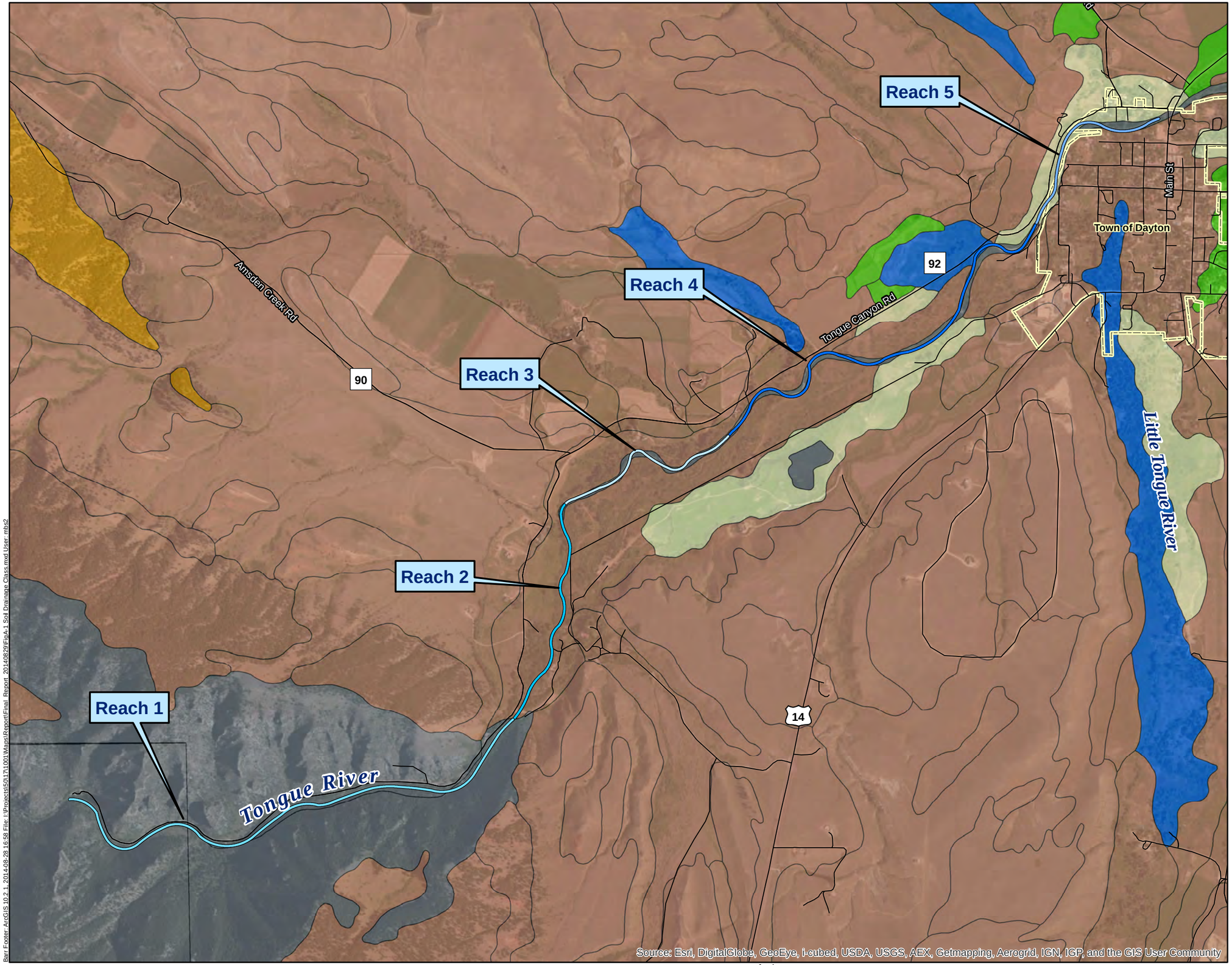
Appendix A

Supplemental Soils Maps



Municipal Boundary

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5

Soil Drainage Class

- Poorly drained
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Excessively drained
- Unrated

N

Feet

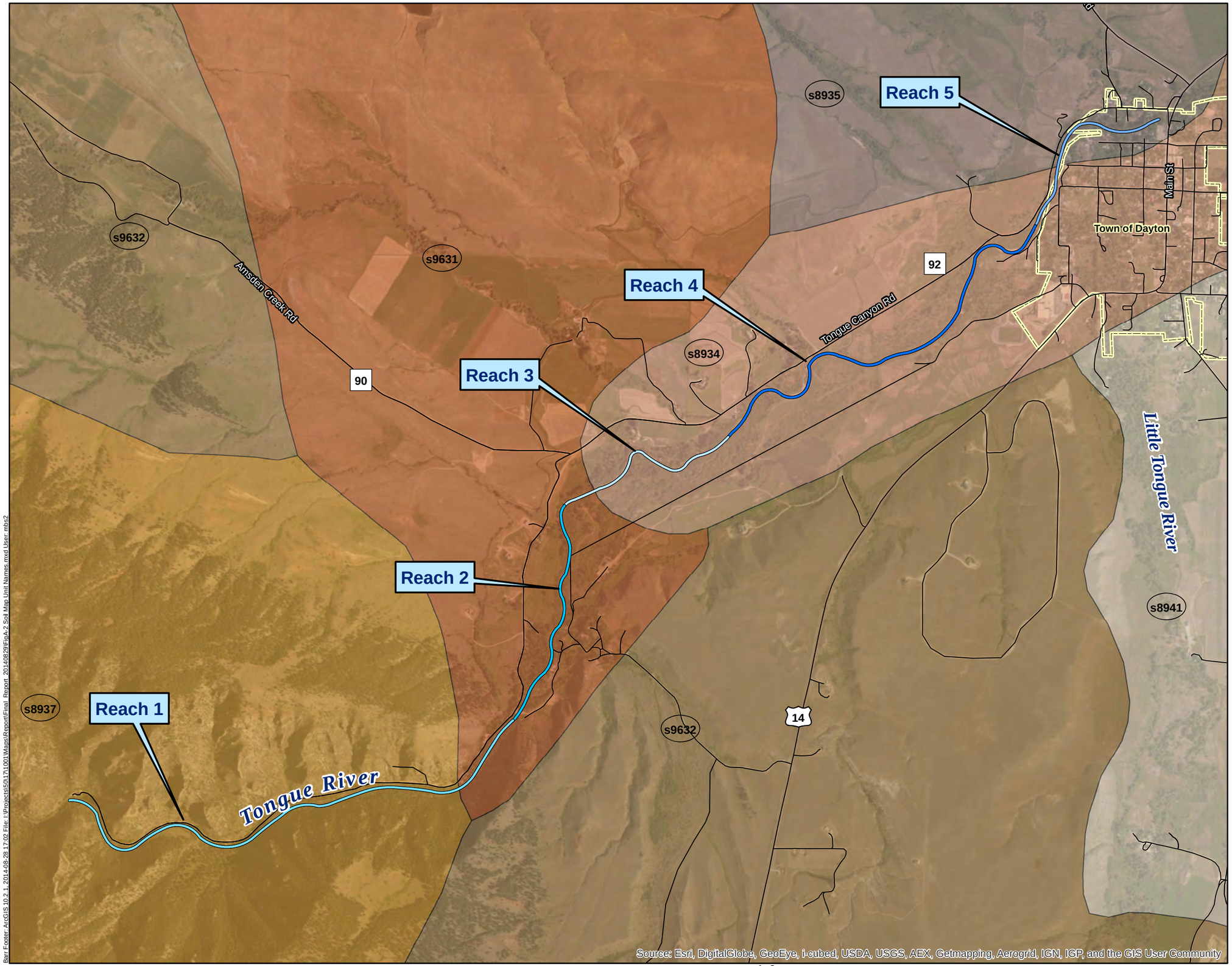
1,500 0 1,500

Figure A-1

SOIL DRAINAGE CLASSES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

Barr Footer: ArcGIS 10.2.1, 2014-08-28 16:58 File: I:\Projects\5017\1001\Mxds\Report\Final_Report_20140829\FigA-1 Soil Drainage Class.mxd User: mbs2



Municipal Boundary

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5

Soil Map Unit Names

- s8934, Zigweid-Yawdim-Nuncho-Havre-Haverdad
- s8935, Wyarno-Worfka-Ulm-Shingle-Samday-Rock outcrop-Renohill-Parmleed-Gaynor
- s8937, Tolman-Starley-Rock outcrop -Cloud Peak-Abac
- s8941, Ulm-Recluse-Platsher-Platner-Parmleed-Nunn
- s9631, Savar-Savage-Norbert
- s9632, Trivar-Trimad-Abac

N

Feet

1,500 0 1,500

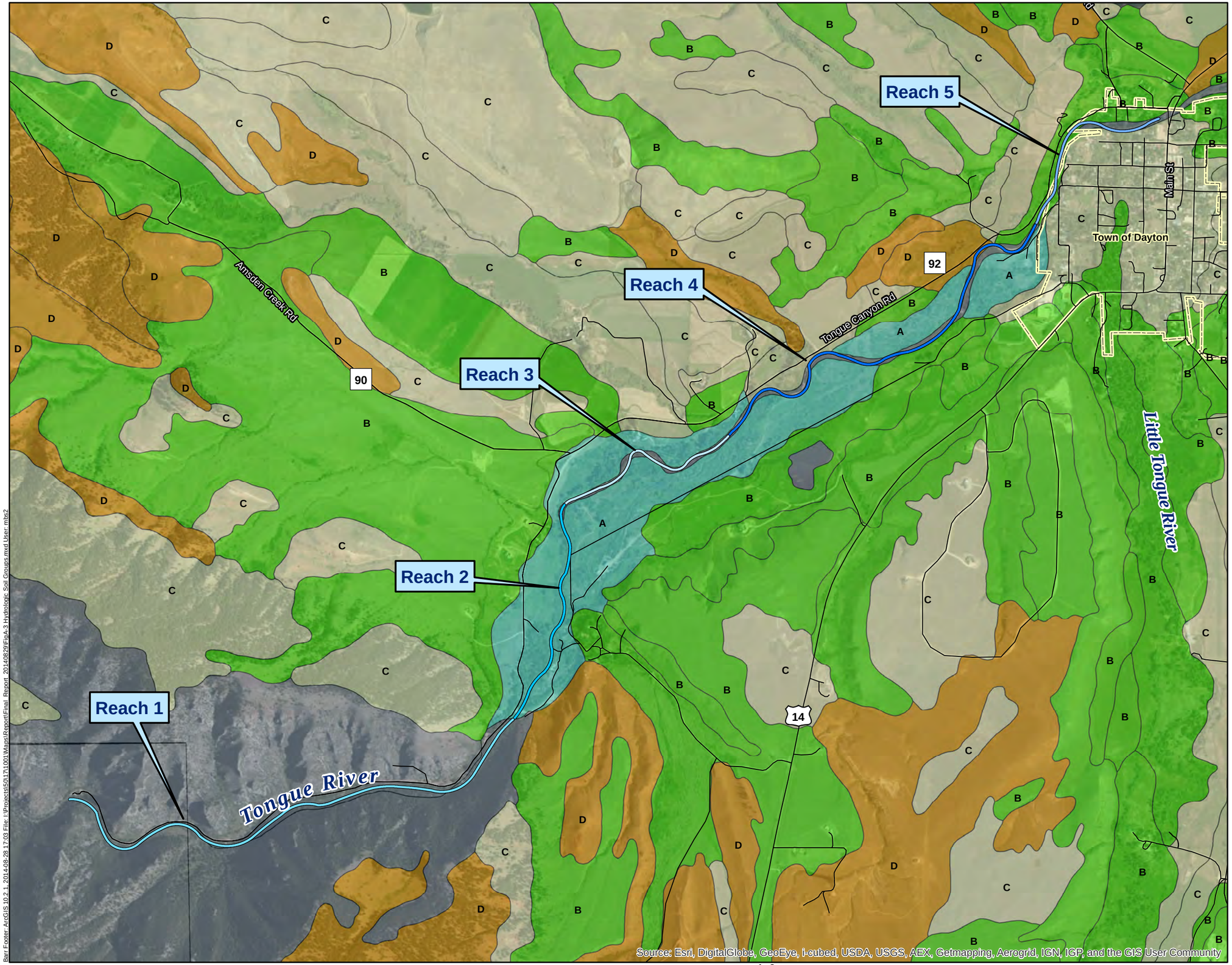
Figure A-2

SOIL MAP UNIT NAMES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Barr Footer: ArcGIS 10.2.1, 2014-08-28 17:02 File: I:\Projects\50\171001\Maps\Report\Final Report_20140829\FigA-2 Soil Map Unit Names.mxd User: mhs2



Municipal Boundary

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5

Hydrologic Soil Group

- Unrated
- A
- B
- C
- D

Feet

1,500 0 1,500

Figure A-3

HYDROLOGIC SOIL GROUPS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Barr Footer: ArcGIS 10.2.1, 2014-08-28 17:03 File: I:\Projects\51\171001\Maps\Report\Final Report 20140829\FinA-3 Hydrologic Soil Groups.mxd User: mbs2

Appendix B

VSAP Evaluations

Stream Visual Assessment Protocol Worksheet

OWNERS NAME: Landowner 1		**DATE:** 1/01/14
EVALUATORS NAME: Paul, Amy, Maria, Oakley		**HUC:** 10090101
STREAM NAME: Tongue River		
REACH LOCATION: Station 100+00 through 215+00 Cross sections 14,15,16 & 17 Note: Refer to Landowner 2 for information on the left bank from station 120+00 to 135+00 Cross section 19-22		
MLRA 58B	**DRAINAGE AREA:**	**GRADIENT:** 2%
REFERENCE SITE: None		
LAND USE WITHIN DRAINAGE AREA (%)		
RESIDENTIAL:	*HAYLAND:*	*PASTURE:*
FOREST:	*CRP:*	OTHER:
WEATHER PAST 2-5 DAYS: snow, wet.	Bankfull width	
ACTIVE CHANNEL WIDTH: 20’		
DOMINANT SUBSTRATE:		

Note: This reach is located and scored between cross sections 14 and 17

PARAMETER	SCORE	PARAMETER	SCORE
Channel Condition: pg. 9-16	4	9. Manure or human waste: pg. 28	7
2. Hydrologic alteration: 17&18	7	10. Pools: pg. 29 &30	3
3. Bank Condition: 19&20	6	11. Barriers to Movement: pg. 31	7
4. Riparian Area Quantity: pg. 21	5	12. Fish Habitat Complexity: pg. 32	6
5. Riparian area Quality: pg. 23	6	13. Aquatic Invertebrate Habitat pg. 34 &35	6
6. Canopy Cover: pg. 24&25	2	14. Aquatic Invertebrate Community pg. 36 - 39	8
7. Water Appearance: pg. 26	9	15. Riffle Embeddedness pg. 40	8
8. Nutrient Enrichment: pg. 27	7	16. Salinity:	N/A

OVERALL SCORE (Total divided by number scored):	**6.1**

EXCELLENT	>9.0	
GOOD	7.5 – 8.9	
FAIR	6.1 – 7.4	X
POOR	<6.0	

SUSPECTED CAUSES OF LOW SVAP OBSERVED SCORES: (Scores less than 5)

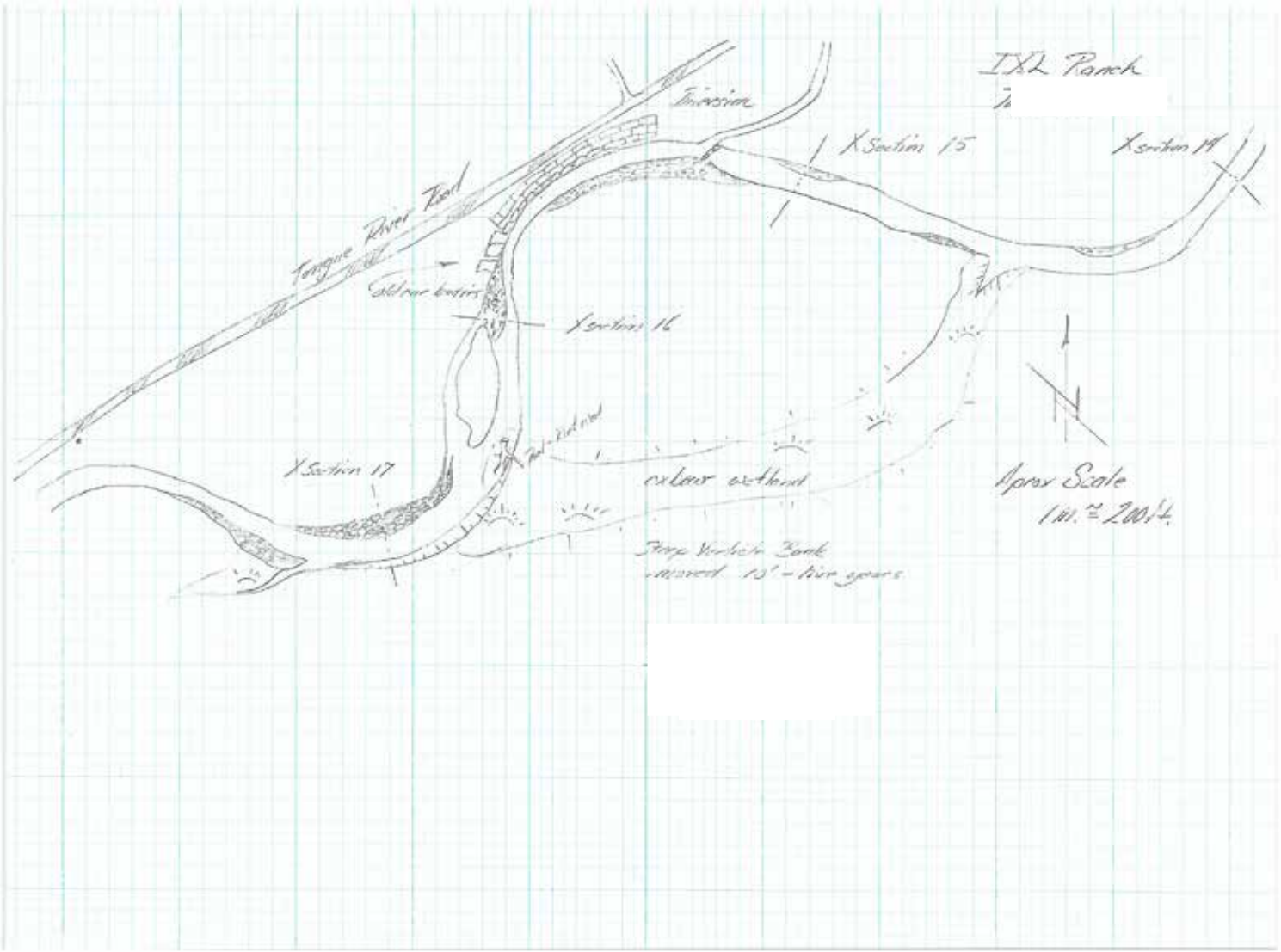
- Element 1: Channel Elevation Model stage III. Active lateral movement.
- Element 4: Riparian Area Quantity. Active bank erosion has removed many of the woody elements through this reach which also affects the canopy cover. Fire in 2003 has removed much of the older vegetation and caused bank instability. The river lacks enough power to move the bed load through this reach due to high width to depth ratio and perhaps by removal of flood water for irrigation.
- Element 5: Riparian Area Quality. The native wetland vegetation has been left high and dry by lowered water table.
- Element 6: The Canopy Cover is lacks the shrub element and overhanging vegetation again to the fire of 03.
- Element 10. Pools this reach however seldom encountered are a primary result of scour from remnant woody material washed into the stream resulting from the fire.

Landowner Concerns:

1. As a rule the landowner allows the river freedom to adjust unhampered. There is concern about erosion both along the bend and about the diversion. Should the river meander into the oxbow it could abandon its present location and shorten the stream length beginning a chain reaction what could become a new set of adjustments.
2. The area in and around the Diversion also have landowner concerned due to erosion.

RECOMMENDATIONS:

1. Stabilize eroding stream banks ether by allowing the river to adjust its length or construct structures. Create riffle pool complexes with the structures. Landowners may use structures downstream as a blueprint for future work on this reach.
2. There is a general lack of woody material in this reach. Consider pine tree revetment, root wade or toe wood installations Add structure to channel at strategic locations to create riffle/pool complexes. Plant trees and shrubs along bank to shade the waterway.
3. Define intermediate berm during low water periods and use the meander pattern in place to enhance pattern.
4. Replace push up diversion with a permanent one that allows for fish passage, keeps fish out of the irrigation ditch and allows the river to pass the bed load.



Site Diagram

Stream Visual Assessment Protocol Worksheet

OWNERS NAME: Landowner 2		**DATE:** 1/01/14
EVALUATORS NAME: Paul, Amy, Maria, Oakley		**HUC:** 10090101
STREAM NAME: Tongue River		
REACH LOCATION: Station 125+00 through 150+00 Cross sections 18,19,20 & 22		
MLRA 58B	**DRAINAGE AREA:**	**GRADIENT:** 2%
REFERENCE SITE: None		
LAND USE WITHIN DRAINAGE AREA (%)		
RESIDENTIAL:	*HAYLAND:*	*PASTURE:*
FOREST:	*CRP:*	OTHER:
WEATHER PAST 2-5 DAYS: snow, wet.	Bankfull width	
ACTIVE CHANNEL WIDTH:		
DOMINANT SUBSTRATE:		

Note: This reach is located and scored between cross sections 14 and 17

PARAMETER	SCORE	PARAMETER	SCORE
Channel Condition: pg. 9-16	4	9. Manure or human waste: pg. 28	3
2. Hydrologic alteration: 17&18	5	10. Pools: pg. 29 &30	9
3. Bank Condition: 19&20	4	11. Barriers to Movement: pg. 31	10
4. Riparian Area Quantity: pg. 21	6	12. Fish Habitat Complexity: pg. 32	9
5. Riparian area Quality: pg. 23	6	13. Aquatic Invertebrate Habitat pg. 34 &35	9
6. Canopy Cover: pg. 24&25	4	14. Aquatic Invertebrate Community pg. 36 - 39	9
7. Water Appearance: pg. 26	8	15. Riffle Embeddedness pg. 40	6
8. Nutrient Enrichment: pg. 27	8	Total	100

OVERALL SCORE (Total divided by number scored):	**6.7**

EXCELLENT	>9.0	
GOOD	7.5 – 8.9	
FAIR	6.1 – 7.4	X
POOR	<6.0	

SUSPECTED CAUSES OF LOW SVAP OBSERVED SCORES: (Scores less than 5)

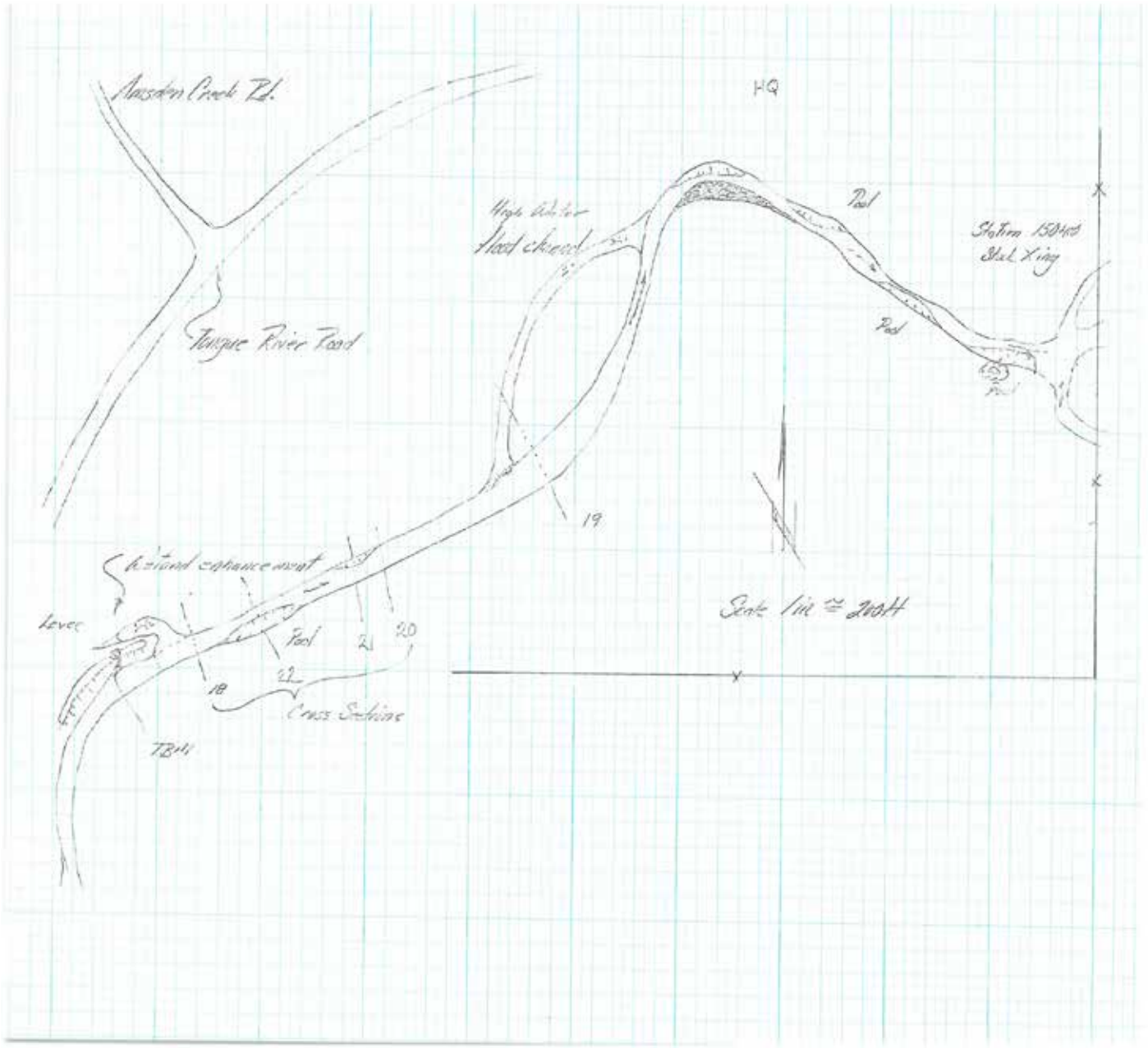
- Element 1: Channel Elevation Model stage III. Active lateral movement.
- Element 4: Riparian Area Quantity. Active bank erosion has removed many of the woody elements through this reach which also affects the canopy cover. Fire in 2003 has removed much of the older vegetation and caused bank instability. The river lacks enough power to move the bed load through this reach due to high width to depth ratio and perhaps by removal of flood water for irrigation.
- Element 5: Riparian Area Quality. The native wetland vegetation has been left high and dry by lowered water table.
- Element 6: The Canopy Cover is lacks the shrub element and overhanging vegetation again to the fire of 03.
- Element 10. Pools this reach however seldom encountered are a primary result of scour from remnant woody material washed into the stream resulting from the fire.

Landowner Concerns:

1. As a rule the landowner allows the river freedom to adjust unhampered. There is concern about erosion both along the bend and about the diversion. Should the river meander into the oxbow it could abandon its present location and shorten the stream length beginning a chain reaction what could become a new set of adjustments.
2. The area in and around the Diversion also have landowner concerned due to erosion.

RECOMMENDATIONS:

1. Stabilize eroding stream banks ether by allowing the river to adjust its length or construct structures. Create riffle pool complexes with the structures. Landowners may use structures downstream as a blueprint for future work on this reach.
2. There is a general lack of woody material in this reach. Consider pine tree revetment, root wade or toe wood installations Add structure to channel at strategic locations to create riffle/pool complexes. Plant trees and shrubs along bank to shade the waterway.
3. Define intermediate berm during low water periods and use the meander pattern in place to enhance pattern.
4. Replace push up diversion with a permanent one that allows for fish passage, keeps fish out of the irrigation ditch and allows the river to pass the bed load.



Site Diagram

Stream Visual Assessment Protocol Worksheet

OWNERS NAME: Landowner 3		**DATE:** 1/01/14
EVALUATORS NAME: Paul, Maria		**HUC:** 10090101
STREAM NAME: Tongue River		
REACH LOCATION: Station 85+00 through 87+00		
MLRA 58B	**DRAINAGE AREA:**	**GRADIENT:** 2%
REFERENCE SITE:		
LAND USE WITHIN DRAINAGE AREA (%)		
RESIDENTIAL:	*HAYLAND:*	*PASTURE:*
FOREST:	*CRP:*	OTHER:
WEATHER PAST 2-5 DAYS: snow, wet.	Bankfull width	
ACTIVE CHANNEL WIDTH:		
DOMINANT SUBSTRATE:		

Note: No cross section completed here. Need to revisit.

PARAMETER	SCORE	PARAMETER	SCORE
Channel Condition: pg. 9-16	6	9. Manure or human waste: pg. 28	9
2. Hydrologic alteration: 17&18	6	10. Pools: pg. 29 &30	8
3. Bank Condition: 19&20	7	11. Barriers to Movement: pg. 31	8
4. Riparian Area Quantity: pg. 21	6	12. Fish Habitat Complexity: pg. 32	6
5. Riparian area Quality: pg. 23	6	13. Aquatic Invertebrate Habitat pg. 34 &35	9
6. Canopy Cover: pg. 24&25	6	14. Aquatic Invertebrate Community pg. 36 - 39	9
7. Water Appearance: pg. 26	8	15. Riffle Embeddedness pg. 40	6
8. Nutrient Enrichment: pg. 27	9	Total Points	109

OVERALL SCORE (Total divided by number scored):	**7.2**

EXCELLENT	>9.0	
GOOD	7.5 – 8.9	
FAIR	6.1 – 7.4	X
POOR	<6.0	

SUSPECTED CAUSES OF LOW SVAP OBSERVED SCORES: (Scores less than 5)

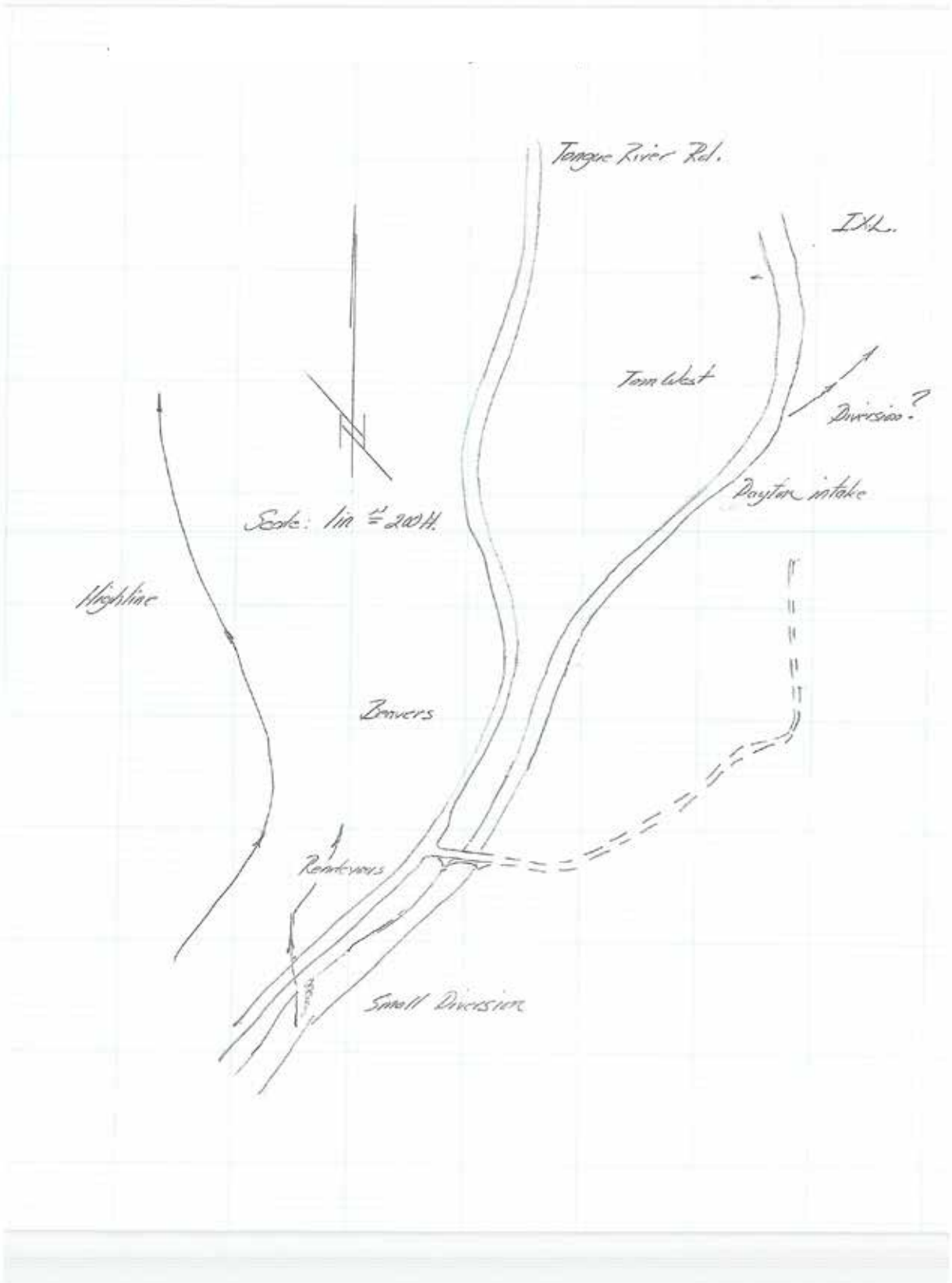
- Element 1: Channel Condition appears to be aggrading. One mid channel bar has formed at about 101+00 and is over wide.
- Element 4: Riparian Area Quantity.
- The river appears to lack enough power to move the bed load through this reach due to high width to depth ratio and perhaps by removal of flood water for irrigation and or change is slope.
- Element 6: The Canopy Cover is lacks the shrub element and overhanging vegetation.
- Element 10. Deep pools (two to three times mean depth) not found. Most pool are a primary result woody material washed into the stream.

Landowner Concerns:

The area in and around the Diversion also have landowner concerned due to erosion.

RECOMMENDATIONS:

- Consider abandoning small diversion and utilizing the highline ditch. The elevation difference between the irrigated land and the water surface in the ditch could allow for a gravity sprinkler conversion from flood. More water efficient and more productive.
- Define the Correct pattern for this reach in terms of width to depth ratio.



Site Diagram

Stream Visual Assessment Protocol Worksheet

OWNERS NAME: Landowner 4		**DATE:** 1/01/14
EVALUATORS NAME: Paul, Amy, Maria		**HUC:** 10090101
STREAM NAME: Tongue River		
REACH LOCATION: Station 102+00 through 103+00		
MLRA 58B	**DRAINAGE AREA:**	**GRADIENT:** 2%
REFERENCE SITE: None		
LAND USE WITHIN DRAINAGE AREA (%)		
RESIDENTIAL:	*HAYLAND:*	*PASTURE:*
FOREST:	*CRP:*	OTHER:
WEATHER PAST 2-5 DAYS: snow, wet.	Bankfull width	
ACTIVE CHANNEL WIDTH: 20’		
DOMINANT SUBSTRATE:		

Note: This reach is located and scored between cross sections 14 and 17

PARAMETER	SCORE	PARAMETER	SCORE
Channel Condition: pg. 9-16	4	9. Manure or human waste: pg. 28	3
2. Hydrologic alteration: 17&18	7	10. Pools: pg. 29 &30	4
3. Bank Condition: 19&20	6	11. Barriers to Movement: pg. 31	7
4. Riparian Area Quantity: pg. 21	4	12. Fish Habitat Complexity: pg. 32	4
5. Riparian area Quality: pg. 23	4	13. Aquatic Invertebrate Habitat pg. 34 &35	9
6. Canopy Cover: pg. 24&25	6	14. Aquatic Invertebrate Community pg. 36 - 39	9
7. Water Appearance: pg. 26	8	15. Riffle Embeddedness pg. 40	6
8. Nutrient Enrichment: pg. 27	9	16. Salinity:	N/A

OVERALL SCORE (Total divided by number scored):	**6.0**

EXCELLENT	>9.0	
GOOD	7.5 – 8.9	
FAIR	6.1 – 7.4	X
POOR	<6.0	

SUSPECTED CAUSES OF LOW SVAP OBSERVED SCORES: (Scores less than 5)

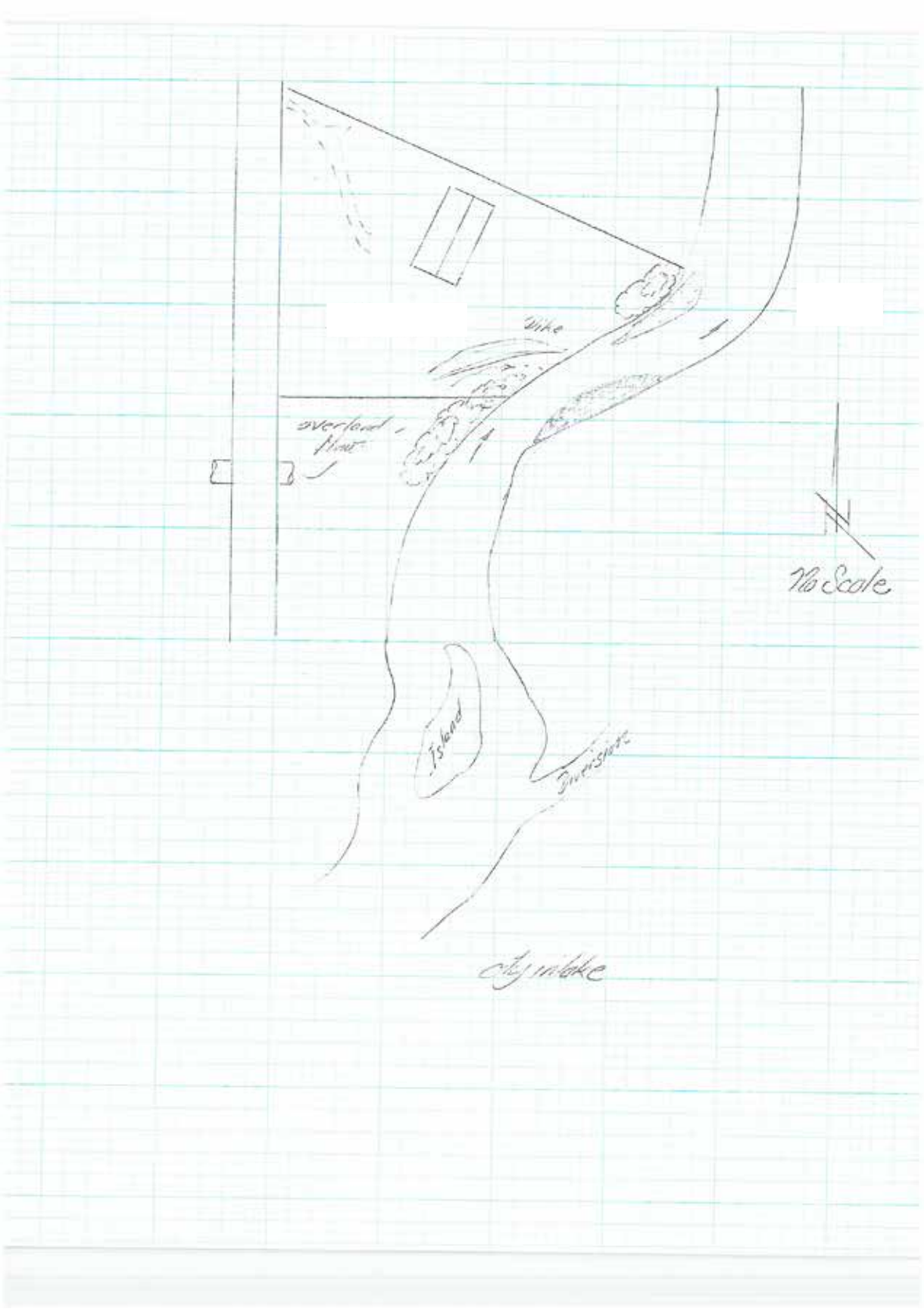
- Element 1: Channel Condition Evolution Model stage III. Active lateral movement.
- Element 4: Riparian Area Quantity. Active bank erosion and land use changes has removed many of the woody elements through this reach which also affects the canopy cover.
- Element 5: Riparian Area Quality has converted riparian woody vegetation with lawn species. The river lacks enough power to move the bed load through this reach due to high width to depth ratio and perhaps by removal of flood water for irrigation and or change is slope.
- Element 6: The Canopy Cover is lacks the shrub element and overhanging vegetation.
- Element 10. Pools are few and relatively.

Landowner Concerns:

1. The view is an important consideration here.

RECOMMENDATIONS:

1. Replace erosion resistant vegetation with structures ether wood, rock, or herbatious low growing buffer.
2. Consider pine tree revetment, root wade or toe wood installations.
3. Define the Correct pattern for this reach in terms of width to depth ration.
4. Protect property from overland flow from uplands with dike.



Site Diagram

Stream Visual Assessment Protocol Worksheet

OWNERS NAME: Dayton Town Group 1		**DATE:**
EVALUATORS NAME: Paul, Amy, Maria, Carrie		**HUC:** 10090101
STREAM NAME: Tongue River		
REACH LOCATION: Station 230+00 through 245+00 Cross sections 1, 2,3,4,5 & 6 This equals about twice the recommended length adjust accordingly.		
MLRA 58B	**DRAINAGE AREA:**	**GRADIENT:**
REFERENCE SITE:		
Note: The Assessment Reach should equal 12 times Bankfull width minimum.		
LAND USE WITHIN DRAINAGE AREA (%)		
RESIDENTIAL:	*HAYLAND:*	*PASTURE:*
FOREST:	*CRP:*	OTHER:
WEATHER PAST 2-5 DAYS: snow, wet.		
ACTIVE CHANNEL WIDTH:		
Bank Full Width measured at X section 1= 76 ft. Regional curve =		
DOMINANT SUBSTRATE:		

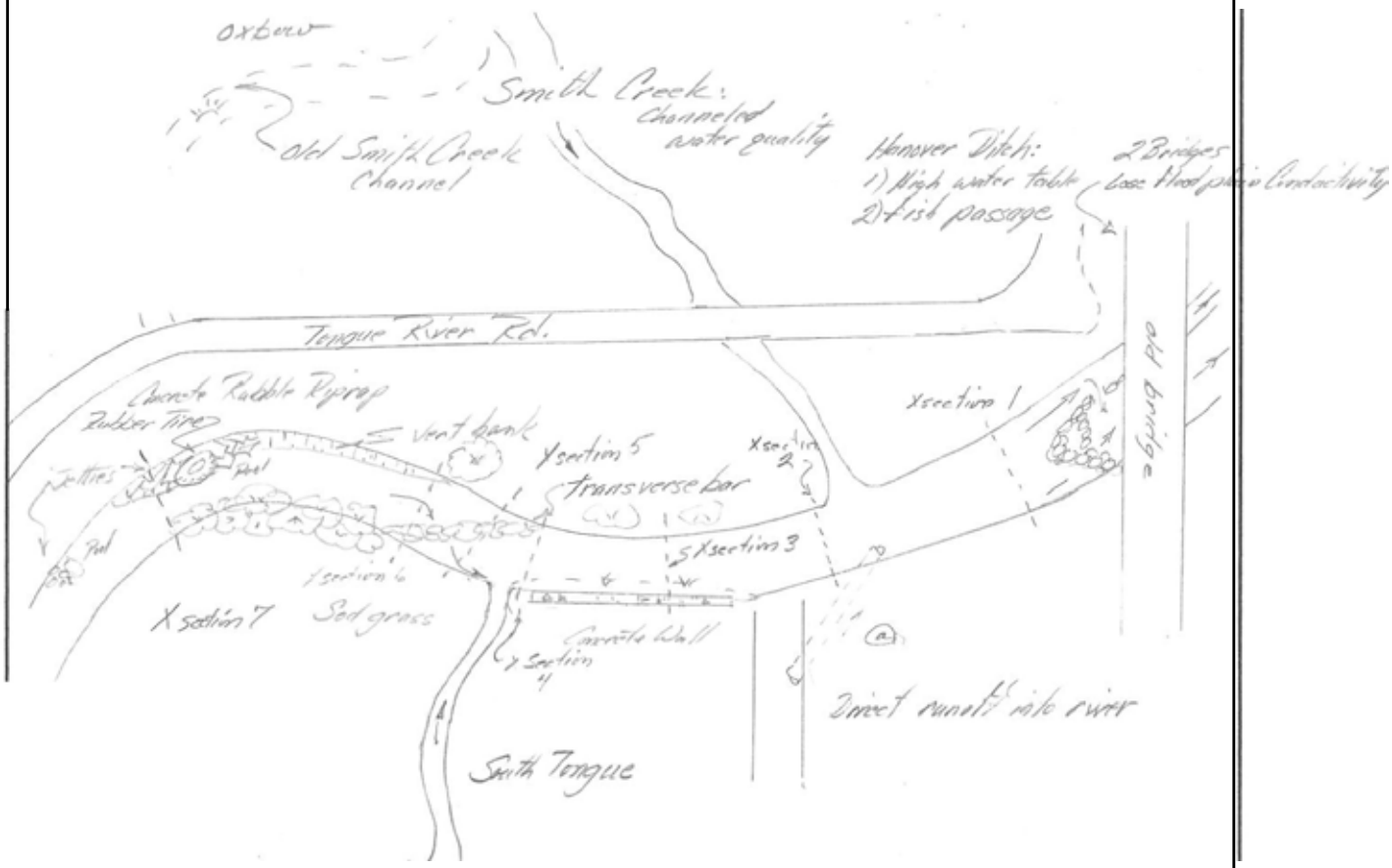
PARAMETER	SCORE	PARAMETER	SCORE
Channel Condition: CEM stage II or III pg. 9-16	6	9. Manure or human waste: pg. 28	9
2. Hydrologic alteration: 17&18	8	10. Pools: pg. 29 &30	5
3. Bank Condition: 19&20	6	11. Barriers to Movement: pg. 31	8
4. Riparian Area Quantity: pg. 21	2	12. Fish Habitat Complexity: pg. 32	6
5. Riparian area Quality: pg. 23	5	13. Aquatic Invertebrate Habitat pg. 34 &35	6
6. Canopy Cover: pg. 24&25	4	14. Aquatic Invertebrate Community pg. 36 - 39	8
7. Water Appearance: pg. 26	9	15. Riffle Embeddedness pg. 40	8
8. Nutrient Enrichment: pg. 27	8	16. Salinity:	N/A

OVERALL SCORE (Total divided by number scored):	**6.5**

EXCELLENT	>9.0	
GOOD	7.5 – 8.9	
FAIR	6.1 – 7.4	X
POOR	<6.0	

SUSPECTED CAUSES OF LOW SVAP OBSERVED SCORES: Scores less than 5

- Element 1: The Channel is trying to adjust its width. The top of bars are below the active flood plain.
- Element 3: Bank erosion high to very high. Stabilization structures covering 1/3 of reach. A Transverse bar is forming at X section 6.
- Element 4: Riparian Area Quantity. The River in incised through this reach which limits the width of the riparian area. Vegetation gapes are about 50% of the total length.
- Element 5: Riparian Area Quality. The native wetland vegetation has been replaced in many areas of this reach with sod forming grasses for lawns. Invasive species like Russian olive and Reed Canary grass have replaced them. Over half the outside meanders aren't adequately buffered.
- Element 6: The Canopy Cover is lacks the shrub element and overhanging vegetation.



Site Diagram

Stream Visual Assessment Protocol Worksheet

OWNERS NAME: Dayton Town Group II		**DATE:** 1/14
EVALUATORS NAME: Paul, Amy, Maria, Carrie		**HUC:** 10090101
STREAM NAME: Tongue River		
REACH LOCATION: Station 235+00 through 250+00 Cross sections 7, 8 & 9 The reach is 1500 ft. long which is about the length needed for assessment. .		
MLRA 58B	**DRAINAGE AREA:**	**GRADIENT:** 2%
REFERENCE SITE: None		
LAND USE WITHIN DRAINAGE AREA (%)		
RESIDENTIAL:	*HAYLAND:*	*PASTURE:*
FOREST:	*CRP:*	OTHER:
WEATHER PAST 2-5 DAYS: snow, wet.	Bankfull width: measured at Cross Section 8 = 85 ft.	
ACTIVE CHANNEL WIDTH:		
DOMINANT SUBSTRATE: Cobble		

PARAMETER	SCORE	PARAMETER	SCORE
Channel Condition: pg. 9-16	6	9. Manure or human waste: pg. 28	9
2. Hydrologic alteration: 17&18	8	10. Pools: pg. 29 &30	8
3. Bank Condition: 19&20	8	11. Barriers to Movement: pg. 31	10
4. Riparian Area Quantity: pg. 21	2	12. Fish Habitat Complexity: pg. 32	6
5. Riparian area Quality: pg. 23	5	13. Aquatic Invertebrate Habitat pg. 34 &35	6
6. Canopy Cover: pg. 24&25	4	14. Aquatic Invertebrate Community pg. 36 - 39	8
7. Water Appearance: pg. 26	9	15. Riffle Embeddedness pg. 40	6
8. Nutrient Enrichment: pg. 27	9	16. Salinity:	N/A

OVERALL SCORE (Total divided by number scored):	**7.0**

EXCELLENT	>9.0	
GOOD	7.5 – 8.9	
FAIR	6.1 – 7.4	X
POOR	<6.0	

SUSPECTED CAUSES OF LOW SVAP OBSERVED SCORES: Scores less than 5

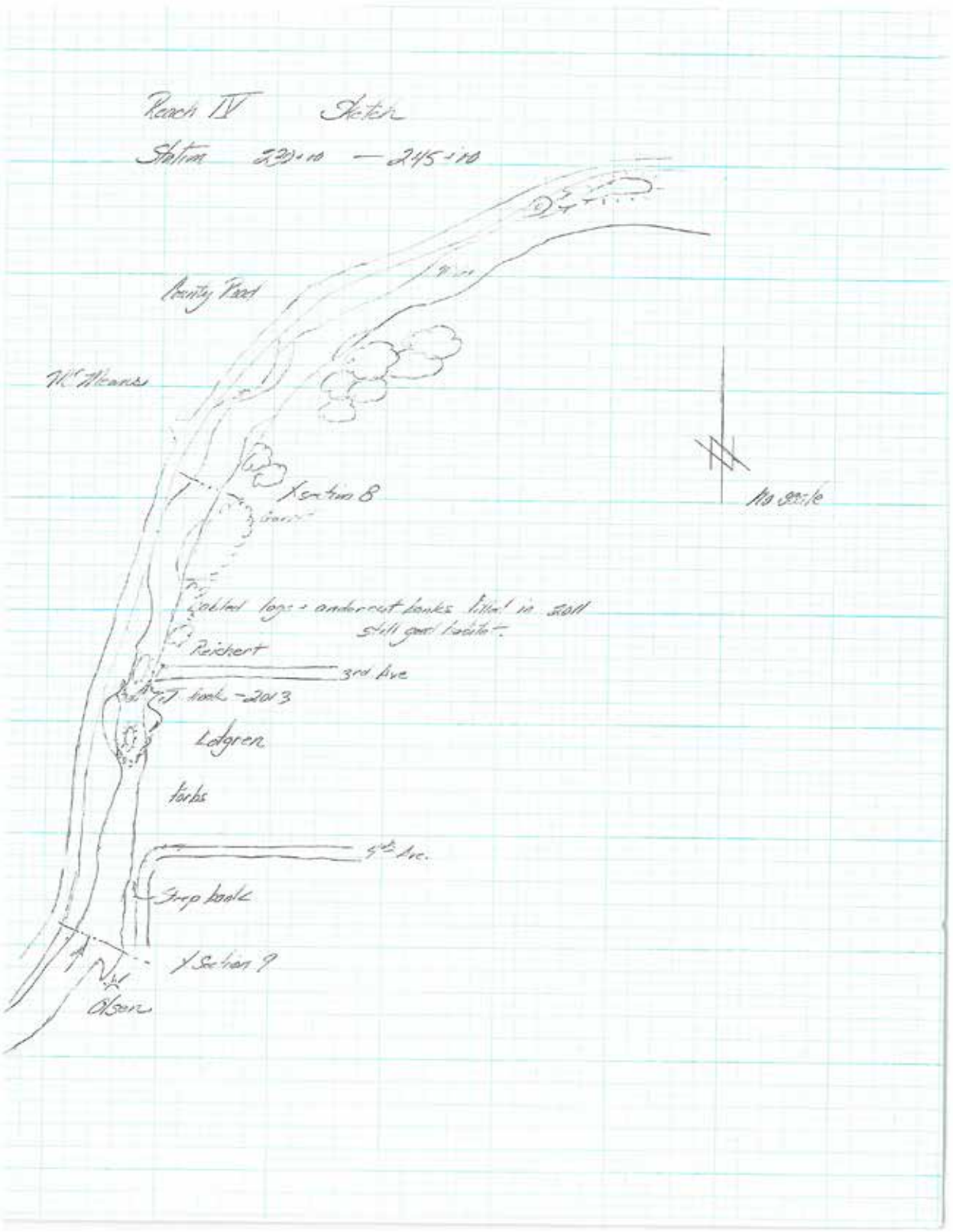
- Element 4: Riparian Area Quantity. The River in incised through this reach: 600 linear ft. x 180 ft. for the lower reach on the right side. The upper half of the right side has gapes in native vegetation which is mostly replaced by lawns. The left side is native but its width is reduced by the Tongue River road.
- Element 5: Riparian Area Quality. The native wetland vegetation has been replaced in many areas of this reach with sod forming grasses for lawns.
- Element 6: The Canopy Cover is lacks the shrub element and overhanging vegetation.

Landowner Concerns:

1. Maintaining a view is preventing establishment of a riparian buffer.
2. Storm sewer flows directly into river from the south.

RECOMMENDATIONS:

1. Work that was completed by Steady Stream Hydrology has provided pools and other fish components as well as breaking up the rivers Embeddedness. Landowners need to maintain these structures and perhaps use them as a blueprint for future work.
2. Develop passive, herbaceous buffer for low growing vegetation that provides stability while maintaining the visual needs of the landowners. Use rock structures and other non-passive measures where needed to provide stability.
3. There is a general lack of woody material in this reach. Consider pine tree revetment, root wade installations or toe wood installations which add structure to channel at strategic locations to create riffle/pool complexes.
4. Define intermediate berm during low water periods and use the meander pattern in place to enhance that observed pattern. Need to incorporate woody vegetation in this effort.
5. Plant shrubs along bank to provide shade to waterway.
6. Install practices to reduce urban input of sediment and nutrients to stream.



