Section E
STREAM CHANNEL CONDITION

INTRODUCTION

This report provides the results of an assessment of the stream channels of the Mendocino Redwood Company (MRC) ownership in the Navarro River watershed, the Navarro WAU. The assessment was conducted following a modified methodology from the Watershed Analysis Manual (Version 4.0, Washington Forest Practices Board). The stream channel analysis is based on field observations and stream channel slope class and channel confinement information developed from a digital terrain model in the company's Geographic Information System (GIS).

The goals of the assessment were to determine the existing channel conditions and identify the sensitivity of the channels to wood and sediment. Stream channels are defined by the transport of water and sediment. A primary structural control of a channel in a forested environment, besides large rock substrate, is from woody debris. Channel morphology and condition therefore reflect the input of sediment, wood and water relative to the ability of the channel to either transport or store these inputs (Sullivan et. al., 1986)

Stream channel conditions represent the strongest link between forest practices and aquatic habitat. Changes in channel condition typically reflect changes to stream habitat. Because of this the fish habitat and stream channel assessments were done in the same reaches. The results for the fish habitat parameters are presented in Section F - Fish Habitat Assessment.

METHODS

The methods of the stream channel assessment are designed to identify channel segments that are likely to respond similarly to changes in sediment or wood and group them into distinct geomorphic units. These geomorphic units enable an interpretation of habitat-forming processes dependent on similar geomorphic and channel morphology conditions. The channels are also evaluated for current channel condition to provide baseline information for the evaluation of channel conditions currently and over time.

Stream Segment Delineation

The stream channel network for the Navarro WAU was partitioned into stream segments based on three classes of channel confinement and several classes of channel gradient. These classifications were based on channel classifications prepared from digital terrain data in Mendocino Redwood Company's Geographic Information System (GIS). The slope classes used for delineation are 0-3%, 3-7%, 7-12%, and 12-20%. Channel confinement was classified by confined, moderately confined, and unconfined. Confined channels have a valley to channel width ratio of <2, moderately confined channels have a valley to channel width ratio of <4, and unconfined channels have a valley to channel width ratio of >4.

Channel segments for observations or analysis were delineated based on either a change in slope class or change in channel confinement. The channel segments were numbered with a two letter code, corresponding to the planning watershed the channel segment is located, followed by a unique number (*1 through n* for each planning watershed). For the Navarro WAU, channel segments for 17 planning watersheds are delineated. The delineated stream segments are shown on Map E-1.

Field Measurements and Observations

Selection of field sites for stream channel observations was based on gathering a sample of response (0-3% gradient) and transport (3-20% gradient) channels from each planning watershed of the WAU. No attention was focused on the source reaches (>20% gradient), this was assumed to be covered in the mass wasting analysis.

For each channel segment the bankfull width, bankfull maximum depth, bankfull average depth, floodprone depth, floodprone width, and channel bankfull width to depth ratio are measured at a cross section representative of the channel segment. A pebble count of 50 randomly selected pebbles is counted at the cross section to determine the D50 (median particle size) of the streambed. Streambed sediment characteristics are interpreted from observations of gravel bars, channel aggradation or degradation and particle size of the stream bed material. The segment is classified by morphology types based on Montgomery and Buffington (1993) and Rosgen (1994). The channel morphology is further interpreted by flood plain interaction for segment (continuous, discontinuous, inactive, none) and channel roughness characteristics. Large woody debris (LWD) functioning in the channel is inventoried (presented in Section D, Riparian Function). The number and type of pools (LWD forced, bank forced, boulder forced, free formed) are observed. The field observations are summarized and defined in Table E-1.

Stream Geomorphic Units

Channel segments were grouped into geomorphic units by similar attributes of channel condition, position in the drainage network, and gradient/confinement classes. The intent of the geomorphic units are to stratify channel segments of the Navarro WAU into units which respond similarly to the input factors of coarse and fine sediment, and LWD. These geomorphic units can then be interpreted to have similar habitat-forming processes.

Interpretations related to sediment supply, transport capacity and LWD response were the basis for development of sensitivity of geomorphic units to coarse sediment, fine sediment and LWD inputs. These interpretations were based primarily on existing conditions observed in the stream channels of the WAU. The channel sensitivity to changes to coarse sediment, fine sediment and LWD are based on how the current state of the channel is likely to respond to inputs of these variables.

Long-Term Stream Monitoring Sites

To monitor stream channel morphology conditions and stream sediment characteristics related to fish habitat, 6 long-term stream channel monitoring segments were established in the Navarro River WAU. Along these segments longitudinal profiles, cross sections and streambed D50 measurements were surveyed. Stream gravel bulk samples and permeability of spawning gravels are also measured (methods and results presented in the Fish Habitat section)(at 8 stream segments). These long-term segments will be re-surveyed and monitored over time to provide insight into long term trends in channel morphology, sediment transport and fish habitat conditions. In future surveys of the long term channel monitoring segments LWD will be included in the surveys. The long-term stream channel monitoring segment locations are shown on Map E-1.

The stream monitoring segments are typically 20-30 bankfull channel widths in length. Permanent benchmarks (PBMs) are placed at the upstream and downstream ends of the monitoring segment. The PBMs are monumented with nails in the base of large trees along with a re-bar pin in the ground adjacent to the nail.

The longitudinal profile is a survey of the thalweg, the deepest point of the channel, excluding any detached or “dead end” scours and/or side channels. At every visually apparent change in thalweg location or depth, the station along the channel and the elevation is recorded. In the absence of visually apparent changes, thalweg measurements are taken every 15-20 feet along the channel. A profile graph of the channel’s thalweg is created from the longitudinal survey (see Appendix E for longitudinal profiles for the Navarro WAU). A computer program (Longpro) developed by the USGS for Redwood National Park was used to analyze the profiles. This program converted the surveys into standardized data sets with uniform five-foot spacing between points and determined the residual water depth of each point. The residual water depth is the depth of water in pools of the channel segment defined by the riffle crest height at the outlet of the pool. No minimum pool depth is specified. The distribution, mean and standard deviation of the residual water depths for the longitudinal profile segment are calculated. This provides the ability to statistically evaluate changes in the residual water depths from the thalweg profile over time.

Along the lonitudinal profile, 3-5 channel cross sections are surveyed (locations are permanently monumented). The cross sections are located along relatively straight reaches in the monitoring segment. Cross sections are surveyed from above the floodprone depth of the channel. A graph of the cross section is created from the survey (see Appendix E for cross sections graphs for the Navarro WAU). At each cross section a pebble count is done, to determine the particle size distribution and median particle size (D50), by measuring 100 randomly selected pebbles along the cross section fall line.

Observations of the long term channel monitoring segments occurred in 1999. In 2001, 2 of the segments were re-surveyed, North Branch North Fork Navarro River and South Branch North Fork Navarro River providing a comparison of the longitudinal profile, cross sections and pebble counts for those segments.

RESULTS

Stream Channel Observations

Stream channel surveys or field observations were taken on 50 stream reaches in the Navarro River WAU during the summer of 1999. Table E-1 provides a summary of the data collected. Further detail specific to in-channel fish habitat relationships is found in Section F - Fish Habitat Assessment of this report.

Key to Table E-1.

Stream Channel Dimensions

Category	Description
ID #	The stream identification number (see Map E-1), two letter planning watershed code followed by unique number for the planning watershed. WL - Lower Navarro WR - Ray Gulch WM - Middle Navarro WN - North Fork Navarro WF- Flynn Creek WU - Upper Navarro WH - Hendy Woods WC - Rancheria Creek WI - Mill Creek WG - Floodgate Creek EJ - John Smith Creek ED - Dutch Henry Creek EL - Lower South Branch Navarro EN - Little North Fork Navarro EM - Middle South Branch Navarro EU - Upper South Branch Navarro EI - North Fork Indian Creek
Geomorphic Unit	Number of the geomorphic unit the channel segment is in.
Channel confinement	Confined-channel width to valley width ratio < 2, moderately confined-channel width to valley width ratio 2-4, unconfined-channel width to valley width ratio >4.
Surveyed Length	Length of segment surveyed.
GIS slope category	Slope class as designated by DTM in GIS.
Observed Slope	Mean slope of segment as observed in field.
Maximum Bankfull Depth	Maximum bankfull depth of representative cross section.
Mean Bankfull Depth	Average bankfull depth of representative cross section.
Bankfull width	Bankfull width of representative cross section.
Width/Depth Ratio	Ratio of bankfull channel width to average bankfull depth.
Floodprone depth	Maximum depth during flooding, estimated by 2 times max. bankfull depth (Rosgen, 1996).
Floodprone width	Width of water at floodprone depth (Rosgen, 1996).
Entrenchment Ratio	Ratio of floodprone width to bankfull channel width.

Sediment/Bedform Characteristics

Category	Description
Montgomery/Buffington Class	The channel morphology type: PR = pool/riffle, FP/R = forced pool/riffle, SP = step pool, PB = plane bed, CAS = cascade (Montgomery and Buffington, 1993)
Rosgen Class	Rosgen channel morphology classification, (Rosgen, 1994).
Floodplain Continuity	Description of floodplain/channel interaction either: continuous, inactive, discontinuous or none.
Aggradation/Degradation in Past	Evidence of past conditions.
Aggradation/Degradation Current	Current condition.
Channel Roughness	B =boulders, C=cobbles, F=bedforms, V=live woody veg., W=large woody veg., R=bedrock, Bk=banks and roots.
Gravel Bar Abundance	Qualitative measure of amount of gravel bars in segment.
Gravel Bar Type	Gravel bar type either: A=alternating point bars, P=point, M=medial or F=forced.
Gravel Bar Proportion Class	Proportion of stream segment in gravel bars: 0-25%, 25-50%, 50-75%, 75-100%.
Fine Sediment Abundance	sparse, moderate, abundant
Fine Sediment Type	type of fine sediment accumulation: P=isolated pockets, M=moderate accumulations, B=high accumulations including in gravel bars.
D50	Median gravel size of the stream bed particle distribution.

Pool Characteristics

Category	Description
Free	number of free formed pools in segment.
LWD Forced	number of LWD forced pools in segment.
Boulder Forced	number of boulder forced pools in segment.
Bank Forced	number of bank forced pools in segment.
Total # Pools	total number of pools in segment.
Pool Spacing	average space between pools by bankfull widths.
Mean Res. Pool Depth	The average of all residual pool depths in segment.

Table E-1. Stream Segment Field Observations for Navarro WAU, 1999

					Stream Channel Dimensions							
Segment Name	ID #	Geomorphic Unit	Channel Confinement	Survey Length (ft)	GIS Slope Category (%)	Field Observed Slope (%)	Maximum Bankfull Depth (ft)	Mean Bankfull Depth (ft)	Bankfull Width (ft)	Width/Depth Ratio	Floodprone Depth	Floodprone Width
N Branch Navarro	ED1	3	Confined	1794	0-3	3.4	5	3.7	73.7	19.9	10.0	205
Cook Creek	ED8	3	Confined	985	0-3	1.3	3.8	2.6	31.4	12.1	7.6	51
North Fork Indian Creek	EI2	3	Confined	1234	0-3	1.6	5.1	2.8	45.5	16.3	10.2	100
West Branch North Fork Indian Creek	EI3	7	Moderately		12-20	>20%						
John Smith Creek	EJ1	3	Confined	704	0-3	3.2	2.7	1.8	42	23.3	5.4	52
John Smith Creek	EJI(2)	3	Confined	719	0-3	0.8	2.6	1.5	25	16.7	5.2	33
SB Navarro	EL1	3	Moderately	1537	0-3	0.2	5	2.9	85.3	29.4	10.0	185.0
South Branch Navarro	EM1	3	Confined	1344	0-3	0.4	4.7	3.4	31.7	9.3	9.6	36
Bear Creek	EM20	4	Confined	504	3-7	2.6	2.5	1.8	16.8	9.3	5.0	26
Bridge Creek	EM29	4	Confined	854	0-3	1.5	1.8	1	26	26.0	3.6	33
Bridge Creek	EM30	4	Confined	575	3-7	2.2	2	1.3	21.7	16.7	4.0	40
Shingle Mill Creek	EM39	4	Confined	564	0-3	2.0	3	2.4	11.4	4.8	6.0	21
Little NF Navarro	EN2	3	Confined	860	0-3	1.4	3.7	2	32.4	16.2	7.4	48
Little NF Navarro	EN25	4	Confined	750	3-7	1.3	3.4	2.3	17.3	7.5	6.8	57
Bottom Creek	EN3	4	Confined	601	0-3	1.1	3	2	16.4	8.2	6.0	23.5
Sawyer Creek	EN38	4	Confined	444	0-3	3.0	2.5	1.5	15	10.0	5.0	22
Spooner Creek	EN4	4	Confined	684	0-3	1.6	3.2	2.2	15	6.8	6.4	24
Upper South Branch Navarro	EU1	3	Confined	2200	0-3	1.5	2.7	2.3	33.1	14.4	5.6	93
Low Gap Creek	EU20	4	Confined	671	0-3	1.6	3.3	2.8	15	5.4	6.6	19
Rose Creek	EU24	6	Confined	565	3-7	4.8	2.8	1.7	15.6	9.2	5.6	27
South Branch Navarro	EU4	3	Confined	1019	0-3	1.9	2.5	1.6	34.5	21.6	5.0	40
McGarvey Creek	EU7	4	Confined	1015	0-3	1.8	3	2.2	14.6	6.6	6.0	20
Flynn Creek	WF1	3	Confined	1075	0-3	0.5	2.5	1.9	31	16.3	4.9	135
Flynn Creek	WF1(2)	3	Confined	861	0-3	1.2	3.8	2.4	24	10.0	7.6	38
Camp 16 Gulch	WF13	4	Confined	761	0-3	1.8	2.9	1.6	16	10.0	5.8	100
Tank Gulch	WF26	4	Confined	297	0-3	0.6	2.3	1.3	9.9	7.6	4.6	33
Tank Gulch	WF27	6	Confined	192	3-7	1.5	1.7	1.3	6.4	4.9	3.4	95
none	WH3	4	Confined	519	0-3	2.4	2.8	2.1	13.4	6.4	5.6	14.5
Murray Gulch	WL19	4	Confined	562	3-7	1.3	1.5	1.25	11.2	9.0	2.9	17.8
Flume Gulch	WL27	3	Confined	1010	3-7	1.9	3.1	2.4	26.3	11.0	6.2	65
Flume Gulch	WL28	3	Confined	569	0-3	1.2	3.1	2.4	17.9	7.5	7.1	40
Navarro River	WL3	2	Confined	3097	0-3	3.2	8	6.7	129	19.3	16.0	140
Marsh Gulch	WL4	4	Confined	448	3-7	1.2	2.7	1.7	16	9.4	5.4	24.7
Racoon Gulch	WM13	4	Confined		3-7	<3%						
Navarro River	WM2	2	Moderately	2774	0-3	2.0	6.4	4.9	136	27.8	12.8	150
Skid Gulch	WM32	6	Confined	334	3-7	7.5	1.7	1.1	6.9	6.3	3.7	12.5
Berry Gulch	WM36	6	Confined	808	7-12	3.2	1.9	1.4	10.8	7.7	3.8	29
Navarro River	WM5	2	Moderately	2381	0-3	0.2	5.8	3.4	170.5	50.1	11.6	190
Dead Horse Gulch	WN10	4	Confined	387	0-3	2.7	2.4	1.25	13.7	11.0	4.8	20
Dead Horse Gulch	WN11	6	Confined	198	7-12	10.8	1.8	1.2	6.6	5.5	3.6	12
Coon Gulch	WN20	4	Confined	650	3-7	2.6	2.1	1.6	10.4	6.5	4.2	18.0
Roller Gulch	WR11	4	Confined	884	3-7	1.5	3.4	1.9	13	7.0	6.8	70
Ray Gulch	WR14	4	Confined	570	0-3	1.3	2.1	1.3	19.3	14.8	4.2	110
Ray Gulch	WR15	4	Confined	525	0-3	3.2	2.9	1.4	16	11.4	5.8	26.0
White Gulch	WR23	6	Confined	575	3-7,0-3	3.8	2.4	1	13.4	13.4	4.8	33
Mustard Gulch	WR26	4	Confined	455	0-3	1.1	2	1.1	16	14.5	4.0	100
Navarro River	WU1	2	Moderately	2371	0-3	0.45	5.7	4.7	139.5	29.7	11.4	155
Kabiki Creek	WU15	6	Confined	500	3-7	3.0	3	2.5	10.2	4.1	6.0	36.6
Sage Gulch	WU18	7	Confined	330	7-12	11.9	2.1	1.6	13.3	8.3	4.2	16
Black Rock Creek	WU4	6	Confined	684	7-12,3-7	5.5	2.4	1.2	14.3	11.9	4.8	25

