

Application of BPG Tool for Bridge Planning

Alberta Transportation, 2010

What is BPG?

- **B**ridge **P**lanning **G**eometry
- Excel tool (with VBA code)
- Interacts with GIS viewing software (e.g. Global Mapper)
- Combines roadway and bridge layout geometry
- Quick ID/evaluation/visualization of bridge planning options

Overview

- Project Data
- Horizontal Alignment
- Profile
- Bridge Fills
- River Protection Works
- Bridge Structure Geometry
- Grading Volume
- Application

Project Data

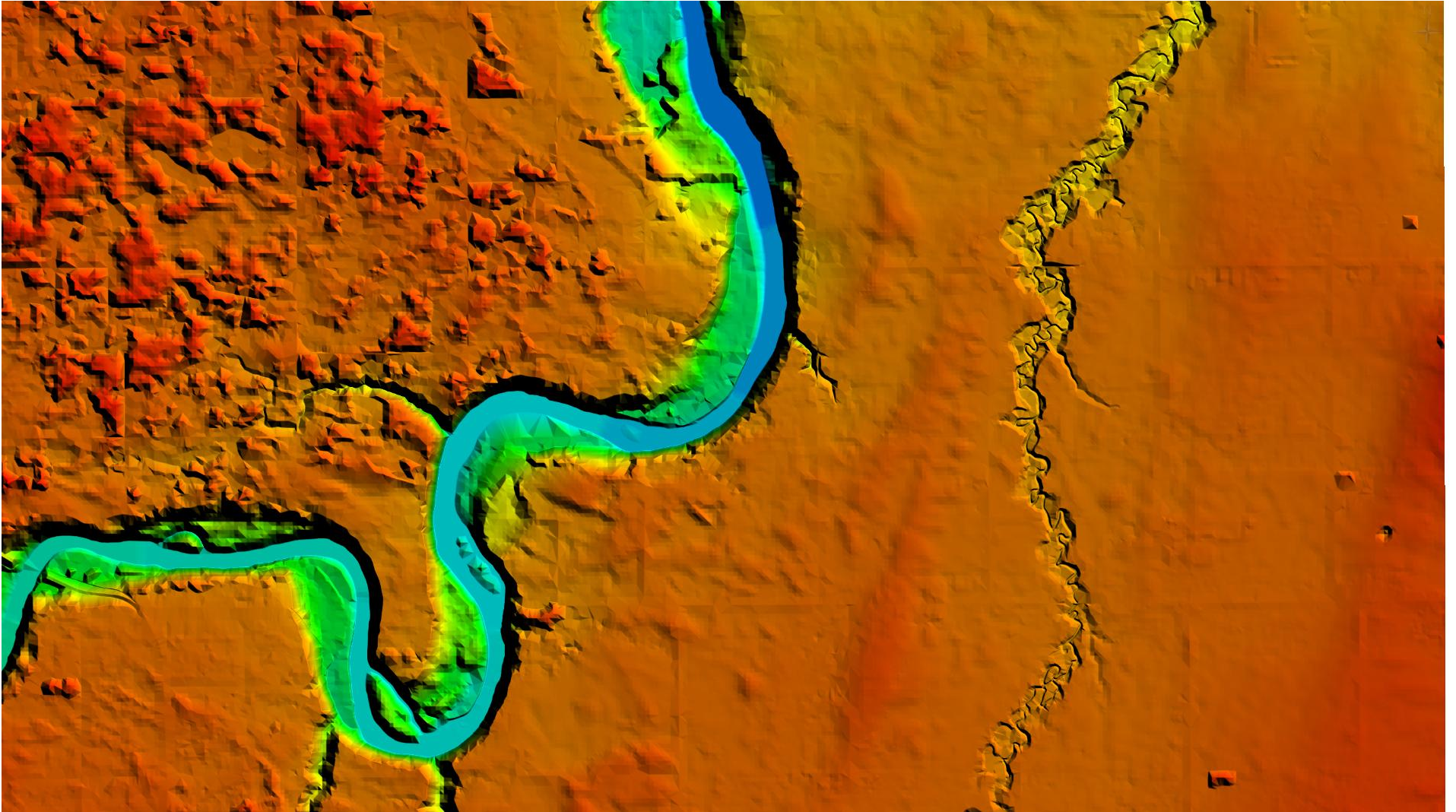
Project Data

	A	B	C	D
1		File Naming		
2		Project Name	NSR SW 1	
3		DEM File Name (.asc)	SW1 DEM.asc	
4				
5		Spacing and Offsets		
6		Station Spacing	20	
7		Offset (m) for SOD lines	20	
8		Spacing for STA Labels	200	
9		Spacing for Vol. Calcs	5	
10				
11		Alignment Options		
12		Design Speed (km/hr)	130	
13		Spiral ('A') Multiplier	1.15	
14				
15				

DEM File Preparation

- Elevations on a defined grid spacing
- Spacing – balance accuracy and speed
- Cover extents (along alignment and transverse)
- Source – LIDAR, Photogrammetry, Survey, Base DTM
- Located in same directory as BGP file
- ASC format (export from Global Mapper)
- Same projection as alignment coordinates

DEM File Visualization



Horizontal Alignment

Horizontal Alignment Factors

- Crossing Location
 - Width - cost
 - Skew – cost, structural complexity
 - Lateral Stability – cost, reliability, environmental impact
 - Slides – cost, maintenance
- Bridge Geometric Requirements
 - Tangent Preferable
 - Increased R – sight distance (rails), max gradient (icing)
 - Constant XS (icing) – no spirals

Horizontal Alignment - Draw



Horizontal Alignment - Input

[illegible]

Horizontal Alignment – Output Data

A	B	C	D	E	F	G
E	N	STA	EL grnd	Brng	e	
28932.251	5915756.661	1000	702.110	269.86	0.020	
28912.251	5915756.613	1020	701.878	269.86	0.020	
28892.251	5915756.565	1040	701.542	269.86	0.020	
28872.251	5915756.517	1060	701.273	269.86	0.020	
28852.251	5915756.470	1080	700.985	269.86	0.020	
28832.251	5915756.422	1100	700.723	269.86	0.020	
25332.261	5915748.049	4600	697.842	269.86	0.020	
25312.261	5915748.001	4620	697.903	269.86	0.020	
25292.261	5915747.953	4640	698.012	269.86	0.020	
25272.261	5915747.912	4660	698.144	269.93	0.020	
25252.261	5915747.920	4680	698.328	270.15	0.020	
25232.262	5915748.034	4700	698.552	270.53	0.028	
25212.264	5915748.307	4720	698.851	271.06	0.041	
25192.269	5915748.777	4740	699.154	271.63	0.041	
25172.281	5915749.448	4760	699.466	272.21	0.041	
25152.300	5915750.317	4780	699.785	272.78	0.041	
25132.328	5915751.387	4800	700.067	273.35	0.041	

Horizontal Alignment – Curve Points

	A	B	C	D	E
1	E	N	STA	Name	
2	25290.161	5915747.948	4642.100	TS1	
3	25217.963	5915748.210	4714.300	SC1	
4	24054.340	5916144.180	5963.666	CS1	
5	23996.967	5916188.010	6035.866	ST1	
6					
7					