Site Diagram

Stream Visual Assessment Protocol Worksheet

OWNERS NAME: Landowner 5		**DATE:** 1/01/14
EVALUATORS NAME: Paul, Amy, Maria, Carrie		**HUC:** 10090101
STREAM NAME: Tongue River		
REACH LOCATION: Station 215+00 through 235+00 Cross sections 9,10,11 & 13 Note: Refer to town group II for information on the left bank from station 235+00 to 250+00 Cross section 7 & 8		
MLRA 58B	**DRAINAGE AREA:**	**GRADIENT:** 2%
REFERENCE SITE: None		
LAND USE WITHIN DRAINAGE AREA (%)		
RESIDENTIAL:	*HAYLAND:*	*PASTURE:*
FOREST:	*CRP:*	OTHER:
WEATHER PAST 2-5 DAYS: snow, wet.	Bankfull width	
ACTIVE CHANNEL WIDTH:		
DOMINANT SUBSTRATE: Cobble		

PARAMETER	SCORE	PARAMETER	SCORE
Channel Condition: pg. 9-16	4	9. Manure or human waste: pg. 28	9
2. Hydrologic alteration: 17&18	9	10. Pools: pg. 29 &30	6
3. Bank Condition: 19&20	5	11. Barriers to Movement: pg. 31	7
4. Riparian Area Quantity: pg. 21	4	12. Fish Habitat Complexity: pg. 32 use a length of 300 to 400 ft. length	5
5. Riparian area Quality: pg. 23	4	13. Aquatic Invertebrate Habitat pg. 34 &35	6
6. Canopy Cover: pg. 24&25	2	14. Aquatic Invertebrate Community pg. 36 - 39	8
7. Water Appearance: pg. 26	7	15. Riffle Embeddedness pg. 40	8
8. Nutrient Enrichment: pg. 27	8	Total Score	

OVERALL SCORE (Total divided by number scored):	**6.4**

EXCELLENT	>9.0	
GOOD	7.5 – 8.9	
FAIR	6.1 – 7.4	X
POOR	<6.0	

SUSPECTED CAUSES OF LOW SVAP OBSERVED SCORES: Scores less than 5

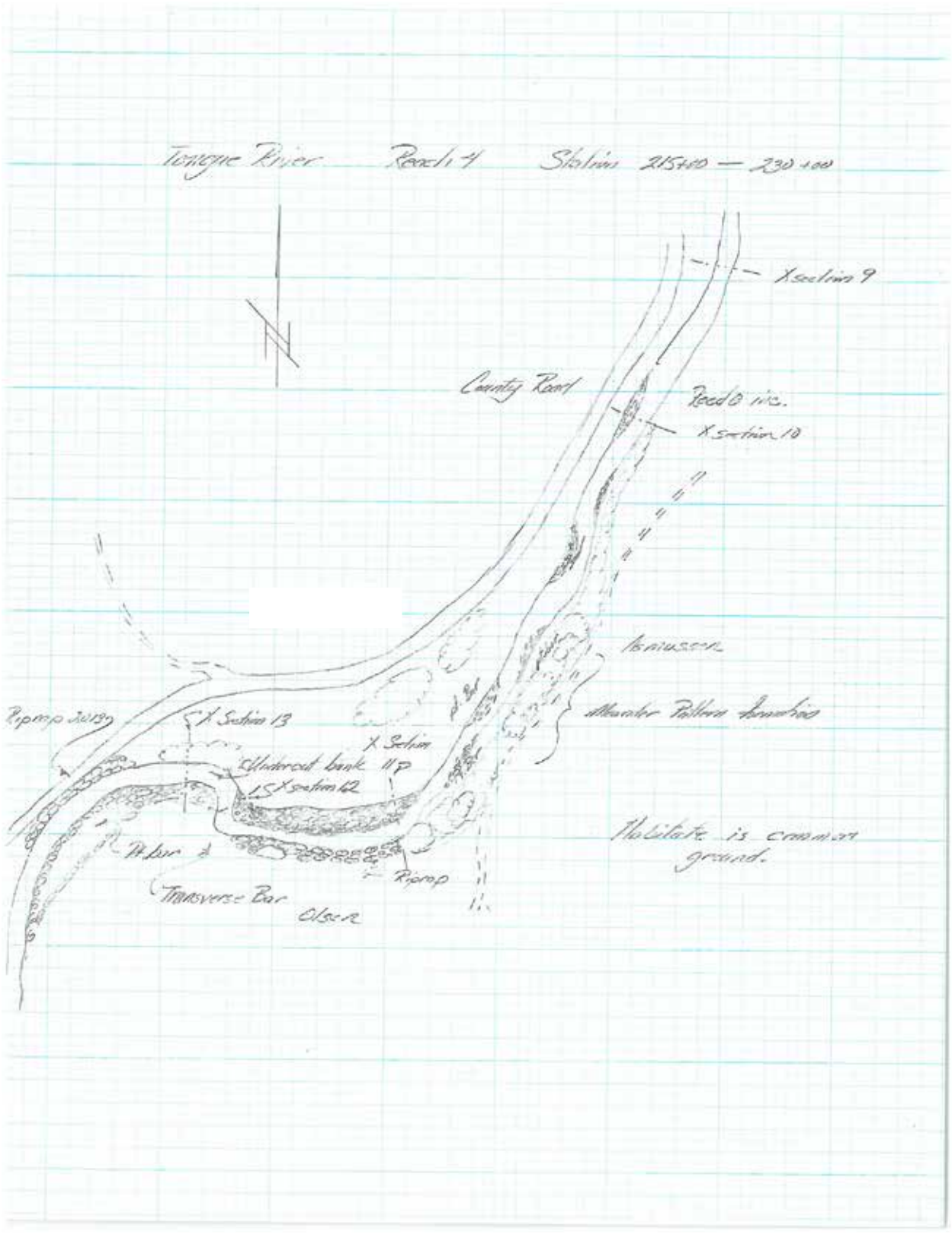
- Element 1: Channel Condition: Head cut moving upstream between cross sections 15 and 16 near county road. It looks to be in channel evolution stage II or III. Annual plants growing on point bars. Extensive riprap along both sides from 220+00 to 225+00. One willow holding bank together and providing a deep pool.
- Element 4: Riparian Area Quantity. Active bank erosion has removed many of the woody elements through this reach which also affects the canopy cover. The lack of woody vegetation could be a result of fire in 2003.
- Element 5: Riparian Area Quality. The native wetland vegetation has been left high and dry by river down cutting through the head cut. Weeds growing on point bars.
- Element 6: The Canopy Cover is less than 20% for the entire reach again due to fire. It also lacks the shrub element; there is little or no overhanging vegetation in much of this reach.

Landowner Concerns:

- The County has placed rock rip rap along the road at station 219+00. Some form of stabilization needs to take place through the rest of this section ether allow the river to carve its own meander length restoring the best pattern or place structures in place to reduce the slope. Some engineering was completed here but due to ownership conflicts the construction phase was never completed.

RECOMMENDATIONS:

- Landowners may use structures downstream as a blueprint for future work on this reach.
- There is a general lack of woody material in this reach. Consider pine tree revetment, root wade installations or toe wood installations which add structure to channel at strategic locations to create riffle/pool complexes.
- Define intermediate berm during low water periods and use the meander pattern in place to enhance pattern.
- Plant shrubs along bank to provide shade to waterway.



Site Diagram

Appendix C

Detailed historic channel maps

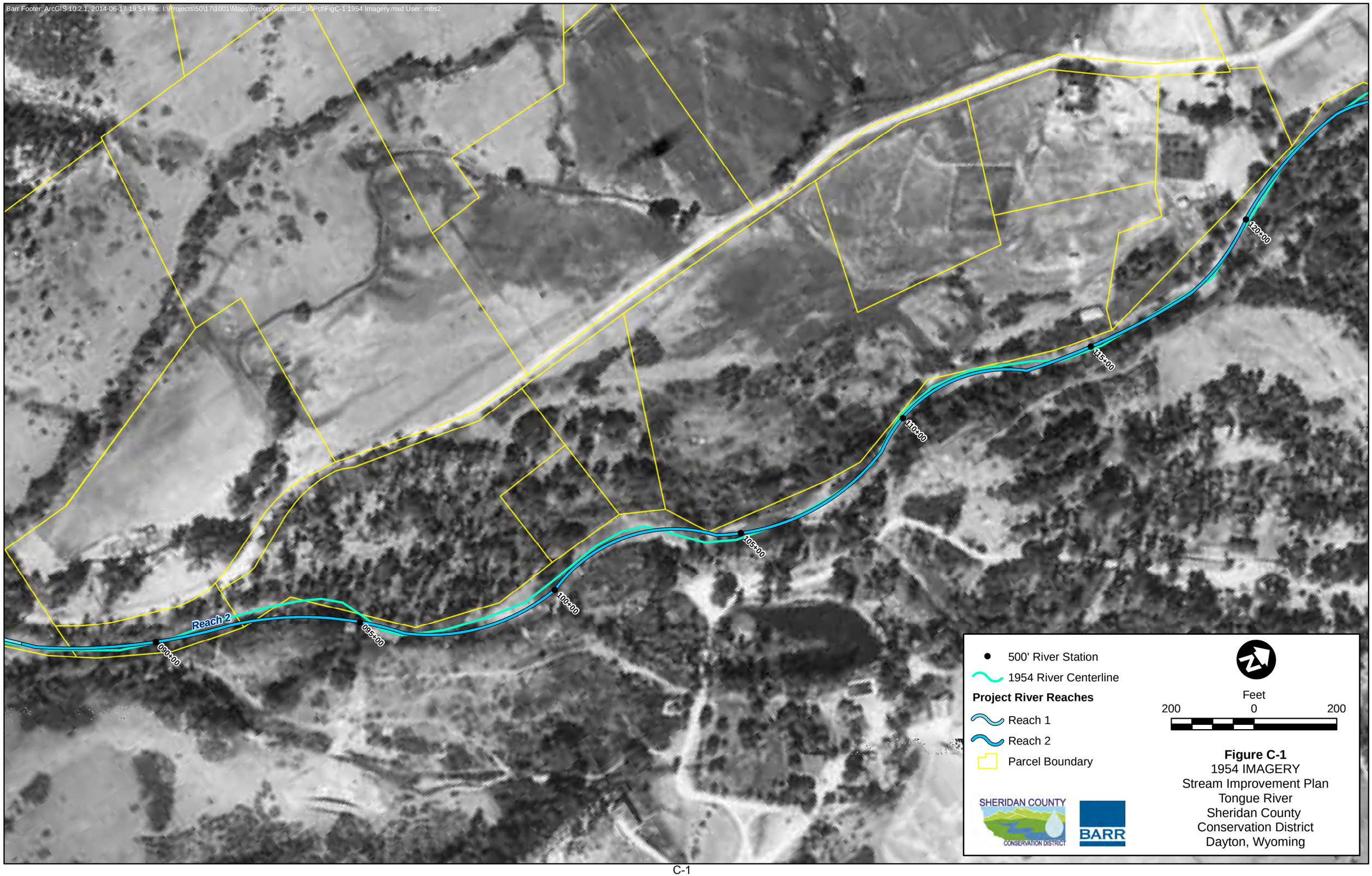
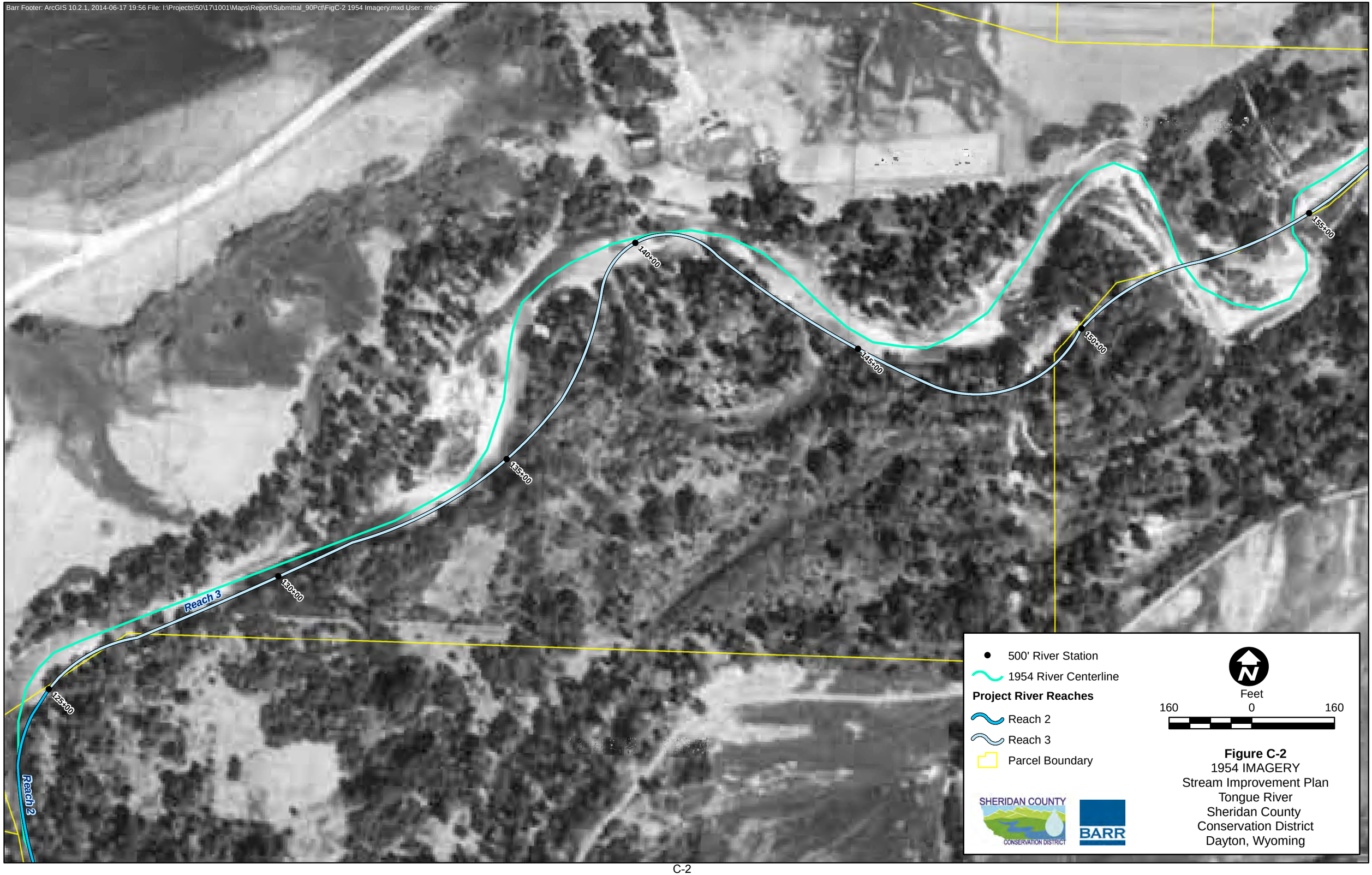


Figure C-1
1954 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming



500' River Station
1954 River Centerline
Project River Reaches
Reach 2
Reach 3
Parcel Boundary

Feet
160 0 160

SHERIDAN COUNTY CONSERVATION DISTRICT
BARR

Figure C-2
1954 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming

Figure C-3
1954 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming

Figure C-4
1954 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming

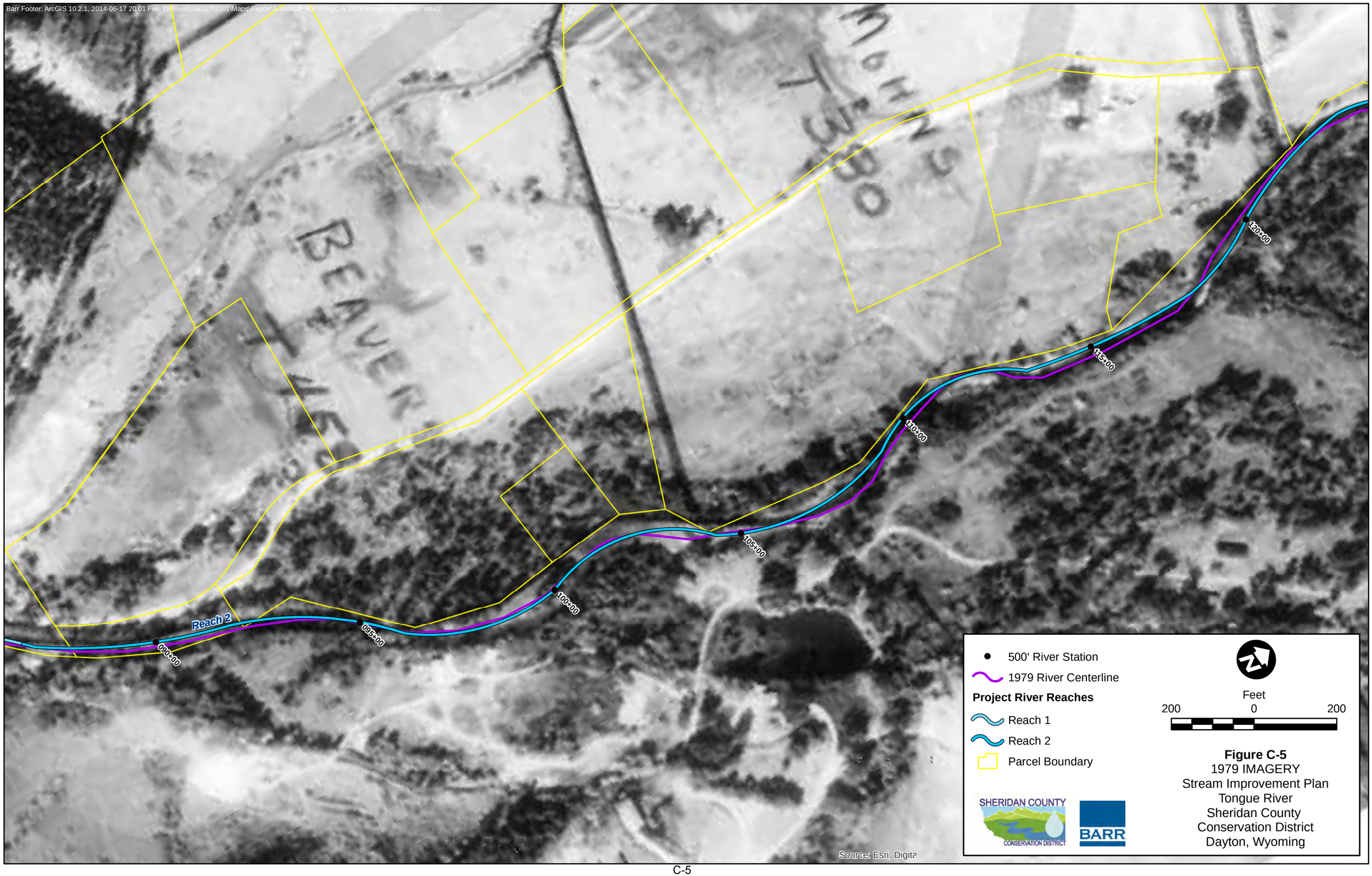


Figure C-5
1979 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming

500' River Station
1979 River Centerline

Project River Reaches

Reach 2
Reach 3
Parcel Boundary

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

N

Feet

160 0 160

Figure C-6
1979 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming

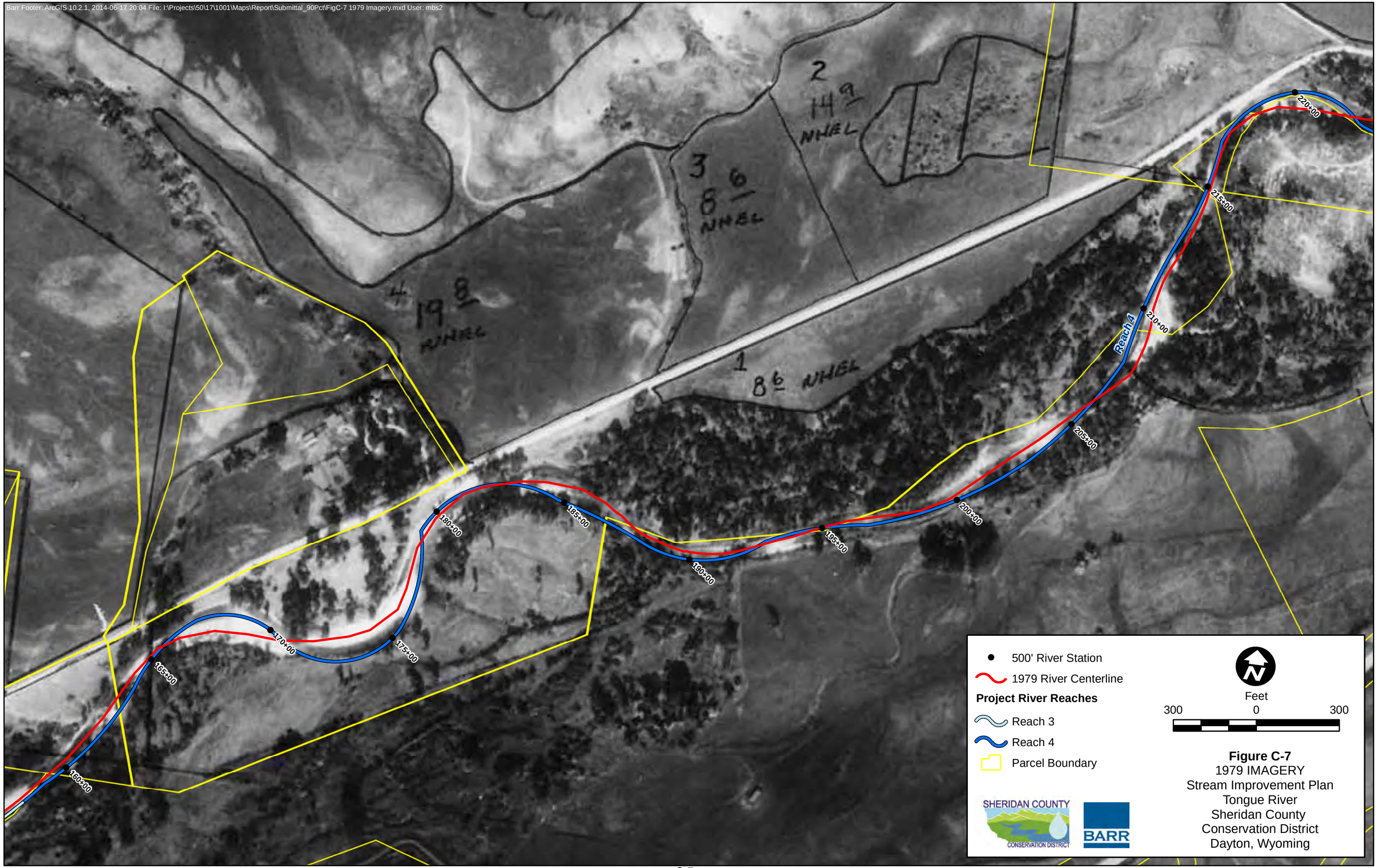
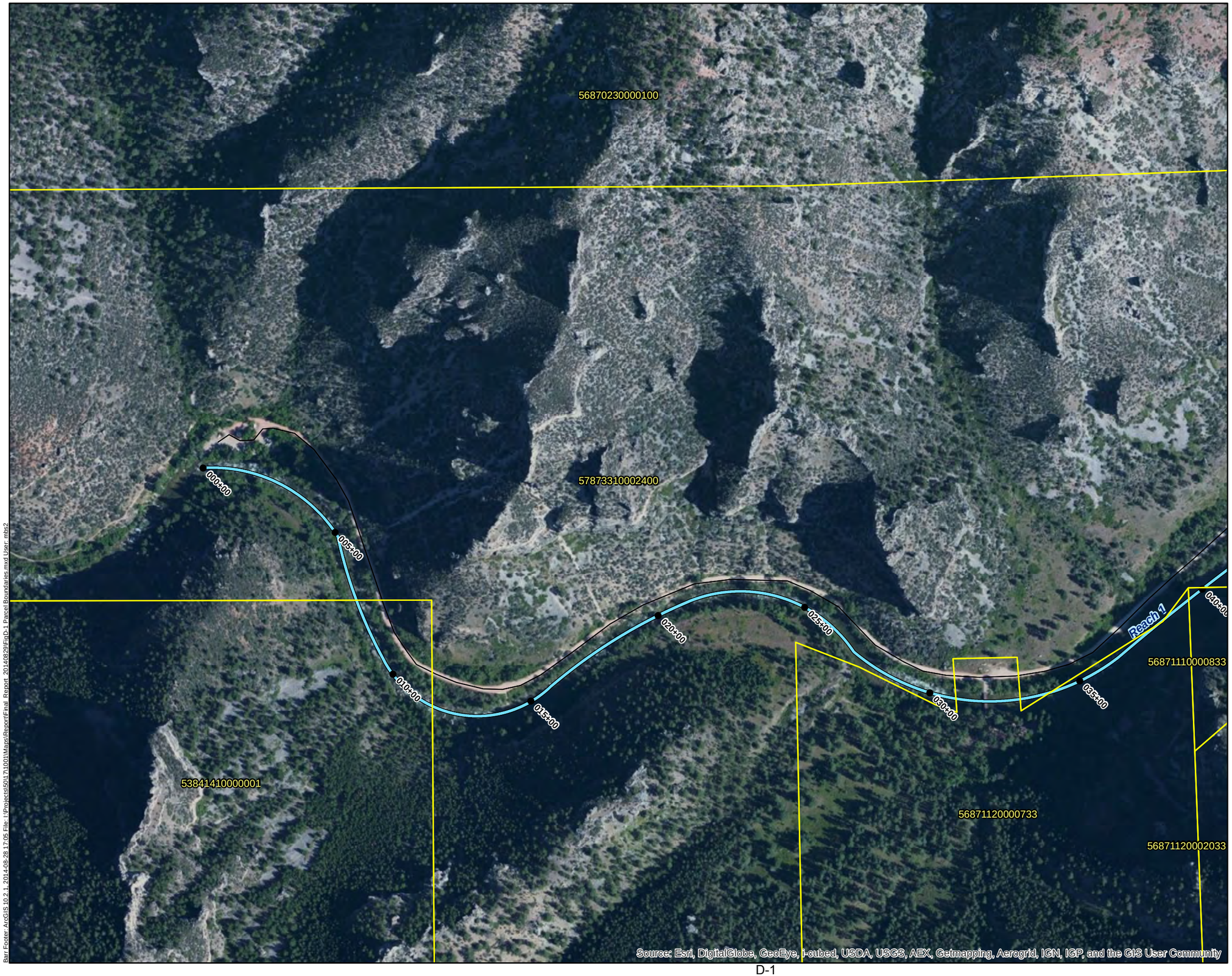


Figure C-7
1979 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming

Figure C-8
1979 IMAGERY
Stream Improvement Plan
Tongue River
Sheridan County
Conservation District
Dayton, Wyoming

Appendix D

Parcel information



Parcel Boundary
500' River Station

Project River Reaches

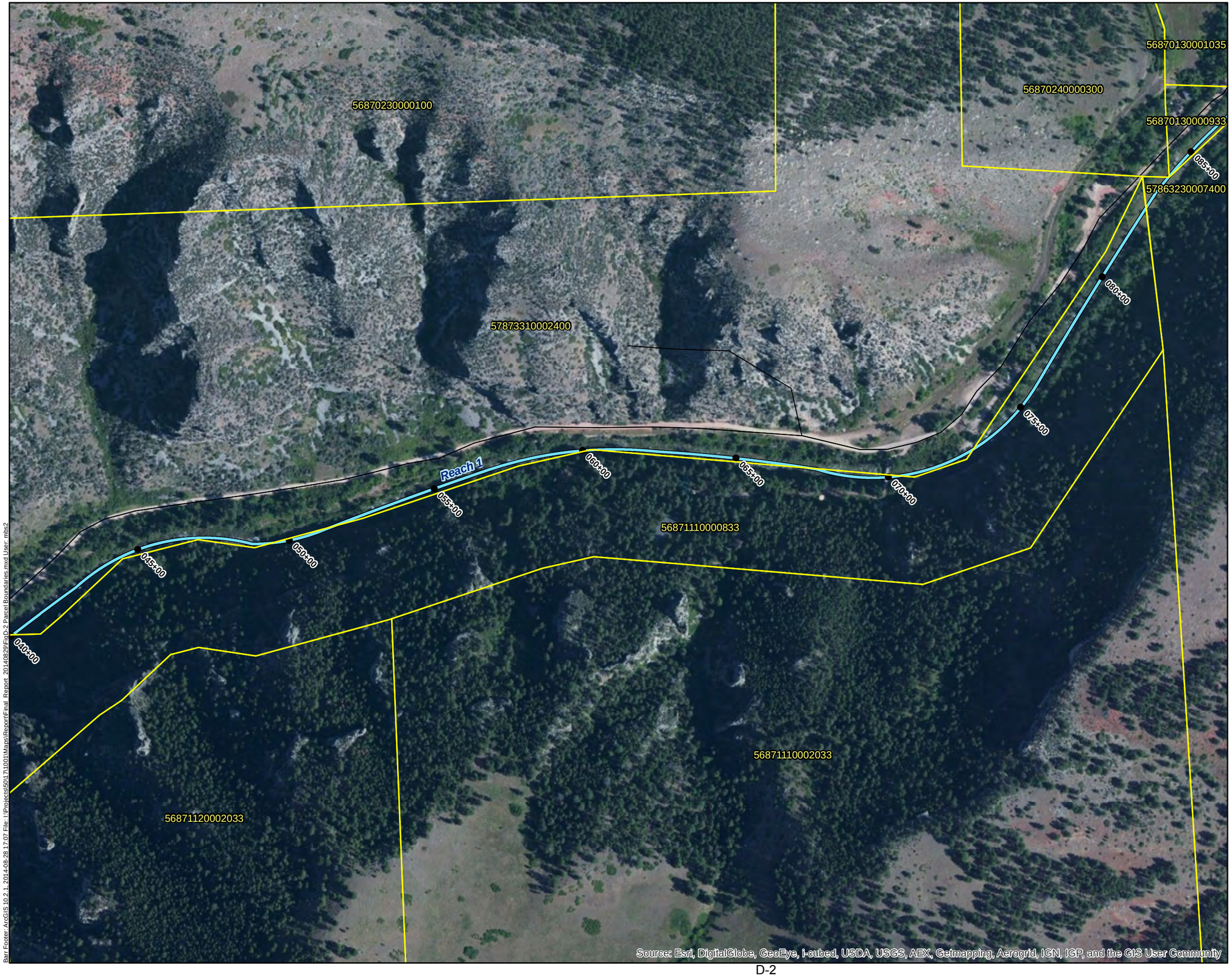
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Municipal Boundary

Feet
300 0 300

Figure D-1

PARCEL BOUNDARIES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT
BARR



Parcel Boundary

500' River Station

Project River Reaches

Reach 1

Reach 2

Reach 3

Reach 4

Reach 5

Municipal Boundary

Feet

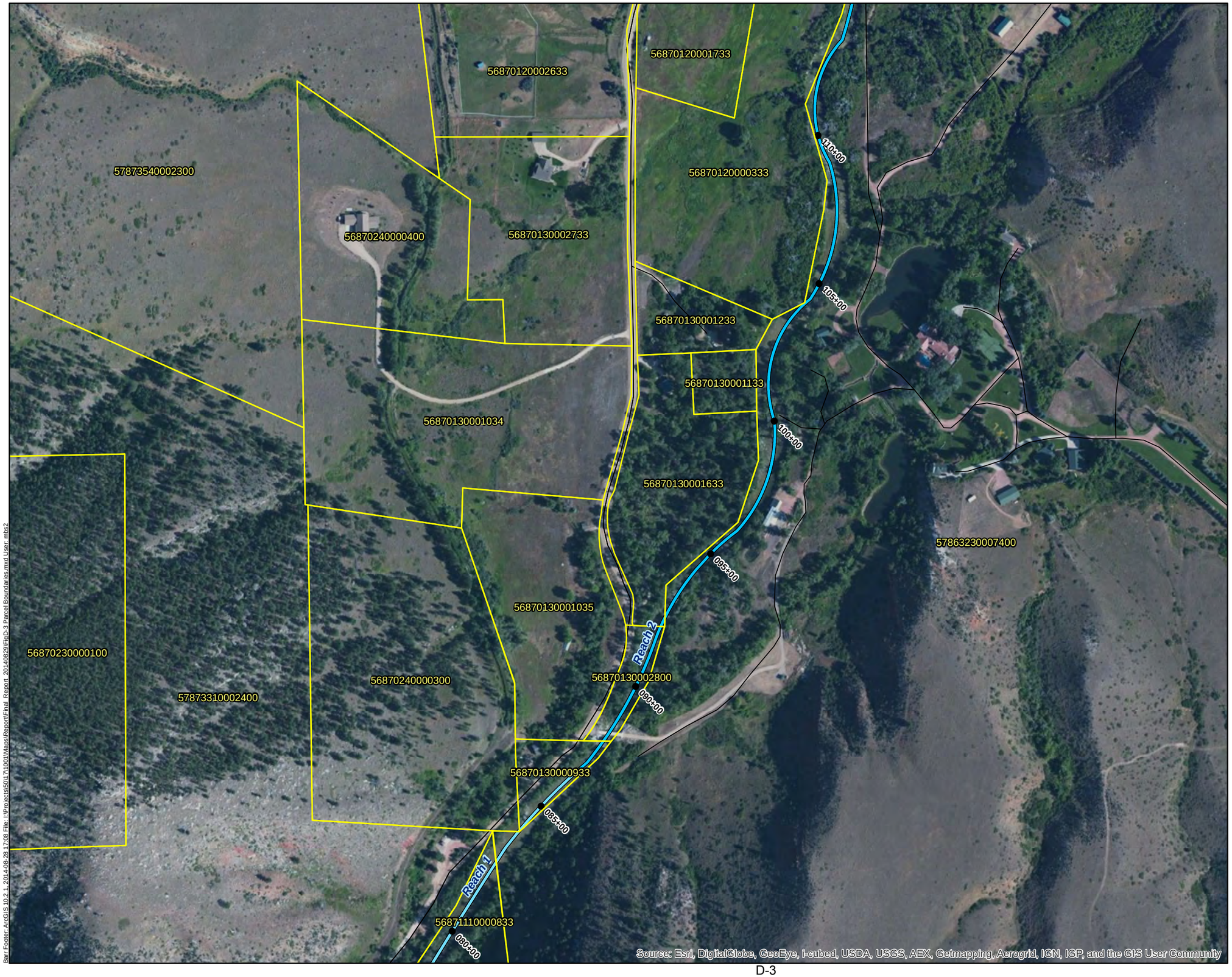
300 0 300

Figure D-2

PARCEL BOUNDARIES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR



Parcel Boundary

500' River Station

Project River Reaches

Reach 1

Reach 2

Reach 3

Reach 4

Reach 5

Municipal Boundary

N

Feet

300 0 300

Figure D-3

PARCEL BOUNDARIES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Parcel Boundary

500' River Station

Project River Reaches

Reach 1

Reach 2

Reach 3

Reach 4

Reach 5

Municipal Boundary

N

Feet

300 0 300

Figure D-4

PARCEL BOUNDARIES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Parcel Boundary

500' River Station

Project River Reaches

Reach 1

Reach 2

Reach 3

Reach 4

Reach 5

Municipal Boundary

Feet

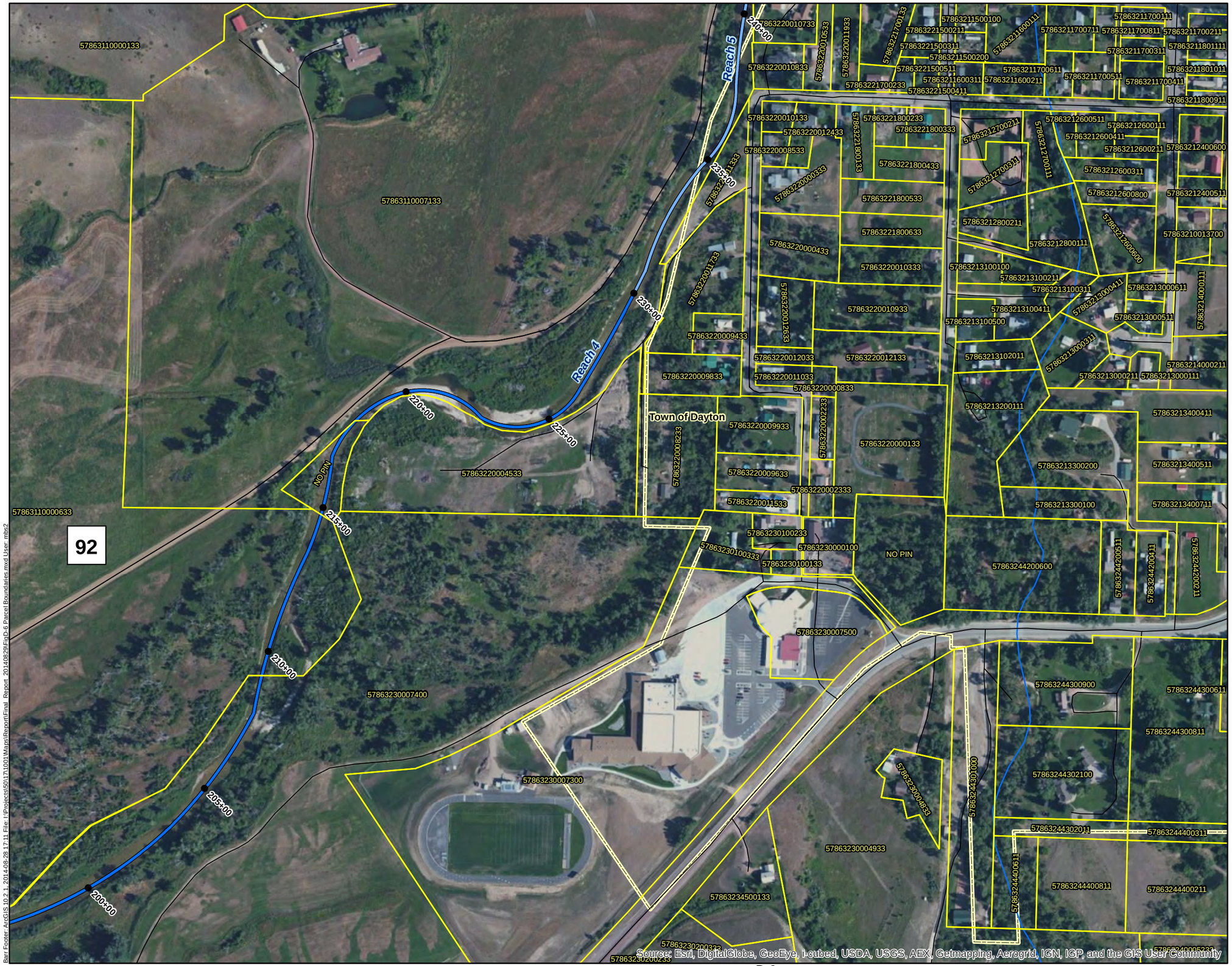
300 0 300

Figure D-5

PARCEL BOUNDARIES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR



Parcel Boundary

500' River Station

Project River Reaches

Reach 1

Reach 2

Reach 3

Reach 4

Reach 5

Municipal Boundary

Feet

300 0 300

Figure D-6

PARCEL BOUNDARIES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Parcel Boundary
500' River Station

Project River Reaches

Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Municipal Boundary

Feet
300 0 300

Figure D-7

PARCEL BOUNDARIES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

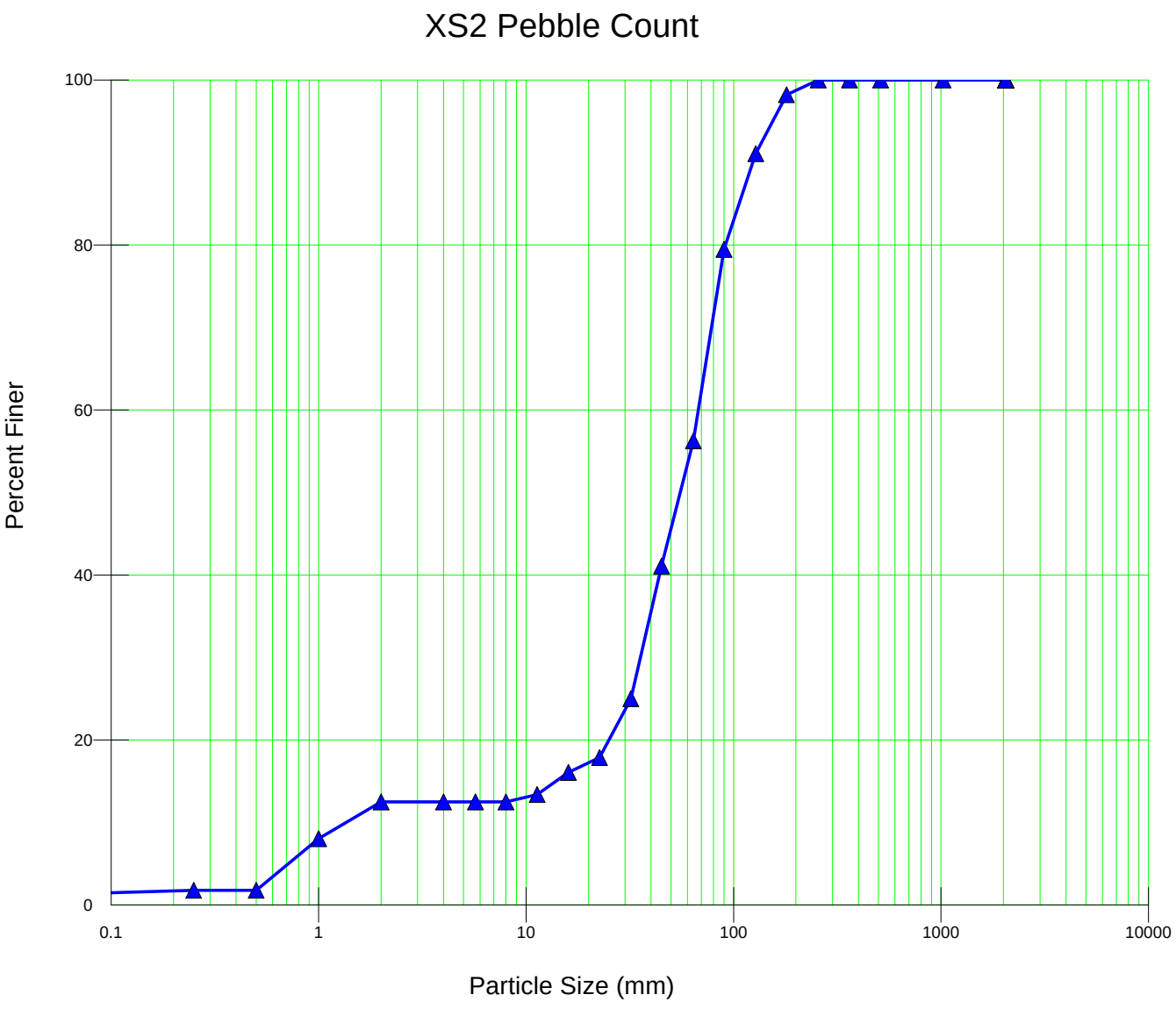
SHERIDAN COUNTY CONSERVATION DISTRICT
BARR

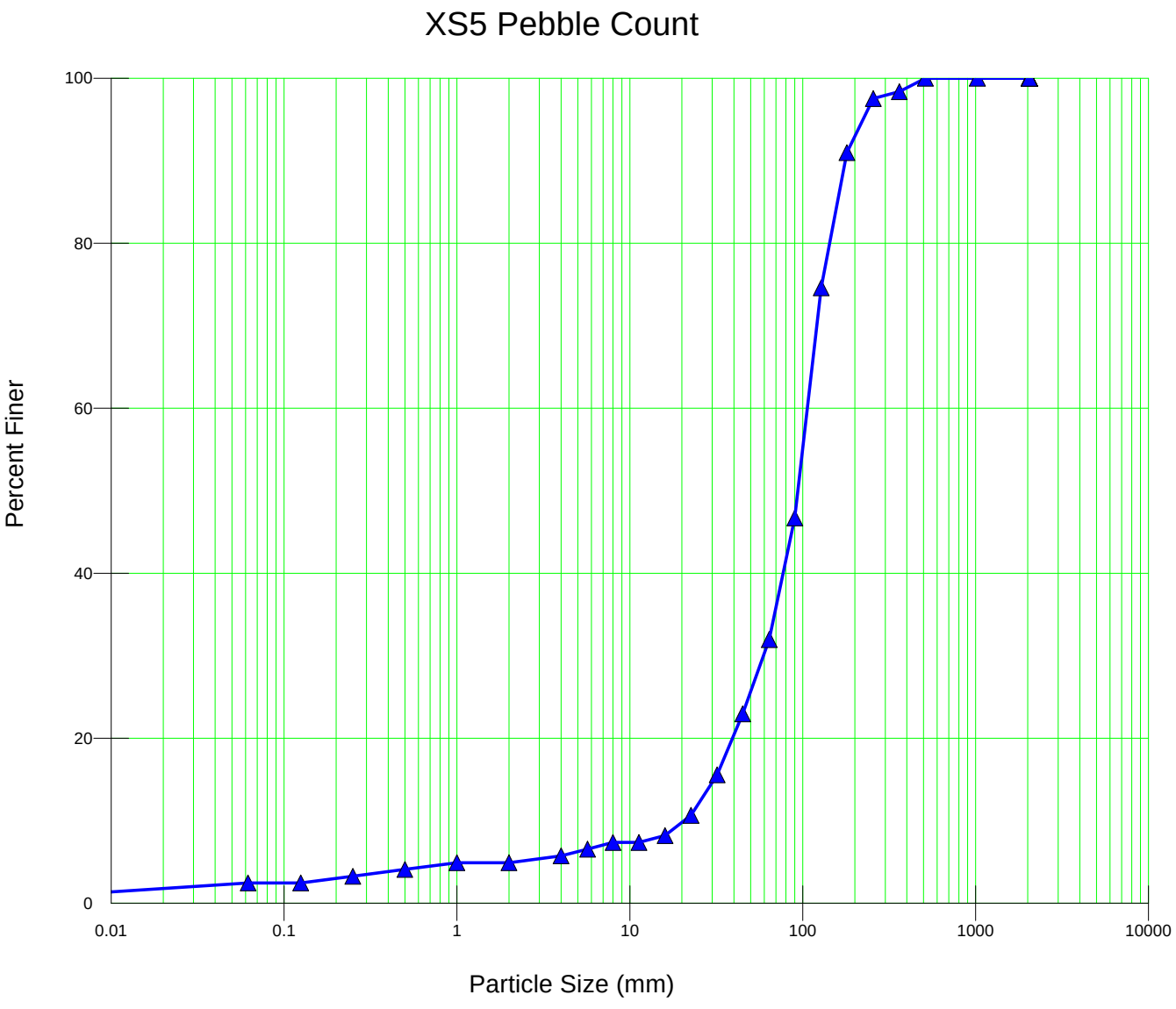
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

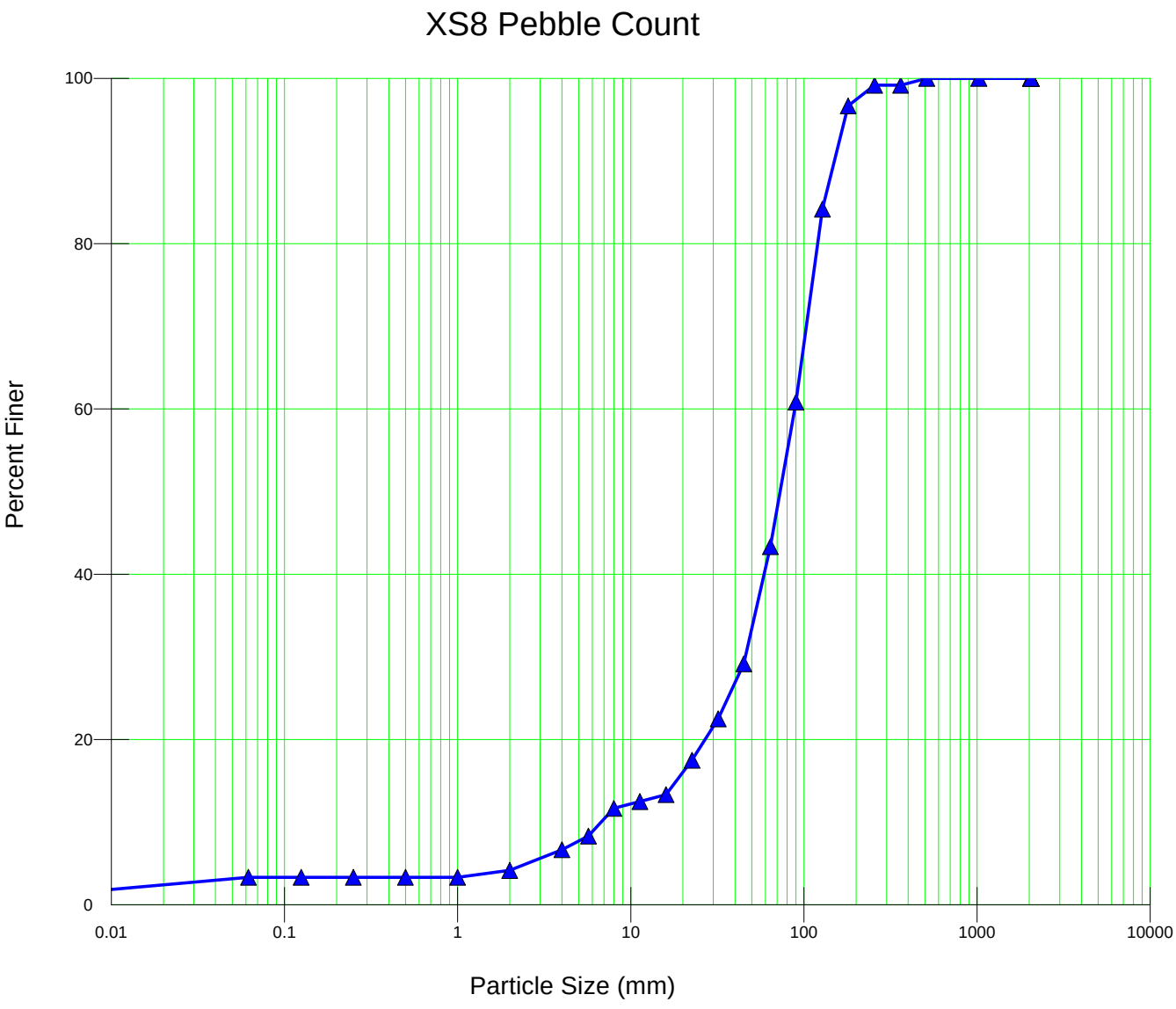
Barr Footer: ArcGIS 10.2.1, 2014-08-28 17:13 File: I:\Projects\5017\1001\Mxds\Report\Final_Report_20140829\Fig\D-7 Parcel Boundaries.mxd User: mbs2

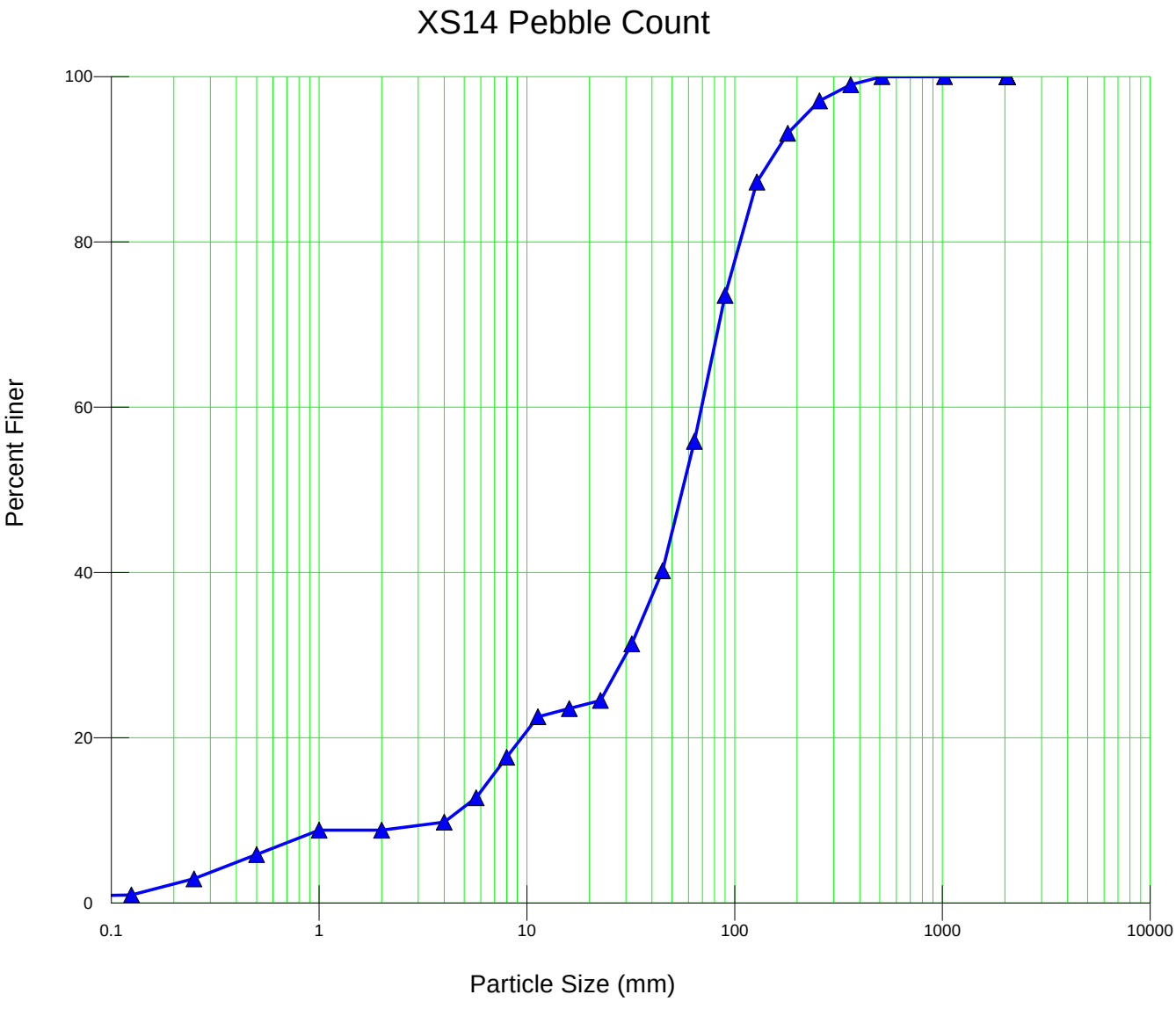
Appendix E

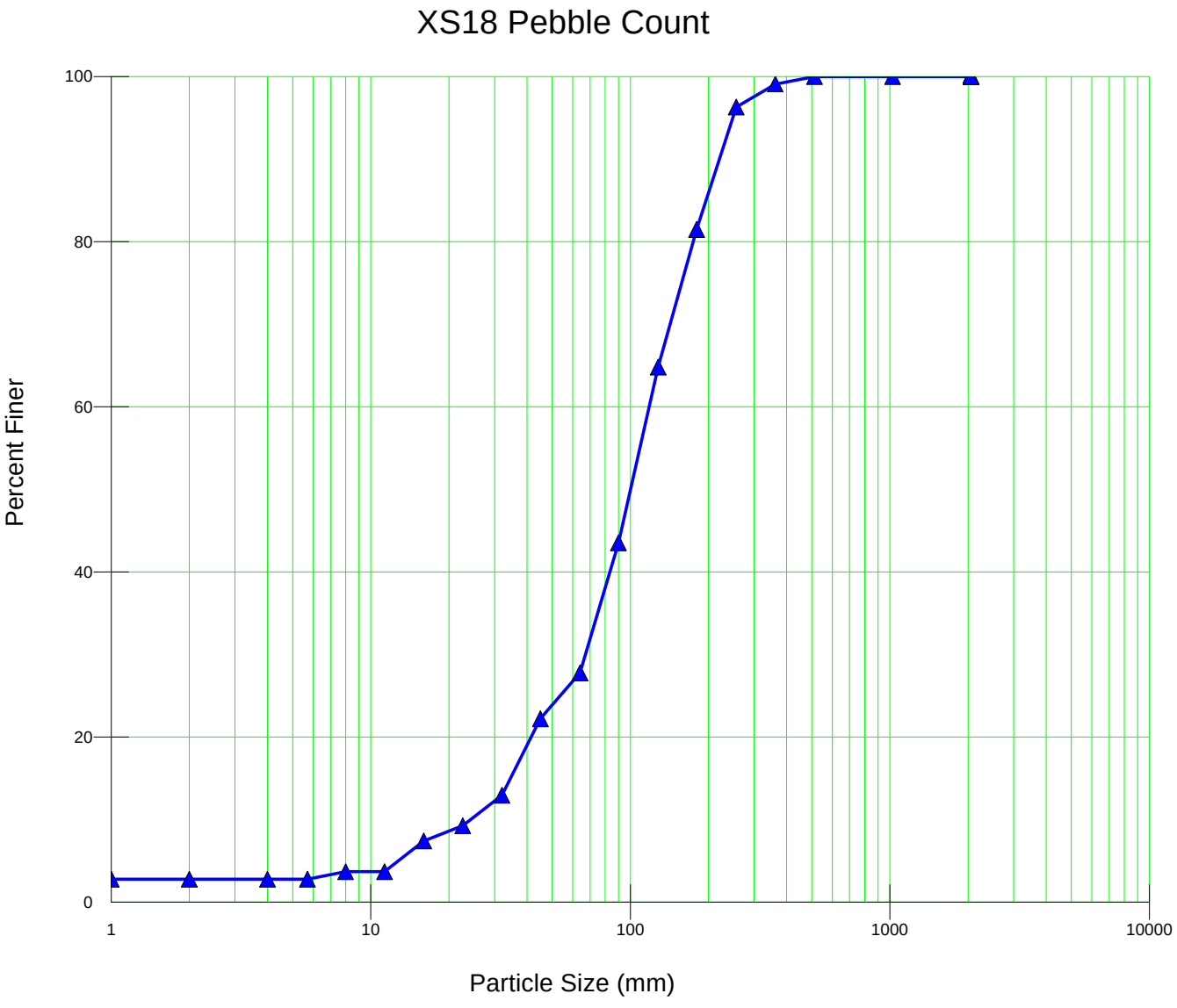
Compiled sediment sampling results


XS2 Pebble Count
Percent Finer
100
80
60
40
20
0
0.1
1
10
100
1000
10000
Particle Size (mm)