Table E-1 (continued). Stream Segment Field Observations for Navarro WAU, 1999

Sediment/bedform Characteristics													Pools						
ID #	Montgomery/ Buffington Class	Rosgen Class	Floodplain Continuity	Aggradation/ Degradation in Past	Aggradation/ Degradation Current	Channel Roughness	Gravel Bar Abundance	Gravel Bar Types	Gravel Bar Proportion Class	Fine Sediment Abundance	Fine Sediment Type	D50 (mm)	Free	LWD Forced	Boulder Forced	Bank Forced	Total # Pools	Pool Spacing	Mean Res. Pool Depth (ft.)
ED1	PR	C4	Continuous	No	No	F-V	Abundant	P,M	50-75%	Abundant	B	33	1	3	0	7	11	2.2	3.5
ED8	PR	F4	None	No	No	V-F-LWD	Common	M	25-50%	Moderate	M/P	14	2	3	0	2	7	4.5	2.3
EI2	PR	C3	Continuous	No	No	C-B-F	Common	P,M	25-50%	Sparse	P	115	1	6	0	5	12	2.3	1.6
EI3	CAS	Aa2+	None			B-LWD													-
EJ1	PR	C4,F3,F4	Discontinuous	No	No	V-F-C	Common	P,F	25-50%	Sparse	P	43	2	3	0	1	6	2.8	1.9
EJI(2)	PR	E4,C4,F4	Discontinuous	No	No	F-V-LWD	Common	P, M	25-50%	Moderate	M	30	0	2	0	8	10	2.9	1.6
EL1	PR	C4,F4	Discontinuous	No	No	F-LWD-N	Common	P,M,F	25-50%	Moderate	M	20	1	10	0	9	20	0.9	2.7
EM1	PR	F4,F3,F1	None	No	No	C-R-B-V	Few	P	0-25%	Sparse	P	79	3	0	0	6	9	4.7	2.1
EM20	PR	Bc4, G4	Discontinuous	No	Aggr.	C-F-LWD	Common	P, F	25-50%	Moderate	B	36	0	5	0	2	7	4.3	0.9
EM29	PR	C4,E4,F4	Discontinuous	No	Aggr.	BK-F	Common	P	0-25%	Moderate	M	36	1	2	0	8	11	3.0	1.4
EM30	PR	F4,C4	Discontinuous	No	No	F-LWD	Common	P, F	25-50%	Moderate	M	35	0	6	0	4	10	2.6	1.3
EM39	PR,SP	F4,G4,B4	None	No	Aggr.	C-BK-F	Few	P, F	0-25%	Sparse	P	45	1	2	0	2	5	9.9	0.9
EN2	PR	F4,B4	Discontinuous	No	No	V-LWD-F	Few	P, M	0-25%	Moderate	M	29	1	5	2	2	10	2.7	1.4
EN25	PR	F4,B4,Bc4	Discontinuous	No	Aggr.	C-BK-LWD	Common	P, F	25-50%	Abundant	B	38	2	8	0	1	11	3.9	1.1
EN3	PR	F4	None	No	No	C-BK-R	Few	P	0-25%	Moderate	M	56	2	1	0	4	7	5.2	0.9
EN38	PR,SP	G4,F4	None	No	No	LWD-BK	Few	forced	0-25%	Sparse	P	38	0	1	1	4	6	4.9	1.4
EN4	PR	F4,G4	None	No	No	C-BK-LWD	Common	P, F	25-50%	Moderate	M	55	0	9	1	2	12	3.8	1.3
EU1	PR	C3,B3	Discontinuous	No	No	C-LWD	Common	P, F	25-50%	Sparse	P	75	0	1	0	8	9	7.4	2.7
EU20	PR,FPR	F3,G4,F4	None	No	No	B-C-R-BK	Common	P, F	25-50%	Moderate	M	74	1	1	1	7	10	4.5	1.6
EU24	CAS,SP	A1,A3,G3	None	No	No	R-C-B	Common	P, F	25-50%	Abundant	M	75	7	1	0	3	11	3.3	2.2
EU4	PR,SP	F3,B2,F2,G2	None	No	No	B-C-R	Common	P	0-25%	Sparse	P	96	1	1	2	3	7	4.2	1.5
EU7	PR	F3,F4,F5	None	No	Aggr.	C-F-LWD	Few	P, F	0-25%	Abundant	M	43	0	7	2	3	12	5.8	1.3
WF1	PR	C4	Continuous	No	Aggr.	F-LWD	Abundant	P, M	50-75%	Moderate	B	14	3	6	0	6	15	2.3	1.6
WF1(2)	PR	F1,F4	None	No	No	R-LWD	Few	F	0-25%	Moderate	P	26	8	2	0	4	14	2.6	1.3
WF13	SP,PR	B1,F3,F1,E4	Discontinuous	No	Aggr.		Few	P, F	0-25%	Moderate	P	18	4	4	0	5	13	3.7	1.1
WF26	PR	F4, B3	None	No	Aggr.	LWD-F	Abundant	P, M, F	50-75%			7	1	10	0	4	15	2.0	-
WF27		E4	Continuous	No	Aggr.	F-LWD	Common	P, M	25-50%			-							-
WH3	PR,SP	F4,G1	None	No	No	F-BK	Common	P	25-50%	Sparse	P	21	1	1	1	7	10	3.9	1.1
WL19	PR	F4	Inactive	Degr.	Aggr.	LWD-F	Abundant	A, M	50-75%	Moderate	M	29	0	7	0	3	10	5.0	1.0
WL27	PR,SP	F4,B3	Discontinuous	No	No	LWD-F-C-B	Common	A	25-50%	Moderate	M	52	2	7	0	9	18	2.1	1.3
WL28	PR	F4	None	No	No	LWD-F	Common	P, M	50-75%	Moderate	M	26	0	10	0	4	14	2.3	1.6
WL3	PR	F4	None	No	No	F-V-BK	Common	A, P, M	25-50%	Abundant	B	18	4	2	0	6	12	2.0	3.8
WL4	PR	F4	Inactive	No	No	C-LWD	Common	A	0-25%	Moderate	M	53	1	6	0	4	11	2.5	1.0
WM13		F4, G4	None		Degr.	F-BK-LWD													-
WM2	PR	F4	None	No	No	F-V-BK	Abundant	A, M	50-75%	Abundant	B	13	3	3	0	3	9	2.3	3.4
WM32	PR,CAS	G4,Aa3,A3	Discontinuous	No	No	LWD-C	-	-	-	Moderate	M	84	1	8	0	0	9	5.4	-
WM36	SP,FP\R,PR	G3,G4,E4B	Discontinuous	Aggr.	Aggr.	C-F	Few	P, F	0-25%	Moderate	M	34	3	2	0	1	6	12.5	0.9
WM5	PB,PR	F4,C4	Continuous	No	No	F	Common	P, M	25-50%	Abundatn	B	16	1	1	0	3	5	2.8	3.9
WN10	PR,CAS,FP\R	E4,A4	Discontinuous	No	No	LWD-C	Few	F	0-25%	Moderate	P & B	26	0	12	0	4	16	1.8	1.6
WN11	SP,CAS	A3,Aa3+	None	No	No	C-R-LWD	Few	F	0-25%	Sparse	P	-							-
WN20	SP,FP\R	E4B,B4	Continuous	No	No	LWD-B-C	Few	P, F	0-25%	Sparse	M	38	0	7	0	2	9	6.9	1
WR11	PR	E4	Continuous	Aggr.	No	V-LWD	Few	P	0-25%	Moderate	M	13	2	6	0	3	11	6.2	1.6
WR14	PR	C4	Continuous	No	No	LWD-F	Common	A, F	25-50%	Sparse	P	14	0	12	0	3	15	2.0	1.7
WR15	PR-SP	F4,A1,C4,B4	None	No	No	LWD-R	Few	F	0-25%	Moderate	M	11	5	8	0	1	14	2.3	-
WR23	PR,FP/R	C4,B4	Continuous	No	No	LWD	Few	P	0-25%	Moderate	M	16	2	9	0	2	13	3.3	1.6
WR26	PR	C4	Continuous	No	Aggr.	LWD-F	Abundant	P, M, F		Moderate	M	24	0	11	0	1	12	2.4	1.1
WU1	PR	F4	None	No	Aggr.	F-B	Common	A	25-50%	Abundant	M	18	0	4	2	2	8	2.1	2.8
WU15	PR,FP\R	F4,B3,G3	None	Aggr.	Degr.	LWD-C	Few	F	0-25%			75							-
WU18	CAS	Aa1+,A1,A3	None	No	No	R-LWD	Few	F	0-25%	Sparse	P	-	4	2	1	0	7	3.5	-
WU4	SP, FP/R, CAS	A3,B4	None	No	No	C-LWD-B	Few	F	0-25%	Sparse	P	55	0	6	2	2	10	4.8	0.8

Stream Geomorphic Units

Stream geomorphic units were developed for the stream network on the MRC property in the Navarro River watershed. These units are general representations of stream channels with similar sensitivities to coarse sediment, fine sediment and large woody debris inputs. Seven stream geomorphic units were developed for interpretation of stream channel response to forest management interactions in the Navarro WAU. The seven stream geomorphic units are described below.

Geomorphic Unit I. Estuarine Channel of the Navarro River.

Segment: WL1

General Description: The river channel within this unit flows through a confined canyon bottom at the mouth of the Navarro River at the ocean. The channels are low gradient (0-1 percent) in this unit, with limited mudflat and wetland areas adjacent to the channels due to the confined canyon. Ocean tides influence the stage of these channels with high tides raising the river level. The channel substrate is predominantly a consolidation of deposited fine silt and clay materials.

Associated Channel Types:
This unit primarily exhibits regime morphology. The Rosgen classifications (Rosgen, 1994) for these channels are predominantly F6 and F5.

Fish Habitat Associations:
Spawning habitat in this geomorphic unit is limited due to availability and has poor site potential because of silt/clay substrate that is dominant in this unit. Rearing salmonids for food and shelter uses highly productive estuarine habitat. Meadow /wetland vegetation along the fringes of the channel provide roughness to slow water flow providing overwintering habitat to juvenile salmonids.

Conditions and Response Potential

Coarse Sediment: Low Response Potential
These channels due to their low gradient and tidal influence are typically not areas of coarse sediment deposition. The breakdown of the competence of coarse sediment as it is transported through the watershed usually results in low levels of coarse sediment reaching the estuarine channels. However, if coarse sediment supply is high then deposition can occur at the upper end of these channels.

Fine Sediment: Moderate Response Potential
Typically estuarine channels are low gradient which slow river flow allowing fine sediment deposition, potentially influencing channel morphology. The confined characteristics of the Navarro River estuary makes large scale fine sediment deposition unlikely because the confined channels direct more stream power and sediment transport. Though high fine sediment supply will likely result in bar formations. A decrease in sediment supply could result in channel degradation or bank erosion.

Large Woody Debris(LWD): Low Response Potential
The regime morphology of this channel does not typically respond greatly to LWD inputs. Although large wood is often the only roughness element of these channels, the high

sedimentation rate and large size of the channel limits pool development. The primary role for wood in habitat development is refuge and cover.

Geomorphic Unit II. Low Gradient, Confined Channel of the Navarro River.

Includes Segments: *Field observed* – WU1, WM5, WM2, WL3
Extrapolated - WL2, WM1, WM3, WM4, WU2

General Description: The channels within this unit meander through confined canyons. High terraces and hillslopes control the lateral movement of the channels. The channels are typically confined on one bank by hillslopes and high terraces on the other, and occasionally has narrow floodplains present, typically on the inside of meander bends. Alternating gravel bars on meander bends often define the bankfull width. The bankfull channel varies from 100 to 200 feet in width. The sinuous path of the flow in these channels lowers the river gradient and creates alternating pool-riffle morphology. This makes the channel very stable, with only limited bank erosion observed even on poorly vegetated outside edges of meander bends despite the confined nature of the channel. The channels in this unit are low gradient (0-2 percent), but sediment transport capacity is high due to the highly confined channel keeping water energy directed within the channel. High flow events within these channels will move all but the most stable large woody debris (LWD) accumulations or push accumulations to the channel margins. The channel bed varies from sand to gravel sized particles.

Associated Channel Types:
This unit primarily exhibits pool/riffle and plane bed morphology. The Rosgen classifications (Rosgen, 1994) for these channels are predominantly F4 with isolated areas of C4.

Fish Habitat Associations:
These channels are low gradient, depositional channels of a large watershed. These channels typically have sand to small gravel substrate that is not highly desirable for spawning habitat. The large size of these channels makes for a very wide bankfull channel with low shade, making for high summer water temperatures thus poor summer rearing habitat for salmonids. The lack of LWD combined with small substrate makes these channels also poor areas for over-wintering habitat, though salmonids likely can find refuge in the deep pools along these channels. These channels overall do not provide highly productive salmonid habitat.

Conditions and Response Potential

Coarse Sediment: Moderate Response Potential
These channels are depositional areas for coarse sediment. Coarse gravel accumulations are common in point and medial gravel bars in this unit. The high confinement of these channels create relatively high sediment transport capacity. However, if the supply of coarse sediment surpasses the transport capacity the impact can be filling of pools or increased scour of the bed.

Fine Sediment: Moderate Response Potential
The channels of this unit have high fine sediment transport capacity due to high flow capacity of the channel. However, the Navarro watershed has a relatively high background sediment rate. This high rate of sediment input can result in pool filling or bed fining from high fine sediment accumulations. Fine sediment accumulations were observed in this unit on the top of gravel bars, accumulated in the bed of plane bed reaches, along pool margins, and in some pools.

Large Woody Debris: Moderate Response Potential
Large woody debris is sparse in this unit. The LWD that is present is providing stream habitat development and cover. The confined high energy flow and large channels of this unit require very large LWD pieces or debris jams to keep the LWD in place. Very large LWD is recruited

into channels infrequently due to the long growing times of streamside trees. However, LWD in this unit is still important because the channels in this unit gain greater pool depths and cover, for fish habitat diversity, with increased LWD.

Geomorphic Unit III. Confined and Moderately Confined Low Gradient Channel Segments in the Navarro River Watershed.

Includes Segments: *Field observed* – ED1, ED8, EI2, EJ1, EJ1(2), EL1, EM1, EN2, EU1, EU4, WF1,WF1(2), WL27
Extrapolated – WN1, WN2, WN3, WG4, WG2, EL2, EL3, EM2, EU2, EU3, EI1, EI11, EI19, ED2, ED3, EN1

General Description:
The channels within this unit meander through confined canyons. Hillslopes or inner gorge topography typically controls the lateral movement of the channels. In wider areas of the valley bottom, high terraces are present and occasionally floodplains are present, though discontinuously. The bankfull channel varies from approximately 15 to 75 feet in width. The channels in this unit are low gradient (0-2 percent), but sediment transport capacity is high due to the confined channel keeping water energy directed within the channel and relatively large drainage areas producing greater water flow.

Associated Channel Types:
This unit primarily exhibits pool/riffle morphology, with some forced pool/riffle morphology. The Rosgen classifications (Rosgen, 1994) for these channels are primarily F4 and F3 with occasional areas of C4.

Fish Habitat Associations:
The confined channels of these units have a high sediment transport capacity during high flows, which flushes fine sediment, with the potential to create high quality spawning gravel. This same high-energy transport, in conjunction with LWD, dominates pool development. Currently this unit has low amounts of large woody debris, however due to the confined canyons wood recruitment would have a positive effect on the quality of in-stream habitat. Overwintering habitat can be limited in areas without large cobble/boulder and bedrock substrates. LWD when present in this unit provides overwintering habitat for juvenile salmonids.

<u>Conditions and Response Potential</u>
Coarse Sediment: Moderate Response Potential
These channels are depositional areas for coarse sediment. The high confinement of these channels creates relatively high sediment transport capacity. If the supply of coarse sediment surpasses the transport capacity of the stream, pools can be filled, and the influence of large woody debris and bedrock controlled sections are reduced. If significant amounts of coarse sediment are supplied to these channels then the channels are vulnerable to widening, creating greater bank erosion, or limited lateral movement reducing meander and increasing bed scour. However, because of the natural confinement of these channels, the tendency toward widening or adjustments in meanders are minimized.

Fine Sediment: Moderate Response Potential
The channels of this unit have high fine sediment transport capacity due to high flow capacity of the channel. However, when there is a high fine sediment supply in transport, accumulations of fine sediment do occur in this unit. Sparse to abundant accumulations of fine sediment was observed in this unit. These accumulations were observed in the gravel bars, along channel margins, and in some pools.

Large Woody Debris: High Response Potential

The alluvial composition of the bed material in conjunction with a low gradient channel makes these channels highly responsive to LWD inputs. LWD is a dominant influence for pool development, sediment storage behind LWD accumulations and stabilization of bank and bedforms within the channels in this unit. LWD forced pool/riffle morphology is evident in some reaches within this unit.

Geomorphic Unit IV. Confined Low Gradient Channel Segments of Small Tributary Streams in the Navarro River Watershed.

Includes Segments: *Field observed* – EM20, EM29, EM30, EM39, EN25, EN3, EN38, EN4, EU20, EU7, WF13, WF26, WH3, WL19, WL28, WL4, WM13, WN10, WN20, WR11, WR14, WR15, WR26
Extrapolated – WL5, WL6, WL7, WL8, WL9, WL29, WL30, WR1, WR2, WR3, WR13, WR23, WR32, WF2, WF3, WN24, WN28, WC1, ED10, ED11, EN14, EN15, EN43, EN40, EN24, EJ2, EJ3, EJ9, EJ12, EM3, EM4, EM31, EU18, EU21

General Description:
The channels within this unit flow through confined canyons. Hillslopes or inner gorge topography typically controls the lateral movement of the channels. Some terraces are present and occasionally floodplains are present, though discontinuously. The bankfull channel is typically less than 15-25 feet in width. The channels in this unit are low gradient (1-3 percent). These channels exhibit moderate sediment transport capacity. The confined channel keeps water energy directed within the channel but the relatively smaller drainage area does not produce water energy as high as Unit III.

Associated Channel Types:
This unit primarily exhibits pool/riffle morphology, forced pool/riffle morphology and some step pool morphology. The Rosgen classifications (Rosgen, 1994) for these channels are primarily F4, F3 and G4 with occasional areas of C4, B3, and B4.

Fish Habitat Associations:
Spawning habitat and gravel are moderate amounts in this unit, but spawning gravel quality is good where present. These channels are confined within narrow canyons that produce good recruitment potential for LWD. The recruited LWD in turn facilitates pool development and offers shelter. Rearing habitat availability can be good where sufficient LWD creates good pool habitat and shelter, however summer rearing can be absent because some of the streams in this unit can go subsurface during the summer rearing period. Young fish would have to migrate to other areas to survive through the summer months. Overwintering habitat is provided by large cobble/boulder and bedrock substrates. LWD when present in this unit also provides overwintering habitat for juvenile salmonids.

<u>Conditions and Response Potential</u>

Coarse Sediment: High Response Potential
These channels are depositional areas for coarse sediment. The moderate sediment transport capacity makes these channels vulnerable to changes in supply of coarse sediment. Fluctuations of coarse sediment can occur that will surpass the transport capacity of the stream. When this occurs pools can be filled, the influence of large woody debris and bedrock controlled sections are reduced and the channels can aggrade. Aggradation of the channel can create greater bank erosion, or produce limited lateral movement increasing localized bed scour thus causing the channels to entrench.

Fine Sediment: Moderate Response Potential
The channels of this unit have high fine sediment transport capacity due to high flow capacity of the channel. However, when there is a high fine sediment supply in transport, accumulations of fine sediment do occur in this unit. Sparse to abundant accumulations of fine sediment was

observed in this unit. These accumulations were observed in the gravel bars, along channel margins, and in some pools.

Large Woody Debris: High Response Potential
The alluvial composition of the bed material in conjunction with a low gradient channel makes these channels highly responsive to LWD inputs. LWD is a dominant influence for pool development, sediment storage behind LWD accumulations and stabilization of bank and bedforms within the channels in this unit. LWD forced pool/riffle morphology is evident in some reaches within this unit.

Geomorphic Unit V. Channel Migration/Avulsion Channel Segments in the Navarro River Watershed.

Includes Segments: WN23, WR10, WR12, WF1 (Partial)

General Description: Channels within this unit flow through unconfined to moderately confined canyon sections in the Navarro River watershed. The channels in this unit are low gradient (<1 percent), with a high degree of deposition. Channels within this unit frequently access the floodplain and abandoned or avulsion channels at high flows. The unconfined channels in combination with access of the floodplain and avulsion channels during high flows makes channel migration to avulsion channels common in this unit. The channel substrate, and adjacent terraces is predominantly a consolidation of fine deposited materials of the silt and clay size classes.

Associated Channel Types:
This unit primarily exhibits pool/riffle morphology, however plane bed morphology is occasionally present. The Rosgen classifications (Rosgen, 1994) for these channels are predominantly C4, C5, C6 with areas of E5 or E6 depending on the substrate or bank configuration.

Fish Habitat Associations:
A high propensity for channel migration causes streams to spread out over the floodplain rather than concentrating flows through a narrow channel. While this increased wetted area may enhance spawning habitat area, it also increases fine sediment deposition in areas of lesser flow. During drought conditions or low summer flows, it is not uncommon for side channel flow to go subsurface. In these situations, rearing habitat is limited to the main channel and deeper residual pools. The unconfined, low gradient nature of these streams combined with large amounts of woody debris result in an abundance of wood-forced pools creating good summer-rearing habitat. These segments are often lacking bedrock and the large cobble/boulder substrates associated with overwintering habitat. However, the LWD provides the roughness element to slow water velocities and provide key overwintering habitat to juvenile salmonids.

Conditions and Response Potential

Coarse Sediment: Moderate Response Potential

Coarse gravel accumulations are primarily in point and LWD forced gravel bars, with some medial bars. In a few isolated circumstances the channels do show evidence of having some aggradation in the past. The unconfined channels and migrating channel areas are not considered high sediment transport areas, but do provide a large amount of sediment storage opportunities buffering impacts from high coarse sediment loads. However, based on evidence of some past and current aggradation, if the coarse sediment supply is high then the channels could be adversely affected lowering channel complexity and fish habitat quality.

Fine Sediment: Low Response Potential

Moderate to high accumulations of fine sediment is observed in this unit. However, the substrate and terraces in this unit are composed of fine material. The unconfined and low gradient characteristic of this unit facilitates high fine sediment deposition. This deposition provides for the flat morphology of the stream channels, and thus the fine material composition of the channel banks, substrate and terraces. This process of fine sediment deposition appears to be the natural process in this unit. This unit is not anticipated to be adversely affected by future fine sediment deposition provided the channel migration and floodplain characteristics are not altered.

