CANE AND MARYS STREAM RESTORATION

FINAL MITIGATION PLAN

Alamance County, North Carolina
SCO Project Number 01055150A

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Prepared for:
North Carolina Ecosystem Enhancement Program
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Status of Plan: Final
Submission Date: June 6, 2006

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EXECUTIVE SUMMARY

The North Carolina Ecosystem Enhancement Program (EEP) restored 2,081.8 linear feet of Unnamed Tributary (UT) to Cane Creek located on the McPherson properties, south of Snow Camp, in Alamance County, North Carolina and 2,231.7 linear feet of two UTs to Marys Creek located on the Dixon property southeast of Saxapahaw, in Alamance County, North Carolina. In addition, just over five acres of riparian buffer was restored at each site. At the UT to Cane Creek, construction of the project began on November 8, 2005, the stream restoration was completed on February 28, 2006 and planting was completed on March 7, 2006. At the UT to Marys Creek project, construction began on January 5, 2006, the stream restoration was completed on March 10, 2006 and planting was completed on March 15, 2006. Four bankfull events occurred during construction.

PRE-CONSTRUCTION SITE CONDITIONS

The UT to Cane Creek flows in a general southwest to northeast direction on the McPherson properties off of Snow Camp Road (SR 1004) and has a drainage area of 2003 acres. Prior to construction, the 2,208 linear foot project reach was relatively sinuous upstream but downstream grew wider and straighter suggesting channelization. Cattle also had unfettered access to the UT to Cane Creek causing bank erosion, vegetation degradation, and decreased water quality. The channel was classified as an unstable C4 channel type.

The UT to Marys Creek project area is divided into two reaches: the main channel and the tributary. The main channel flows south to north through the project area before making a more than 90-degree turn to the east. The tributary flows in from the south and joins the main channel in the upstream portion of the reach. The project is located on the southeast corner of the Dixon property off of Dixon Lamb Road (SR 2336) and has a total drainage area of 1,145 acres. The banks of both reaches were severely eroded and unstable with little or no riparian buffer. Cattle have unlimited access to the stream channels, and as many as 30 crossings were observed in the project reaches. The tributary and the smaller upstream portion of the main channel were classified as unstable C4 channel types while the downstream portion of the main channel was classified as an F4 channel type.

RESTORATION PLAN

Priority 2 stream restoration was carried out on each of the reaches resulting in restored C type channels. Cattle were excluded from each of the newly planted riparian areas. Streambanks, the floodplain and the upland areas within the easements were all planted with vegetation to stabilize the channel and provide shading, food, and habitat as well as a vegetated buffer to treat surrounding overland flows. Six acres of riparian buffer were restored on the UT to Cane Creek and 5.4 acres on the UT to Marys Creek. Infiltration in the riparian buffer zones will help improve water quality in the creeks.

The pre-construction and restored lengths on the UT to Cane Creek vary from the original restoration plan due to onsite constraints, including property boundaries and bedrock, that shortened the proposed project length by approximately 100 feet.

POST CONSTRUCTION SITE CONDITIONS

Project goals and objectives for the UT to Cane Creek and the UT to Marys Creek projects included:

1. Improving water quality;
2. Providing wildlife habitat through the creation of a riparian zone;
3. Improving aquatic habitat with the use of natural material stabilization structures and a riparian buffer;
4. Excluding cattle from the stream;
5. Reducing nutrient loads from entering the stream via the buffer acting as a filter exclusion of cattle;
6. Increasing the stream's access to its floodplain; and
7. Reducing erosion and sedimentation.

The following table summarizes pre- and post-construction stream lengths as well as the restoration approach implemented.

Table 1. Project Reaches Summary Table

Reach	Pre-Construction Length (ft)	Restored Length (ft)	Restoration Approach
UT to Cane Creek	2,301	2,231.7	Changed dimension, pattern, and profile using Priority 2 restoration.
UT to Marys Creek (Main Channel)	1,750	1,631.8	Changed dimension, pattern, and profile using Priority 2 restoration.
UT to Marys Creek (Tributary)	360	450	Changed dimension, pattern, and profile using Priority 2 restoration.
Total	**4,411**	**4,313.5**	

MONITORING PLAN

Mulkey Engineers & Consultants conducted the as-built survey and Stantec will conduct the first year survey. Stantec will monitor the site as per the monitoring schedule submitted in this mitigation plan for the first year (2006). The monitoring will include visual assessments of the site once every quarter (three times) following construction. These assessments are intended to identify any problem areas early, in order to allow for quick remedial measures. At the end of the first year following construction, Stantec will carry out a technical assessment of the site (e.g., detailed surveys, stem counts, photographs, pebble counts) and compile the data. Two permanent cross-sections and one vegetative sampling plot were installed on each of the three reaches. These areas will be monitored based on an adapted methodology that utilizes 3-D survey technology with the methodology contained in the USDA Forest Service Manual, Stream Channel Reference Sites (Harrelson, et. al, 1994). Baseline "as-built" information including cross-sectional measurements, longitudinal surveys, and vegetation data were gathered from each site in May 2006 and is presented in this report.

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1.0 Narrative

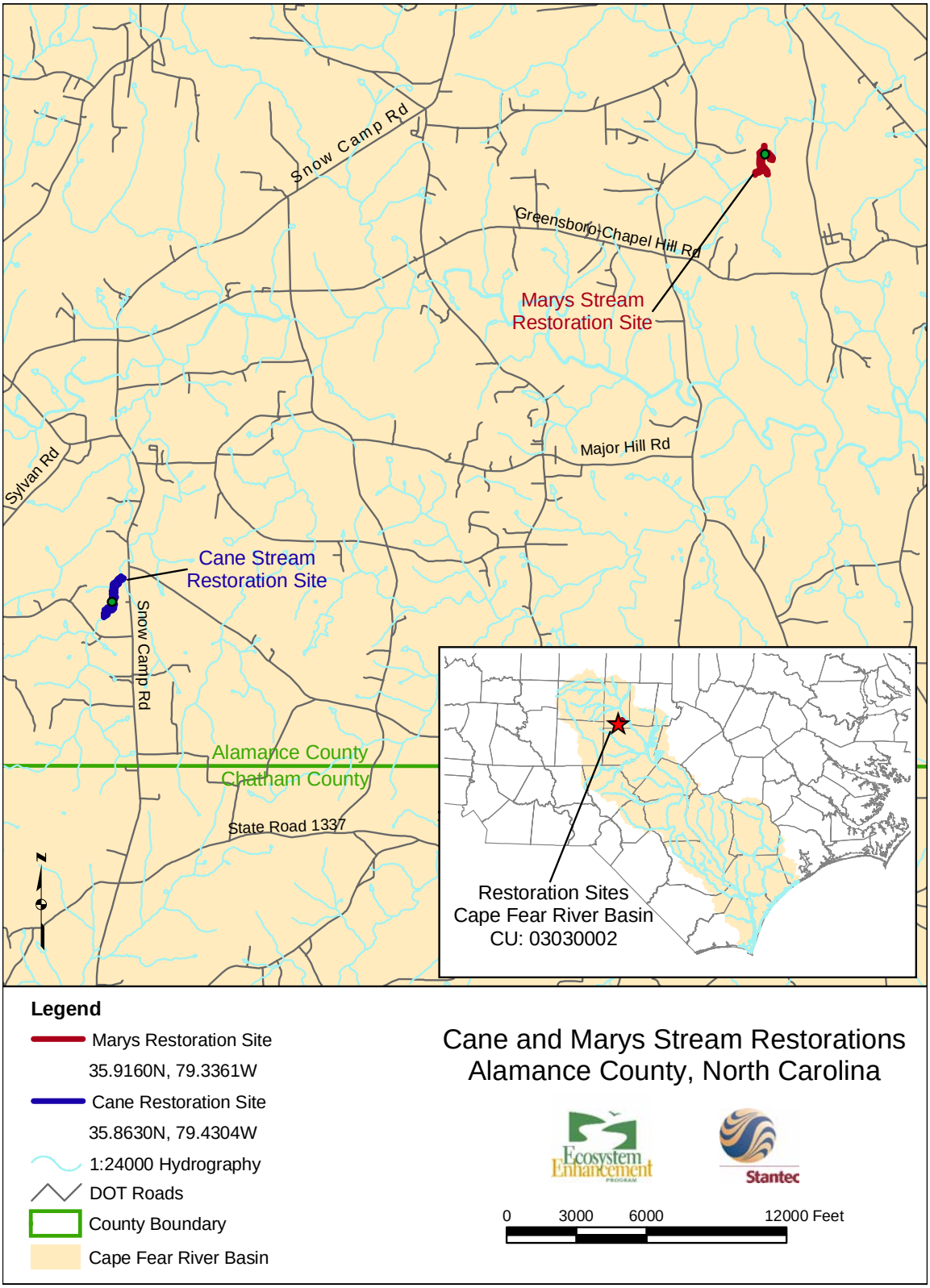
1.1 INTRODUCTION

The UT to Cane Creek Restoration Site is located on the Stephen and Tammy McPherson and Herbert and Yvonne McPherson properties off Snow Camp Road (SR 1004) south of Snow Camp, North Carolina. The UT to Marys Creek Restoration Site is located on the Dixon property off of Dixon Lamb Road (SR 2336), east of Lindley Mill Road (SR 1003) and northwest of the Eli Whitney community (See map in Section 1.3). Both projects are located in Alamance County, North Carolina, in the Cape Fear 03030002 Cataloging Unit (CU).

The UT to Cane Creek is a third order stream that flows in a general southwest to northeast direction on the McPherson properties and has a drainage area of 2003 acres. The conservation easement is approximately 6.9 acres. Prior to construction, the 2,301 linear foot project reach was relatively sinuous upstream but downstream grew wider and straighter suggesting channelization. Cattle also had unfettered access to the UT to Cane Creek causing bank erosion, vegetation degradation, and decreased water quality. The channel was classified as an unstable C4 channel type. Wetland restoration was not undertaken at the UT to Cane Creek site.

The UT to Marys Creek project area is divided into two reaches: the main channel and the tributary. The main channel is a third order channel and flows south to north through the majority of the project area before making a more than 90 degree turn to the east. The tributary is a first order stream that flows in from the south and joins the main channel in the upstream portion of the reach. The project is located on the southeast corner of the Dixon property off of Dixon Lamb Road (SR 2336) and has a total drainage area of 1,145 acres. The project is contained within a 6.8 acre conservation easement. The banks of both reaches are severely eroded and unstable with little or no riparian buffer. Cattle have unlimited access to the stream channels, and as many as 30 cattle crossings were observed in the project reaches. The tributary and the smaller upstream portion of the main channel were classified as unstable C4 channel types while the downstream portion of the main channel was classified as an F4 channel type. Wetland restoration was not undertaken at the UT to Marys Creek site.

1.2 LOCATION MAP



1.3 RESTORATION SUMMARY

The stream restorations were based upon the principles of natural channel design. Every effort was made to consider future land use changes within each watershed while completing the designs. Priority 2 stream restoration was carried out on each of the reaches resulting in restored C type channels. The pattern, dimension, and profile were restored throughout the two project sites. Rock structures and root wads were installed to provide further stability to the streams. Cattle were excluded from each of the newly planted riparian areas. Streambanks, the floodplain and the upland areas within the easements were all planted with vegetation to stabilize the channel and provide shading, food, and habitat as well as a vegetated buffer to treat surrounding overland flows. Six acres of riparian buffer were restored on the UT to Cane Creek and 5.4 acres on the UT to Marys Creek. Infiltration in the riparian buffer zones will help improve water quality in the creeks.