Horizontal Alignment - Plot



Profile

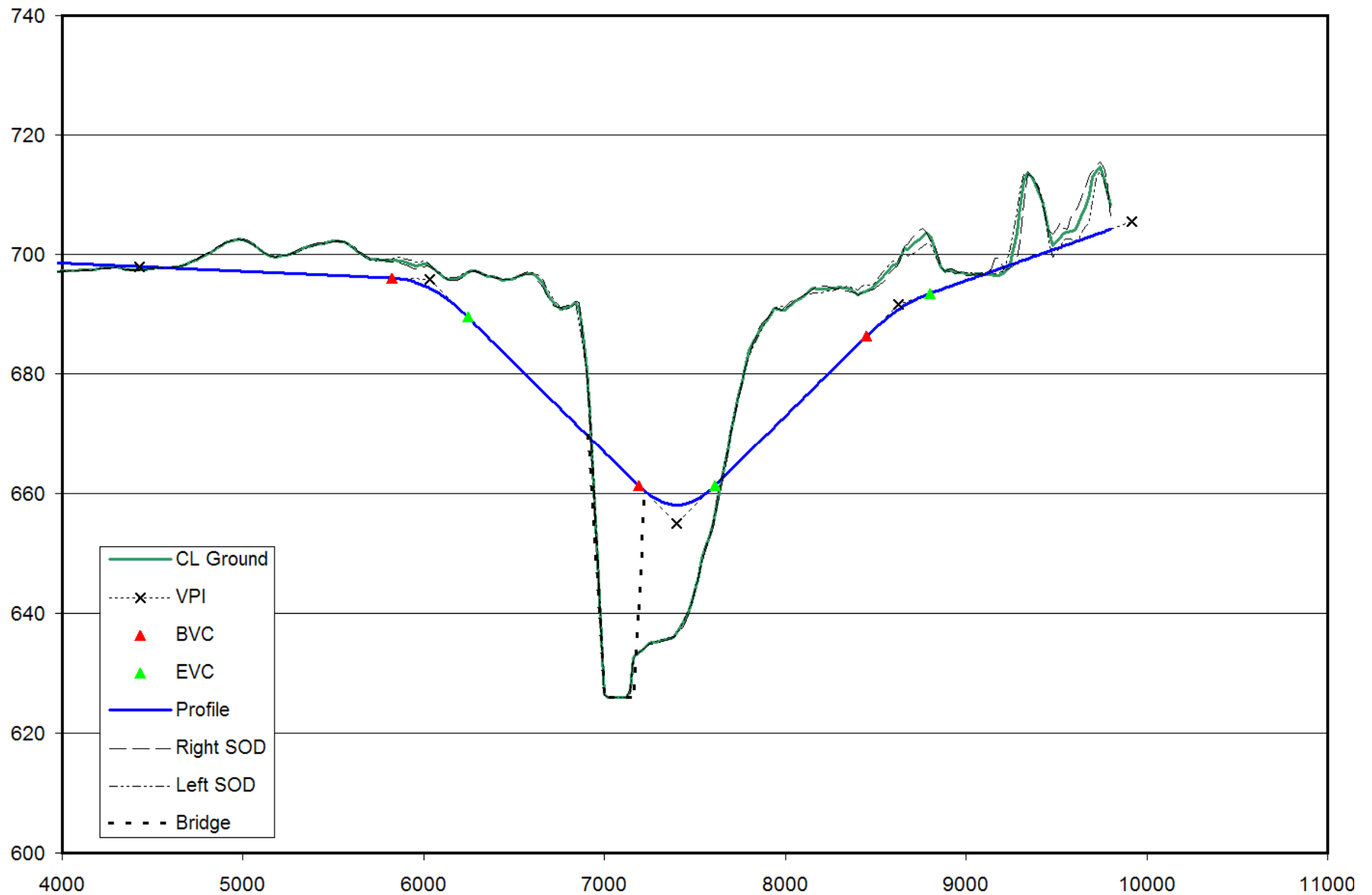
Profile Factors

- Min Elevation (Hydraulic Control)
 - Min EL = HW EL + Freeboard + Structure Depth
 - HW EL based on AT HDG
 - Freeboard – BPG 12
 - Structure Depth – max span
- Deck Gradient Limits (AT BSDC)
 - Max 4% resultant (~ 3% longitudinal) – preferential icing
 - Min 1% - deck drainage (BPG 11)
- Valley Issues
 - Cut/Fill Balance
 - Max Hwy Grade – benefit/cost
 - Visual – Min. $L(m) = 2X \text{ Design Speed (km/hr)}$

Profile - Input

	B	C	D	E	F	G	L	M	N	O	P	Q	Spot Elevations			T	
	STA	EL	L	G	K	Type	Lmx	Warn				Pt	STA	EL	G		
	4427	698.000								GO		1	7000.00	666.885	-3.00		
	6035	695.800	420	-0.14	146.9	Crest	2310	OK			2						
	7400	654.900	420	-3.00	70.1	Sag	2100	OK			3						
	8625	691.600	350	3.00	182.4	Crest	2030	OK			4						
	9915	705.500		1.08							5						

Profile - Plot



Profile – Summary Output

[illegible]

Profile – Align Data + Prof

[illegible]

Bridge Fills

Bridge Fills Factors

- Fill Location

- Hydraulically Feasible – V , headloss, u/s flooding
- Lateral tie-in to existing natural banks
- Starting point – match existing natural banks

- Fill Configuration

- Headslope ratio (typ 2:1, geotechnical, remediation)
- Berms – geotechnical, access
- Elliptical fill transition vs. guidebank

Bridge Fills – Initial Fill STA

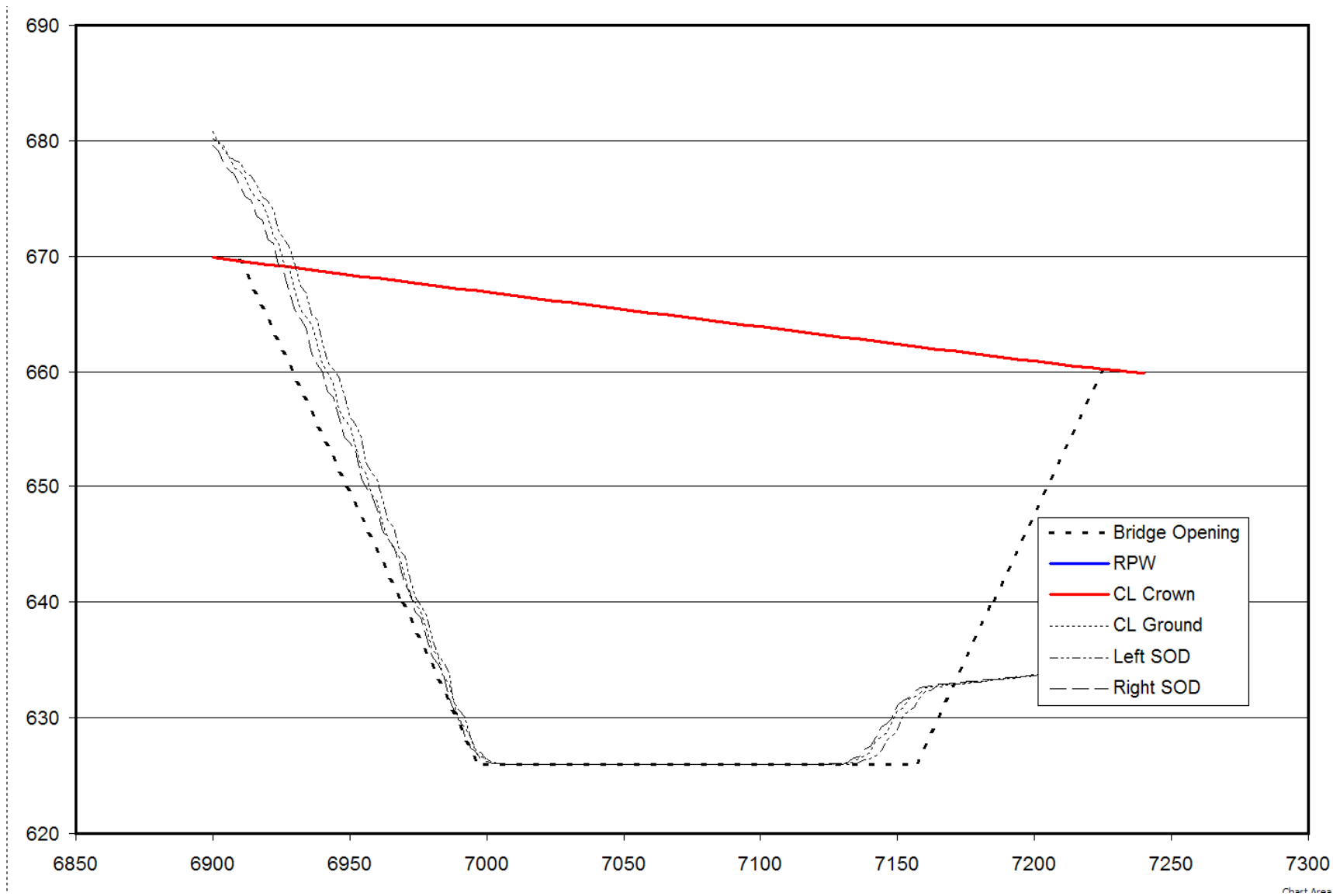
	Calc Top of Fill From Toe	STA	EL				
	Near Fill Toe	7000.000	627.000				
	Far Fill Toe	7200.000	627.000				
	Near Fill Top	6896.63	677.90				
	Far Fill Top	7280.01	666.40				