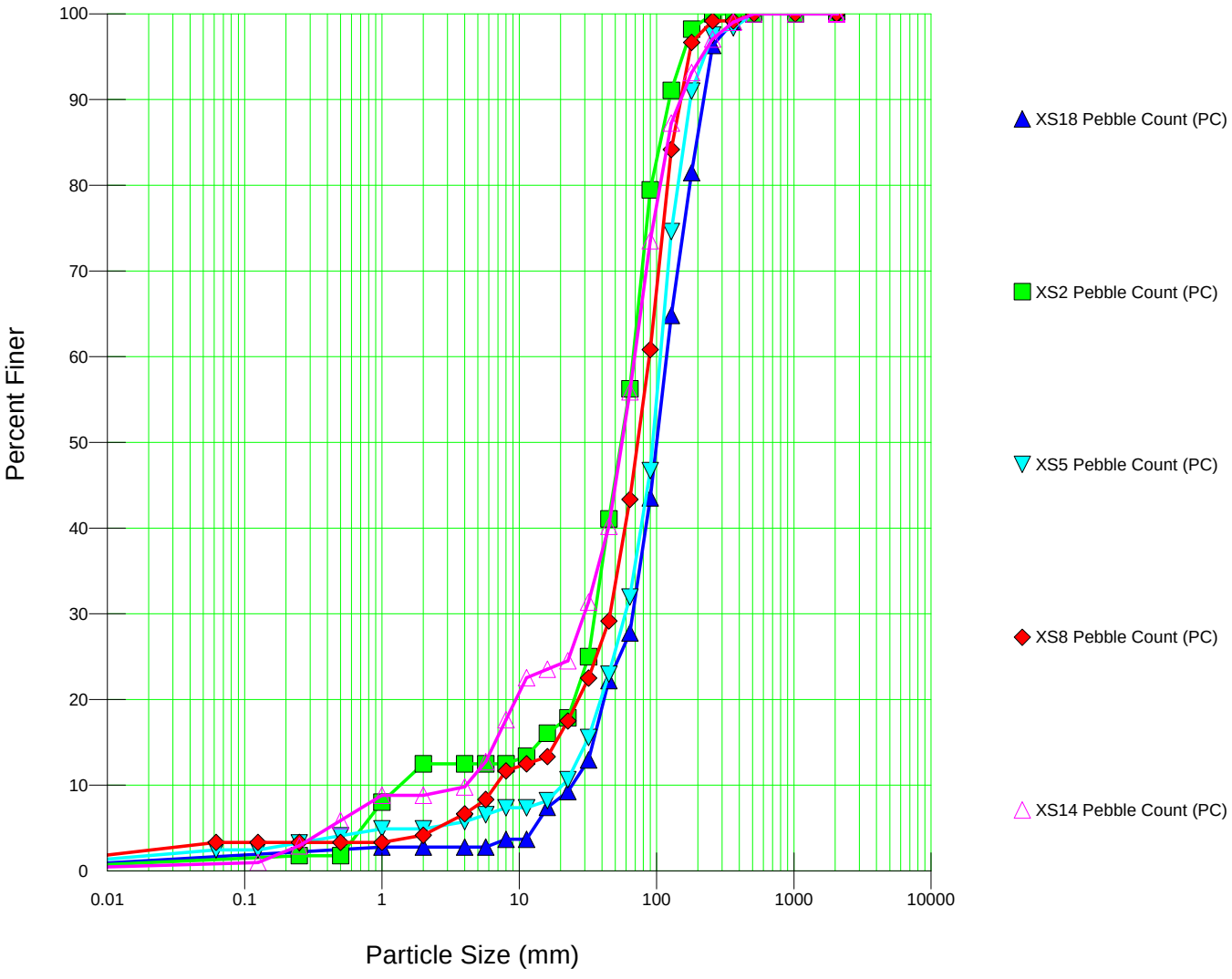

XS5 Pebble Count
Percent Finer
100
80
60
40
20
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)

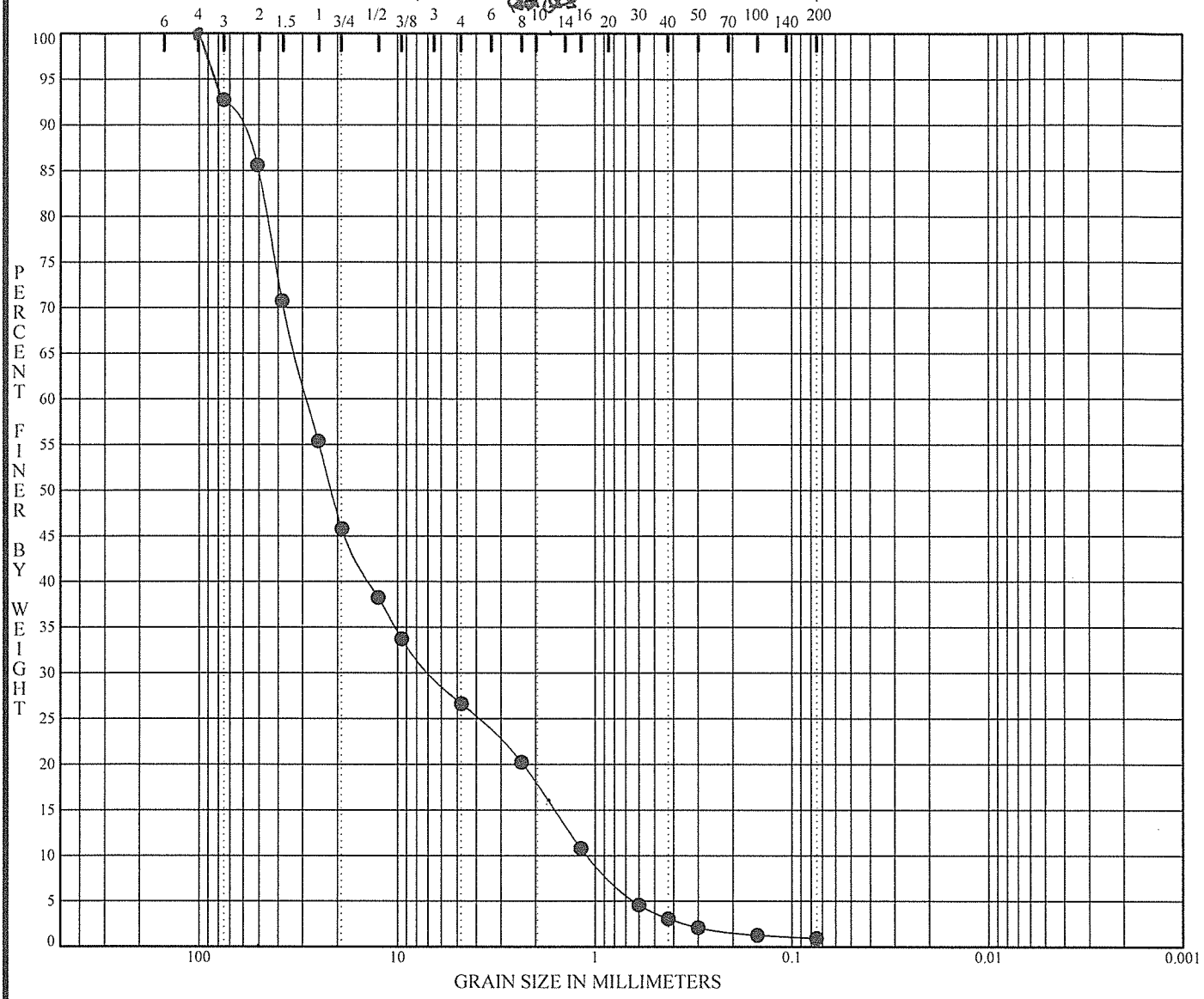

XS8 Pebble Count
Percent Finer
100
80
60
40
20
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)


XS14 Pebble Count
Percent Finer
100
80
60
40
20
0
0.1
1
10
100
1000
10000
Particle Size (mm)


XS18 Pebble Count
Percent Finer
100
80
60
40
20
0
1
10
100
1000
10000
Particle Size (mm)

Pebble Count Comparison





COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
#12	**WELL-GRADED GRAVEL with SAND**					**1.42**	**26.2**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
#12	102.00	**28.38**	**6.607**	**1.0833**	**66.1**	**25.7**	**0.9**	

D_{16} - 1.7mm = .06in

D_{35} - 10mm = .39in

D_{50} - 21mm = .83in

D_{84} - 50mm = 1.97in

D_{95} - 90mm = 3.54in

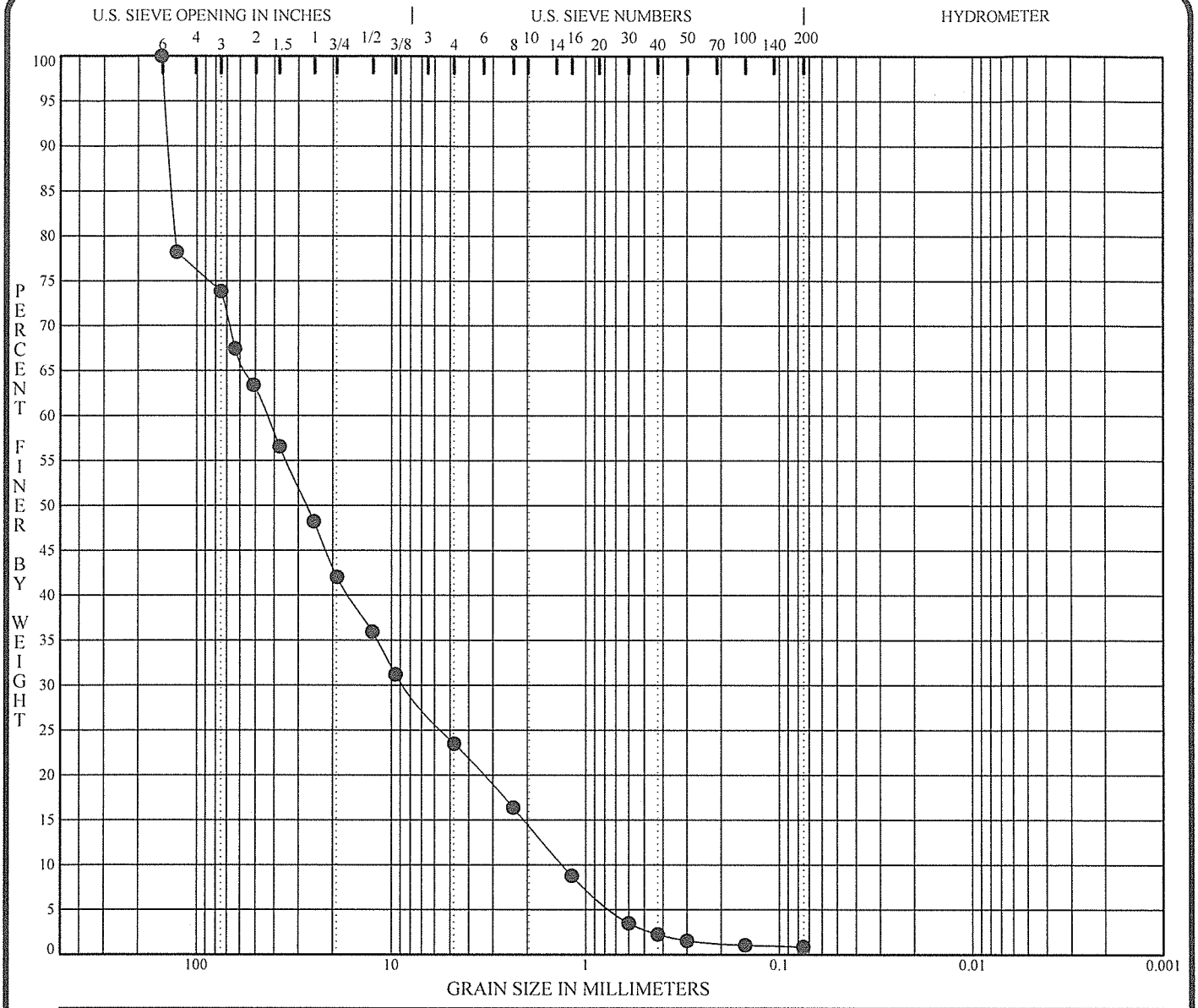
PROJECT **Game Fish & Parks;**

AET JOB NO. **17-01831**

DATE **11/6/13**

AMERICAN ENGINEERING TESTING, INC.

GRADATION CURVES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● #17	**WELL-GRADED GRAVEL with SAND**					**1.26**	**33.2**

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● #17	**152.00**	**43.78**	**8.530**	**1.3203**	**50.4**	**22.6**	**0.9**	

D_{16} - 2.36 mm = .09 in
D_{35} - 12 mm = .47 in
D_{50} - 28 mm = 1.1 in
D_{84} - 125 mm = 4.9 in
D_{95} - 147 mm = 5.8 in

PROJECT **Game Fish & Parks;**

AET JOB NO. **17-01831**

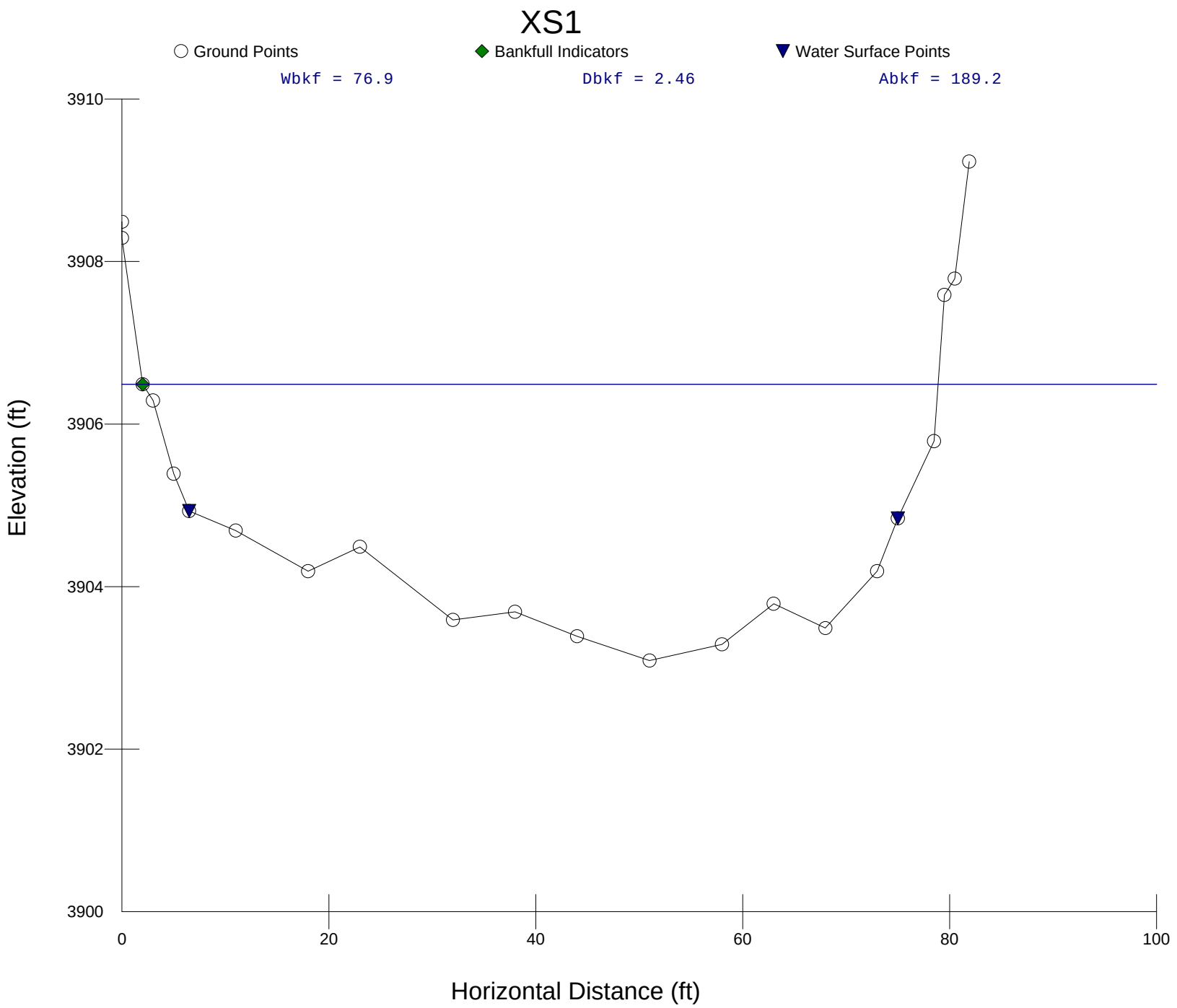
DATE **11/5/13**

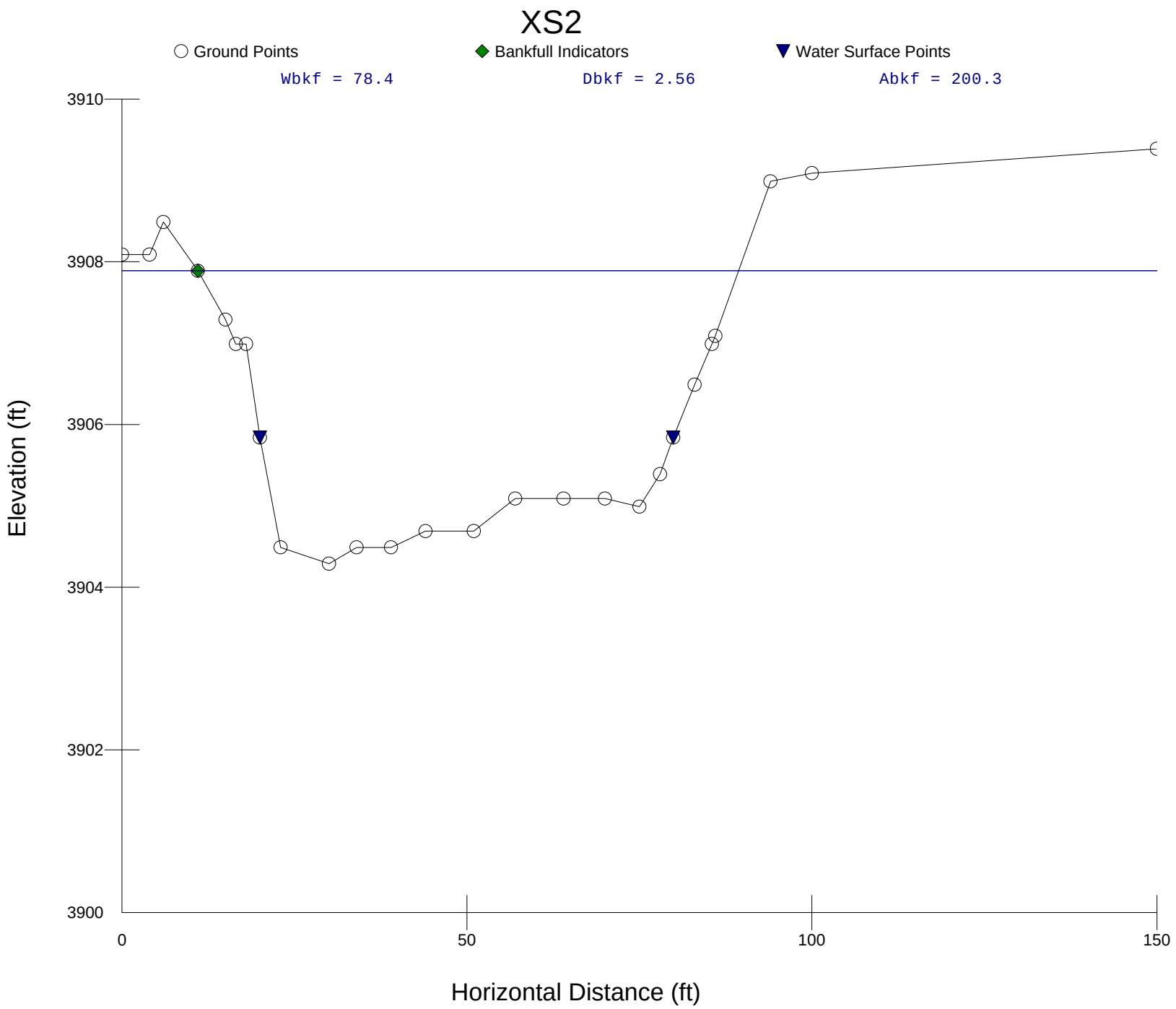
AMERICAN ENGINEERING TESTING, INC.

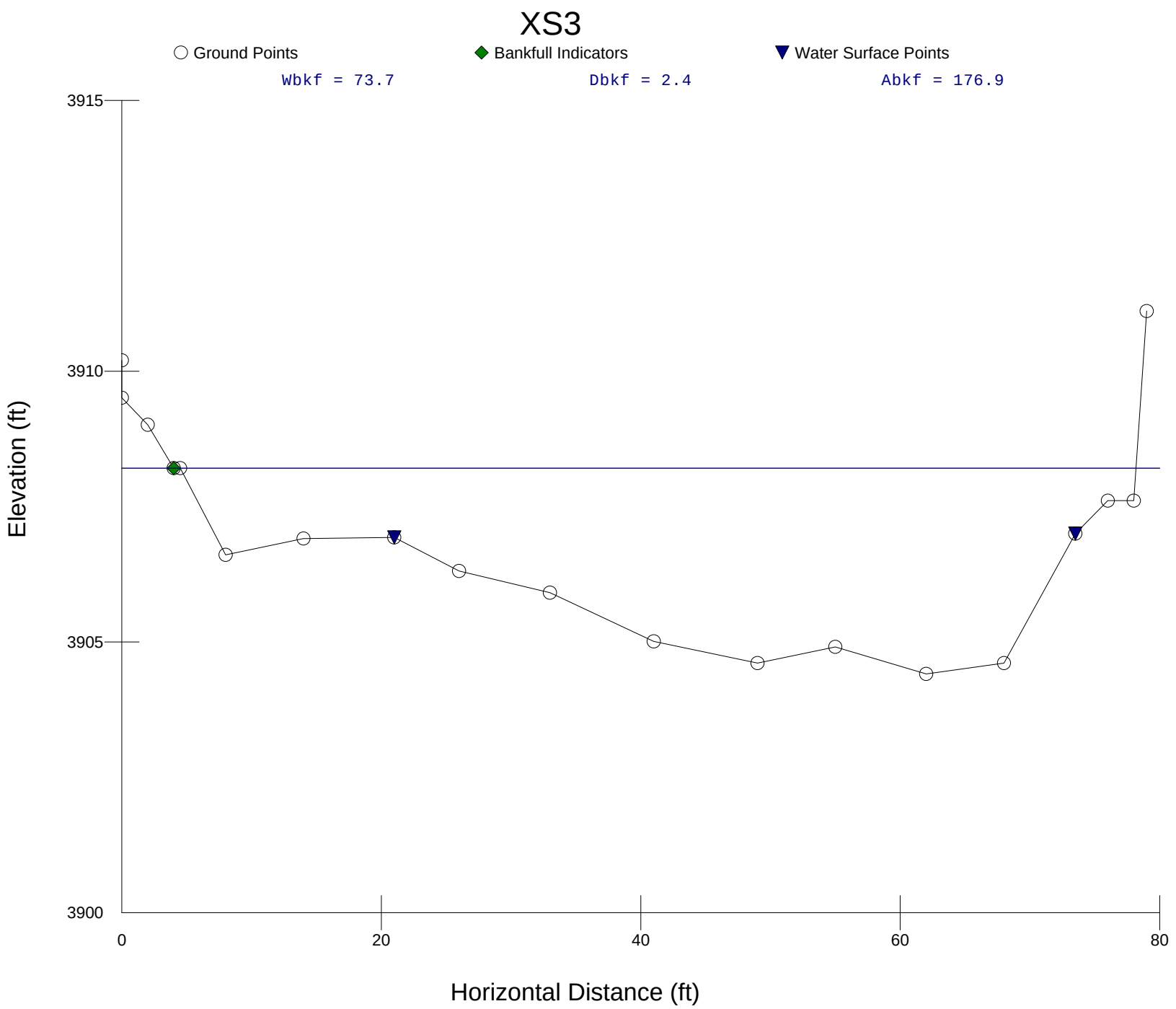
GRADATION CURVES

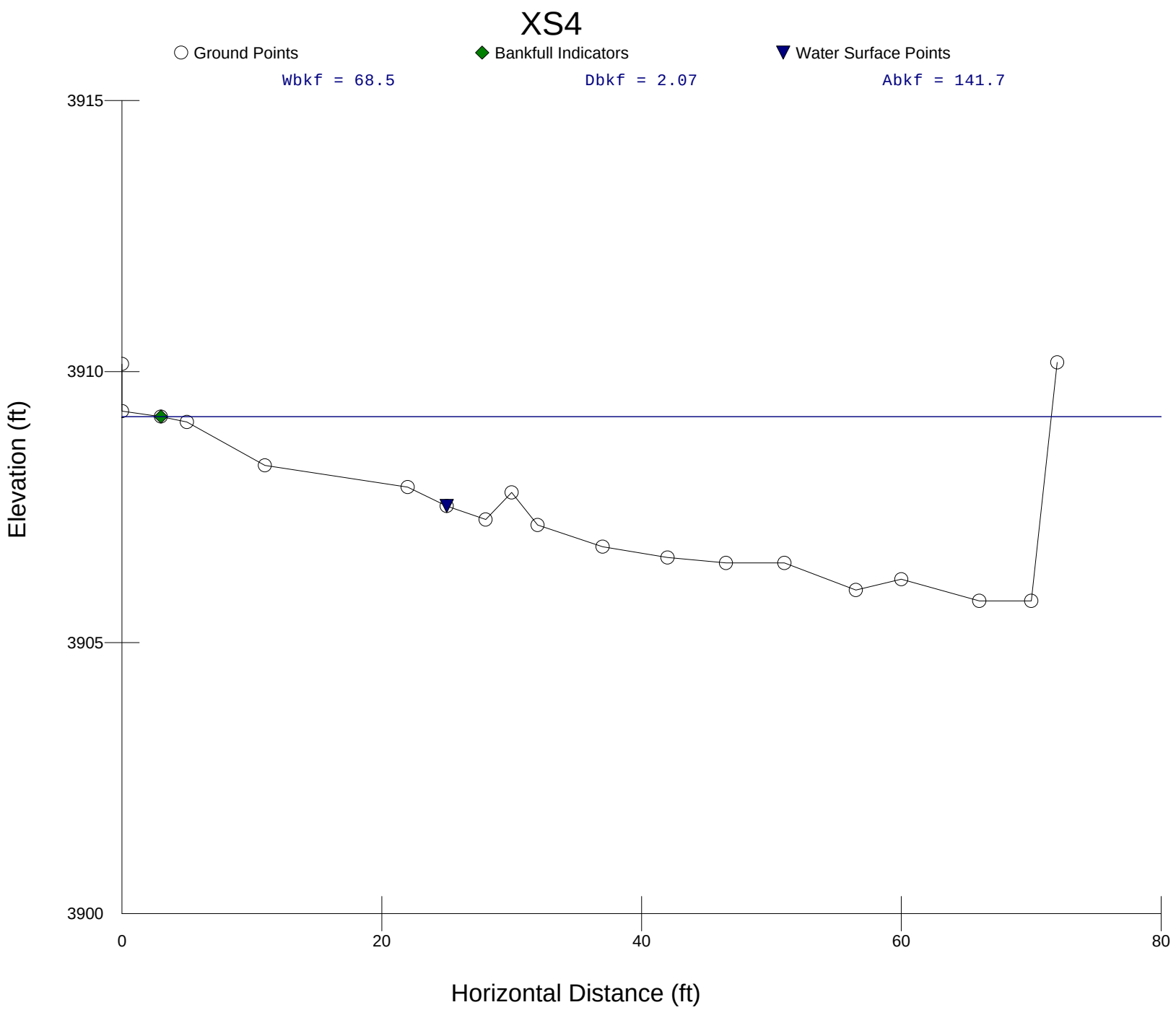
Appendix F

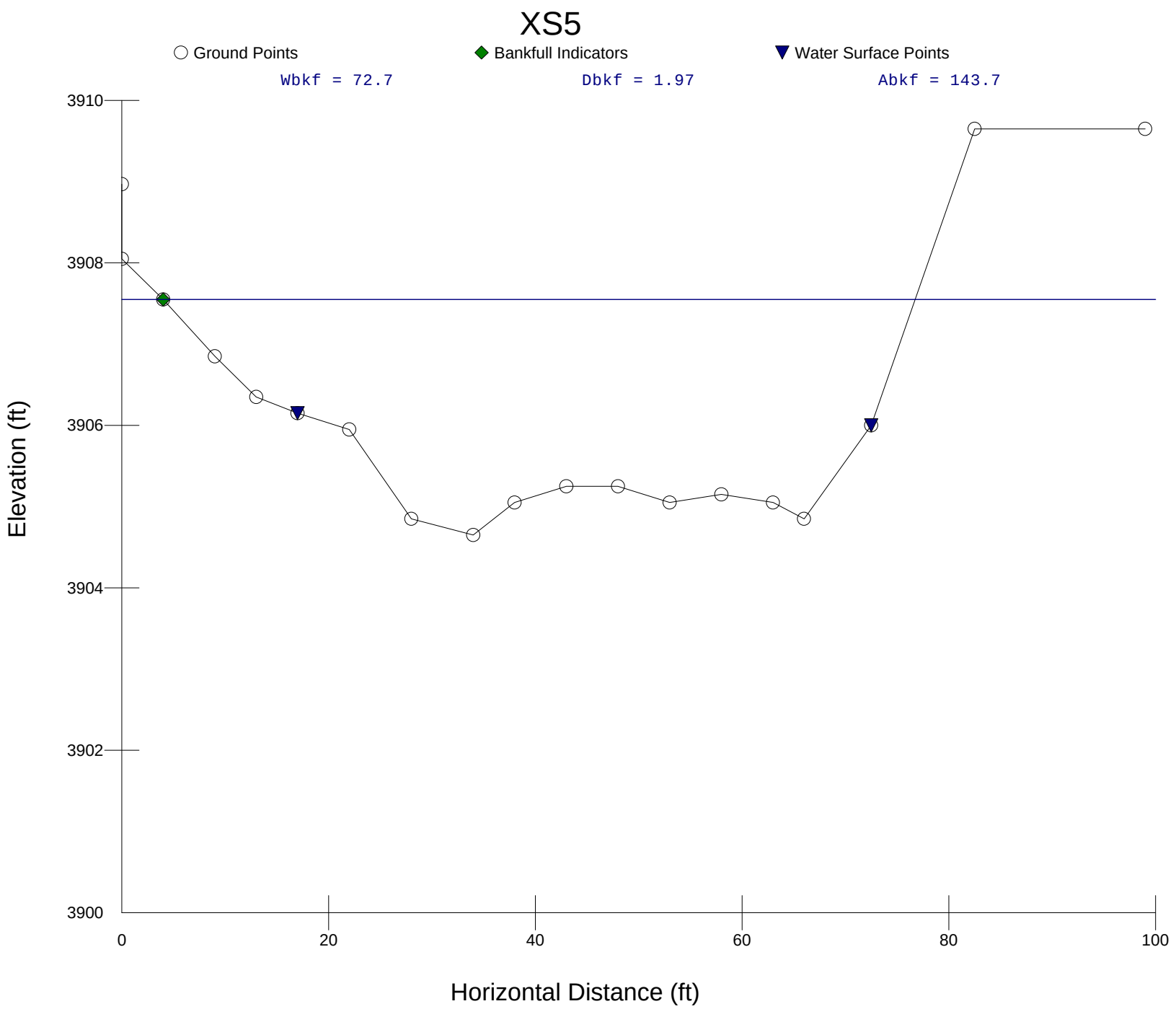
Compiled cross section information

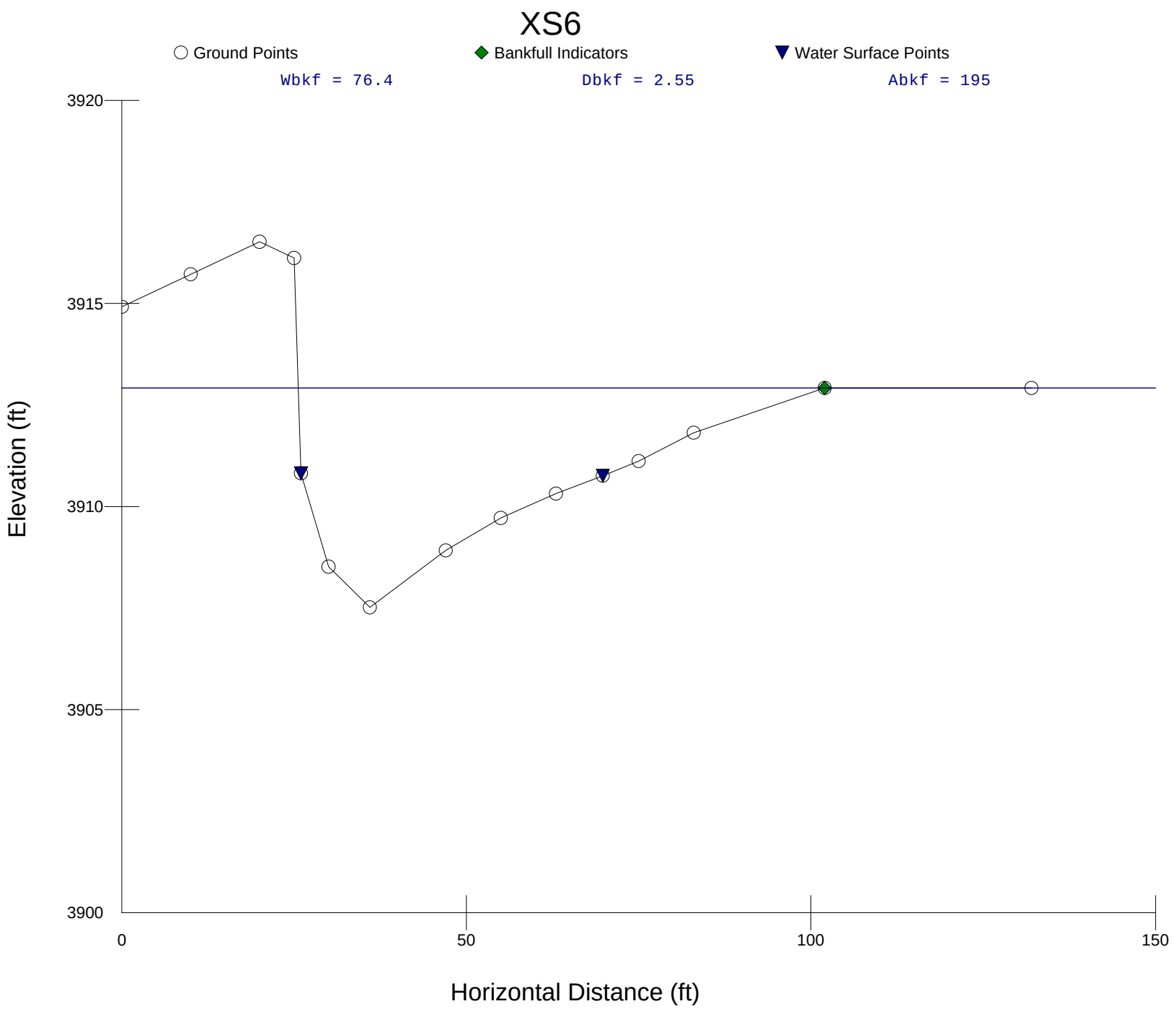

XS1
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 76.9
Dbkf = 2.46
Abkf = 189.2
3910
3908
3906
3904
3902
3900
Elevation (ft)
0
20
40
60
80
100
Horizontal Distance (ft)

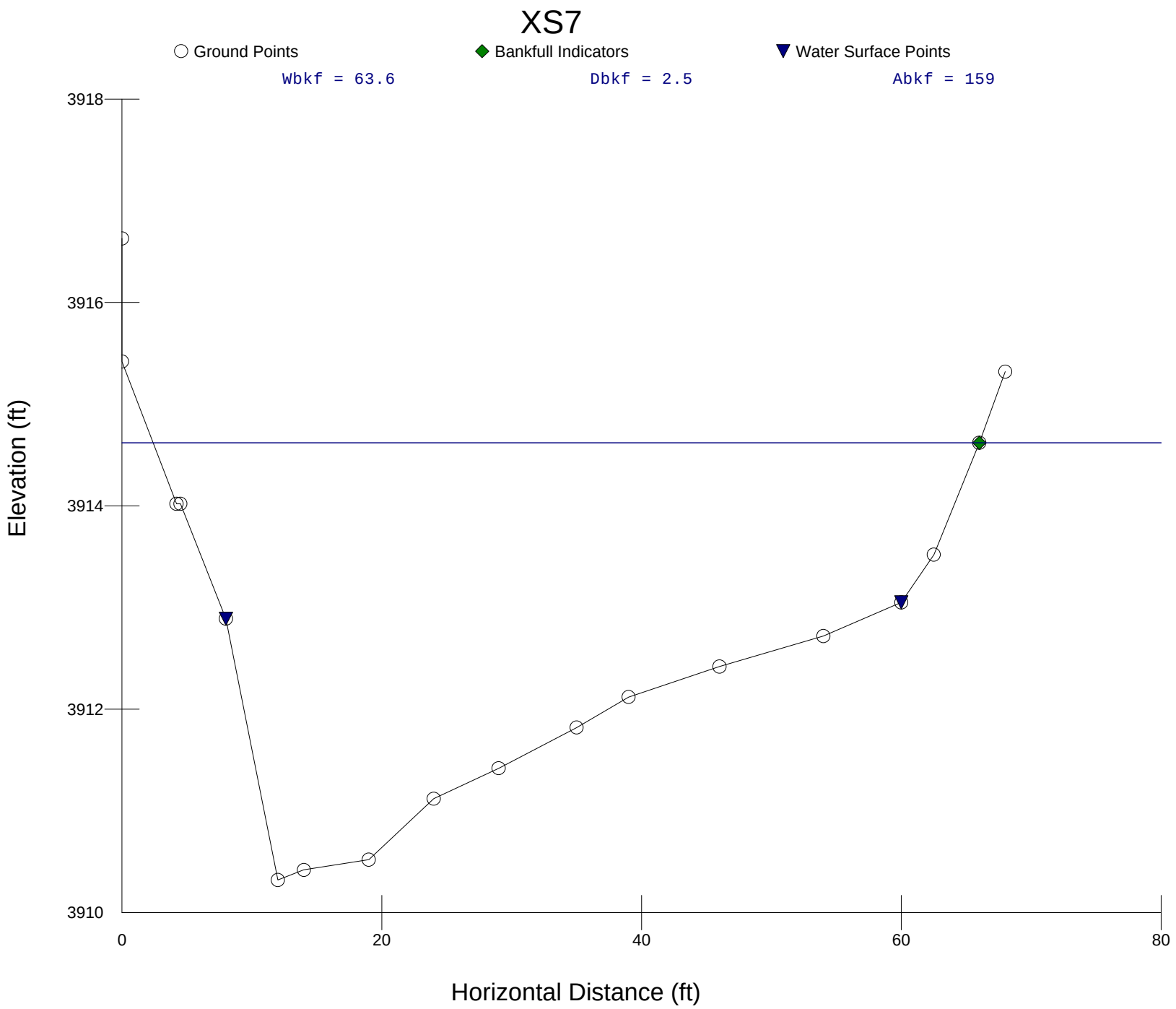

XS2
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 78.4
Dbkf = 2.56
Abkf = 200.3
3910
3908
3906
3904
3902
3900
Elevation (ft)
0
50
100
150
Horizontal Distance (ft)

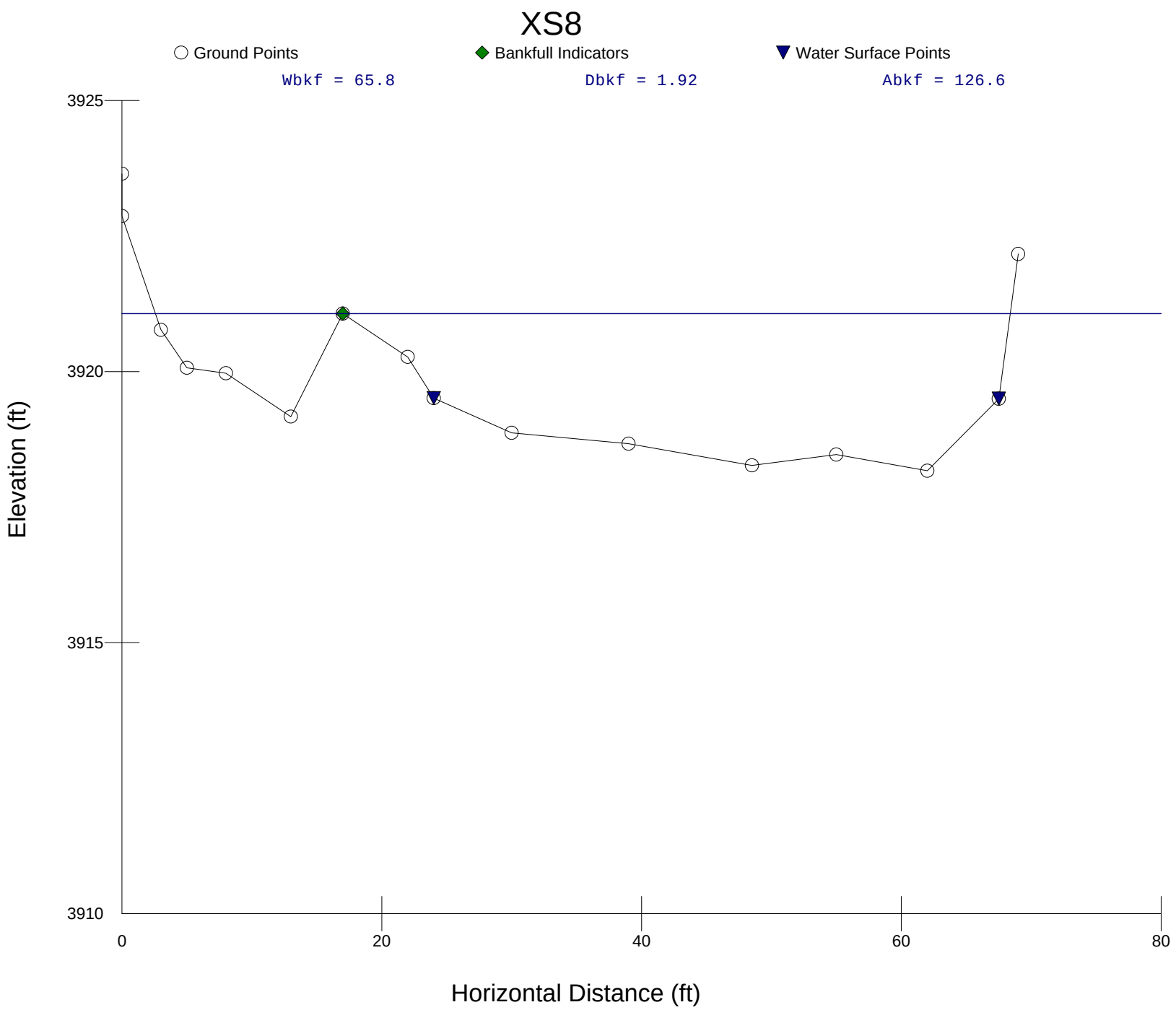

XS3
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 73.7
Dbkf = 2.4
Abkf = 176.9
3915
3910
3905
3900
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)

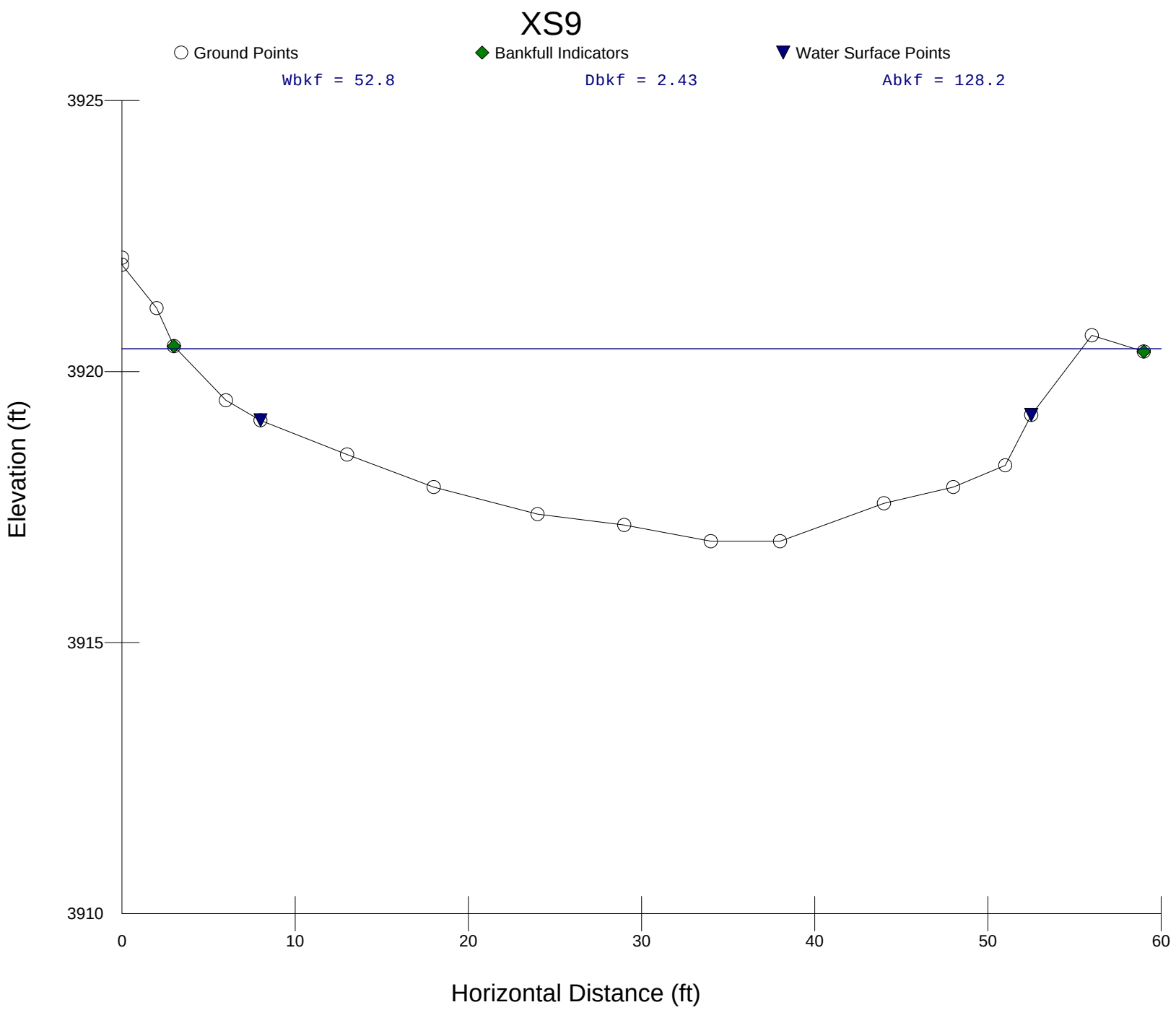

XS4
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 68.5
Dbkf = 2.07
Abkf = 141.7
3915
3910
3905
3900
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)

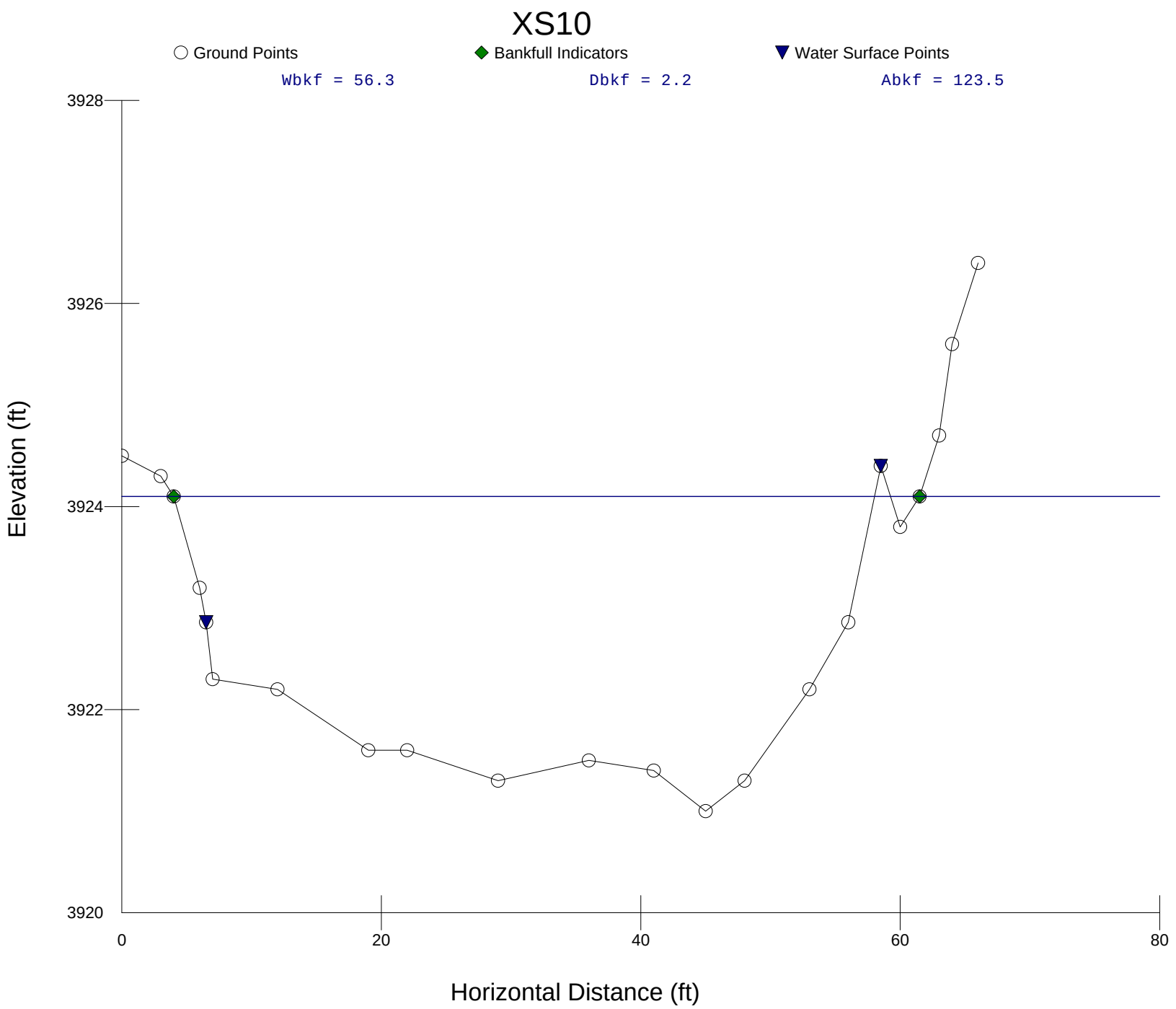

XS5
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 72.7
Dbkf = 1.97
Abkf = 143.7
3910
3908
3906
3904
3902
3900
Elevation (ft)
0
20
40
60
80
100
Horizontal Distance (ft)

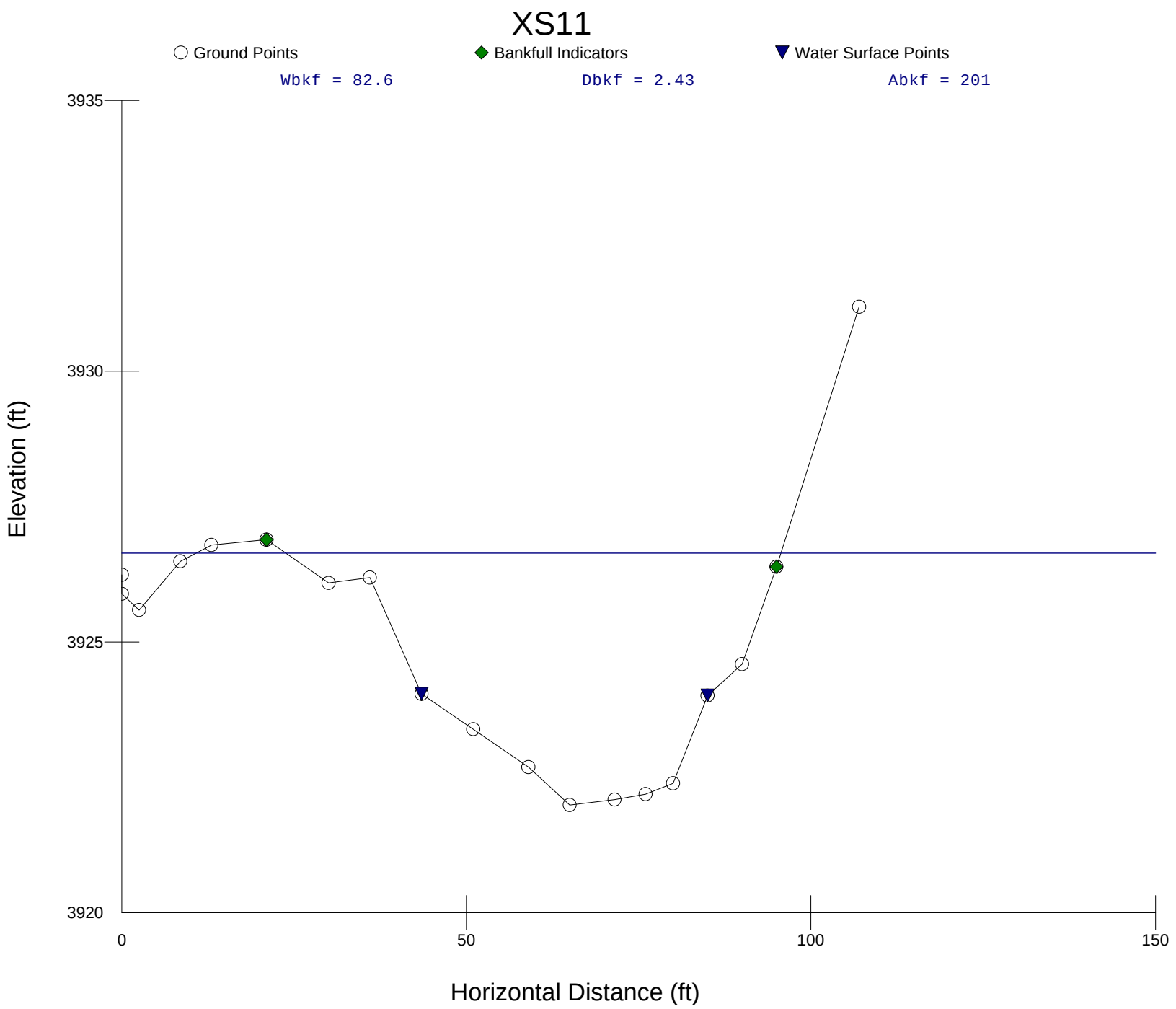

XS6
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 76.4
Dbkf = 2.55
Abkf = 195
3920
3915
3910
3905
3900
Elevation (ft)
0
50
100
150
Horizontal Distance (ft)

