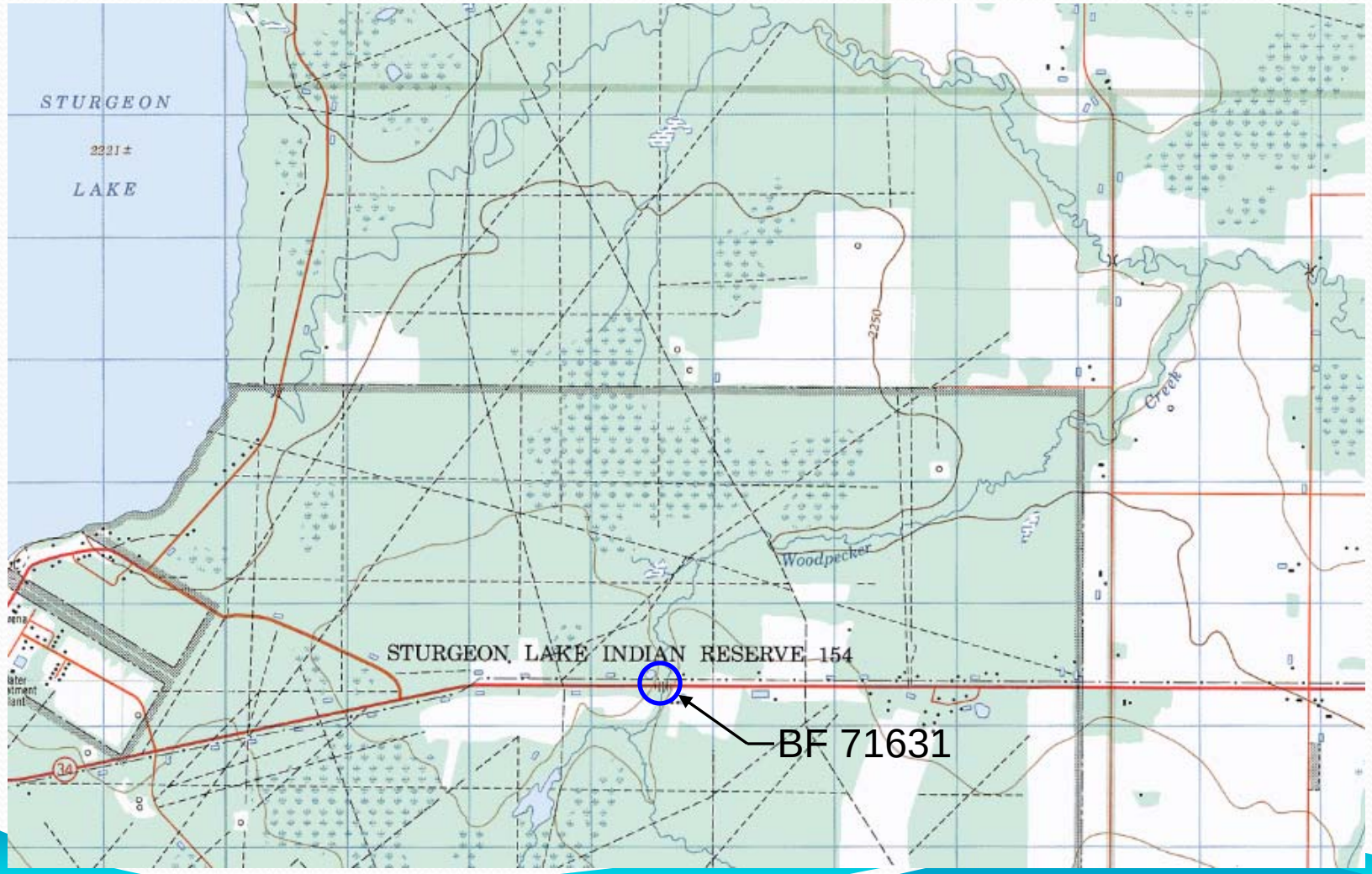
# Bridge Planning Culvert Case Study BF 71631 Woodpecker Creek

Bridge Planning
Practitioners Workshop
April 2012

# Site Summary

- Located on Highway 43:06
- Tributary to Sturgeon Creek which flows into Sturgeon Lake
- Sturgeon Lake Indian Reserve u/s and d/s
- Information available in HIS
  - Drainage area = 54 $km^2$
  - S = 0.0033
  - B = 3 m, h = 1.5 m, T = 6 m
  - Y = 2.3 m, V = 1.6 m,Q = 18 cms