Calc Top

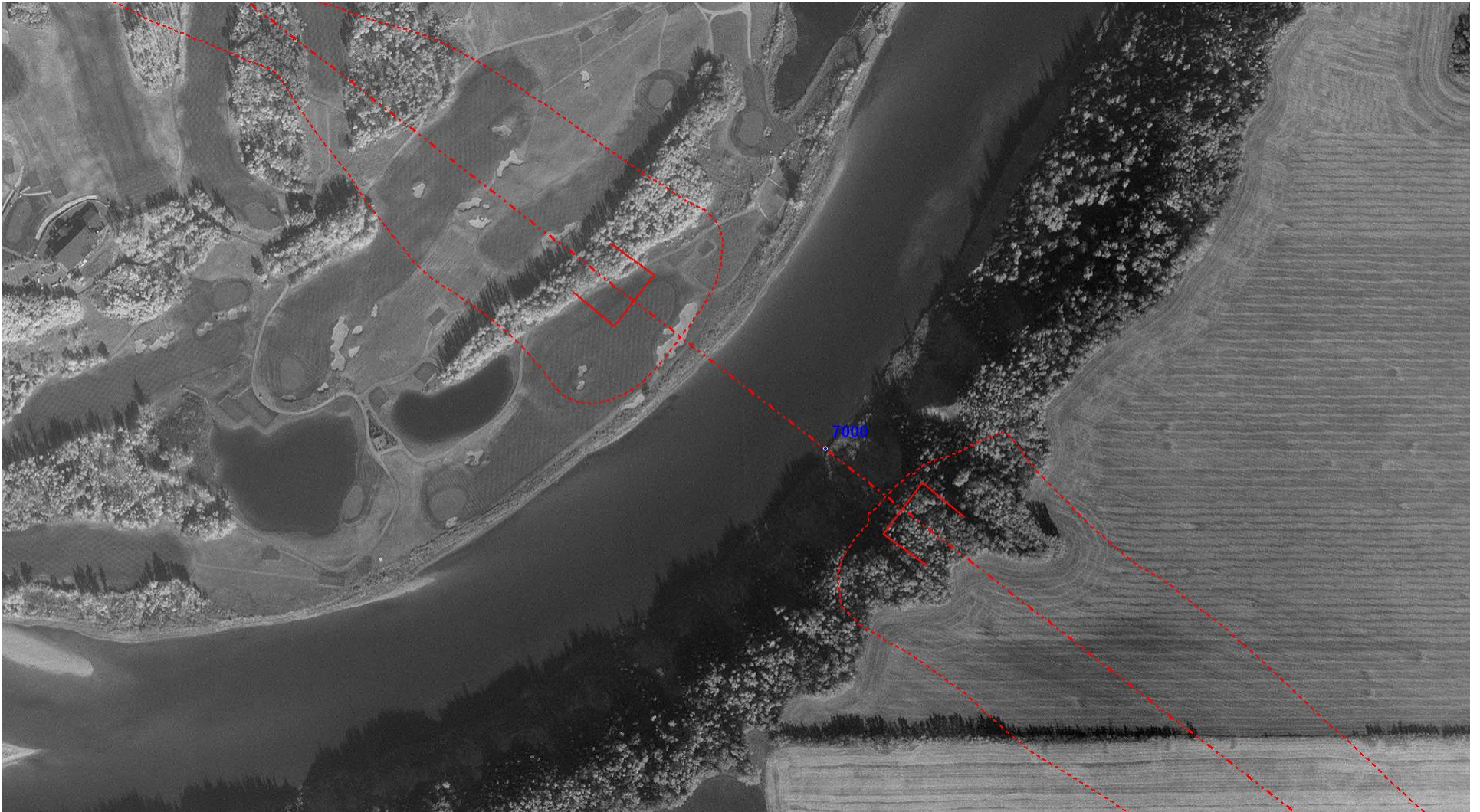
Bridge Fills - Input

	A	B	C	D	E	
1			EL	G		
2	Near Fill Station	6910.000	669.582	-2.996		
3	Far Fill Station	7225.000	660.231	-2.497		
4	Top of Fill Width	60.0				
5	Headslope Ratio	2.0				
6	Fill Sideslope Ratio	3.0				
7	Skew	0.0				
8	Bed EL (Theor.)	627.000				
9	Berm EL	640.000				
10	Headslope Berm Width	0.0				
11	GB Berm Width	0.0				
12	Protection (H,G,N)	N				
	Bank Thickness (ft)	0.0				

Bridge Fills - Elevation



Bridge Fills - Plan

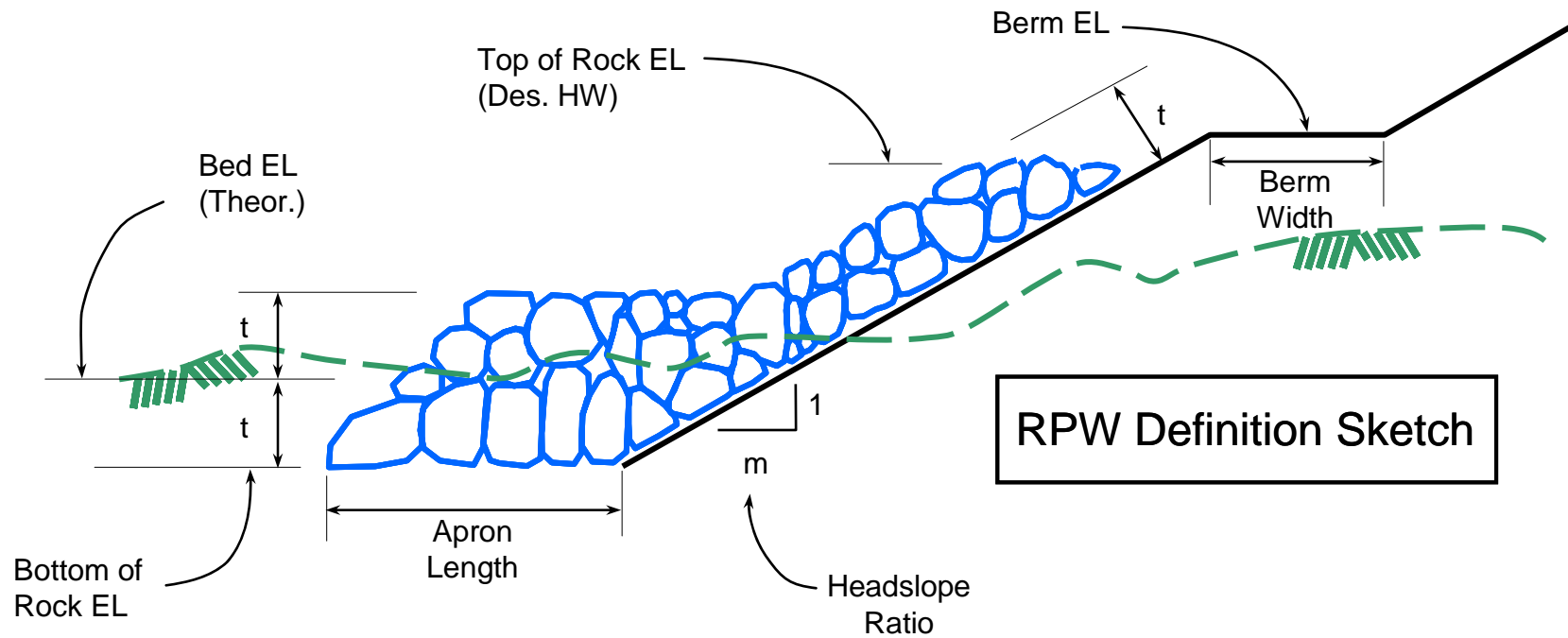


River Protection Works

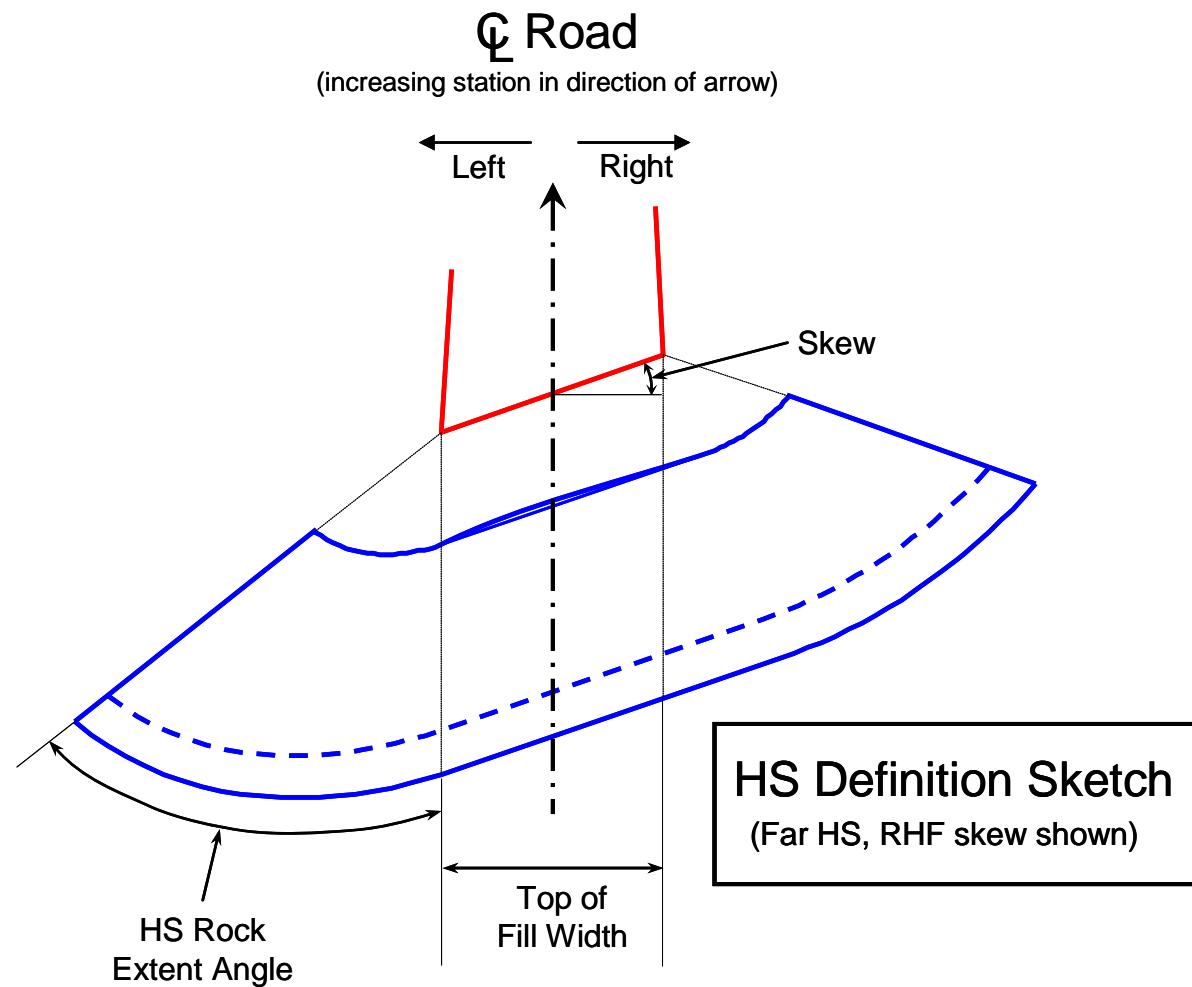
Bridge Fills Protection Factors

- Need
 - Fill in active channel
 - Lateral movement history
 - Signs of local bank instability
- Protection Details (BPG 9)
 - Rock (Class 1,2,3 – size distribution, BCS, Section 10)
 - Select based on V, lateral movement history
 - Launching Apron, rock to HW
- Extent
 - Configuration - headslope vs. guidebank
 - Tie apron into toe of banks
 - Smooth transition, target 2:1 (along stream vs. lateral)
- Additional River Engineering Features
 - Spurs – groups, spacing, projection
 - Channel realignment – align flow, reduce skew, maintain S