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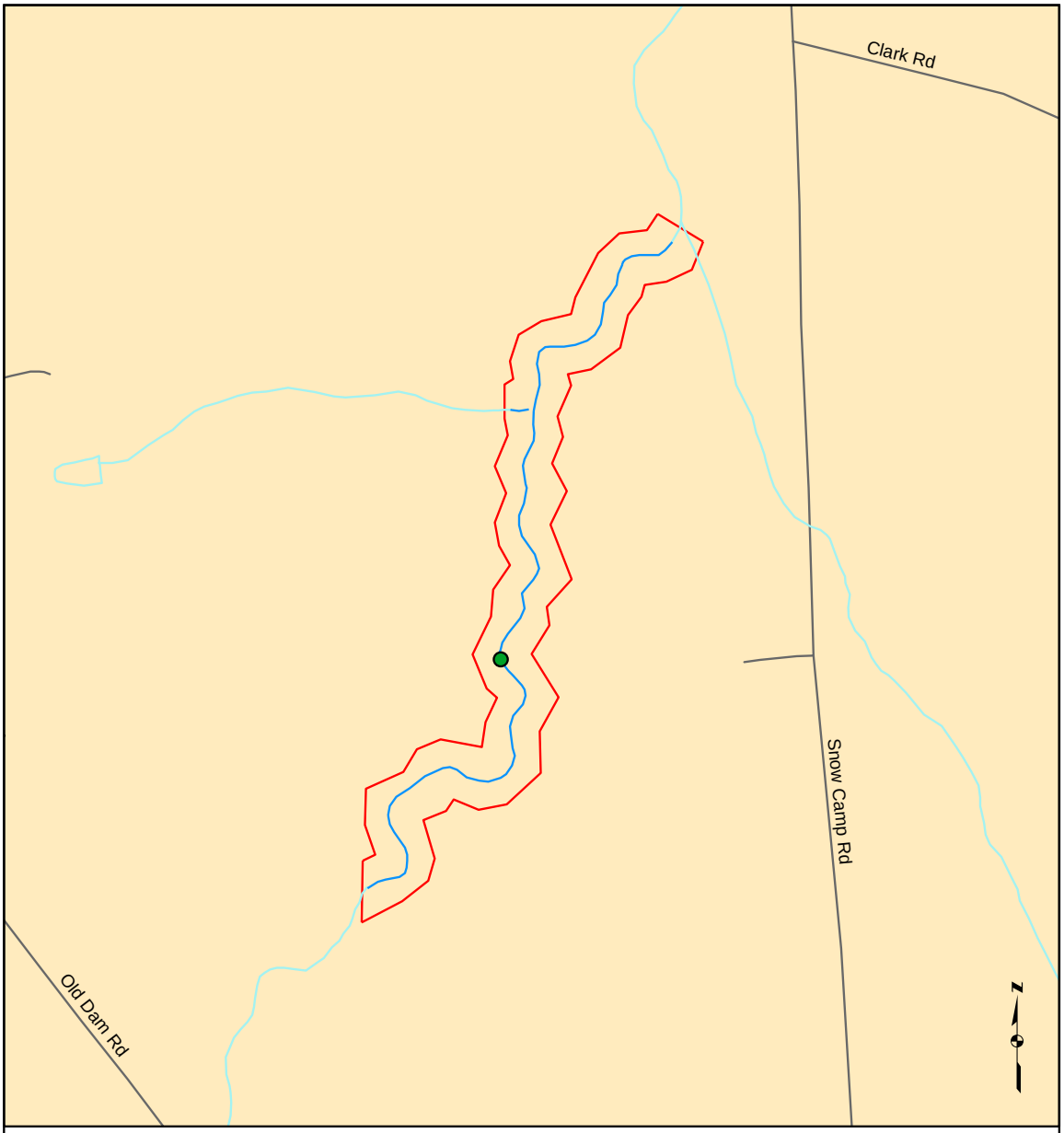
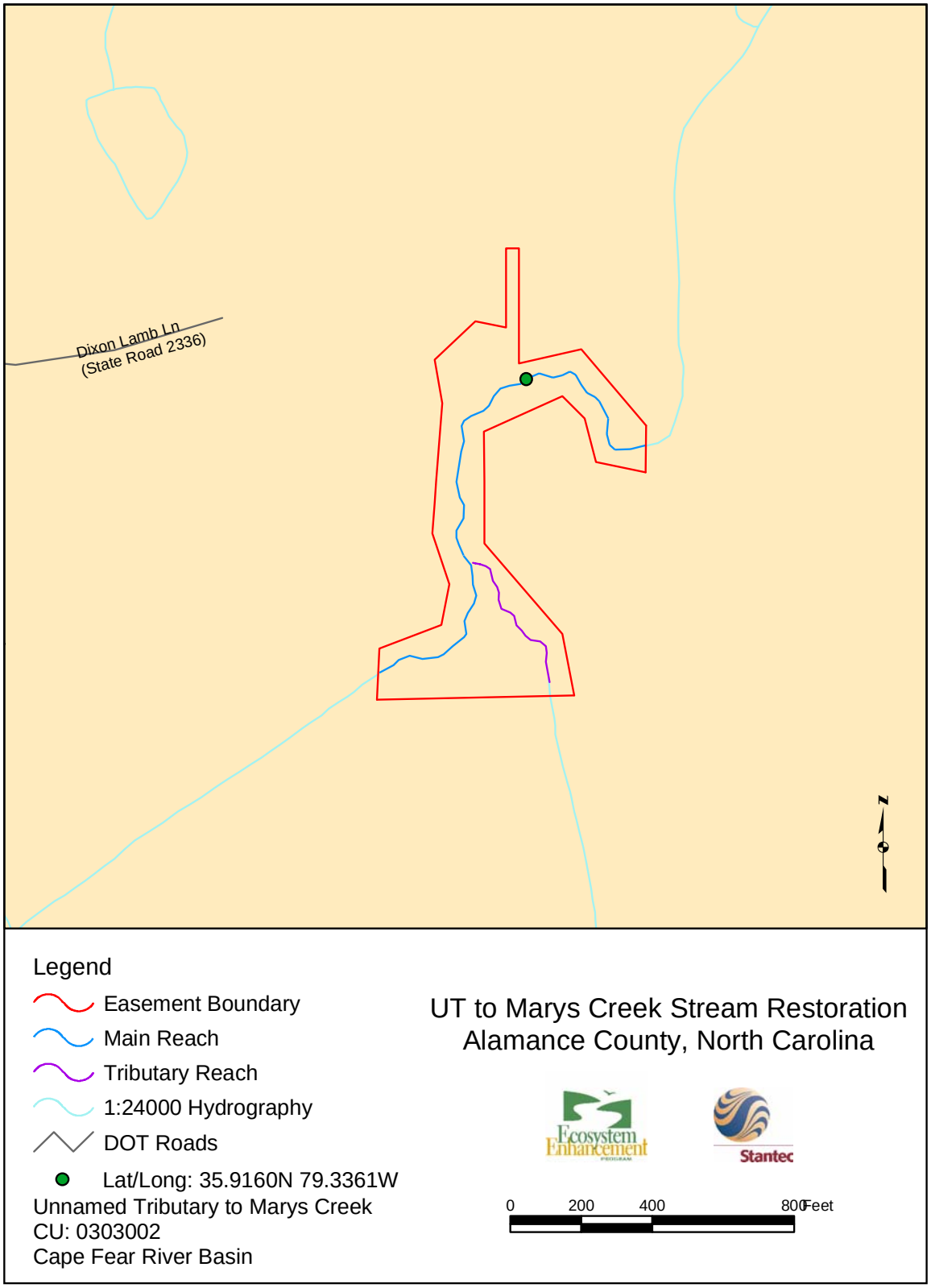
The pre-construction and restored lengths on the UT to Cane Creek vary from the original restoration plan due to onsite constraints, including property boundaries and bedrock, that shortened the proposed project length by approximately 100 feet.

1.4 UT TO CANE CREEK PROJECT MAP



1.5 UT TO MARYS CREEK PROJECT MAP



1.6 SUMMARY TABLE

Parameter	UT to Cane Creek	UT to Marys Creek (Main Channel)	UT to Marys Creek (Tributary Reach)
Pre-construction stream length	2,301 lf	1,750 lf	360 lf
Restored stream length	2,231.7 lf	1,631.8 lf	450 lf
Wetlands	None	None	None
Riparian buffer restoration	6.9 acres	5.4 acres	
Restoration level	Priority 2 Restoration	Priority 2 Restoration	Priority 2 Restoration
Proposed credit ratio	1:1	1:1	1:1
SMU	2,231.7	1,631.8	450

2.0 As-Builts

Pocket 1: Unnamed Tributary to Cane Creek

Pocket 2: Unnamed Tributary to Marys Creek

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3.0 Monitoring Plan

The stability of the stream channel will be monitored annually for five years or until success criteria are met. Three reaches (two permanent cross-sections in each reach) will be monitored for dimension, pattern and profile as detailed below. The longitudinal profile will be a minimum of 20 bankfull widths or 200 feet. As vegetation establishes and the channel stabilizes, the channel's cross-section is expected to tighten slightly; however, the cross-section should not indicate downcutting or widening. Monitoring efforts will evaluate any changes by overlaying each year's cross-section and longitudinal profile with the previous years' for comparison. In addition, photo reference points are included on the "as-built" plans. Photos were taken at each site shortly after construction and are included in Appendix 1.

3.1 HYDROLOGY

Any changes to land use in the two watersheds that would affect changes to flow within the project streams will be assessed over the five-year monitoring period. As per the project scope, Stantec will not be measuring flows with peak stage recorders.

3.2 PROFILE

A longitudinal profile survey, at least 20 bankfull widths in length, will be completed at each reach each monitoring year. Additional data collected will include riffle length, riffle slope, pool length and pool spacing. Success will be measured based on whether the channel features stay within the natural variability of the dimensionless ratios of the reference reaches and that there is no observed channel eveolution. The "as-built" longitudinal survey for each reach is included in Appendix 2.

3.3 PATTERN

During the longitudinal survey each year, additional pattern data will be collected including channel beltwidth, radius of curvature, meander wavelength and meander width ratio. Stability will be visually assessed. Success will be measured based on whether the channel features stay within the natural variability of the dimensionless ratios of the reference reaches and that there is no observed channel eveolution.

3.4 DIMENSION

Two cross-sections on each reach (six total) will be characterized each monitoring year. Permanent cross section pins were installed in each of the six cross sections. Data collected will include, at a minimum, cross-sectional area, bankfull width, bankfull mean depth, bankfull max depth, floodprone width, width to depth ratio, and entrenchment ratio. Stream type will be determined in riffle cross-sections only. Success will be measured based on whether the channel features stay within the natural variability of the dimensionless ratios of the reference reaches and that there is no observed channel evolution. The "as built" cross-sections are included in Appendix 3.

3.5 BED MATERIAL

Pebble counts will be completed in a typical riffle section of each reach each monitoring year using the modified Wolman Pebble Count procedure (Rosgen, 1994). Data reported will include the d50 and d84 particle sizes. The "as-built" pebble counts are included in Appendix 4.

3.6 VEGETATION

Vegetative sample plots will be quantitatively monitored during the growing season. One $100m^2$ plot was established for each of the three stream reaches (three plots total). Species composition, density, and survival will be monitored. In each plot, two plot corners, opposite one another, were permanently located with rebar and included in the "as-built" plans.

The vegetative success of the riparian buffer will be evaluated based on the species density and survival rates. According to the US Army Corps of Engineers Stream Mitigation Guidelines (USACE, 2003), vegetation monitoring will be considered successful if at least 260 trees/acre are surviving at the end of five years. The "as-built" stem counts within each of the vegetative monitoring plots is included in Appendix 5.

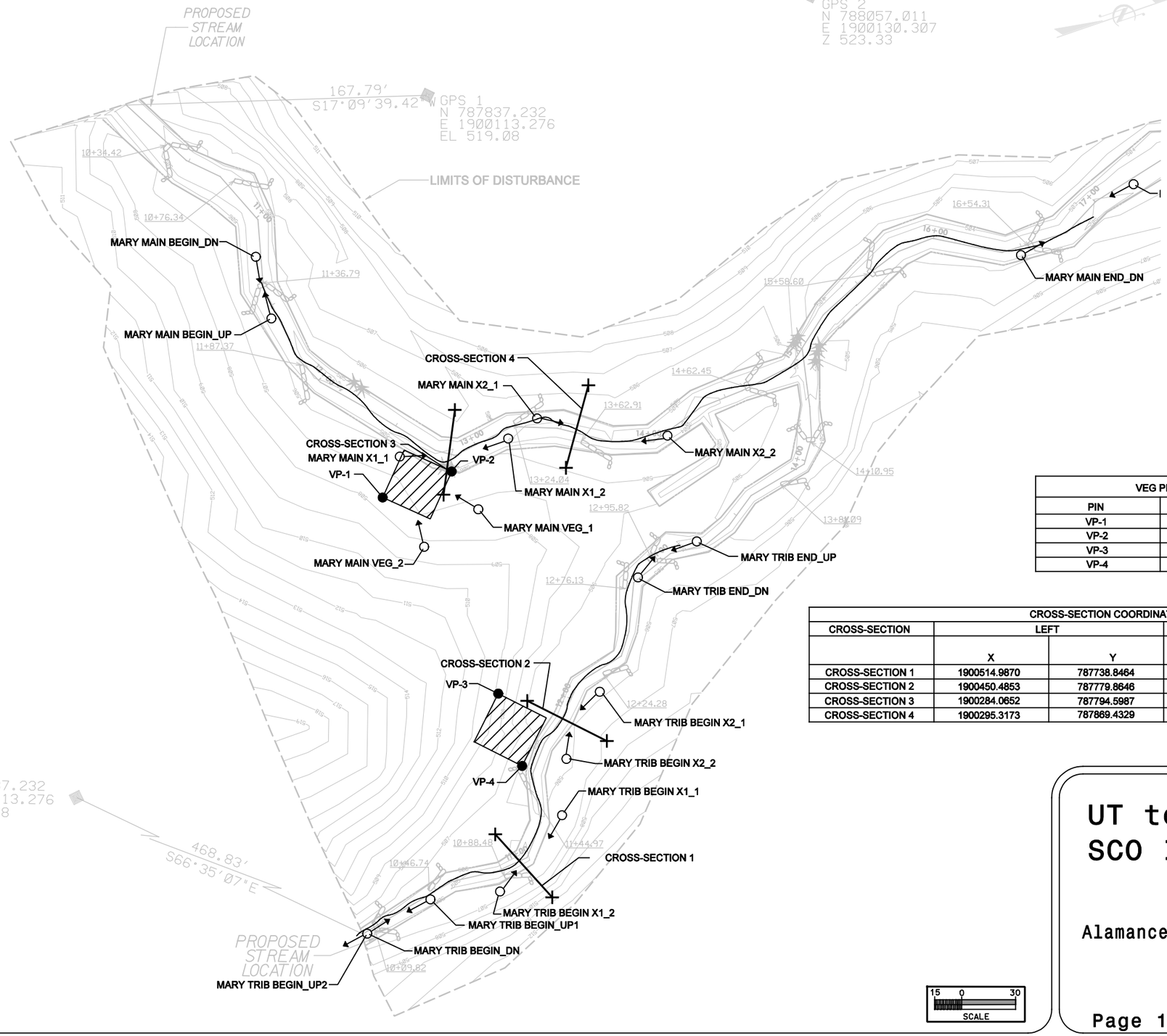
Any vegetative problem area in the project will be noted and reported in each subsequent monitoring report. Vegetative problem areas include areas that either lack vegetation or include populations of exotic vegetation.