Large Woody Debris: High Response Potential

LWD is common to abundant in this unit with some areas with sparse accumulations. LWD is functional for stream habitat development or cover in this unit. The greatest portion of pool formation in this unit is LWD forced. The channel substrate and terraces in this unit are predominantly composed of fine particles (silt and clay), providing little in the way of roughness elements for stream habitat or channel diversity. LWD and streamside vegetation in this unit is the primary source of channel roughness for stream habitat development and quality. In the areas where channel migration is prevalent, LWD recruitment across the entire canyon bottom is essential to ensure adequate LWD for channel roughness and habitat as the channel migrates.

Geomorphic Unit VI. Moderate Gradient Confined Transport Segments.

Includes Segments: *Field observed* – EU24, WF27, WM32 (partial), WM36, WN11 (partial), WR23, WU4.
Extrapolated – WL10, WL11, WL20, WL21, WL22, WL23, WL31, WL32, WR5, WR8, WR16, WR18, WR20, WR27, WR36, WR40, WN8, WN13, WN14, WN20, WN26, WF6, WF9, WF17, WF18, WF21, WM36, WU7, WU15, WH4, WH12, WC2, WC3, WC8, WI1, WI2, WI3, ED4, ED12, ED14, ED17, ED27 (partial), ED30, EJ5, EJ7, EJ4, EJ10, EJ11, EJ13, EJ14, EJ17, EL9, EL18, EN5, EN6, EN8, EN16, EN17, EN19, EN20, EN26, EN27, EN39, EN45, EM5, EM6, EM7, EM8, EM16, EM20, EM27, EM32, EM40, EM41, EI5, EI6, EU5, EU8.

General Description:
Stream channel segments in this unit are confined to moderately confined within canyons. Typically valley widths are between 2 and 5 bankfull channel widths. This valley width is sufficient to allow some isolated terrace formation and channel meandering. The channel segments in this unit are near the transition between deposition and transport channels. Due to the moderate gradient (3-8 percent) of the channels, they are responsive to aggradation and degradation from changes in the stream sediment supply. The stream bed of these channels varies from gravel to boulder sized particles. The terraces in this unit appear to be created from large episodic sediment loads such as frequent mass wasting. The gradient of the stream is high enough that stream segments in this unit easily down-cut through the terrace deposits when flow is concentrated.

Associated Channel Types:
This unit primarily exhibits step pool and cascade morphology, with areas of pool/riffle morphology. The Rosgen classifications (Rosgen, 1994) for these channels vary from A1-4 and G1-4 with areas of B3, B4 and C4 depending on the bank configuration, slope and channel substrate.

Fish Habitat Associations:
Spawning areas in this unit are infrequent, due to lack of accumulations of gravel sized particles. The steeper gradient segments of this unit typically form step-pool, cascade, and some pool-riffle habitat. The step-pools that are typically boulder formed, and offer substrate refugia, which provide both rearing and overwintering habitat.

<u>Conditions and Response Potential</u>

Coarse Sediment: Moderate Response Potential
The channels in this unit have relatively high sediment transport capacity. In the lower gradient sections of these channels coarse sediment can create pool filling and aggradation, resulting in increased bank erosion and poor stream habitat. The step pool sections of these channels have relatively stable cobble and boulder component that can remain relatively static except in extreme flows. Increased coarse sediment supply can create pool filling, but is only moderately influential on the morphology because pool filling at these moderate gradients creates lower channel roughness which in turn promotes more step pool or cascade development, provided high inputs of coarse sediment subside.

Fine Sediment: Low Response Potential
The channels of this unit have high fine sediment transport capacity due to high flow capacity of the channel. However, when there is a high fine sediment supply in transport, accumulations of fine sediment do occur but typically have short residence times in this unit. Sparse to moderate accumulations of fine sediment was observed in this unit. These accumulations were observed in the bed and along channel margins.

Large Woody Debris: Moderate Response Potential
The high confinement or entrenchment of these channels provides little opportunity for the channel to meander or develop a floodplain. Water energy is concentrated within the confines of canyon walls or stream banks making the role of LWD less sensitive as channels with less confinement or entrenchment. LWD is less likely to enter the channel because it becomes suspended over the channels narrower bankfull width. The role of LWD is typically as sediment storage or forced step pool development in these channels. Bed morphology in channels with slope gradients of 4-10% is typically step pool (Montgomery and Buffington, 1993). The large bed forming material of step pool morphology is generally stable making the role of LWD in these channels less sensitive than other channel types.

Geomorphic Unit VII. High Gradient Transport Segments.

Includes Segments: EL4, EL5, EL6, EL7, EL8, EL10, EL11, EL12, EL13, EL14, EL15, EL16, EL17, EL19, ED5, ED6, ED7, ED9, ED13, ED15, ED16, ED18, ED19, ED20, ED22, ED23, ED24, ED25, ED27, ED29, ED31, ED32, ED33, ED34, EJ8, EJ14, EJ15, EJ16, EJ18, EN7, EN9, EN10, EN11, EN12, EN13, EN18, EN21, EN22, EN23, EN28, EN29, EN30, EN31, EN32, EN33, EN34, EN35, EN36, EN37, EN41, EN42, EN44, EN46, EN47, EN48, EN49, EN50, EN51, EN52, EM9, EM10, EM11, EM12, EM13, EM14, EM15, EM17, EM17, EM18, EM19, EM21, EM22, EM23, EM24, EM25, EM26, EM33, EM34, EM35, EM36, EM37, EM38, EM42, EM43, EM44, EM45, EM46, EM47, EM48, EM49, EM50, EI3, EI4, EI6, EI7, EI8, EI10, EI12, EI13, EI14, EI15, EI16, EI18, EU6, EU9, EU10, EU11, EU12, EU13, EU15, EU16, EU19, EU22, EU23, EU25, EU26, EU27, EU28, EU29, EU30, EU31, EU32, EU33, EU34, EU35, EU36, WI4, WC4, WC5, WC6, WC7, WC9, WC10, WC11, WH5, WH6, WH7, WH8, WH9, WH10, WH11, WH13, WH14, WU3, WU5, WU6, WU7, WU8, WU9, WU10, WU11, WU12, WU13, WU14, WU16, WU18, WU19, WU20, WU21, WU23, WU24, WG3, WG4, WG5, WG6, WM8, WM9, WM10, WM12, WM14, WM15, WM16, WM17, WM18, WM19, WM20, WM21, WM22, WM24, WM25, WM26, WM27, WM28, WM29, WM30, WM32(partial), WM33, WM34, WM35, WM38, WM39, WM40, WM41, WM42, WM43, WM44, WM47, WN4, WN5, WN6, WN7, WN9, WN11(partial), WN12, WN15, WN16, WN17, WN19, WN21, WN22, WN25, WN27, WN29, WN30, WN31, WN32, WN33, WF7, WF8, WF10, WF11, WF12, WF19, WF20, WF22, WF23, WF24, WF25, WF28, WF30, WR4, WR6, WR7, WR9, WR17, WR19, WR21, WR22, WR24, WR25, WR28, WR29, WR30, WR31, WR34, WR35, WR37, WR38, WR39, WL17, WL18, WL24, WL25, WL26, WL33, WL34, WL35, WL36, WL37, WL38, WL39, WL40.

General Description:
Channel segments in this unit are high gradient transport reaches from 8-20% with high sediment transport capacity. The channel segments in this unit typically flow through tightly confined, steep-sided, V-shaped canyons. These are typically zones of scour during high flows, and periodically influenced by shallow-seated landslides. Stream substrate is typically from cobble to large boulders. Typically, there is no water flow in this unit in the summer drought season.

Associated Channel Types:
This unit varies morphology from step pool to cascades with some occasional waterfalls. The cascades and waterfalls occur in the steepest segments of this unit and only during winter storm events. The Rosgen (Rosgen, 1996) classification for these channels varies between A2, A3, and AA2, AA3 depending on channel gradient and substrate composition.

Fish Habitat Associations:
The high gradient channels of this unit prevent coho salmon from accessing these areas. Potential for steelhead trout utilization is low due to the high gradient; 8% to 20%. Rearing would be unlikely because stream flow typically goes subsurface in the summer months.

Conditions and Response Potential
Coarse Sediment: Low Response Potential
Typically the channel morphology in this unit is cascade, with some step pool morphology at the lower gradients observed in these channels. These channels have bed material that is coarse and relatively immobile. Down cutting or bank erosion are not common in these high gradient, large substrate dominated channels even with increases in sediment supply. Debris flows can cover

the substrate creating the cascade morphology but this is generally short-lived due to the high sediment transport capacity of the channels.

Fine Sediment: Low Response Potential
The high gradient of the channels in this unit creates a high fine sediment transport capability. Pools or storage areas for fine sediment in these channels are limited making the impacts from fine sediment minimal. Down cutting or bank erosion are not common in these high gradient, large substrate dominated channels even with increases in sediment supply.

Large Woody Debris: Low Response Potential
The role of LWD in these channels is to provide storage of sediment and also as a source for downstream LWD. LWD is needed in these channels however the need for LWD as a source for downstream LWD is episodic and therefore the least sensitive as other channel types. The storage of sediment by LWD in these channels is necessary, but can be accomplished by a range of size classes of LWD not necessarily very key LWD pieces.

DAM UNDER CONSTRUCTION ON THE NAVARRO RIVER - PROBABLY USED IN WATER DRIVING LOGS TO MILL.
#C3399 GEORGIA PACIFIC

Long Term Stream Monitoring

During the Summer of 1999 six long term channel monitoring segment were surveyed for longitudinal profiles, cross sections, and particle size distribution, while eight segments for stream gravel permeability and stream gravel composition in the Navarro River WAU. In 2001, 2 of the segments were re-surveyed, North Branch North Fork Navarro River and South Branch North Fork Navarro River providing a comparison of the thalweg, cross sections and pebble counts for those segments. The plots of the surveys are included in the appendix of this module (Appendix E) for display. The results of the stream gravel bulk samples and permeability are presented in section F - Fish Habitat Assessment of this report.

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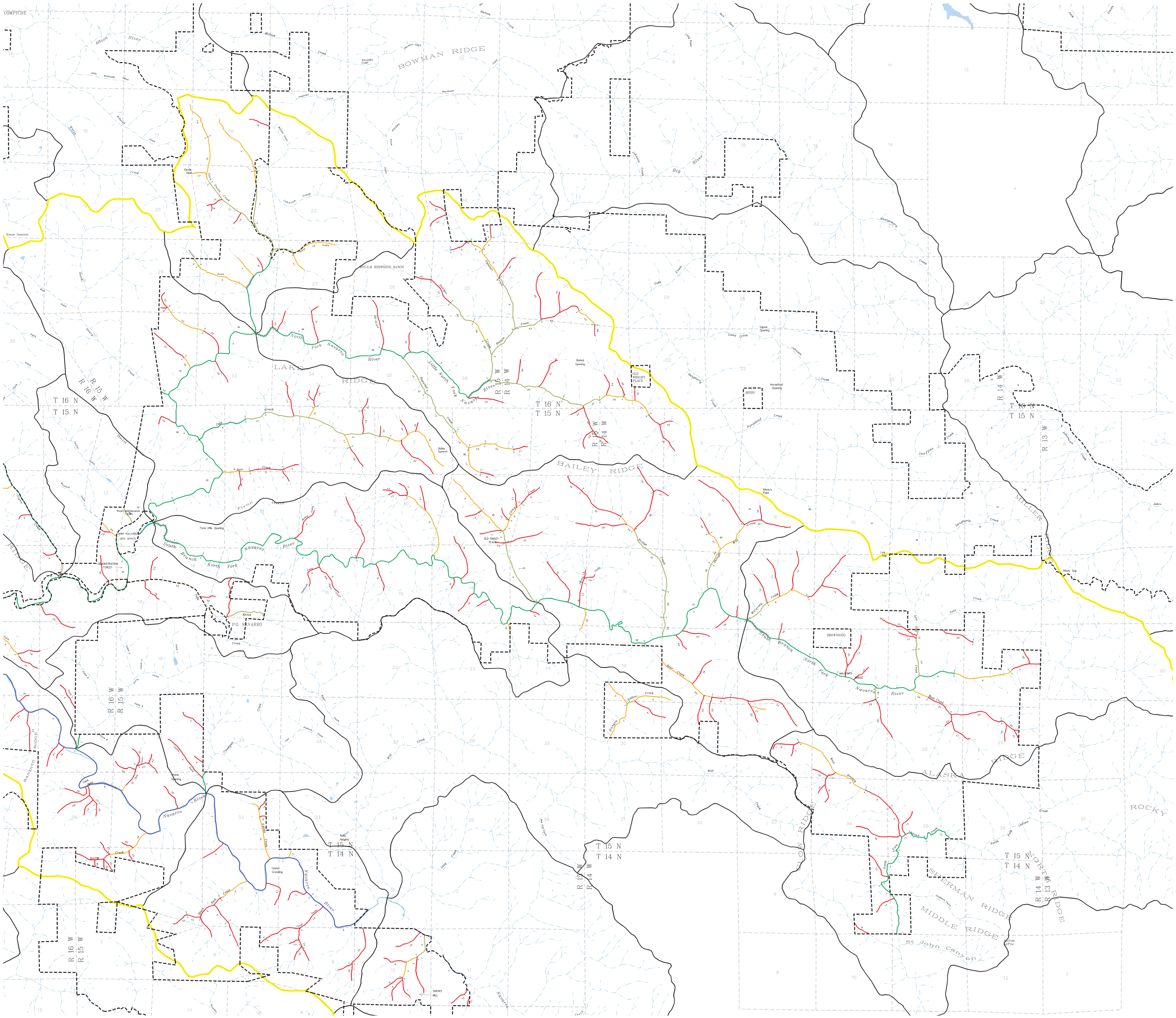


Navarro River -- East Watershed Analysis Unit

Map E-1 (A) Stream Channel Geomorphic Units and Segments

This map presents the stream channel network for the Navarro WAU partitioned into stream segments based on three classes of channel confinement and several classes of channel gradient. The slope classes used for delineation are 0-3%, 3-7%, 7-12%, and 12-20%. Channel segments were grouped into geomorphic units by similar attributes of channel condition, position in the drainage network, and gradient/confinement classes. The intent of the geomorphic units are to stratify channel segments of the Navarro WAU into units which respond similarly to the input factors of coarse and fine sediment, and LWD. These geomorphic units can then be interpreted to have similar habitat-forming processes.

Geomorphic Classes

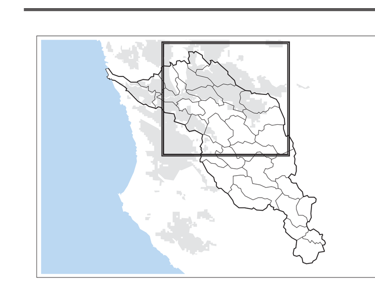
- Unit I. Estuarine Channels of the Navarro River Watershed
- Unit II. Low Gradient Confined Channels of the Navarro River Watershed
- Unit III. Confined and Moderately Confined Low Gradient Channel Segments in the Navarro River Watershed
- Unit IV. Confined Low Gradient Channel Segments of Small Tributary Streams in the Navarro River Watershed
- Unit V. Channel Migration/Avulsion Channel Segments in the Navarro River Watershed
- Unit VI. Moderate Gradient Confined Transport Segments
- Unit VII. High Gradient Transport Segments

Long Term Channel Monitoring Sites

MRC Ownership
Planning Watershed Boundary
Navarro River Watershed Boundary

Flow Class

- Class I
- Class II
- Class III



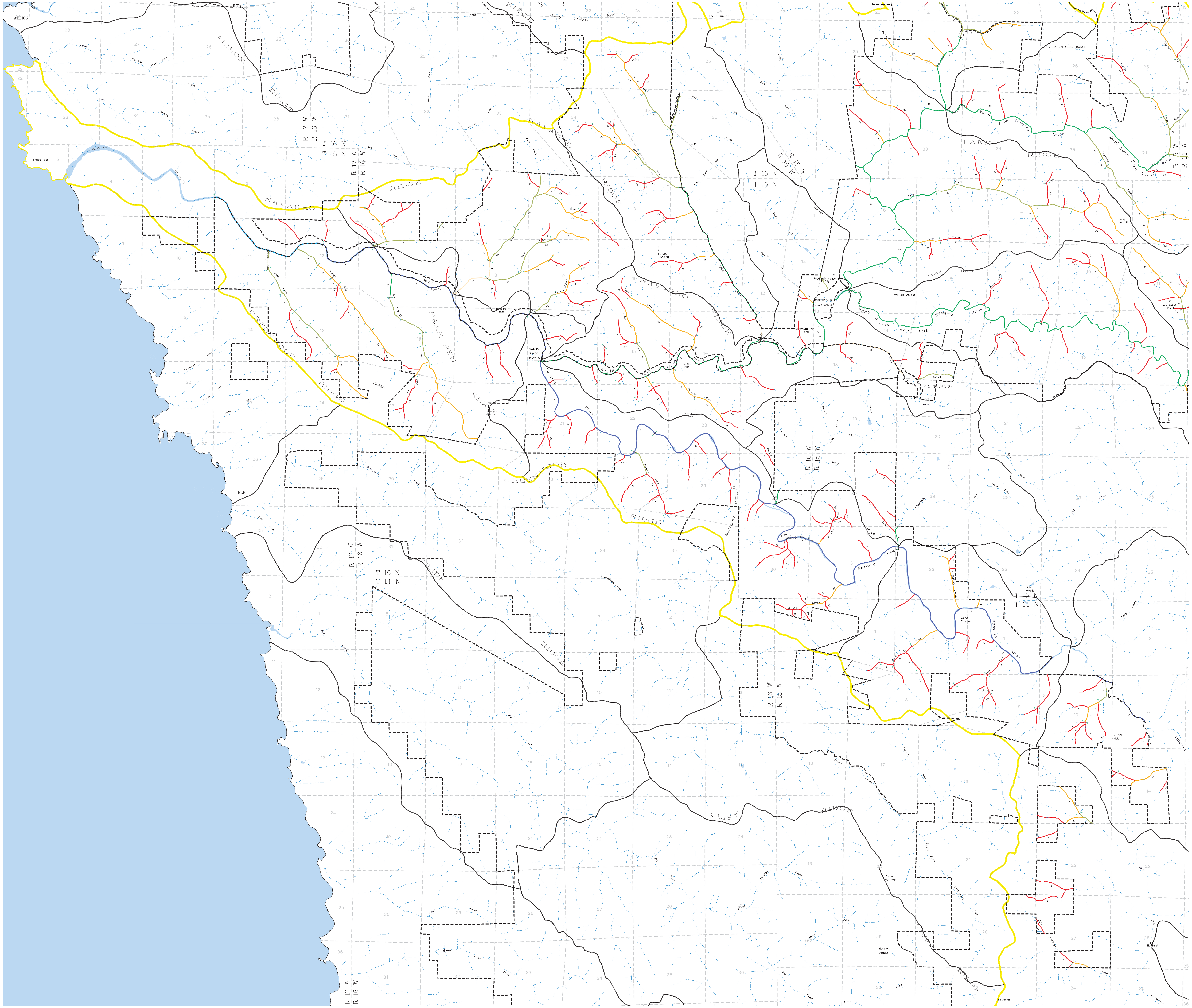
0 1/2 1 Mile

August 2002

Navarro River -- West Watershed Analysis Unit

Map E-1 (B) Stream Channel Geomorphic Units and Segments

This map presents the stream channel network for the Navarro WAU partitioned into stream segments based on three classes of channel confinement and several classes of channel gradient. The slope classes used for delineation are 0-3%, 3-7%, 7-12%, and 12-20%. Channel segments were grouped into geomorphic units by similar attributes of channel condition, position in the drainage network, and gradient/confinement classes. The intent of the geomorphic units are to stratify channel segments of the Navarro WAU into units which respond similarly to the input factors of coarse and fine sediment, and LWD. These geomorphic units can then be interpreted to have similar habitat-forming processes.