# Site Summary



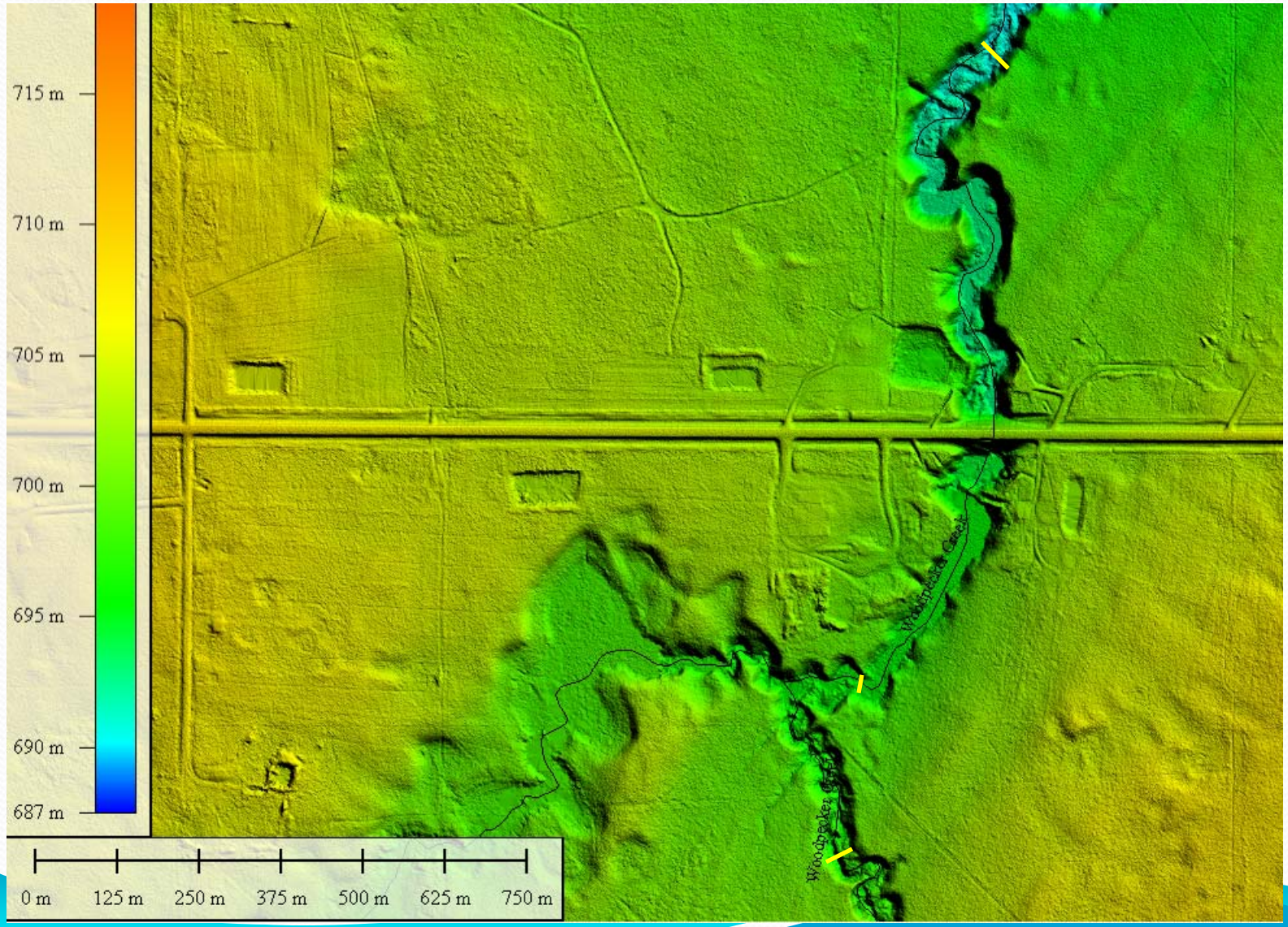
# File History

- 1931 original bridge built, 3-18'spans, dh=20'
- Bridge replaced in 1944, 4-18' spans
- 1954 – hydrotechnical summary
  - B = 10', T = 18', h = 4', Y = 5-8', Q = 200 cfs
- 1954 installed 96" CSP x 224'
- 1963 HW (Apr) : 0.6m > u/s crown
- 1966 HW (Apr) : Y ~ 0.5 – 1.0 m < u/s crown, Y ~ 1 m d/s
- 1979 Erosion at both ends repaired with rock
- 1988 BIM HWM Y = 1.6 m

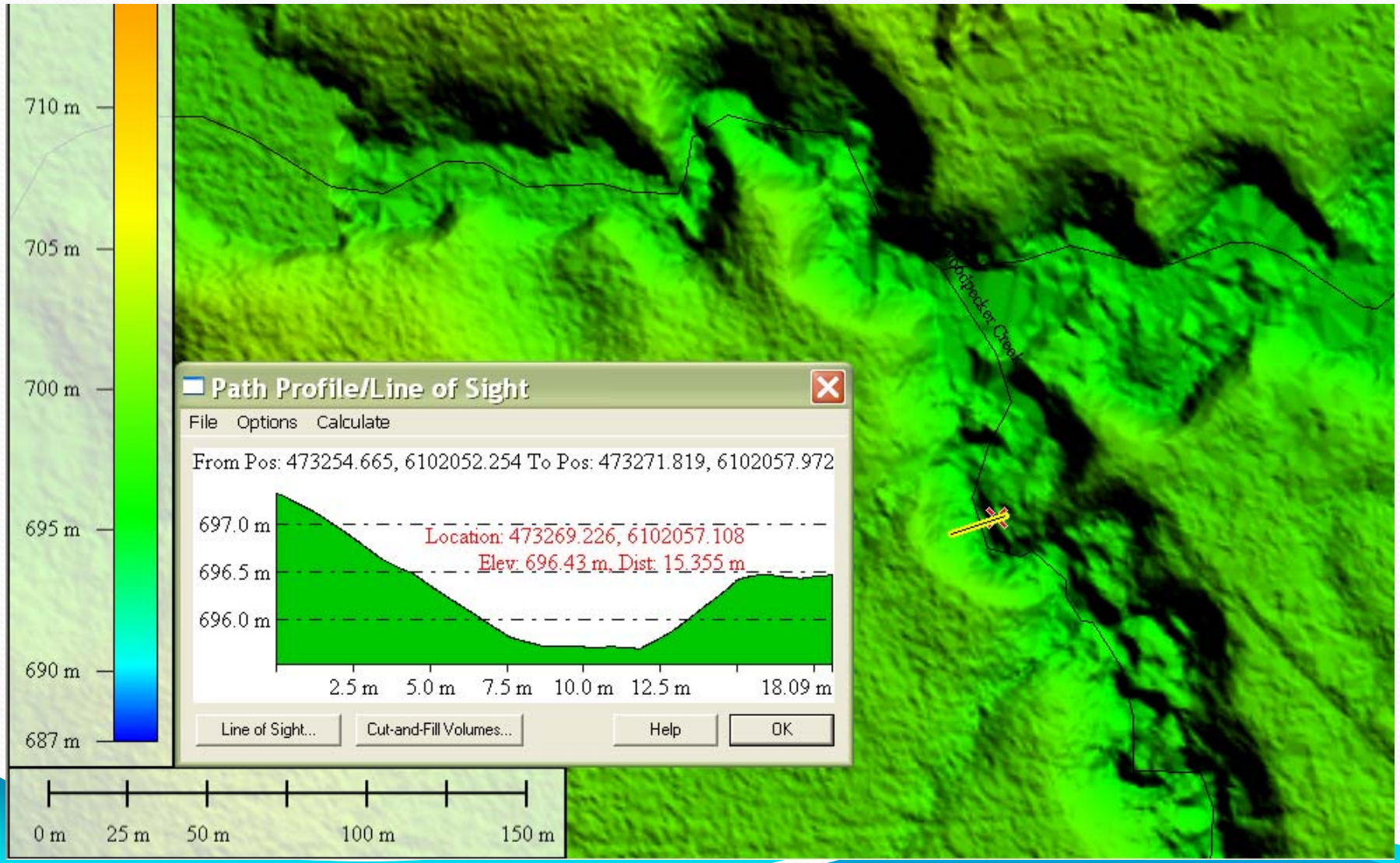
# File History

- 1992 Photo: B = 3 m, h = 1.5 m, T = 6 m, lots of drift.
- 1993 Report: Q = 27 cms, Y = 2.1 m, V = 1.5 m/s
- 1996 Photo: drift to ~ 0.5 – 1.0 m below u/s crown
  - Note : DA = 54 $km^2$, Q = 18 cms, S = 0.005, rec. 4.3m SP
- 1999 Design
  - DA = 56 $km^2$, Q = 23 cms, S = 0.005, Y = 2.0 m, recommended 4.3 m CSP x 110 m
  - Photo: B = 3 m, h = 1.5 m, T = 6 m, ponding u/s behind beaver dam at inlet, scour hole d/s

# DEM

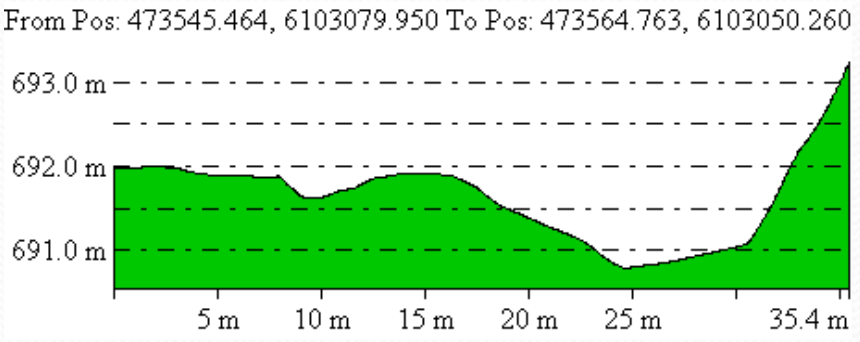

715 m
710 m
705 m
700 m
695 m
690 m
687 m
0 m
125 m
250 m
375 m
500 m
625 m
750 m
Woodpecker Creek

