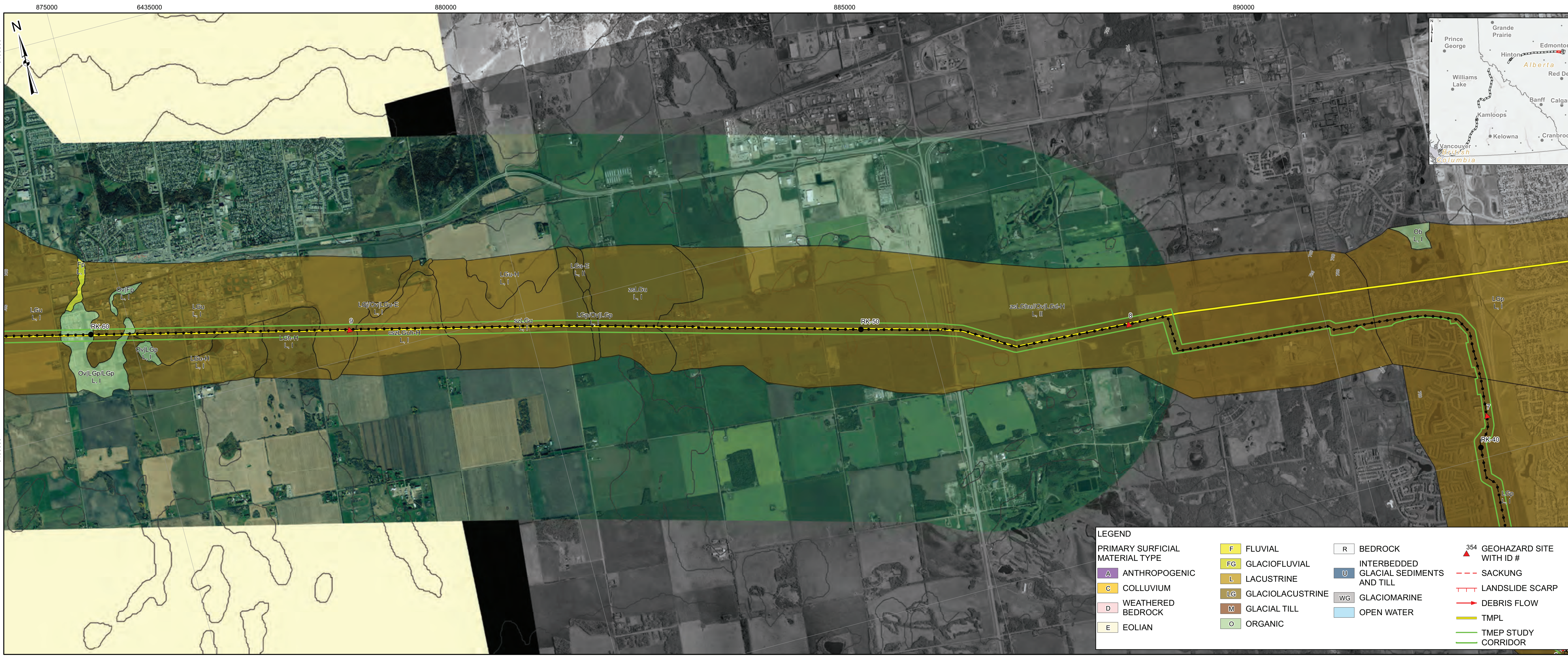
CLIENT: TRANSMOUNTAIN

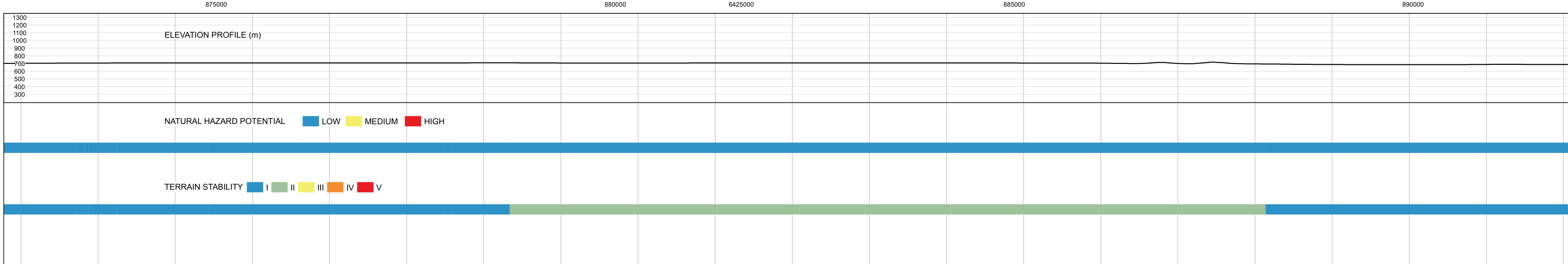
PROJECT: TRANS-MOUNTAIN EXPANSION PROJECT

TITLE: TERRAIN MAP
MAP NUMBER 2 OF 54

PROJECT No.: 0095150
DWG No.: 2
REV.:

DWG TO BE READ WITH BGC REPORT TITLED "TRANS-MOUNTAIN EXPANSION PROJECT" DATED NOVEMBER 2013





10 m CONTOUR INTERVAL
KMC

SCALE 1:50000

600 300 0 600 1200 1800

METERS

NOTES:

1. SMALL MAGNITUDE GEOHAZARDS EXIST (E.G. LOCALIZED ROCKFALL) THAT WERE TOO SMALL TO MAP
2. ARROWED LANDSLIDE PATHS SHOW GENERAL SLIDE TRAJECTORIES. THEY DO NOT SHOW HAZARD EXTENTS. PATH ARROWS EXTEND INTO THE GENERAL RUNOUT ZONE BUT DO NOT REPRESENT THE MAXIMUM RUNOUT LIMIT.
3. LANDSLIDE HAZARD EXTENTS ARE SHOWN BY SHADED POLYGONS. THEY SHOW EXISTING LANDSLIDE HAZARD INITIATION ZONE AND RUNOUT AREAS. POLYGON BOUNDARIES SHOULD BE REGARDED AS TRANSITIONS, NOT SHARP BOUNDARIES.
4. THIS MAP IS A SNAPSHOT IN TIME. CHANGES IN LAND USE (E.G. DEVELOPMENT, RIVER MIGRATION) MAY WARRANT RE-DRAWING OF CERTAIN AREAS.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:50000
DATE:	NOV 2013
DRAWN:	JVC, GLT
DESIGNED:	AB
CHECKED:	
APPROVED:	