Geomorphic Classes

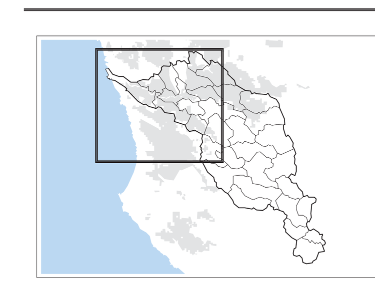
- Unit I. Estuarine Channels of the Navarro River Watershed
- Unit II. Low Gradient Confined Channels of the Navarro River Watershed
- Unit III. Confined and Moderately Confined Low Gradient Channel Segments in the Navarro River Watershed
- Unit IV. Confined Low Gradient Channel Segments of Small Tributary Streams in the Navarro River Watershed
- Unit V. Channel Migration/Avulsion Channel Segments in the Navarro River Watershed
- Unit VI. Moderate Gradient Confined Transport Segments
- Unit VII. High Gradient Transport Segments

- Long Term Channel Monitoring Sites

- MRC Ownership
- Planning Watershed Boundary
- Navarro River Watershed Boundary

Flow Class

- Class I
- Class II
- Class III

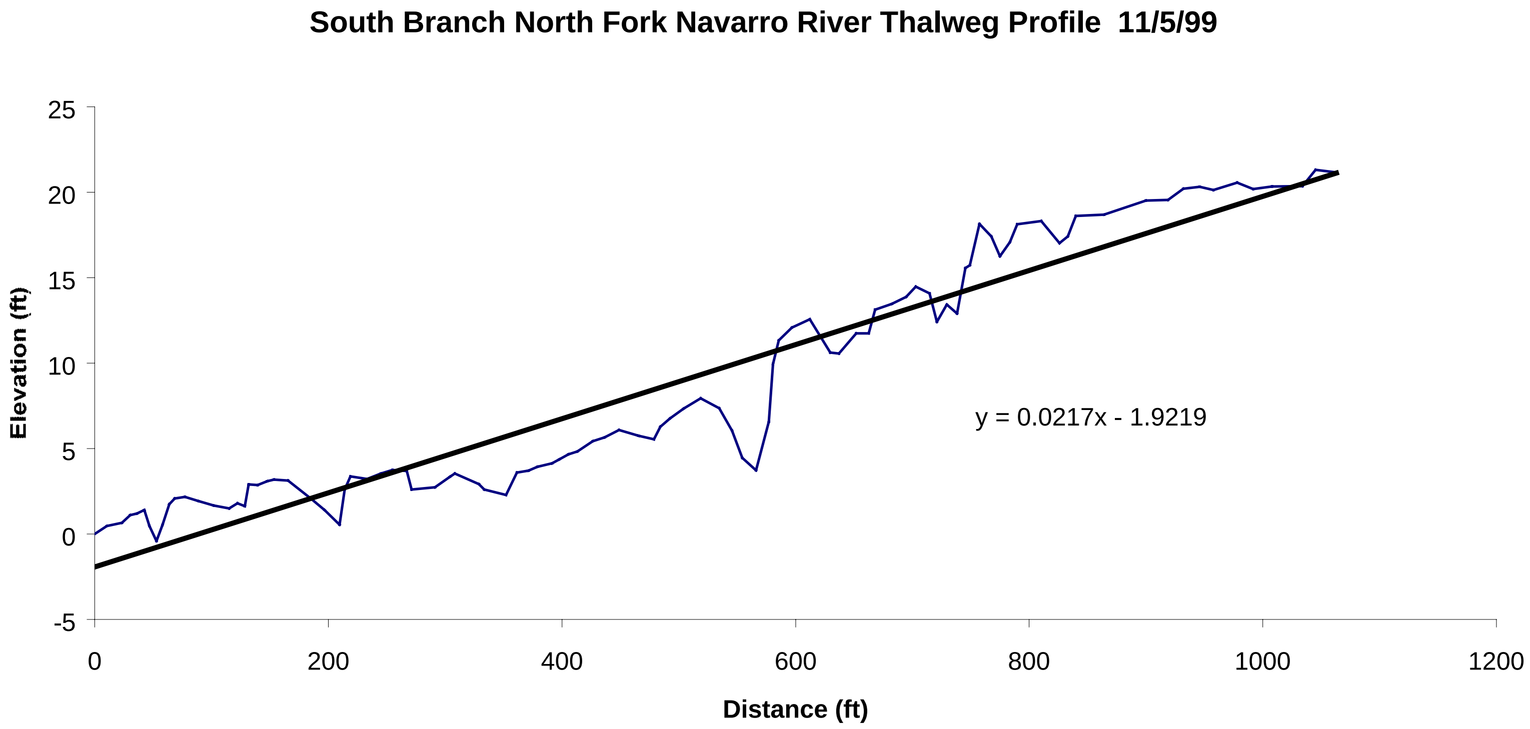


0 1/2 1 Mile

August 2002

Appendix E

Stream Channel Condition Module


South Branch North Fork Navarro River Thalweg Profile 11/5/99
Elevation (ft)
25
20
15
10
5
0
-5
0
200
400
600
800
1000
1200
Distance (ft)
y = 0.0217x - 1.9219

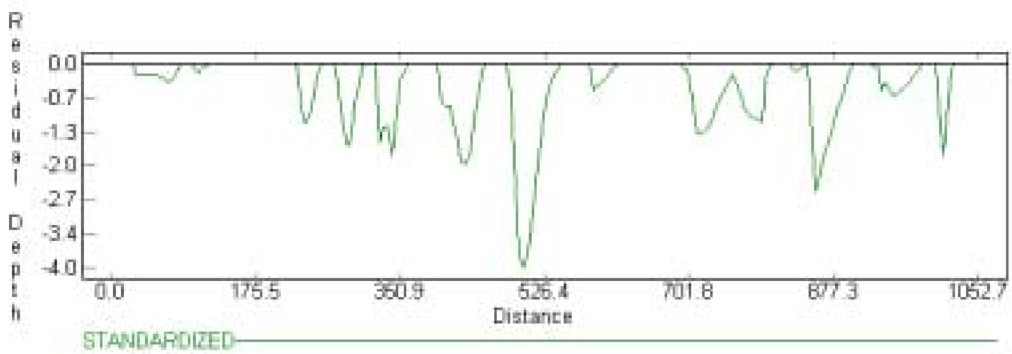
South Branch North Fork Navarro River Residual Depth Statistics 1999

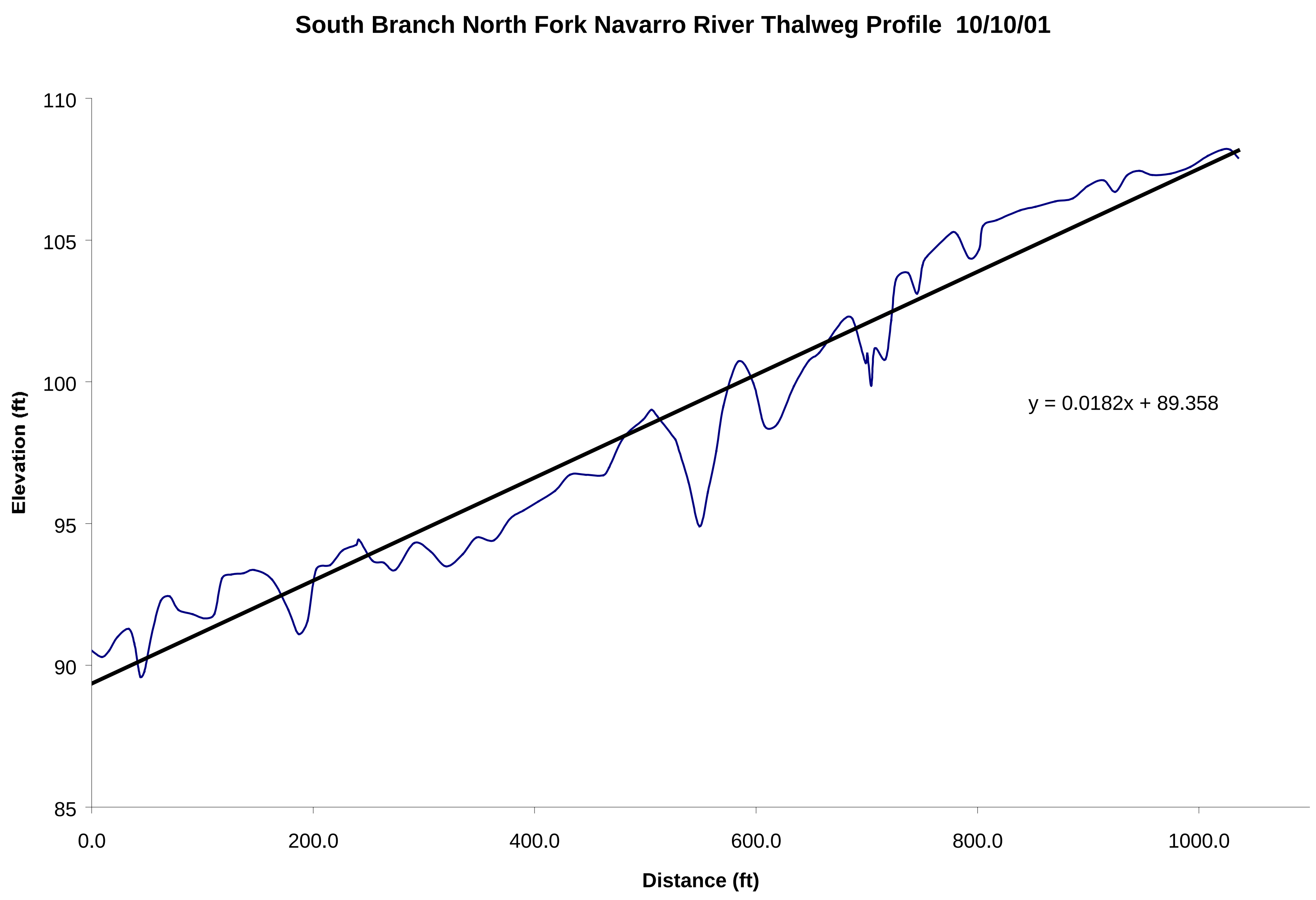
Top Elevation: 21.32
Bottom Elevation: -0.42
Reach Length: 1052.70

Reach Step Distance: 5.00

Max Residual Depth: 4.02
Mean Residual Depth: 0.46
Standard Deviation: 0.73

Number of non-zero Residual Depths: 121
Percent of Reach as pool: 57.35
Percent of Reach as riffle: 42.65




South Branch North Fork Navarro River Thalweg Profile 10/10/01
Elevation (ft)
110
105
100
95
90
85
0.0
200.0
400.0
600.0
800.0
1000.0
Distance (ft)
y = 0.0182x + 89.358

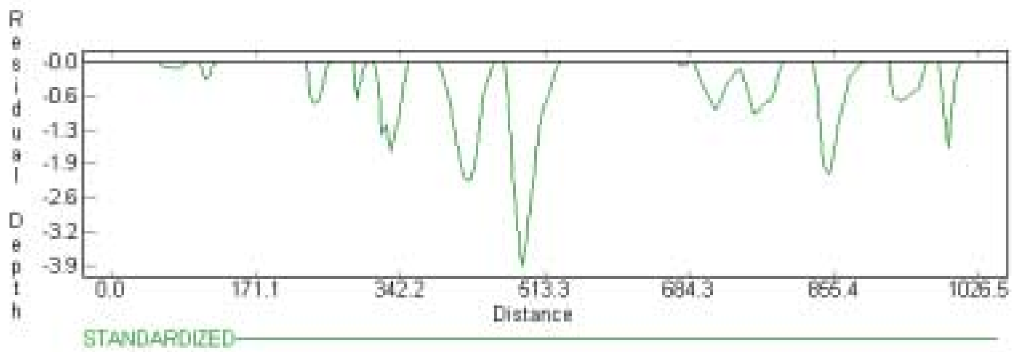
South Branch North Fork Navarro River Residual Depth Statistics 2001

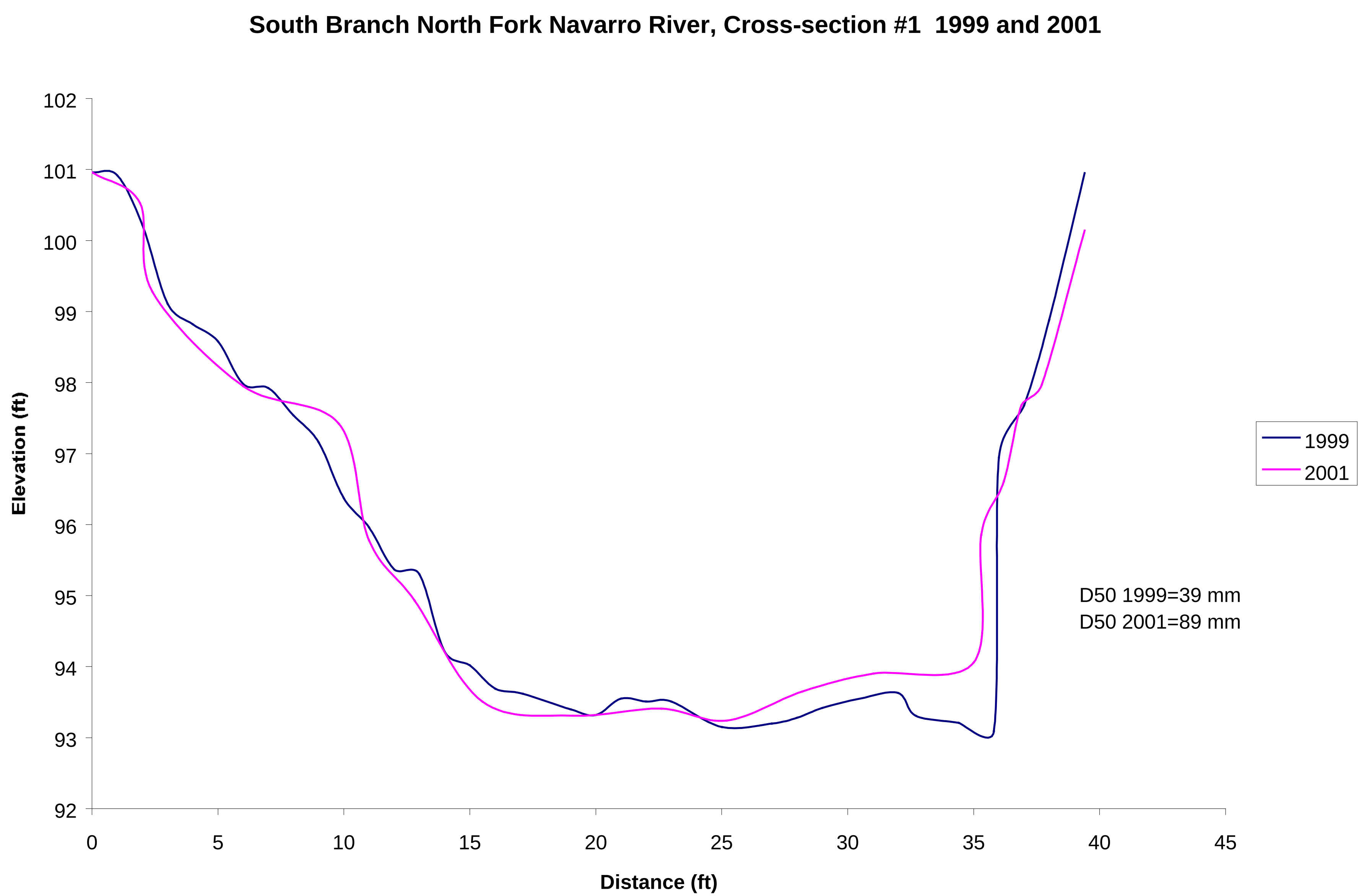
Top Elevation: 108.18
Bottom Elevation: 89.60
Reach Length: 1026.50

Reach Step Distance: 5.00

Max Residual Depth: 3.87
Mean Residual Depth: 0.40
Standard Deviation: 0.69

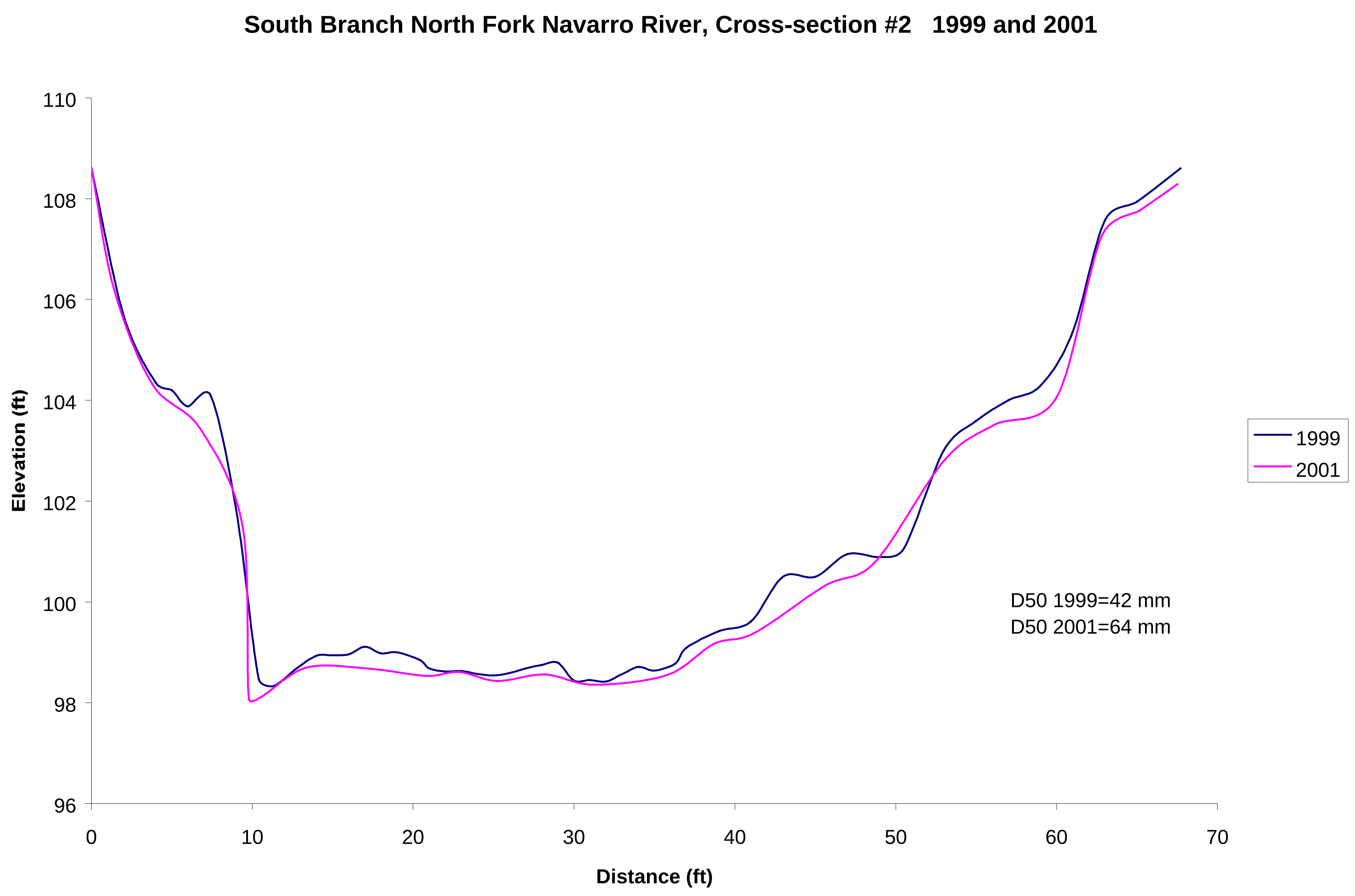
Number of non-zero Residual Depths: 102
Percent of Reach as pool: 49.76
Percent of Reach as riffle: 50.24