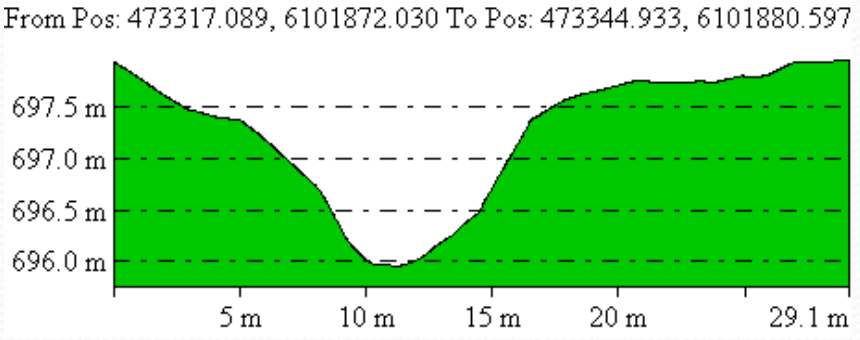
# DEM – cutting stream sections



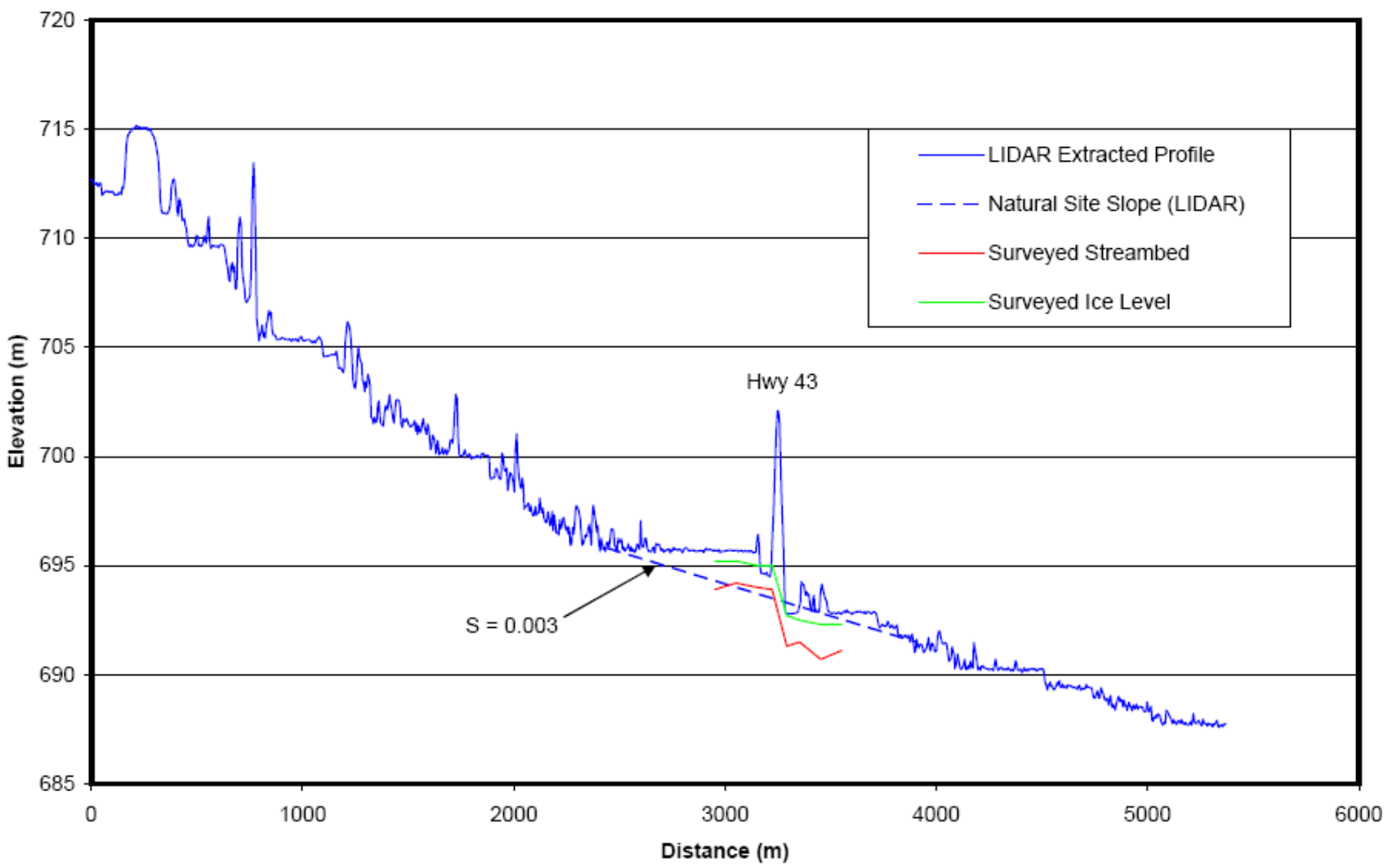
# Estimating Channel Parameters

- Note differences between sections
- Use judgment and estimate B, h and T
- Visit the site to confirm estimates



# Estimating Slope



- Discuss the B, T and h values presented.  Do you agree with them why or why not?  Do you think it will impact the magnitude of the design parameters?

- How would you propose to deal slope issue at this site? Why is there a difference between the LiDAR and survey?

- What are some of the bridge planning issues at this site? Remember to broaden your view away from just the crossing.

# Estimating Slope

- Slope variation due to aggradation u/s, scour downstream
- set the invert at a slope of 0.0033 and match the d/s channel with burial
- Create a transition to the upstream channel that will self correct over time

# Hydrotechnical Summary

- Channel Capacity
  - S = 0.0033
  - B = 3 m, h = 1.5 m, T = 6 m
  - Use n = 0.05
  - At Bank Height : Y = 1.5 m, V = 1.1 m/s, Q = 7 cms
  - At Channel Capacity : Y = 2.3 m, V = 1.6 m/s, Q = 18 cms

# Hydrotechnical Summary

- Historical Highwater Data
  - April 1963 (0.6 m > u/s crown, Q ~ 15 cms)
  - April 1966 (~0.8m < u/s crown)
  - 1988 BIM HWM was noted with Y = 1.6 m
  - 1996 photo shows drift to about 0.8 m < u/s crown
  - Past designs have been based on Q = 17 – 27 cms
  - No WSC gauges on this stream
  - Gauges in the area suggest HW in July 1971 and June 1996.
  - Largest storms in the storm database for this area are about 130 mm in July 1987 and about 100 mm in Jun 1961, August 1976, July 1982, and June 1993

# Hydrotechnical Summary

- Basin Runoff Potential
  - d = 70 mm, $T_p$ = 20 hrs
  - Recall that q ($m^3/s$) = d/(3.6*$T_p$), therefore q = 1.0 cms/$km^2$
  - Gross DA = 54 $km^2$
  - $Q_p$ = q * DA, therefore Qp = 54 cms

# Hydrotechnical Summary

- Design Discharge Recommendation
  - The channel capacity estimate is consistent with historic observations and is within the basin runoff potential
  - Recommended parameters : Y = 2.3 m, V = 1.6 m/s, Q = 18 cms.

# Consultant Hydrotechnical Recommendation

- Completed more on site investigation
- Recommend Y = 2.2 m, V =1.6 m/s, Q = 25 cms

**Channel Capacity Calculator**

| | | | | h | $Y_{cc}$ | $Y_{spec}$ |
|---|---|---|---|---|---|---|
| S | 0.00330 | | Y | 1.5 | 2.25 | 2.2 |
| B | 3.0 | | A | 9 | 16 | 15.3 |
| h | 1.5 | | d | 0.9 | 1.7 | 1.6 |
| $T_h$ | 9 | | V | 1.1 | 1.6 | 1.6 |
| Roughness | 0.050 | | Q | 9.8 | 25.5 | 24.3 |
| | | | | | | |
| HDG 'n' | 0.050 | | | | | |

# Culvert Sizing

- Investigated several alternatives including:
  - Several sizes of SPCSP
  - 4.5 m x 7 m HESPCSP
  - 7 m x 14 m steel or concrete arch
- Remember the design process is iterative