3.7 BENTHOS

As per the project scope, Stantec will not monitor macrobenthic invertebrates.

3.8 BEHI

Using Rosgen (1996) methodology, Stantec will monitor the near bank stress (NBS) and/or bank erodibility hazard index (BEHI) as needed at any problem areas during the first year monitoring effort. Initial conditions at the project reaches for both the NBS and BEHI rated as 'low' to 'moderate' with no existing problem areas.



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LEGEND

- ROCK CROSS VANE
- ROCK VANE
- ROOT WAD
- VEG PLOT PINS
- VEG PLOT
- CROSS-SECTIONS
- PHOTO POINTS

VEG PLOT PIN COORDINATES

PIN	X	Y
VP-1	1900514.9870	787738.8464
VP-2	1900450.4853	787779.8646
VP-3	1900441.4089	787765.9571
VP-4	1900483.8318	787765.4050

CROSS-SECTION COORDINATES

CROSS-SECTION	LEFT		RIGHT	
	X	Y	X	Y
CROSS-SECTION 1	1900514.9870	787738.8464	1900558.5179	787757.3850
CROSS-SECTION 2	1900450.4853	787779.8646	1900486.0404	787814.5657
CROSS-SECTION 3	1900284.0652	787794.5987	1900326.6578	787773.2383
CROSS-SECTION 4	1900295.3173	787869.4329	1900334.7273	787842.6464

UT to Marys Creek
SCO ID# 01055150A

Mitigation Plan

Alamance County, North Carolina

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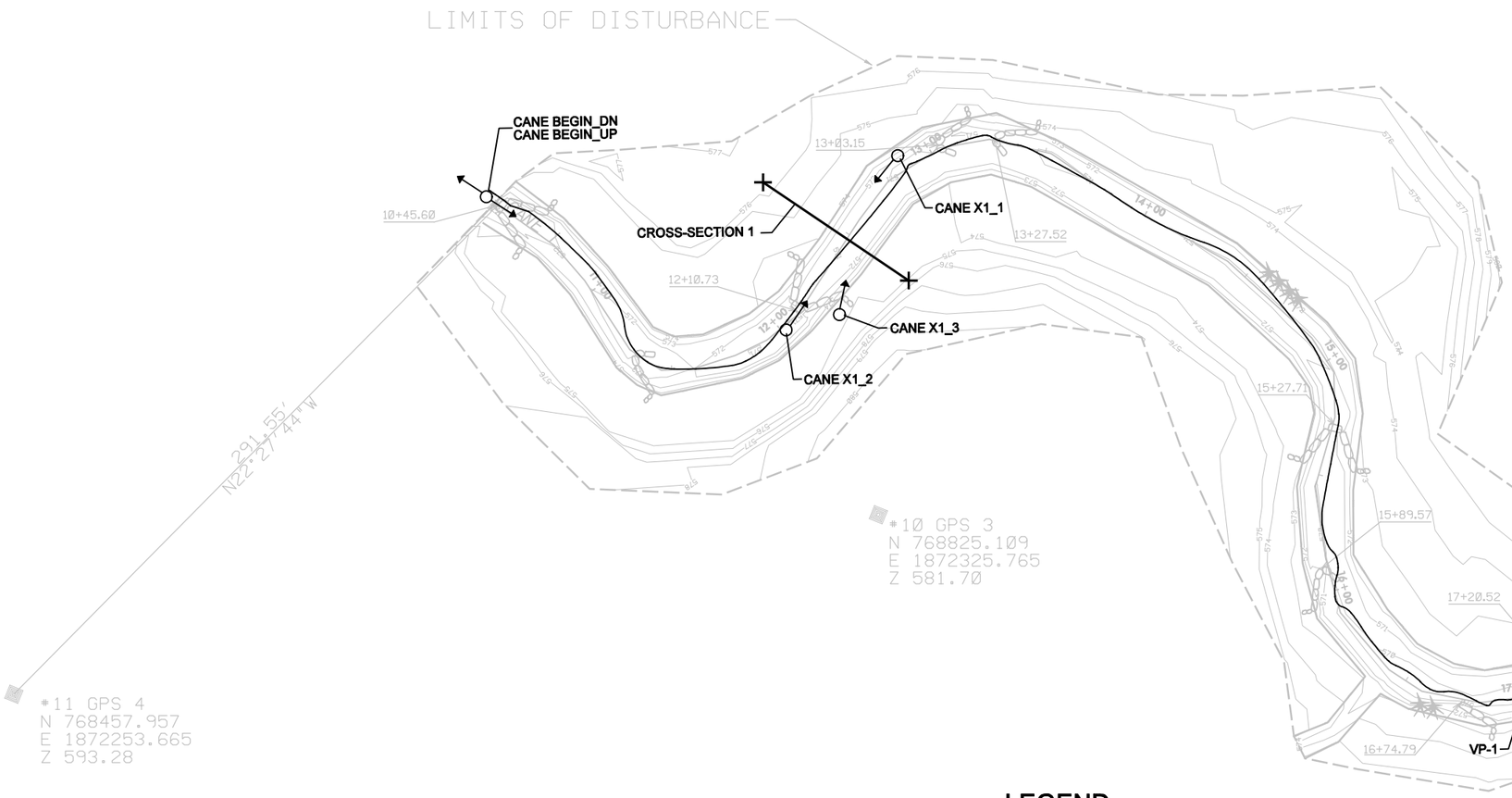

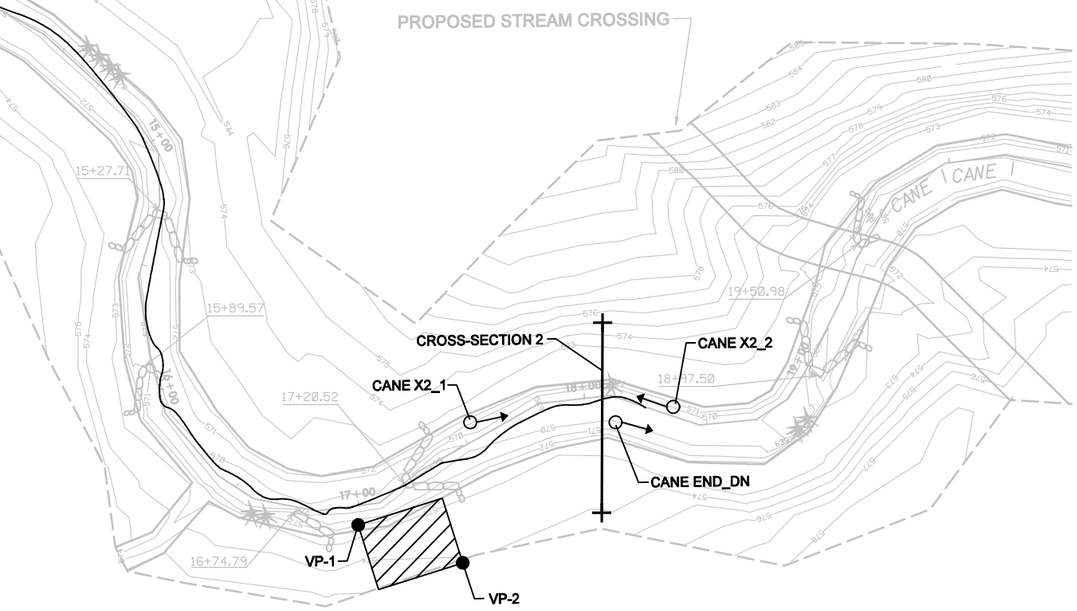

LEGEND

- ROCK CROSS VANE
- J-HOOK VANE
- ROCK VANE
- ROOT WAD
- VEG PLOT PINS
- VEG PLOTS
- CROSS-SECTIONS
- PHOTO POINTS

SCALE: 15 0 30

VEG PLOT PIN COORDINATES		
PIN	X	Y
VP-1	1872509.4977	769042.1784
VP-2	1872539.1102	769074.1637

CROSS-SECTION COORDINATES				
CROSS-SECTION	LEFT		RIGHT	
	X	Y	X	Y
CROSS-SECTION 1	1872177.0477	768834.7380	1872473.6479	769161.2531
CROSS-SECTION 2	1872239.3630	768875.5027	1872542.1455	769132.0083

UT TO CANE CREEK
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Monitoring Plan

4.0 Maintenance and Contingency Plans

Any maintenance needs will be determined during monitoring visits. During the first year after construction, Stantec will perform any small maintenance tasks that can be quickly done by hand either at the time the need is identified or rescheduled for a later time. Any large maintenance items will be coordinated with NCEEP to determine the appropriate course of action.

Stantec will monitor the structures within the first year of monitoring to verify that they are functioning as needed and to note any adjustments that may be necessary.

NCEEP will oversee monitoring for subsequent years to provide a total of five years of monitoring.

5.0 References

Harrelson, C.C., C.L. Rawlins and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. United States Department of Agriculture, Fort Collins, CO.

NCEEP. 2005. Content, Format and Data Requirements for EEP Monitoring Reports. North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program. Raleigh, NC. Version 1.1 September 16, 2005.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

United States Army Corps of Engineers – Wilmington District, North Carolina Division of Water Quality, United States Environmental Protection Agency – Region IV, Natural Resources Conservation Service, North Carolina Wildlife Resources Commission. 2003. Stream Mitigation Guidelines.