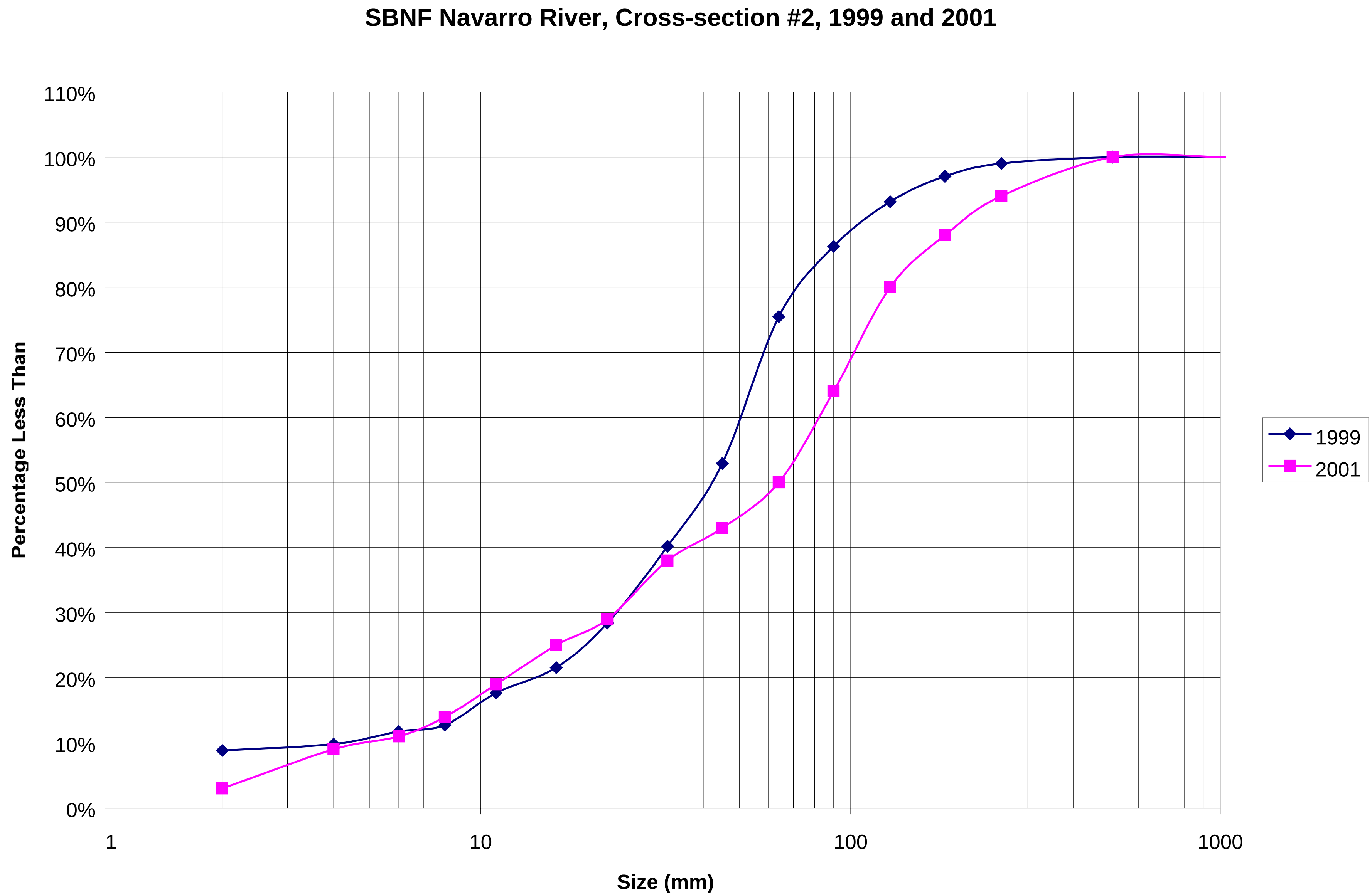


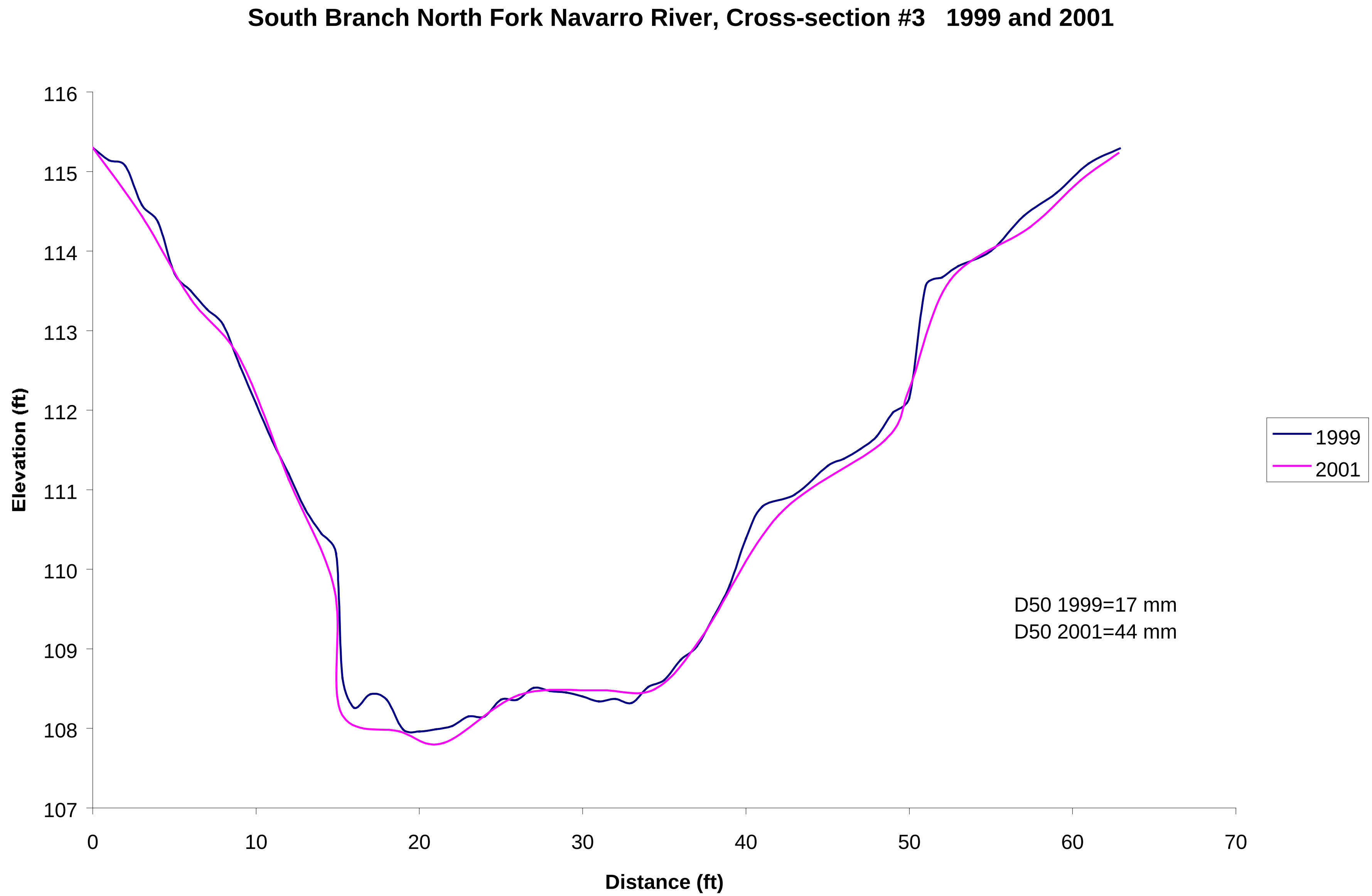


South Branch North Fork Navarro River, Cross-section #1 1999 and 2001
Elevation (ft)
102
101
100
99
98
97
96
95
94
93
92
0
5
10
15
20
25
30
35
40
45
Distance (ft)
1999
2001
D50 1999=39 mm
D50 2001=89 mm

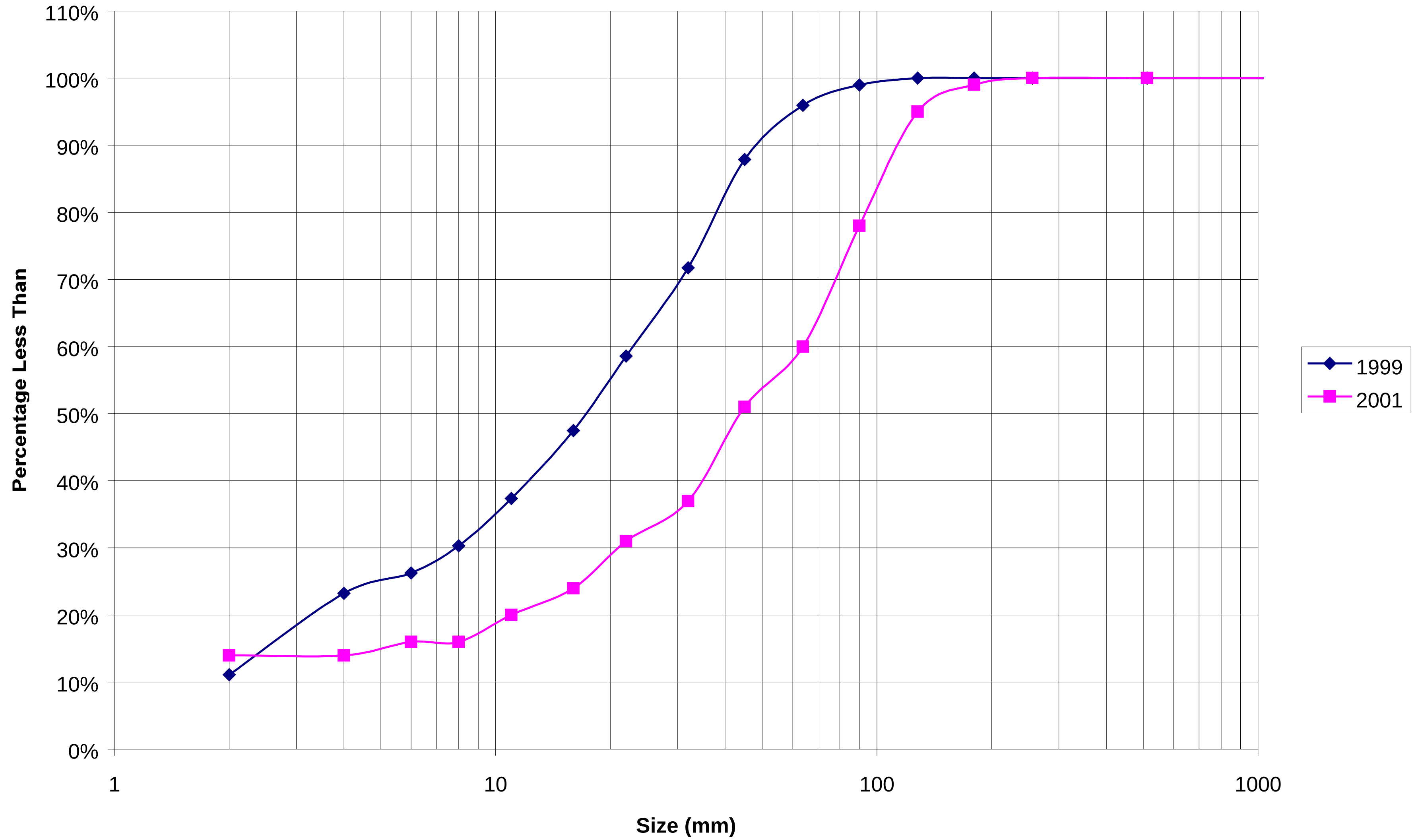
SBNF Navarro River, Cross-section #1, 1999 and 2001
Percentage Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)
1999
2001

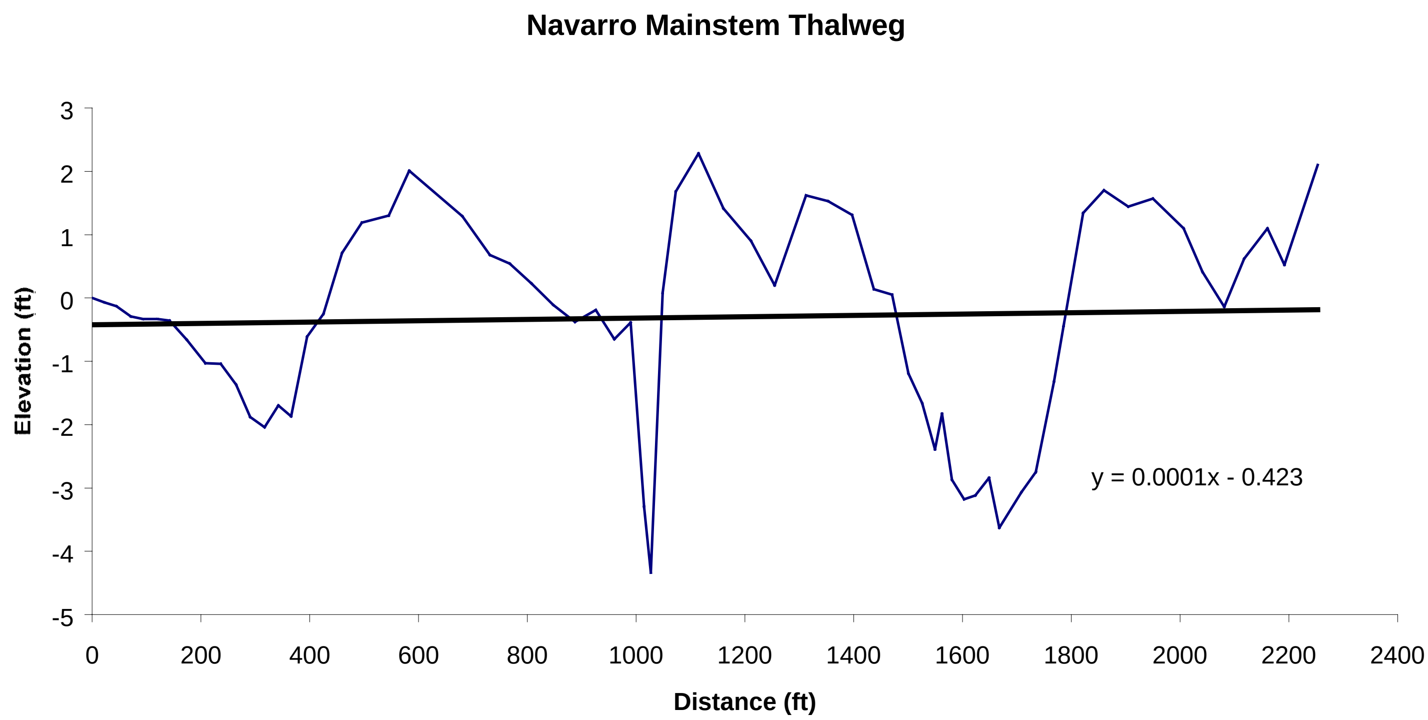

South Branch North Fork Navarro River, Cross-section #2 1999 and 2001
110
108
106
104
102
100
98
96
Elevation (ft)
0
10
20
30
40
50
60
70
Distance (ft)
1999
2001
D50 1999=42 mm
D50 2001=64 mm


SBNF Navarro River, Cross-section #2, 1999 and 2001
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage Less Than
1
10
100
1000
Size (mm)
1999
2001


South Branch North Fork Navarro River, Cross-section #3 1999 and 2001
Elevation (ft)
116
115
114
113
112
111
110
109
108
107
0
10
20
30
40
50
60
70
Distance (ft)
1999
2001
D50 1999=17 mm
D50 2001=44 mm

SBNF Navarro River, Cross-section #3, 1999 and 2001





Navarro Mainstem Thalweg
3
2
1
0
-1
-2
-3
-4
-5
Elevation (ft)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
Distance (ft)
y = 0.0001x - 0.423

<u>Mainstem Navarro River 1999 Residual Depth Statistics</u>

Top Elevation: 2.28
Bottom Elevation: -4.34
Reach Length: 2231.40

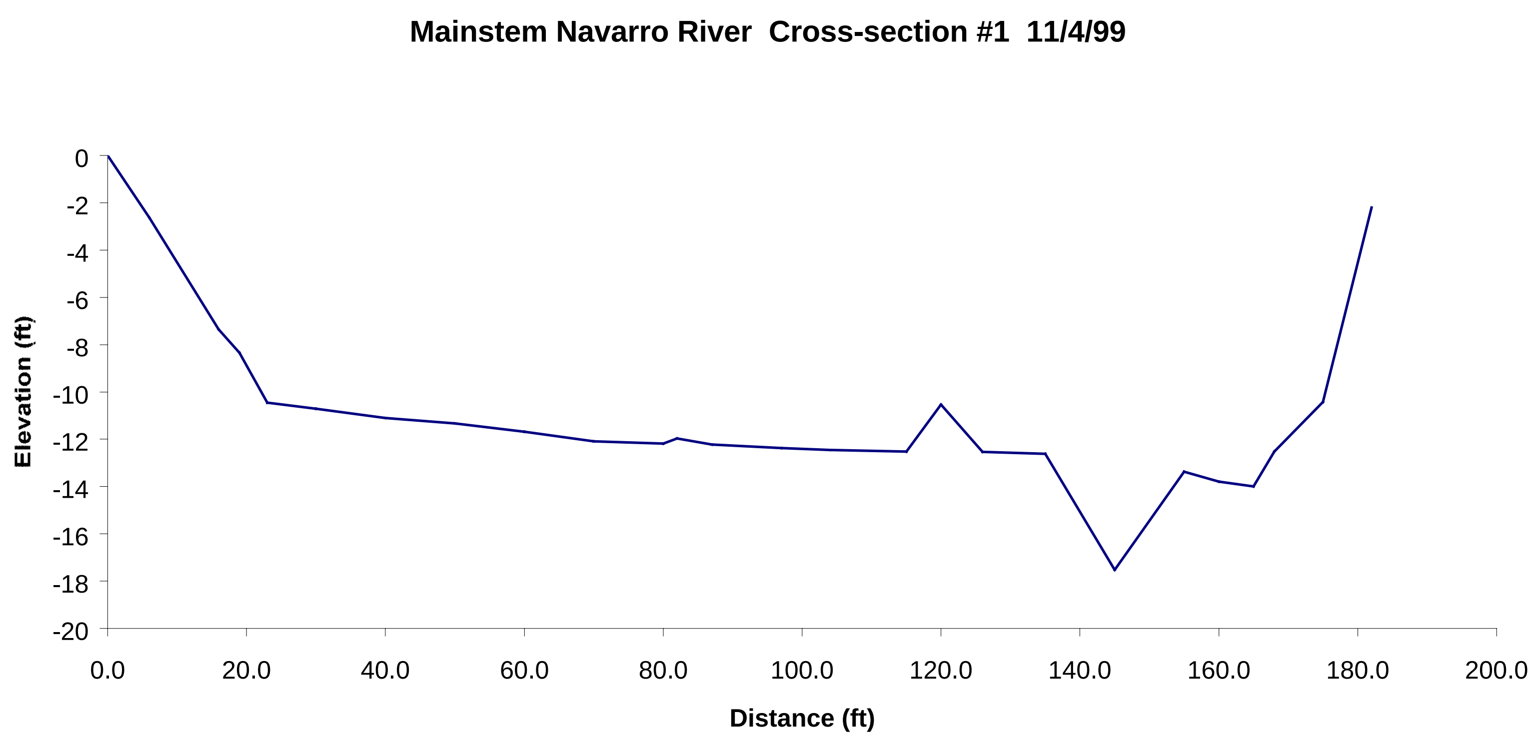
Standardized Statistics:
Number of data points in raw data: 69
Number of data points in Standardized data: 446