# Hydraulic Analysis - Input

- Flow Profile tool
- Template screen and Input Screen
- Note different slopes on Input screen

| Typical Channel | | Single Culvert | | Bridge | |
|---|---|---|---|---|---|
| B | 3 | Shape | R | B | 8 |
| h | 1.5 | Rise | 4.3 | m | 2 |
| T | 8 | Span | | W | 20 |
| S | 0.0030 | Length | 117.7 | | |
| Elev | 691.8 | Burial | 1 | | |
| | | $L_{trans}$ | 9.2 | | |
| | | Prep Culvert Data | | Prep Bridge Data | |

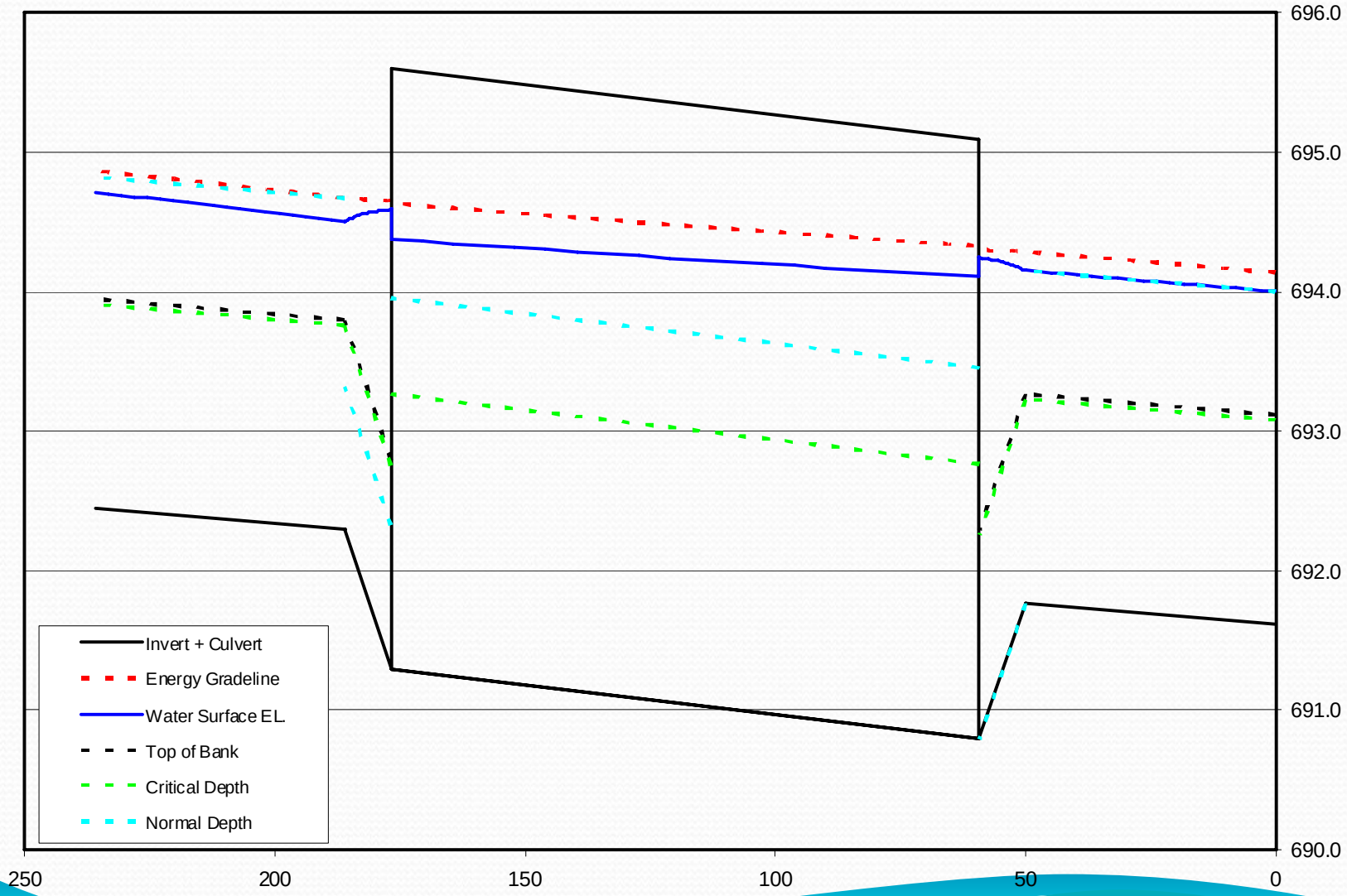
| | Boundary Conditions | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q (cms) | 25 | | | Run | | | | | | | |
| | D/S BC Type | | | | | | | | | | | |
| No. | Section Description | U/S Elev | D/S Elev | Length | Shape | Rise / h | Span / B | T | n | Substrate | n used | S |
| 1 | D/S Channel | 691.8 | 691.6 | 50 | T | 1.5 | 3 | 8 | | | 0.05 | 0.003 |
| 2 | D/S Transition | 690.8 | 691.8 | 9.2 | T | 1.5 | 3 | 8 | 0.05 | | 0.05 | -0.1057 |
| 3 | Culvert | 691.3 | 690.8 | 117.7 | R | 4.3 | | | | | 0.028 | 0.00426 |
| 4 | U/S Transition | 692.3 | 691.3 | 9.2 | T | 1.5 | 3 | 8 | 0.05 | | 0.05 | 0.1087 |
| 5 | U/S Channel | 692.5 | 692.3 | 50 | T | 1.5 | 3 | 8 | | | 0.05 | 0.00306 |