6.0 Appendices

Appendix 1. Photos (Year 0)

Appendix 2. Longitudinal Survey (Year 0)

Appendix 3. Cross-Sections (Year 0)

Appendix 4. Pebble Counts (Year 0)

Appendix 5. Vegetation Plots (Year 0)

Appendix 6. Reference Reach Morphological Data

Appendix 1. Photos (Year 0)

Photo 1. Station CaneBegin_Dn
(Note: Locations of Cane Creek stations are shown on Figure 3.2)

Photo 2. Station CaneBegin_Up

Photo 3. Station CaneEnd_Dn

Photo 4. Station CaneX1_1

Photo 5. Station CaneX1_2

Photo 6. Station CaneX1_3

Photo 7. Station CaneX2_1

Photo 8. Station CaneX2_2

Photo 9. Station MaryMainBegin_Dn
(Note: Locations of Marys Creek stations are shown on Figure 3.1)

Photo 10. Station MaryMainBegin_Up

Photo 11. Station MaryMainEnd_Dn

Photo 12. Station MaryMainEnd_Up

Photo 13. Station MaryMainVeg_1

Photo 14. Station MaryMainVeg_2

Photo 15. Station MaryMainX1_1

Photo 16. Station MaryMainX1_2

Photo 17. Station MaryMainX2_1

Photo 18. Station MaryMainX2_2

Photo 19. Station MaryTribBegin_Up

Photo 20. Station MaryTribBegin_Up1

Photo 21. Station MaryTribBegin_Up2

Photo 22. Station MaryTribEnd_Dn

Photo 23. Station MaryTribEnd_Up

Photo 24. Station MaryTribVeg_1

Photo 25. Station MaryTribVeg_2

Photo 26. Station MaryTribX1_1

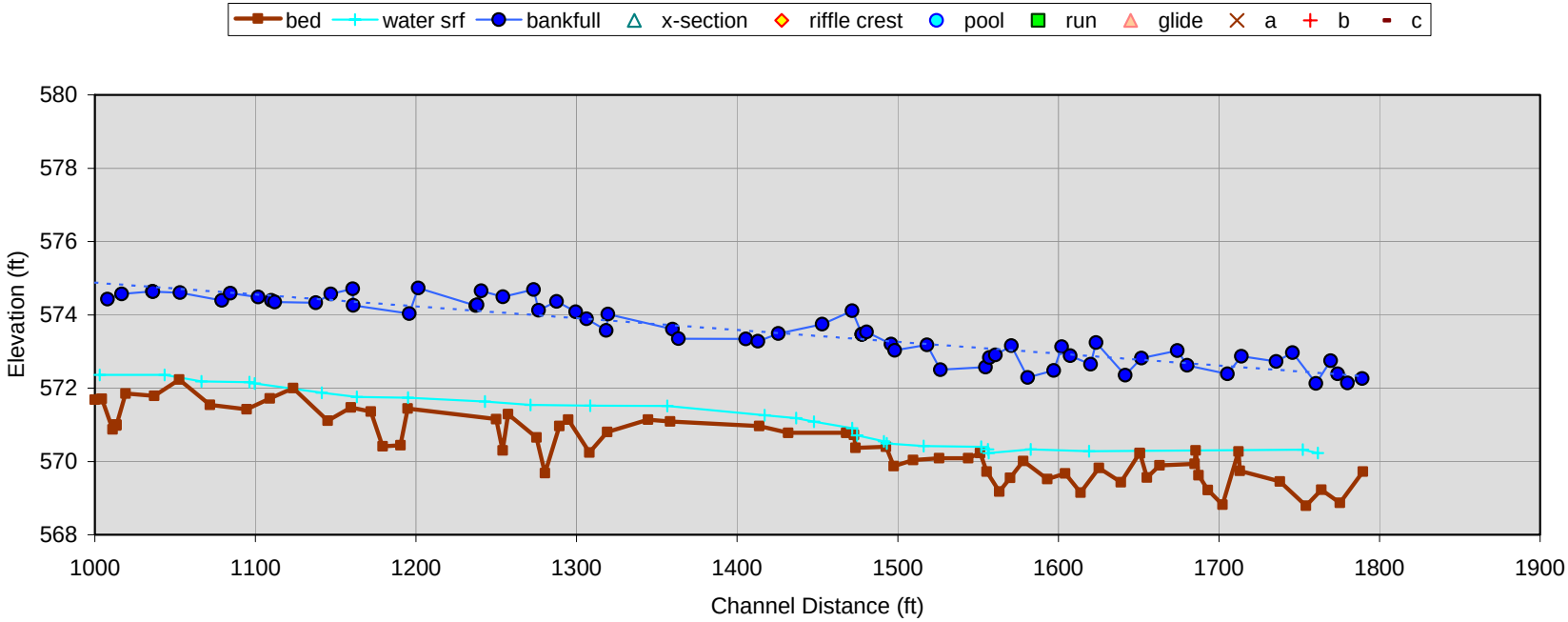
Photo 27. Station MaryTribX1_2

Photo 28. Station MaryTribX2_1

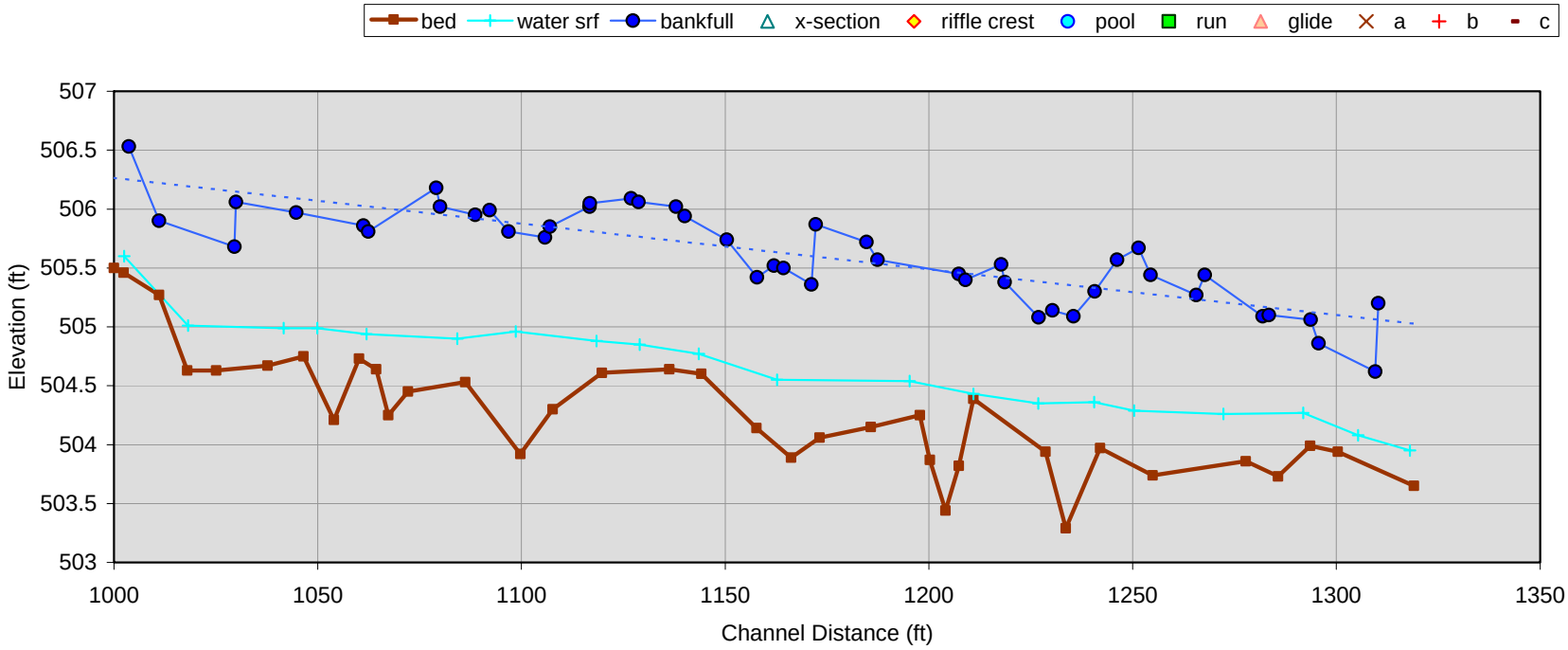
Photo 29. Station MaryTribX2_2

Appendix 2. Longitudinal Survey (Year 0)

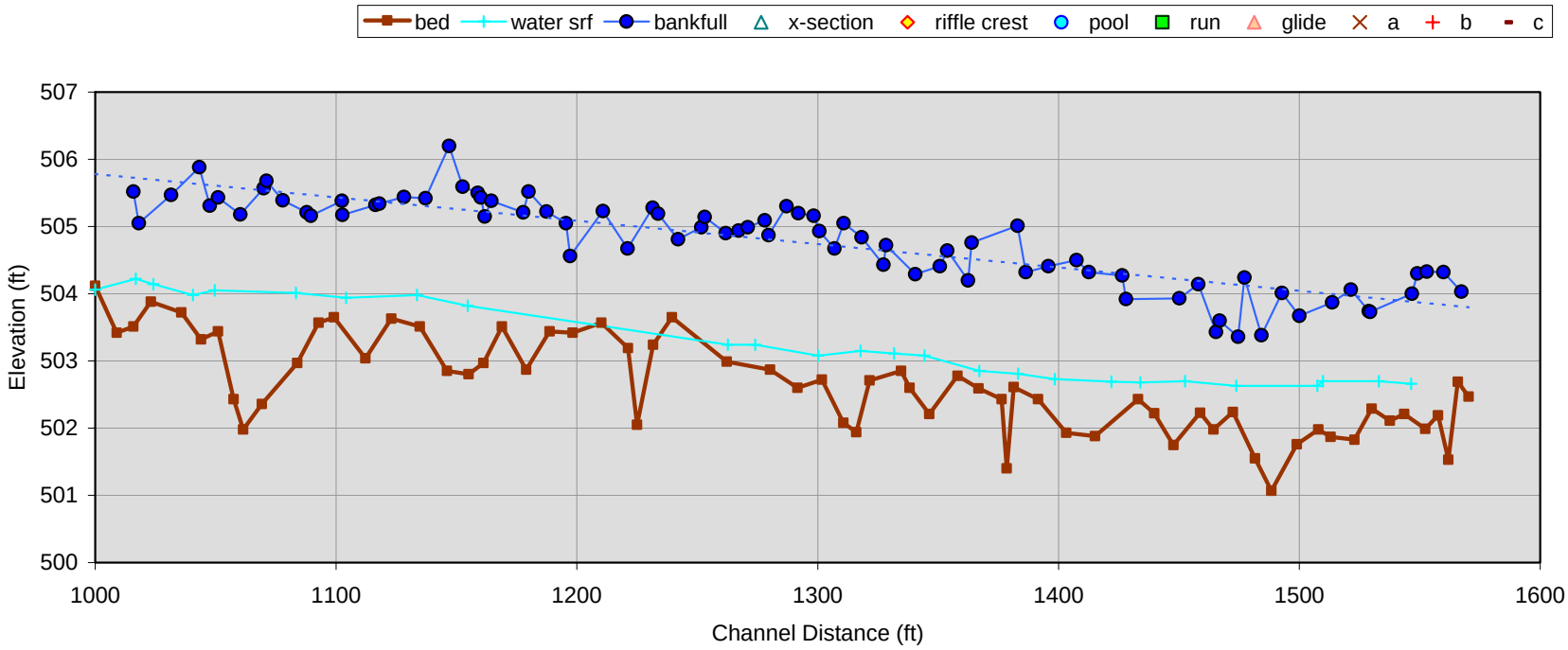
Cane Creek


bed
water srf
bankfull
x-section
riffle crest
pool
run
glide
a
b
c
580
578
576
574
572
570
568
Elevation (ft)
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Channel Distance (ft)