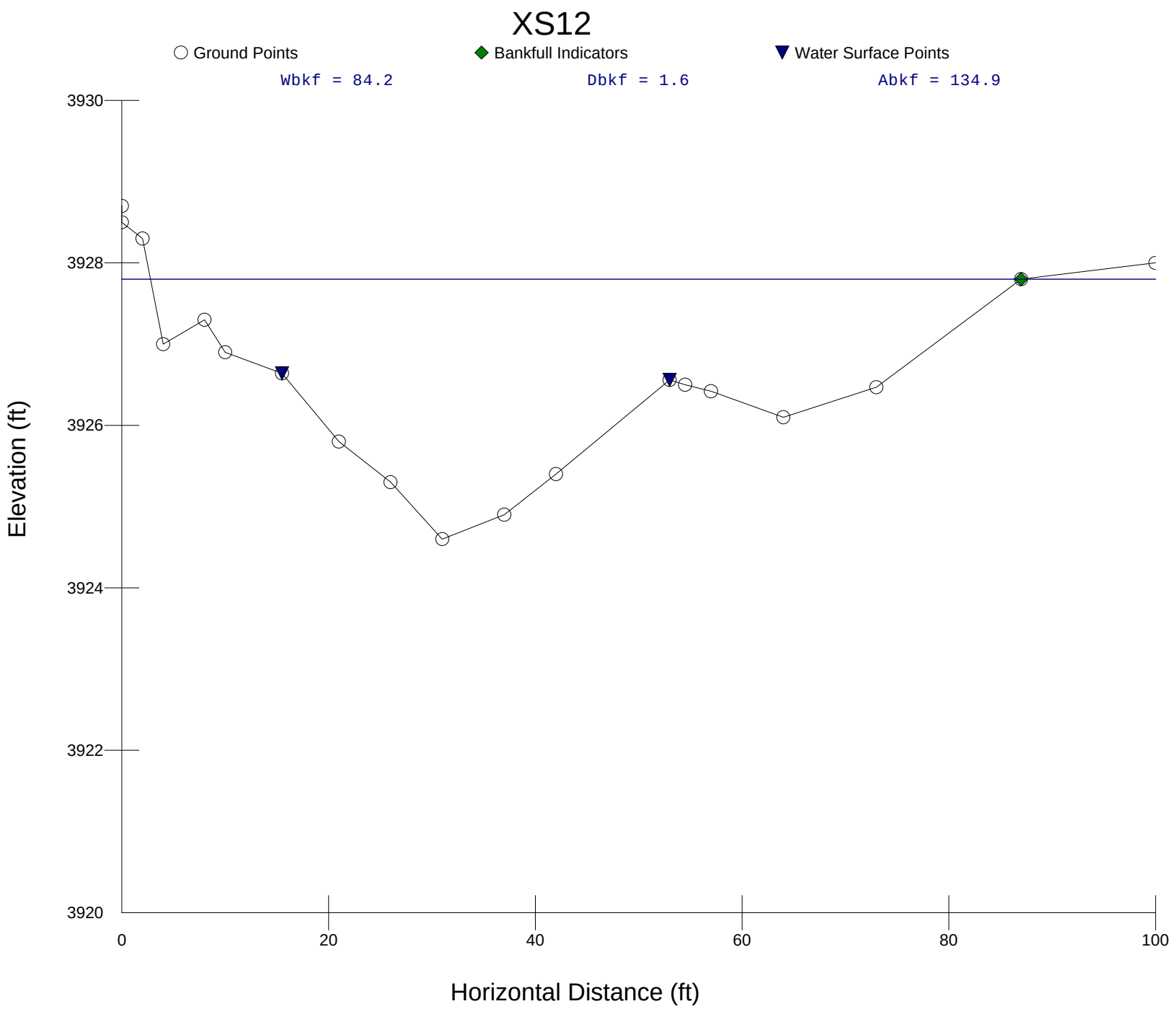

XS7
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 63.6
Dbkf = 2.5
Abkf = 159
3918
3916
3914
3912
3910
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)

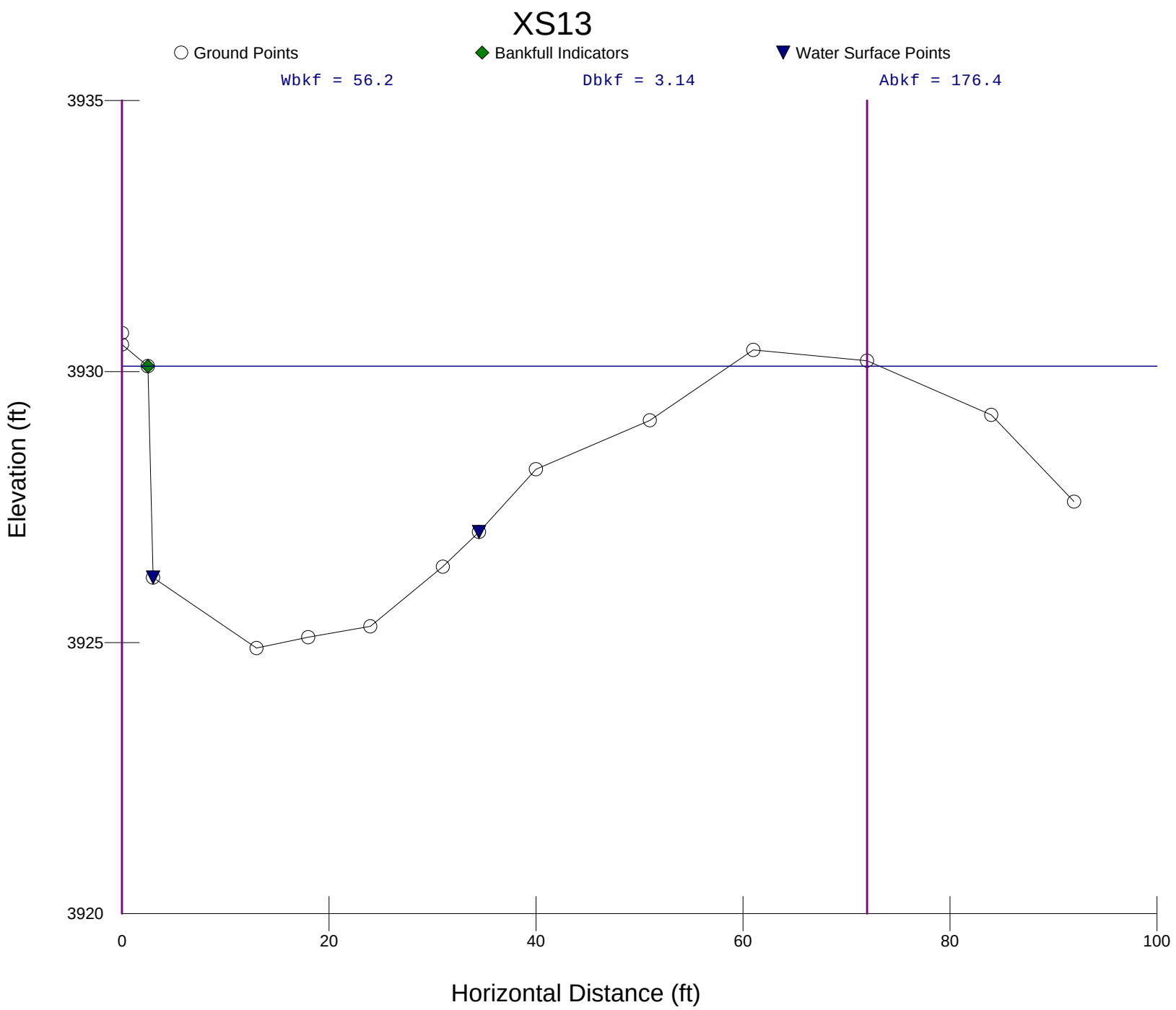

XS8
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 65.8
Dbkf = 1.92
Abkf = 126.6
3925
3920
3915
3910
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)

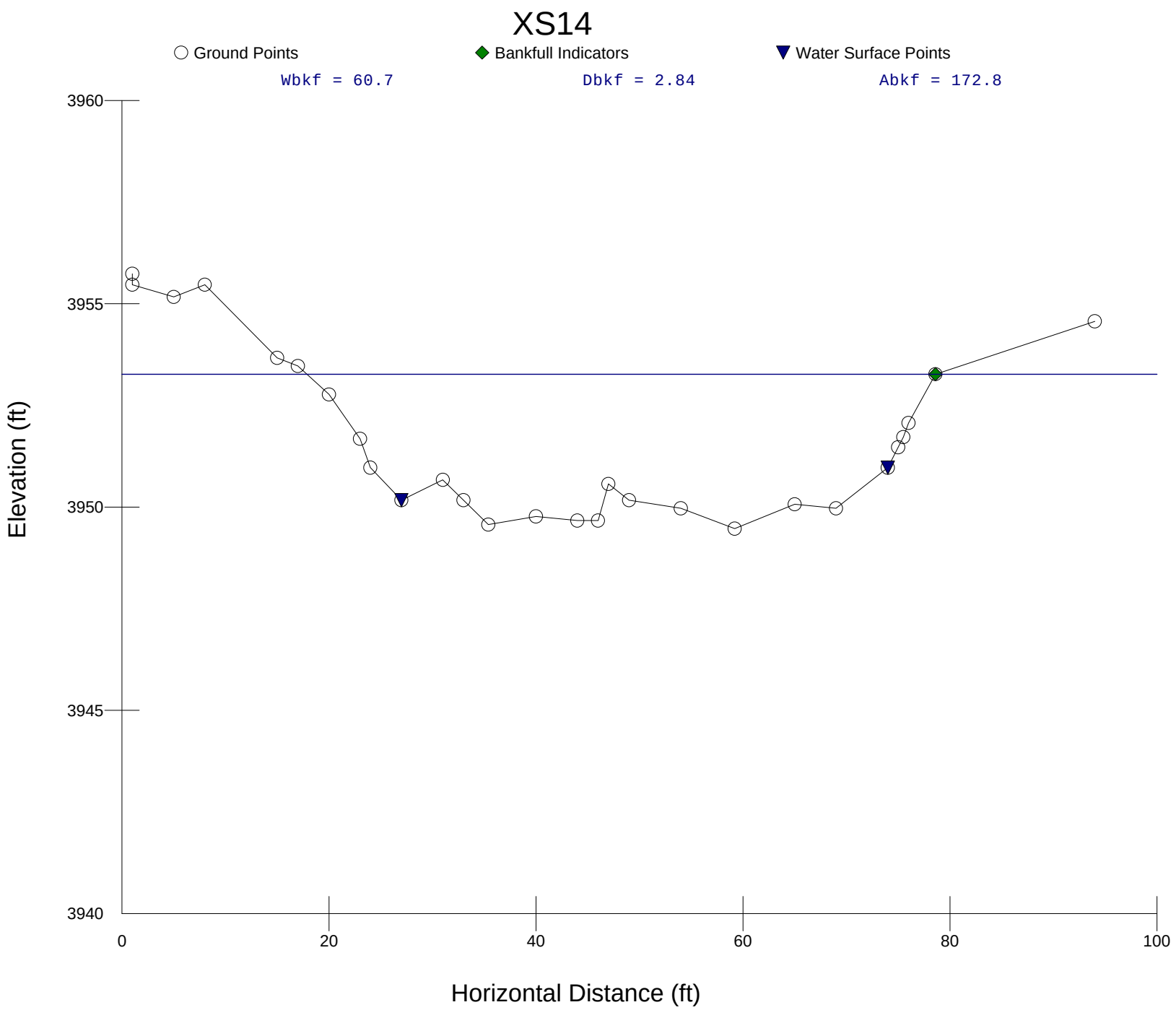

XS9
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 52.8
Dbkf = 2.43
Abkf = 128.2
3925
3920
3915
3910
Elevation (ft)
0
10
20
30
40
50
60
Horizontal Distance (ft)

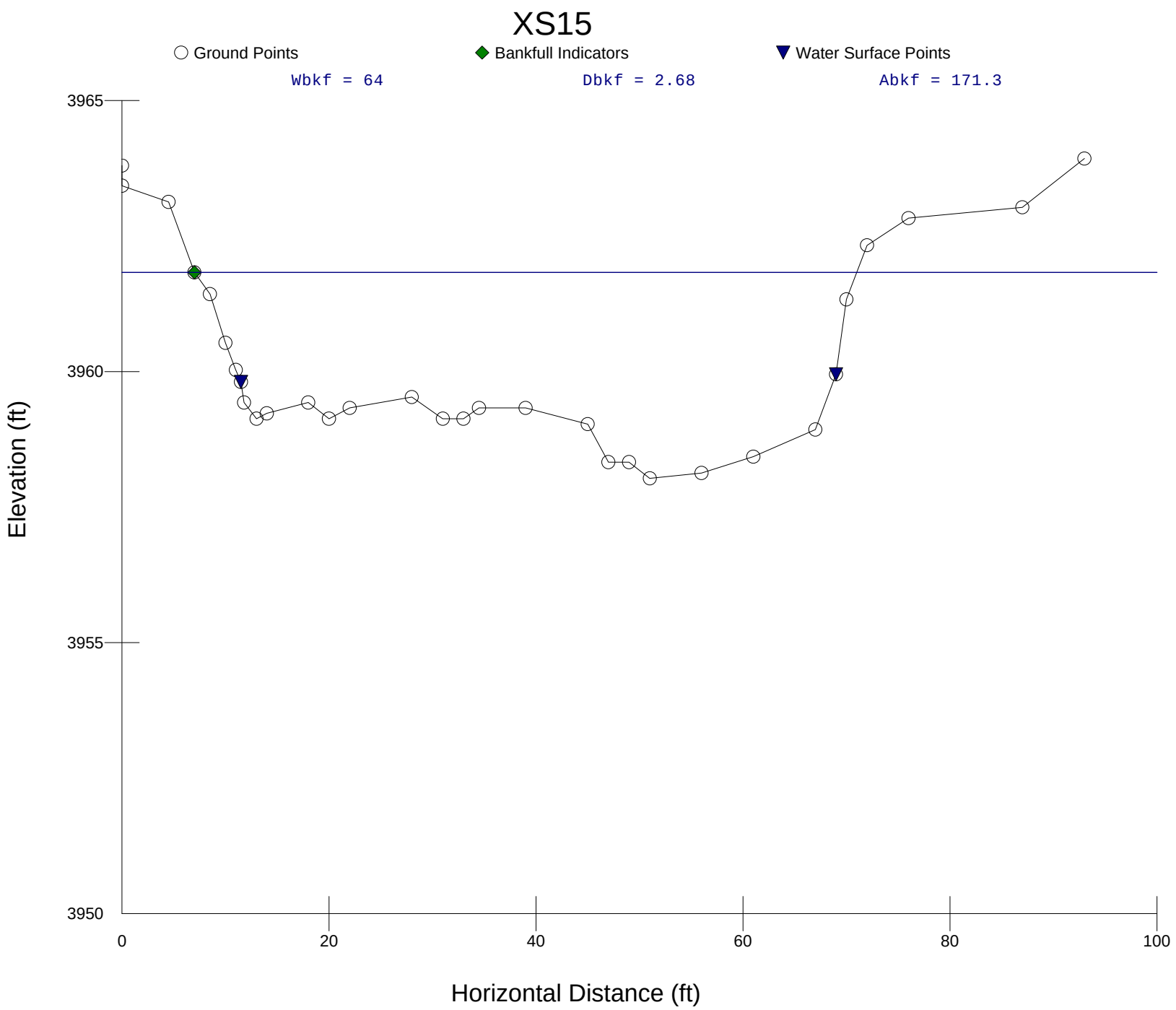

XS10
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 56.3
Dbkf = 2.2
Abkf = 123.5
3928
3926
3924
3922
3920
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)

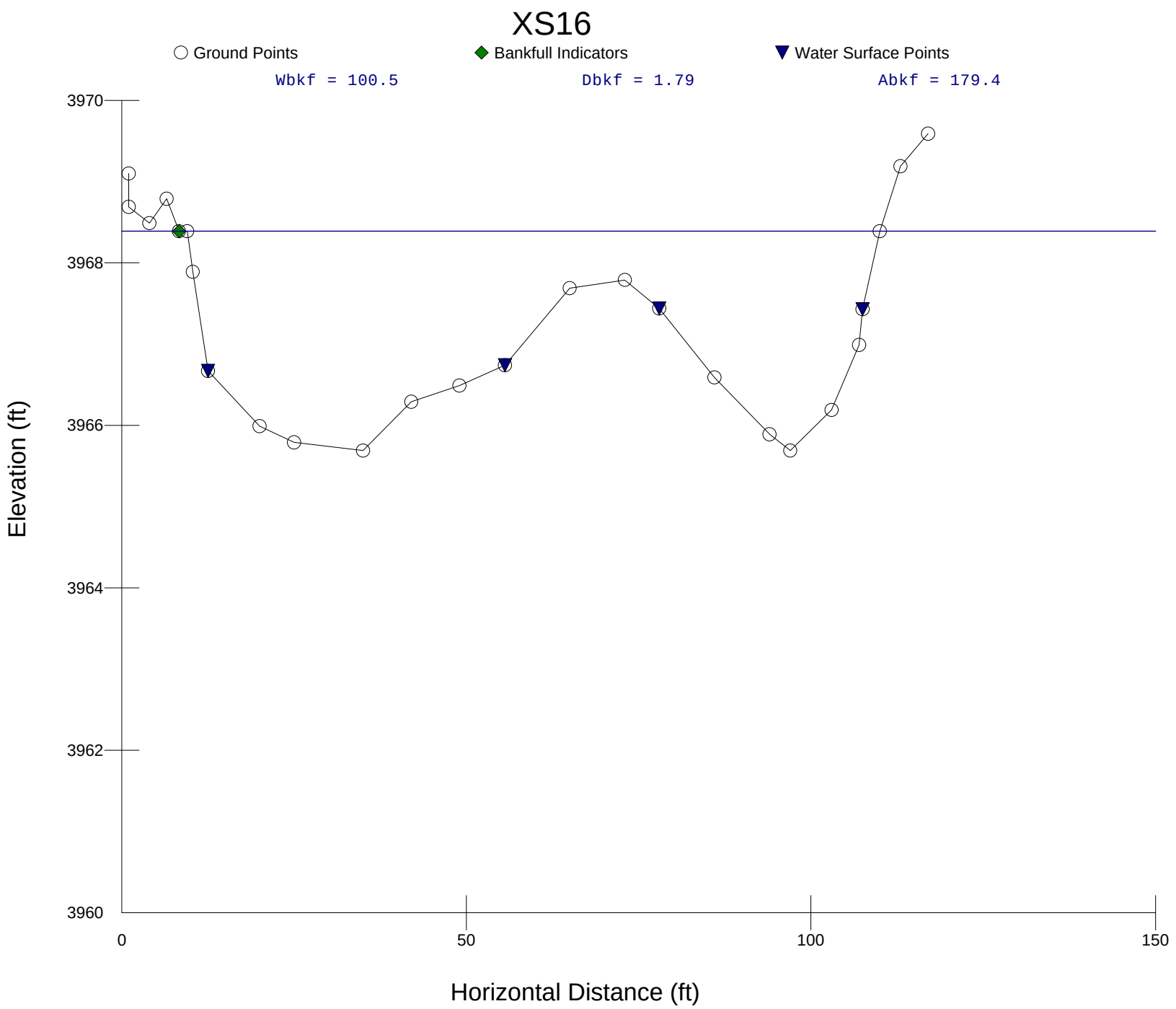

XS11
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 82.6
Dbkf = 2.43
Abkf = 201
3935
3930
3925
3920
Elevation (ft)
0
50
100
150
Horizontal Distance (ft)

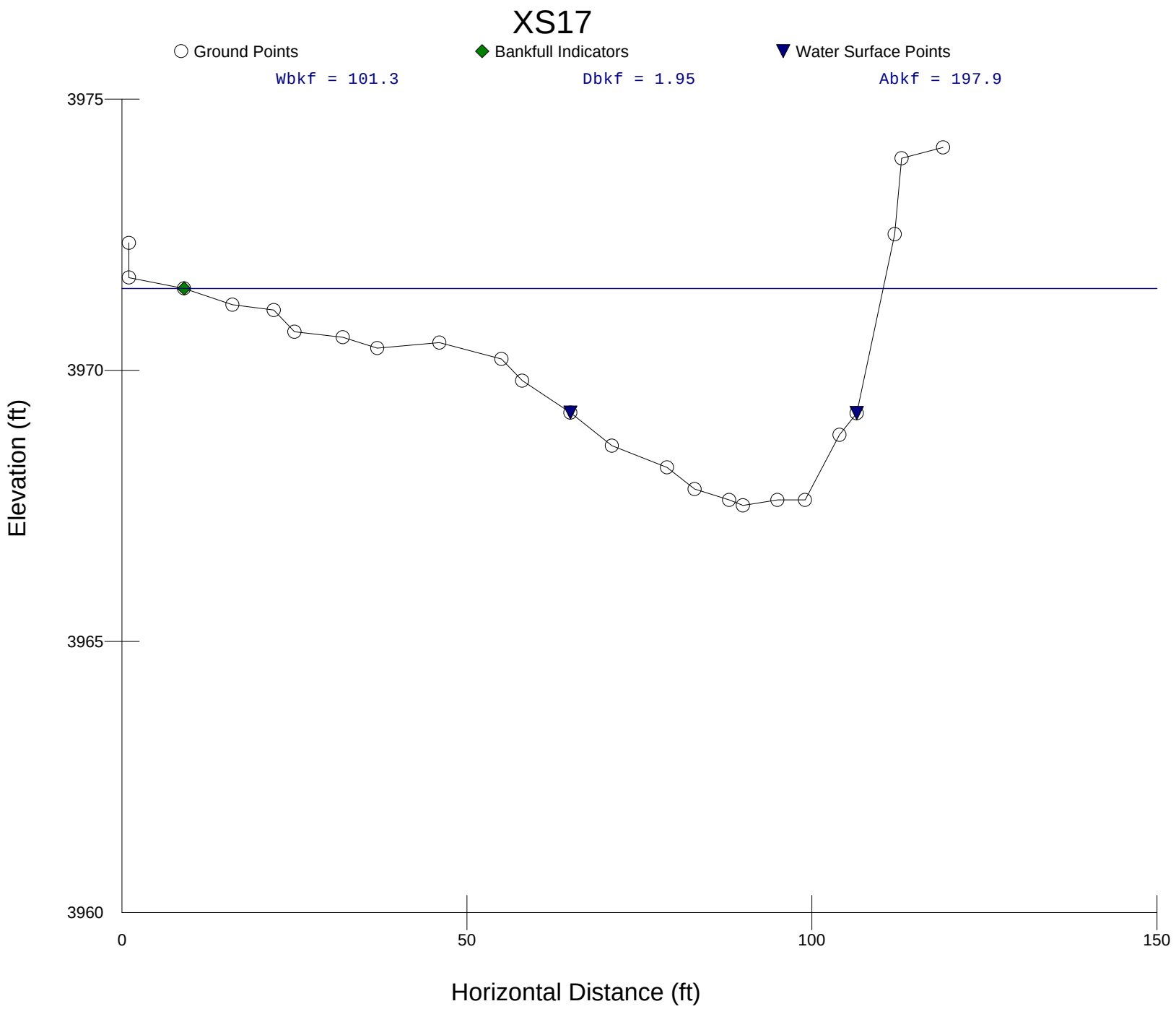

XS12
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 84.2
Dbkf = 1.6
Abkf = 134.9
3930
3928
3926
3924
3922
3920
Elevation (ft)
0
20
40
60
80
100
Horizontal Distance (ft)

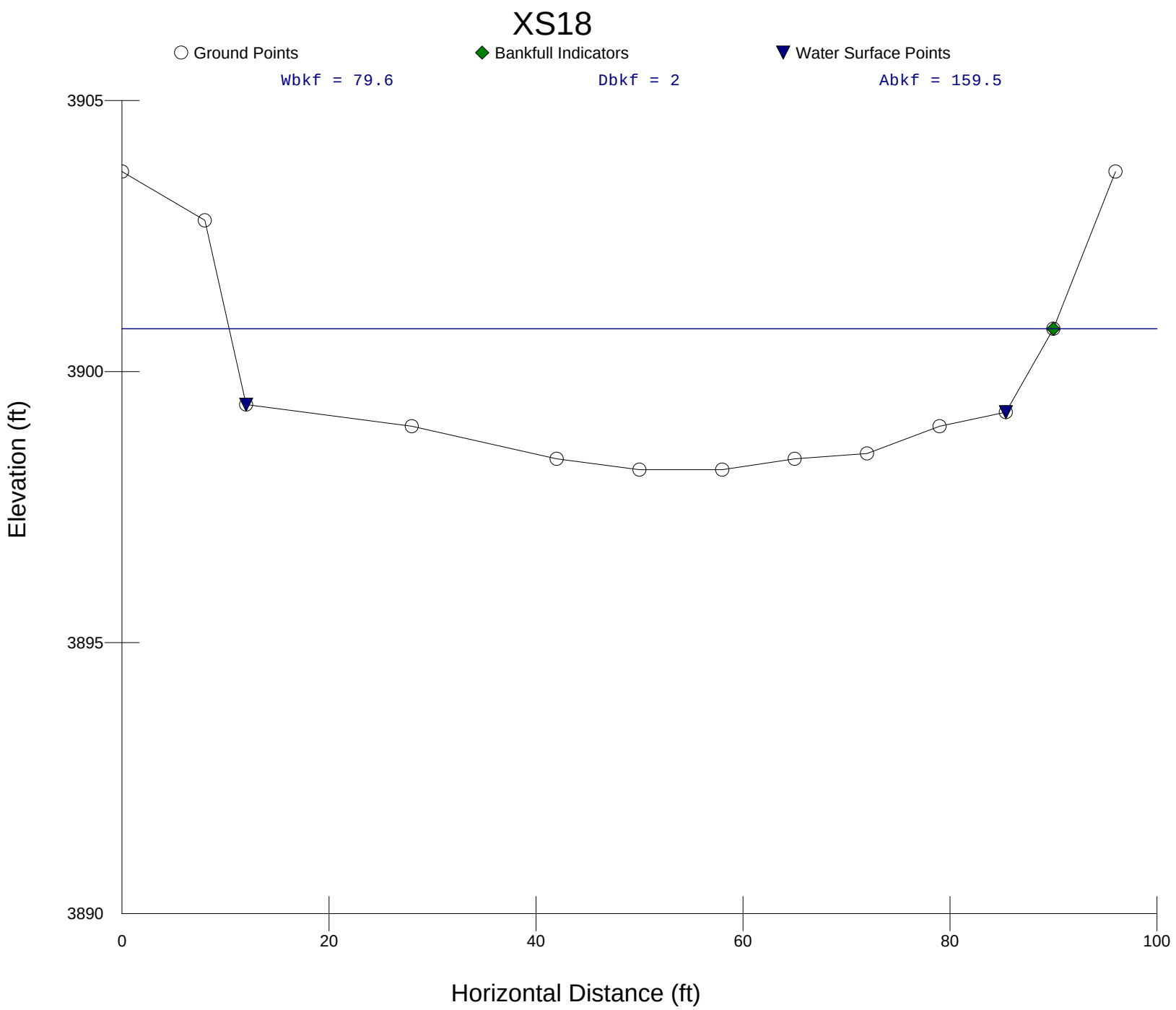

XS13
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 56.2
Dbkf = 3.14
Abkf = 176.4
3935
3930
3925
3920
Elevation (ft)
0
20
40
60
80
100
Horizontal Distance (ft)

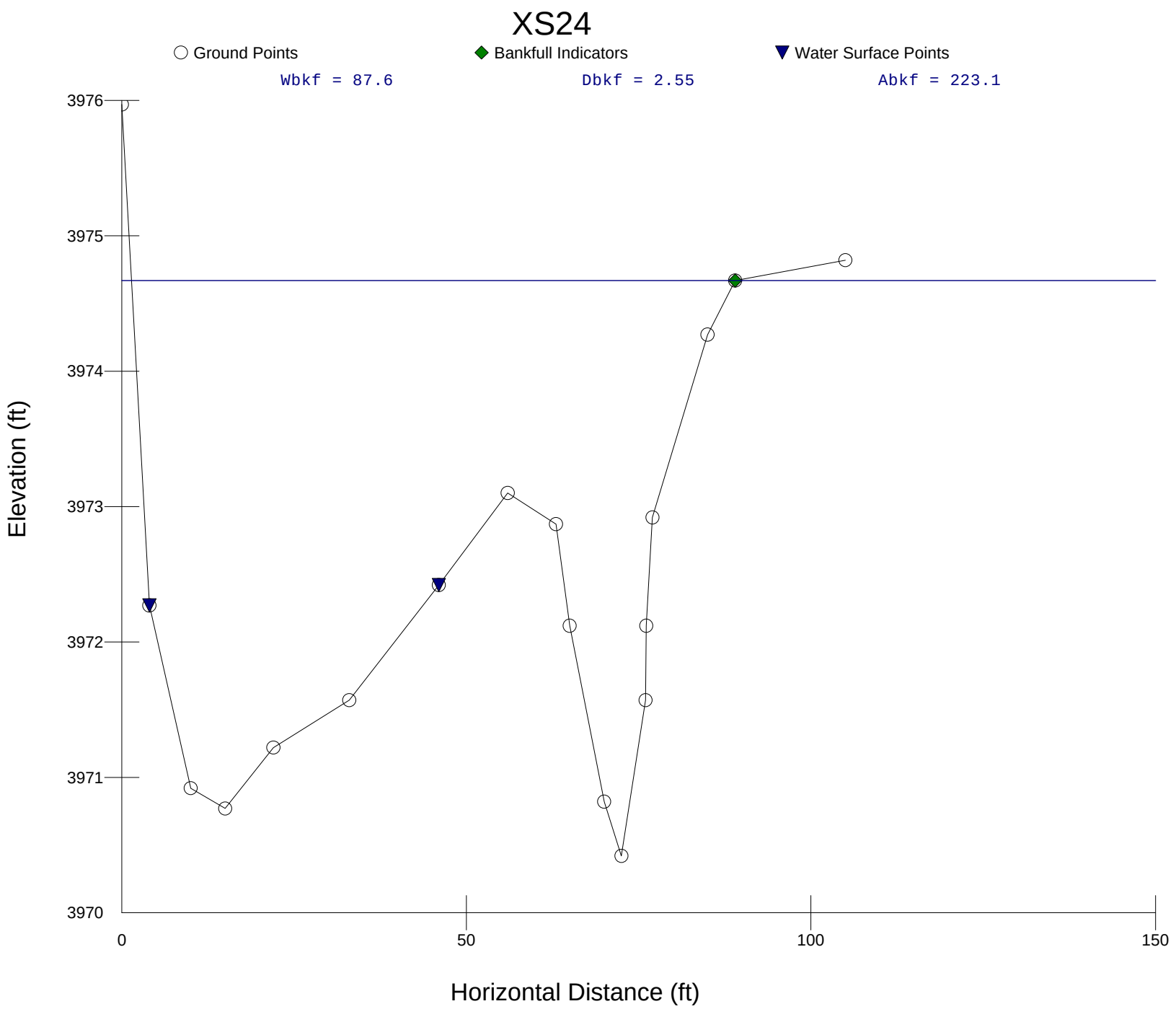

XS14
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 60.7
Dbkf = 2.84
Abkf = 172.8
3960
3955
3950
3945
3940
Elevation (ft)
0
20
40
60
80
100
Horizontal Distance (ft)

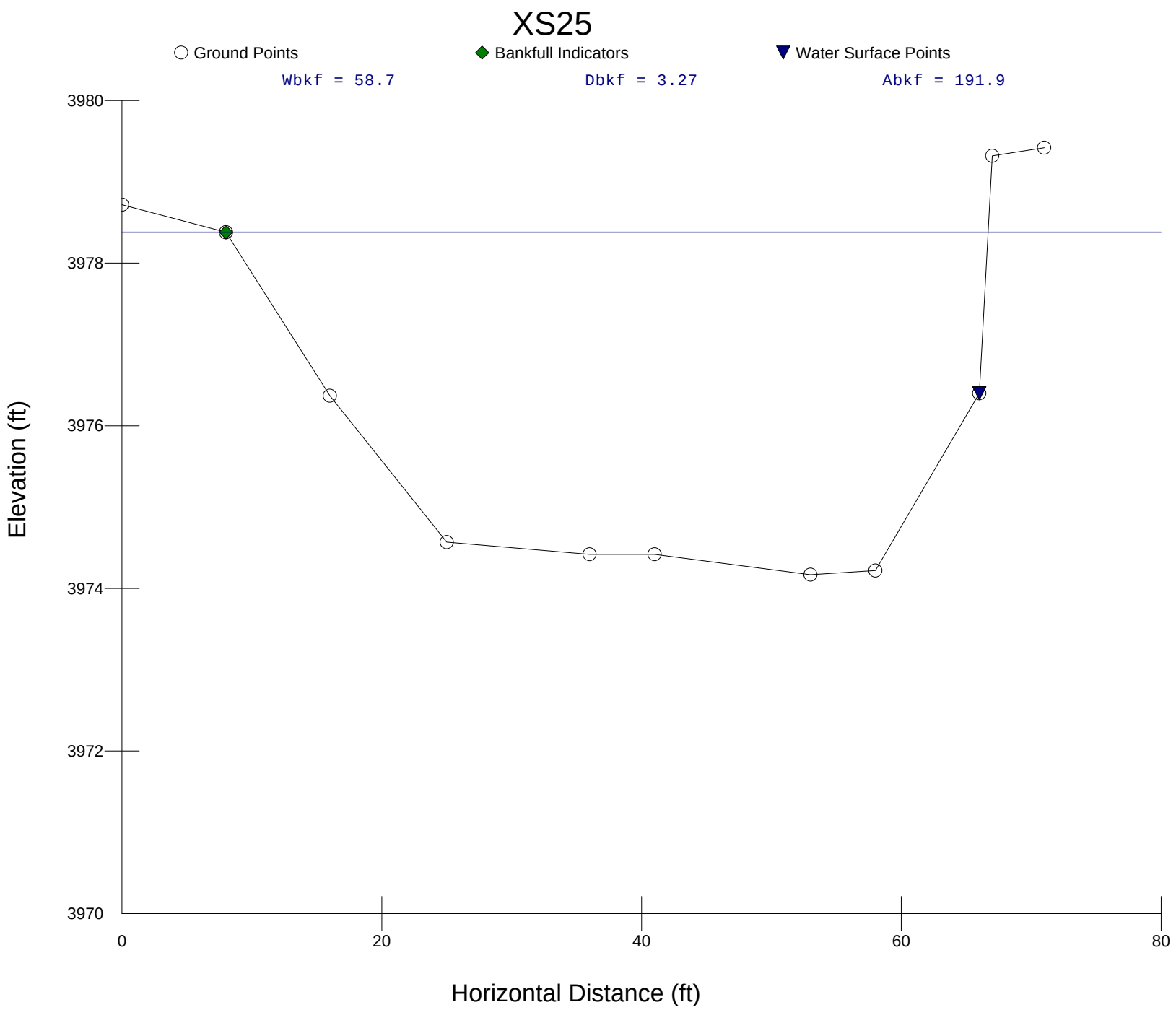

XS15
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 64
Dbkf = 2.68
Abkf = 171.3
3965
3960
3955
3950
Elevation (ft)
0
20
40
60
80
100
Horizontal Distance (ft)

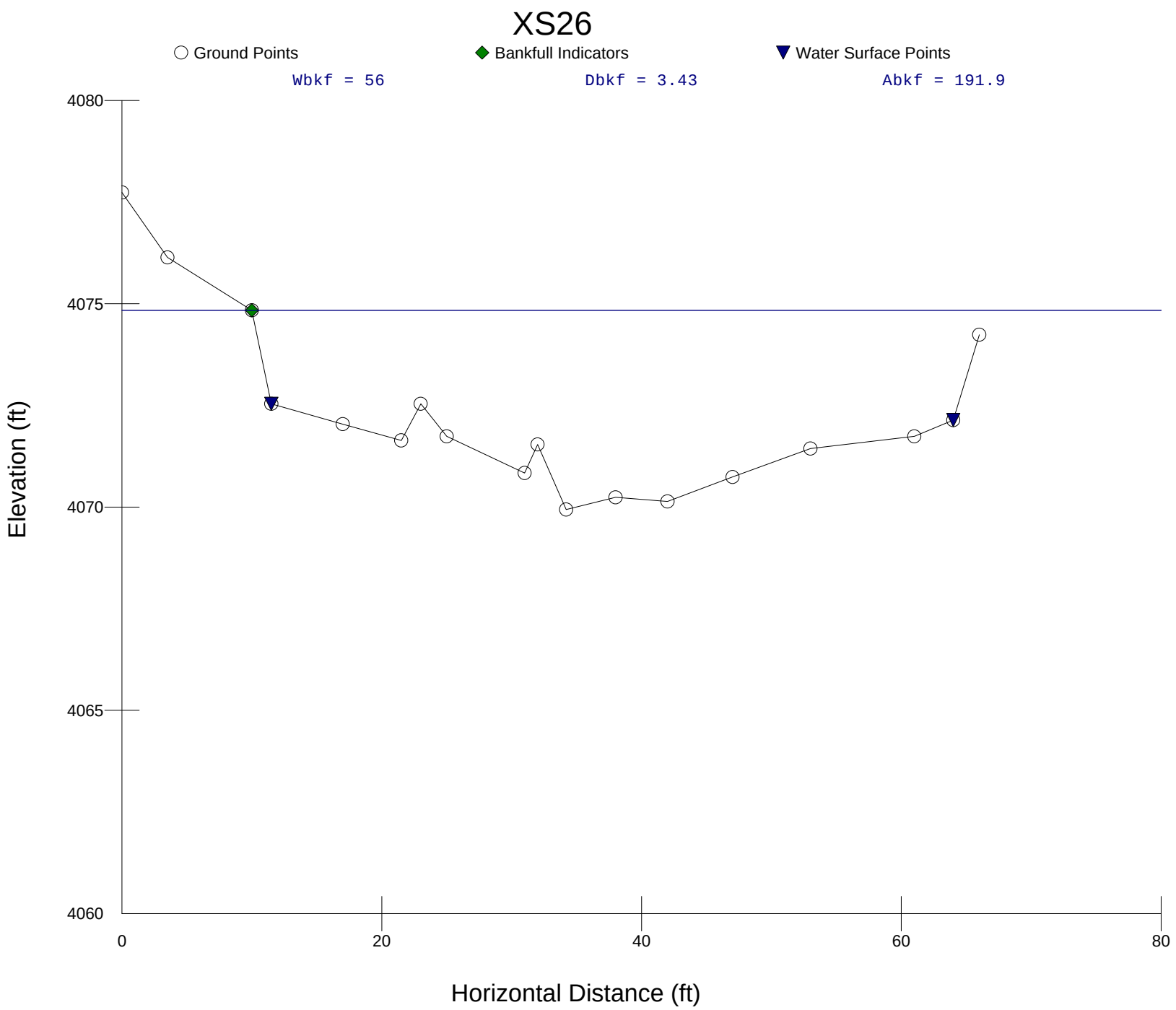

XS16
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 100.5
Dbkf = 1.79
Abkf = 179.4
3970
3968
3966
3964
3962
3960
Elevation (ft)
0
50
100
150
Horizontal Distance (ft)

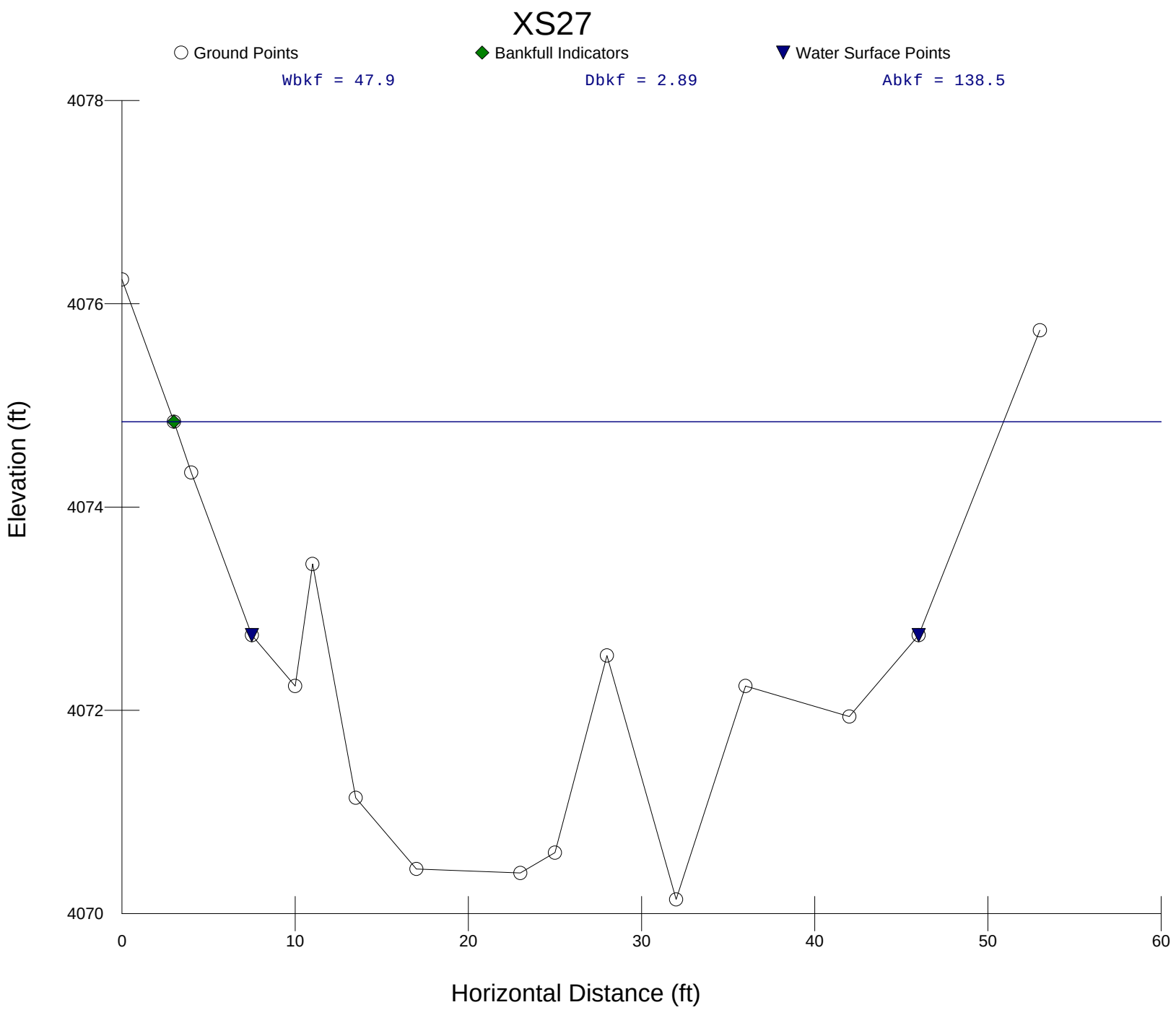

XS17
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 101.3
Dbkf = 1.95
Abkf = 197.9
3975
3970
3965
3960
Elevation (ft)
0
50
100
150
Horizontal Distance (ft)


XS18
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 79.6
Dbkf = 2
Abkf = 159.5
3905
3900
3895
3890
Elevation (ft)
0
20
40
60
80
100
Horizontal Distance (ft)


XS24
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 87.6
Dbkf = 2.55
Abkf = 223.1
3976
3975
3974
3973
3972
3971
3970
Elevation (ft)
0
50
100
150
Horizontal Distance (ft)


XS25
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 58.7
Dbkf = 3.27
Abkf = 191.9
3980
3978
3976
3974
3972
3970
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)


XS26
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 56
Dbkf = 3.43
Abkf = 191.9
4080
4075
4070
4065
4060
Elevation (ft)
0
20
40
60
80
Horizontal Distance (ft)


XS27
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 47.9
Dbkf = 2.89
Abkf = 138.5
4078
4076
4074
4072
4070
Elevation (ft)
0
10
20
30
40
50
60
Horizontal Distance (ft)

Appendix G

Rosgen Level III analysis sheets

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Tongue River**		Location: **Reach 4, XS 11**						
Observers: **Starkey, Mikus, Burke**						Date: **11/7/2013**		
List ALL COMBINATIONS that APPLY.....☞	**P7**	**P1**						

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order			
Stream:	**Tongue**		
Location:	**Reach 4, XS 11**		
Observers:	**Starkey, Mikus, Burke**		
Date:	**11/7/2013**		
Stream Size Category and Order ☞			**S6**
Category	**STREAM SIZE: Bankfull width**		**Check (✓) appropriate category**
	meters	**feet**	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☐
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☑
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐
Stream Order			
Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).			

Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

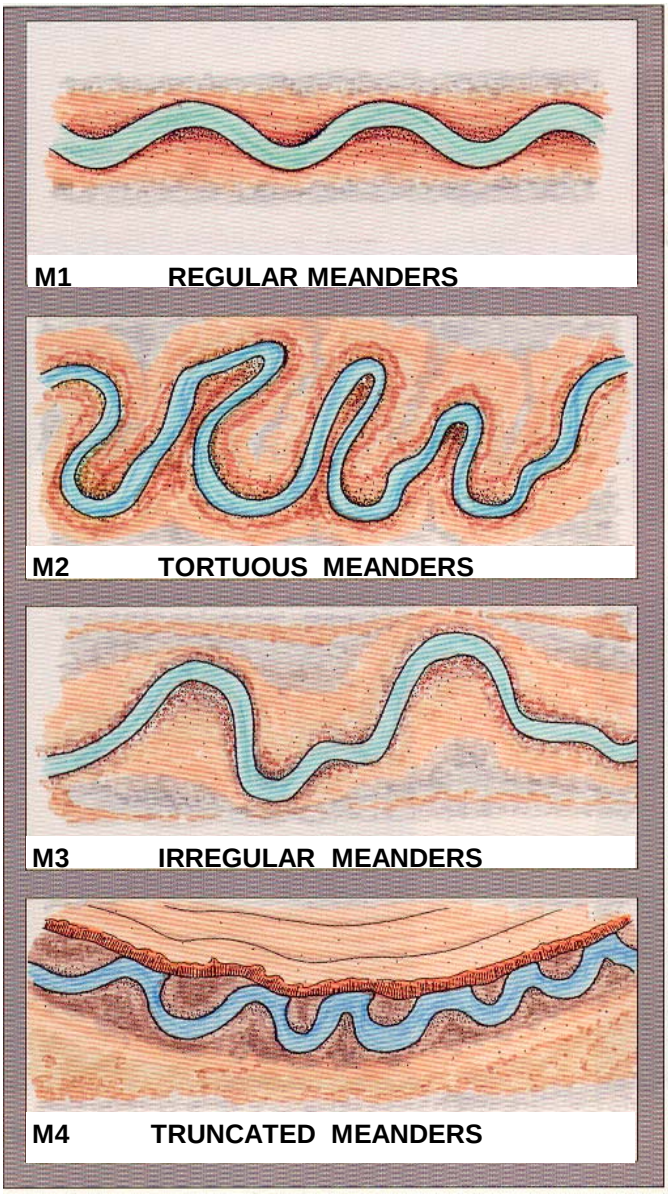
Meander Patterns

Stream: **Tongue** Reach: **Reach 4, XS11**

Observers: **Starkey, Mikus, Burke** Date: **11/7/2013**

List ALL CATEGORIES that APPLY ☞	M3				

Various Meander Pattern variables modified from Galay et al. (1973)

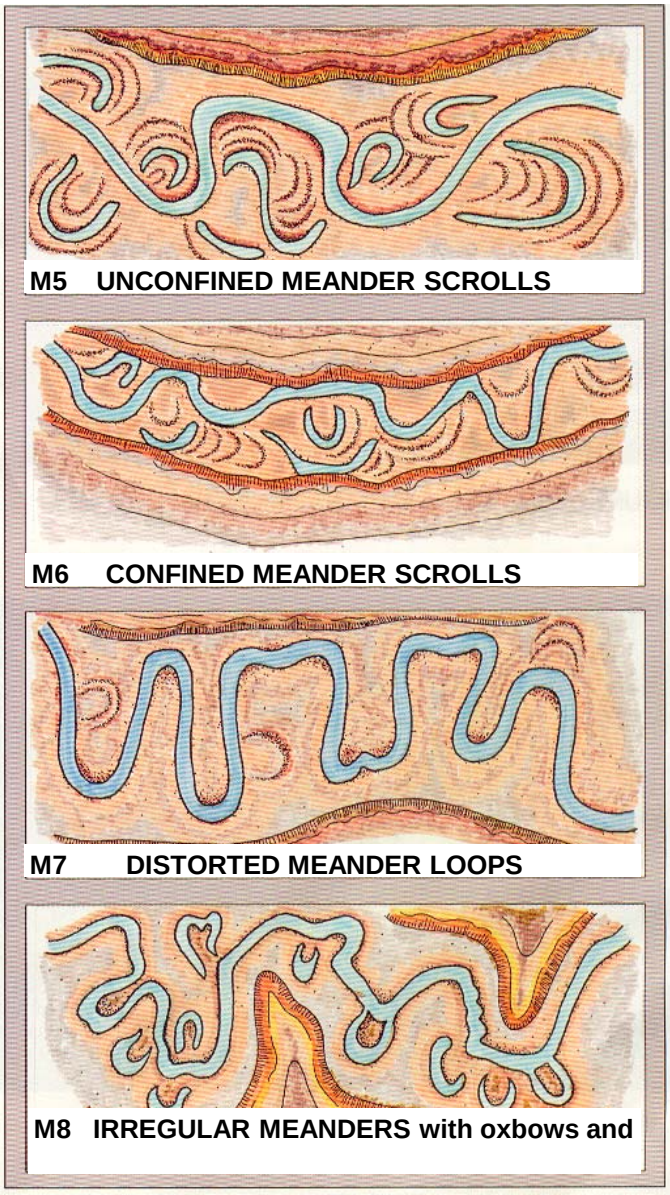


M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

M3 IRREGULAR MEANDERS

M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS

M6 CONFINED MEANDER SCROLLS

M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

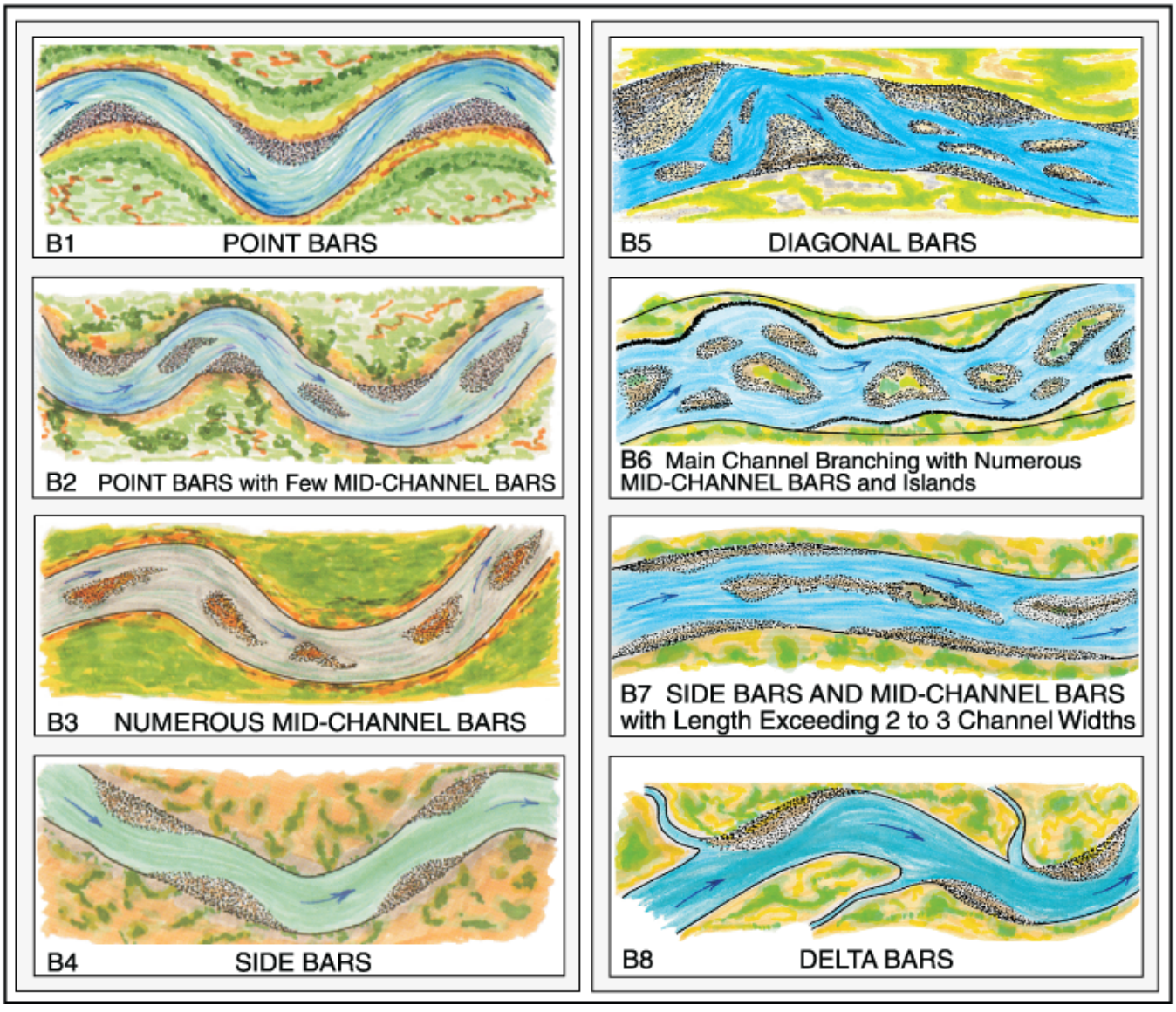
Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns

Stream:	**Tongue**	Reach:	**Reach 4, XS11**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/7/2013**

List ALL CATEGORIES that APPLY ☞	B1	B2			

Various Depositional Features modified from Galay et al. (1973)



Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: **Tongue**		Location: **Reach 4, XS11**	
Observers: **Starkey, Mikus, Burke**		Date: **11/7/2013**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

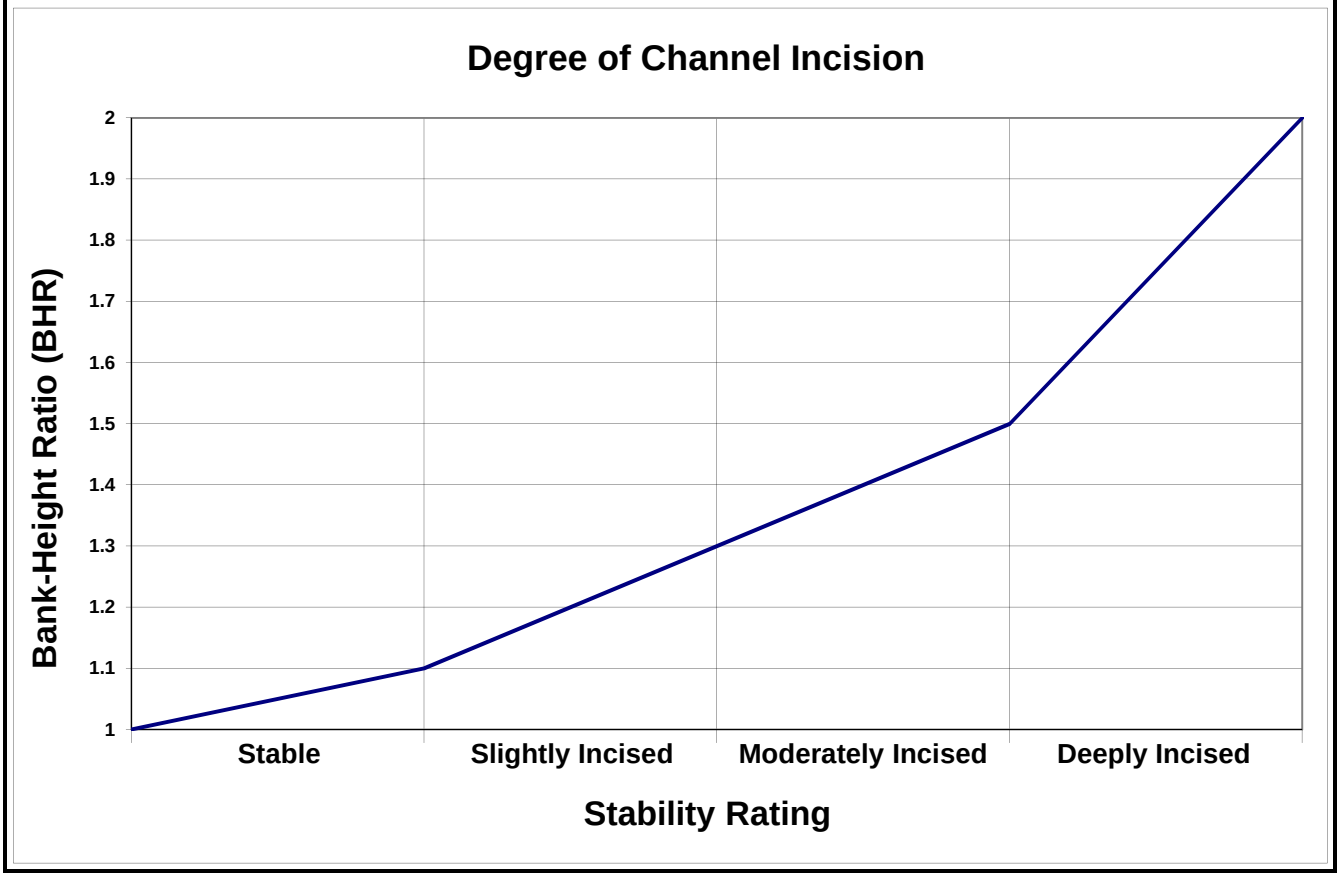
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision

Low Bank Height:	**3.6**
Max Bankfull Depth:	**3.1**

Bank-Height Ratio:	**1.2**

Degree of Channel Incision Stability Rating ☞	**Slightly Incised**



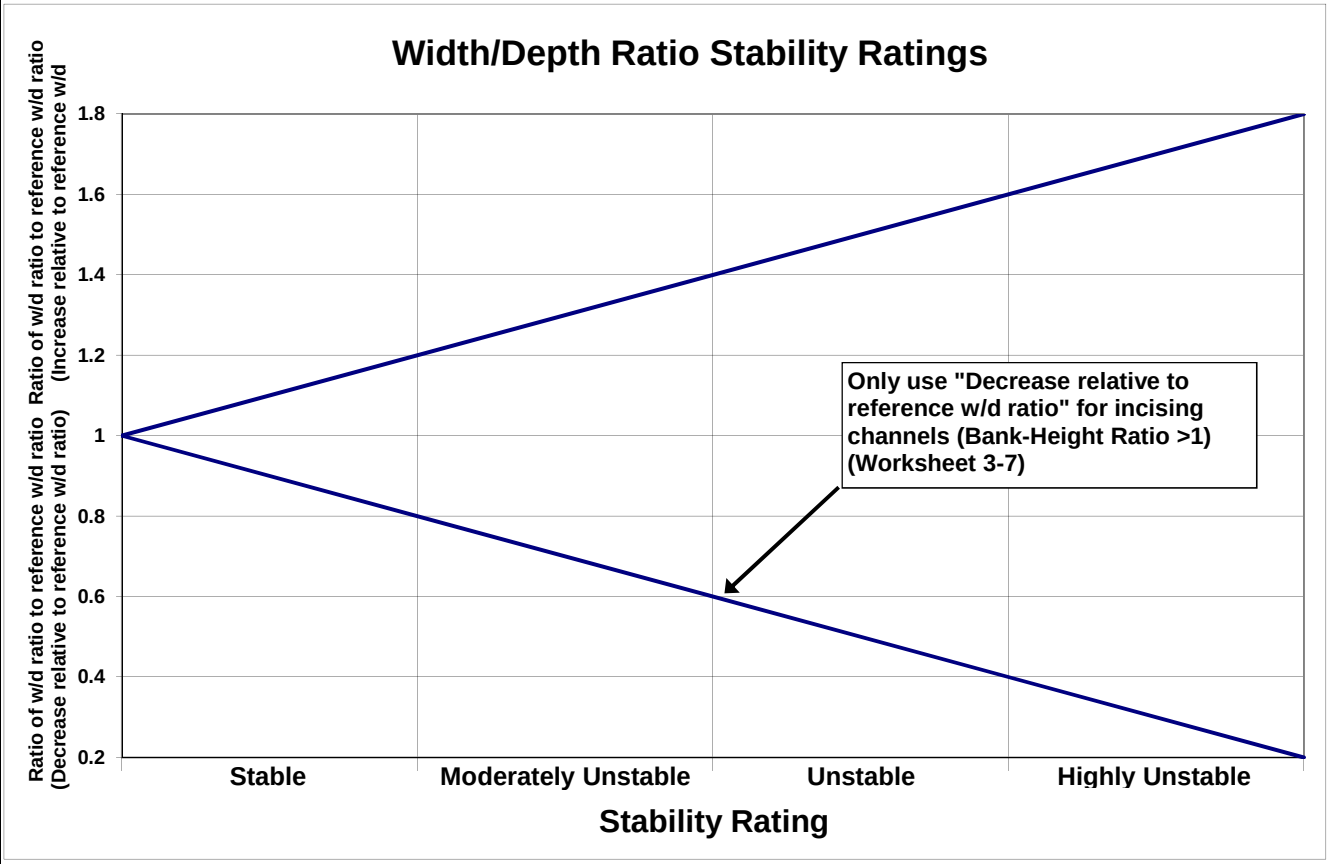
Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**25.5**
Reference Width/Depth Ratio:	**39**

Ratio of existing W/d to reference W/d:	**0.65**

Width/Depth Ratio State Stability Rating ☞ **Moderately Unstable**



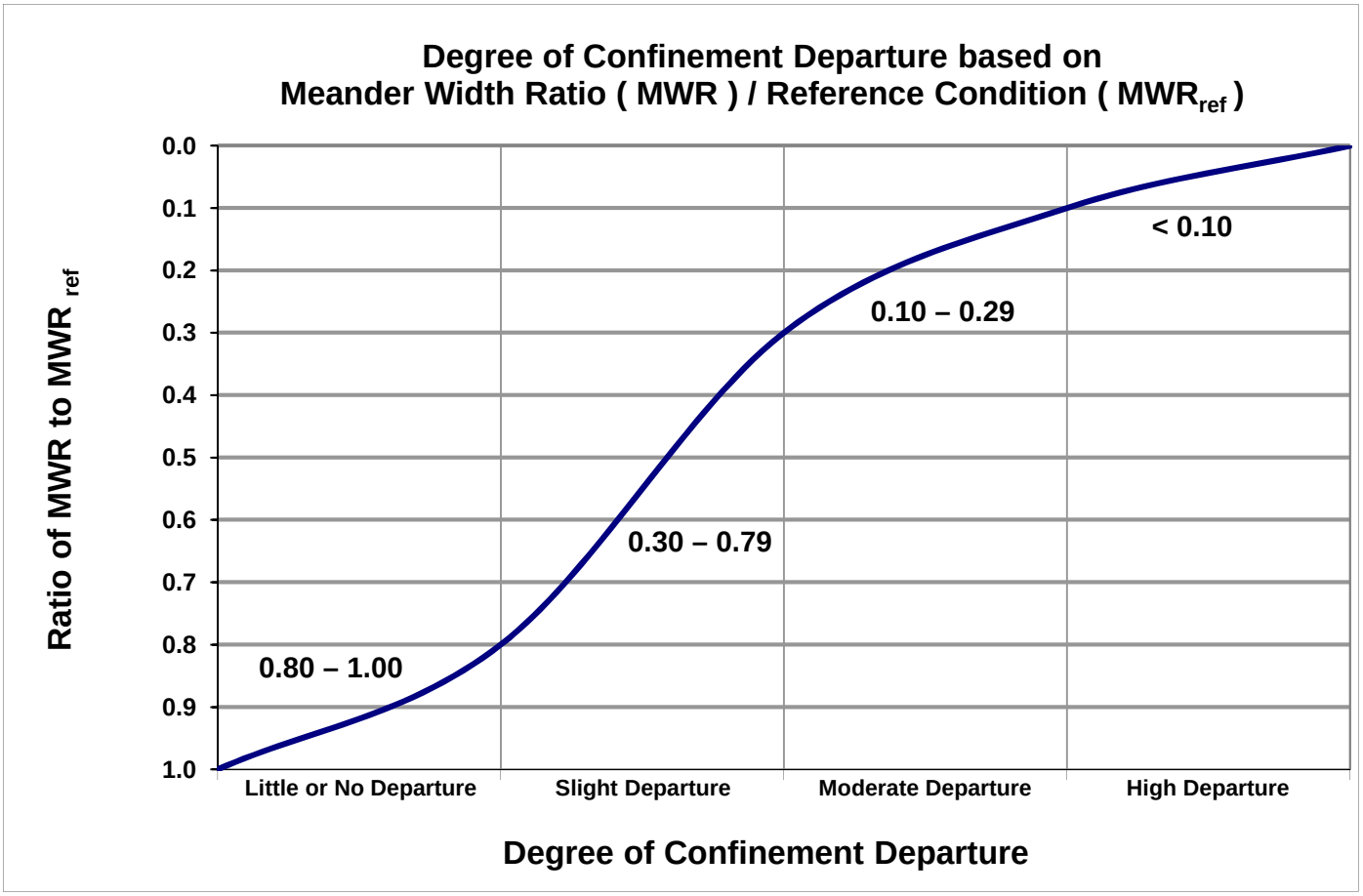
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**3.125**
Reference Meander Width Ratio (MWR_{ref}):	**3.82**

Ratio of MWR to MWR_{ref}:	**0.82**

Degree of Confinement Stability Rating ☞ **Slight Departure**



Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Tongue River**	Stream Type: **C-4**
Location: **Reach 4, XS 11**	Valley Type: **VIII**
Observers: **Starkey, Mikus, Burke**	Date: **11/07/2013**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☑ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Tongue River**	Stream Type:	**C-4**
Location:	**Reach 4, XS11**	Valley Type:	**VIII**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/07/2013**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 W/d Ratio State (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Depositional Patterns (Worksheet 3-5)	B1, B2	B4, B8	B3	B5, B6, B7	**1**
	(1)	**(2)**	**(3)**	**(4)**	
3 Meander Patterns (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		**1**
	(1)		**(3)**		
4 Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)	< 0.006	0.006 - 0.04	0.041 - 0.07	> 0.07	**6**
	(2)	**(4)**	**(6)**	**(8)**	
5 Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	> 0.8	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
	(1)	**(2)**	**(3)**	**(4)**	
				Total Points	**13**

Overall Lateral Stability Category (use total points and check stability rating)	**Lateral Stability Category Point Range**			
	Stable **< 10** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Tongue River**	Stream Type:	**C-4**
Location:	**Reach 4, XS11**	Valley Type:	**VIII**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/07/2013**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points (from each row)**
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 Sediment competence (Worksheet 3-14)	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Sediment Capacity (POWERSED)	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**4**
	(2)	**(4)**	**(6)**	**(8)**	
3 W/d Ratio State (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**2**
	(2)	**(4)**	**(6)**	**(8)**	
4 Stream Succession States (Worksheet 3-16)	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b)	(C→D), (F→D)	**6**
	(2)	**(4)**	**(6)**	**(8)**	
5 Depositional Patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	**2**
	(1)	**(2)**	**(3)**	**(4)**	
6 Debris / Blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	(1)	**(2)**	**(3)**	**(4)**	
				Total Points	**19**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **< 15** ☐	***Moderate Deposition*** **15 – 20** ☑	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream: **Tongue River**		Stream Type: **C-4**	
Location: **Reach 4, XS11**		Valley Type: **VIII**	
Observers: **Starkey, Mikus, Burke**		Date: **11/07/2013**	

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points (from each row)**
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 Sediment Competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed	D_{100} of bed moved	Particles much larger than D_{100} of bed moved	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Sediment Capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	**4**
	(2)	**(4)**	**(6)**	**(8)**	
3 Degree of Channel Incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**4**
	(2)	**(4)**	**(6)**	**(8)**	
4 Stream Succession States (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has W/d between 5–10	If BHR > 1.1 and stream type has W/d less than 5	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A)	**2**
	(2)	**(4)**	**(6)**	**(8)**	
5 Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	(1)	**(2)**	**(3)**	**(4)**	
				Total Points	**15**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised **< 12** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Tongue**		Stream Type: **C-4**	
Location: **Reach 4, XS11**		Valley Type: **VIII**	
Observers: **Starkey, Mikus, Burke**		Date: **11/07/2013**	

Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 Successional Stage Shift (Worksheet 3-16)	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	(B→High W/d B), (C→High W/d C), (E→C)	(G→F), (F→D)	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F)	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Lateral Stability (Worksheet 3-17)	*Stable*	*Moderately Unstable*	*Unstable*	*Highly Unstable*	**6**
	(2)	**(4)**	**(6)**	**(8)**	
3 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	*No Deposition*	*Moderate Deposition*	*Excess Deposition*	*Aggradation*	**4**
	(2)	**(4)**	**(6)**	**(8)**	
4 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	*Not Incised*	*Slightly Incised*	*Moderately Incised*	*Degradation*	**4**
	(2)	**(4)**	**(6)**	**(8)**	
				Total Points	**18**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream:	**Tongue**	Stream Type:	**C-4**
Location:	**Reach 4, XS 11**	Valley Type:	**VIII**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/07/2013**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 3-17)	***Stable***	**1**	**3**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	***No Deposition***	**1**	**2**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	***Not Incised***	**1**	**2**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 3-20)	***No Increase***	**1**	**3**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 3-10)	***Good: Stable***	**1**	**1**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**11**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **< 6** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **> 15** ☐

Worksheet 3-22. Summary of stability condition categories.

Row	A	B–AM					
1	Stream:	Tongue River		Location:	Reach 4, XS 11		
2	Observers:	Starkey, Mikus, Burke	Date: 11/7/2013	Stream Type:	C-3	Valley Type:	VIII
3–4	**Channel Dimension**	Mean Bankfull Depth (ft): **2.19**	Bankfull Width (ft): **81.8**	Cross-Sectional Area (ft^2): **174.8**	Width/Depth Ratio: **39.1**	Entrenchment Ratio: **2.06**	
5–6	**Channel Pattern**	Mean: / Range:	λ/W_{bkf}: **12.56** / **15.55-10.55**	L_m/W_{bkf}: **14.48** / **16.25-13.23**	R_c/W_{bkf}: **1.98** / **2.03-1.94**	MWR: **3.82** / **4.61-3.28**	Sinuosity: **1.25**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec): **5.46**	Bankfull Discharge (Q_{bkf}): **979**	Estimation Method: **Manning**	Drainage Area (mi^2): **206**		
9	**River Profile & Bed Features**	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed	
10–12		Max Bankfull Depth (ft): Riffle **3.24**, Pool **4.3**	Depth Ratio (max to mean): Riffle **1.48**, Pool **1.96**	Pool-to-Pool Spacing: Ratio **3.1**	Slope: Valley: **0.01**	Water Surface: **0.007**	
13–14	**Level III Stream Stability Indices**	Riparian Vegetation	Current Composition/Density: **50% of cover is shrubs**	Potential Composition/Density: **Willow, dogwood dominant**	Remarks: Condition, Vigor & Usage of Existing Reach: **Pastureland, with and without veg. buffers**		
15–16		Flow Regime: **P7** **P1**	Stream Size & Order: **S7**	Meander Patterns: **M3**	Depositional Patterns: **B1 B2**	Debris/Channel Blockages: **D3 D10**	
17–18		Degree of Incision (Bank-Height Ratio): **1.2**	Degree of Incision Stability Rating: **Moderately Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **56, Good**			
19–20		Width/depth Ratio (W/d): **25.5**	Reference W/d Ratio (W/d_{ref}): **39**	Width/Depth Ratio State (W/d) / (W/d_{ref}): **0.65**	W/d Ratio State Stability Rating: **Moderately Unstable**		
21–22		Meander Width Ratio (MWR): **3.125**	Reference MWR_{ref}: **3.82**	Degree of confinement (MWR / MWR_{ref}): **0.82**	MWR / MWR_{ref} Stability Rating: **Slight Departure**		
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft): **550**	Annual Streambank Erosion Rate: **55** (tons/yr) **0.1** (tons/yr/ft)	Curve Used: **Yellowstone**	Remarks: **Station 224+00 to 229+00**		
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks: Did not run POWERSED		
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm): **102**	$\tau =$ **1.05**	$\tau^* =$ **0.028**	Existing Depth: **2.4** / Required Depth: **0.87**	Existing Slope: **0.0070**	Required Slope: **0.0025**
28–29	**Successional Stage Shift**	**C → F → C → F → C →**		Existing Stream State (Type): **C-3**	Potential Stream State (Type):		
30	**Lateral Stability**	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes: **Typical for type C-3 channels**	
31	**Vertical Stability (Aggradation)**	☐ *No Deposition*	☑ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes: **Typical for type C-3 channels**	
32	**Vertical Stability (Degradation)**	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	
33	**Channel Enlargement**	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*	Remarks/causes:	
34–35	**Sediment Supply (Channel Source)**	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:	

Worksheet 3-2. Flow regime variables that influence channel characteristics, sediment regime and biological interpretations.

FLOW REGIME

Stream: **Tongue River**			Location: **Reach 4, XS17**					
Observers: **Starkey, Mikus, Burke**							Date: **11/7/2013**	
List ALL COMBINATIONS that APPLY.....☞	**P7**	**P1**						

General Category

E	Ephemeral stream channels: Flows only in response to precipitation
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a sub-surface flow that follows the stream bed.
I	Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology where losing/gaining reaches create flows that disappear then reappear farther downstream.
P	Perennial stream channels: Surface water persists yearlong.

Specific Category

1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.
4	Streamflow regulated by glacial melt.
5	Ice flows/ice torrents from ice dam breaches.
6	Alternating flow/backwater due to tidal influence.
7	Regulated streamflow due to diversions, dam release, dewatering, etc.
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.
9	Rain-on-snow generated runoff.

Worksheet 3-3. Stream order and stream size categories for stratification by stream type.

Stream Size and Order			
Stream:	**Tongue River**		
Location:	**Reach 4, XS17**		
Observers:	**Starkey, Mikus, Burke**		
Date:	**11/7/2013**		
Stream Size Category and Order ☞			**S6**
Category	**STREAM SIZE: Bankfull width**		**Check (✓) appropriate category**
	meters	**feet**	
S-1	0.305	<1	☐
S-2	0.3 – 1.5	1 – 5	☐
S-3	1.5 – 4.6	5 – 15	☐
S-4	4.6 – 9	15 – 30	☐
S-5	9 – 15	30 – 50	☐
S-6	15 – 22.8	50 – 75	☐
S-7	22.8 – 30.5	75 – 100	☑
S-8	30.5 – 46	100 – 150	☐
S-9	46 – 76	150 – 250	☐
S-10	76 – 107	250 – 350	☐
S-11	107 – 150	350 – 500	☐
S-12	150 – 305	500 – 1000	☐
S-13	>305	>1000	☐
Stream Order			
Add categories in parenthesis for specific stream order of reach. For example a third order stream with a bankfull width of 6.1 meters (20 feet) would be indexed as: S-4(3).			

Worksheet 3-4. Meander pattern relations used for interpretations for river stability.

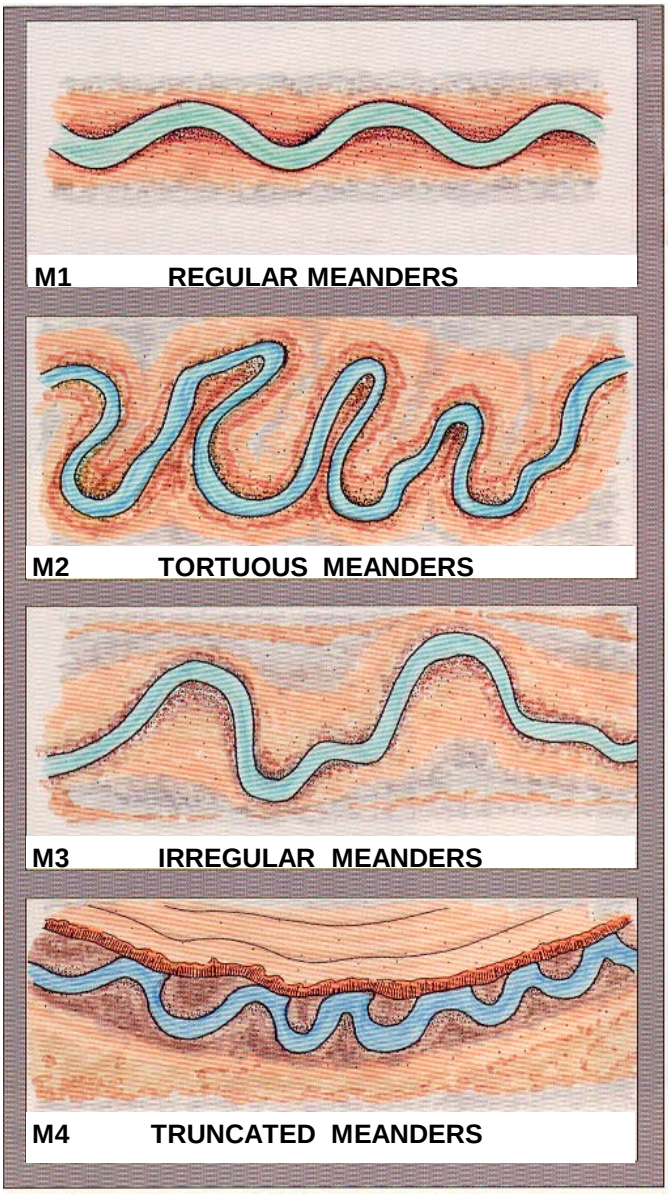
Meander Patterns

Stream: **Tongue River** Reach: **Reach 4, XS17**

Observers: **Starkey, Mikus, Burke** Date: **11/7/2013**

List ALL CATEGORIES that APPLY ☞	M3				

Various Meander Pattern variables modified from Galay et al. (1973)

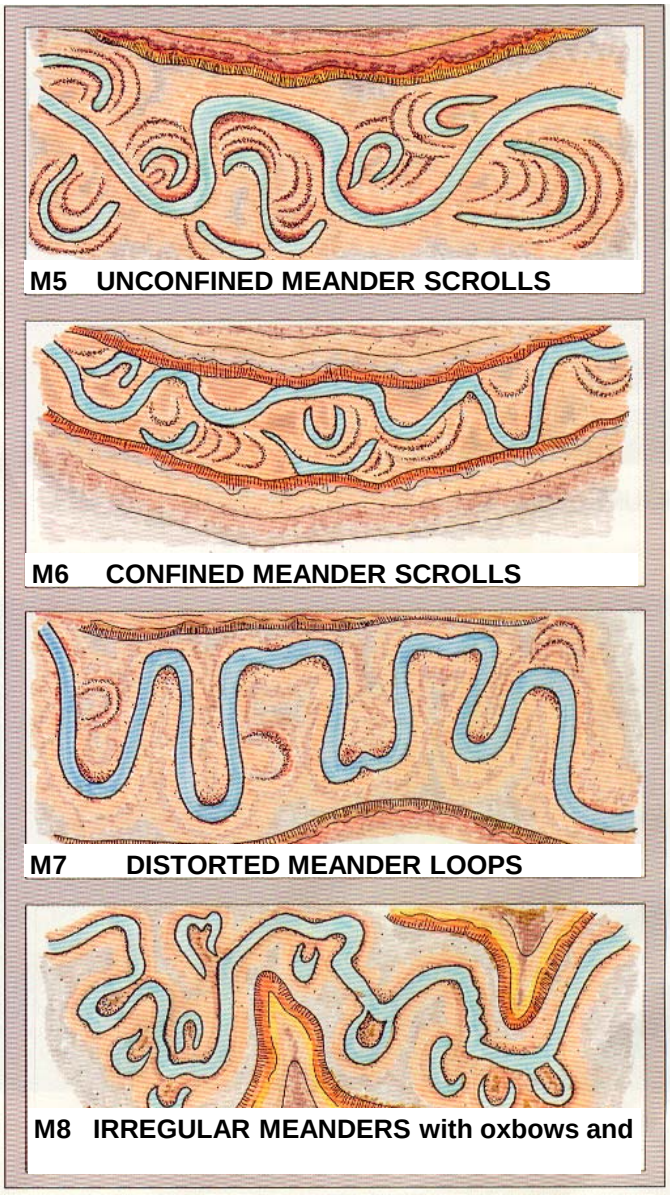


M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

M3 IRREGULAR MEANDERS

M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS

M6 CONFINED MEANDER SCROLLS

M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

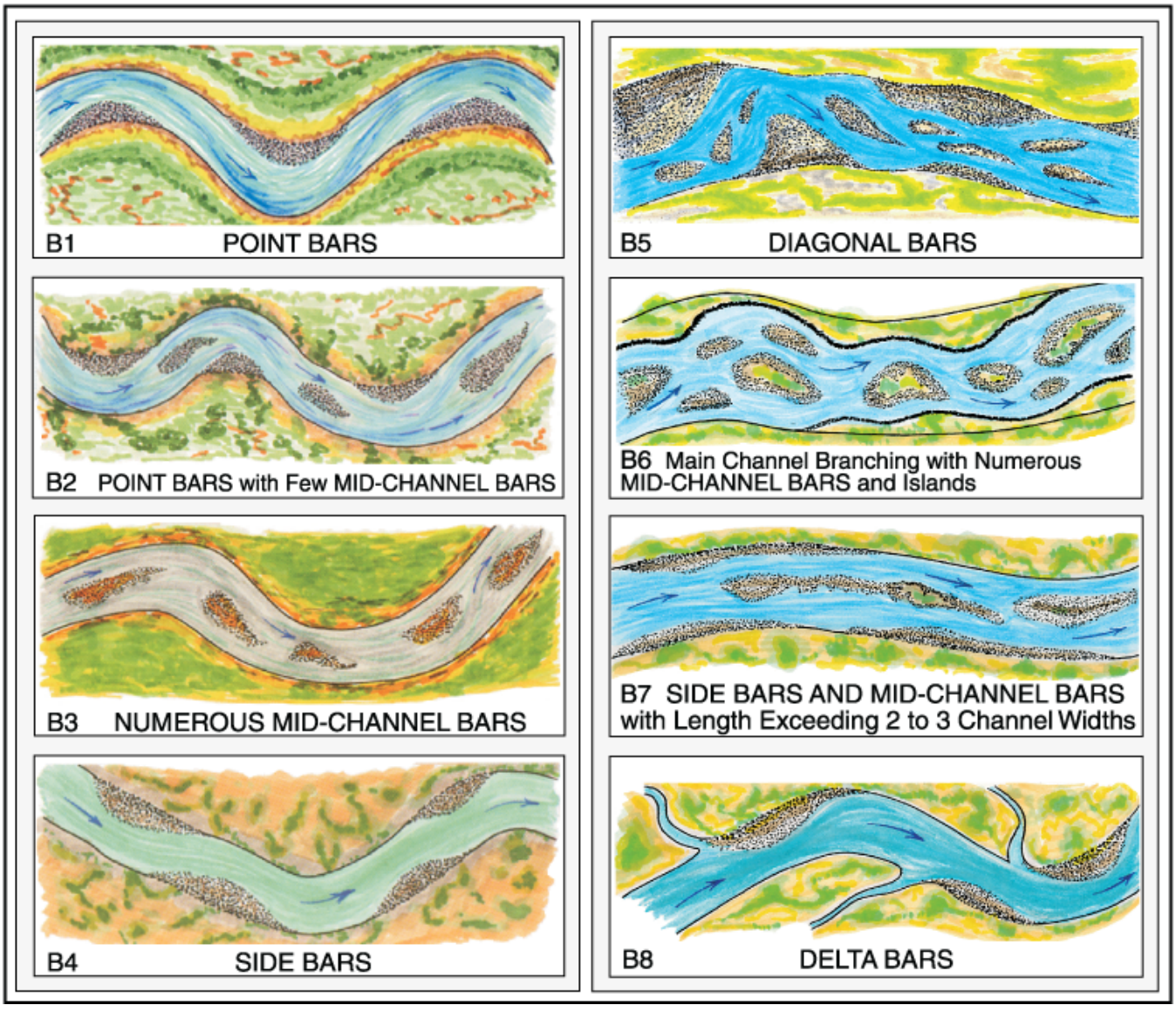
Worksheet 3-5. Depositional patterns used for stabiilty assessment interpretations.

Depositional Patterns

Stream:	**Tongue River**	Reach:	**Reach 4, XS17**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/7/2013**

List ALL CATEGORIES that APPLY ☞	B1	B2			

Various Depositional Features modified from Galay et al. (1973)



Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: **Tongue River**		Location: **Reach 4, XS17**	
Observers: **Starkey, Mikus, Burke**		Date: **11/7/2013**	
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	☐
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	☑
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	☐
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	☐
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	☐
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	☐
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	☐
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	☐
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	☑

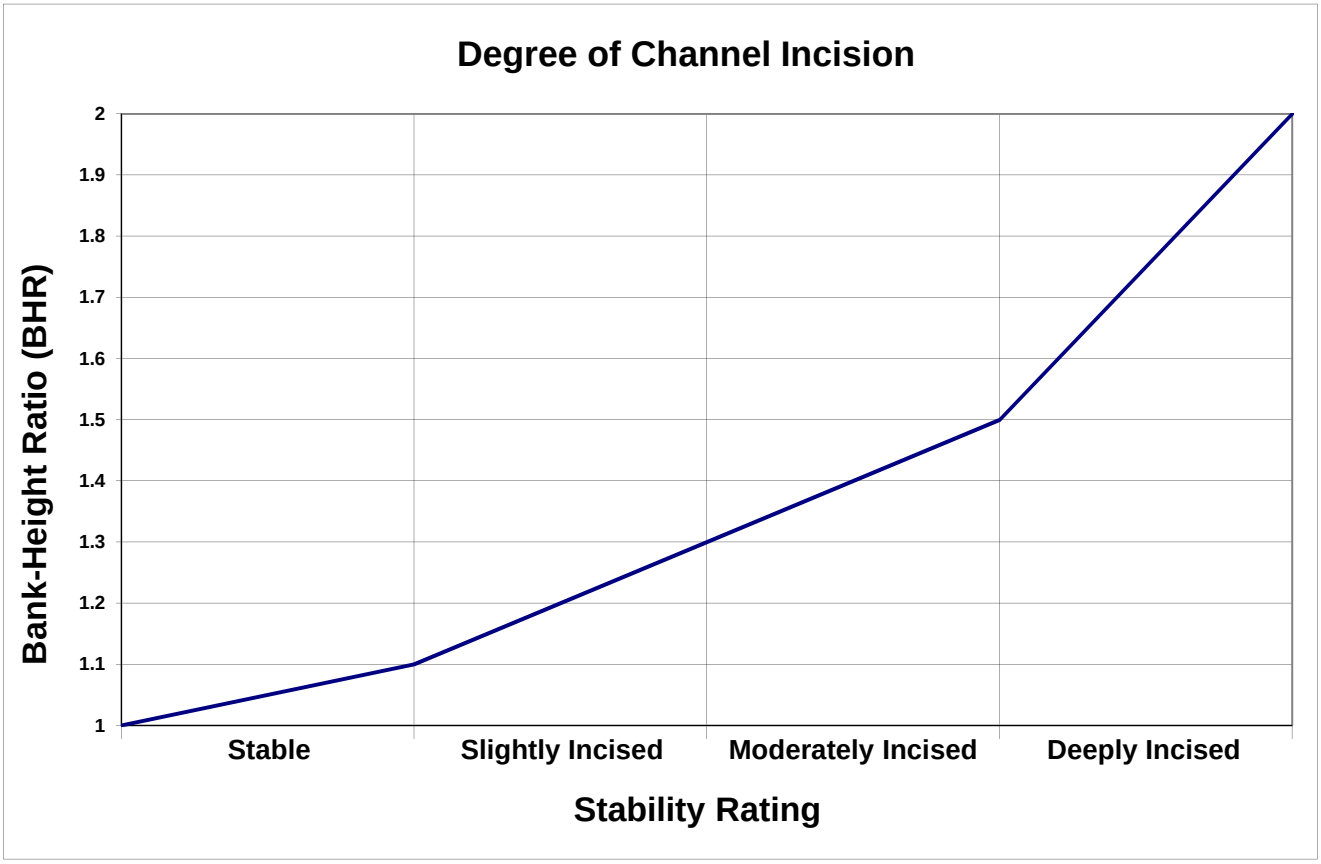
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.

Degree of Channel Incision

Low Bank Height:	**3.7**
Max Bankfull Depth:	**2.7**

Bank-Height Ratio:	**1.4**

Degree of Channel Incision Stability Rating ☞ **Moderately Incised**

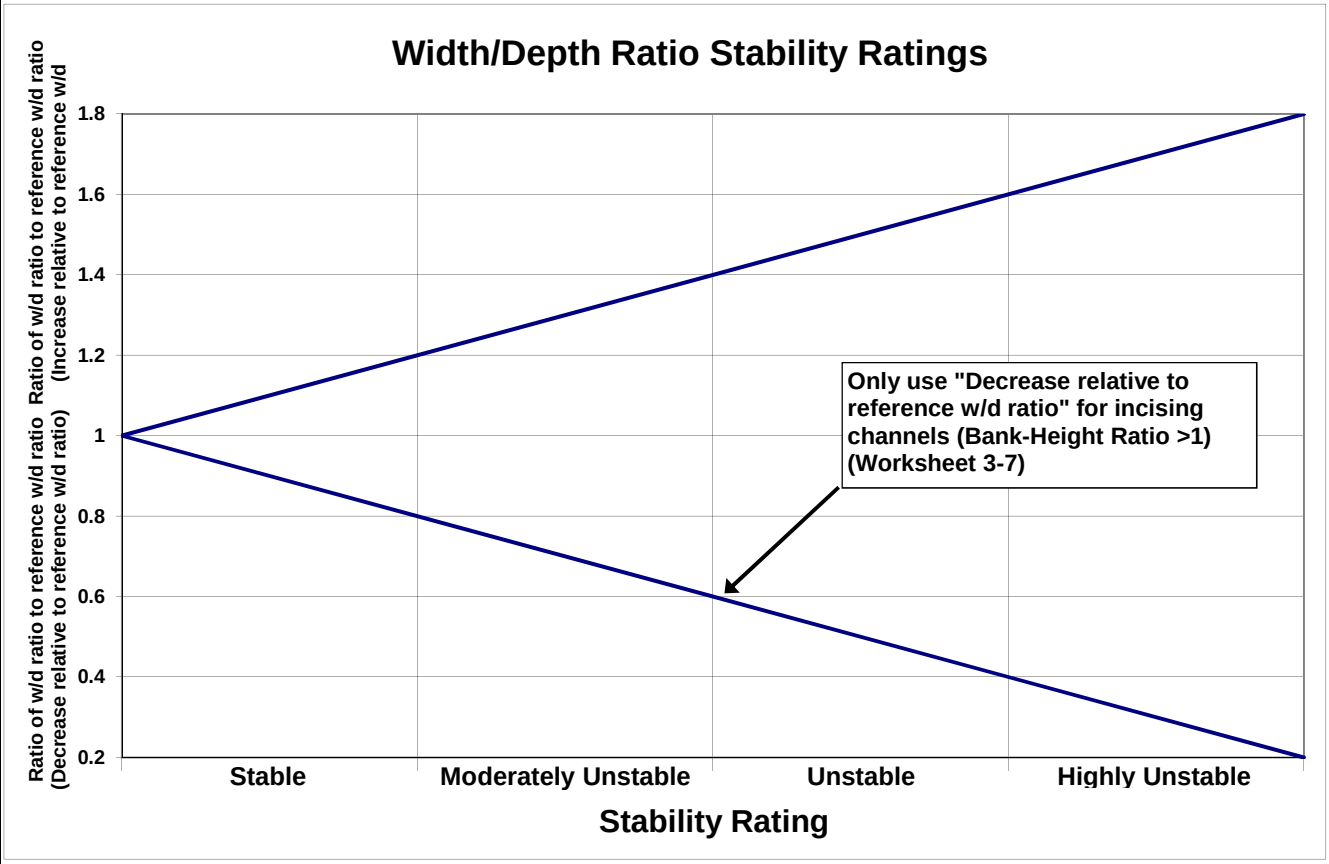


Worksheet 3-8. Stability ratings based on departure of width/depth ratio from reference condition.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**23.8**	Ratio of existing W/d to reference W/d:	**0.61**
Reference Width/Depth Ratio:	**39**		

Width/Depth Ratio State Stability Rating ☞ **Moderately Unstable**



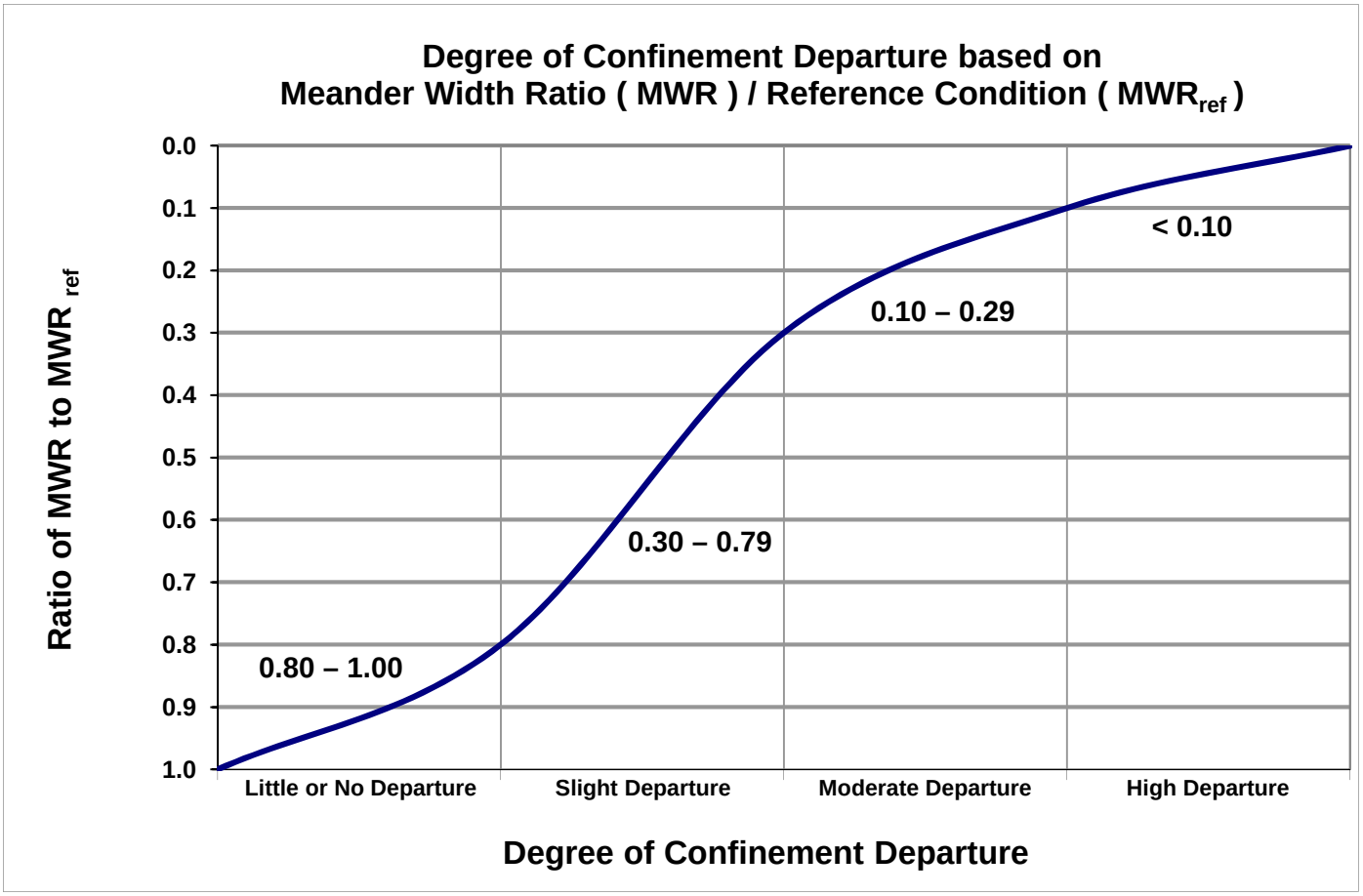
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**3.28**
Reference Meander Width Ratio (MWR_{ref}):	**3.82**

Ratio of MWR to MWR_{ref}:	**0.86**

Degree of Confinement Stability Rating ☞ **Slight Departure**



Worksheet 3-16. Stability ratings for corresponding successional stage shifts of stream types. Check the appropriate stability rating.

Stream: **Tongue River**	Stream Type: **C-4**
Location: **Reach 4, XS17**	Valley Type: **VIII**
Observers: **Starkey, Mikus, Burke**	Date: **11/07/2013**
Stream Type Stage Shifts (Figure 3-14)	**Stability Rating (Check Appropriate Rating)**
Stream Type at potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	☐ Stable
(E→C), (B→High W/d B), (C→High W/d C)	☑ Moderately Unstable
(G_c→F), (G→F_b), (F→D), (C→F)	☐ Unstable
(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A)	☐ Highly Unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream:	**Tongue River**	Stream Type:	**C-4**
Location:	**Reach 4, XS17**	Valley Type:	**VIII**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/07/2013**

Lateral stability criteria (choose one stability category for each criterion 1–5)	**Lateral Stability Categories**				**Selected Points (from each row)**
	Stable	***Moderately Unstable***	***Unstable***	***Highly Unstable***	
1 W/d Ratio State (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Depositional Patterns (Worksheet 3-5)	B1, B2	B4, B8	B3	B5, B6, B7	**1**
	(1)	**(2)**	**(3)**	**(4)**	
3 Meander Patterns (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		**1**
	(1)		**(3)**		
4 Streambank Erosion: Unit Rate (Tons/yr/ft) (Worksheet 3-13)	< 0.006	0.006 - 0.04	0.041 - 0.07	> 0.07	**6**
	(2)	**(4)**	**(6)**	**(8)**	
5 Degree of Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	> 0.8	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
	(1)	**(2)**	**(3)**	**(4)**	
				Total Points	**13**

Overall Lateral Stability Category (use total points and check stability rating)	**Lateral Stability Category Point Range**			
	Stable **< 10** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	**Tongue River**	Stream Type:	**C-4**
Location:	**Reach 4, XS17**	Valley Type:	**VIII**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/07/2013**

Vertical Stability Criteria (choose one stability category for each criterion 1–6)	**Vertical Stability Categories for Excess Deposition / Aggradation**				**Selected Points (from each row)**
	No Deposition	***Moderate Deposition***	***Excess Deposition***	***Aggradation***	
1 Sediment competence (Worksheet 3-14)	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Sediment Capacity (POWERSED)	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**4**
	(2)	**(4)**	**(6)**	**(8)**	
3 W/d Ratio State (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**2**
	(2)	**(4)**	**(6)**	**(8)**	
4 Stream Succession States (Worksheet 3-16)	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F), (G_c→F), (G→F_b)	(C→D), (F→D)	**6**
	(2)	**(4)**	**(6)**	**(8)**	
5 Depositional Patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	**2**
	(1)	**(2)**	**(3)**	**(4)**	
6 Debris / Blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	(1)	**(2)**	**(3)**	**(4)**	
				Total Points	**19**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **< 15**	***Moderate Deposition*** **15 – 20**	***Excess Deposition*** **21 – 30**	***Aggradation*** **> 30**
	☐	☑	☐	☐

Worksheet 3-19. Vertical stability prediction for channel incision or degradation.

Stream: **Tongue River**		Stream Type: **C-4**	
Location: **Reach 4, XS17**		Valley Type: **VIII**	
Observers: **Starkey, Mikus, Burke**		Date: **11/07/2013**	

Vertical Stability Criteria (choose one stability category for each criterion 1–5)	**Vertical Stability Categories for Channel Incision / Degradation**				**Selected Points (from each row)**
	Not Incised	***Slightly Incised***	***Moderately Incised***	***Degradation***	
1 Sediment Competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D_{100} of bar or > D_{84} of bed	D_{100} of bed moved	Particles much larger than D_{100} of bed moved	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Sediment Capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	**4**
	(2)	**(4)**	**(6)**	**(8)**	
3 Degree of Channel Incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**6**
	(2)	**(4)**	**(6)**	**(8)**	
4 Stream Succession States (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has W/d between 5–10	If BHR > 1.1 and stream type has W/d less than 5	(B→G), (C→G), (E→G), (D→G), (A→G), (E→A)	**2**
	(2)	**(4)**	**(6)**	**(8)**	
5 Confinement (MWR / MWR_{ref}) (Worksheet 3-9)	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	(1)	**(2)**	**(3)**	**(4)**	
				Total Points	**17**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised **< 12** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 3-20. Channel enlargement prediction summary.

Stream: **Tongue River**			Stream Type: **C-4**		
Location: **Reach 4, XS17**			Valley Type: **VIII**		
Observers: **Starkey, Mikus, Burke**			Date: **11/07/2013**		
Channel Enlargement Prediction Criteria (choose one stability category for each criterion 1–4)	**Channel Enlargement Prediction Categories**				**Selected Points (from each row)**
	No Increase	***Slight Increase***	***Moderate Increase***	***Extensive***	
1 Successional Stage Shift (Worksheet 3-16)	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	(B→High W/d B), (C→High W/d C), (E→C)	(G→F), (F→D)	(C→D), (A→G), (B→G), (D→G), (C→G), (E→G), (E→A), (C→F)	**4**
	(2)	**(4)**	**(6)**	**(8)**	
2 Lateral Stability (Worksheet 3-17)	*Stable*	*Moderately Unstable*	*Unstable*	*Highly Unstable*	**6**
	(2)	**(4)**	**(6)**	**(8)**	
3 Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)	*No Deposition*	*Moderate Deposition*	*Excess Deposition*	*Aggradation*	**4**
	(2)	**(4)**	**(6)**	**(8)**	
4 Vertical Stability Channel Incision or Degradation (Worksheet 3-19)	*Not Incised*	*Slightly Incised*	*Moderately Incised*	*Degradation*	**4**
	(2)	**(4)**	**(6)**	**(8)**	
				Total Points	**18**
	Category Point Range				
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **< 11** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐	

Worksheet 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream:	**Tongue River**	Stream Type:	**C-4**
Location:	**Reach 4, XS17**	Valley Type:	**VIII**
Observers:	**Starkey, Mikus, Burke**	Date:	**11/07/2013**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)		**Stability Rating**	**Points**	**Selected Points**
1	**Lateral Stability (Worksheet 3-17)**	***Stable***	**1**	**3**
		Mod. Unstable	**2**	
		Unstable	**3**	
		Highly Unstable	**4**	
2	**Vertical Stability Excess Deposition or Aggradation (Worksheet 3-18)**	***No Deposition***	**1**	**2**
		Mod. Deposition	**2**	
		Excess Deposition	**3**	
		Aggradation	**4**	
3	**Vertical Stability Channel Incision or Degradation (Worksheet 3-19)**	***Not Incised***	**1**	**2**
		Slightly Incised	**2**	
		Mod. Incised	**3**	
		Degradation	**4**	
4	**Channel Enlargement Prediction (Worksheet 3-20)**	***No Increase***	**1**	**2**
		Slight Increase	**2**	
		Mod. Increase	**3**	
		Extensive	**4**	
5	**Pfankuch Channel Stability (Worksheet 3-10)**	***Good: Stable***	**1**	**2**
		Fair: Mod. Unstable	**2**	
		Poor: Unstable	**4**	
			Total Points	**11**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **< 6** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **> 15** ☐

Worksheet 3-22. Summary of stability condition categories.

	A	B C D E F G H I J K L M N O P Q R S T U V W X Y Z AA AB AC AD AE AF AG AH AI AJ AK AL AM									
1	Stream:	**Tongue River**				Location:	**Reach 4, XS 17**				
2	Observers:	**Starkey, Mikus, Burke**		Date:	**11/7/2013**	Stream Type:	**C-4**	Valley Type:	**VIII**		
3–4	**Channel Dimension**	Mean Bankfull Depth (ft):	**2.19**	Bankfull Width (ft):	**81.8**	Cross-Sectional Area (ft^2):	**174.8**	Width/Depth Ratio:	**39.1**	Entrenchment Ratio:	**2.07**
5–6	**Channel Pattern**	Mean: / Range: λ/W_{bkf}:	**12.56** / **15.55-10.55**	L_m/W_{bkf}:	**14.48** / **16.25-13.23**	R_c/W_{bkf}:	**1.98** / **2.03-1.94**	MWR:	**3.82** / **4.61-3.28**	Sinuosity:	**1.25**
7–8	**Streamflow**	Bankfull Mean Velocity ($\bar{u}_{bkf}$) (ft/sec):	**5.46**	Bankfull Discharge (Q_{bkf}):	**979**	Estimation Method:	**Manning's**	Drainage Area (mi^2):	**206**		
9	**River Profile & Bed Features**	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed					
10–12		Max Bankfull Depth (ft):	Riffle **3.24**	Pool **4.3**	Depth Ratio (max to mean):	Riffle **1.48**	Pool **1.96**	Pool-to-Pool Spacing:	Ratio **3.1**	Slope — Valley: **0.01**	Water Surface: **0.006**
13–14	**Level III Stream Stability Indices**	Riparian Vegetation	Current Composition/Density: **85% of cover is herbaceous**		Potential Composition/Density: **Bluegrass, wheatgrass, willov**		Remarks: Condition, Vigor & Usage of Existing Reach: **Pastureland, with and without veg. buffers**				
15–16		Flow Regime:	**P7** **P1**	Stream Size & Order:	**S7**	Meander Patterns:	**M3**	Depositional Patterns:	**B1 B2**	Debris/Channel Blockages:	**D3 D10**
17–18		Degree of Incision (Bank-Height Ratio):	**1.4**	Degree of Incision Stability Rating:	**Moderately Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**104, Fair**				
19–20		Width/depth Ratio (W/d):	**23.8**	Reference W/d Ratio (W/d_{ref}):	**39**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**0.61**	W/d Ratio State Stability Rating:	**Moderately Unstable**		
21–22		Meander Width Ratio (MWR):	**3.28**	Reference MWR_{ref}:	**3.82**	Degree of confinement (MWR / MWR_{ref}):	**0.86**	MWR / MWR_{ref} Stability Rating:	**Slight Departure**		
23–24	**Bank Erosion Summary**	Length of Reach Studied (ft):	**600**	Annual Streambank Erosion Rate: **84** (tons/yr)	**0.14** (tons/yr/ft)	Curve Used: **Yellowstone**	Remarks:	**Station 171+00 to 178+00**			
25	**Sediment Capacity (POWERSED)**	☐ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks: Did not run POWERSED						
26–27	**Entrainment/ Competence**	Largest Particle from Bar Sample (mm):	**152**	$\tau =$ **0.749**	$\tau^* =$ **0.021**	Existing Depth:	**2**	Required Depth:	**1.1**	Existing Slope: **0.0060**	Required Slope: **0.0030**
28–29	**Successional Stage Shift**	**C** → **F** → **C** → **F** → **C** → **F**				Existing Stream State (Type):	**C-3**	Potential Stream State (Type):			
30	**Lateral Stability**	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**Typical for type C-3 channels**				
31	**Vertical Stability (Aggradation)**	☐ *No Deposition*	☑ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:					
32	**Vertical Stability (Degradation)**	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:					
33	**Channel Enlargement**	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*	Remarks/causes:	**Typical for type C-3 channels**				
34–35	**Sediment Supply (Channel Source)**	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:					

Appendix H

GPS Survey data

Point #	X (ft)	Y (ft)	Elev (ft)	Note
5000	16308342	1048377	3981.504	TBM
5100	16301789	1042957	4068.951	USGS BRASS
5002	16301789	1042957	4068.903	USGS BRASS
5101	16301105	1036332	4204.672	ROCK SW BTHHSE
5102	16300250	1037192	4177.766	ROCK
5103	16300618	1037848	4155.981	ROCK
5104	16300274	1038773	4140.336	EAST B AB TIP
5105	16300785	1039573	4121.071	ROCK
5106	16301166	1042319	4081.554	NAIL WEST BDG
5107	16302434	1043496	4061.719	EAST BDG AB
5108	16308218	1048280	3976.984	BOLT
5109	16308345	1048479	3979.938	BOLT
5110	16310075	1051164	3935.956	PROP C TRACT BEG
5111	16310212	1051344	3937.288	PROP C TRACT A
5112	16310160	1051463	3935.003	PROP C TRACT B
5113	16310417	1051882	3929.765	PROP C TRACT B
5114	16310500	1051883	3929.612	H BRACE
5115	16310505	1051886	3929.612	H BRACE
5116	16310510	1051889	3929.593	H BRACE
5117	16312033	1052666	3917.908	ROCK
5118	16312172	1054062	3916.372	METAL PLATE
5119	16307983	1048173	3968.937	XS 16 LEFT
5120	16307743	1048200	3971.372	31 TP
5121	16307636	1048026	3972.536	XS 17 LEFT
5122	16307695	1047451	3979.322	57 TBM
5123	16305853	1044255	4018.872	TBM 15
5124	16305963	1044455	4015.268	XS 18 LEFT
5125	16306027	1044653	4012.656	XS 23 LEFT
5126	16306045	1044692	4012.255	XS 22 LEFT
5127	16306179	1044987	4010.546	XS 20 LEFT
5128	16306485	1045276	4005.411	XS 19 LEFT
5129	16306508	1045199	4009.148	LEFT TER XS 19
5130	16308249	1048832	3963.803	XS 15 LEFT
5131	16308290	1049653	3955.737	XS 14 LEFT
5132	16308347	1048940	3963.224	SEC CNR
5133	16309875	1051572	3930.958	OLSEN TBM
5134	16309237	1051206	3942.208	38 TBM
5135	16308569	1050664	3951.341	12 TBM
5136	16308235	1050249	3954.142	30 TBM
5137	16308278	1050041	3953.722	MID H BRACE
5138	16308188	1049783	3956.277	EAST PST GATE
5139	16312107	1053904	3908.488	XS 1 LEFT
5140	16312013	1053036	3914.609	XS 6 LEFT
5141	16311542	1052297	3918.969	XS 8 LEFT

Dossett, Adam - NRCS, Douglas, WY

From: opus <opus@ngs.noaa.gov>
Sent: Thursday, December 19, 2013 9:04 AM
To: Dossett, Adam - NRCS, Douglas, WY
Subject: OPUS solution : 5000 TR657489078709
Attachments: 5000352q.13o.xml

FILE: 5000 TR657489078709

2005 NOTE: The IGS precise and IGS rapid orbits were not available
2005 at processing time. The IGS ultra-rapid orbit was/will be used to
2005 process the data.
2005

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.jsp#accuracy

USER: adam.dossett@wy.usda.gov DATE: December 19, 2013
RINEX FILE: 5000352q.13o TIME: 16:04:04 UTC

SOFTWARE: page5 1209.04 master52.pl 072313 START: 2013/12/18 16:11:00
EPHEMERIS: igu17713.eph [ultra-rapid] STOP: 2013/12/18 20:27:00
NAV FILE: brdc3520.13n OBS USED: 10348 / 11152 : 93%
ANT NAME: TRMR8_GNSS NONE # FIXED AMB: 69 / 71 : 97%
ARP HEIGHT: 1.327 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000) IGS08 (EPOCH:2013.9637)

X:	-1345576.463(m)	0.007(m)	-1345577.309(m)	0.007(m)
Y:	-4324314.270(m)	0.018(m)	-4324313.012(m)	0.018(m)
Z:	4477788.046(m)	0.003(m)	4477788.004(m)	0.003(m)

LAT:	44 52 3.72997	0.012(m)	44 52 3.75071	0.012(m)
E LON:	252 42 56.41879	0.002(m)	252 42 56.36498	0.002(m)
W LON:	107 17 3.58121	0.002(m)	107 17 3.63502	0.002(m)
EL HGT:	1201.599(m)	0.014(m)	1200.896(m)	0.014(m)
ORTHO HGT:	1213.565(m)	0.030(m)	[NAVD88 (Computed using GEOID12A)]	

	UTM COORDINATES (UTM (Zone 13))	STATE PLANE COORDINATES (SPC (4902 WYEC))
Northing (Y) [meters]	4970792.475	585164.215
Easting (X) [meters]	319545.876	403872.546
Convergence [degrees]	-1.61196325	0.03457182
Point Scale	1.00000044	0.99993768
Combined Factor	0.99981208	0.99974933

US NATIONAL GRID DESIGNATOR: 13TCK1954570792(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL7728	P051 BILLINGSAPMT2005 CORS ARP	N454823.741	W1083246.070	143790.6
DM7161	WYSH SHERIDAN CORS ARP	N444801.769	W1070035.715	22952.3
DG9745	MTEI ENGINC CORS ARP	N454447.035	W1083600.736	142096.4

NEAREST NGS PUBLISHED CONTROL POINT

PW0266	4026.58	N445147.	W1071638.	762.9

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

12/18/2013

Project Name: TR Assessment

Survey Party:

Ron (Barr Engineering)
Chris G. (Engineer NRCS)
Adam (Engineer NRCS)
Oakley (S.C. NRCS)
MariaB. (SCCD)

Notes: NRCS Engineers brought the Trimble R8 to reconnect Benchmarks from the top of survey reach to The Dayton Bridge. Trimble R8 was set up at the corner of Tongue River Canyon Road and _____ driveway. River left refers to the left side of channel looking downstream. Same with the river right side of channel. GPS points for BM's were always taken on the top of rebar except when noted differently.