# Hydraulic Analysis - Output

- Summary of output from Flow Profile tool, Results tab

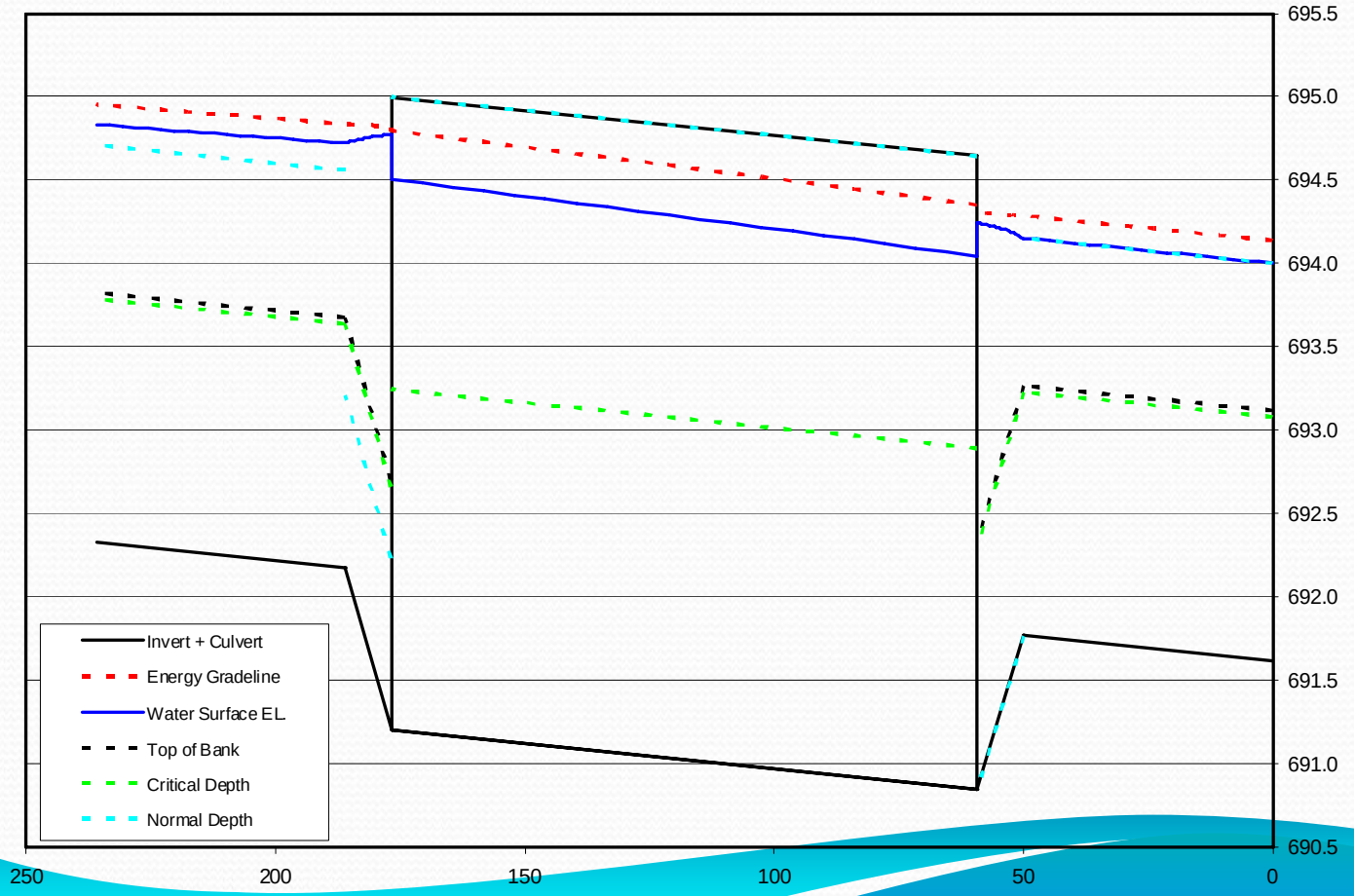
| | | | | | U/S | | | D/S | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Element | Description | Yn | Yc | Profile | Y | V | E | Y | V | E |
| 1 | D/S Channel | 2.38 | 1.46 | Normal | 2.38 | 1.63 | 694.29 | 2.38 | 1.63 | 694.14 |
| 2 | D/S Transition | 0.00 | 1.46 | A2 | 3.45 | 1.05 | 694.30 | 2.38 | 1.63 | 694.29 |
| 3 | Culvert | 2.66 | 1.97 | M1 | 3.08 | 2.25 | 694.63 | 3.31 | 2.08 | 694.33 |
| 4 | U/S Transition | 1.03 | 1.46 | S1 | 2.21 | 1.79 | 694.67 | 3.30 | 1.11 | 694.65 |
| 5 | U/S Channel | 2.37 | 1.46 | M2 | 2.26 | 1.74 | 694.87 | 2.21 | 1.79 | 694.67 |
| | | | | | | | | | | |

# Hydraulic Analysis - Output

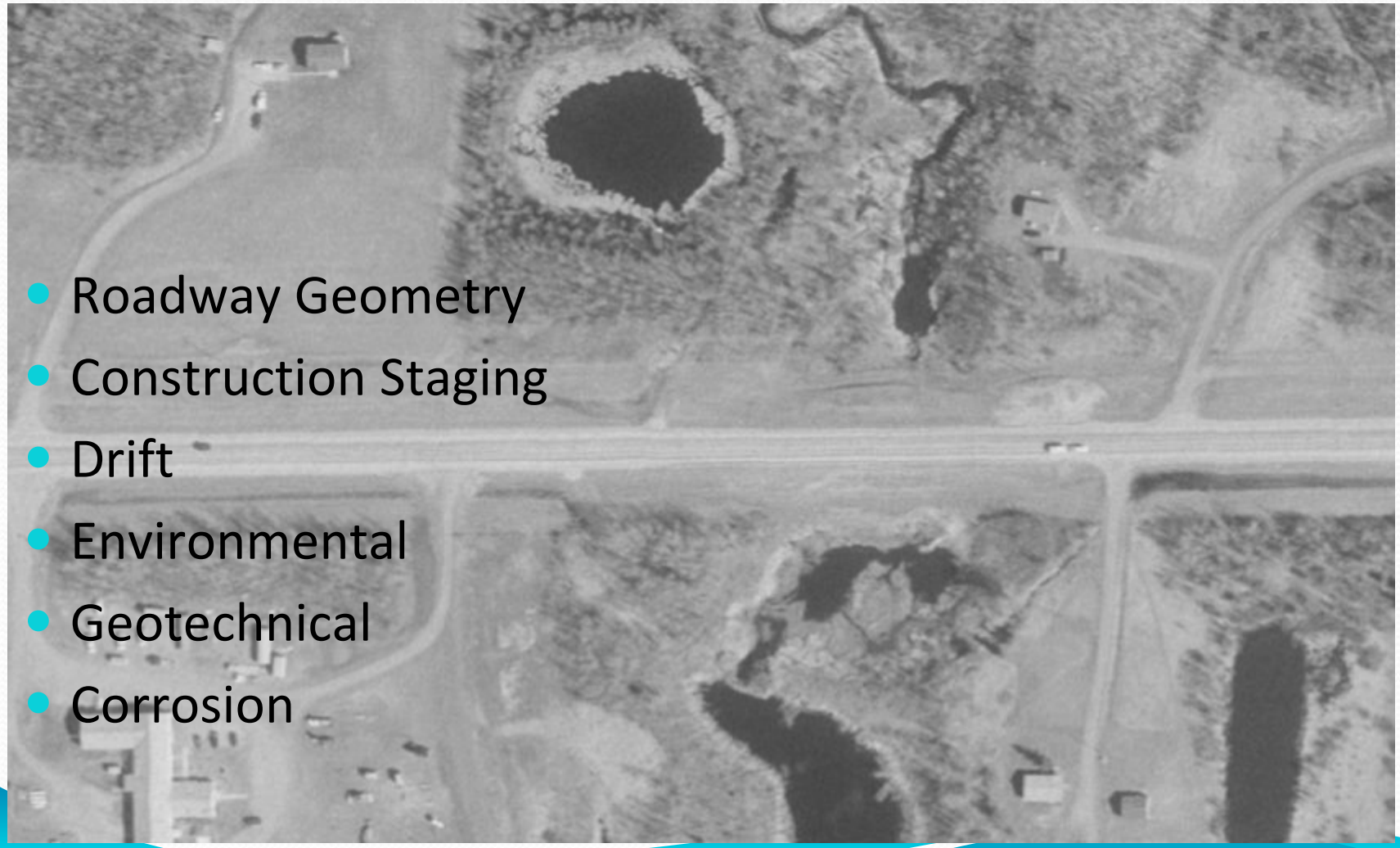


# Hydraulic Analysis – Alternate Size

- Modify culvert diameter to 3.8 and change embedment to 0.95 m



# Other Design Considerations



- Roadway Geometry
- Construction Staging
- Drift
- Environmental
- Geotechnical
- Corrosion