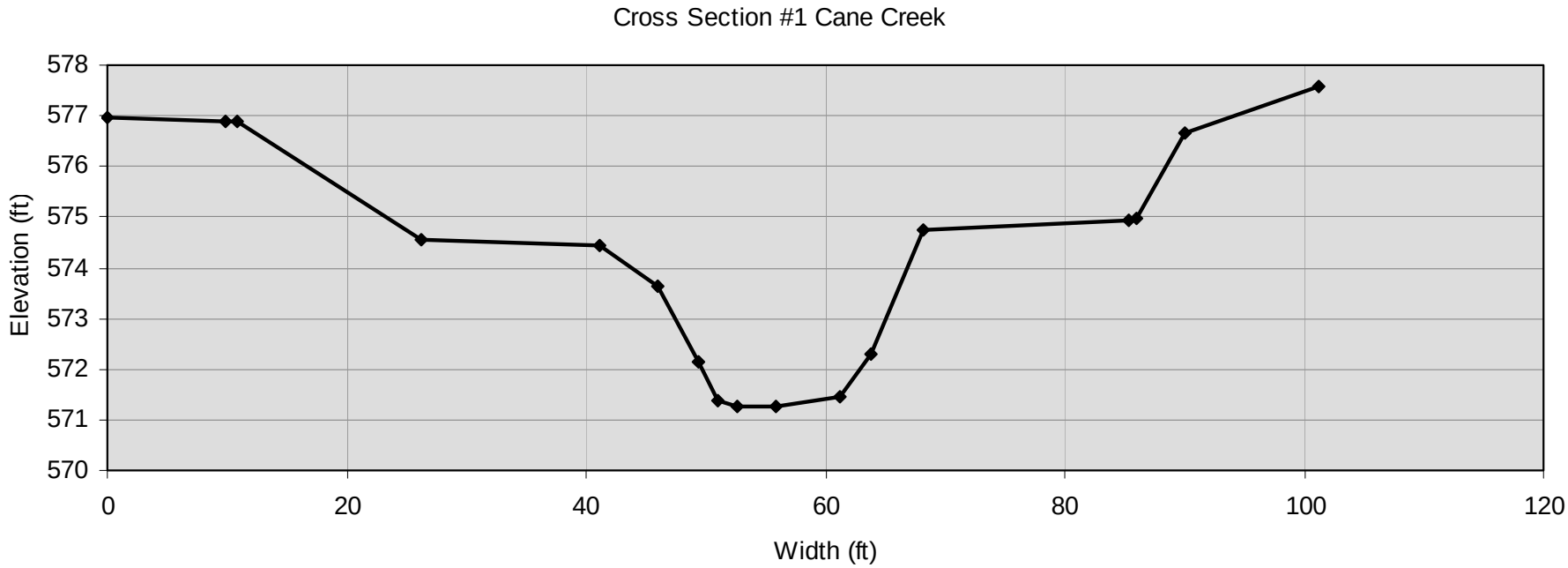
UT Marys Creek Main

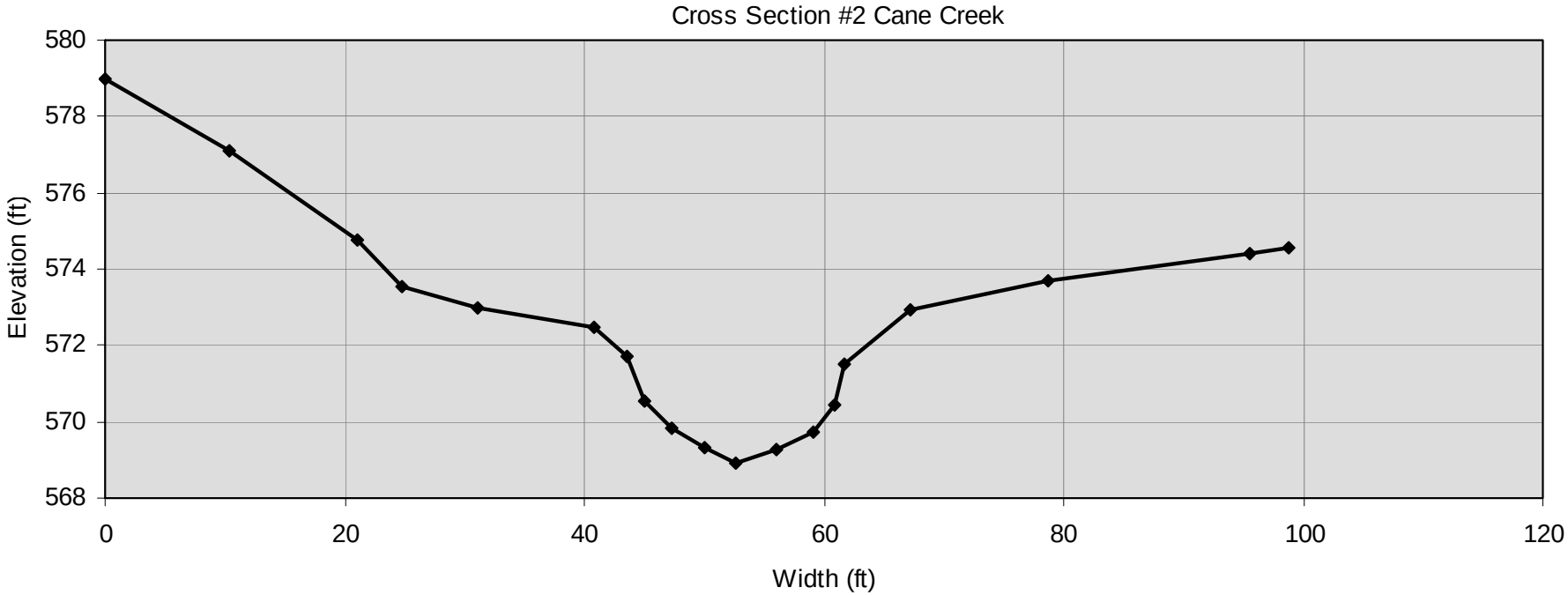


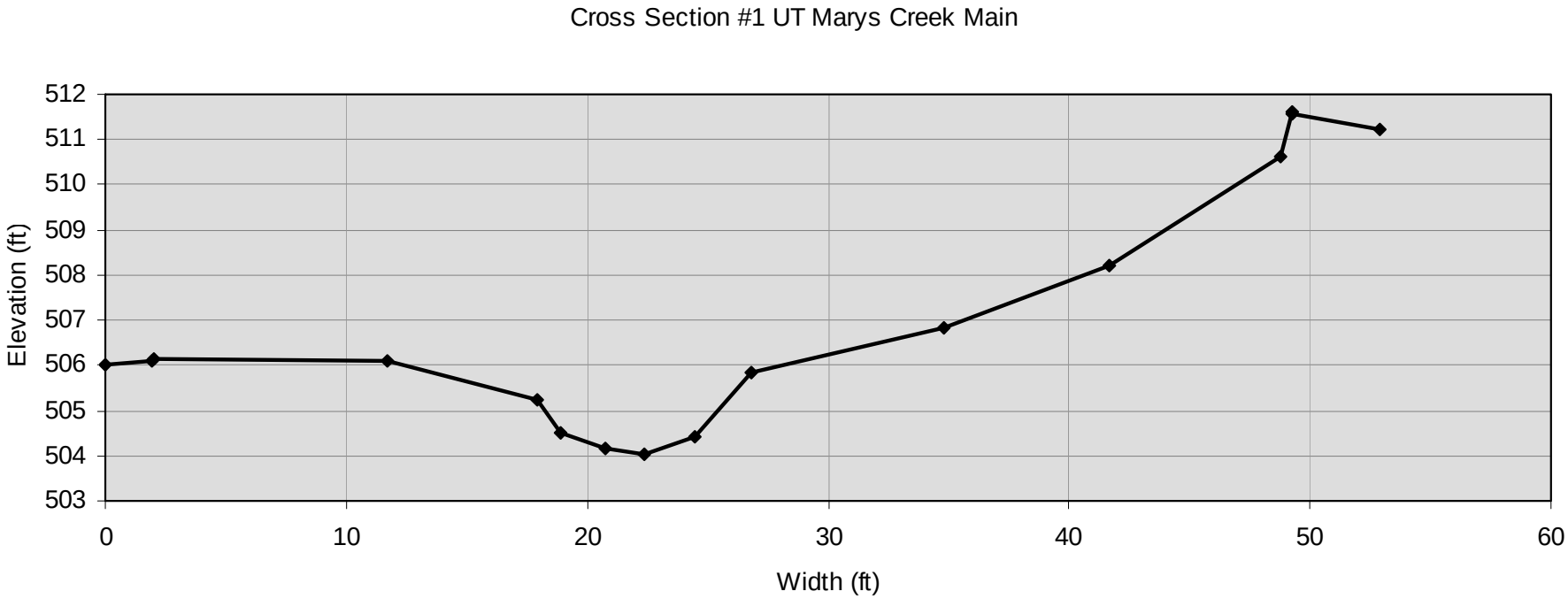
UT Marys Creek Secondary

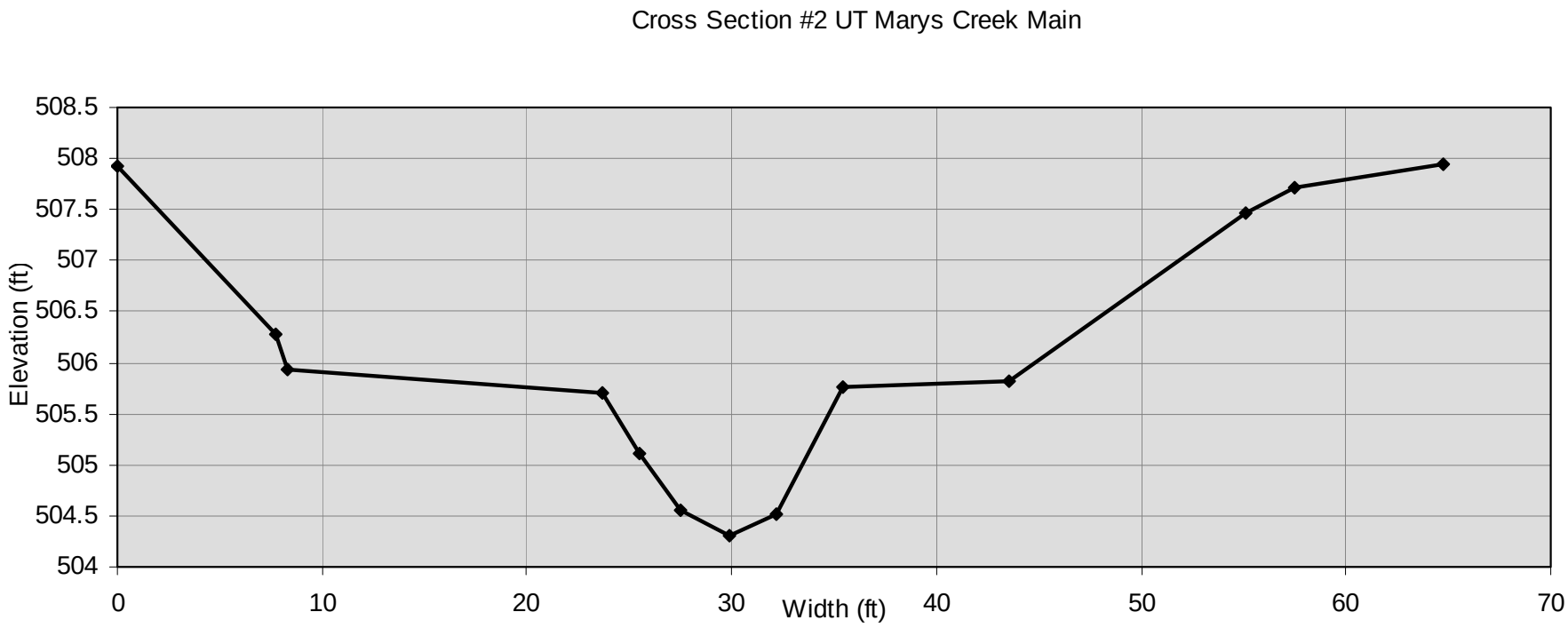


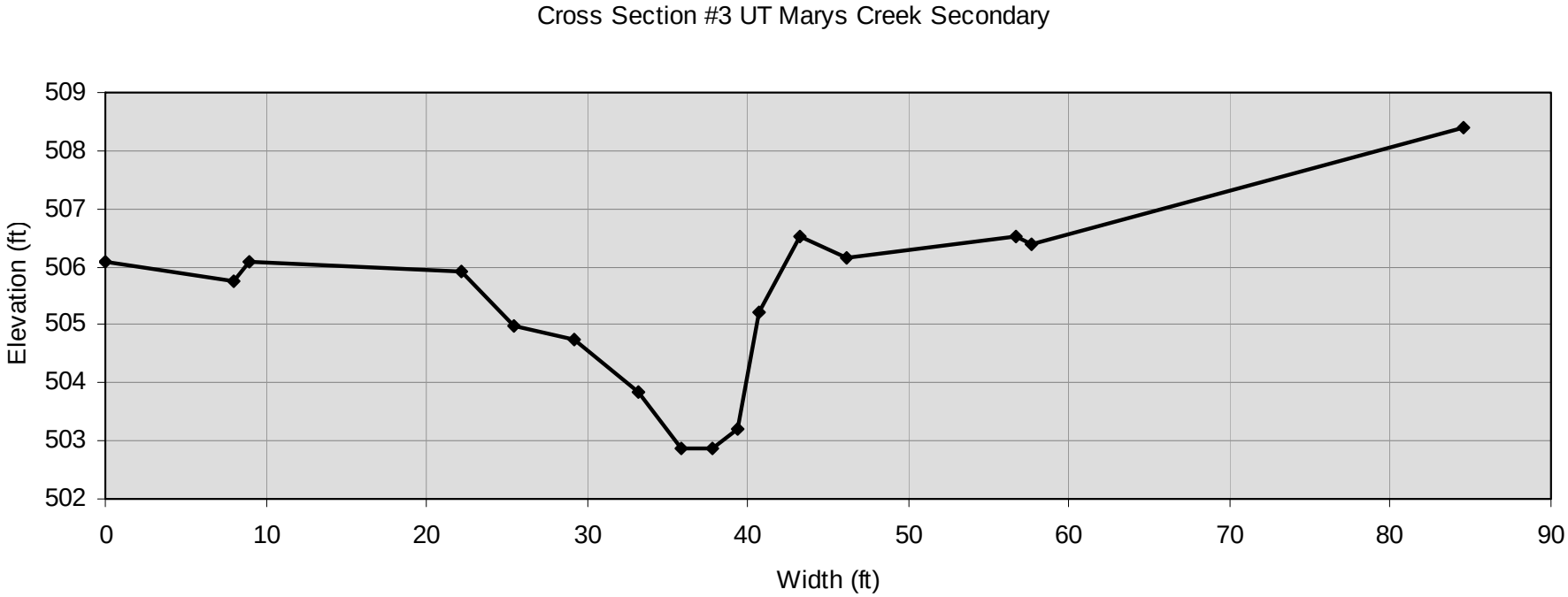
Appendix 3. Cross-Sections (Year 0)