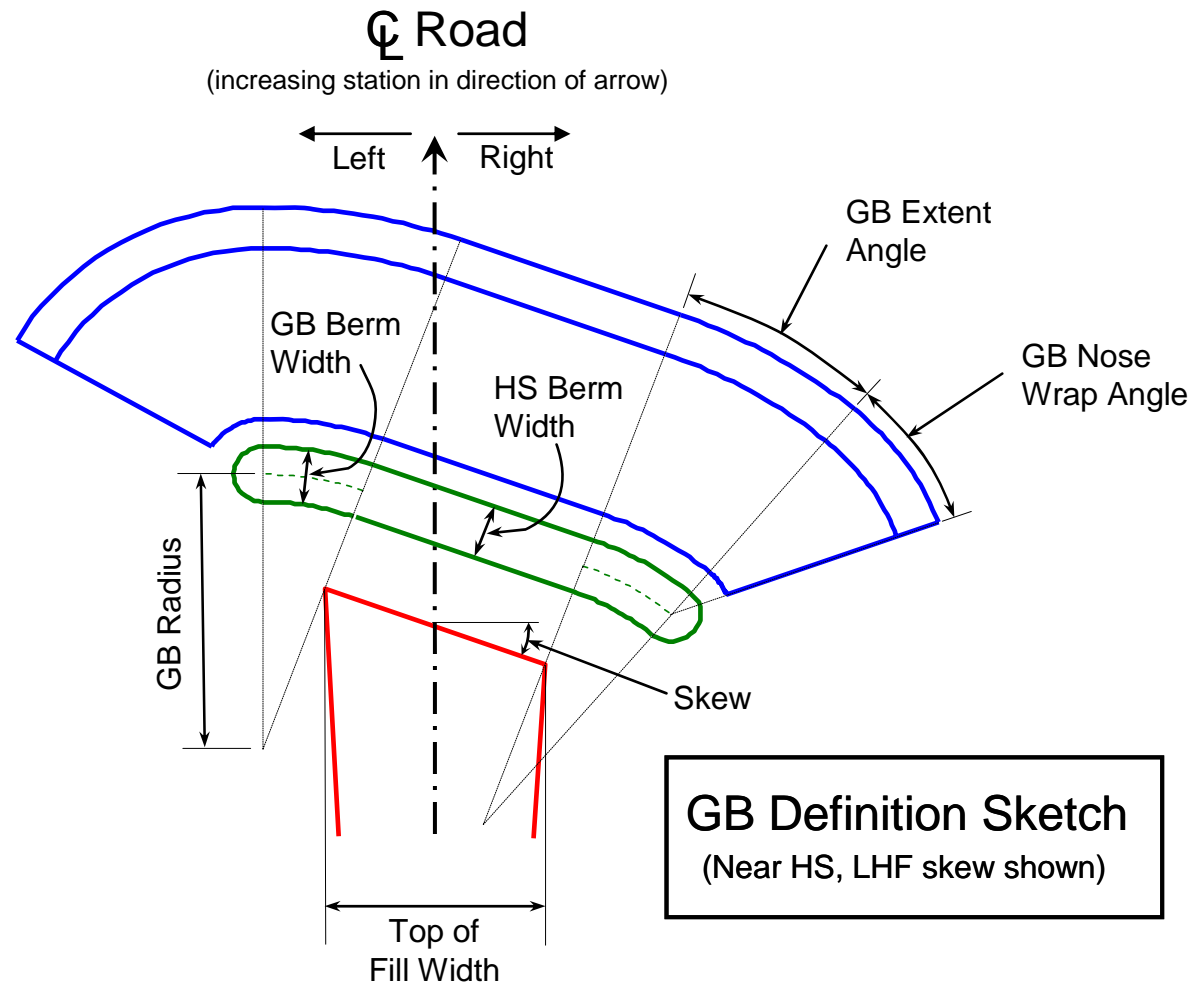
Bridge Fills Protection - Detail



Bridge Fills Protection - Headslope



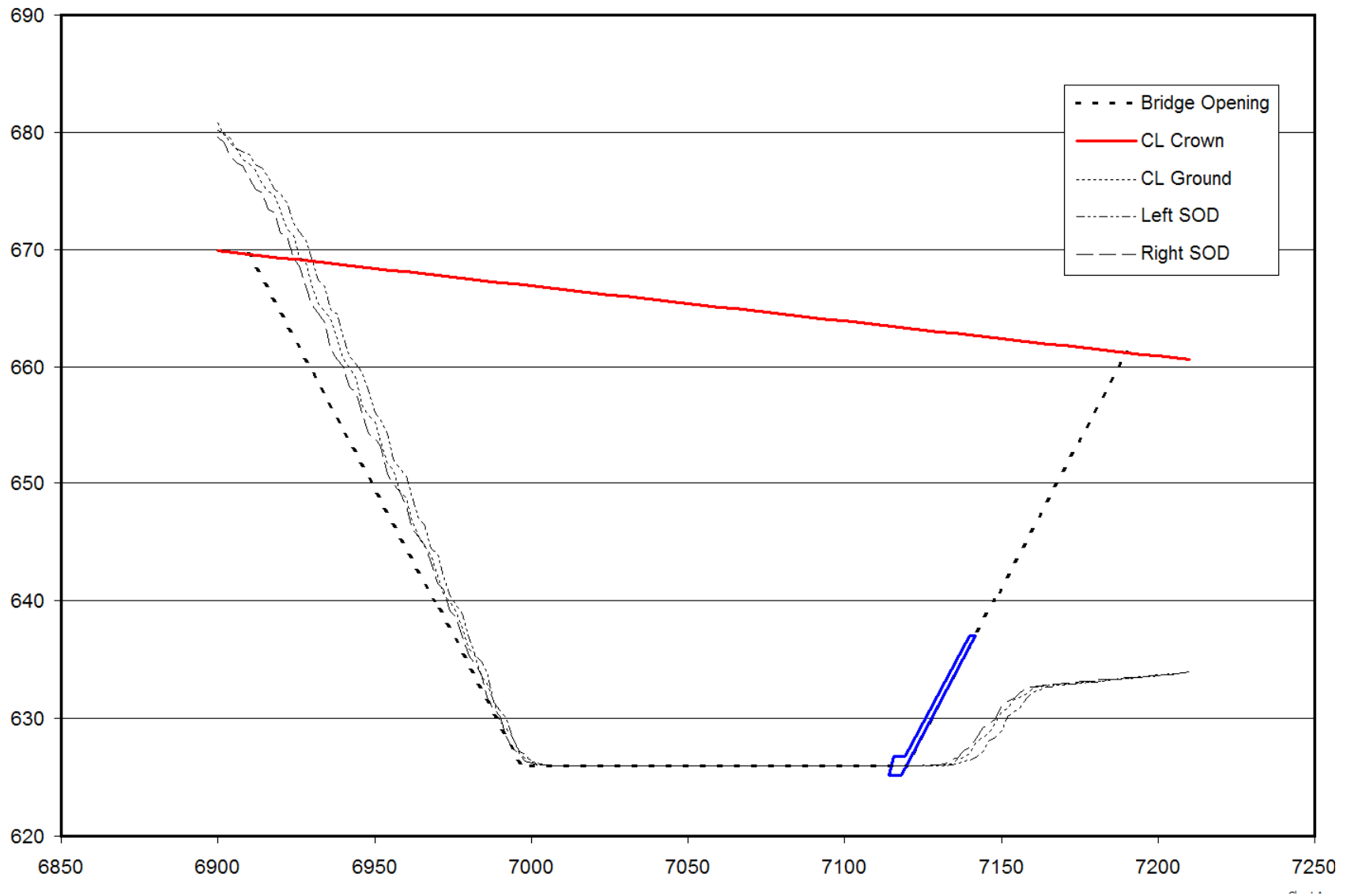
Bridge Fills Protection - Guidebank



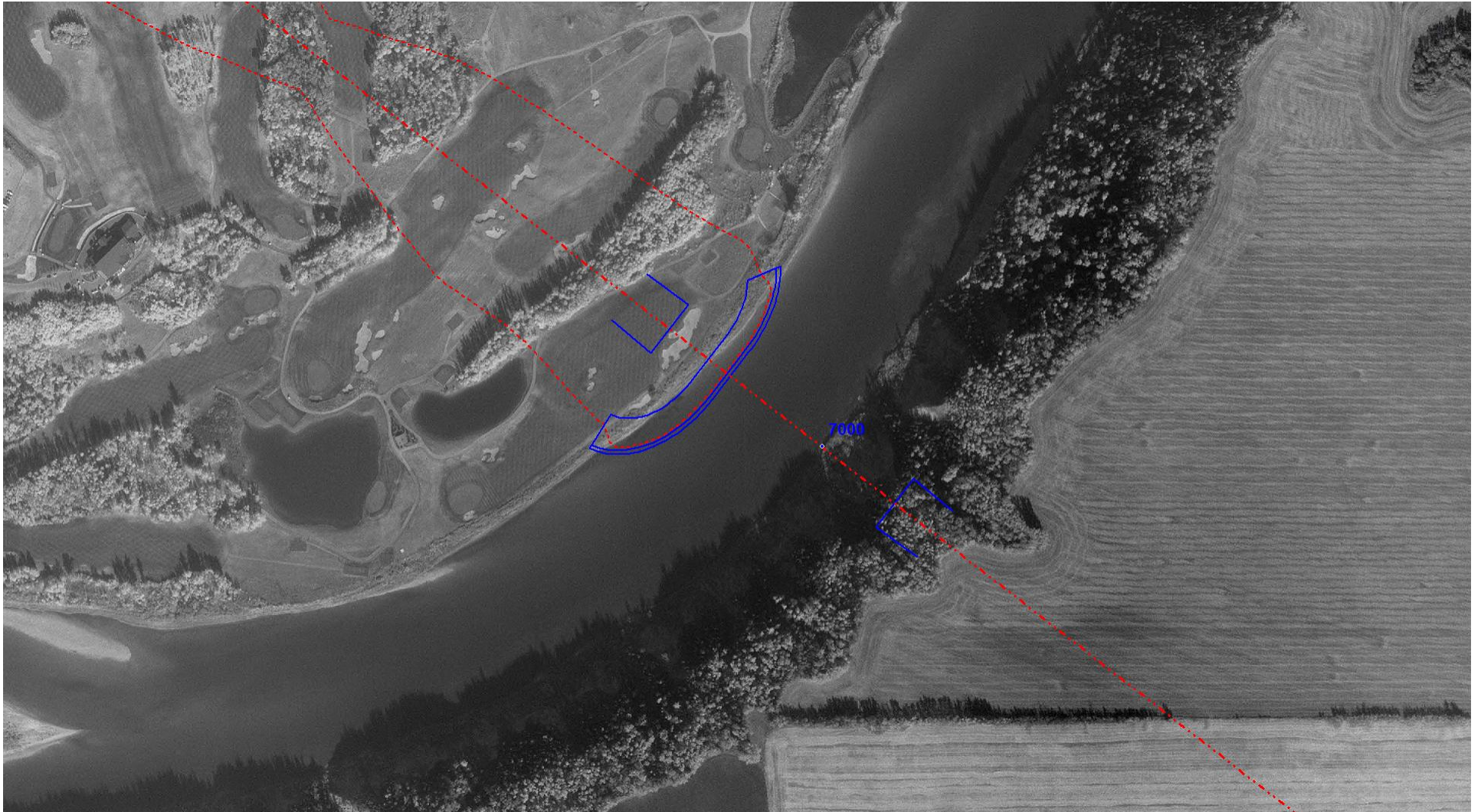
Bridge Fills Protection - Input

10	Headslope Berm Width	0.0			
11	GB Berm Width	0.0			
12	Protection (H,G,N)	H			
13	Rock Thickness 't' (m)	0.8			
14	Top Of Rock EL	637			
15	Bottom Of Rock EL	625.2			
16	Apron Length	4.0			
17					
18		Near Fill		Far Fill	
19		Left	Right	Left	Right
20	HS Rock Extent Angle	50.0	50.0	85.0	60.0
21	GB Radius	20.0	20.0	80.0	80.0
22	GB Extent Angle	25.0	25.0	30.0	20.0
23	GB Nose Wrap Angle	30.0	30.0	30.0	30.0
24					
25		Square	Skew		