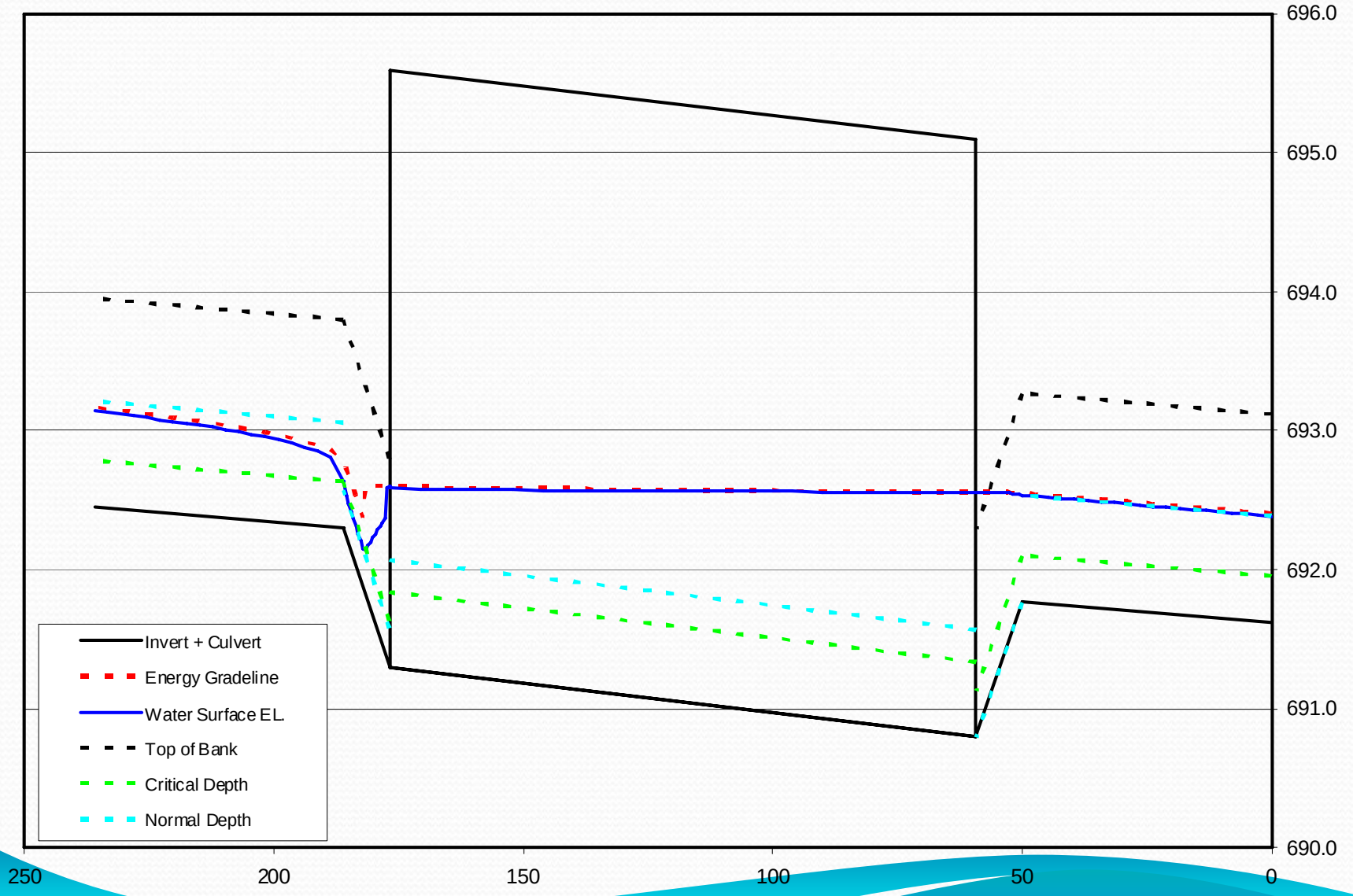
# Fish Passage

- Low potential for large bodied fish utilization
- Due to potential check passage

- Fish flow Q = 2 cms, increased roughness to 0.06 (decreased depth)

| | Boundary Conditions | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q (cms) | 2 | | | Run | | | | | | | |
| | D/S BC Type | | | | | | | | | | | |
| No. | Section Description | U/S Elev | D/S Elev | Length | Shape | Rise / h | Span / B | T | n | Substrate | n used | S |
| 1 | D/S Channel | 691.8 | 691.6 | 50 | T | 1.5 | 3 | 8 | 0.06 | | 0.06 | 0.003 |
| 2 | D/S Transition | 690.8 | 691.8 | 9.2 | T | 1.5 | 3 | 8 | 0.06 | | 0.06 | -0.1057 |
| 3 | Culvert | 691.3 | 690.8 | 117.7 | R | 4.3 | | | 0.035 | | 0.035 | 0.00426 |
| 4 | U/S Transition | 692.3 | 691.3 | 9.2 | T | 1.5 | 3 | 8 | 0.06 | | 0.06 | 0.1087 |
| 5 | U/S Channel | 692.5 | 692.3 | 50 | T | 1.5 | 3 | 8 | 0.06 | | 0.06 | 0.00306 |