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

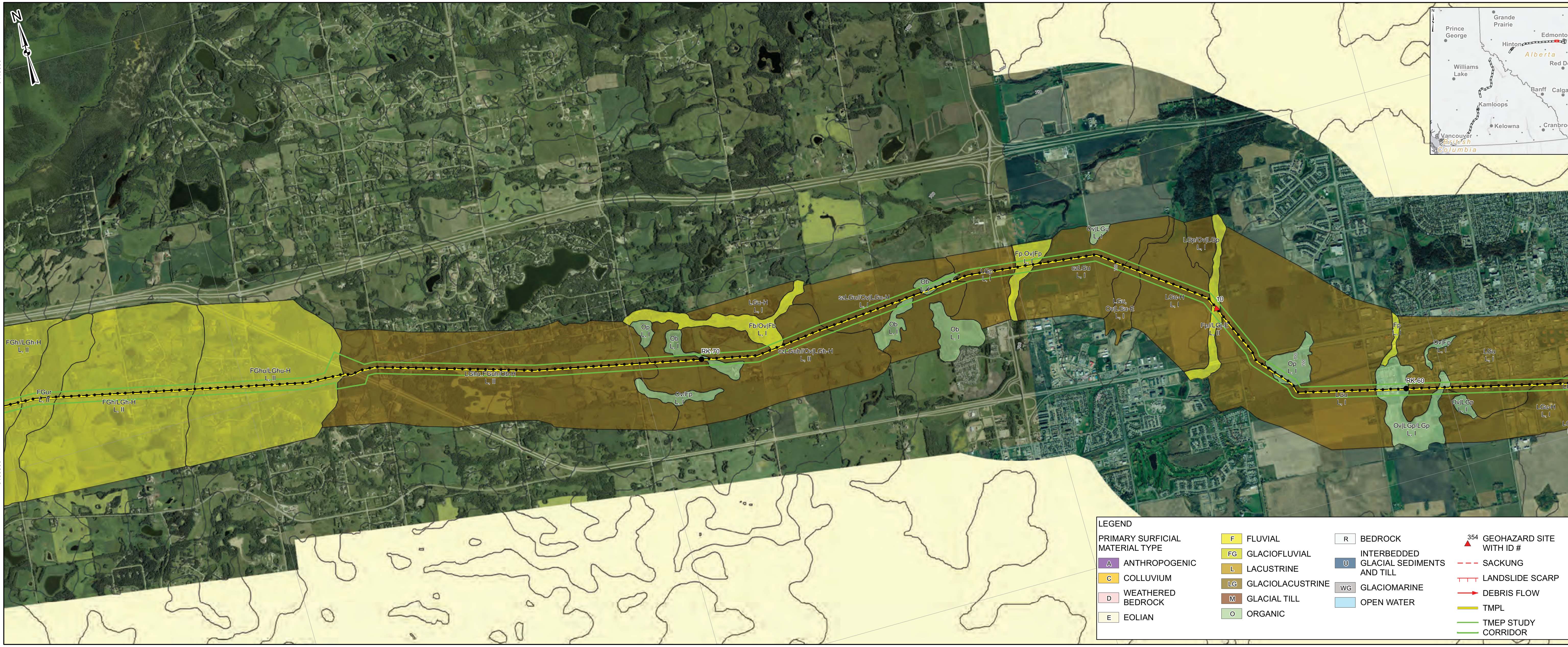
CLIENT: TRANSMOUNTAIN

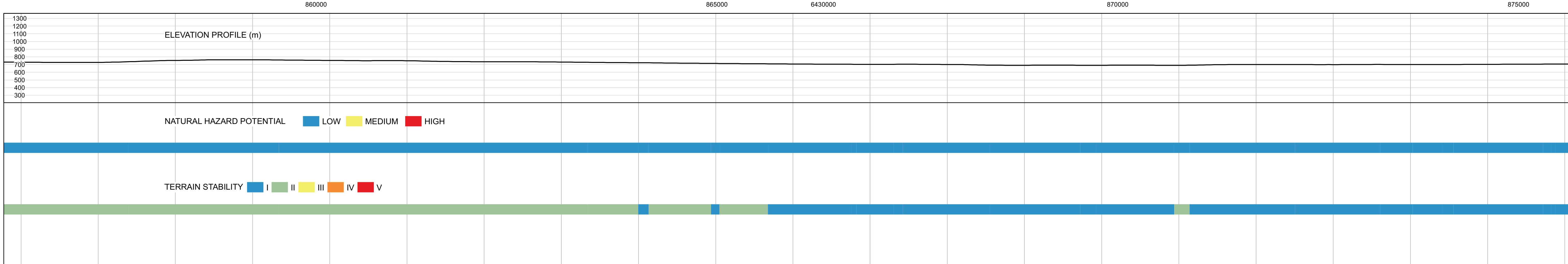
PROJECT: TRANS-MOUNTAIN EXPANSION PROJECT

TITLE: TERRAIN MAP
MAP NUMBER 3 OF 54

PROJECT No.: 0095150 | DWG No.: 3 | REV.:

DWG TO BE READ WITH BGC REPORT TITLED "TRANS-MOUNTAIN EXPANSION PROJECT" DATED NOVEMBER 2013





10 m CONTOUR INTERVAL
KMC

SCALE 1:50000

600 300 0 600 1200 1800

METERS

NOTES:

1. SMALL MAGNITUDE GEOHAZARDS EXIST (E.G. LOCALIZED ROCKFALL) THAT WERE TOO SMALL TO MAP
2. ARROWED LANDSLIDE PATHS SHOW GENERAL SLIDE TRAJECTORIES. THEY DO NOT SHOW HAZARD EXTENTS. PATH ARROWS EXTEND INTO THE GENERAL RUNOUT ZONE BUT DO NOT REPRESENT THE MAXIMUM RUNOUT LIMIT.
3. LANDSLIDE HAZARD EXTENTS ARE SHOWN BY SHADED POLYGONS. THEY SHOW EXISTING LANDSLIDE HAZARD INITIATION ZONE AND RUNOUT AREAS. POLYGON BOUNDARIES SHOULD BE REGARDED AS TRANSITIONS, NOT SHARP BOUNDARIES.
4. THIS MAP IS A SNAPSHOT IN TIME. CHANGES IN LAND USE (E.G. DEVELOPMENT, RIVER MIGRATION) MAY WARRANT RE-DRAWING OF CERTAIN AREAS.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:50000
DATE:	NOV 2013
DRAWN:	JVC, GLT
DESIGNED:	AB
CHECKED:	
APPROVED:	

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

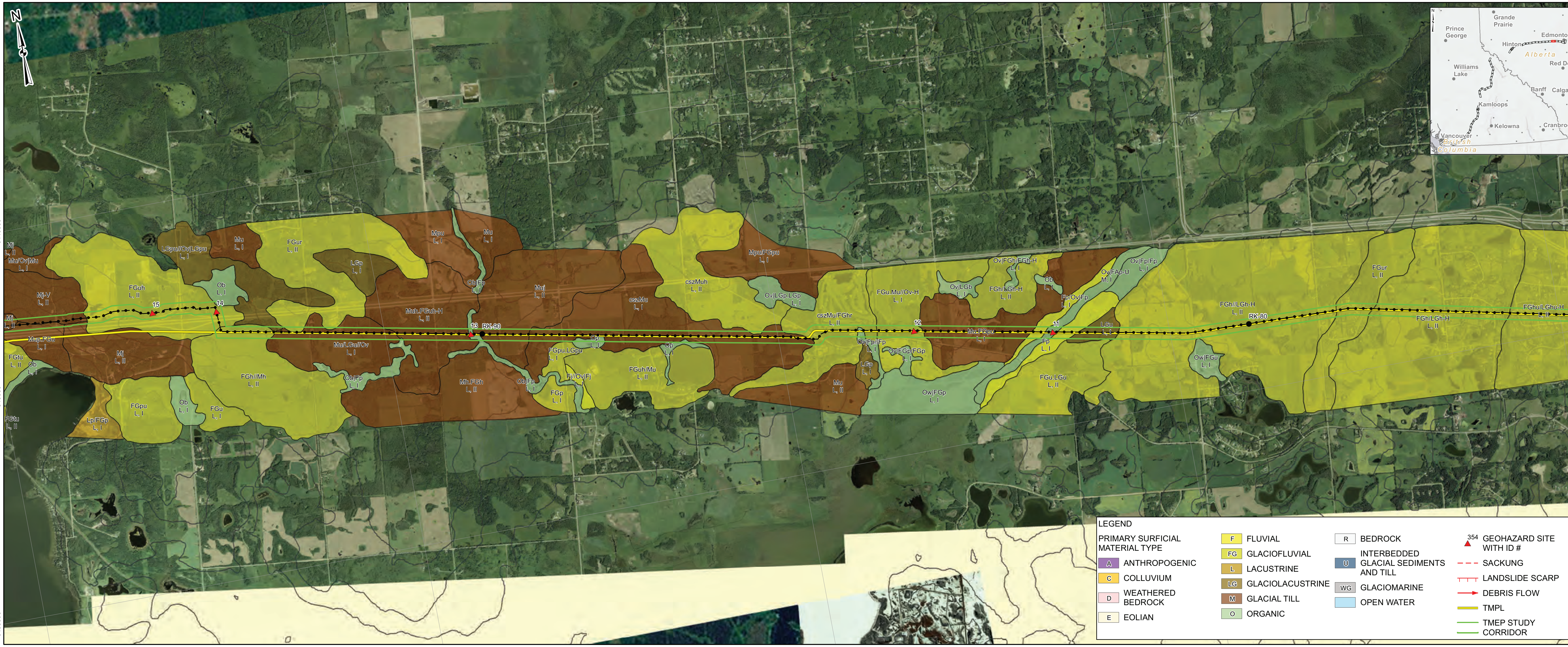
CLIENT: TRANSMOUNTAIN

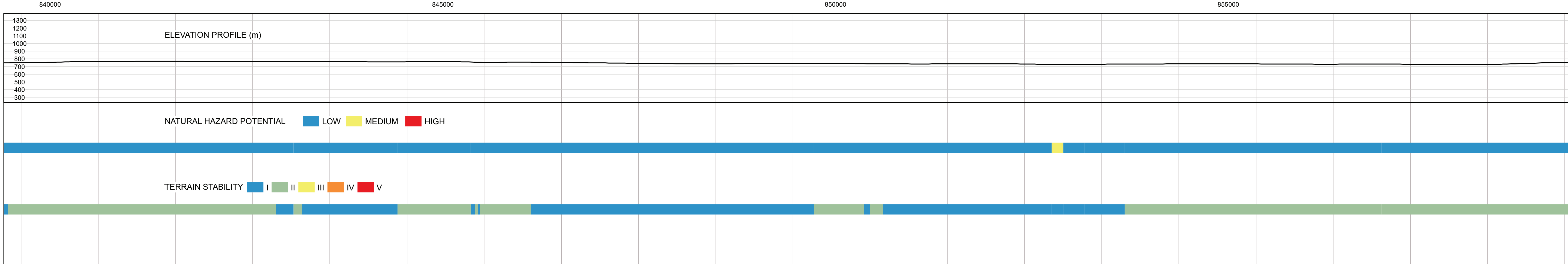
PROJECT: TRANS-MOUNTAIN EXPANSION PROJECT

TITLE: TERRAIN MAP
MAP NUMBER 4 OF 54

PROJECT No.:	DWG No.:	REV.:
0095150	4	

DWG TO BE READ WITH BGC REPORT TITLED "TRANS-MOUNTAIN EXPANSION PROJECT" DATED NOVEMBER 2013