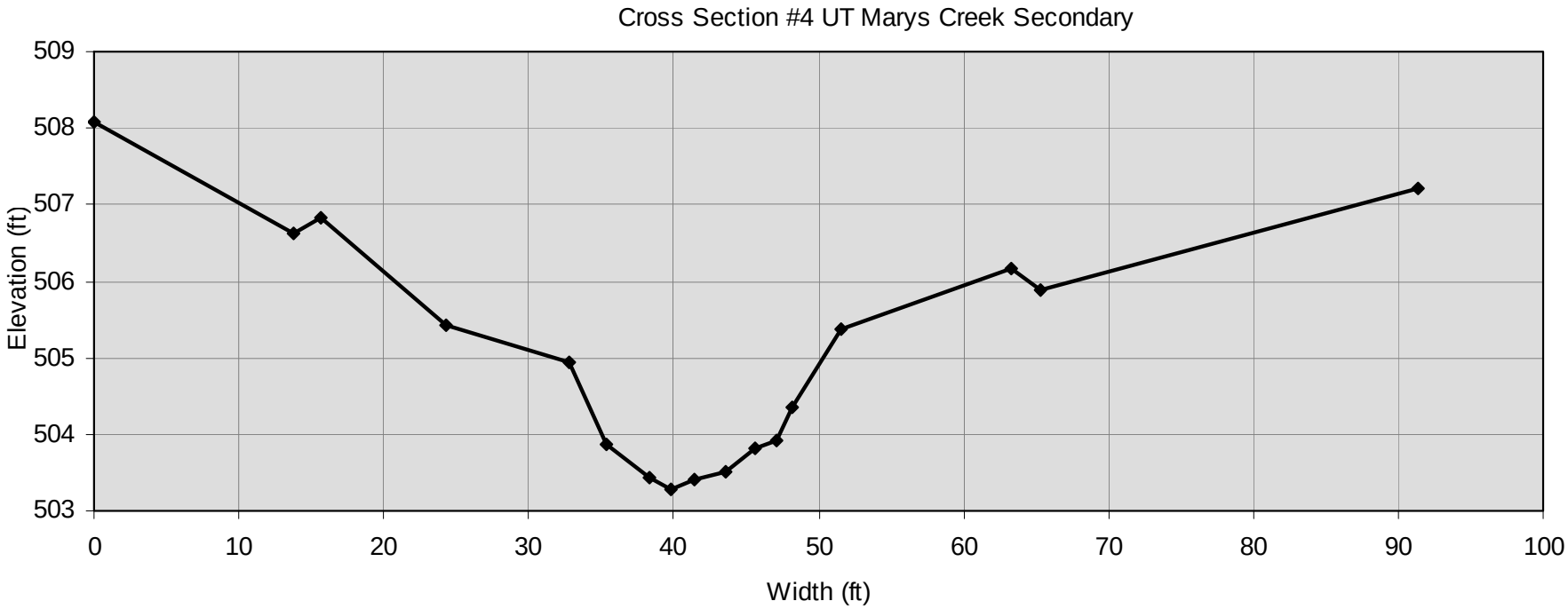

Cross Section #1 Cane Creek
Elevation (ft)
578
577
576
575
574
573
572
571
570
0
20
40
60
80
100
120
Width (ft)


Cross Section #2 Cane Creek
580
578
576
574
572
570
568
Elevation (ft)
0
20
40
60
80
100
120
Width (ft)


Cross Section #1 UT Marys Creek Main
Elevation (ft)
512
511
510
509
508
507
506
505
504
503
0
10
20
30
40
50
60
Width (ft)

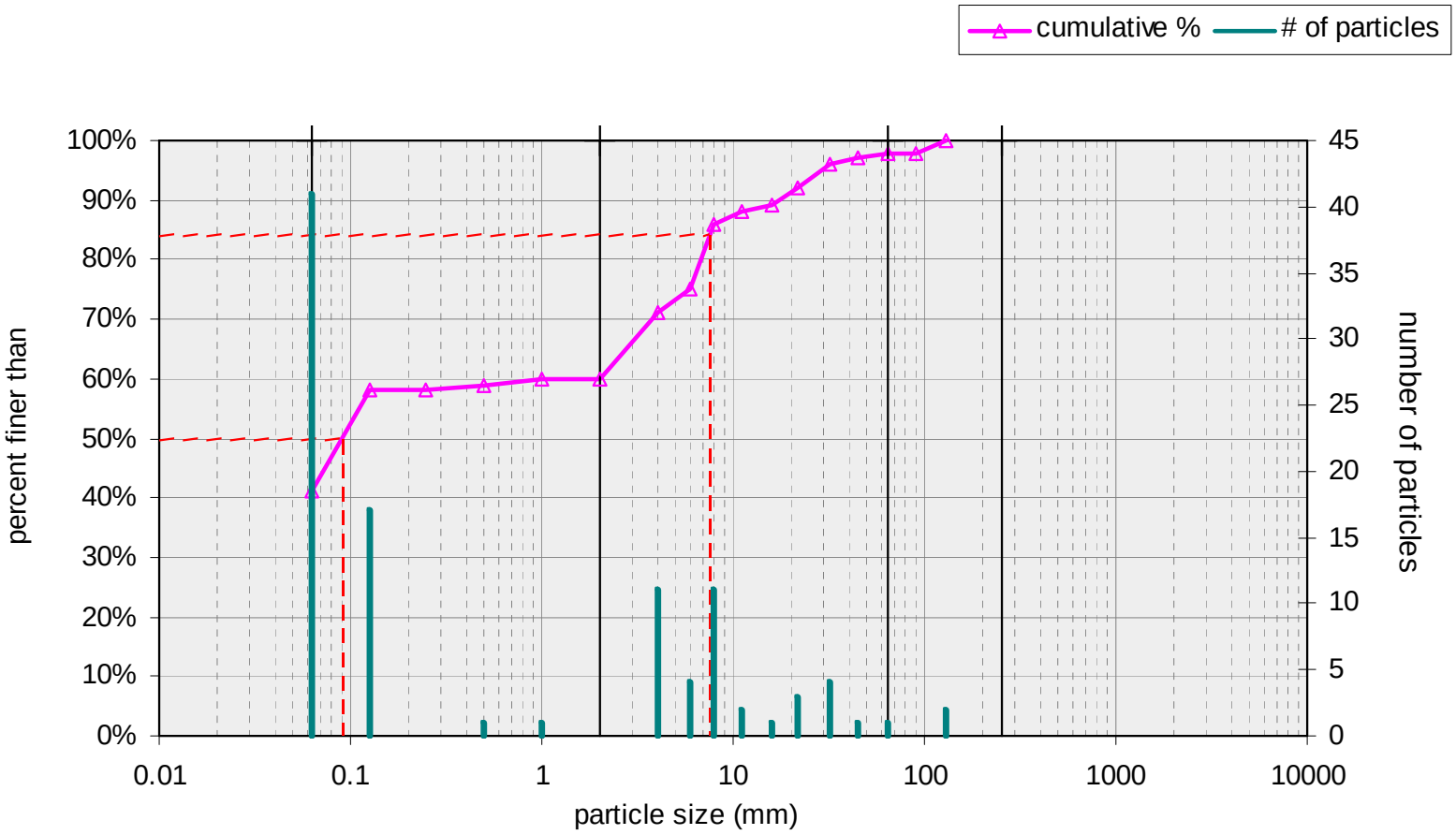

Cross Section #2 UT Marys Creek Main
Elevation (ft)
508.5
508
507.5
507
506.5
506
505.5
505
504.5
504
0
10
20
30
40
50
60
70
Width (ft)


Cross Section #3 UT Marys Creek Secondary
Elevation (ft)
509
508
507
506
505
504
503
502
0
10
20
30
40
50
60
70
80
90
Width (ft)

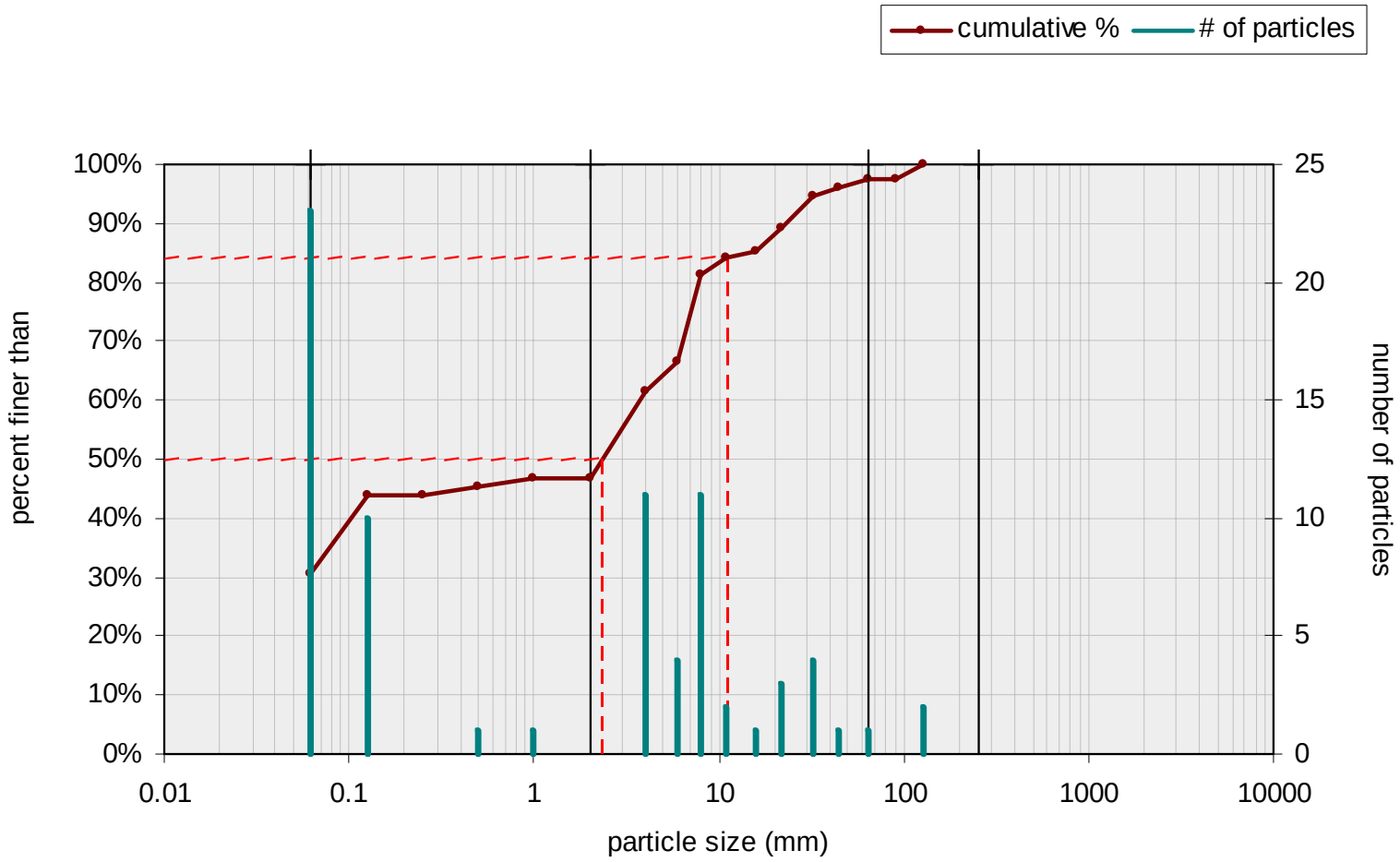

Cross Section #4 UT Marys Creek Secondary
Elevation (ft)
509
508
507
506
505
504
503
0
10
20
30
40
50
60
70
80
90
100
Width (ft)

Appendix 4. Pebble Counts (Year 0)