X-section 16: River left BM found. GPS taken. River right BM was not GPS'd because we could not cross the river.

BM @ top of island upstream of xs16, rebar was put in and GPS was then taken.

X-section 17: River left stake was found to mark end of x-section. Rebar was put in a stake and GPS point was taken.

BM @ fence post near TR Canyon Road that was near old telephone pole, was GPS'd.

Moved up to reference reach area —

Found BM @ the bottom of old levee. Took GPS point

X-section 18: Found river left BM. Took GPS point.

x-section 23: Could not find river left BM, if there was one (?). Put in rebar at location where GPS survey point was, Took GPS point. Flagged tree that was 7-10 meters away.

X-section 22: Could not find river left BM, if there was one (?). Put in rebar at location where GPS survey point was. Took GPS point on rebar, Flagged tree.

X-section 21: Cant not find river left BM, if there was one (?). Just GPS'd location again from the surveyed GPS point. Did not put rebar in.

X-section 20: Could not find river left BM, if there was one (?). Put in rebar at location where GPS survey point led us. Took GPS point on rebar. Flagged tree.

X-section 19: Could not find river left BM. Took new GPS point @ location of GPS survey point led us. No rebar was put in.

Adam then GPS'd old stake & rebar not GPS'd from last survey. Oakley found it and said it was one Army and him put in the day before the reference reach survey today. Rebar was slightly downstream on xsection 19. Still on river left side,

* * # * * # * Look at Back Notes * # * # *

Moved to the parking lot of Olsen's property —

X-section 12: Could not find BM from right right side, if there was one (?). Unsure if Adam GPS'd location.

Walked toward high school —

BM northeast of old abandoned rock levee was found and GPS point was taken.

BM 12 - Found and took GPS point.

BM 30 - Fand and took GPS point.

Mid-H Brace, GPS point was taken at Fence line near TR.

Green Fish Gate GPS point was taken at fenceline - almost across from x-section 14.

Moved to Dayton Bridge:

X-section 1: Found BM. Took GPS location.

X-section 6: Found BM. Took GPS location.

X-section 8: Found wooden stake. Put in new rebar. Took GPS point @ top of rebar.

**** Look to pg 3 ****

Moved back to Trimble R8 station —

X-section 15- Found BM. Took GPS location.

X-section 14 - Found BM. No wooden stake with rebar BM. Took GPS location.

GPS'd boundary survey marker. Named it SSC CNR

Appendix I

Detailed lateral erosion maps

Lateral Erosion Rate*

- 0.1-0.3 ft/yr, Estimated
- 0.3-0.8 ft/yr, Estimated
- 0.3-0.8 ft/yr, Measured
- 0.8-1.1 ft/yr, Estimated
- 0.8-1.1 ft/yr, Measured
- 1.1-1.8 ft/yr, Estimated
- 1.1-1.8 ft/yr, Measured
- >1.8 ft/yr, Estimated
- >1.8 ft/yr, Measured

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

*To convert from feet/yr to cubic ft/year, multiply by bank length and height

*To convert from feet/year to tons/ft/year, multiply by bank height and by 0.048

Notes:
Lateral erosion rates calculated based on Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) values, per Rosgen curves from Yellowstone National Park

N

Feet

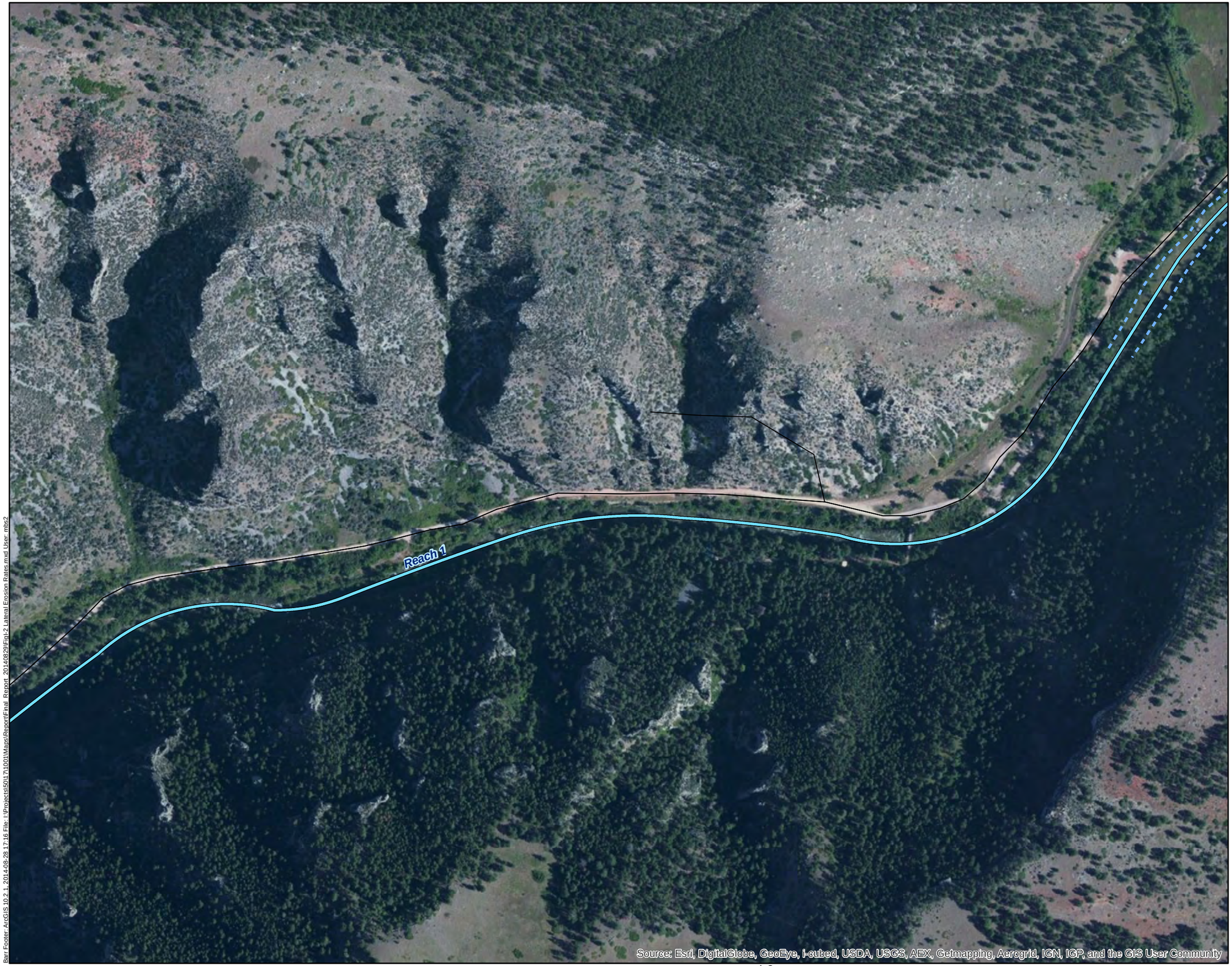
300 0 300

Figure I-1

LATERAL EROSION RATES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR



Lateral Erosion Rate*

- 0.1-0.3 ft/yr, Estimated
- 0.3-0.8 ft/yr, Estimated
- 0.3-0.8 ft/yr, Measured
- 0.8-1.1 ft/yr, Estimated
- 0.8-1.1 ft/yr, Measured
- 1.1-1.8 ft/yr, Estimated
- 1.1-1.8 ft/yr, Measured
- >1.8 ft/yr, Estimated
- >1.8 ft/yr, Measured

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

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Notes:
Lateral erosion rates calculated based on Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) values, per Rosgen curves from Yellowstone National Park

N

Feet
300 0 300

Figure I-2

LATERAL EROSION RATES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

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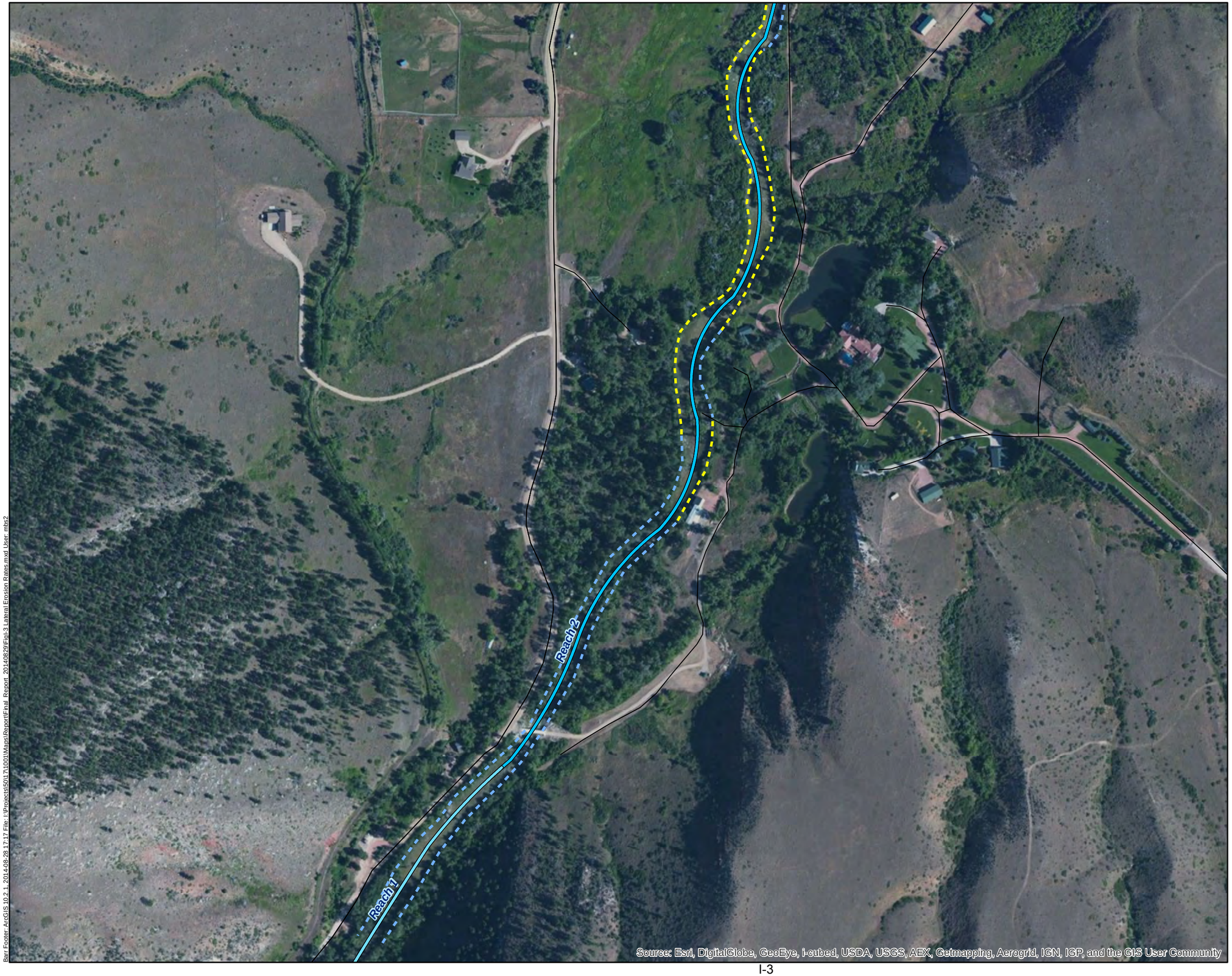

Lateral Erosion Rate*

- 0.1-0.3 ft/yr, Estimated
- 0.3-0.8 ft/yr, Estimated
- 0.3-0.8 ft/yr, Measured
- 0.8-1.1 ft/yr, Estimated
- 0.8-1.1 ft/yr, Measured
- 1.1-1.8 ft/yr, Estimated
- 1.1-1.8 ft/yr, Measured
- >1.8 ft/yr, Estimated
- >1.8 ft/yr, Measured

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

*To convert from feet/yr to cubic ft/year, multiply by bank length and height

*To convert from feet/year to tons/ft/year, multiply by bank height and by 0.048

Notes:
Lateral erosion rates calculated based on Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) values, per Rosgen curves from Yellowstone National Park

N

Feet

300 0 300

Figure I-3

LATERAL EROSION RATES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

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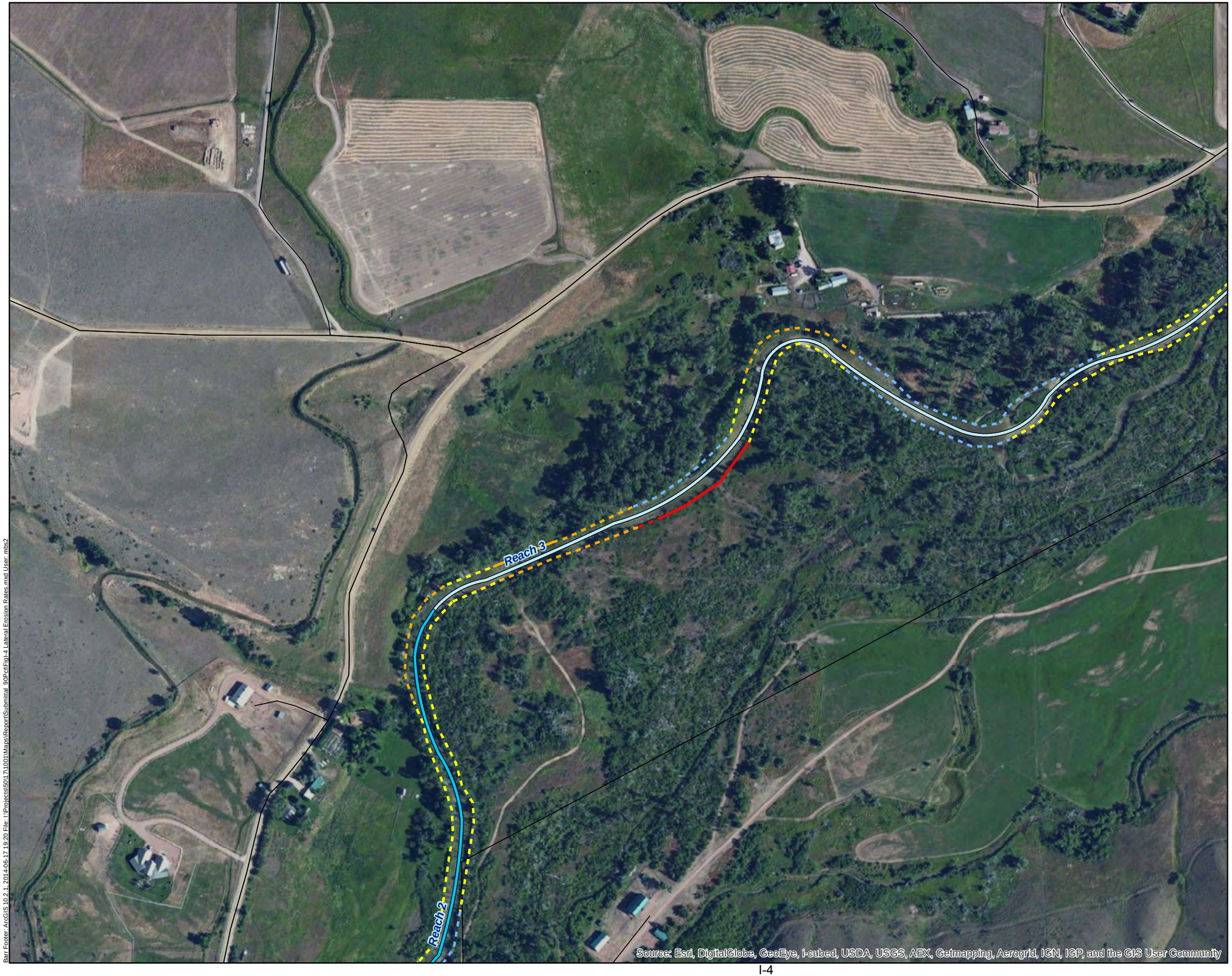

Lateral Erosion Rate*

- 0.1-0.3 ft/yr, Estimated
- 0.3-0.8 ft/yr, Estimated
- 0.3-0.8 ft/yr, Measured
- 0.8-1.1 ft/yr, Estimated
- 0.8-1.1 ft/yr, Measured
- 1.1-1.8 ft/yr, Estimated
- 1.1-1.8 ft/yr, Measured
- >1.8 ft/yr, Estimated
- >1.8 ft/yr, Measured

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

*To convert from feet/yr to cubic ft/year, multiply by bank length and height

*To convert from feet/year to tons/ft/year, multiply by bank height and by 0.048

Notes:
Lateral erosion rates calculated based on Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) values, per Rosgen curves from Yellowstone National Park

N

Feet

300 0 300

Figure I-4

LATERAL EROSION RATES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

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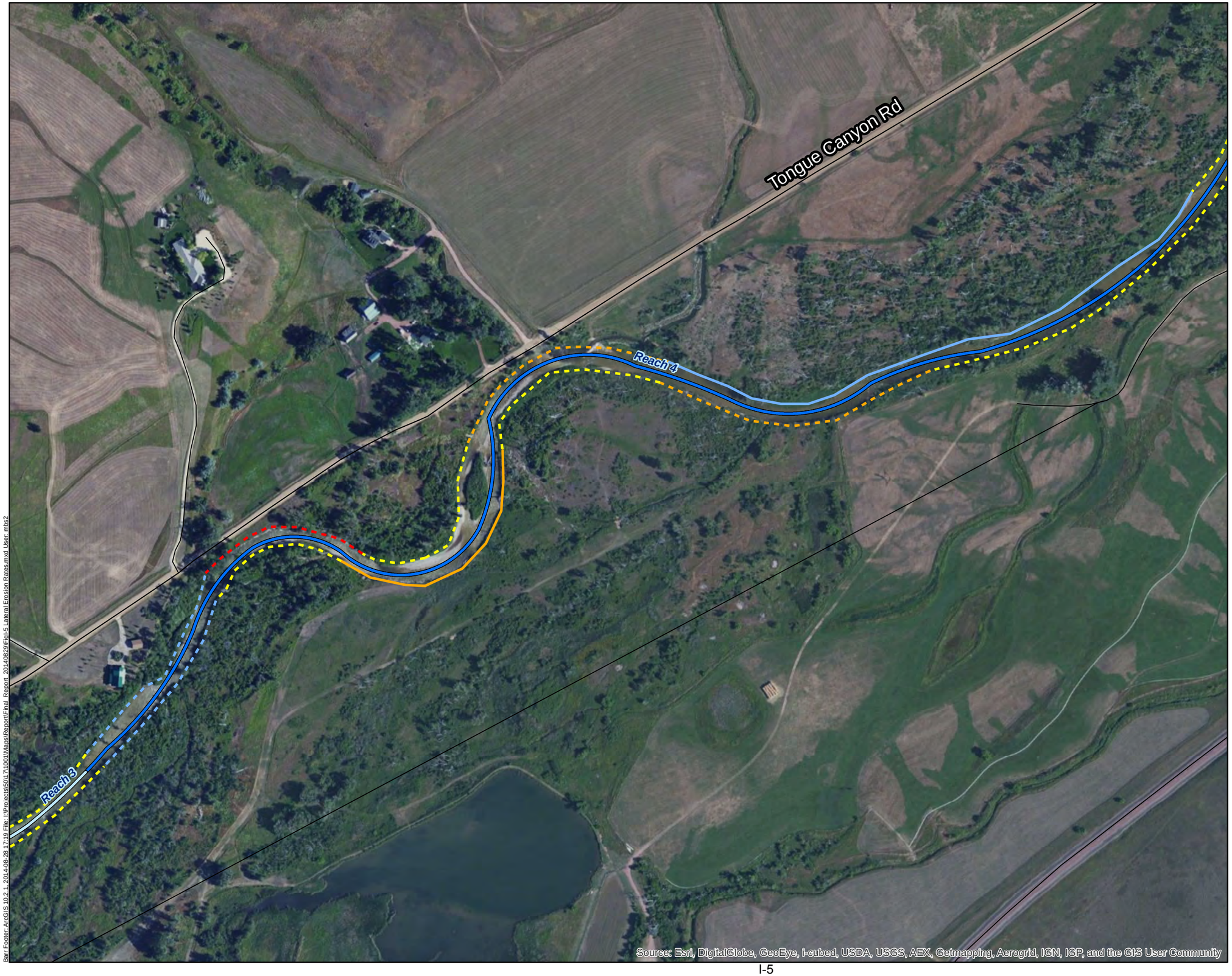


Lateral Erosion Rate*

- 0.1-0.3 ft/yr, Estimated
- 0.3-0.8 ft/yr, Estimated
- 0.3-0.8 ft/yr, Measured
- 0.8-1.1 ft/yr, Estimated
- 0.8-1.1 ft/yr, Measured
- 1.1-1.8 ft/yr, Estimated
- 1.1-1.8 ft/yr, Measured
- >1.8 ft/yr, Estimated
- >1.8 ft/yr, Measured

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

*To convert from feet/yr to cubic ft/year, multiply by bank length and height

*To convert from feet/year to tons/ft/year, multiply by bank height and by 0.048

Notes:
Lateral erosion rates calculated based on Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) values, per Rosgen curves from Yellowstone National Park

N

Feet

300 0 300

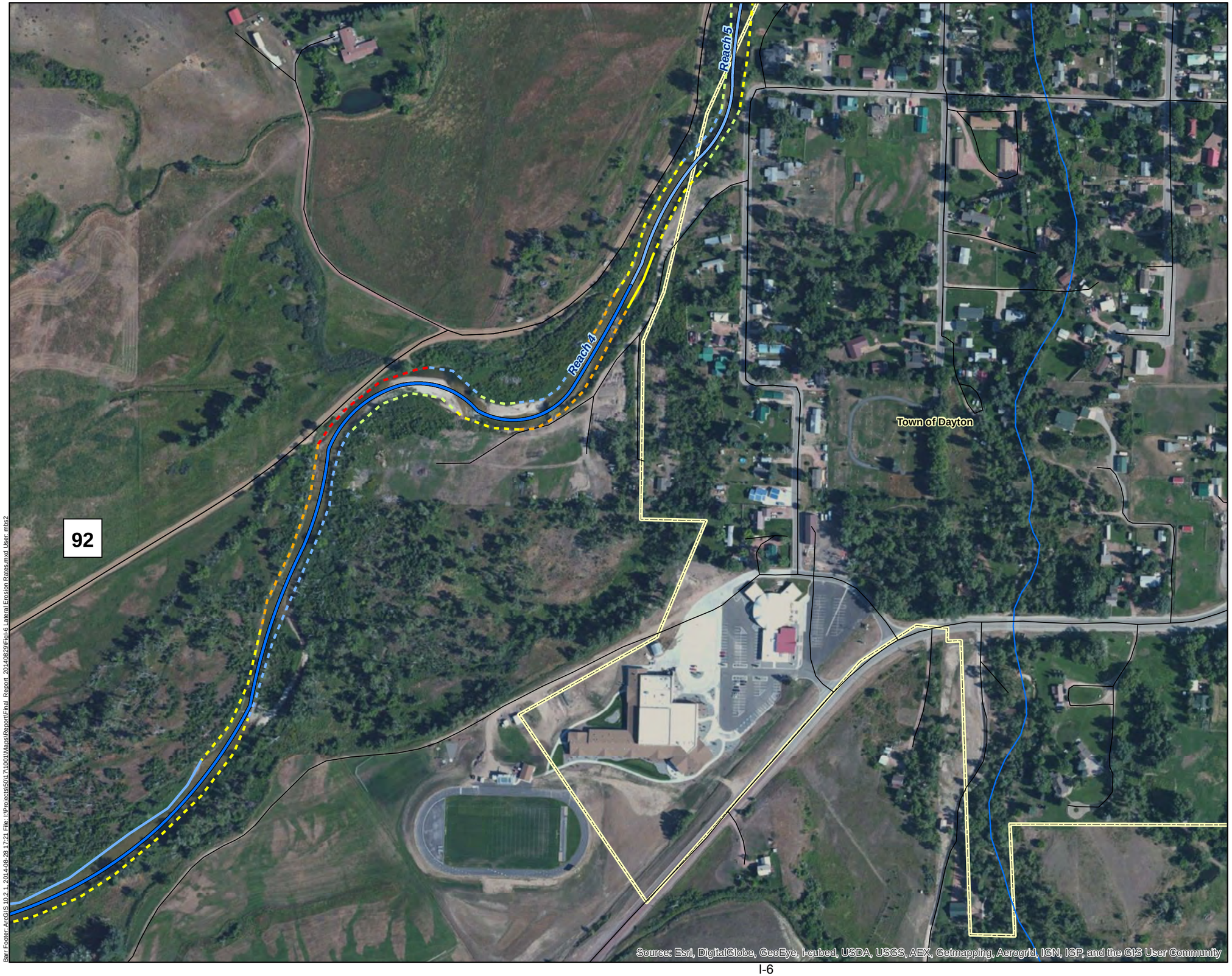
Figure I-5

LATERAL EROSION RATES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Barr Footer: ArcGIS 10.2.1, 2014-08-28 17:19 File: I:\Projects\5017\10001\Mapsi\Report\Final Report 20140829\Fig I-5 Lateral Erosion Rates.mxd User: mbs2



Lateral Erosion Rate*

- 0.1-0.3 ft/yr, Estimated
- 0.3-0.8 ft/yr, Estimated
- 0.3-0.8 ft/yr, Measured
- 0.8-1.1 ft/yr, Estimated
- 0.8-1.1 ft/yr, Measured
- 1.1-1.8 ft/yr, Estimated
- 1.1-1.8 ft/yr, Measured
- >1.8 ft/yr, Estimated
- >1.8 ft/yr, Measured

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

*To convert from feet/yr to cubic ft/year, multiply by bank length and height

*To convert from feet/year to tons/ft/year, multiply by bank height and by 0.048

Notes:
Lateral erosion rates calculated based on Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) values, per Rosgen curves from Yellowstone National Park

Feet
300 0 300

Figure I-6

LATERAL EROSION RATES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Barr Footer: ArcGIS 10.2.1, 2014-08-28 17:21 File: I:\Projects\50\17\10\01\Maps\Report\Final Report_20140829\Fig I-6 Lateral Erosion Rates.mxd User: mbs2

Lateral Erosion Rate*

- 0.1-0.3 ft/yr, Estimated
- 0.3-0.8 ft/yr, Estimated
- 0.3-0.8 ft/yr, Measured
- 0.8-1.1 ft/yr, Estimated
- 0.8-1.1 ft/yr, Measured
- 1.1-1.8 ft/yr, Estimated
- 1.1-1.8 ft/yr, Measured
- >1.8 ft/yr, Estimated
- >1.8 ft/yr, Measured

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

*To convert from feet/yr to cubic ft/year, multiply by bank length and height

*To convert from feet/year to tons/ft/year, multiply by bank height and by 0.048

Notes:
Lateral erosion rates calculated based on Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) values, per Rosgen curves from Yellowstone National Park

Feet
300 0 300

Figure I-7

LATERAL EROSION RATES
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Appendix J

Detailed sediment loading maps

Estimated Erosion Rate

- 0.005 - 0.02 tons/ft/year
- 0.02 - 0.06 tons/ft/year
- 0.06 - 0.10 tons/ft/year
- 0.10 - 0.14 tons/ft/year
- 0.14 - 0.30 tons/ft/year

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

Feet

300 0 300

Figure J-1

ESTIMATED SEDIMENT LOADS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

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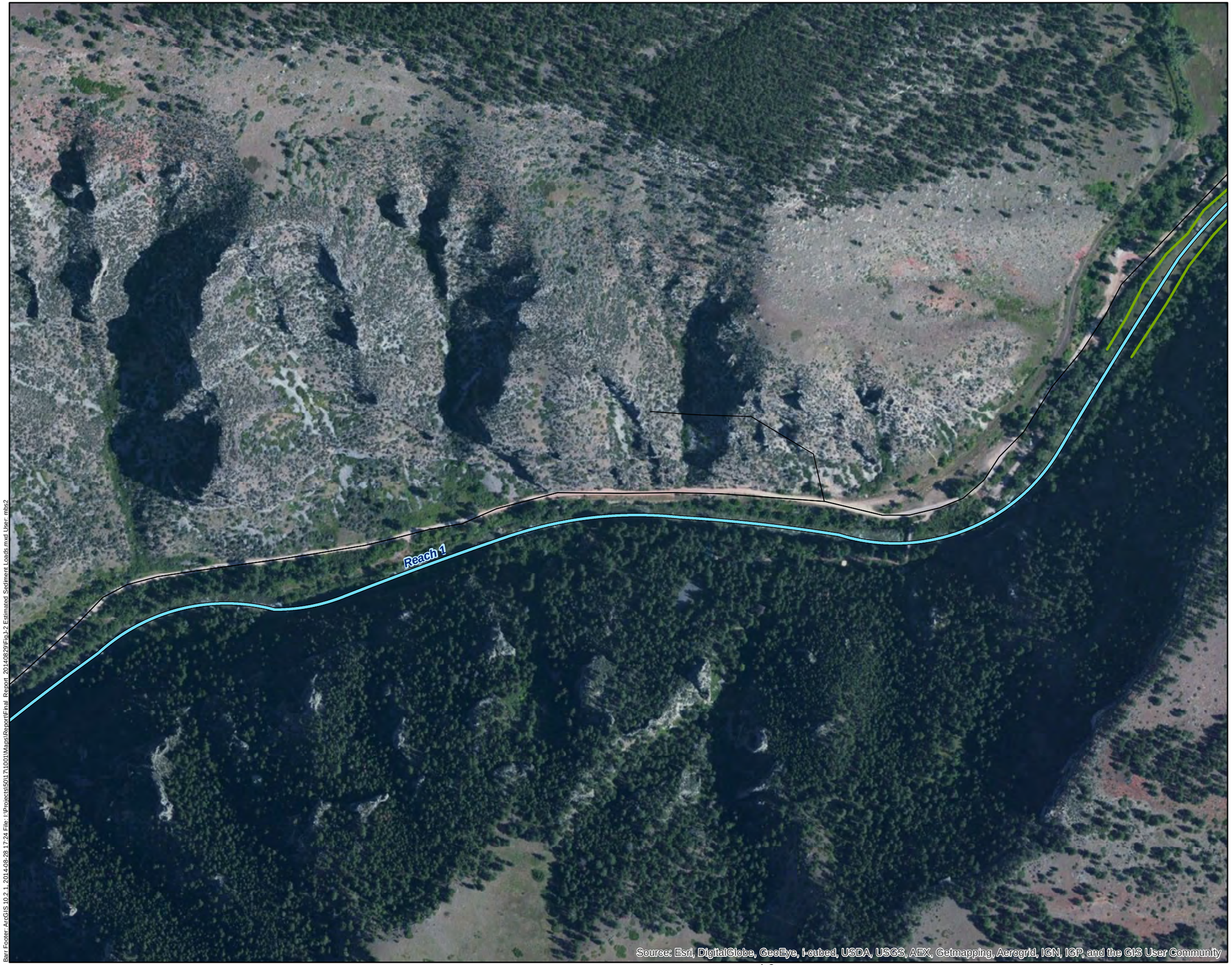


Estimated Erosion Rate

- 0.005 - 0.02 tons/ft/year
- 0.02 - 0.06 tons/ft/year
- 0.06 - 0.10 tons/ft/year
- 0.10 - 0.14 tons/ft/year
- 0.14 - 0.30 tons/ft/year

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

Feet

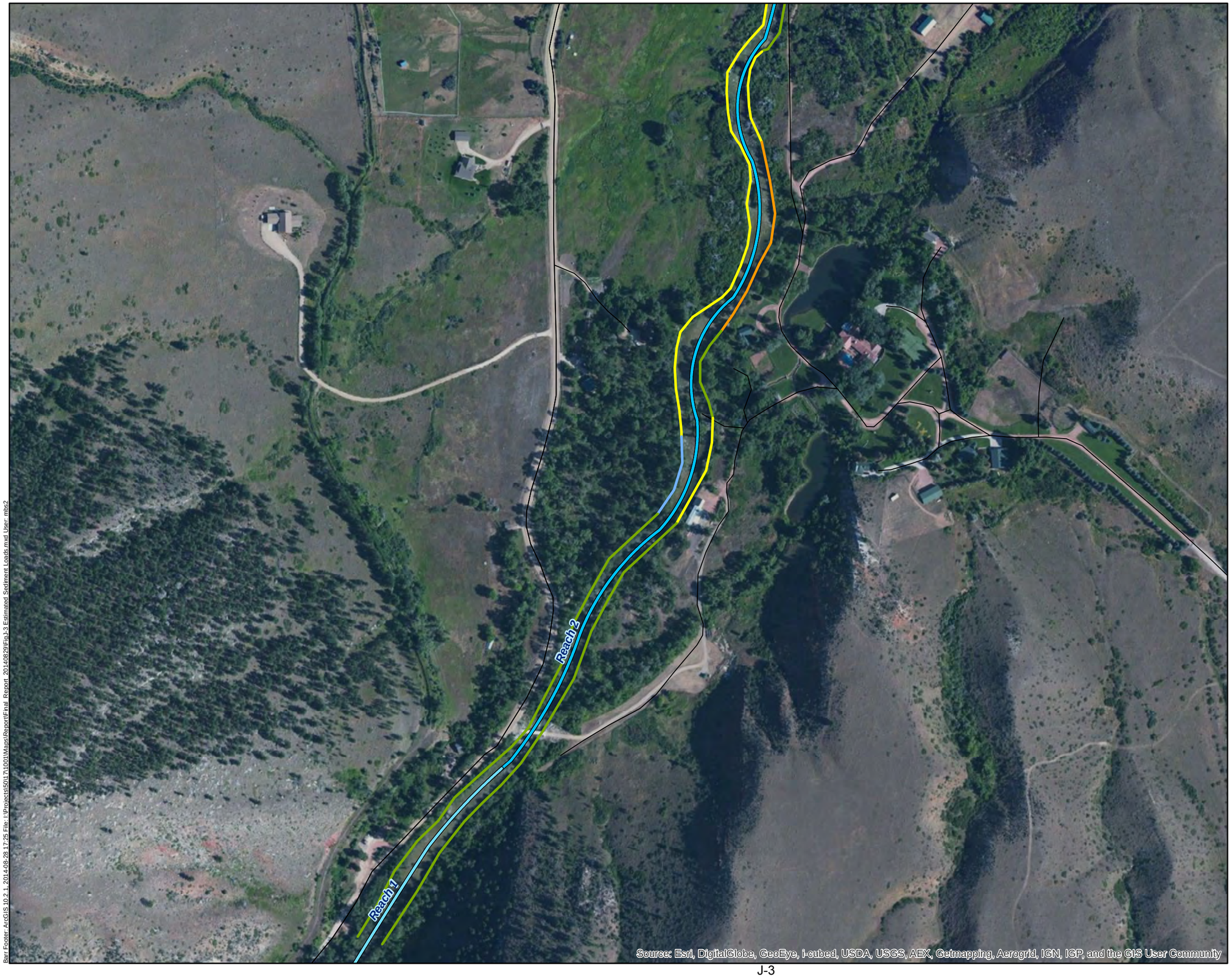
300 0 300

Figure J-2

ESTIMATED SEDIMENT LOADS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR



Estimated Erosion Rate

- 0.005 - 0.02 tons/ft/year
- 0.02 - 0.06 tons/ft/year
- 0.06 - 0.10 tons/ft/year
- 0.10 - 0.14 tons/ft/year
- 0.14 - 0.30 tons/ft/year

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

N

Feet

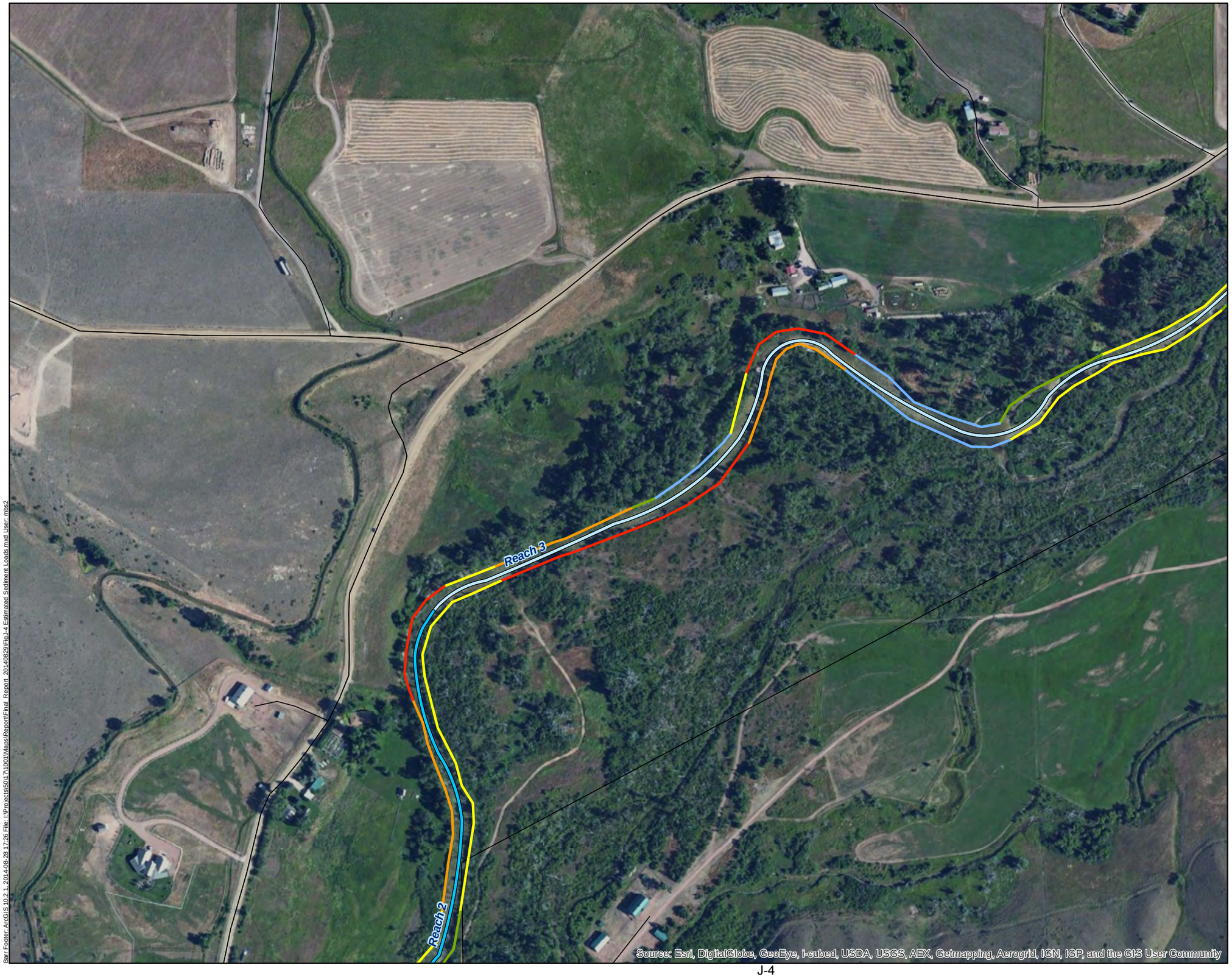
300 0 300

Figure J-3

ESTIMATED SEDIMENT LOADS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR



Estimated Erosion Rate

- 0.005 - 0.02 tons/ft/year
- 0.02 - 0.06 tons/ft/year
- 0.06 - 0.10 tons/ft/year
- 0.10 - 0.14 tons/ft/year
- 0.14 - 0.30 tons/ft/year

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

Feet

300 0 300

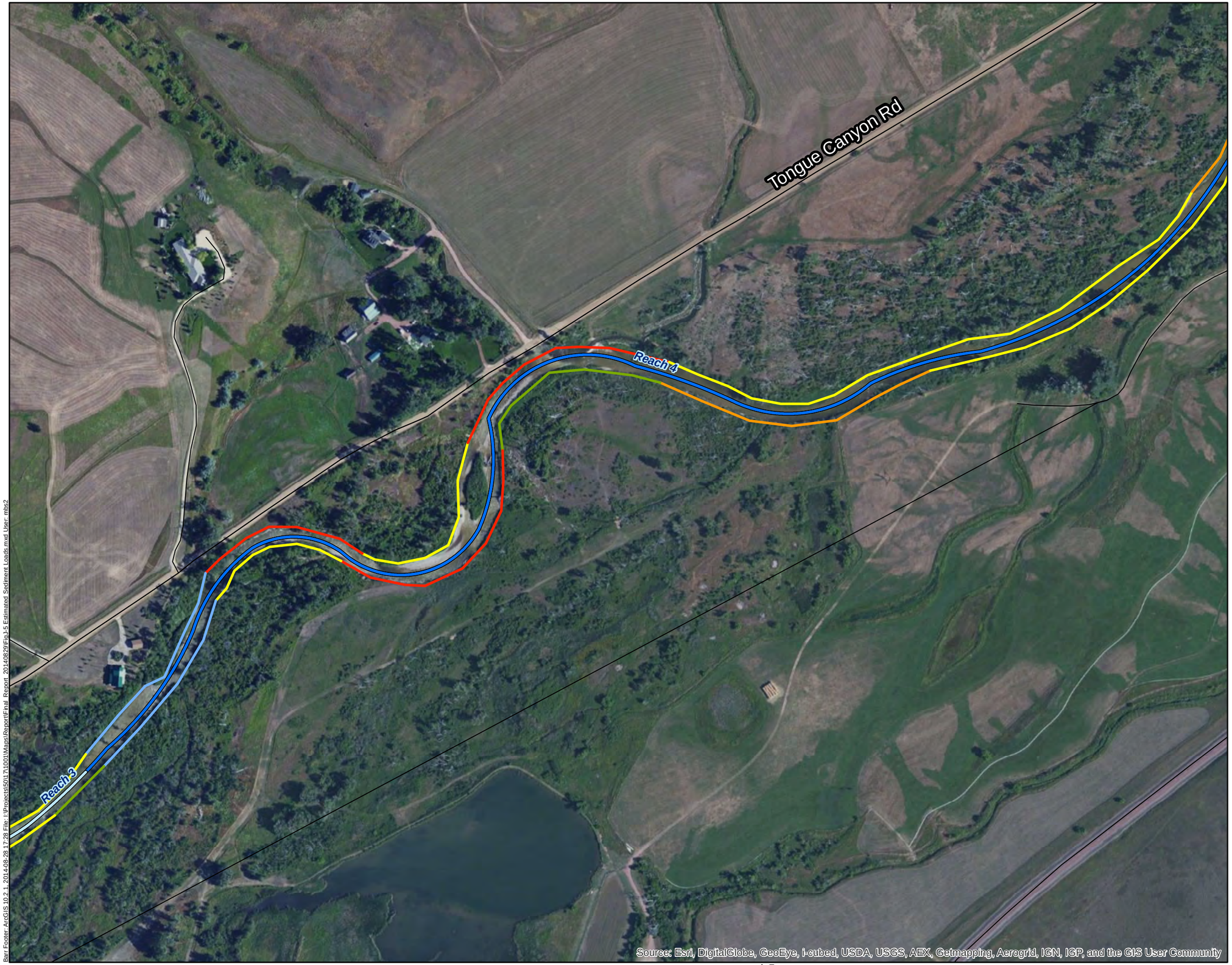
Figure J-4

ESTIMATED SEDIMENT LOADS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

BARR

Barr Footer: ArcGIS 10.2.1, 2014-08-28 17:26 File: I:\Projects\5013\71\001\Maps\Report\Final_Report_20140829\Fig-J-4 Estimated Sediment Loads.mxd User: mbs2



Estimated Erosion Rate

- 0.005 - 0.02 tons/ft/year
- 0.02 - 0.06 tons/ft/year
- 0.06 - 0.10 tons/ft/year
- 0.10 - 0.14 tons/ft/year
- 0.14 - 0.30 tons/ft/year

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

N

Feet

300 0 300

Figure J-5

ESTIMATED SEDIMENT LOADS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

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Estimated Erosion Rate

- 0.005 - 0.02 tons/ft/year
- 0.02 - 0.06 tons/ft/year
- 0.06 - 0.10 tons/ft/year
- 0.10 - 0.14 tons/ft/year
- 0.14 - 0.30 tons/ft/year

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

N

Feet

300 0 300

Figure J-6

ESTIMATED SEDIMENT LOADS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

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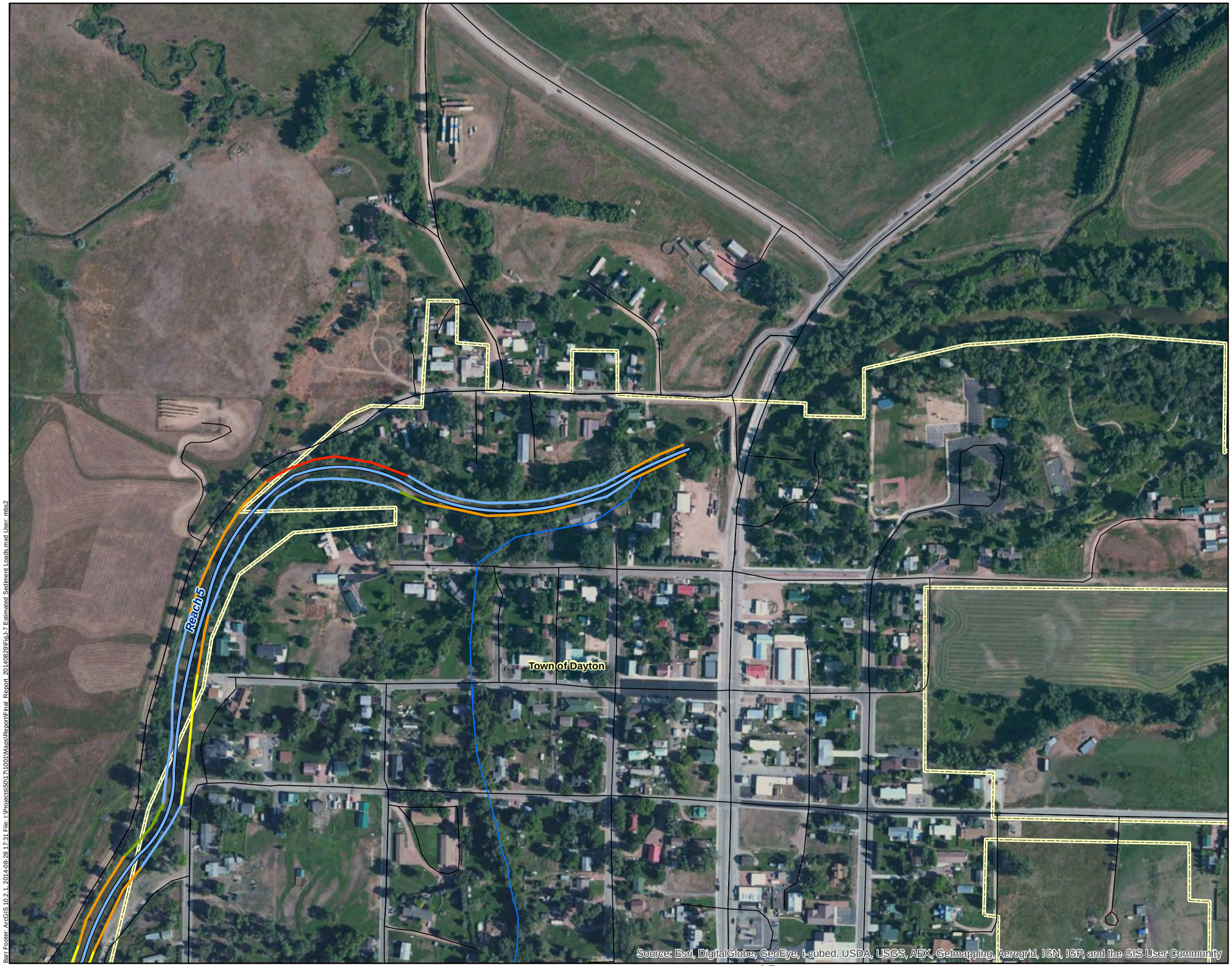

Estimated Erosion Rate

- 0.005 - 0.02 tons/ft/year
- 0.02 - 0.06 tons/ft/year
- 0.06 - 0.10 tons/ft/year
- 0.10 - 0.14 tons/ft/year
- 0.14 - 0.30 tons/ft/year

Project River Reaches

- Reach 1
- Reach 2
- Reach 3
- Reach 4
- Reach 5
- Municipal Boundary

N

Feet

300 0 300

Figure J-7

ESTIMATED SEDIMENT LOADS
Tongue River Stream Improvement Plan
Sheridan County Conservation District
Dayton, Wyoming

SHERIDAN COUNTY CONSERVATION DISTRICT

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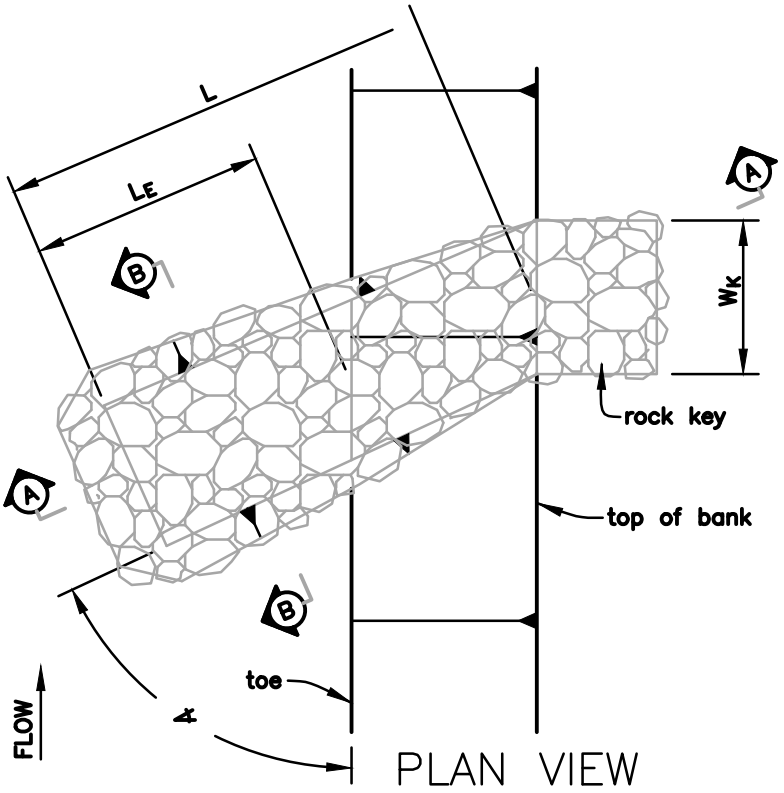
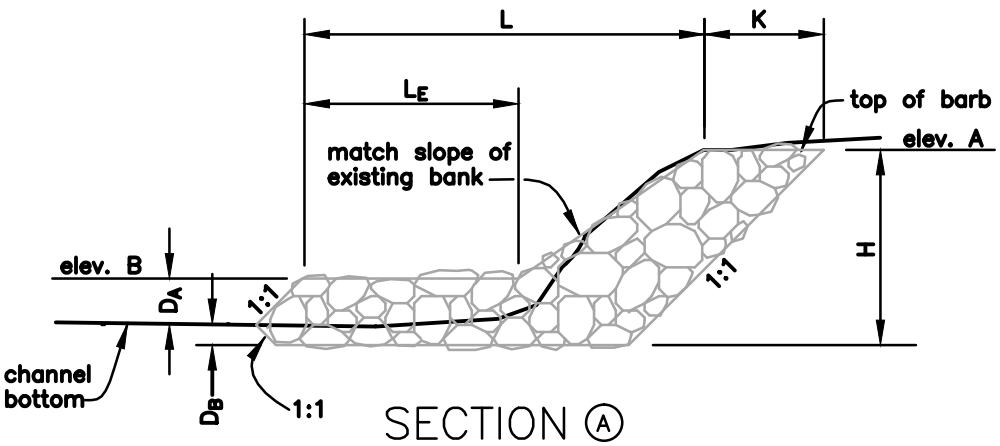
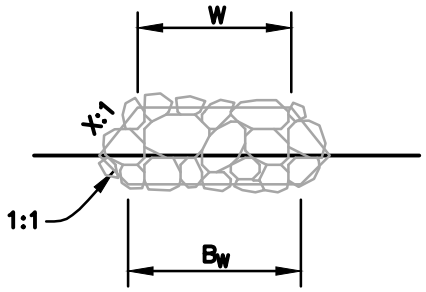
Appendix K

In-stream structure generic design details







DETAIL: BANK BARB
NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES

|| BANK BARB ||

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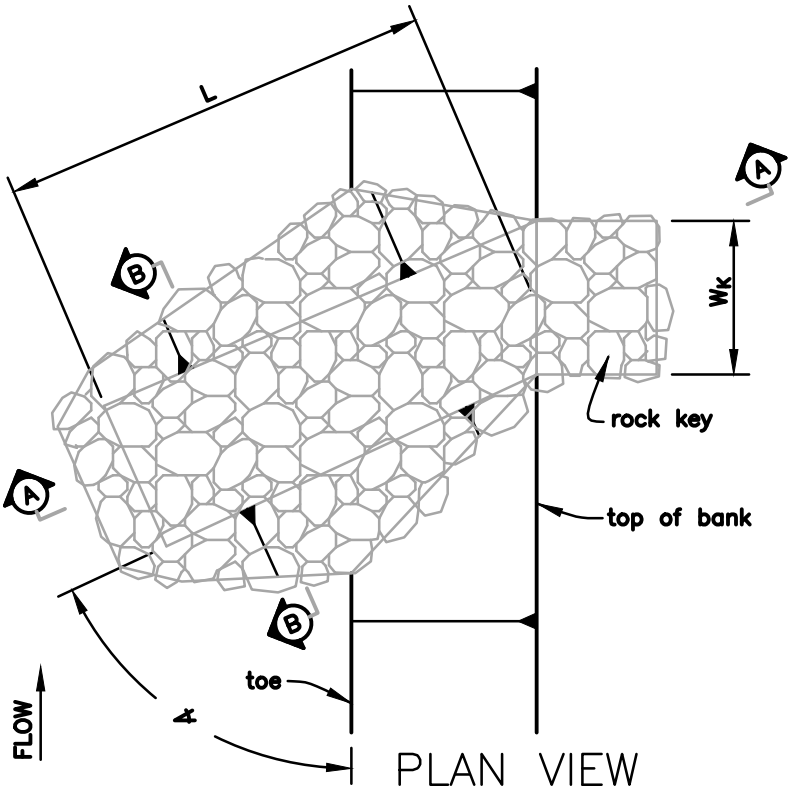
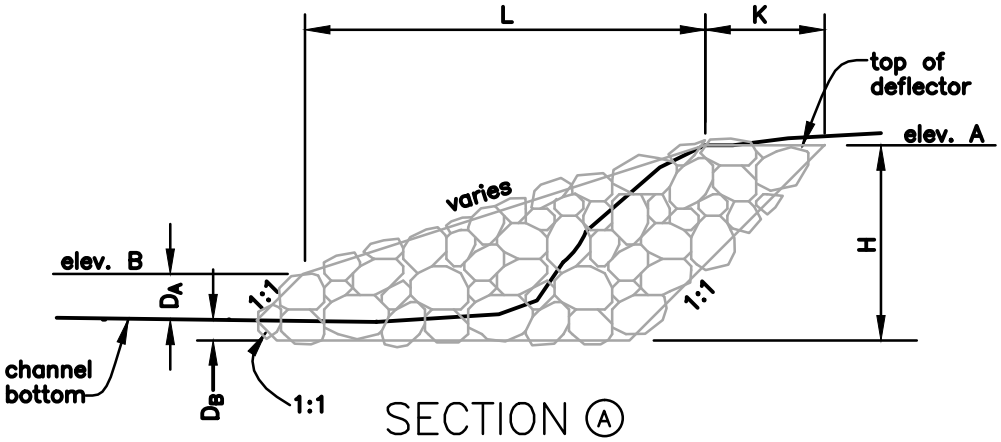
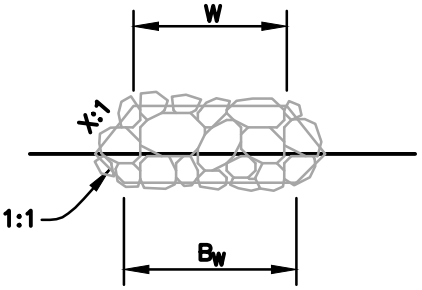


PLAN VIEW



SECTION Ⓐ



SECTION Ⓑ

– DETAIL: BANK DEFLECTOR
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|| BANK DEFLECTOR ||

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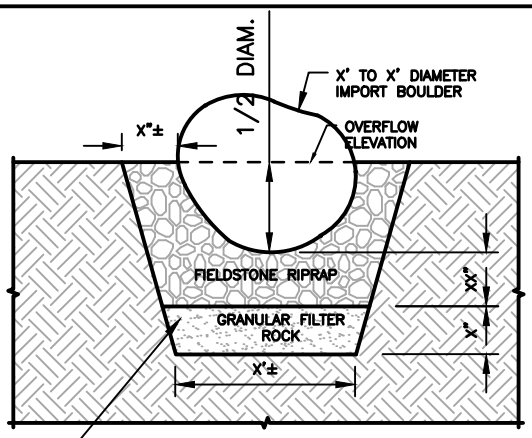
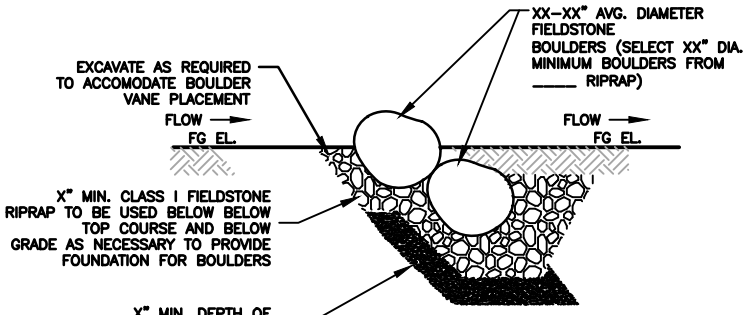
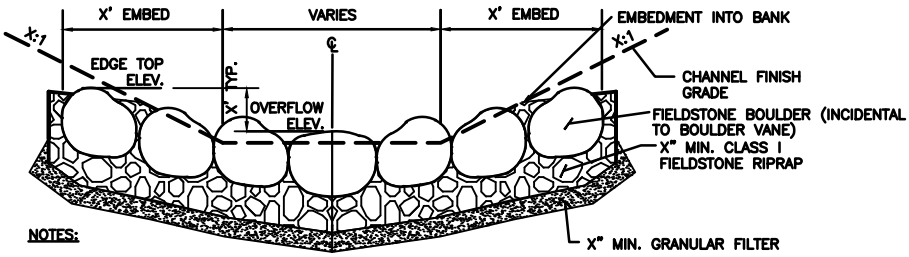


SECTION: BOULDER VANE TRENCH
NOT TO SCALE

GRANULAR FILTER ROCK MUST MATCH MnDOT STANDARD SPEC 3601.2



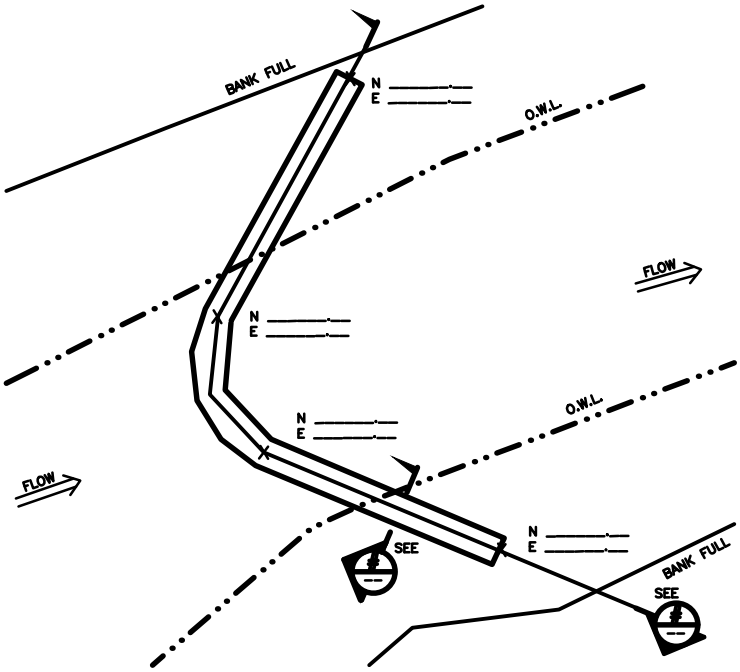
SECTION: DOUBLE BOULDER VANE
NOT TO SCALE



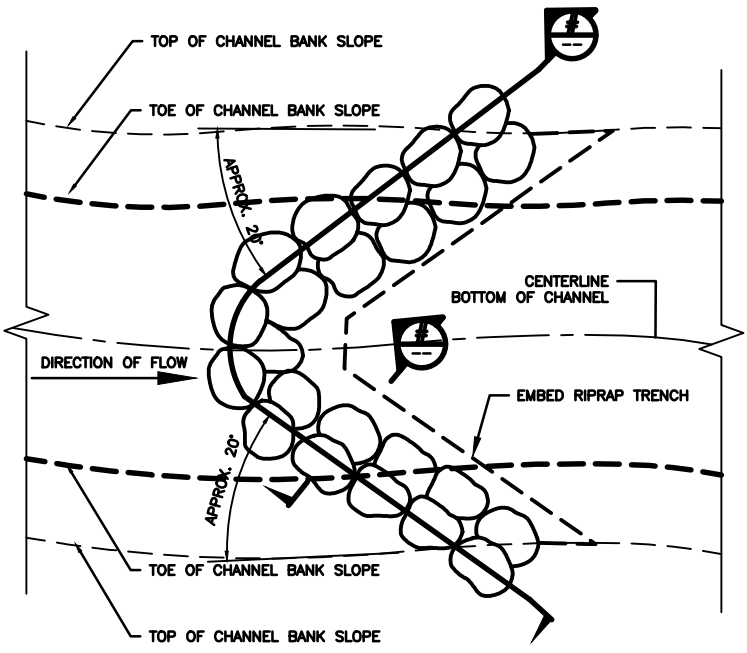
NOTES:

1. LOCATION AND ELEVATIONS TO BE DETERMINED IN FIELD.
2. EXCAVATE EXISTING MATERIAL AS NECESSARY TO INSTALL BOULDER VANES AND REGRADE BANK.