10 m CONTOUR INTERVAL
KMC

SCALE 1:50000

600 300 0 600 1200 1800

METERS

NOTES:

1. SMALL MAGNITUDE GEOHAZARDS EXIST (E.G. LOCALIZED ROCKFALL) THAT WERE TOO SMALL TO MAP
2. ARROWED LANDSLIDE PATHS SHOW GENERAL SLIDE TRAJECTORIES. THEY DO NOT SHOW HAZARD EXTENTS. PATH ARROWS EXTEND INTO THE GENERAL RUNOUT ZONE BUT DO NOT REPRESENT THE MAXIMUM RUNOUT LIMIT.
3. LANDSLIDE HAZARD EXTENTS ARE SHOWN BY SHADED POLYGONS. THEY SHOW EXISTING LANDSLIDE HAZARD INITIATION ZONE AND RUNOUT AREAS. POLYGON BOUNDARIES SHOULD BE REGARDED AS TRANSITIONS, NOT SHARP BOUNDARIES.
4. THIS MAP IS A SNAPSHOT IN TIME. CHANGES IN LAND USE (E.G. DEVELOPMENT, RIVER MIGRATION) MAY WARRANT RE-DRAWING OF CERTAIN AREAS.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:50000
DATE:	NOV 2013
DRAWN:	JVC, GLT
DESIGNED:	AB
CHECKED:	
APPROVED:	

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: TRANSMOUNTAIN

PROJECT: TRANS-MOUNTAIN EXPANSION PROJECT

TITLE: TERRAIN MAP
MAP NUMBER 5 OF 54

PROJECT No.:	DWG No.:	REV.:
0095150	5	

DWG TO BE READ WITH BGC REPORT TITLED "TRANS-MOUNTAIN EXPANSION PROJECT" DATED NOVEMBER 2013