26	Out to Out of Fill Length	280.000	280.000		
27	Theoretical Bed Width	122.451	122.451		
28					
29	Rock Vol. (Near)	5675			
30	Rock Vol. (Far)	6981			
31	Total Rock Volume	12656			
32					

Bridge Fills – Elevation + RPW



Bridge Fills – Plan + RPW



Bridge Structure Geometry

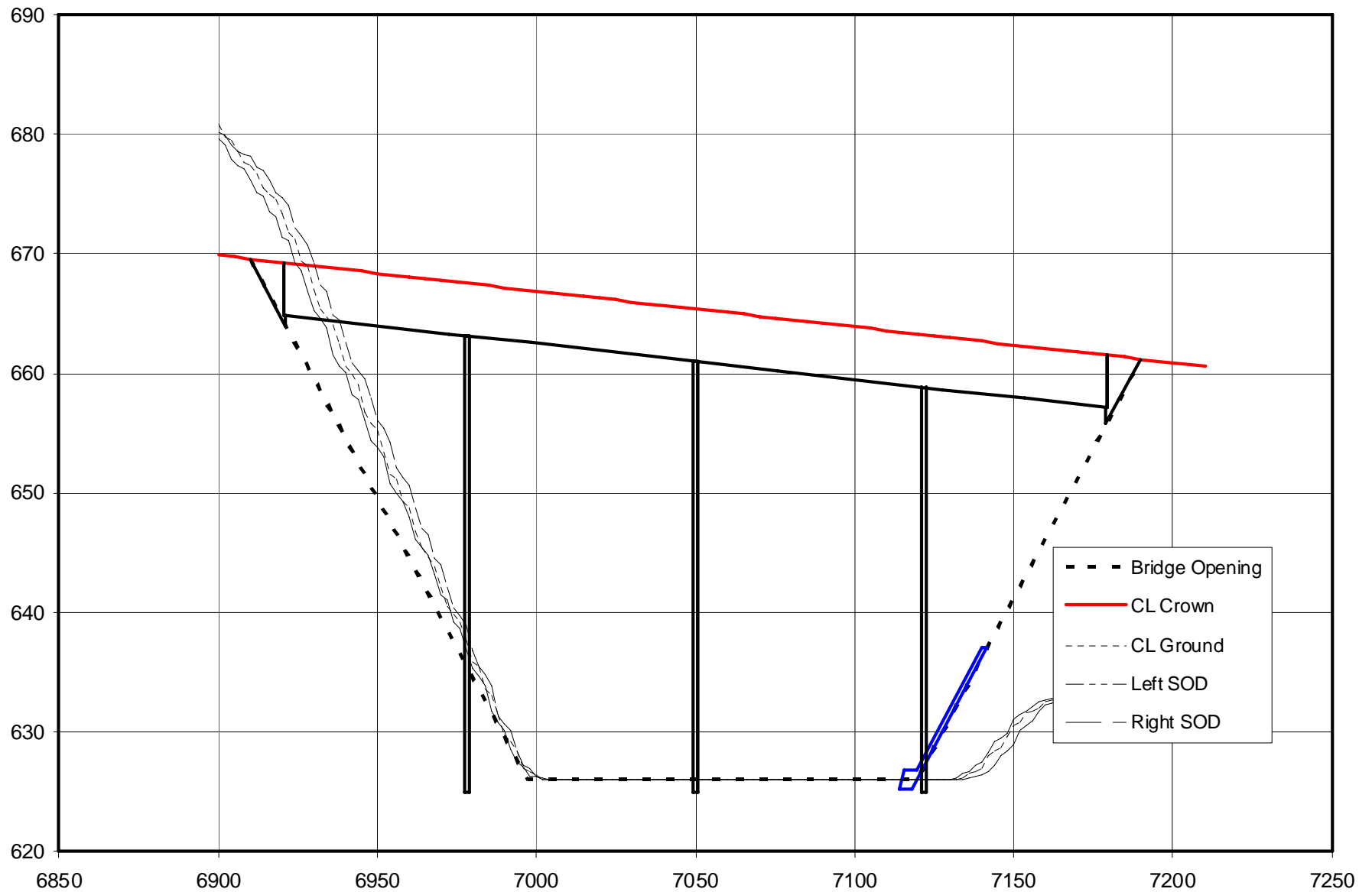
Bridge Structure Geometry Factors

- Check grades, XS at bridge ends
- Visually check flow alignment, skew in 3D
- ID potential span options
 - No. Spans, Piers
 - Span lengths – structure options
- Pier location issues
 - Drift, ice – blockage potential
 - Construction berm extents
 - Bank proximity – blockage, erosion

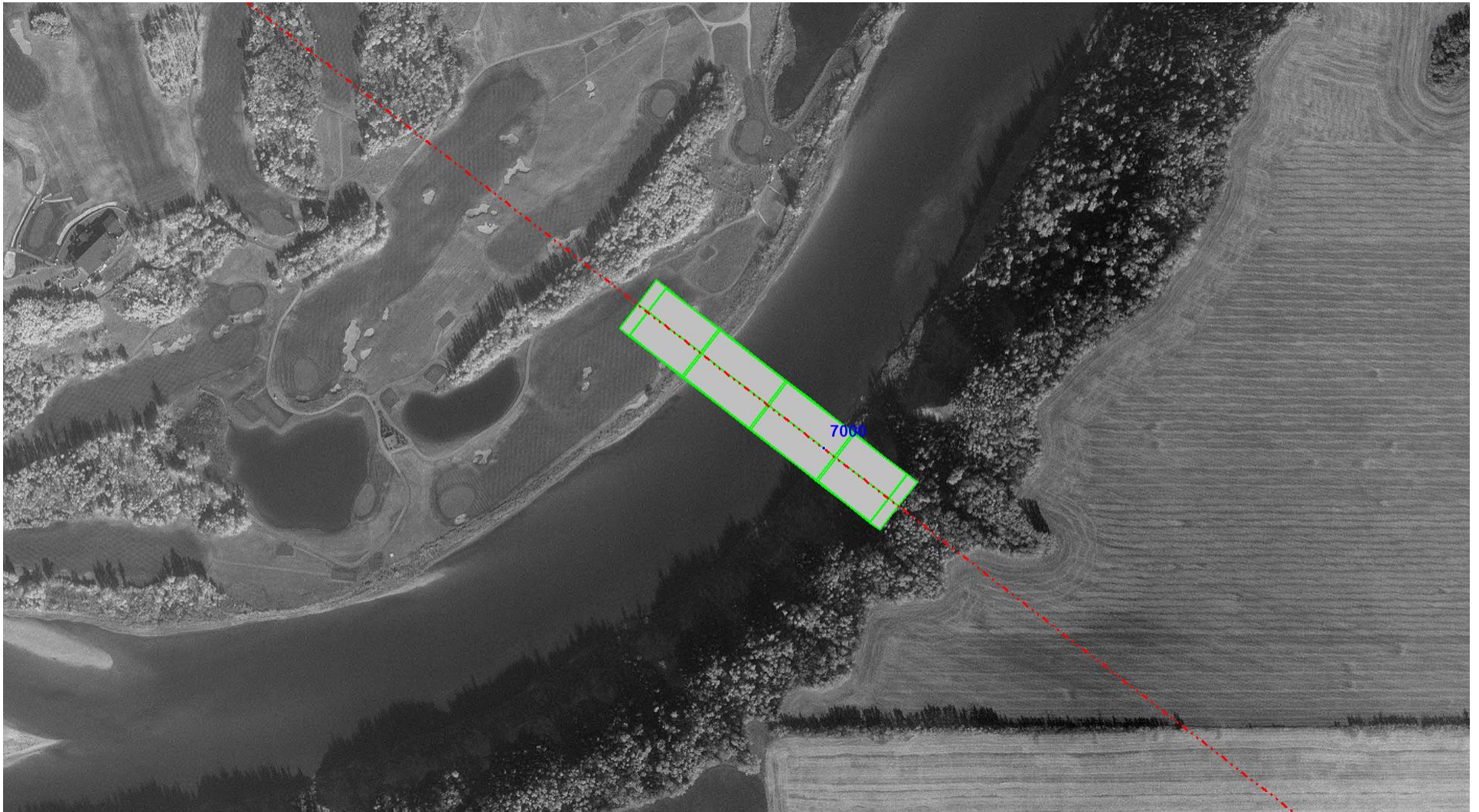
Bridge Geometry - Input

[illegible]