SECTION: BOULDER CROSS VANE
NOT TO SCALE



DETAIL: SINGLE BOULDER CROSS VANE



DETAIL: DOUBLE BOULDER CROSS VANE

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|| BOULDER CROSS VANE ||

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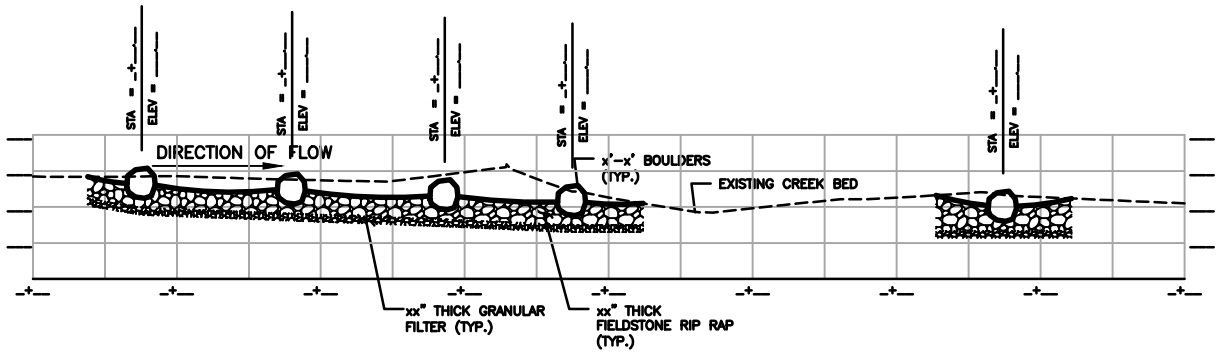
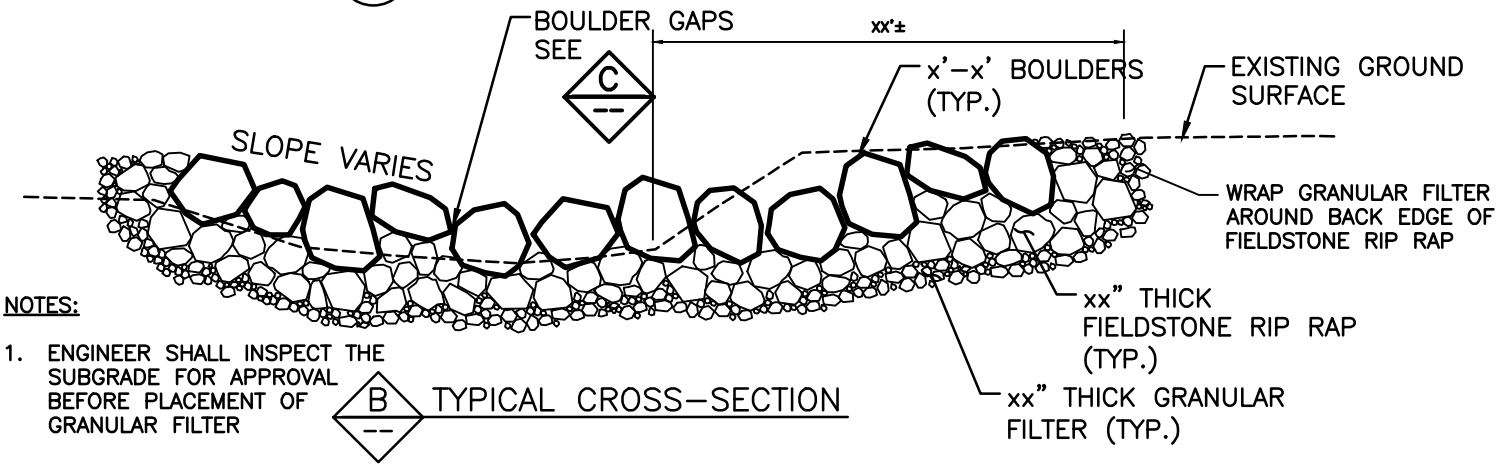


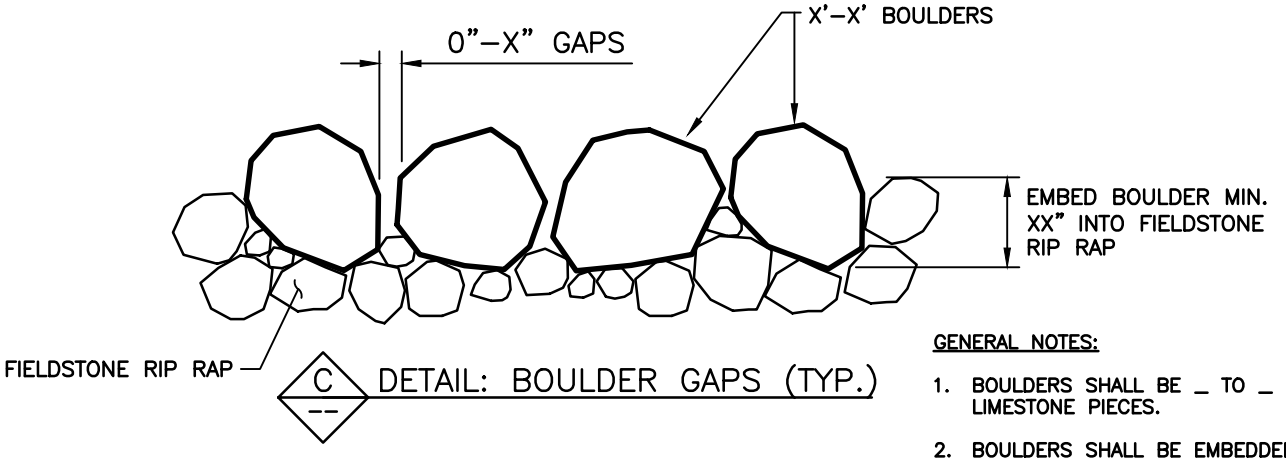
A -- PROFILE: SPILLWAY PROFILE



NOTES:

1. ENGINEER SHALL INSPECT THE SUBGRADE FOR APPROVAL BEFORE PLACEMENT OF GRANULAR FILTER

B -- TYPICAL CROSS-SECTION



C -- DETAIL: BOULDER GAPS (TYP.)

GENERAL NOTES:

1. BOULDERS SHALL BE _ TO _ FOOT APPROVED LIMESTONE PIECES.
2. BOULDERS SHALL BE EMBEDDED A MINIMUM OF __" AND A MAXIMUM OF __" INTO RIP RAP.
3. LOCATION OF BOULDERS SHOWN ON PLANS ARE APPROXIMATE. ACTUAL PLACEMENT OF BOULDERS WILL BE DIRECTED IN THE FIELD BY OWNER.
4. POOL DEPTHS BETWEEN BOULDER WEIRS SHALL BE A MINIMUM OF _.__ FEET DEEP AND A MAXIMUM OF _._ FEET DEEP. POOL DEPTHS SHALL VARY BETWEEN WEIRS AND WILL BE DETERMINED IN THE FIELD BY OWNER.
5. ON-SITE TOPSOIL SHALL BE SALVAGED AND REUSED.

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STREAM RESTORATION STANDARD PLATES

|| ROCK ARCH RAPIDS ||

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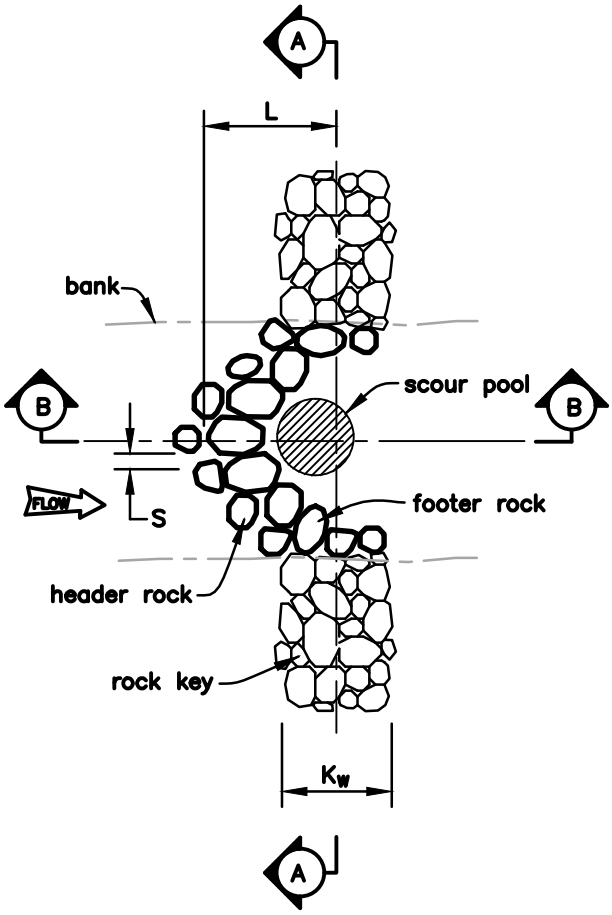
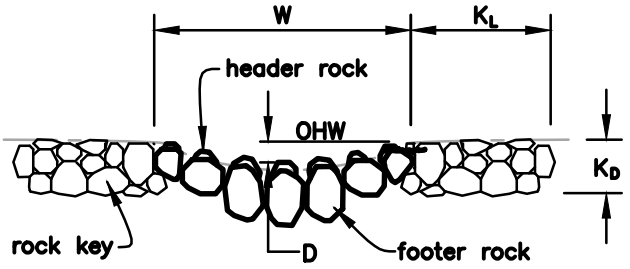
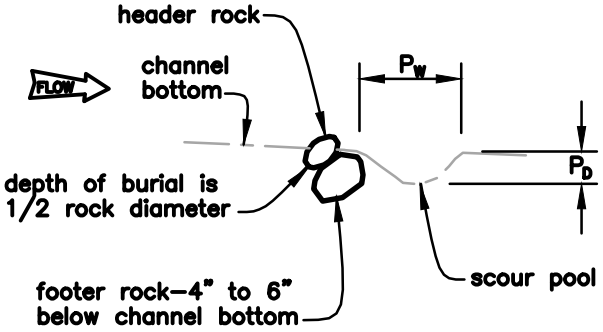


PLAN VIEW



Note: Scour pool is not shown in this view.

SECTION (A)



SECTION (B)

DETAIL: CURVED VORTEX ROCK WEIR

NTS

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STREAM RESTORATION STANDARD PLATES

|| CURVED VORTEX ROCK WEIR ||

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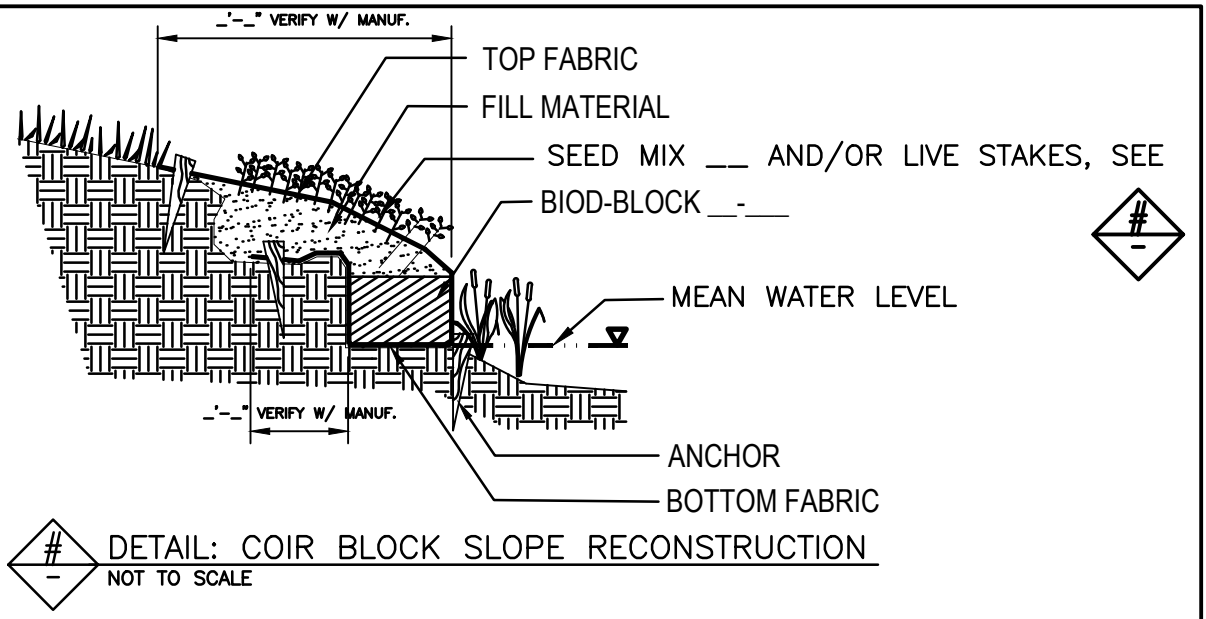
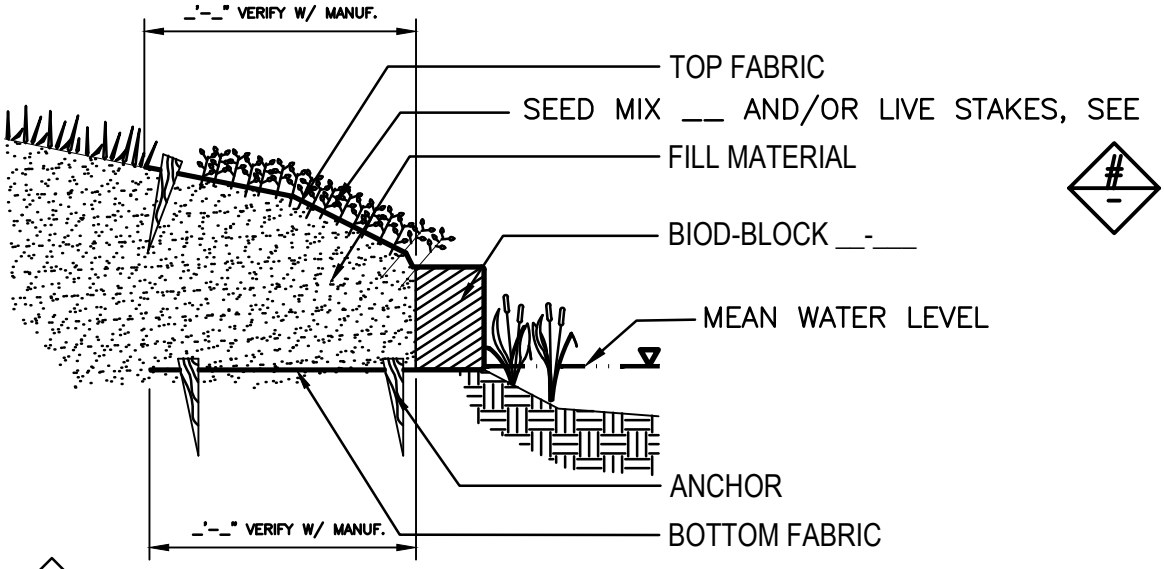


DETAIL: COIR BLOCK SLOPE RECONSTRUCTION
NOT TO SCALE



DETAIL: COIR BLOCK SLOPE CONSTRUCTION
NOT TO SCALE

NOTES:

1. INSTALLATION TO BE COMPLETED IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATIONS.
2. DO NOT SCALE DRAWINGS.
3. LIVE PLANTS AND CUTTINGS SHOULD BE USED IN EITHER SITUATION.
4. CONTRACTORS NOTE: FOR PRODUCT AND COMPANY INFORMATION VISIT www.CADdetails.com/info REFERENCE NUMBER 084-011.
5. DETAILS ADAPTED FROM ROLANKA INTERNATIONAL, INC. : BIOD-BLOCK COIR BLOCK SYSTEM

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STREAM RESTORATION STANDARD PLATES
|| SINGLE COIR BLOCK SLOPE STABILIZATION ||

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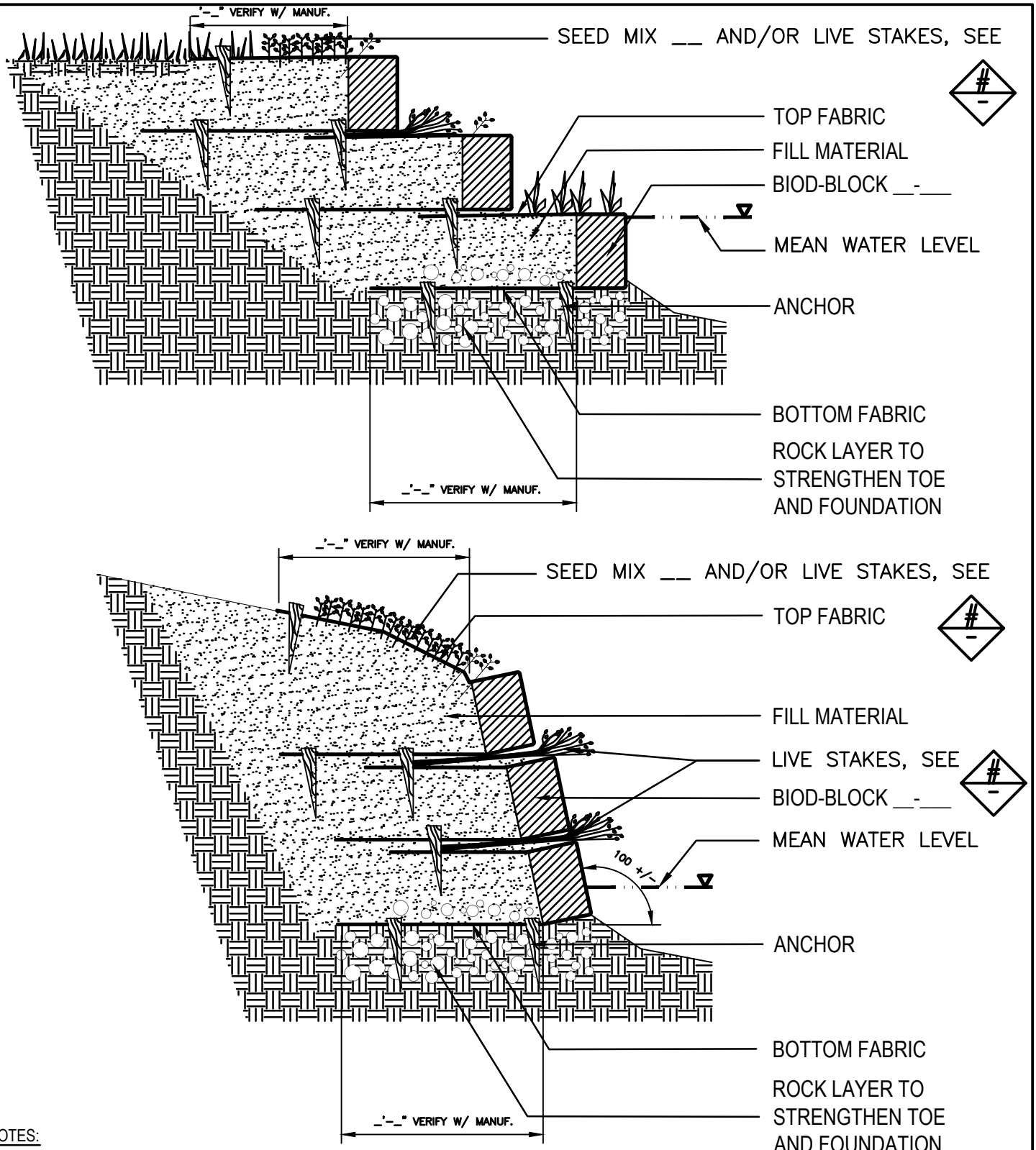

NOTES:

1. INSTALLATION TO BE COMPLETED IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATIONS.
2. DO NOT SCALE DRAWINGS.
3. LIVE PLANTS AND CUTTINGS SHOULD BE USED IN EITHER SITUATION.
4. CONTRACTORS NOTE: FOR PRODUCT AND COMPANY INFORMATION VISIT www.CADdetails.com/info REFERENCE NUMBER 084-010.
5. DETAILS ADAPTED FROM ROLANKA INTERNATIONAL, INC. : BIOD-BLOCK COIR BLOCK SYSTEM

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STREAM RESTORATION STANDARD PLATES

|| TIERED COIR BLOCK SLOPE STABILIZATION ||

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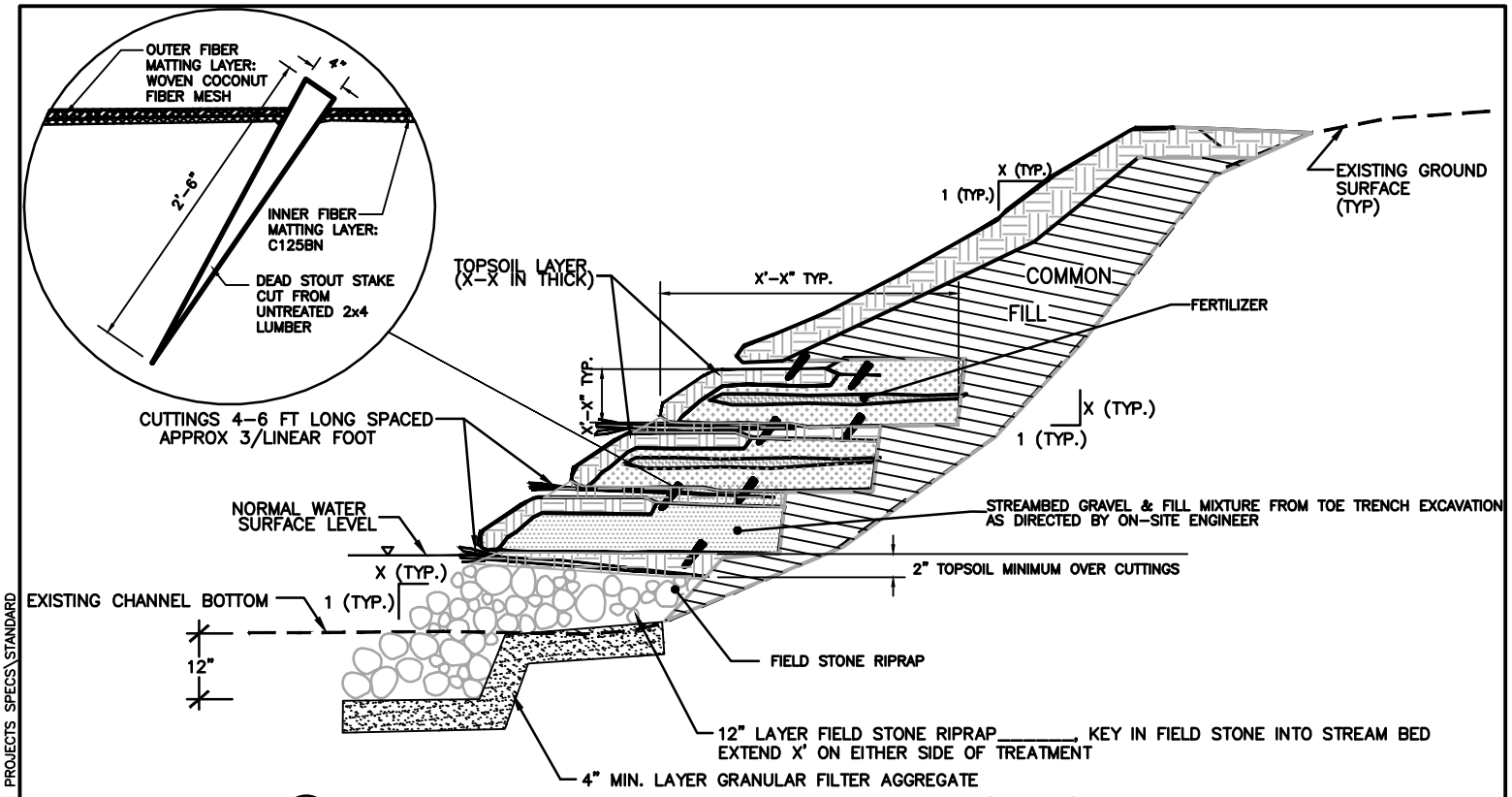
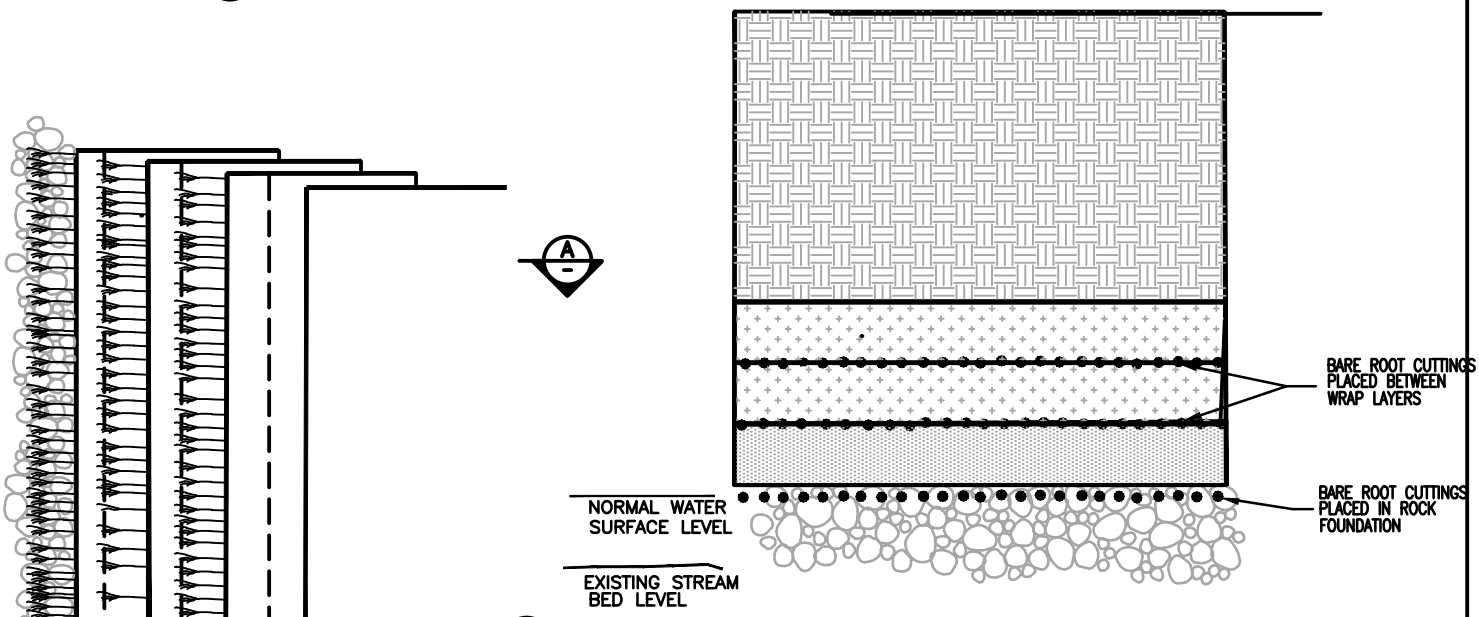


A – SECTION: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.)
NOT TO SCALE



B – ELEVATION: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.)
NOT TO SCALE

FILL TYPE (SEE NOTES)
- FERTILIZER MIXTURE
- TOPSOIL MIXTURE
- BACKFILL MIXTURE
- GRAVEL MIXTURE
- RIPRAP

X – DETAIL: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.)
NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES
|| VEGETATED REINFORCED SOIL SLOPES ||

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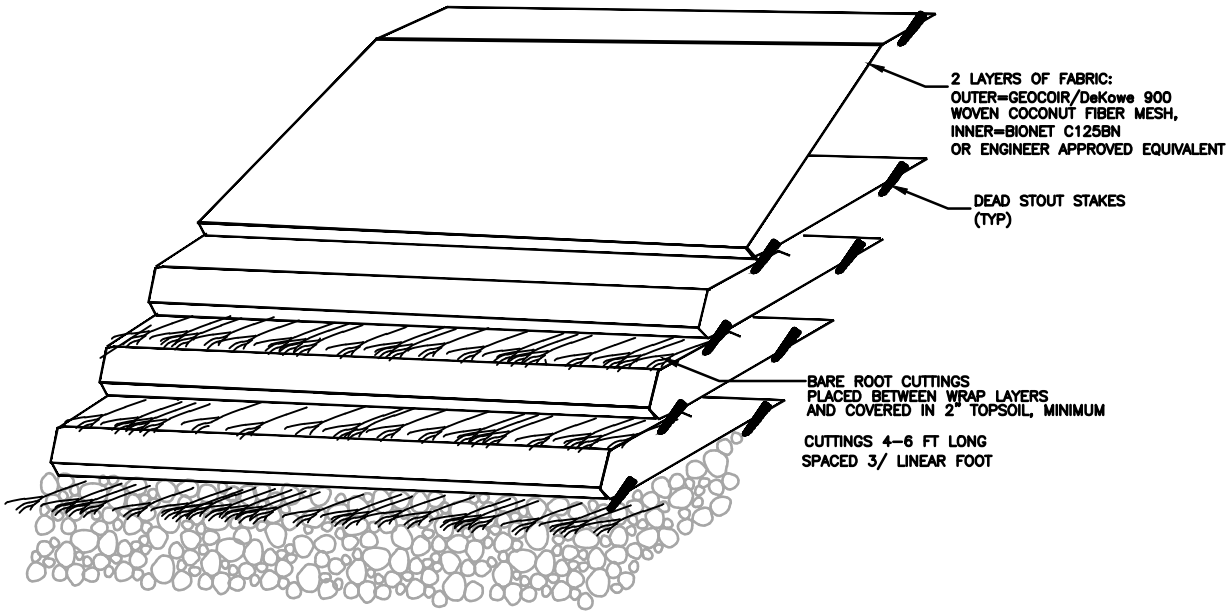

– DETAIL: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.) ISOMETRIC VIEW
NOT TO SCALE

GENERAL NOTES ON V.R.S.S.

1. The ENGINEER must be notified at least 3 days prior to VRSS installation and must be on site during installation.
2. Soak dormant cuttings for a minimum of 24 hours in flowing water before planting. Soaking for 5–7 days is considered ideal. The dormant cuttings should only be installed during the dormant season, after leaf drop in the fall and before bud break in the spring.
3. Install riprap and granular filter aggregate as specified in Section _____ and as shown on the Drawings.
4. Excavate the existing streambank slope shoreward from and level with the top of the riprap to form a stable, undisturbed surface. A flat bench should be created from the toe of the stable cut slope to the toe of the proposed stream bank riprap.
5. Dormant cuttings are to be placed on top of the riprap excavated bench at 3 branches per linear foot; the basal end of the cuttings should extend at least 2 foot past the back of the riprap. No more than 6 inches of the budding end of the live branch should extend past the front of the riprap. Cover the dormant cuttings with at least 2" of topsoil to create an even surface for the construction of the first soil lift.
6. Wooden or metal jigs should be placed along each reach of bank in order to provide a stable face for each soil lift to be shaped and constructed.
7. Lay natural fiber matting on bottom of the bench, overlapping adjacent matting by 1 foot. The outer exposed fiber matting layer of each soil lift shall be GEOCOIR/DeKowe 900 woven coconut fiber mesh, BioD–MatTM 90, or an ENGINEER approved equivalent.
8. The inner layer of each soil lift shall be BioNet C125BN or an ENGINEER approved equivalent. Lay the inner layer of BioNet on top of natural fiber matting of each soil lift. Fabric should be installed smooth with no unnecessary folds or wrinkles. Stake the shoreward end of the fiber matting in place with dead stout stakes spaced every three feet as shown on the Drawings.
9. The first 6 to 8 inches of the bottom soil lift shall be filled with gravel and sand material excavated from the stream bed. The top 6 to 8 inches on the front of surface layer should be comprised of topsoil mix as shown on the Drawings.
10. The topsoil layer shall be seeded with the _____ seed mix at 0.7 pounds per 1,000 square feet of lift surface area as shown on the Drawings.
11. Fold the fiber matting over the fill material and stake in place so the fabric is taut and smooth with no unnecessary folds or wrinkles. Backfill behind the bottom soil lift with granular filter material to meet the existing slope as shown on the Drawings.
12. Dormant cuttings are to be placed on top of the soil lift at 3 branches per linear foot; the basal end of the cuttings should extend at least 2–4 feet into the bank. No more than 6 inches of the budding end of the live branch should extend past the front of the riprap. Cover the dormant cuttings with 2 inches of topsoil to create an even surface for the construction of the second soil lift.
13. Remove jigs and place atop finished lift in order to shape new lift. Repeat for each subsequent lift.
14. The face of the second soil lift shall be offset shoreward by one foot from the face of the bottom soil lift. The first 6 inches of the second soil lift shall be filled with common fill and topsoil material as shown on the Drawings. The top 6 to 8 inches on the front and top layer should be comprised of topsoil mix as shown on the Drawings. Common fill and topsoil shall be hand tamped and not mechanically compacted to ensure vegetative success.
15. Fertilizer shall be placed at the middle of wrap layers between the backfill and topsoil during placement of fill material. Fertilizer shall be applied along the entire length of each wrap layer at a rate of 2.9 lbs per 50 foot long, 5 foot wide lift wrap.
16. The topsoil layer shall be seeded with the _____ seed mix at 0.7 pounds per 1,000 square feet of lift surface area as shown on the Drawings.
17. Fold the fiber matting over the fill material and stake in place so the fabric is taut and smooth with no unnecessary folds or wrinkles. Backfill behind the soil lift with common fill material to meet the existing slope as shown on the Drawings. Fill placed behind the second and third soil lifts should be placed in eight inch lifts and properly compacted; hand tamped and not mechanically compacted to ensure vegetative success.
18. On both terminal ends of the soil lifts, excess matting shall be used to fold over the ends of the lift and staked firmly. On the first lift layer backfill with or fill adjacent to the end of the lift and compact to secure it firmly.
19. In locations where a third soil lift is shown in the Drawings, a third soil lift shall be constructed in the same manner as the second lift. The face of the third soil lift shall be offset shoreward by one foot from the face of the second soil lift. Dormant cuttings are not placed on top of the upper soil lift.
20. The final slope shall be shaped above the top soil lift as shown on the Drawings. Common fill with a 4 to 6 inch topsoil layer shall be used to form the final slope. The slope shall be seeded with the _____ seed mix and stabilized as specified in Section _____.

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STREAM RESTORATION STANDARD PLATES
|| VEGETATED REINFORCED SOIL SLOPES ||

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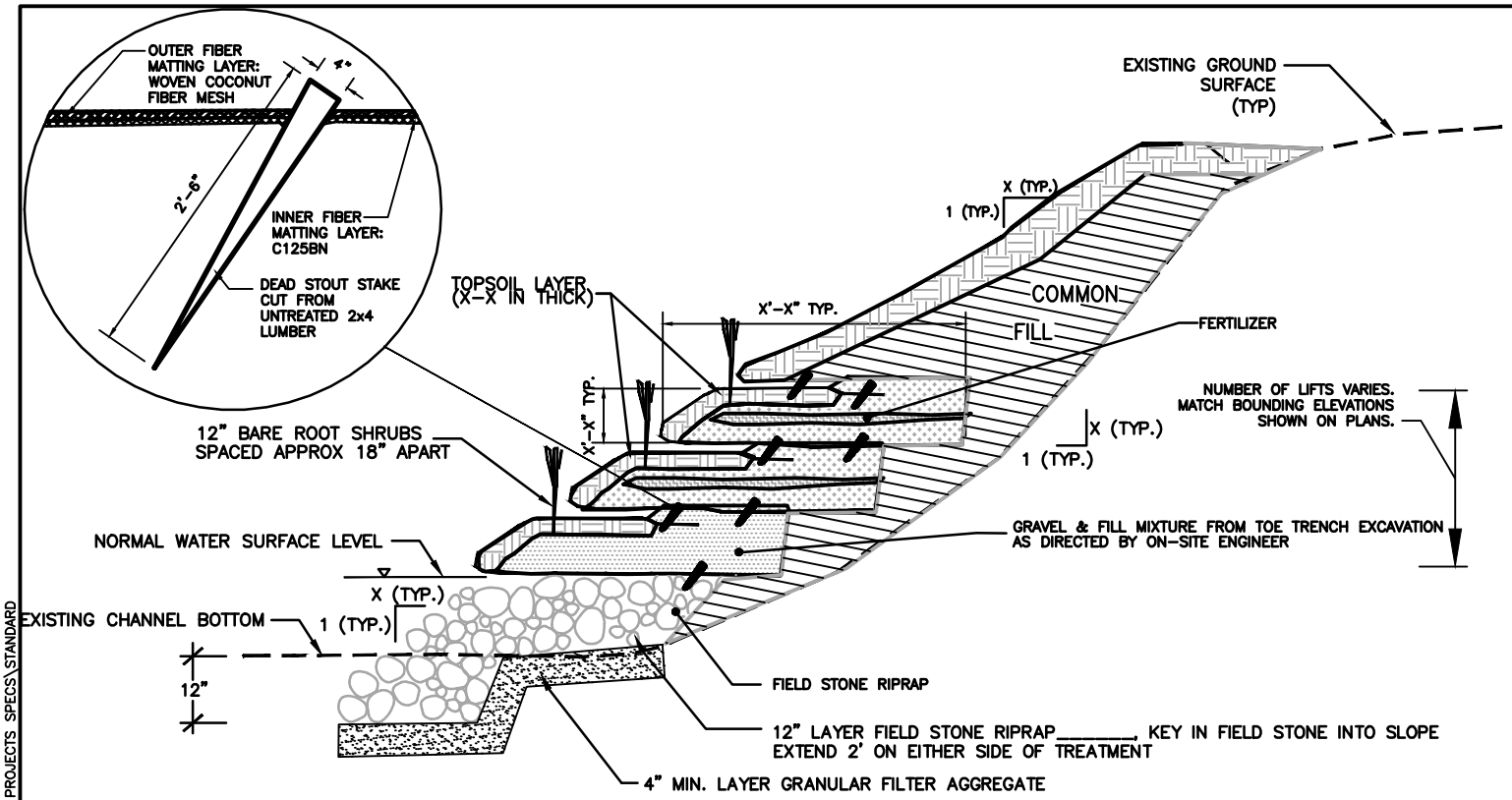
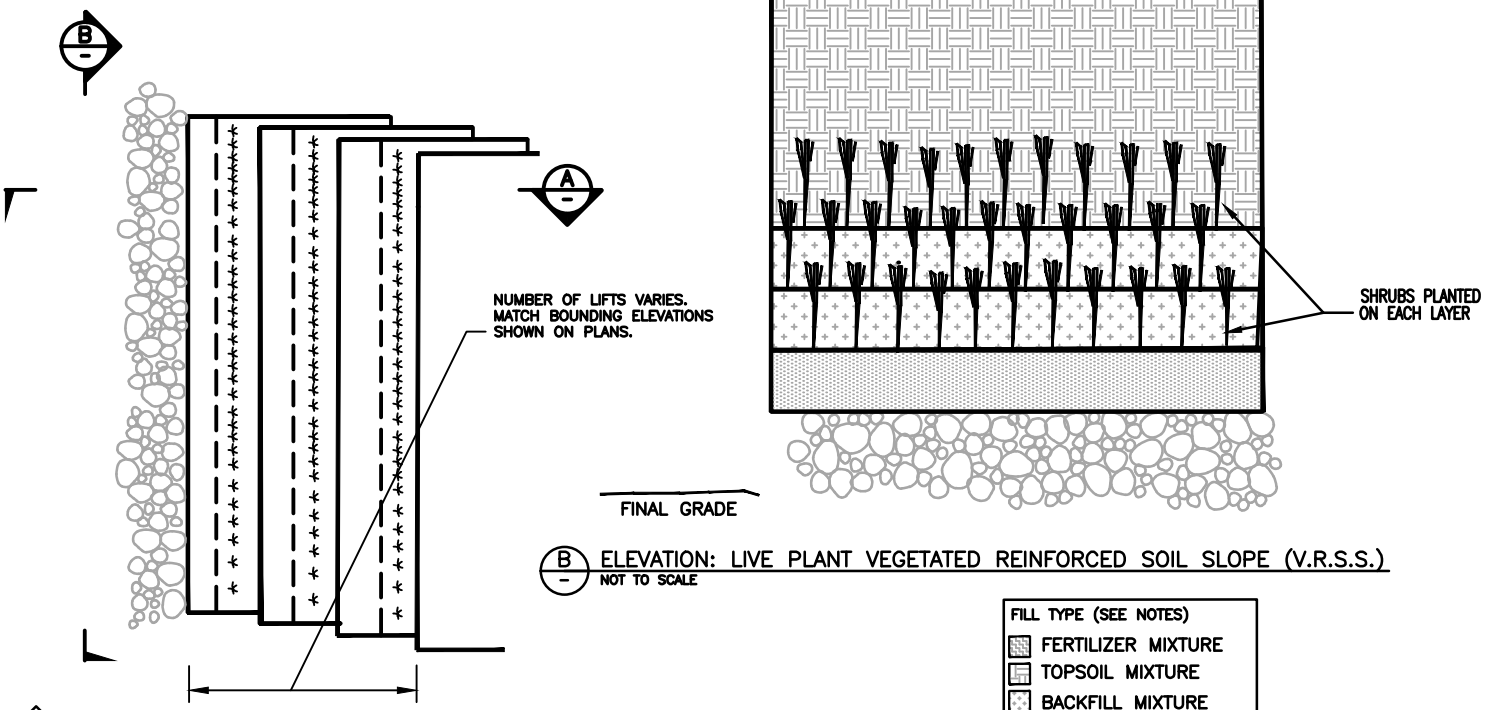


A – SECTION: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.)
NOT TO SCALE



B – ELEVATION: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.)
NOT TO SCALE

X – DETAIL: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.)
NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES
|| VEGETATED REINFORCED SOIL SLOPES ||
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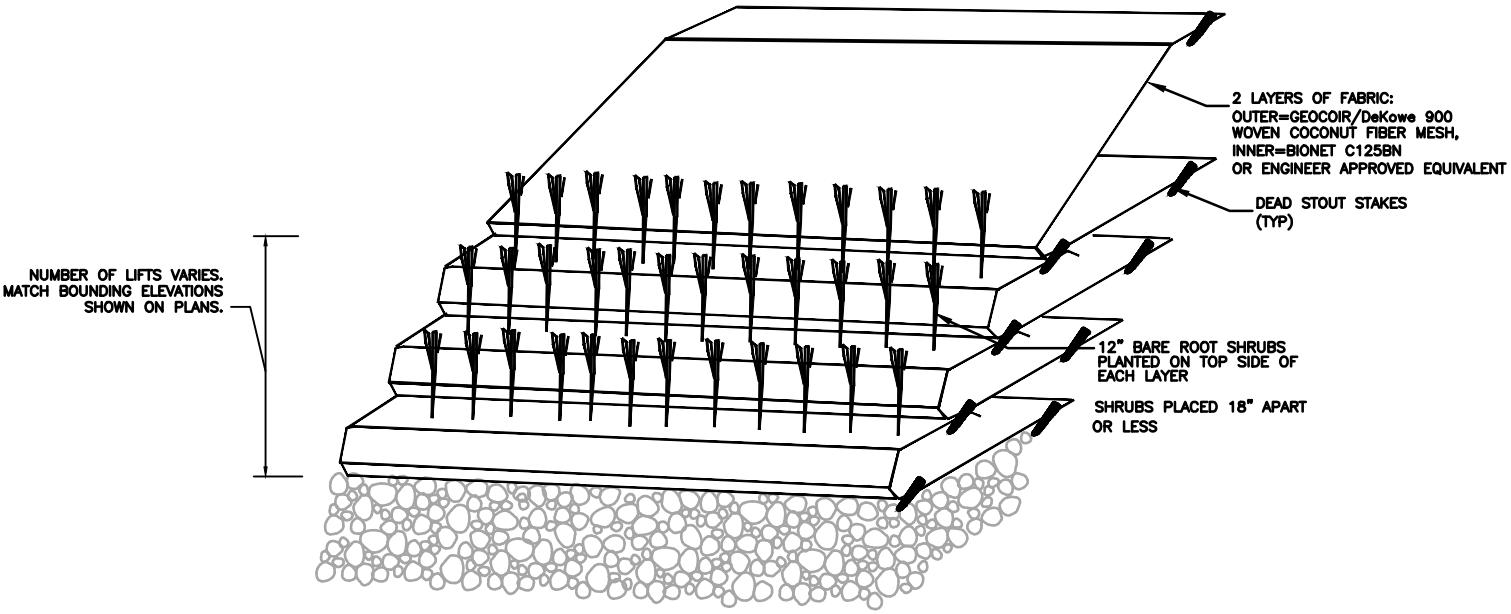

– DETAIL: LIVE PLANT VEGETATED REINFORCED SOIL SLOPE (V.R.S.S.) ISOMETRIC VIEW

NOT TO SCALE

GENERAL NOTES ON V.R.S.S.

1. The ENGINEER must be notified at least 3 days prior to VRSS installation and must be on site during installation.
2. If bare root specimens have not been dipped in hydrogel slurry, soak tree roots in water for 12–24 hours before planting. The bare root shrubs should only be installed after leaf drop in the fall and before bud break in the spring.
3. Install riprap and granular filter aggregate as specified in Section _____ and as shown on the Drawings.
4. Excavate the existing streambank slope shoreward from and level with the top of the riprap to form a stable, undisturbed surface. A flat bench should be created from the toe of the stable cut slope to the toe of the proposed stream bank riprap.
5. Wooden or metal jigs should be placed along each reach of bank in order to provide a stable face for each soil lift to be shaped and constructed.
6. Lay natural fiber matting on bottom of the bench, overlapping adjacent matting by 1 foot. The outer exposed fiber matting layer of each soil lift shall be GEOCOIR/DeKowe 900 woven coconut fiber mesh, BioD–MatTM 90, or an ENGINEER approved equivalent.
7. The inner layer of each soil lift shall be BioNet C125BN or an ENGINEER approved equivalent. Lay the inner layer of BioNet on top of natural fiber matting of each soil lift. Fabric should be installed smooth with no unnecessary folds or wrinkles. Stake the shoreward end of the fiber matting in place with dead stout stakes spaced every three feet as shown on the Drawings.
8. The first 6 to 8 inches of the bottom soil lift shall be filled with gravel and sand material excavated from the stream bed. The top 6 to 8 inches on the front of surface layer should be comprised of topsoil mix as shown on the Drawings.
9. The topsoil layer shall be seeded with the _____ seed mix at 0.7 pounds per 1,000 square feet of lift surface area as shown on the Drawings.
10. Fold the fiber matting over the fill material and stake in place so the fabric is taut and smooth with no unnecessary folds or wrinkles. Backfill behind the bottom soil lift with granular filter material to meet the existing slope as shown on the Drawings.
11. Bare root shrubs are to be planted into the topsoil at the top of each lift, spaced every 18".
12. Remove jigs and place atop finished lift in order to shape new lift. Repeat for each subsequent lift.
13. The face of the second soil lift shall be offset shoreward by one foot from the face of the bottom soil lift. The first 6 inches of the second soil lift shall be filled with common fill and topsoil material as shown on the Drawings. The top 6 to 8 inches on the front and top layer should be comprised of topsoil mix as shown on the Drawings. Common fill and topsoil shall be hand tamped and not mechanically compacted to ensure vegetative success.
14. Fertilizer shall be placed at the middle of wrap layers between the backfill and topsoil during placement of fill material. Fertilizer shall be applied along the entire length of each wrap layer at a rate of 2.9 lbs per 50 foot long, 5 foot wide lift wrap.
15. The topsoil layer shall be seeded with the _____ seed mix at 0.7 pounds per 1,000 square feet of lift surface area as shown on the Drawings.
16. Fold the fiber matting over the fill material and stake in place so the fabric is taut and smooth with no unnecessary folds or wrinkles. Backfill behind the soil lift with common fill material to meet the existing slope as shown on the Drawings. Fill placed behind the second and third soil lifts should be placed in eight inch lifts and properly compacted; hand tamped and not mechanically compacted to ensure vegetative success.
17. On both terminal ends of the soil lifts, excess matting shall be used to fold over the ends of the lift and staked firmly. On the first lift layer backfill with or fill adjacent to the end of the lift and compact to secure it firmly.
18. In locations where a third soil lift is shown in the Drawings, a third soil lift shall be constructed in the same manner as the second lift. The face of the third soil lift shall be offset shoreward by one foot from the face of the second soil lift.
19. The final slope shall be shaped above the top soil lift as shown on the Drawings. Common fill with a 4 to 6 inch topsoil layer shall be used to form the final slope. The slope shall be seeded with the _____ seed mix and stabilized as specified in Section _____.