# Fish Passage



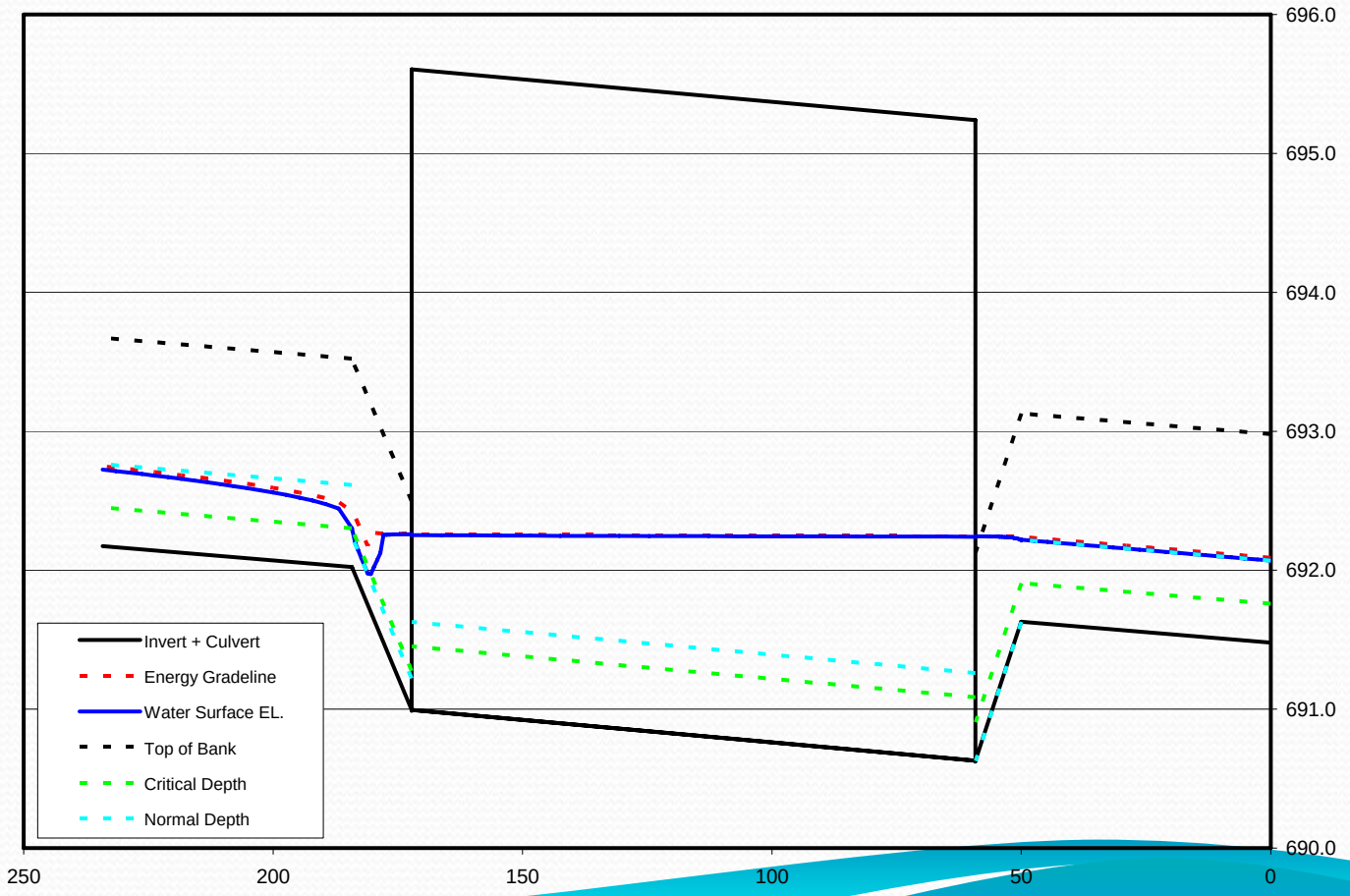
# Fish Passage

| Element | Station | X | Y | V | Invert | Crown | WL | EGL |
|---|---|---|---|---|---|---|---|---|
| | (m) | (m) | (m) | (m/s) | (m) | (m) | (m) | (m) |
| 4 | 176.85 | 0.00 | 1.30 | 0.30 | 691.297 | 692.797 | 692.595 | 692.599 |
| 4 | 177.33 | 0.48 | 1.24 | 0.32 | 691.350 | 692.850 | 692.594 | 692.599 |
| 4 | 177.82 | 0.97 | 0.97 | 0.45 | 691.402 | 692.902 | 692.368 | 692.600 |
| 4 | 178.30 | 1.45 | 0.88 | 0.51 | 691.455 | 692.955 | 692.339 | 692.600 |
| 4 | 178.79 | 1.94 | 0.80 | 0.57 | 691.508 | 693.008 | 692.311 | 692.600 |
| 4 | 179.27 | 2.42 | 0.72 | 0.66 | 691.560 | 693.060 | 692.283 | 692.601 |
| 4 | 179.76 | 2.91 | 0.64 | 0.76 | 691.613 | 693.113 | 692.255 | 692.601 |
| 4 | 180.24 | 3.39 | 0.56 | 0.90 | 691.665 | 693.165 | 692.227 | 692.602 |
| 4 | 180.72 | 3.87 | 0.48 | 1.09 | 691.718 | 693.218 | 692.199 | 692.603 |
| 4 | 181.21 | 4.36 | 0.40 | 1.36 | 691.771 | 693.271 | 692.171 | 692.603 |
| 4 | 181.69 | 4.84 | 0.32 | 1.77 | 691.823 | 693.323 | 692.143 | 692.605 |
| 4 | 182.18 | 5.33 | 0.28 | 2.09 | 691.876 | 693.376 | 692.153 | 692.375 |
| 4 | 182.66 | 5.81 | 0.28 | 2.09 | 691.929 | 693.429 | 692.205 | 692.428 |
| 4 | 183.14 | 6.29 | 0.28 | 2.09 | 691.981 | 693.481 | 692.258 | 692.480 |
| 4 | 183.63 | 6.78 | 0.28 | 2.09 | 692.034 | 693.534 | 692.311 | 692.533 |
| 4 | 184.11 | 7.26 | 0.28 | 2.09 | 692.086 | 693.586 | 692.363 | 692.586 |
| 4 | 184.60 | 7.75 | 0.28 | 2.09 | 692.139 | 693.639 | 692.416 | 692.638 |
| 4 | 185.08 | 8.23 | 0.28 | 2.07 | 692.192 | 693.692 | 692.471 | 692.689 |
| 4 | 185.57 | 8.72 | 0.28 | 2.02 | 692.244 | 693.744 | 692.529 | 692.738 |
| 4 | 186.05 | 9.20 | 0.33 | 1.68 | 692.297 | 693.797 | 692.631 | 692.776 |
| 5 | 186.05 | 0.00 | 0.34 | 1.67 | 692.297 | 693.797 | 692.633 | 692.776 |
| 5 | 188.68 | 2.63 | 0.51 | 1.03 | 692.305 | 693.805 | 692.812 | 692.866 |
| 5 | 191.31 | 5.26 | 0.54 | 0.96 | 692.313 | 693.813 | 692.850 | 692.897 |
| 5 | 193.94 | 7.89 | 0.56 | 0.91 | 692.321 | 693.821 | 692.882 | 692.924 |
| 5 | 196.58 | 10.53 | 0.58 | 0.87 | 692.329 | 693.829 | 692.908 | 692.947 |
| 5 | 199.21 | 13.16 | 0.59 | 0.84 | 692.337 | 693.837 | 692.932 | 692.968 |
| 5 | 201.84 | 15.79 | 0.61 | 0.82 | 692.345 | 693.845 | 692.952 | 692.987 |
| 5 | 204.47 | 18.42 | 0.62 | 0.80 | 692.353 | 693.853 | 692.972 | 693.004 |
| 5 | 207.10 | 21.05 | 0.63 | 0.79 | 692.361 | 693.861 | 692.989 | 693.021 |
| 5 | 209.73 | 23.68 | 0.64 | 0.77 | 692.370 | 693.870 | 693.006 | 693.037 |
| 5 | 212.37 | 26.32 | 0.64 | 0.76 | 692.378 | 693.878 | 693.022 | 693.052 |
| 5 | 215.00 | 28.95 | 0.65 | 0.75 | 692.386 | 693.886 | 693.037 | 693.066 |