Reach Step Distance: 5.00

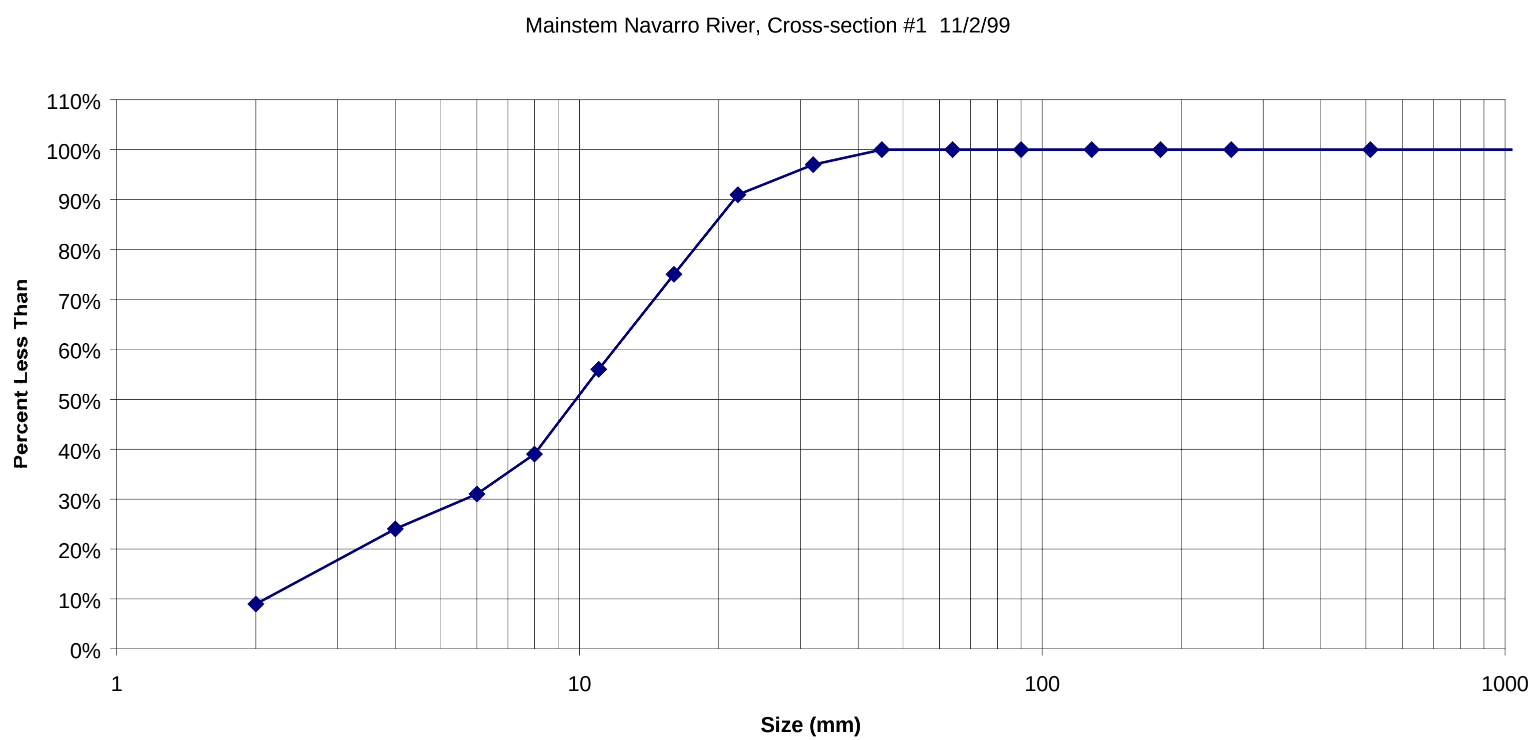
Max Residual Depth: 6.08
Mean Residual Depth: 1.67
Standard Deviation: 1.53

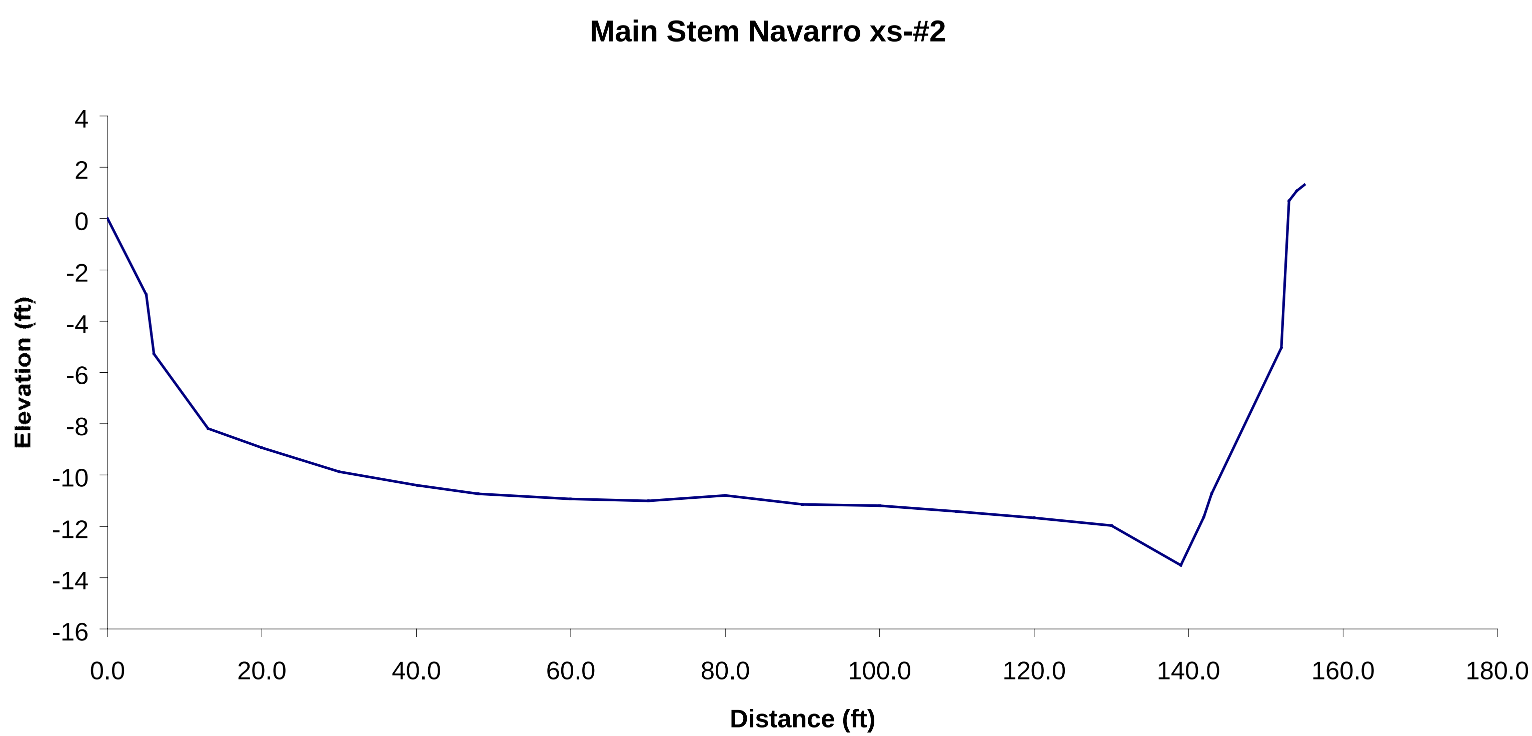
Number of non-zero Residual Depths: 411
Percent of Reach as pool: 92.15
Percent of Reach as riffle: 7.85

****Added artificial point at beginning of data set which was 1' higher than the previous.**

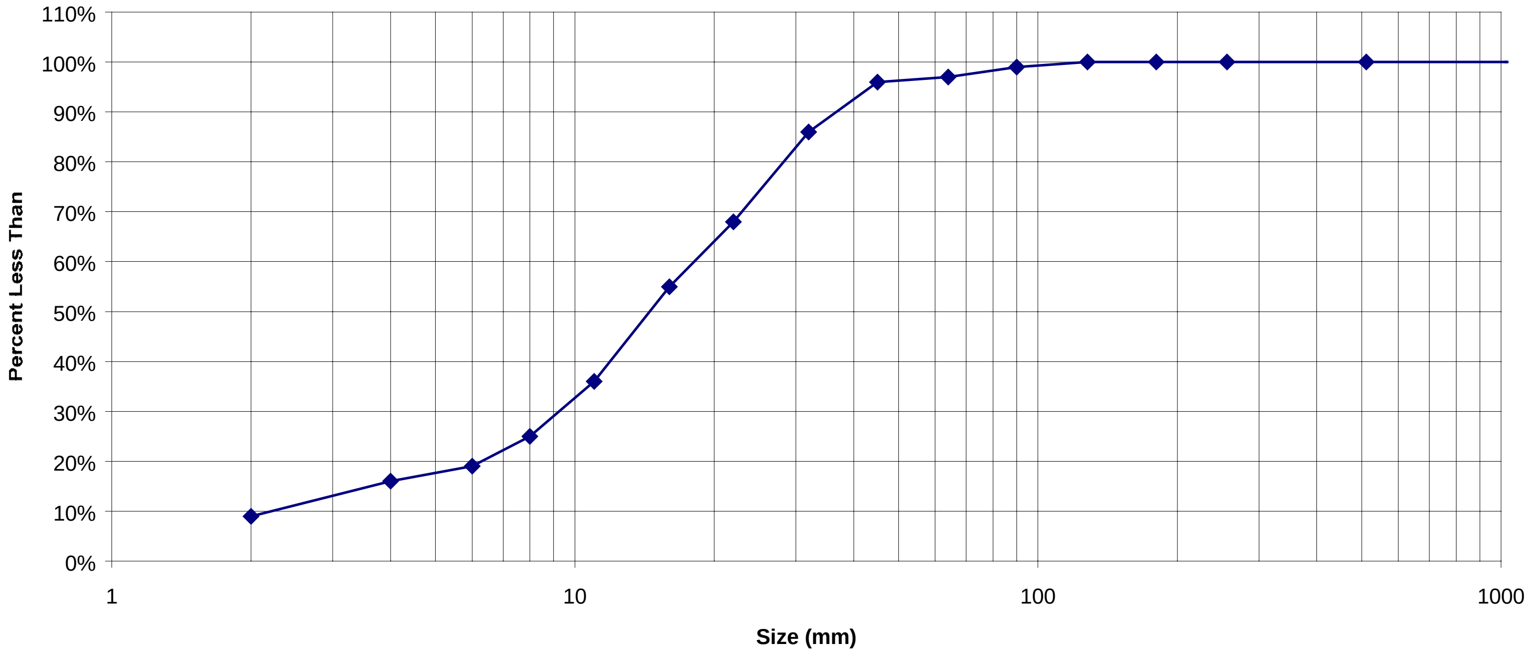


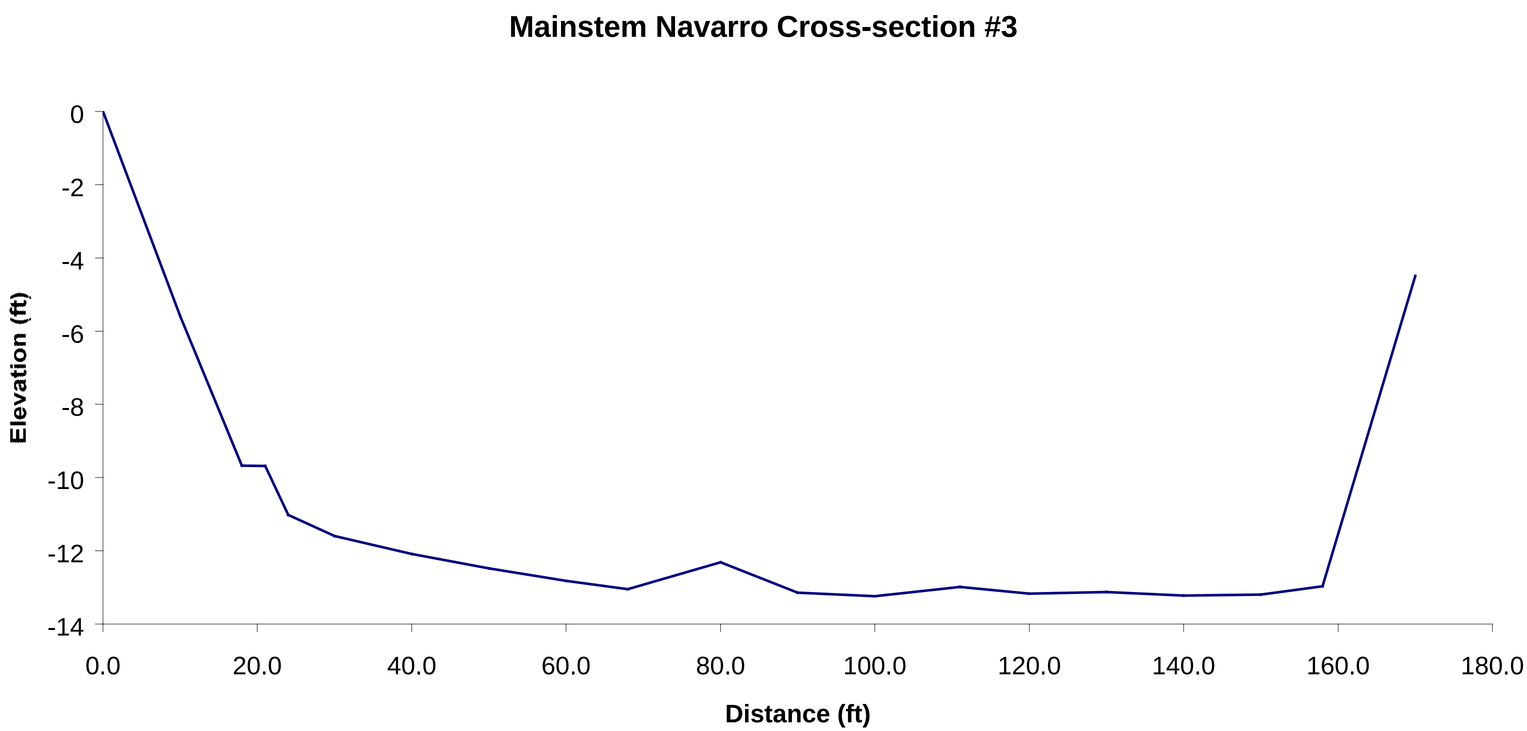
Mainstem Navarro River Cross-section #1 11/4/99
Elevation (ft)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
Distance (ft)

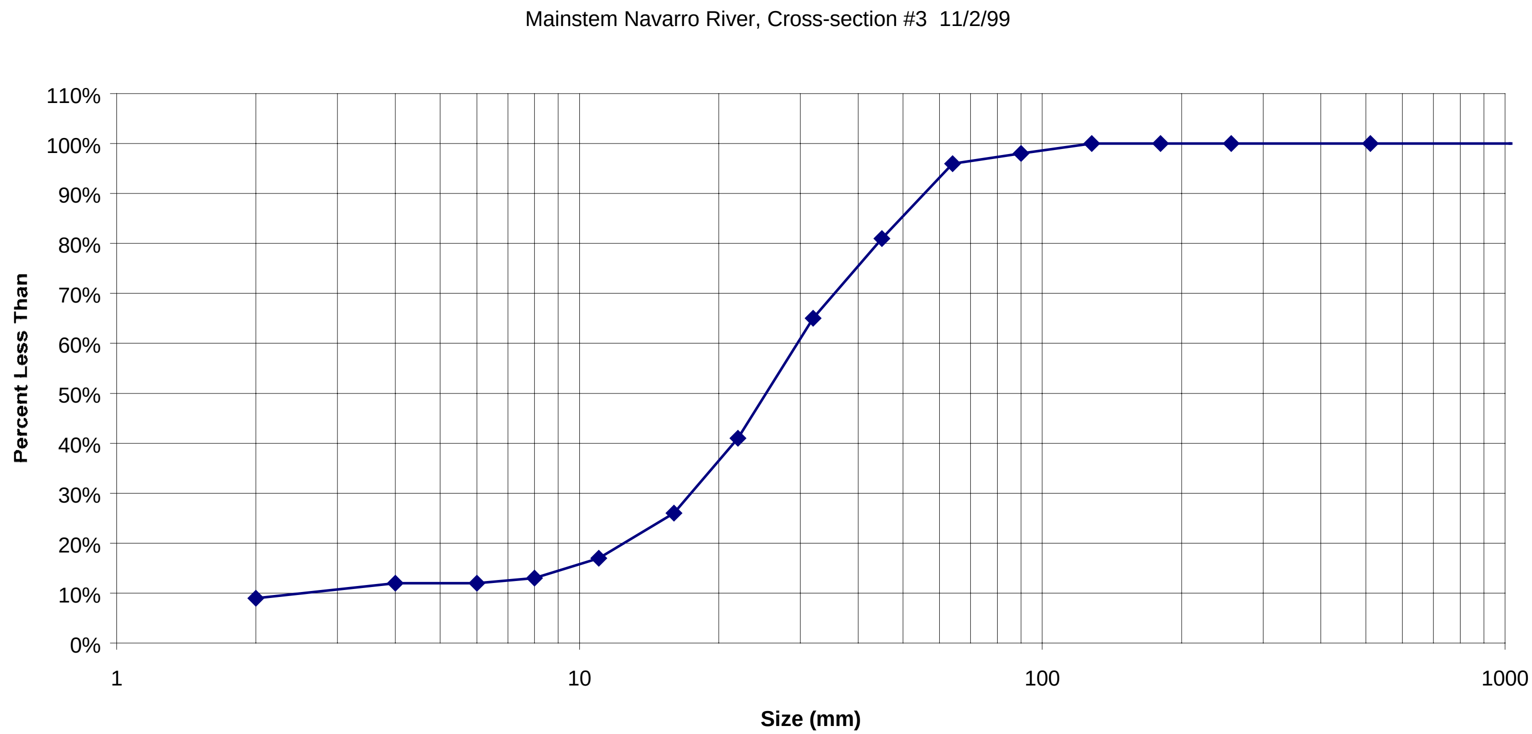

Mainstem Navarro River, Cross-section #1 11/2/99
Percent Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)