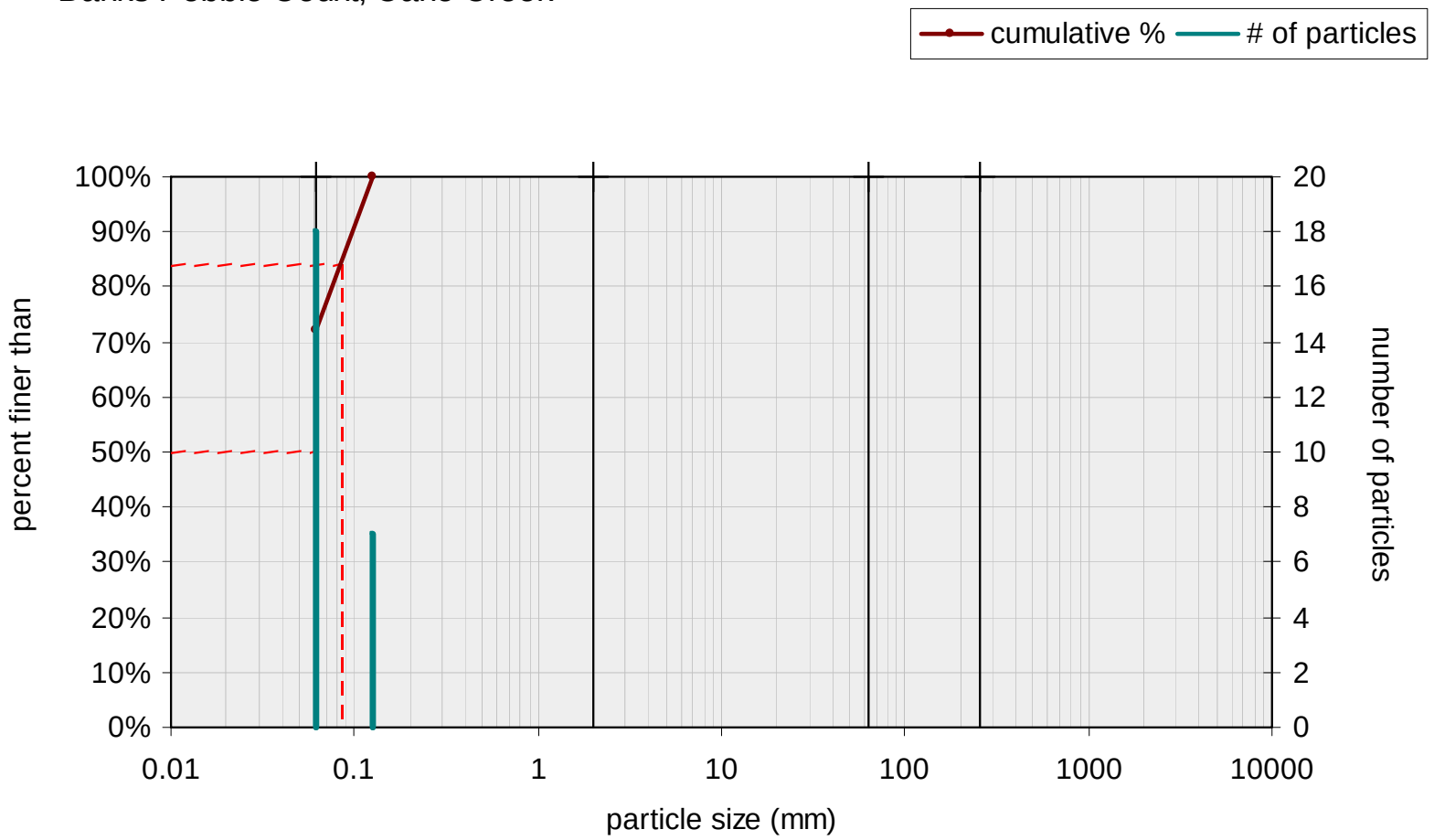
Riffle and Bank Pebble Count, Cane Creek



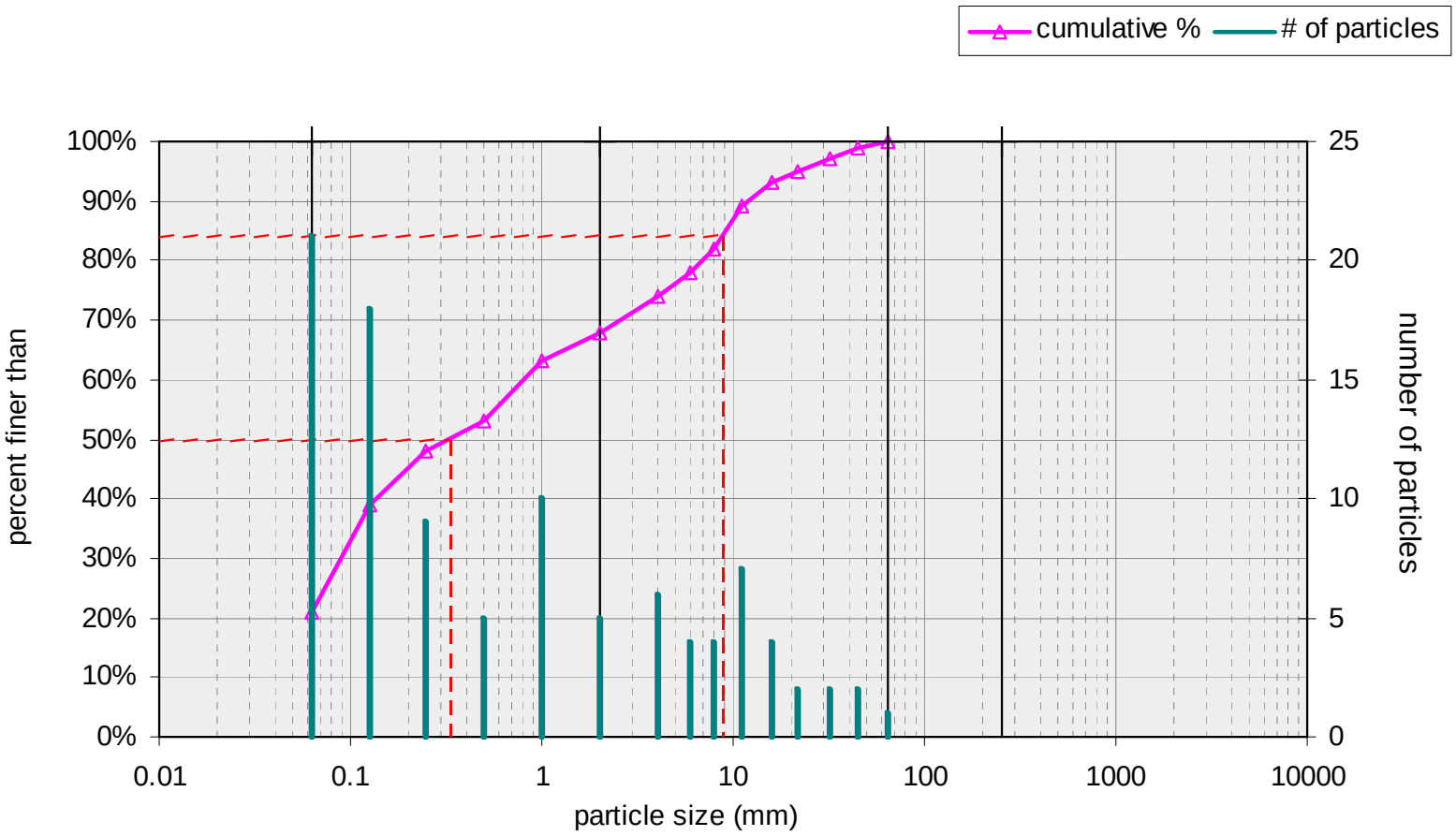
Riffle Surface Pebble Count, Cane Creek



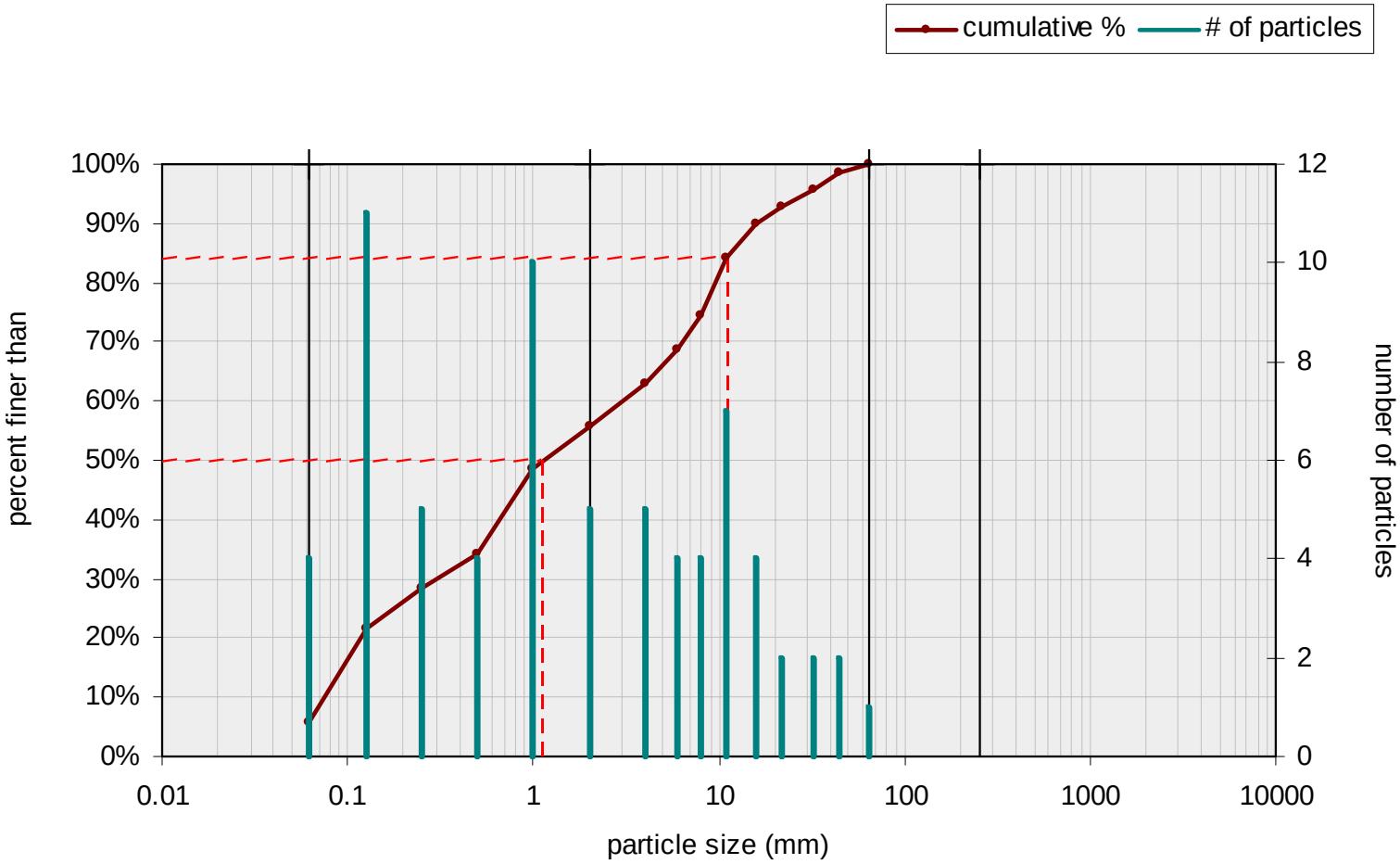
Banks Pebble Count, Cane Creek



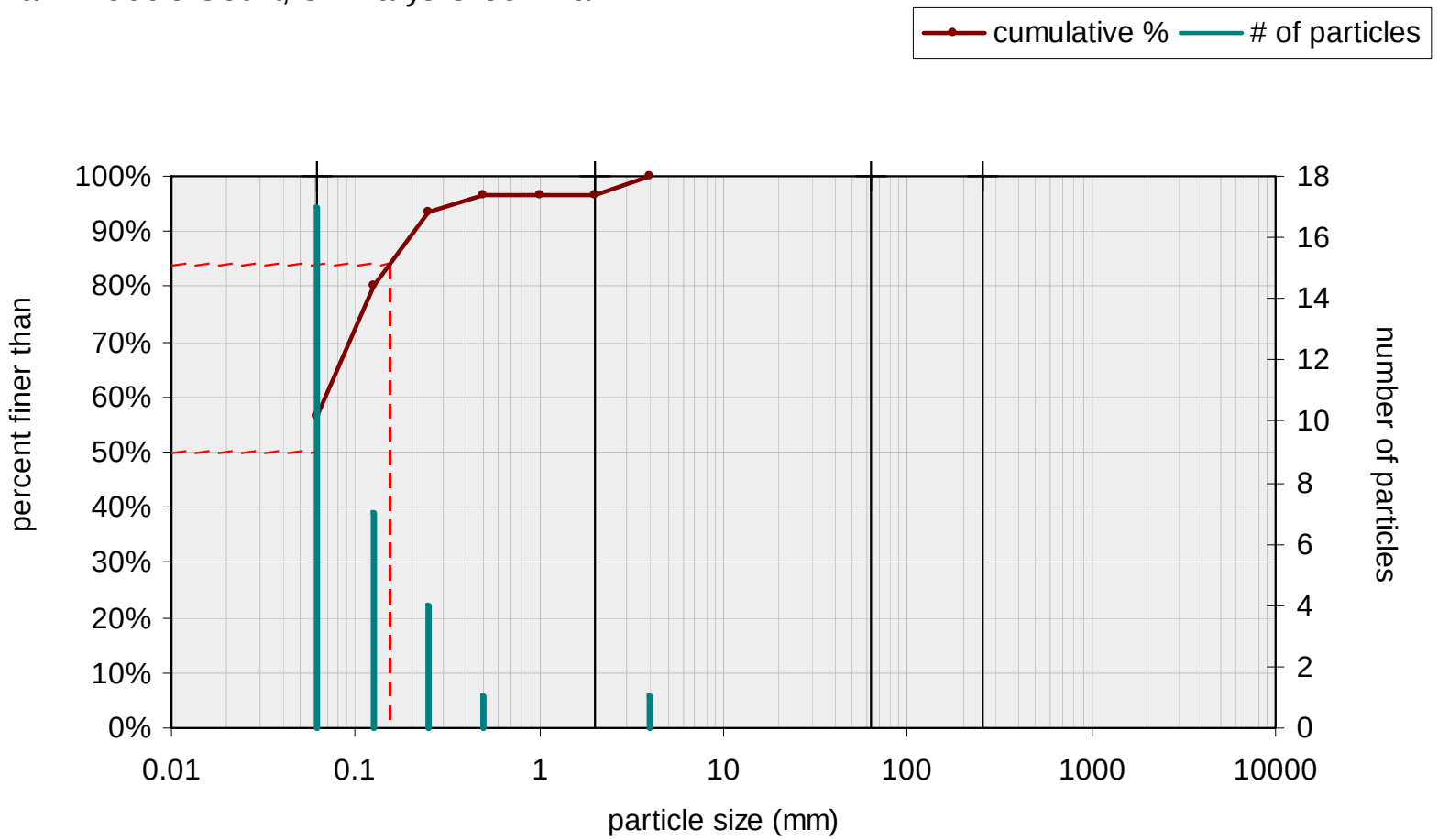
Riffle and Bank Pebble Count, UTMarys Creek Main