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STREAM RESTORATION STANDARD PLATES

|| VEGETATED REINFORCED SOIL SLOPES ||

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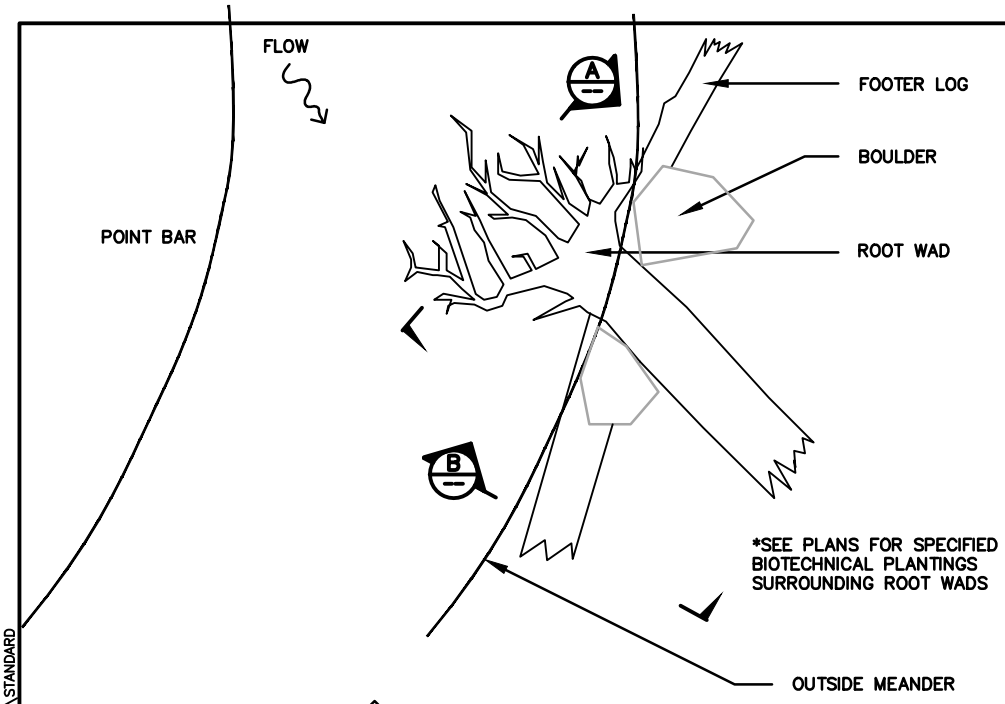
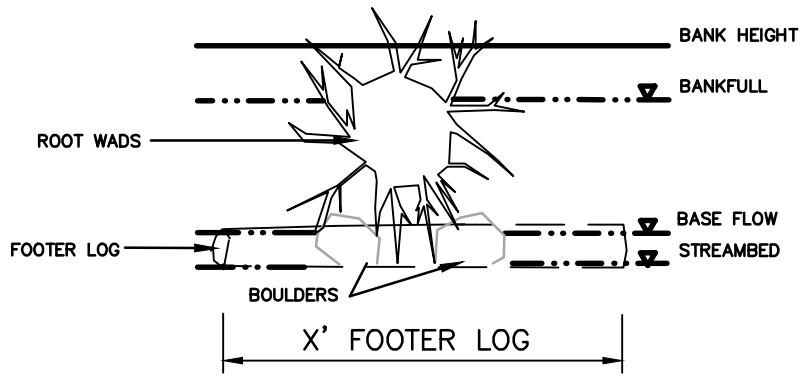


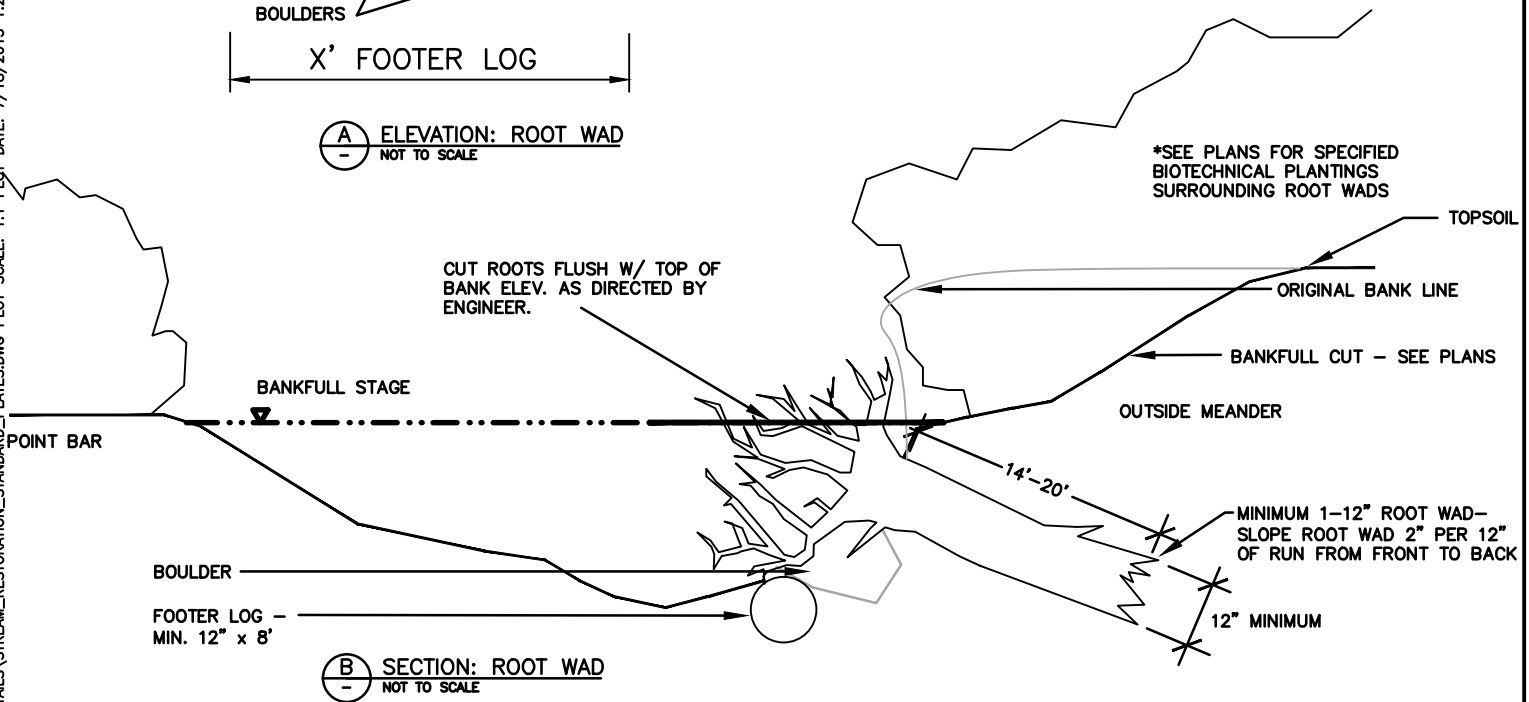
PLAN: ROOT WAD
NOT TO SCALE

GENERAL NOTES:

1. The ENGINEER must be notified at least 3 days prior to root wad installation and must be on site during installation.
2. To the extent possible, root wads should be created from trees that will be removed from the sites within the project area.
3. Construction should proceed from downstream to upstream in areas where more than one root wad will be installed as shown on the Drawings.
4. Excavate a trench along the streambank toe for the footer logs.
5. Place the footer logs into the trench, with the tops of the logs at specified elevations for each site.
6. Either drive the root wad into the bank, or excavate a trench in which to place the root wad. If the root wad is driven into the bank, sharpen the end of the root wad to a point.
7. The root wad must be placed in the bank so that the back of the root fan rests against the front of the footer log.
8. The root fan must be placed such that the fan is perpendicular to the flow in the stream.
9. Moving upstream, the process is repeated for each additional root wad as shown on the Drawings.
10. Large boulders are placed at the ends of each footer log and on either side of the trunk of each rootwad.
11. Place back fill over the boulders as necessary with a coarse filter aggregate (Mn/DOT Standard Specification 3142.2H) and match existing grade with X" of topsoil.
12. Revegetate and stabilize with erosion control blanket as specified for each site as shown in the Drawings and directed by the ENGINEER.
13. Trim the roots that extend above the stream bank to a height slightly below back height as directed by the ENGINEER.



A ELEVATION: ROOT WAD
NOT TO SCALE



B SECTION: ROOT WAD
NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES
|| ROOT WADS ||

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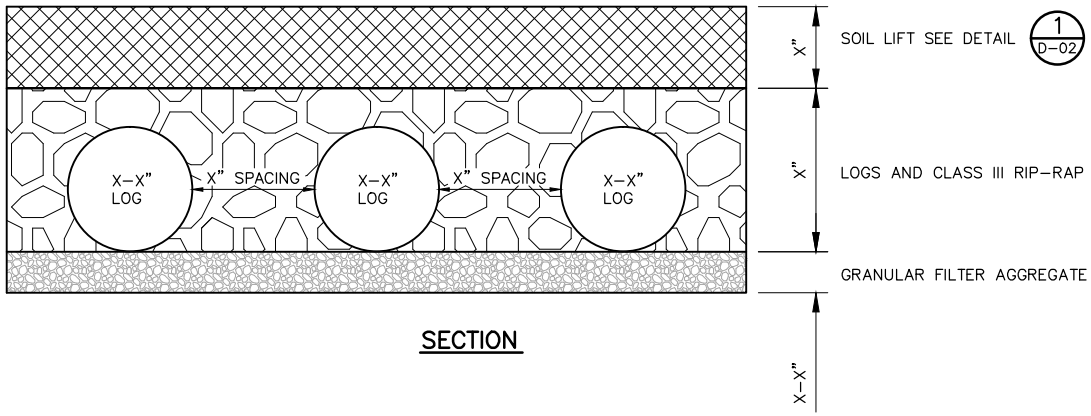
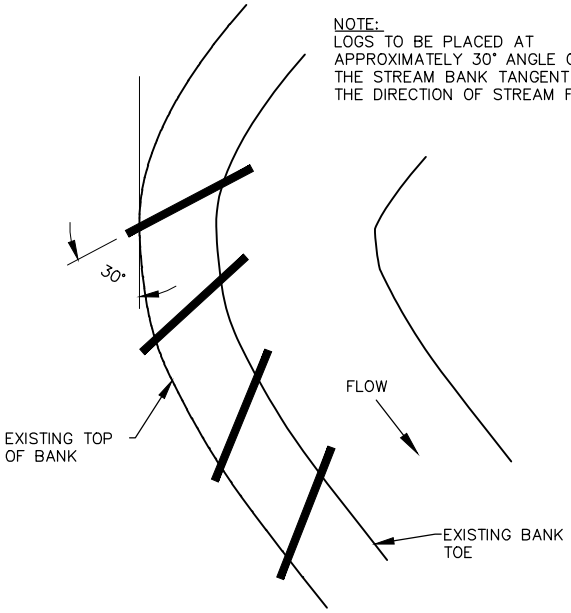


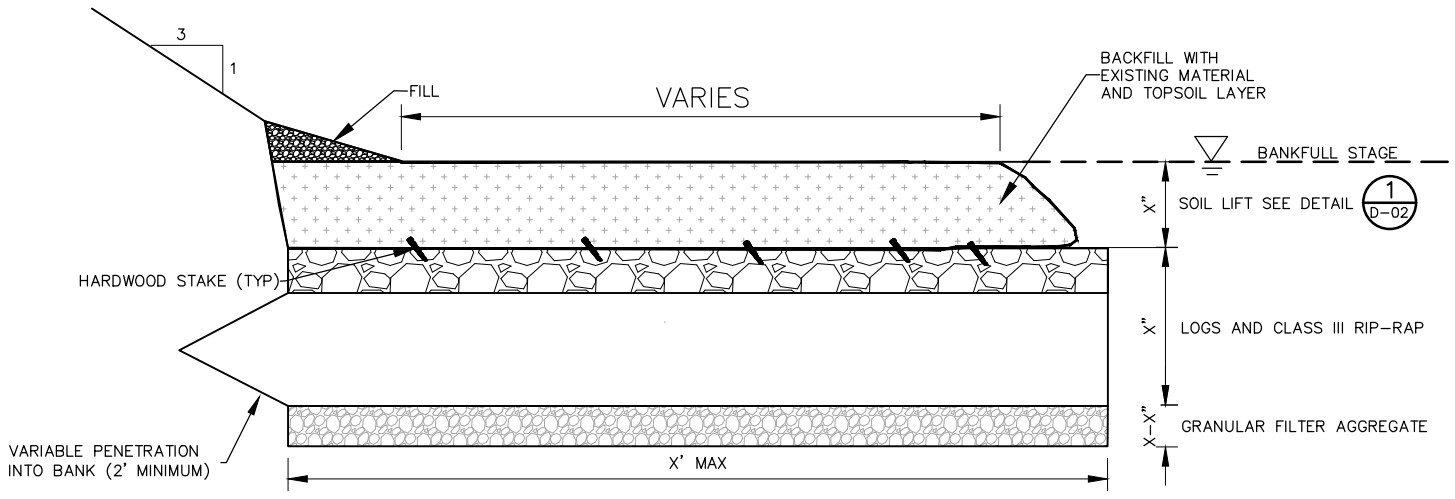
SECTION



PLAN

NOTES:

1. ENGINEER MUST BE NOTIFIED AT LEAST 3 DAYS PRIOR TO COMPOSITE ROCK WOOD BANK PROTECTION INSTALLATION AND MUST BE ON SITE DURING INSTALLATION.
2. EXCAVATE A LEVEL BENCH ALONG THE STREAMBANK TOE. PLACE COARSE FILTER AGGREGATE (MNDOT STANDARD SPECIFICATION 3149.2H) AS NECESSARY TO PROVIDE A STABLE FOUNDATION FOR LOGS AND BOULDERS (INCIDENTAL).
3. EITHER DRIVE THE LOG INTO THE BANK, OR WITH THE AUTHORIZATION OF THE ENGINEER EXCAVATE A TRENCH IN WHICH TO PLACE THE LOG. IF THE LOG IS DRIVEN INTO THE BANK, SHARPEN THE END OF THE LOG TO A POINT.
4. THE LOG MUST BE PLACED SUCH THAT THE LOG IS ANGLED UPSTREAM, AS SHOWN ON THE DRAWINGS AND AS DIRECTED BY ENGINEER.
5. THE PROCESS IS REPEATED FOR EACH ADDITIONAL LOG AS SHOWN ON THE DRAWINGS.
6. PLACE STONE RIPRAP MNDOT CLASS III ON EITHER SIDE OF THE TRUNK OF EACH LOG WITH A THICKNESS AND TO THE LIMITS SHOWN ON THE DRAWING AND AS DIRECTED BY ENGINEER.
7. PLACE BACK FILL OVER THE BOULDERS AS NECESSARY AND MATCH EXISTING GRADE WITH NO MORE THAN 4 INCHES OF TOPSOIL.
8. CONSTRUCT A 6 INCH SOIL LIFT AS SHOWN ON THE DRAWINGS.
9. TRIM THE LOGS THAT EXTEND BEYOND THE NEW BANK BENCH TO LENGTH AS DIRECTED BY ENGINEER.



DETAIL: COMPOSITE ROCK WOOD BANK PROTECTION

NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES

|| COMPOSITE ROCK WOOD BANK PROTECTION ||

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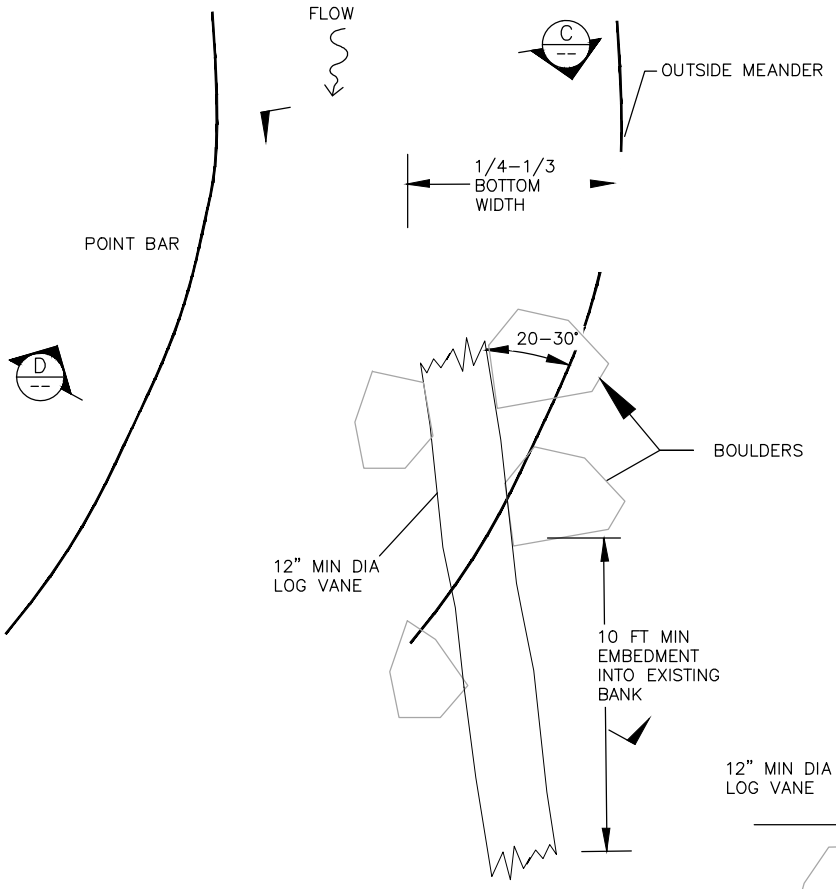
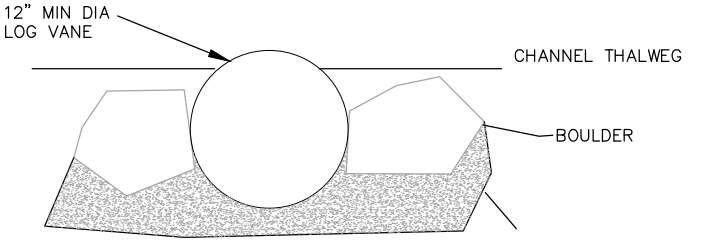


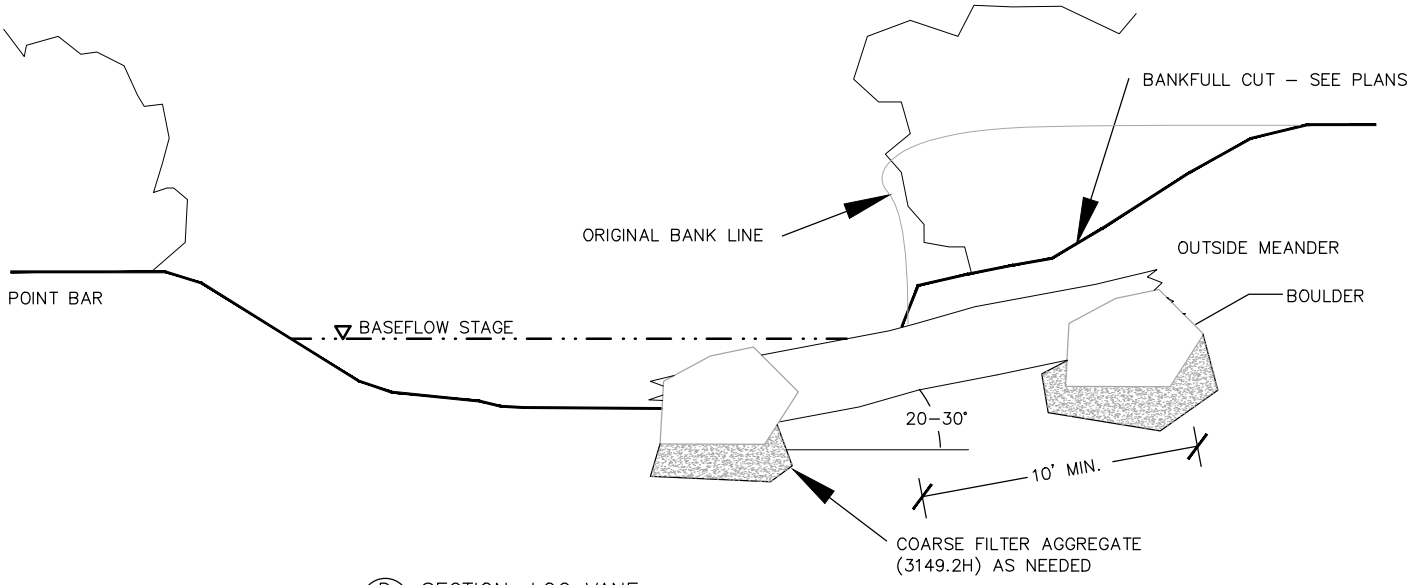
2 PLAN: LOG VANE
NOT TO SCALE

GENERAL NOTES:

1. THE ENGINEER MUST BE NOTIFIED AT LEAST 3 DAYS PRIOR TO LOG VANE INSTALLATION AND MUST BE ON SITE DURING INSTALLATION.
2. TO THE EXTENT POSSIBLE, LOG VANES SHOULD BE CREATED FROM TREES THAT WILL BE REMOVED FROM THE SITES WITHIN THE PROJECT AREA.
3. EITHER DRIVE THE LOG VANE INTO THE BANK, OR EXCAVATE A TRENCH IN WHICH TO PLACE THE LOG VANE. IF THE LOG VANE IS DRIVEN INTO THE BANK, SHARPEN THE END OF THE LOG VANE TO A POINT.
4. THE LOG VANE MUST BE PLACED AT APPROXIMATELY A 20–30 DEGREE ANGLE, OR AS DIRECTED BY THE ENGINEER.
5. THE LOG VANE MUST BE PLACED IN THE BANK SO THAT AT LEAST 2/3 OF THE LOG VANE IS EMBEDDED INTO THE BANK.
6. LARGE BOULDERS ARE PLACED ON BOTH SIDES OF THE LOG VANE AT THE INTERFACE WITH THE BANK.
7. LARGE BOULDERS ARE ALSO PLACED AT THE END OF THE LOG VANE IN THE CHANNEL AS DIRECTED BY THE ENGINEER.
8. PLACE COARSE FILTER AGGREGATE (MN/DOT STANDARD SPECIFICATION 3149.2H) AS BEDDING FOR BOULDERS IF NECESSARY.
9. MATCH EXISTING GRADE OR PLANNED GRADE AS APPROPRIATE WITH BACKFILL.
10. REVEGETATE AND STABILIZE WITH SEED AND MULCH AS SPECIFIED FOR EACH SITE AS SHOWN IN THE DRAWINGS AND DIRECTED BY THE ENGINEER.
11. EXCAVATE SCOUR HOLE IN STREAM BED ADJACENT TO LOG VANE AS DIRECTED BY THE ENGINEER.



C ELEVATION: LOG VANE
NOT TO SCALE



D SECTION: LOG VANE
NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES
|| LOG VANE ||

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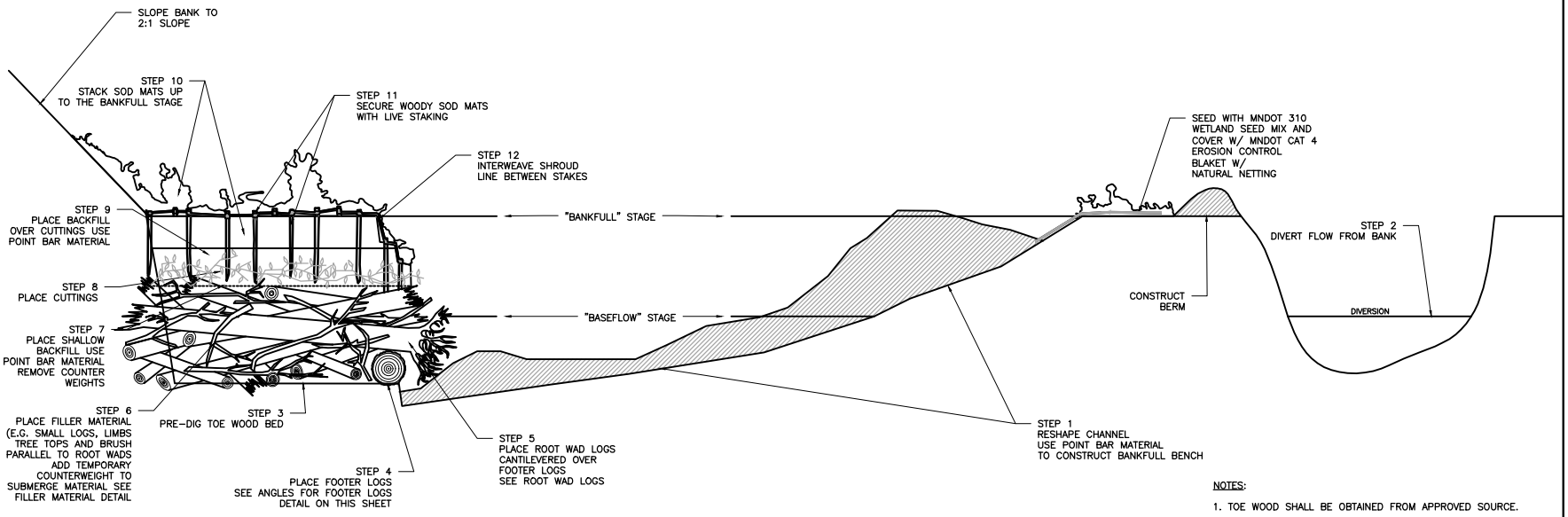
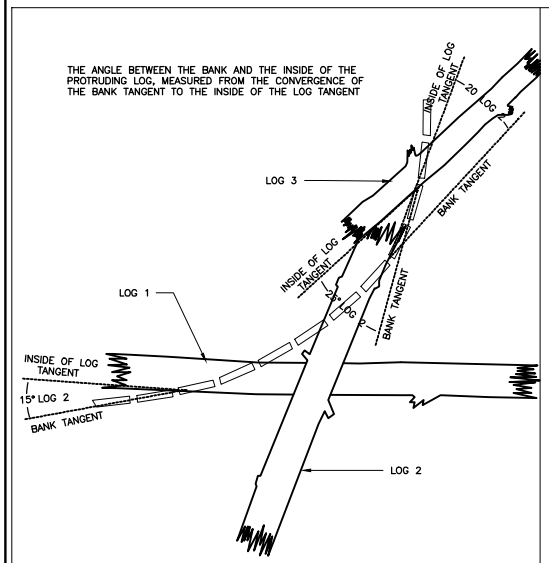


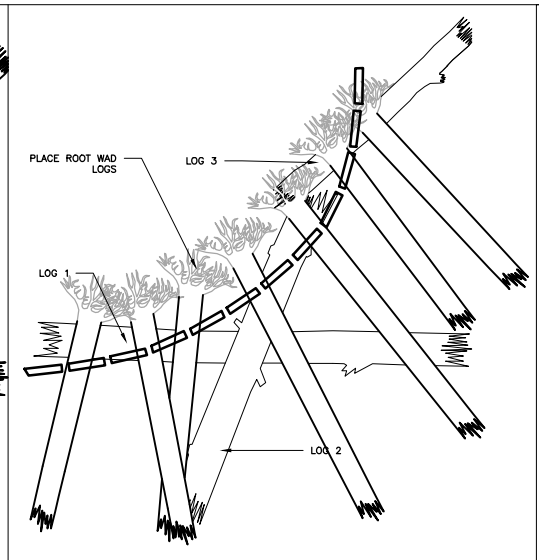
NOTES:

1. TOE WOOD SHALL BE OBTAINED FROM APPROVED SOURCE.
2. WOODY SOD MAT SHALL BE COLLECTED ON SITE. SOD MAT SHALL BE A MINIMUM OF 1' THICK AND CONSIST OF ALDER, DOGWOOD, OR WILLOW SPECIES.

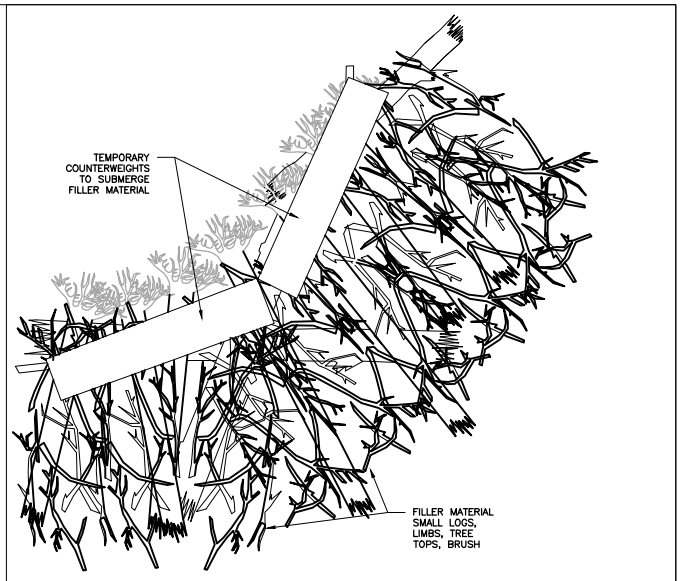
DETAIL: TOE WOOD SEQUENCING
NOT TO SCALE



DETAIL: ANGLES FOR FOOTER LOGS
NOT TO SCALE



DETAIL: ROOT WAD LOGS
NOT TO SCALE



DETAIL: FILLER MATERIAL
NOT TO SCALE

STREAM RESTORATION STANDARD PLATES

|| TOE WOOD SEQUENCING ||

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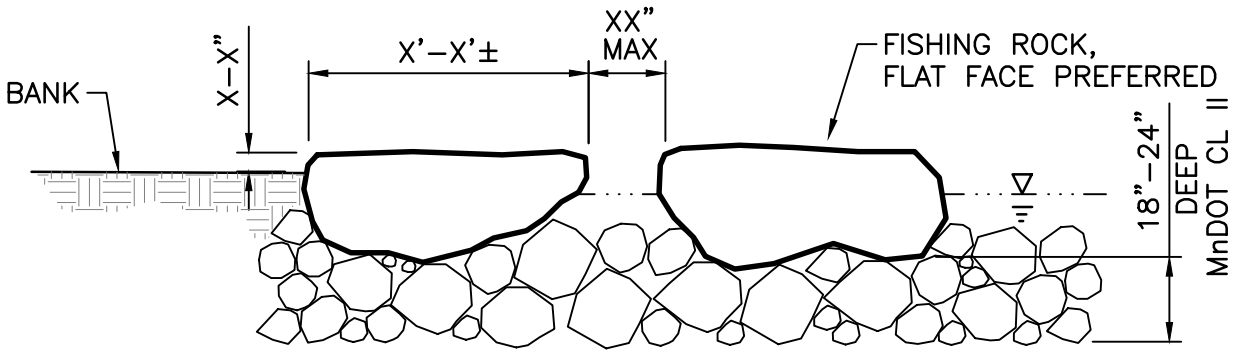

DETAIL: FISHING ROCK (TYP.)

NOTES:

1. ENGINEER WILL LOCATE FISHING ROCK LOCATIONS ONCE RIFFLES HAVE BEEN COMPLETED

2. FISHING ROCKS MUST BE APPROVED BY THE ENGINEER PRIOR TO PLACEMENT

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STREAM RESTORATION STANDARD PLATES

|| FISHING ROCKS ||

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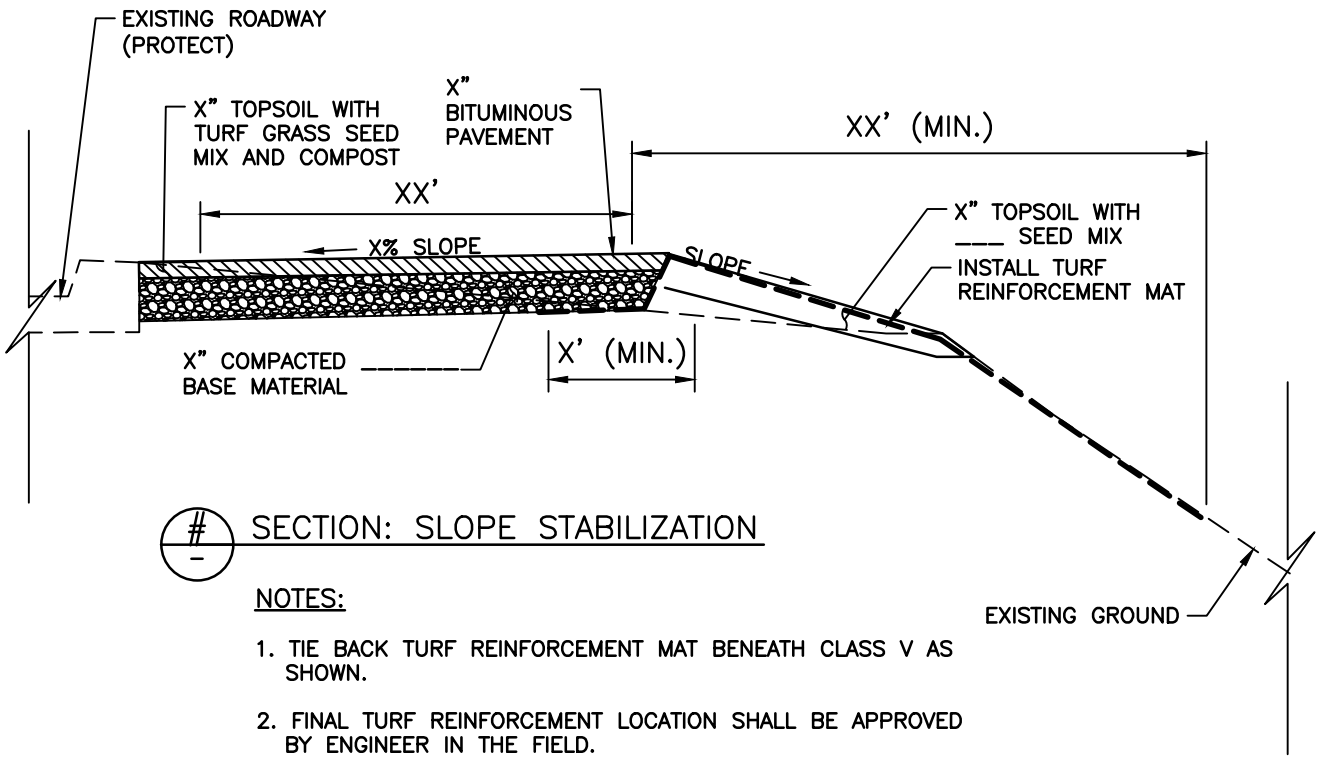

SECTION: SLOPE STABILIZATION

NOTES:

1. TIE BACK TURF REINFORCEMENT MAT BENEATH CLASS V AS SHOWN.
2. FINAL TURF REINFORCEMENT LOCATION SHALL BE APPROVED BY ENGINEER IN THE FIELD.

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STREAM RESTORATION STANDARD PLATES

|| SLOPE STABILIZATION ||

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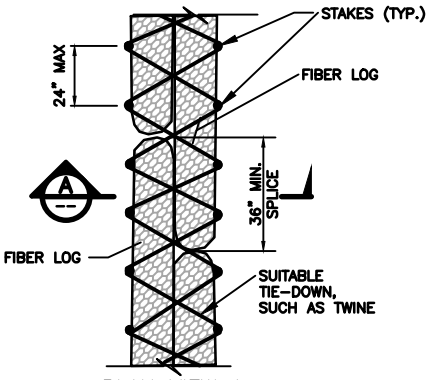
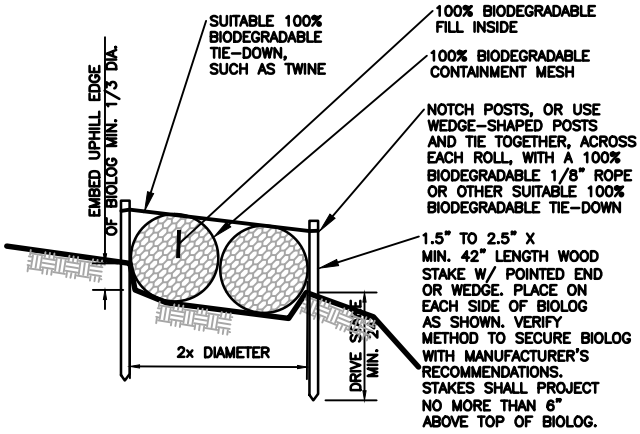
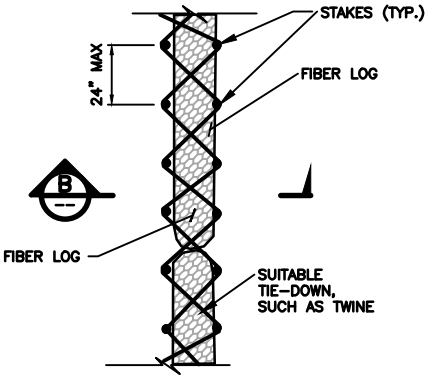


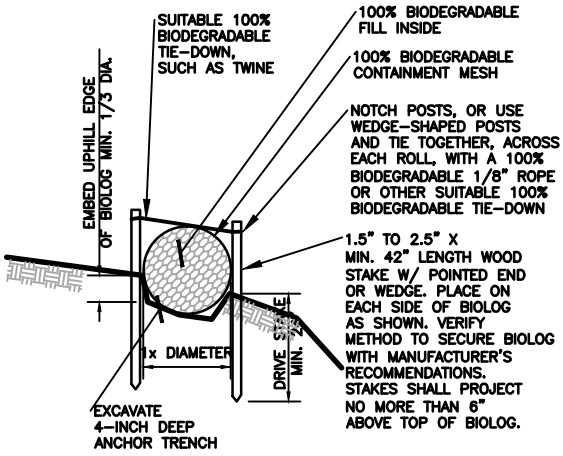
PLAN VIEW A
DOUBLE ROW



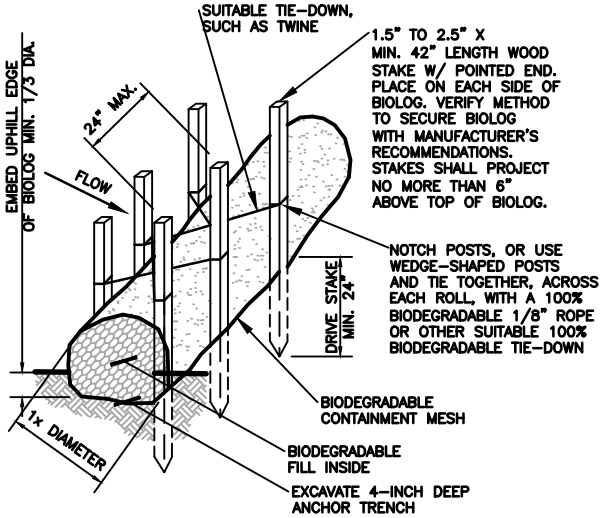
SECTION VIEW A
DOUBLE ROW



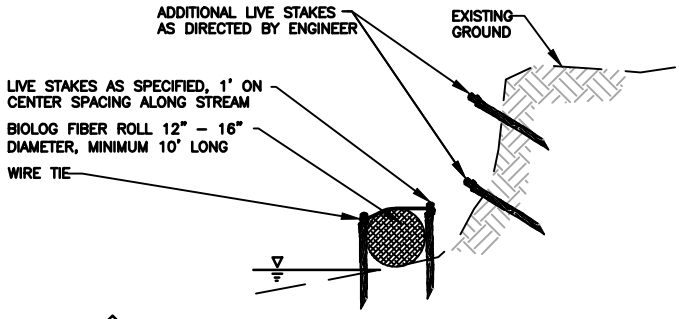
PLAN VIEW B
SINGLE ROW



SECTION VIEW B
SINGLE ROW



ISOMETRIC VIEW



DETAIL: BIOLOG SECURED WITH LIVE STAKES
NOT TO SCALE

DETAIL: BIODEGRADABLE EROSION CONTROL LOG (BIOLOG)
NOT TO SCALE

NOTES:
1. BIOLOG SHALL BE IN ACCORDANCE WITH _____.
2. CORE MATERIAL SHALL BE BIODEGRADABLE OR RECYCLABLE, SUCH AS COCONUT FIBERS OR OTHER ENGINEER–APPROVED MATERIAL. CORE MATERIAL SHALL BE COMPRESSED AND STUFFED INTO A NETTING.
3. CONTAINMENT MESH (NETTING) SHALL BE 100% BIODEGRADABLE MATERIAL SUCH AS BURLAP, TWINE, ETC.
4. BIOLOG SHALL BE PLACED AS INDICATED ON THE PLANS AND WITHIN 24 HOURS OF VEGETATATION REMOVAL.
5. SECURE BIOLOG IN A METHOD ADEQUATE TO PREVENT DISPLACEMENT AS A RESULT OF NORMAL RAIN EVENTS, SUCH THAT FLOW IS NOT ALLOWED UNDER THE BIOLOG. ALL MATERIALS USED TO SECURE BIOLOG SHALL BE 100% BIODEGRADABLE.
6. BIOLOG SHALL BE NO LESS THAN 9" IN DIAMETER.

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STREAM RESTORATION STANDARD PLATES
|| BIOLOGS ||

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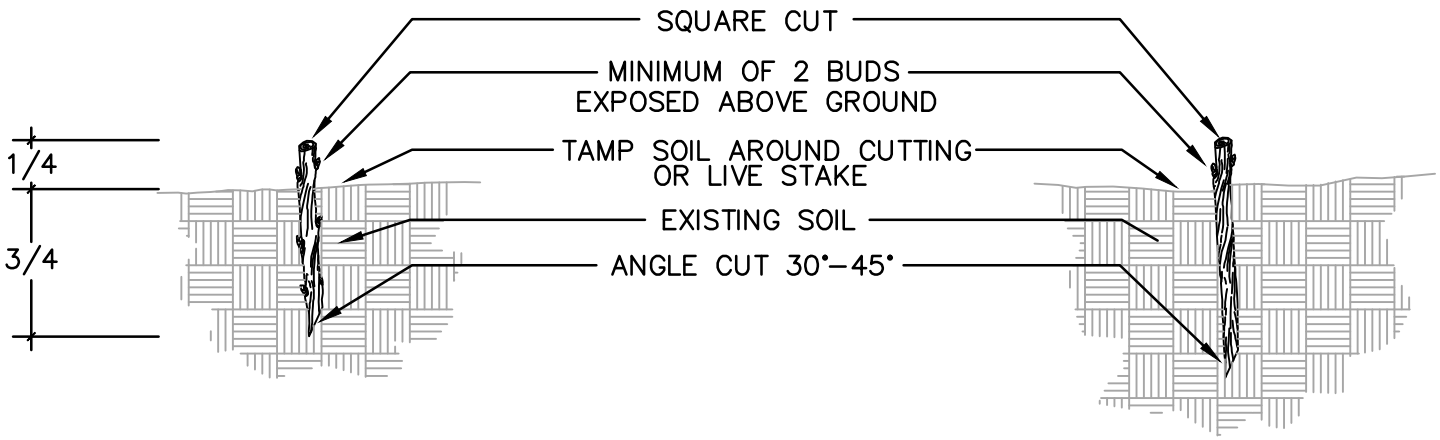
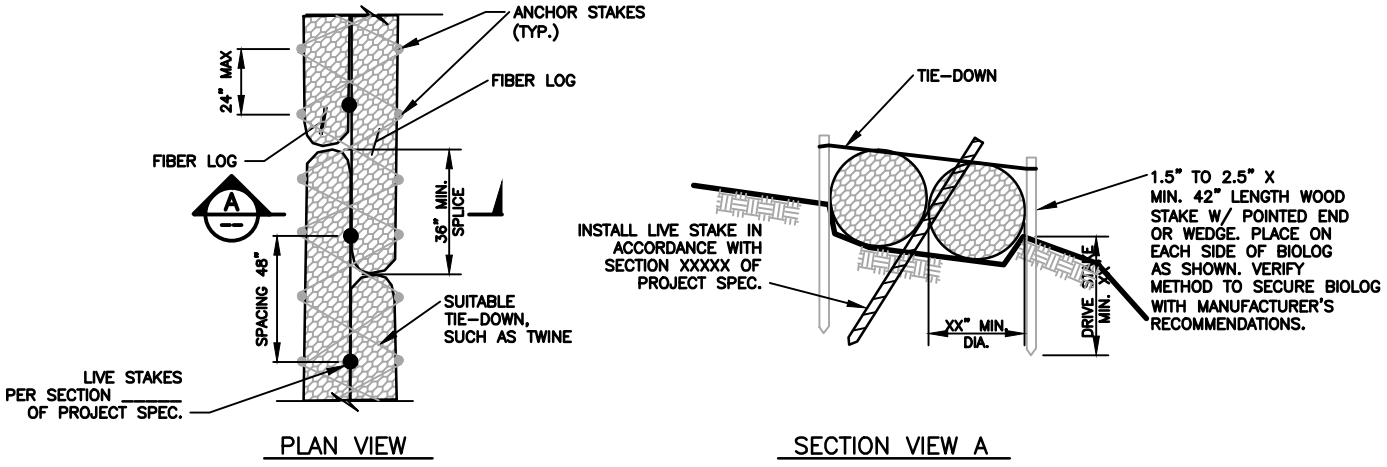


DETAIL: LIVE CUTTING OR LIVE STAKE
NOT TO SCALE

GENERAL NOTES:

1. LIVE STAKE OR CUTTING PLANTED PERPENDICULAR TO GROUND SURFACE.
2. SEE PLANT MATERIAL LIST FOR SPECIES LENGTH AND SPACING.
3. LIVE STAKES – 2" DIAMETER MINIMUM.



NOTES:
1. LIVE STAKES SHALL BE INSTALLED IN ACCORDANCE WITH SECTION XXXXX OF THE PROJECT SPECIFICATIONS

DETAIL: LIVE STAKES
NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES
|| LIVE CUTTINGS / LIVE STAKES ||
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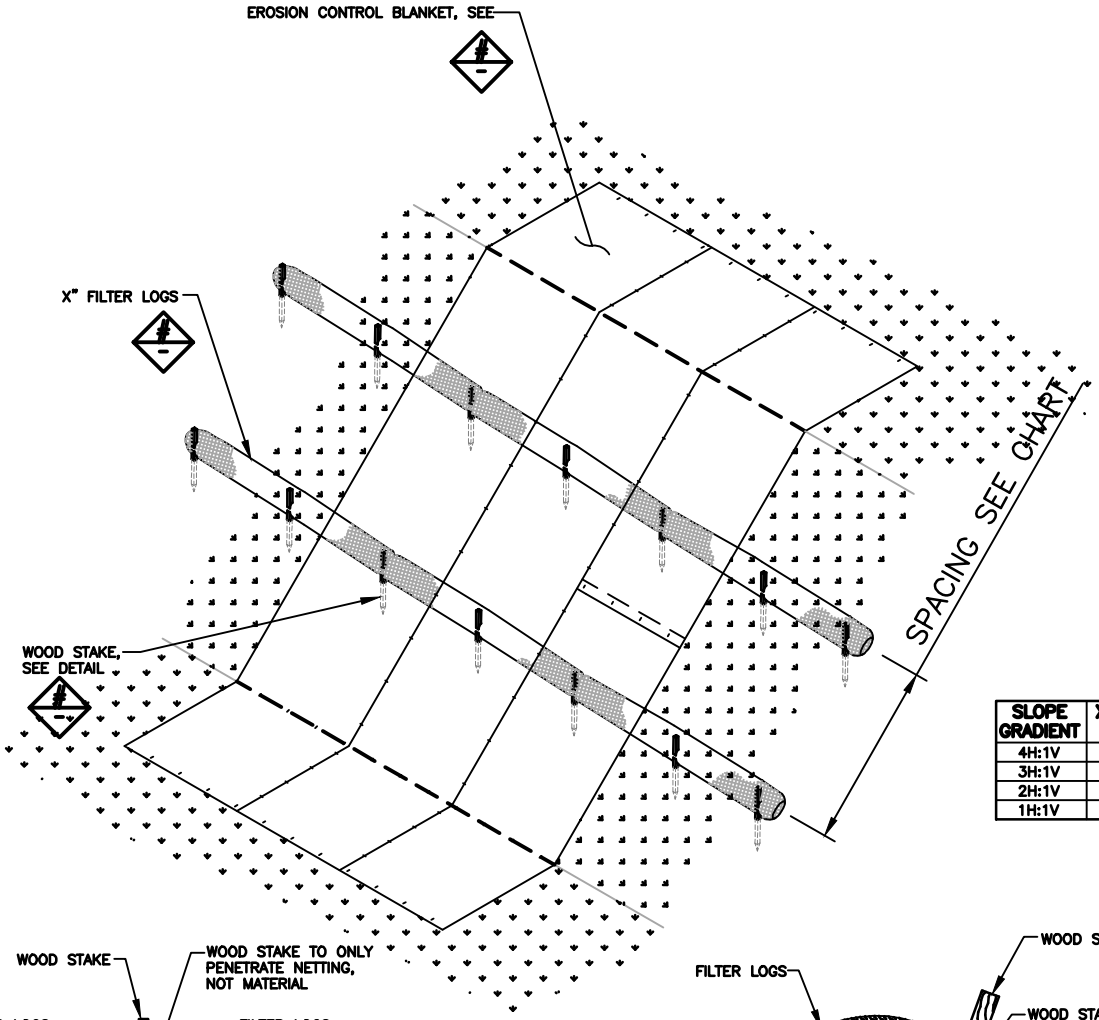
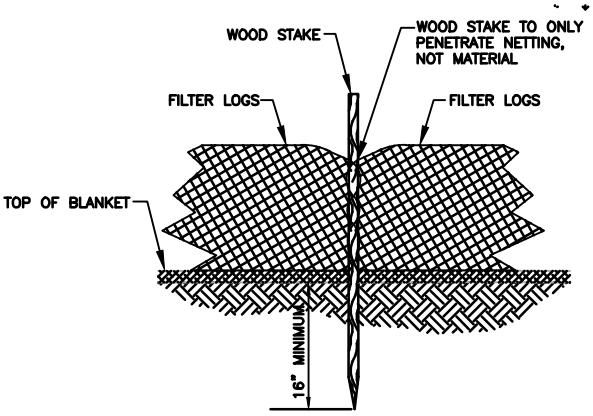
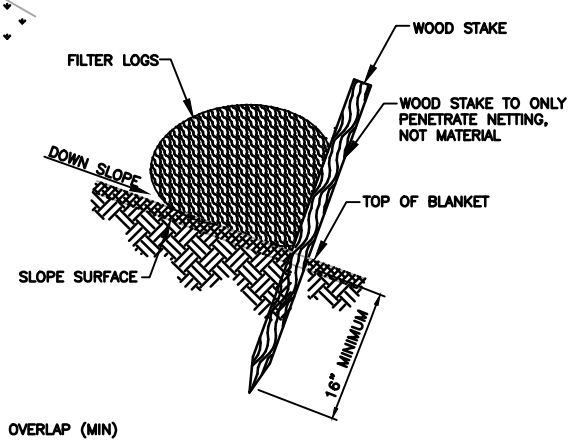


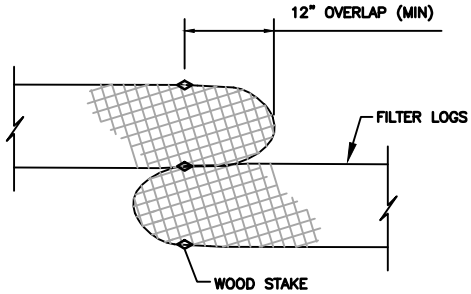
SLOPE GRADIENT	X" FILTER LOG (ft)
4H:1V	20
3H:1V	15
2H:1V	10
1H:1V	5



STAKE DETAIL—FRONT VIEW



STAKE DETAIL—TOP VIEW



FILTER LOG OVERLAP

DETAIL: FILTER LOGS
NOT TO SCALE

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STREAM RESTORATION STANDARD PLATES
|| FILTER LOGS ||

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FIELD REQUIREMENTS

The following storm water pollution prevention field requirements are required:

– CONTRACTOR must install all down gradient perimeter controls before any up gradient disturbance begins, and maintained until final stabilization.

– All erosion control measures must be installed and maintained by CONTRACTOR according to the details included in the construction documents. All silt must be removed from silt fence by CONTRACTOR when it reaches a height equal to one–third of the height of the silt fence. The CONTRACTOR must perform any corrective measures within 24 hours of such notice. The CONTRACTOR shall also place any additional erosion control measures deemed necessary by MPCA within 24 hours of notice.

– Timing and installation of sediment control devices can be adjusted by CONTRACTOR to accommodate short–term activities such as clearing and grubbing.

– Rock construction entrances or equivalent system must be installed by CONTRACTOR to minimize tracking from site. Construction entrances will be checked daily by CONTRACTOR. If the entrance becomes inundated with sediment, the entrance will be cleaned or replaced as appropriate by CONTRACTOR.

– If present, all storm sewer inlets and outlets shall be protected by CONTRACTOR with appropriate BMP's during the work. These practices shall remain in place until the potential sources for discharging sediment to inlets have been stabilized by CONTRACTOR.

– Streets leading to and from the construction entrance shall be checked daily by CONTRACTOR for evidence of off–site sediment tracking onto paved surfaces. These areas will be swept clean of any tracked materials by CONTRACTOR as soon as possible and within 24 hours of discovery. CONTRACTOR shall extend sweeping to the extremity of any sediment tracking that occurs off site.

– CONTRACTOR's dewatering activities that have sediment–laden discharge must discharge into a temporary or permanent sedimentation basin when possible, otherwise it must be discharged through some form of best management practice (BMP) by CONTRACTOR to limit sediment from leaving the site.

– The CONTRACTOR must implement the SWPPP and install BMPs identified in the SWPPP in an appropriate and functional manner.

– The location of areas not to be disturbed must be delineated on the site before construction begins.

– All exposed areas with a continuous positive slope within 200 feet of a surface water must have temporary erosion protection or permanent cover installed by CONTRACTOR for the exposed soil area, year round. The following maximum times and area can remain open when the areas are not actively being worked:

1. Slopes steeper than 1:3 (7 days).
2. Slopes of 1:10 to 1:3 (7 days).
3. Slopes of 1:10 or flatter (7 days).

– The normal wetted perimeter of any temporary or permanent drainage ditch that drains water from a construction site or diverts water around a site must be stabilized by CONTRACTOR within 200 feet from the property edge, or from the point of discharge to any surface water within 24 hours of connecting to a surface water.

– CONTRACTOR shall be responsible for keeping existing paved surfaces clean of sediment. Any sediment tracked off–site is to be removed by CONTRACTOR within 24 hours.

– CONTRACTOR shall be responsible for implementing the following pollution management measures on the site:

1. Solid waste: collected sediment, asphalt, concrete millings, floating debris, paper, plastic, fabric, construction and demolition debris and other wastes must be disposed of properly and must comply with MPCA disposal requirements.
2. Hazardous materials: oil, gasoline, paint and any hazardous substances must be stored in appropriate containers. Including secondary containment to prevent spills, leaks or other discharges. Restricted access to storage areas must be provided to prevent vandalism. Storage and disposal of hazardous waste must comply with MPCA regulations.
3. A defined area of the site must be designated for use as a wash area for trucks and other equipment. No engine degreasing allowed on site.

– CONTRACTOR shall install silt fence protection around the limits of all temporary soil stockpile areas. All stockpiles that remain undisturbed for a period greater than one month shall be protected by CONTRACTOR with cover of mulch, erosion control mats, or plastic sheeting.

– Temporary and permanent sedimentation basins must be drained and sediment removed by CONTRACTOR once the sediment collected reaches one third the storage volume within 72 hours, as field conditions allow.

– All sediment deposits within surface waters must be removed and restabilized by CONTRACTOR within 7 days of discovery. This includes deltas and storm sewer sediment deposits.

– During excavation, sediment and erosion control devices must be utilized by CONTRACTOR to prevent sedimentation and the area must be staked off and marked so that heavy construction equipment will not compact the soil.

– All infiltration/filtration areas must be inspected to ensure that no sediment from ongoing construction is accumulating over the infiltration/filtration area. Sediment accumulated over infiltration/filtration must be removed by CONTRACTOR.

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STREAM RESTORATION STANDARD PLATES

|| NOTES ||

This template is for REFERENCE ONLY and should be carefully considered and edited to match the project's specific situation.

Appendix L

Reach-appropriate treatments and representative photos

Appendix L
Reach-appropriate treatments and representative photos

Reach	Classification	Applicable Habitat and Bank Treatments*	Photo and Name of Representative Treatment	Potentially Applicable Design Detail (Located in Appendix K)
1	B-2	None recommended	NA	NA
2	B-2	Woody or deep-rooted plant buffers, log/rock vanes in select locations	 **Log vane**	Root wad, double boulder vane, log vane
3	F-3	Woody or deep-rooted plant buffers, re-meander, log/rock vanes at toe of bank and in-stream, grading for floodplain access, buffer/watering lane development, in-stream wood cover placements	 **Floodplain grade re-vegetation**  **Floodplain grading**  **Root wad**	Bank barb, bank deflector, double boulder vane, root wad, boulder riffle, log vane

Reach	Classification	Applicable Habitat and Bank Treatments*	Photo and Name of Representative Treatment	Potentially Applicable Design Detail (Located in Appendix K)
4	C-4	VRSS, toe wood, rock and/or log vanes, in-stream wood cover placements	 **VRSS**	VRSS, toewood, composite rock/wood bank protection, curved vortex rock weir
			 **Toewood**	
			 **VRSS New**	
5	C-4	VRSS, log/rock vanes, J-hook vanes and/or cross vanes, toewood	 **Vane**	Curved vortex rock weir, toewood, composite rock/wood bank protection, VRSS

* Applicable techniques based on Rosgen (1996) and best professional judgment of the assessment team; site specific applications/dimensions to be determined during project design; all habitat or bank treatments recommended can directly or indirectly improve fish habitat