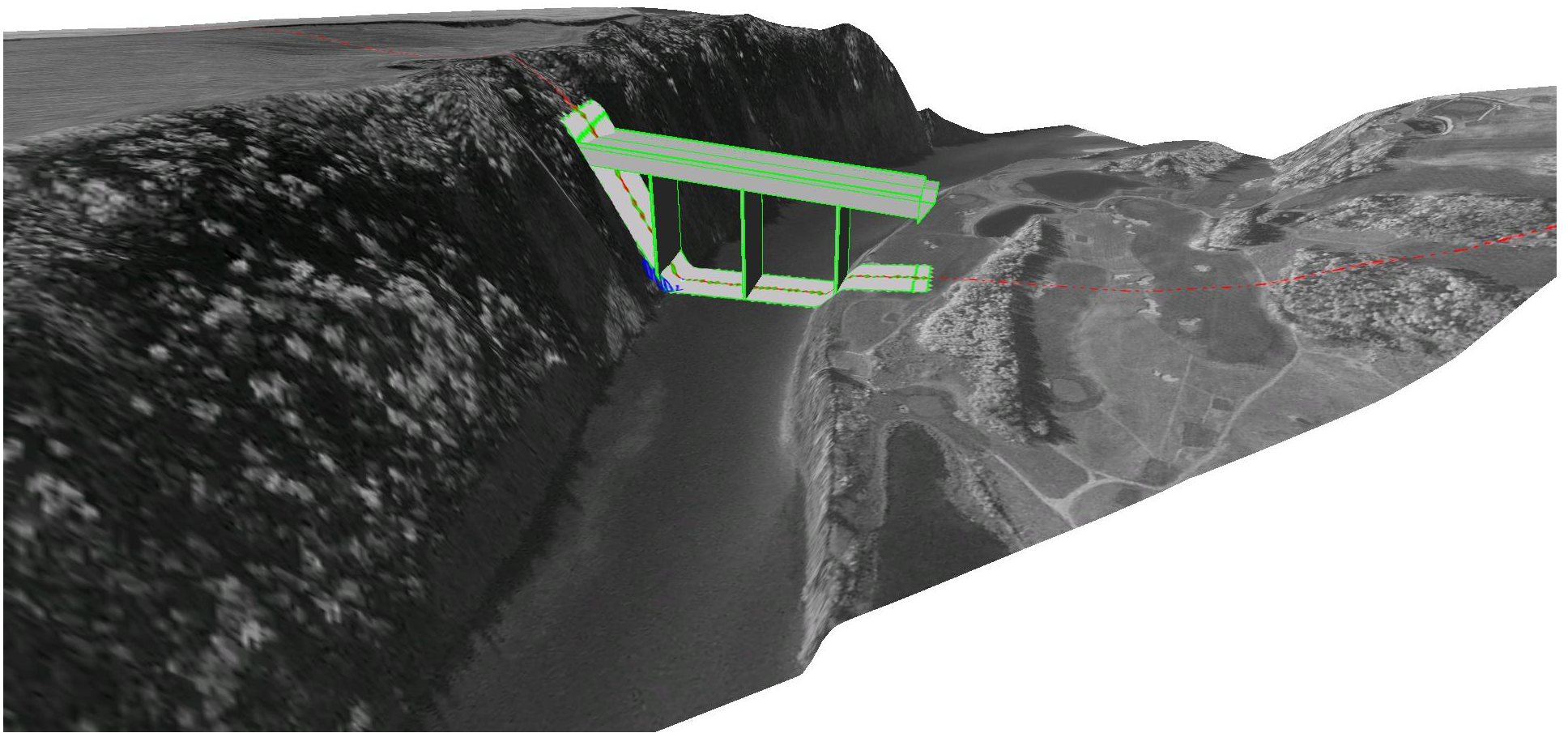
Bridge Geometry – Elevation View



Bridge Geometry - Plan



Bridge Geometry – 3D



Grading Volume

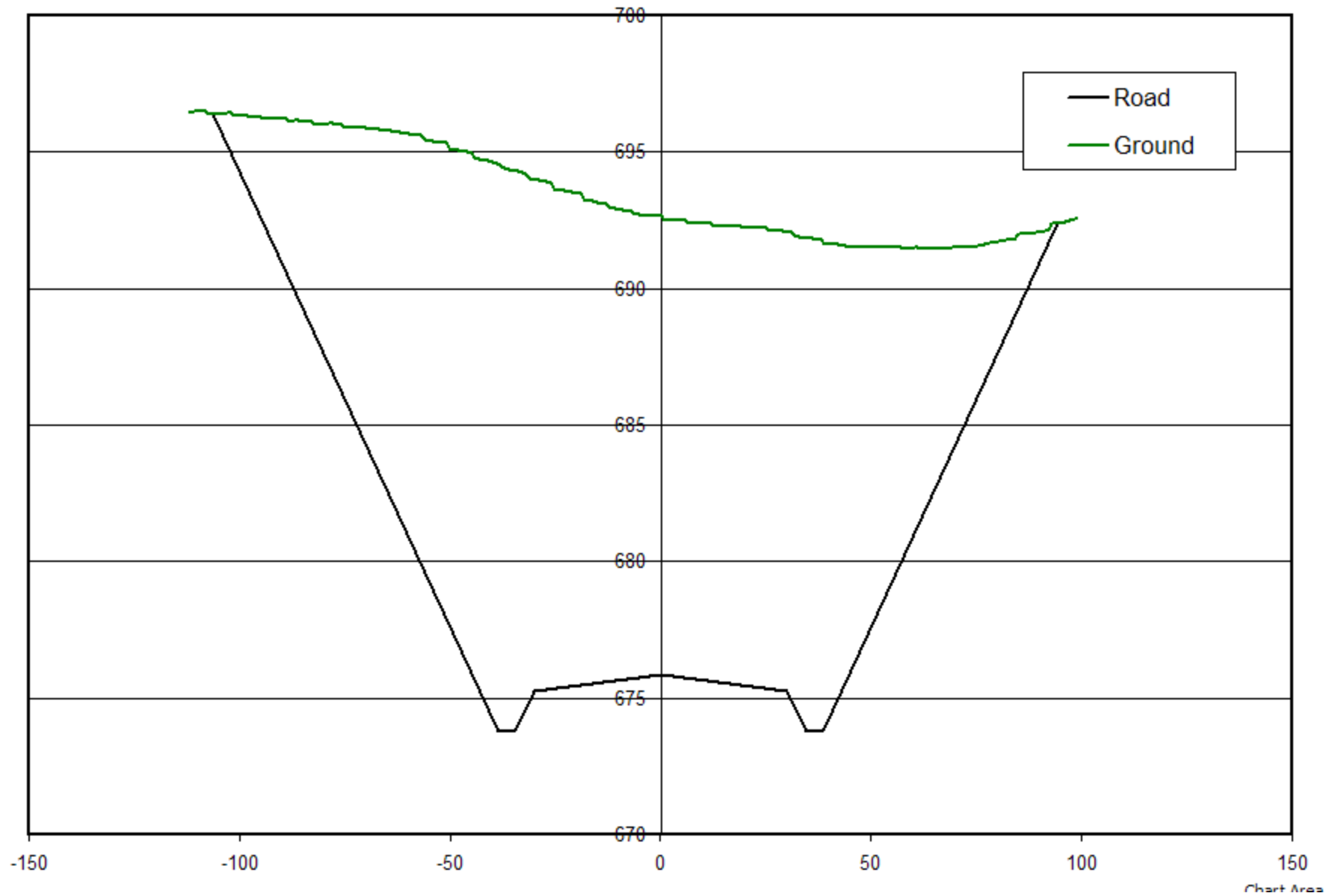
Grading Volume Factors

- Grading Volume Costs
 - Alignment
 - Profile
 - Bridge Length
 - XS
- Feasibility
 - Depth of cut, Height of fill – geotechnical stability
 - Lateral Extent of impact – land, river, wetland, development
- Issues
 - Balance cut and fill
 - Borrow Source / Waste areas

Grading Volume - Input

Cross Section Parameters			
Design Road Width (m)	60		
Road Sideslope Ratio (H:V)	3		
Backslope Ratio (H:V)	3		
Ditch Depth (m)	1.5		
Ditch Width (m)	4		
Sideslope Transition Location (m)	100		
Sideslope Transition Length (m)	20		
XS Data and Plot			
STA	6700.000	Go XS	
Left Limit	-106.4		
Right Limit	94.3		
Area - Fill	0.0		
Area - Cut	2557.0		
Road Grading Volume			
STA 1	4600.000	Go Vol	Make Grading Limits File
STA 2	9200.000		
Vol. Fill	849455		Make 3D Road Vector File
Vol. Cut	4135113		Make 3D Road Pts File