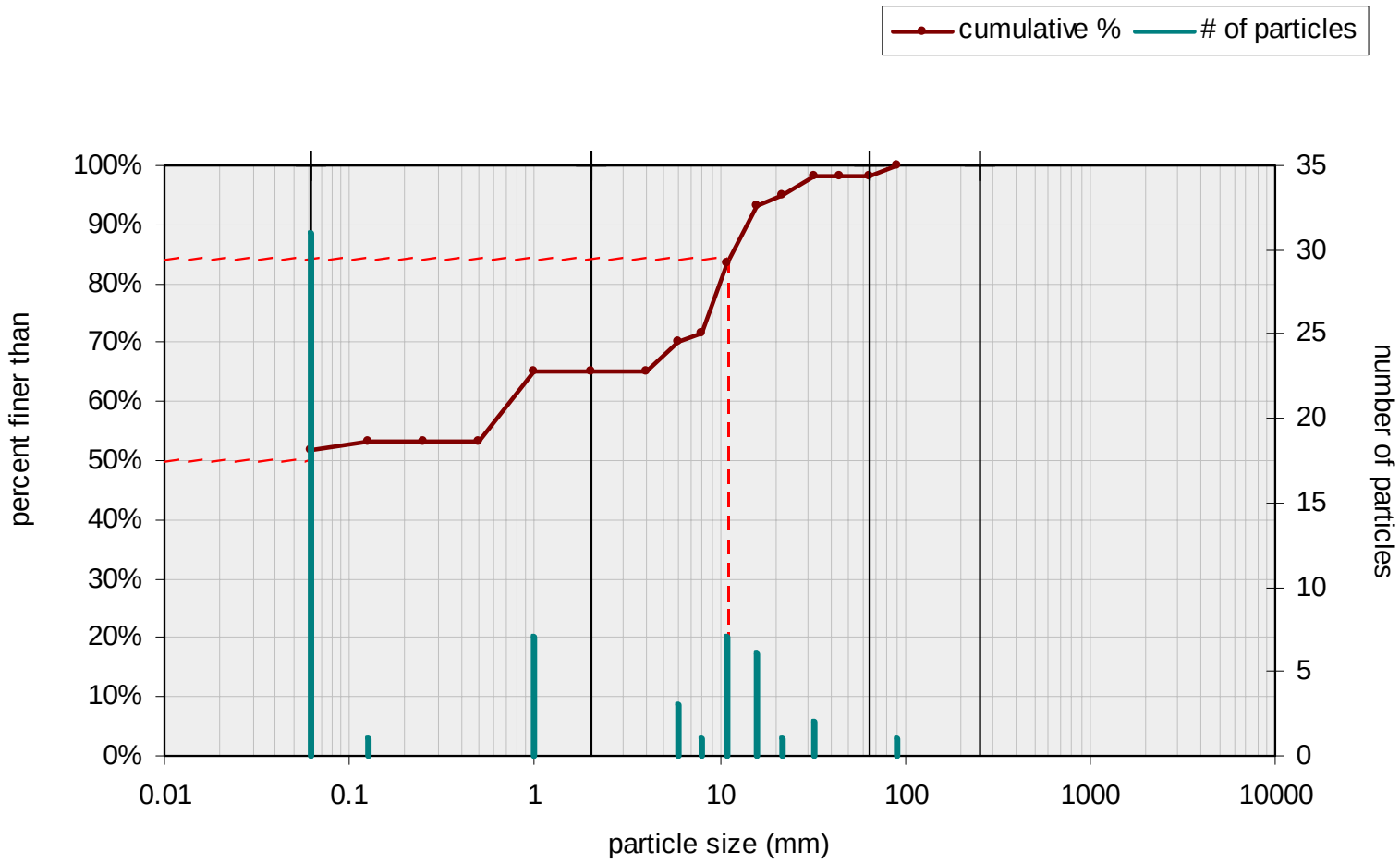
Riffle Surface Pebble Count UT Marys Creek Main



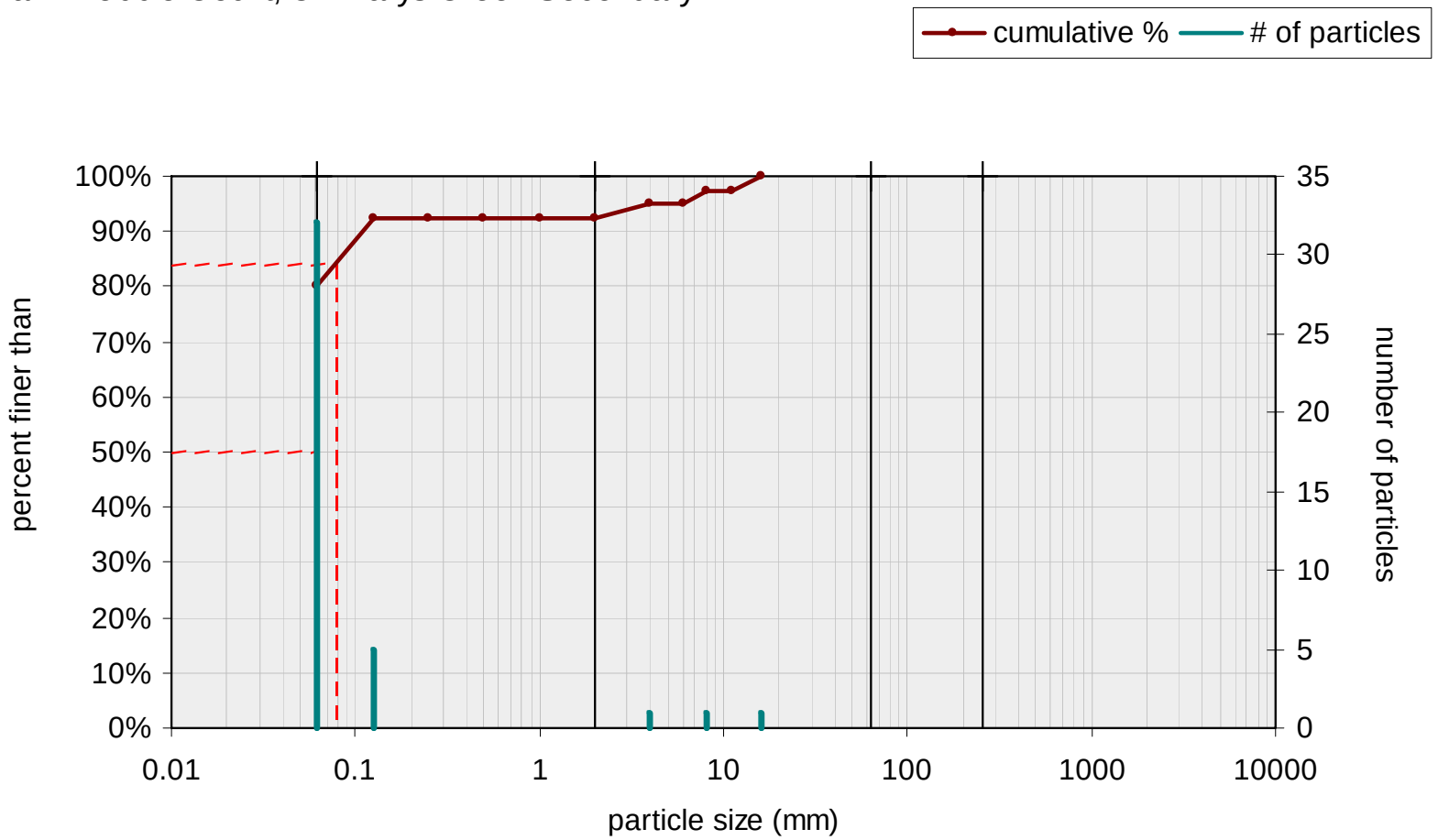
Bank Pebble Count, UT Marys Creek Main



Riffle Surface Pebble Count UT Marys Creek Secondary



Bank Pebble Count, UT Marys Creek Secondary



Appendix 5. Vegetation Plots (Year 0)

UT to Cane Creek

Common Name	**Scientific Name**	**Number**
Elderberry	*Sambucus canadensis*	11
Green ash	*Fraxinus pennsylvanica*	1
Overcup oak	*Quercus lyrata*	1
Silky dogwood	*Cornus amomum*	6
Silky willow	*Salix sericea*	13
Black willow	*Salix nigra*	28

UT to Marys Creek

Common Name	**Scientific Name**	**Number**
Tributary Plot		
Elderberry	*Sambucus canadensis*	4
Silky dogwood	*Cornus amomum*	15
Black willow	*Salix nigra*	7
Main Channel Plot		
Black willow	*Salix nigra*	12
Elderberry	*Sambucus canadensis*	6

Appendix 6. Reference Reach Morphological Data

UT to Cane Creek and UT to Marys Creek Restoration Plans Reference Reach Morphological Data		
PARAMETER	**REFERENCE REACH**	**REFERENCE REACH**
LOCATION	UT Cabin Branch	Landrum Creek
STREAM TYPE	C4b	C4
DRAINAGE AREA (acres)	806	1619
BANKFULL WIDTH (ft)	14.3	27.6
BANKFULL MEAN DEPTH (ft)	1.5	1.2
WIDTH/DEPTH RATIO	10	23
BANKFULL X-SECTION AREA (ft^2)	21.4	33.5
BANKFULL MEAN VELOCITY (ft/s)	4.9	5.2
BANKFULL DISCHARGE (cfs)	105	174
BANKFULL MAX DEPTH (ft)	2.2	2.0
WIDTH OF FLOOD-PRONE AREA (ft)	47	140
ENTRENCHMENT RATIO	3.3	5.1
MEANDER LENGTH (ft)	32 - 92	94 - 100
RATIO OF MEANDER LENGTH TO BANKFULL WIDTH	2.2 - 6.4	3.4 - 3.6
RADIUS OF CURVATURE (ft)	9.3 - 29	10 - 13
RATIO OF RADIUS OF CURVATURE TO BANKFULL WIDTH	0.7 - 3.0	0.4 - 0.6
BELT WIDTH (ft)	80	77
MEANDER WIDTH RATIO	5.6	2.8
SINUOSITY (K)	1.20	1.12
VALLEY SLOPE (ft/ft)	0.0169	0.0080
AVERAGE SLOPE (ft/ft)	0.0149	0.0077
POOL SLOPE (ft/ft)	0.0000 - 0.0011	0.0000
RATIO OF POOL SLOPE TO AVERAGE SLOPE	0.0 - 0.1	0.0
MAX POOL DEPTH (ft)	2.5	2.8
RATIO OF POOL DEPTH TO AVERAGE BANKFULL DEPTH	1.7	2.3
POOL WIDTH (ft)	14.7	27.4
RATIO OF POOL WIDTH TO BANKFULL WIDTH	1.0	1.0
POOL TO POOL SPACING (ft)	9 - 49	25 - 104
RATIO OF POOL TO POOL SPACING TO BANKFULL WIDTH	0.6 - 3.4	0.9 - 3.8
PREDOMINATE BED MATERIAL	gravel	gravel