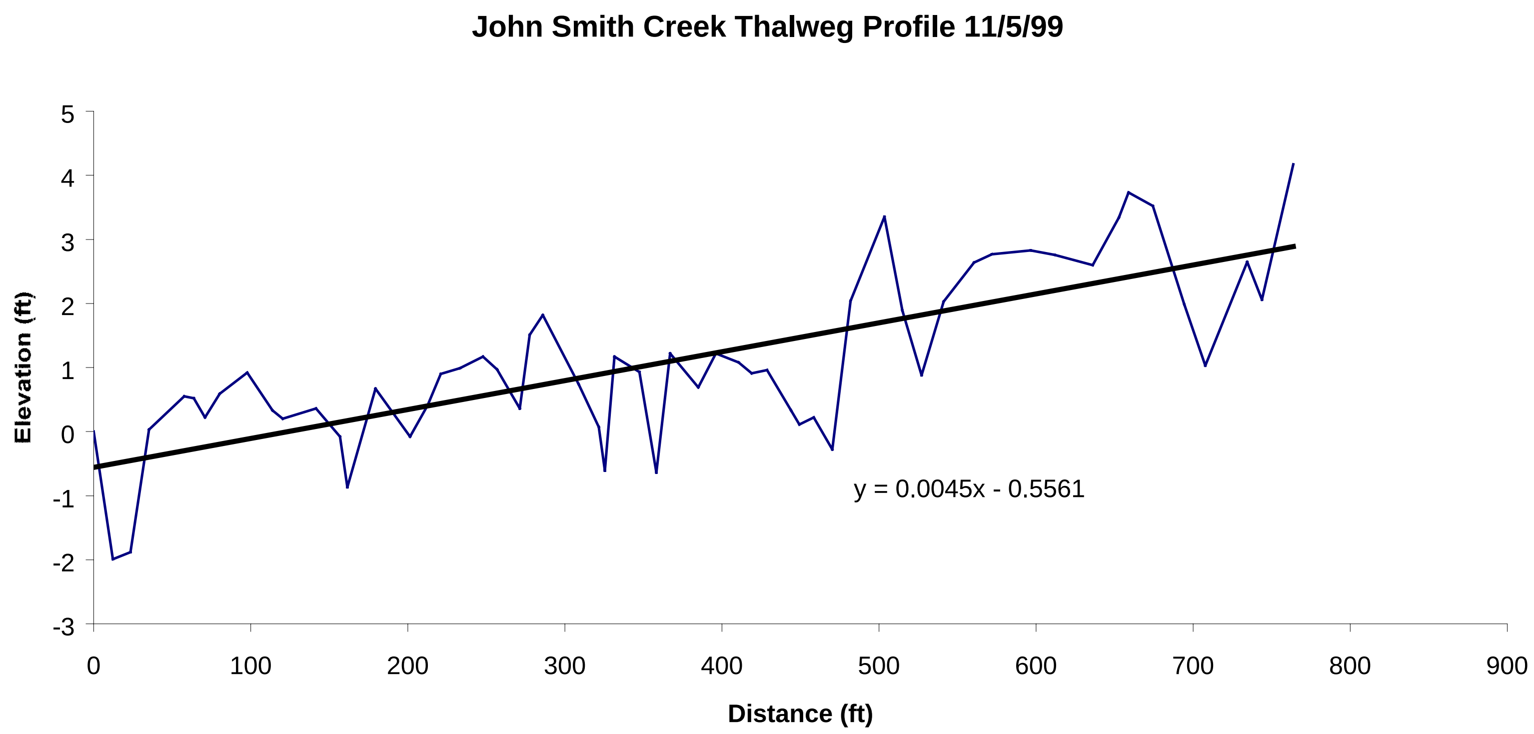

Main Stem Navarro xs-#2
Elevation (ft)
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
Distance (ft)

Mainstem Navarro River, Cross-section #2 11/2/99




Mainstem Navarro Cross-section #3
Elevation (ft)
0
-2
-4
-6
-8
-10
-12
-14
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
Distance (ft)


Mainstem Navarro River, Cross-section #3 11/2/99
Percent Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)


John Smith Creek Thalweg Profile 11/5/99
Elevation (ft)
5
4
3
2
1
0
-1
-2
-3
0
100
200
300
400
500
600
700
800
900
Distance (ft)
y = 0.0045x - 0.5561

John Smith Creek 1999 Residual Depth Statistics

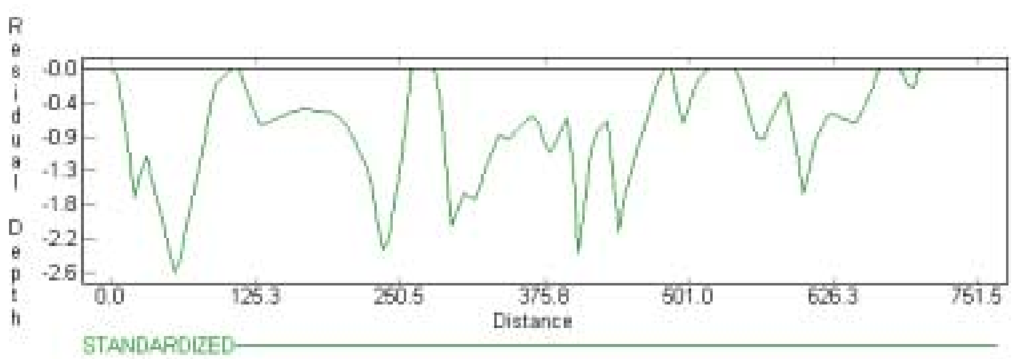
Top Elevation: 4.17
Bottom Elevation: -1.99
Reach Length: 751.50

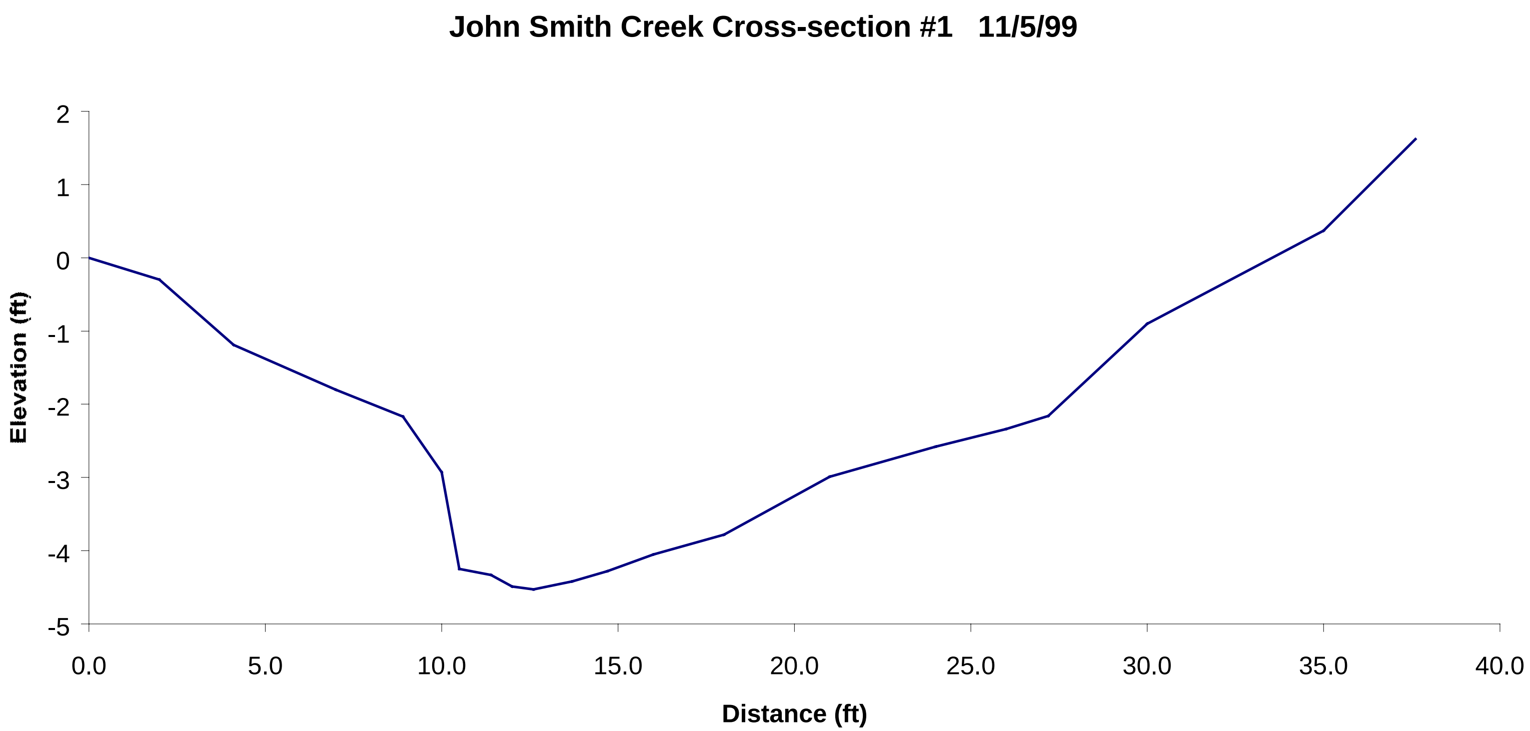
Standardized Statistics:
Number of data points in raw data: 57
Number of data points in Standardized data: 150

Reach Step Distance: 5.00

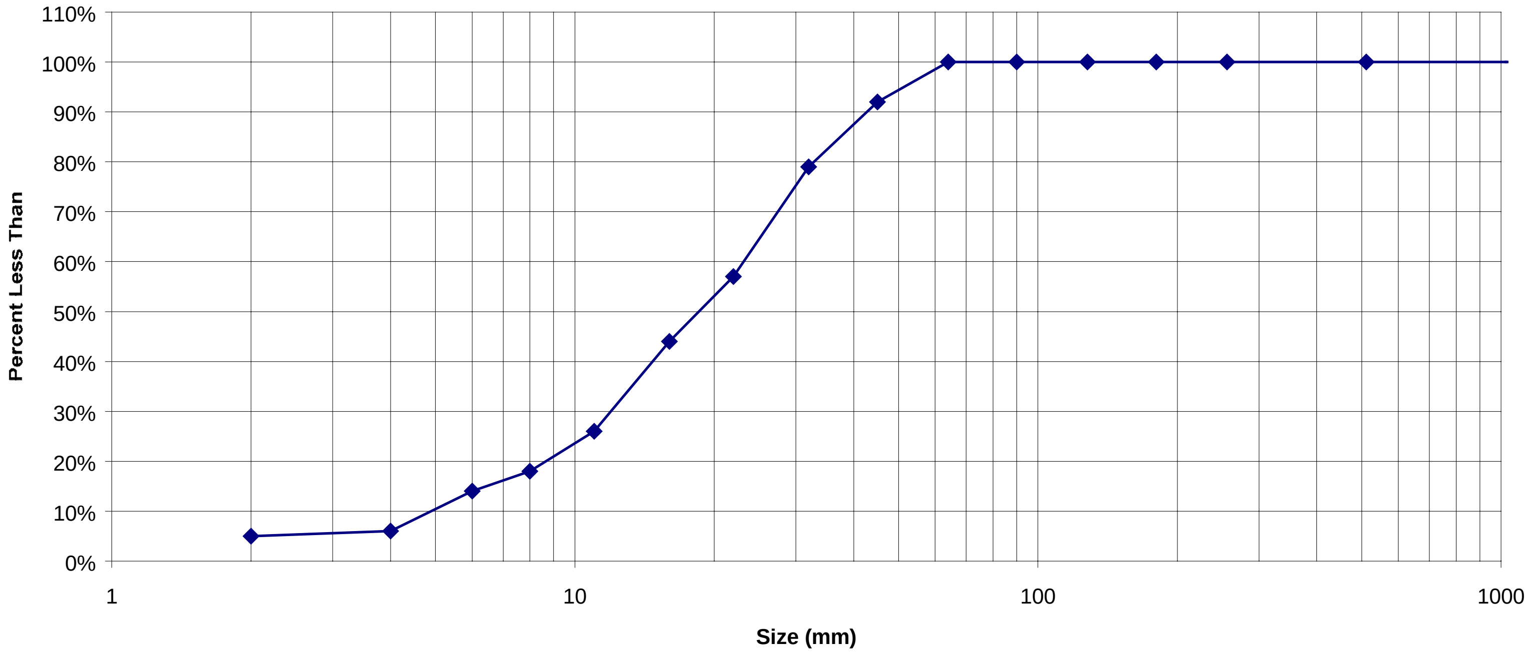
Max Residual Depth: 2.64
Mean Residual Depth: 0.76
Standard Deviation: 0.65

Number of non-zero Residual Depths: 126
Percent of Reach as pool: 84.00
Percent of Reach as riffle: 16.00

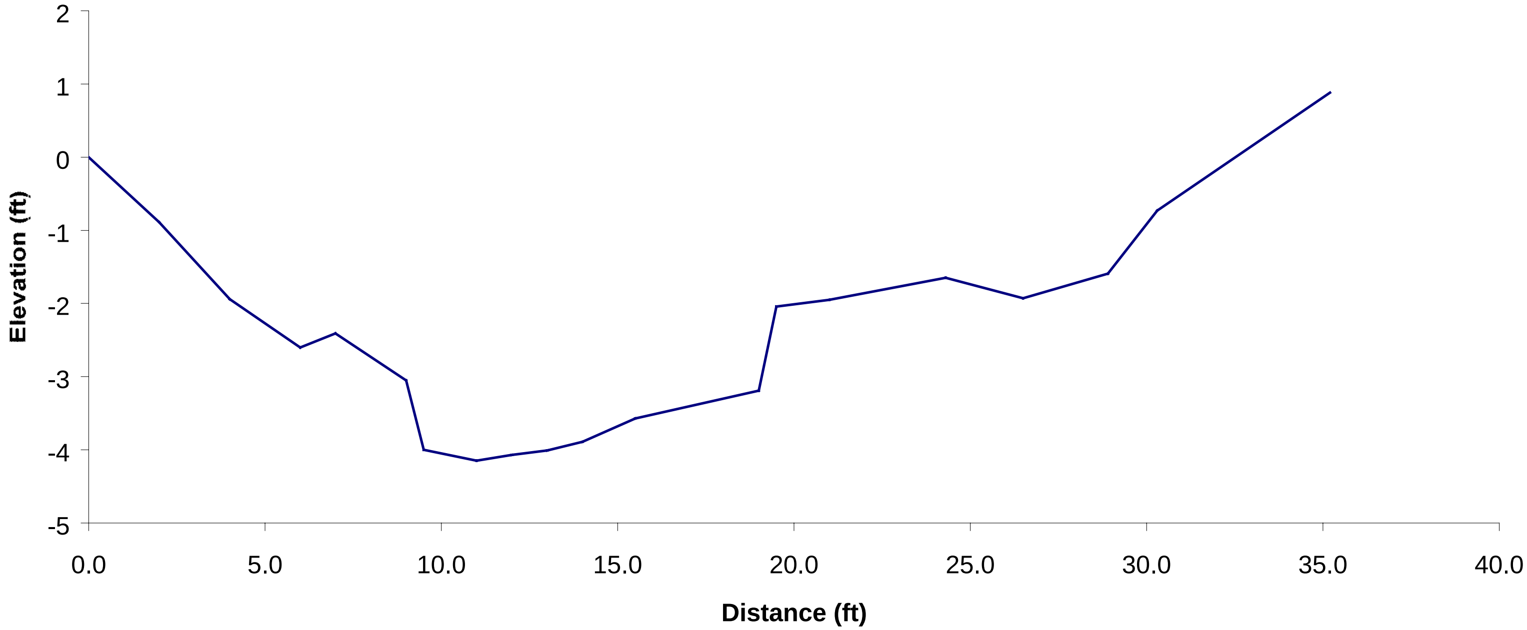



John Smith Creek Cross-section #1 11/5/99
Elevation (ft)
2
1
0
-1
-2
-3
-4
-5
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
Distance (ft)

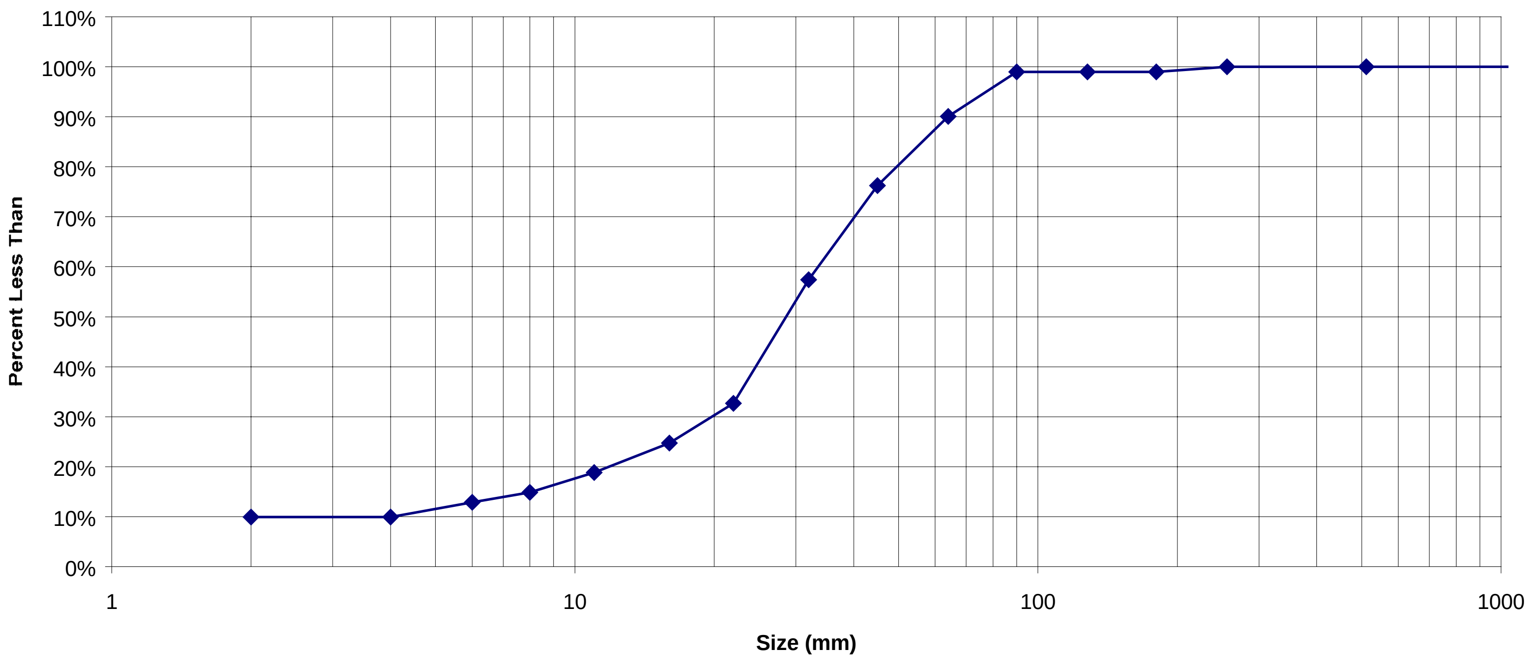
John Smith Creek, Cross-section #1 11/4/99