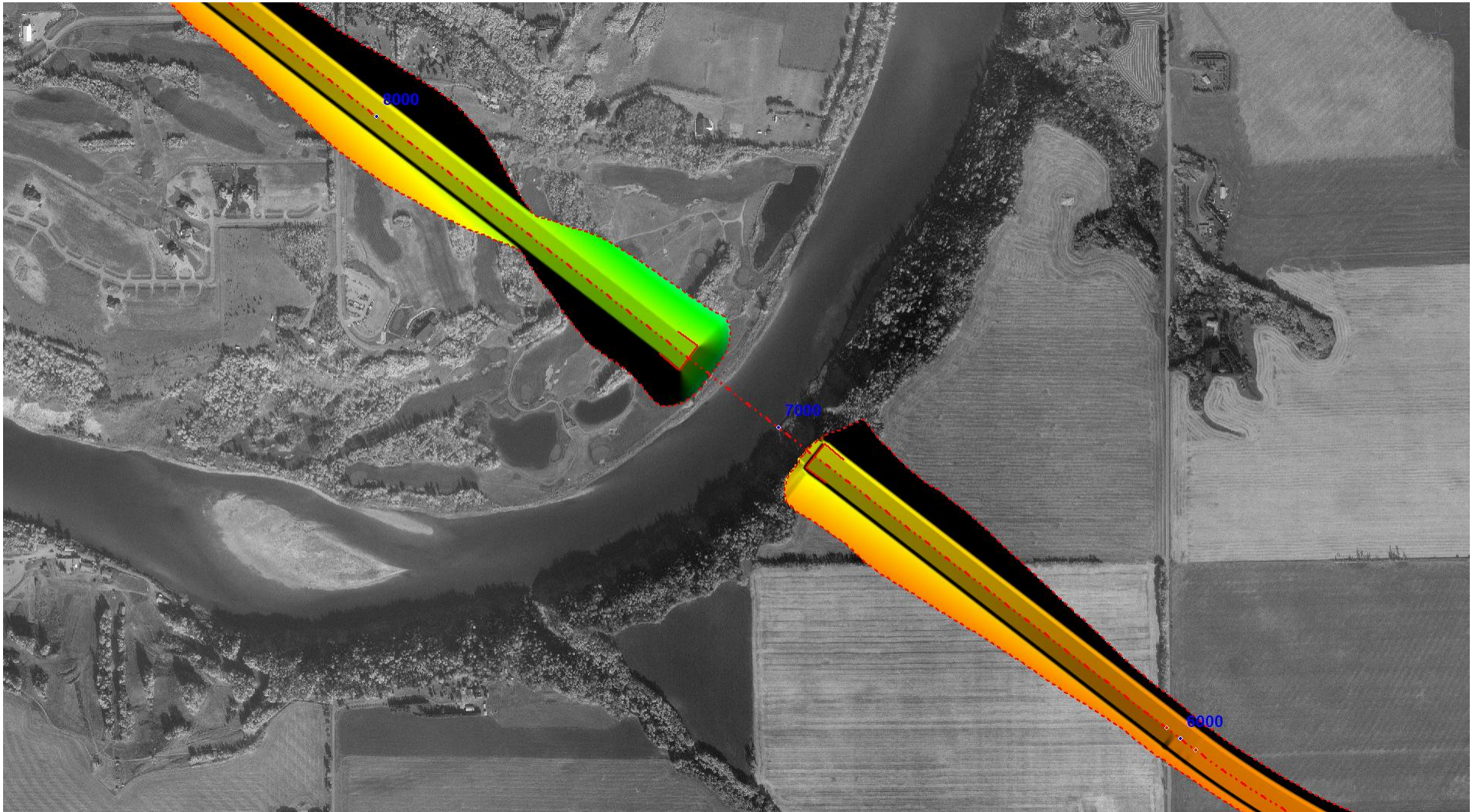
XS Plot



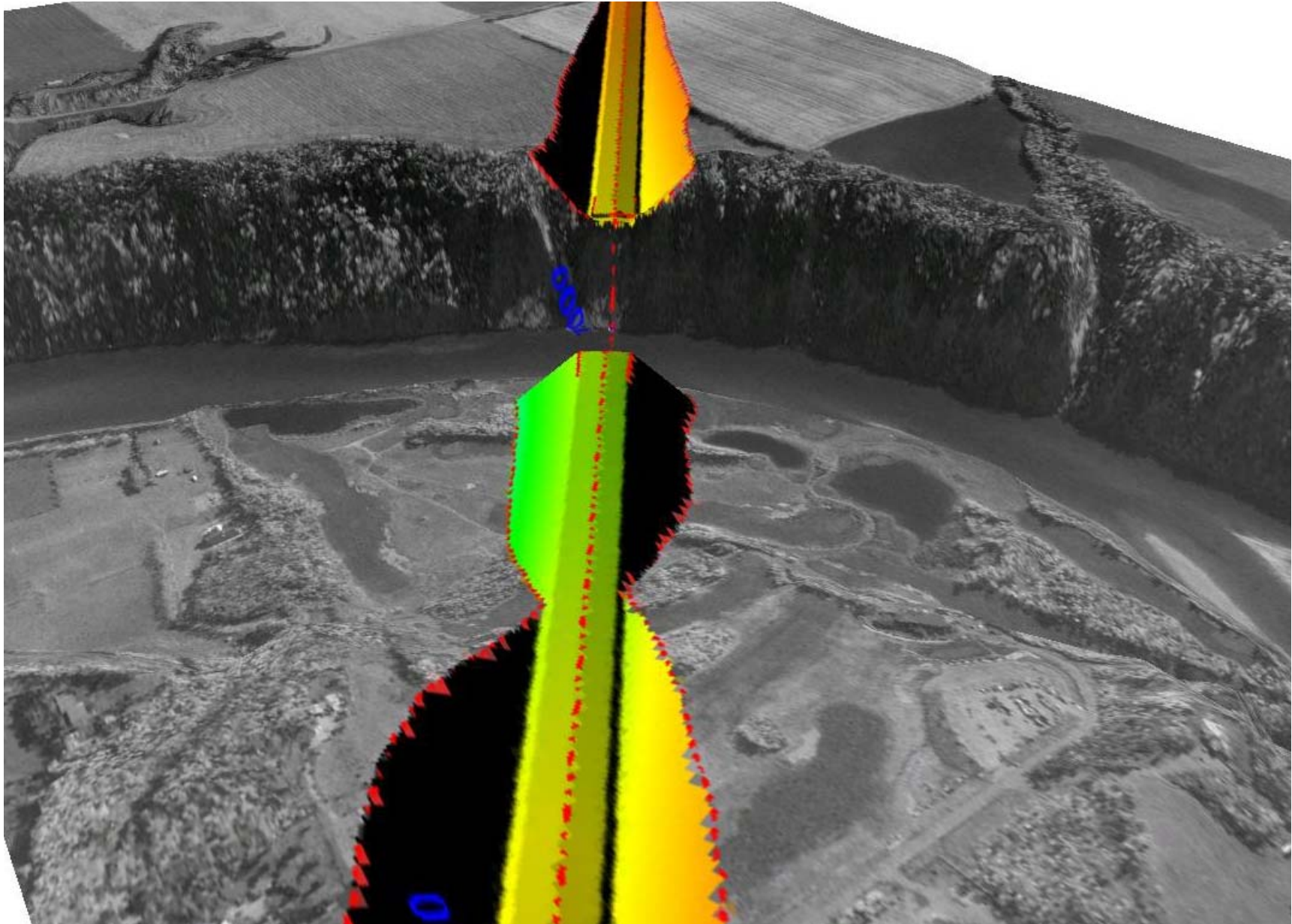
Grading Limits



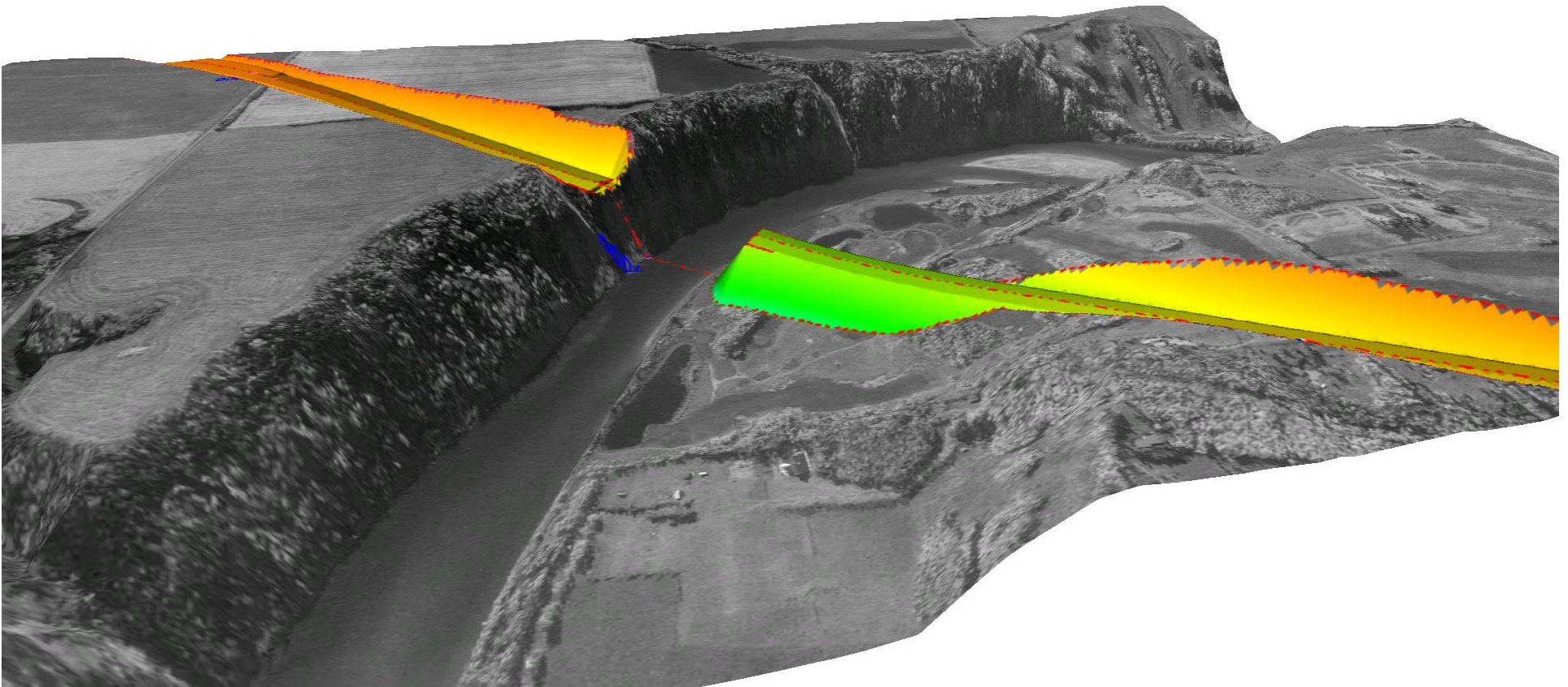
3D Grading Plan



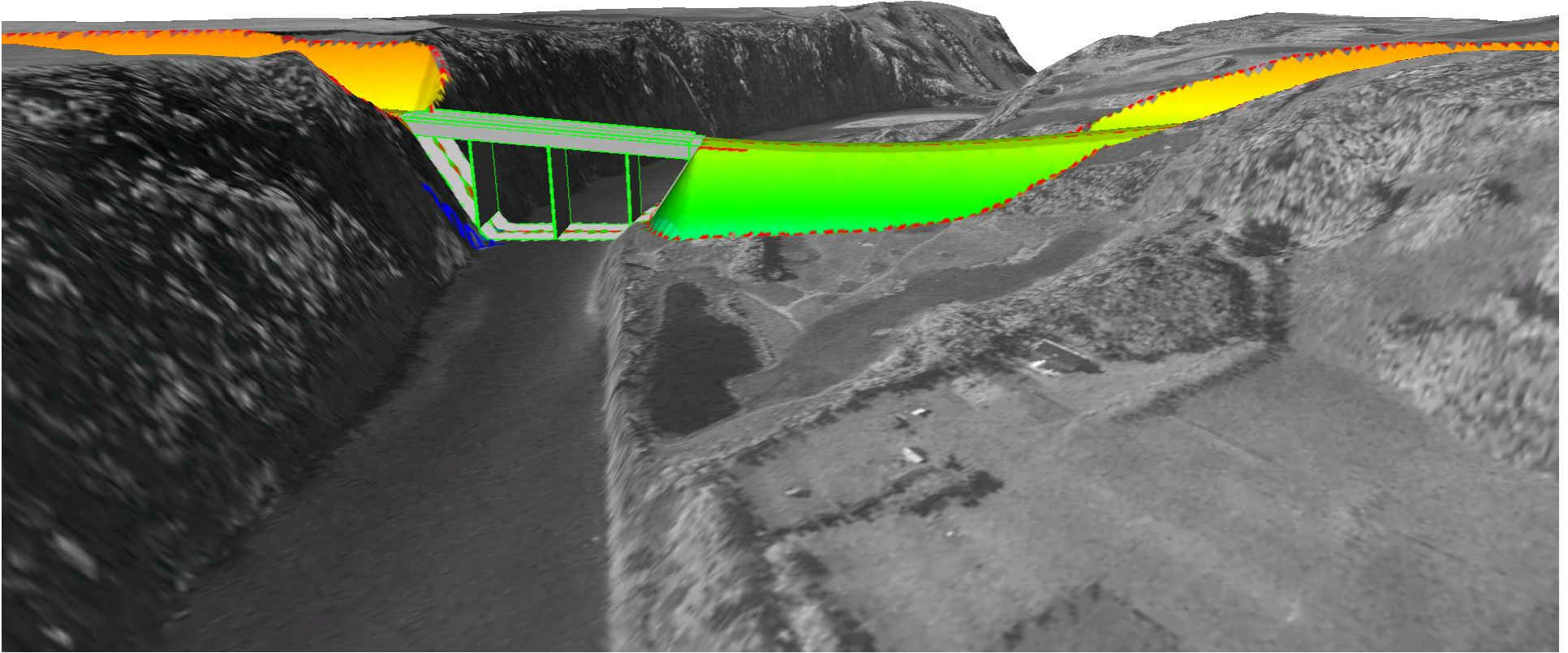
3D Grading View – Along Hwy



3D Grading View – Along Stream



3D Grading View – Bridge

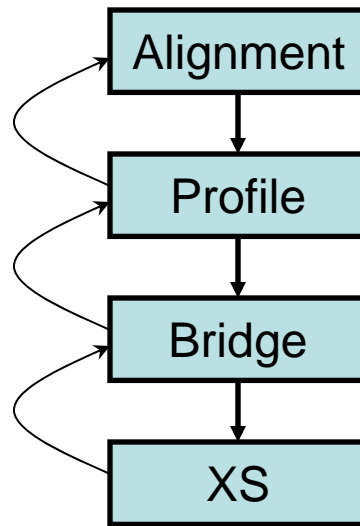


Application

Study Types

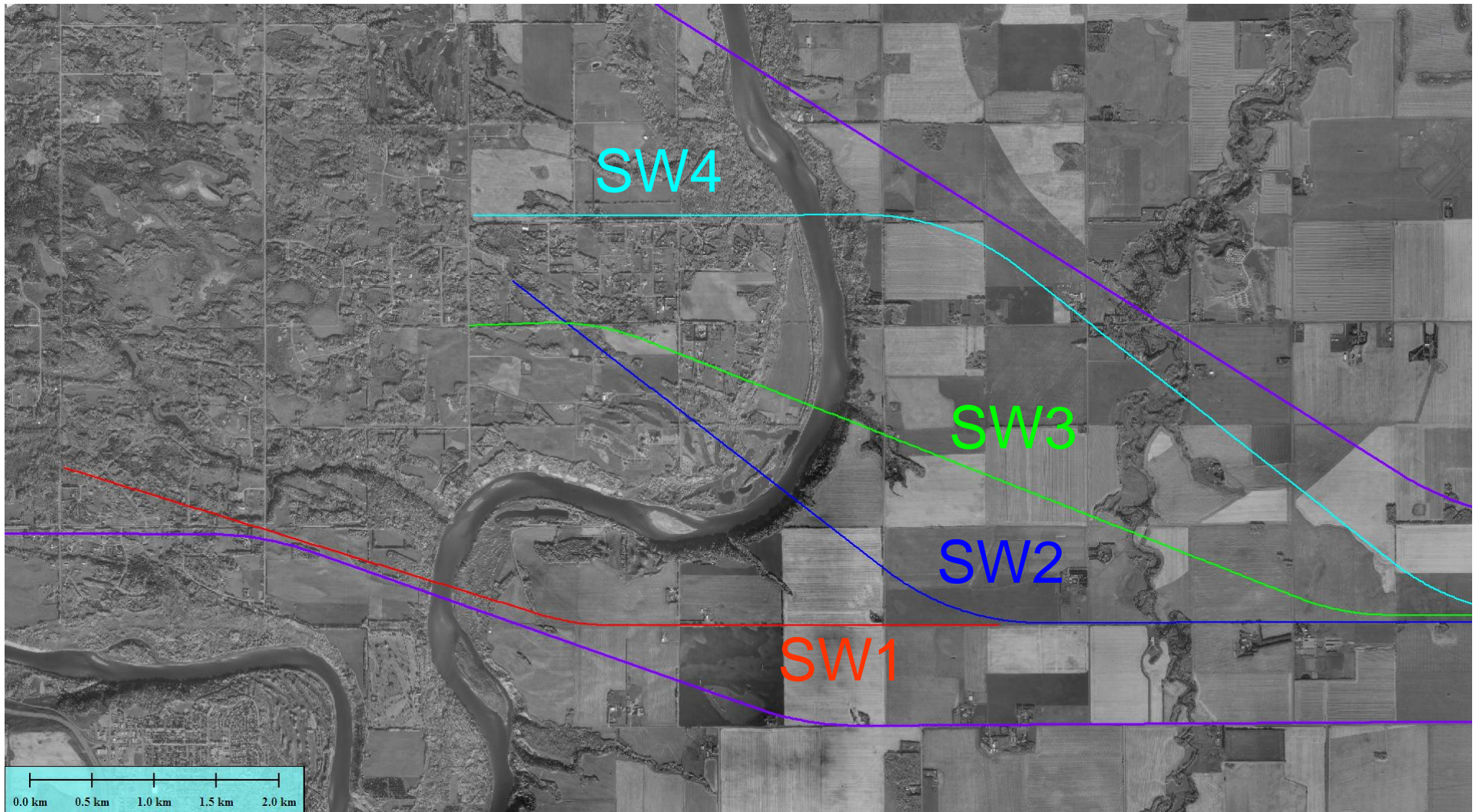
- Bridge Location Studies
 - Develop and Compare Alignment Options
- Participate in FPS
 - Interact with Roadway Planning
- Design - Bridge Planning Phase
 - Optimize bridge plan
 - Assist DD Drafting - CAD ready files

Work Flow



- Many Combinations of Alignment, Profile, and Bridge
- Iterative Process To Develop a Feasible Option
- Many Steps to Develop Optimized Option for Alignment

Alignment Options



Alignment Comparison

	Option	SW1	SW2	SW3	SW4
Quantities	Bridge Width (m)	42	42	42	42
	Bridge Length (m)	355	318	375	395
	Bridge Height (m)	40	40	40	35
	Bridge Skew (degrees)	10	10	0	15
	Max Span (m)	79	74	82	84
	Fill (1000m ³)	385	830	1170	130
	Cut (1000m ³)	4530	4030	2890	2860
	Rock (m ³)	0	0	0	0
Costs (\$M)	Height factor	1.40	1.40	1.40	1.35
	Span Factor	1.13	1.10	1.15	1.17
	Bridge	106.2	92.3	114.1	118.0
	Grading	52.1	43.4	27.7	33.5
	Rock	0.0	0.0	0.0	0.0
	Total	158.3	135.7	141.8	151.5