- Target velocity is 0.61 m/s

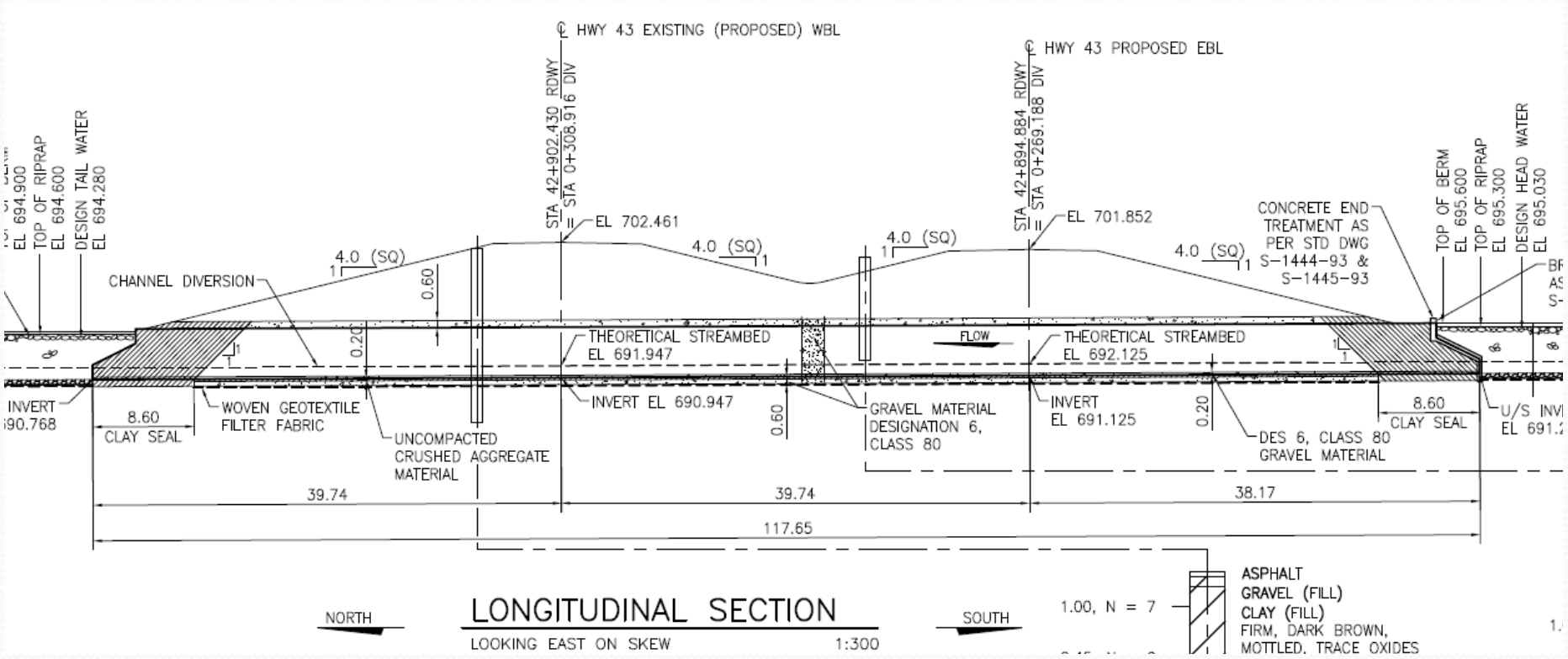
# Fish Passage

- Things to try to reduce velocity - increase roughness, flatten slope

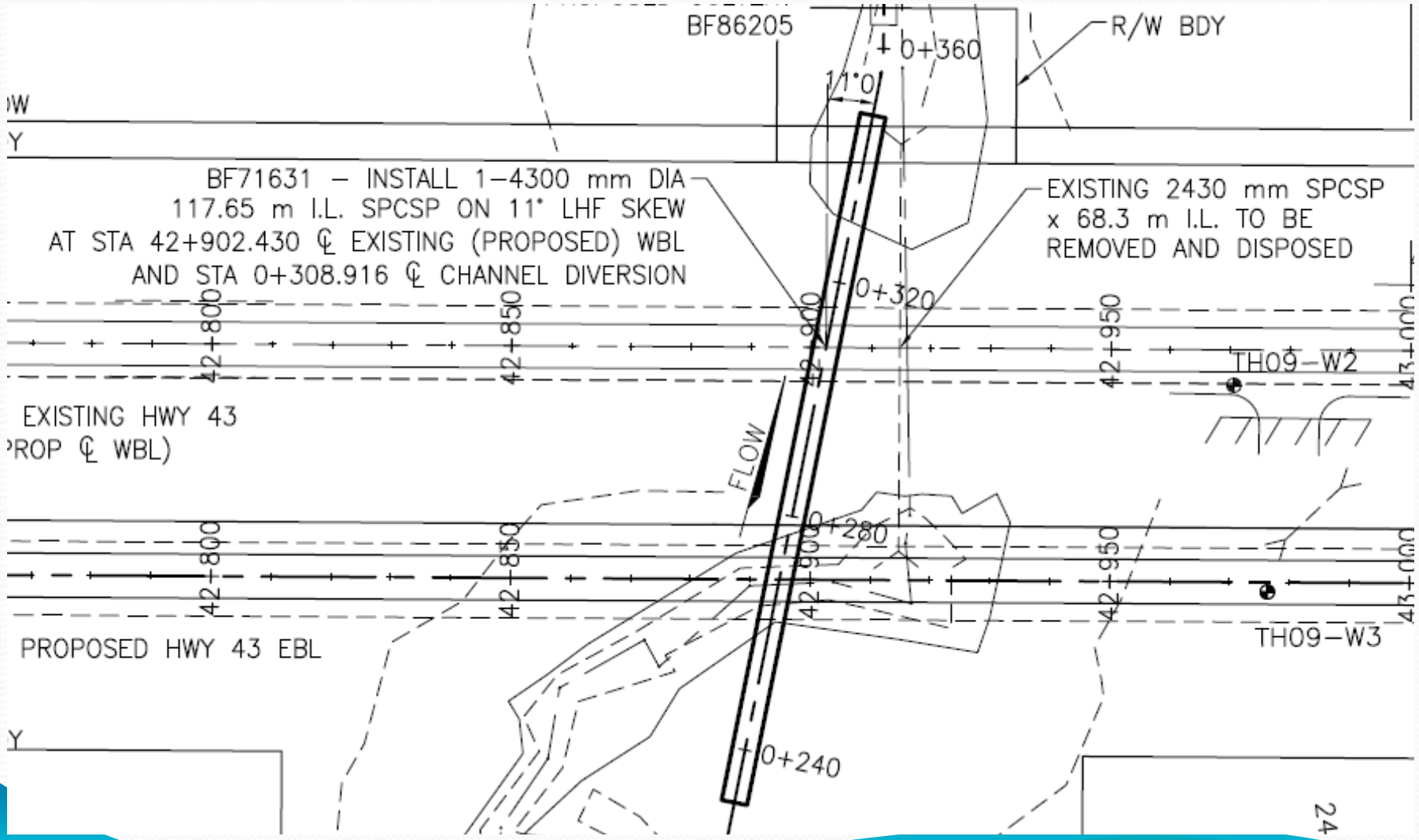


# Recommended Design

- 4.3 m x 117.65 m SPCSP



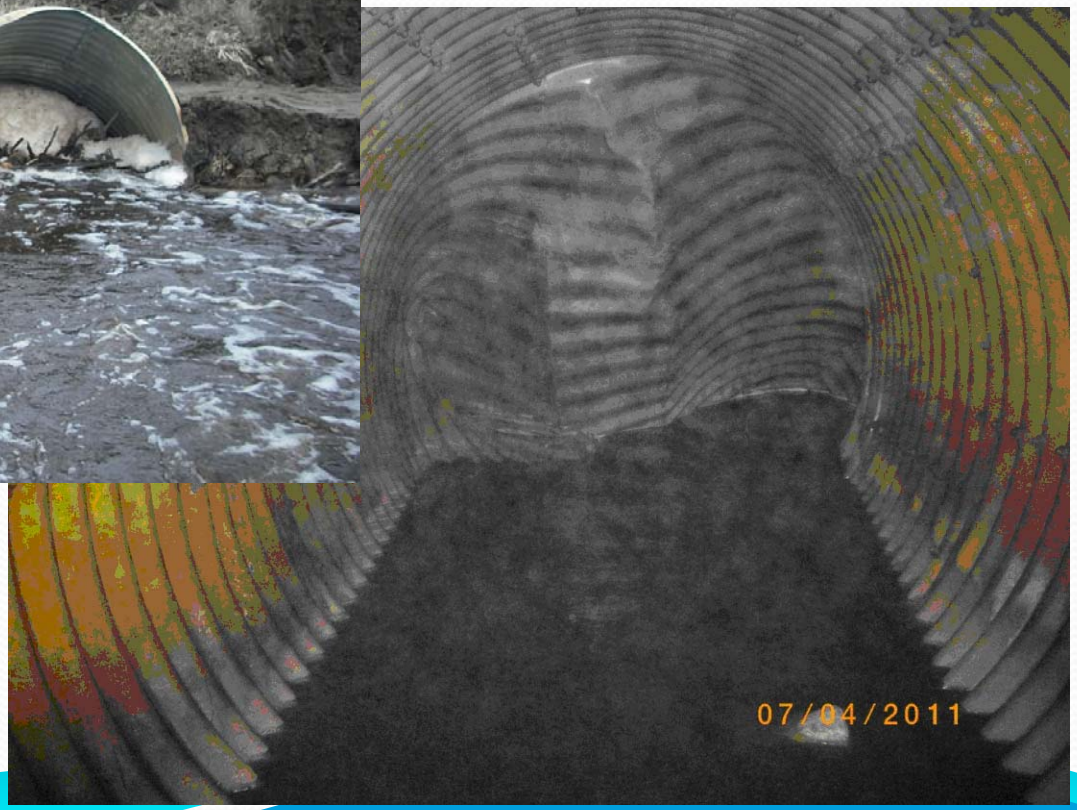
# Recommended Design



# And then what happened?

- July 2011 flood
- Culvert failed – uplift at inlet

# Uplift failure

# Installing liner

# Installed liner (temporary)