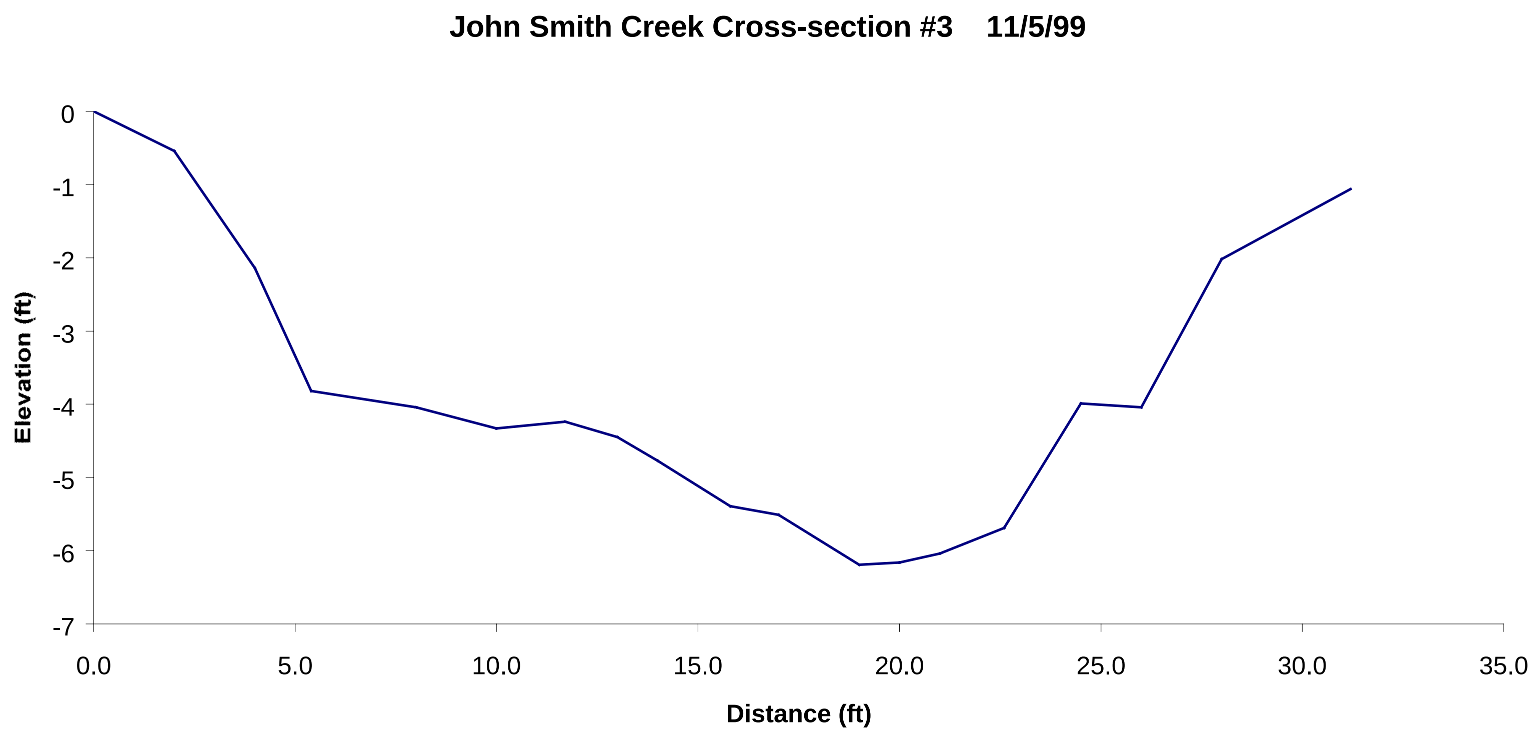


John Smith Creek Cross-section #2 11/5/99



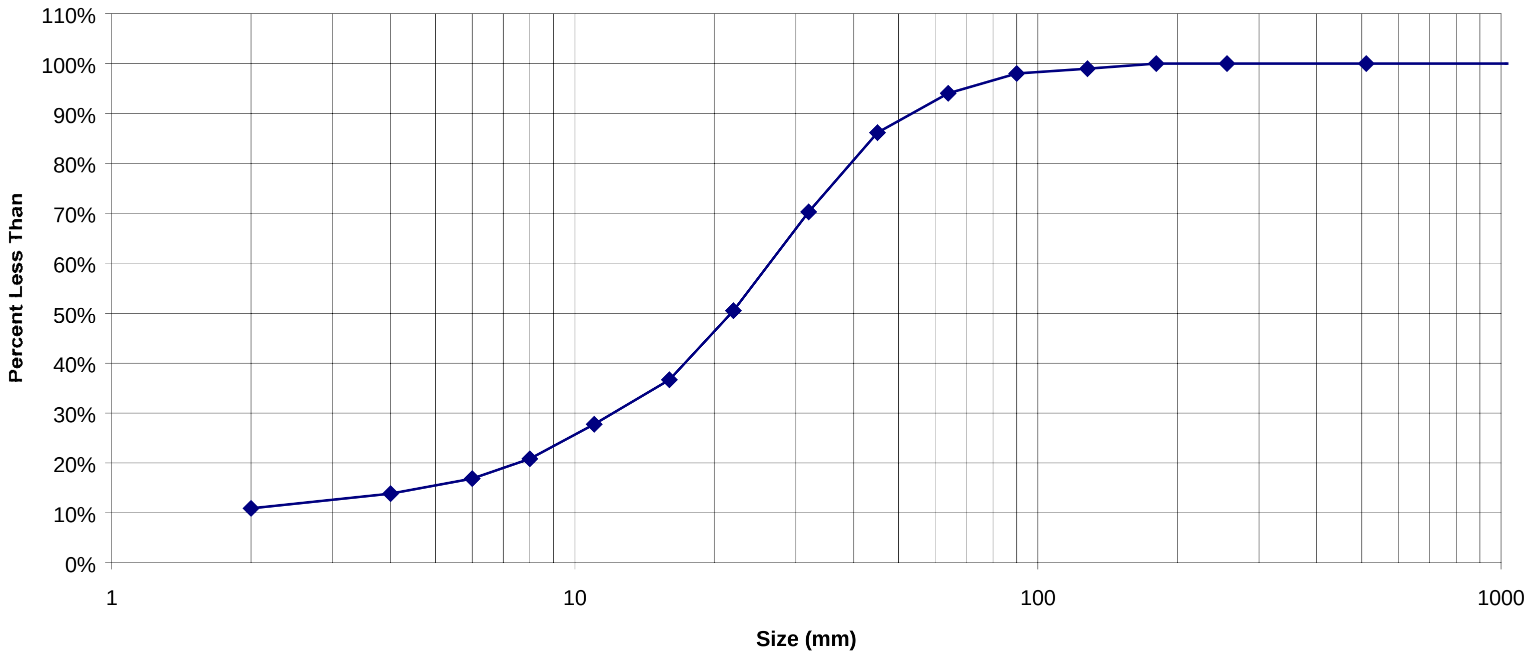
John Smith Creek, Cross-section #2 11/4/99

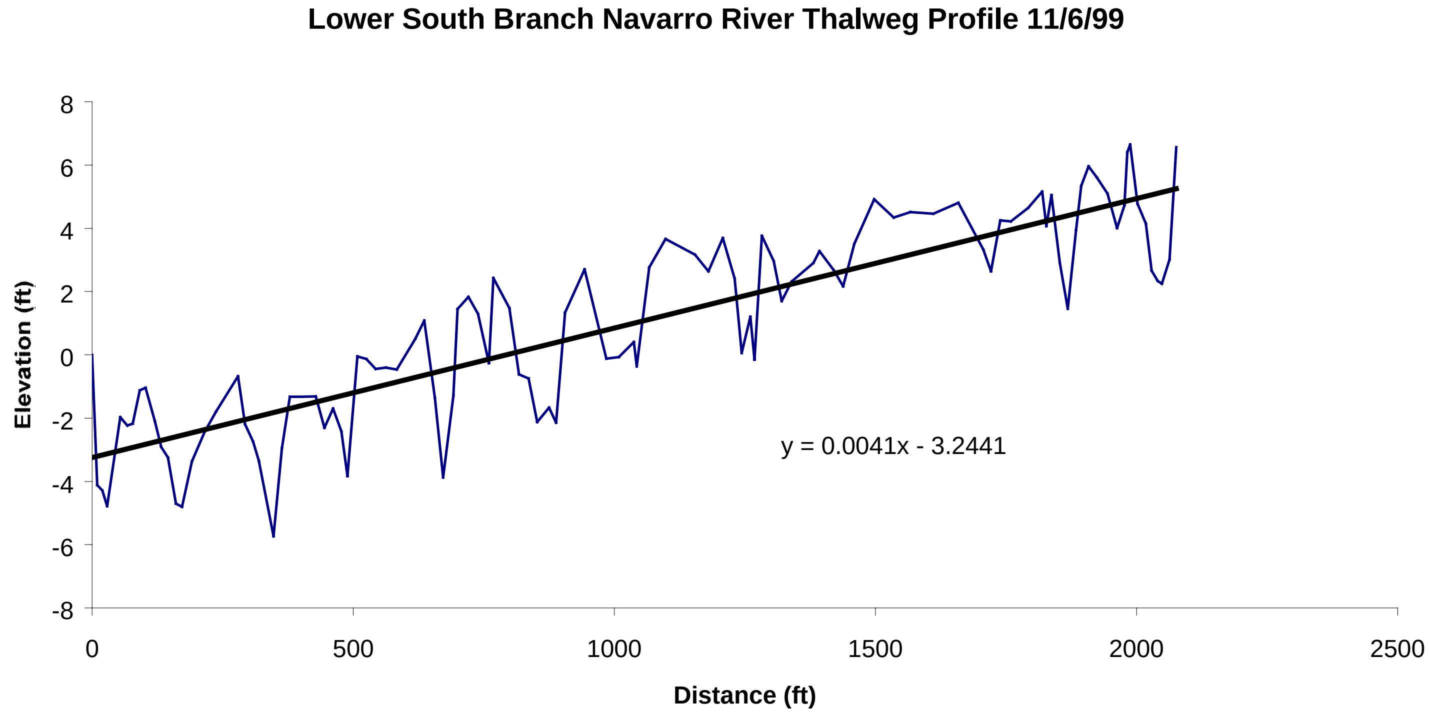




John Smith Creek Cross-section #3 11/5/99
Elevation (ft)
0
-1
-2
-3
-4
-5
-6
-7
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Distance (ft)

John Smith Creek, Cross-section #3 11/4/99





Lower South Branch Navarro River Thalweg Profile 11/6/99
Elevation (ft)
8
6
4
2
0
-2
-4
-6
-8
0
500
1000
1500
2000
2500
Distance (ft)
y = 0.0041x - 3.2441

Lower South Branch Navarro River 1999 Residual Depth Statistics

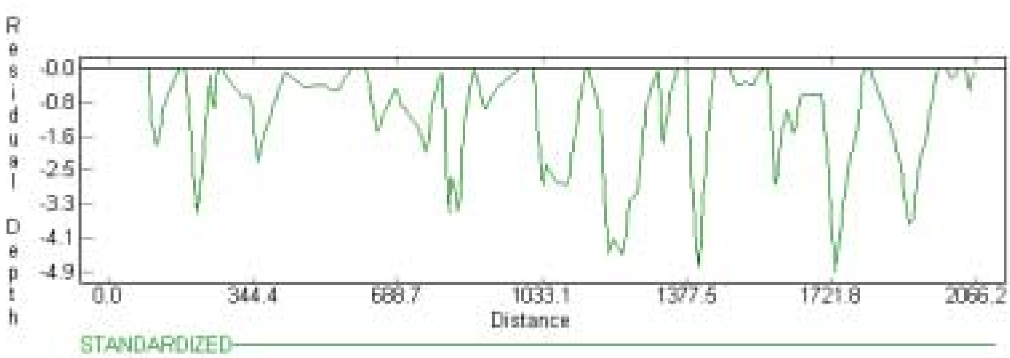
Top Elevation: 6.64
Bottom Elevation: -5.73
Reach Length: 2066.20

Standardized Statistics:
Number of data points in raw data: 105
Number of data points in Standardized data: 413

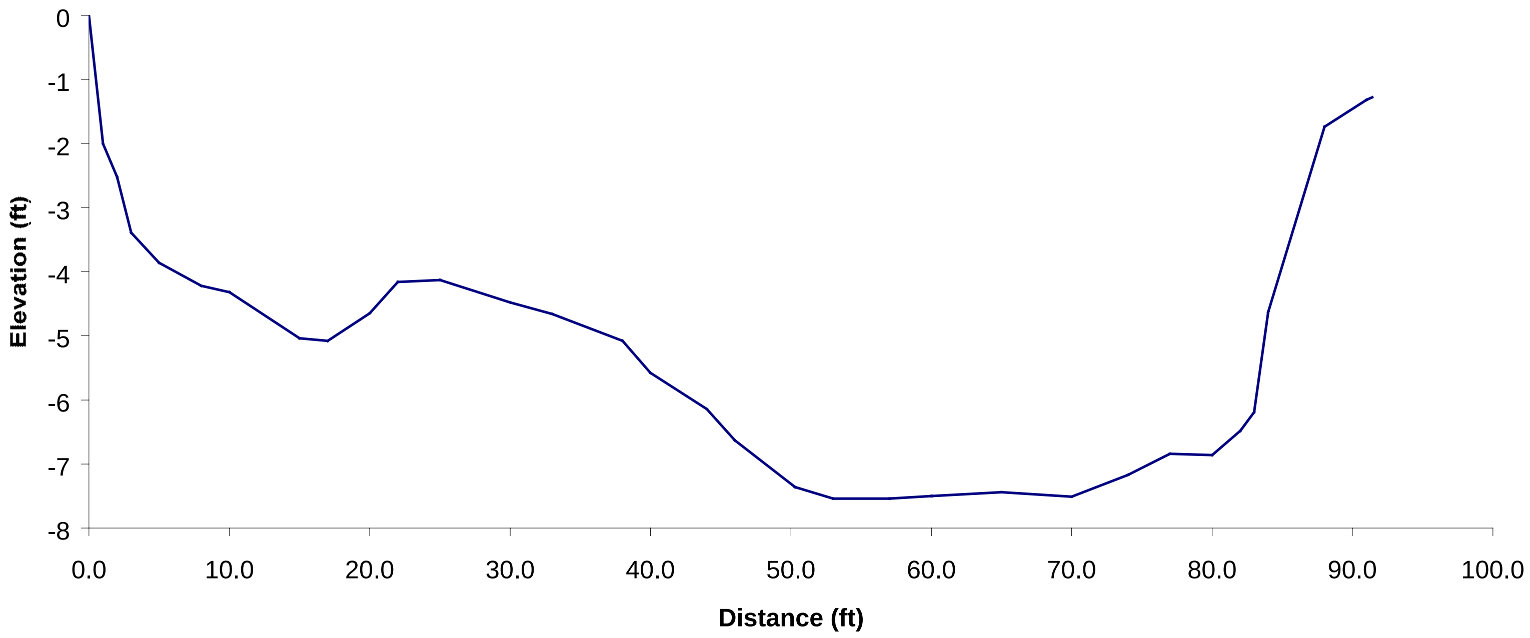
Reach Step Distance: 5.00

Max Residual Depth: 4.93
Mean Residual Depth: 1.12
Standard Deviation: 1.19

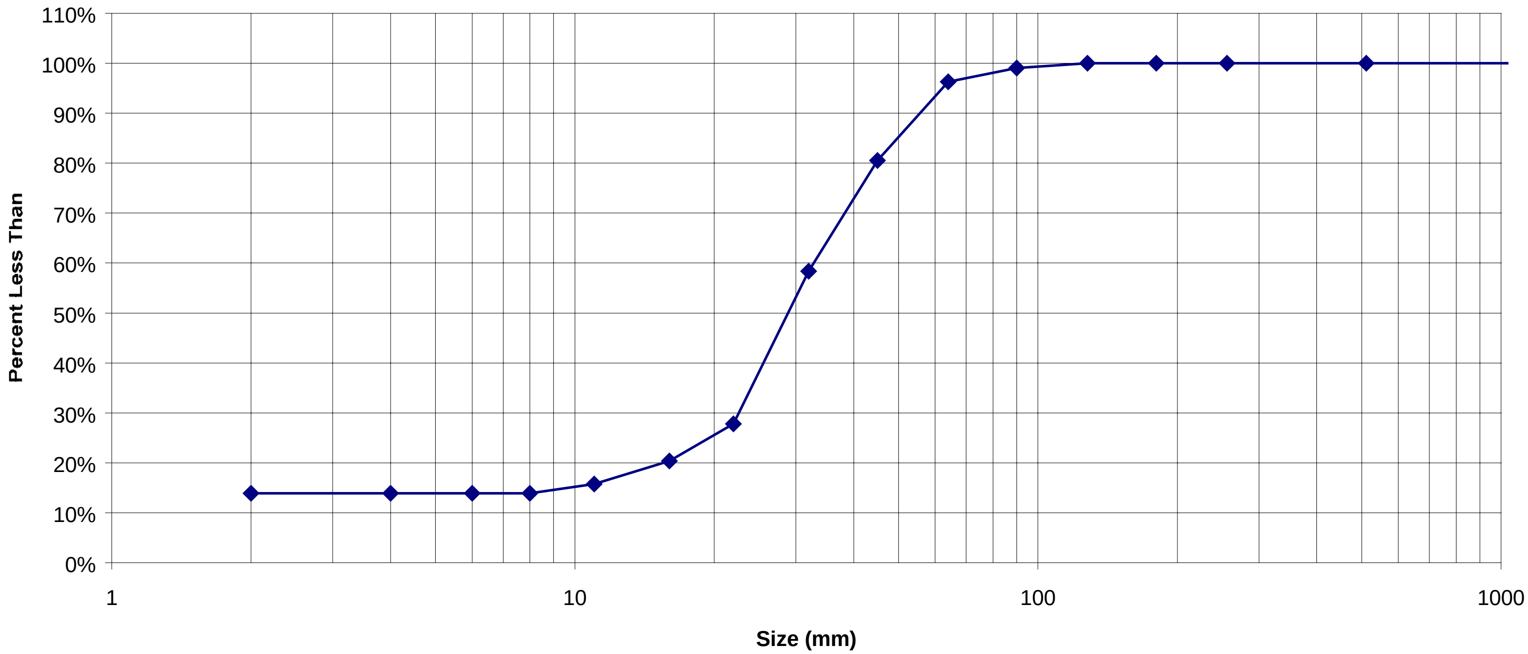
Number of non-zero Residual Depths: 349
Percent of Reach as pool: 84.50
Percent of Reach as riffle: 15.50

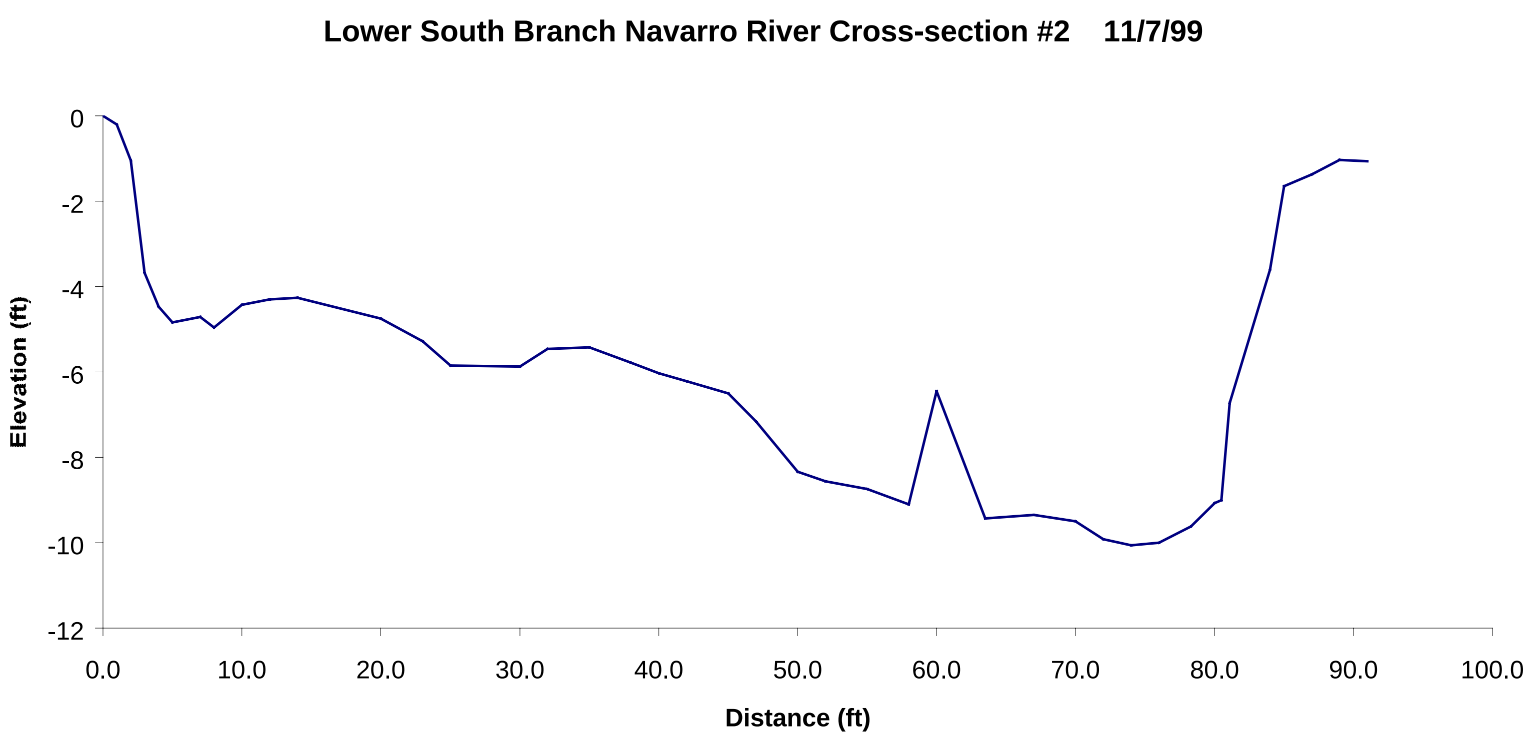


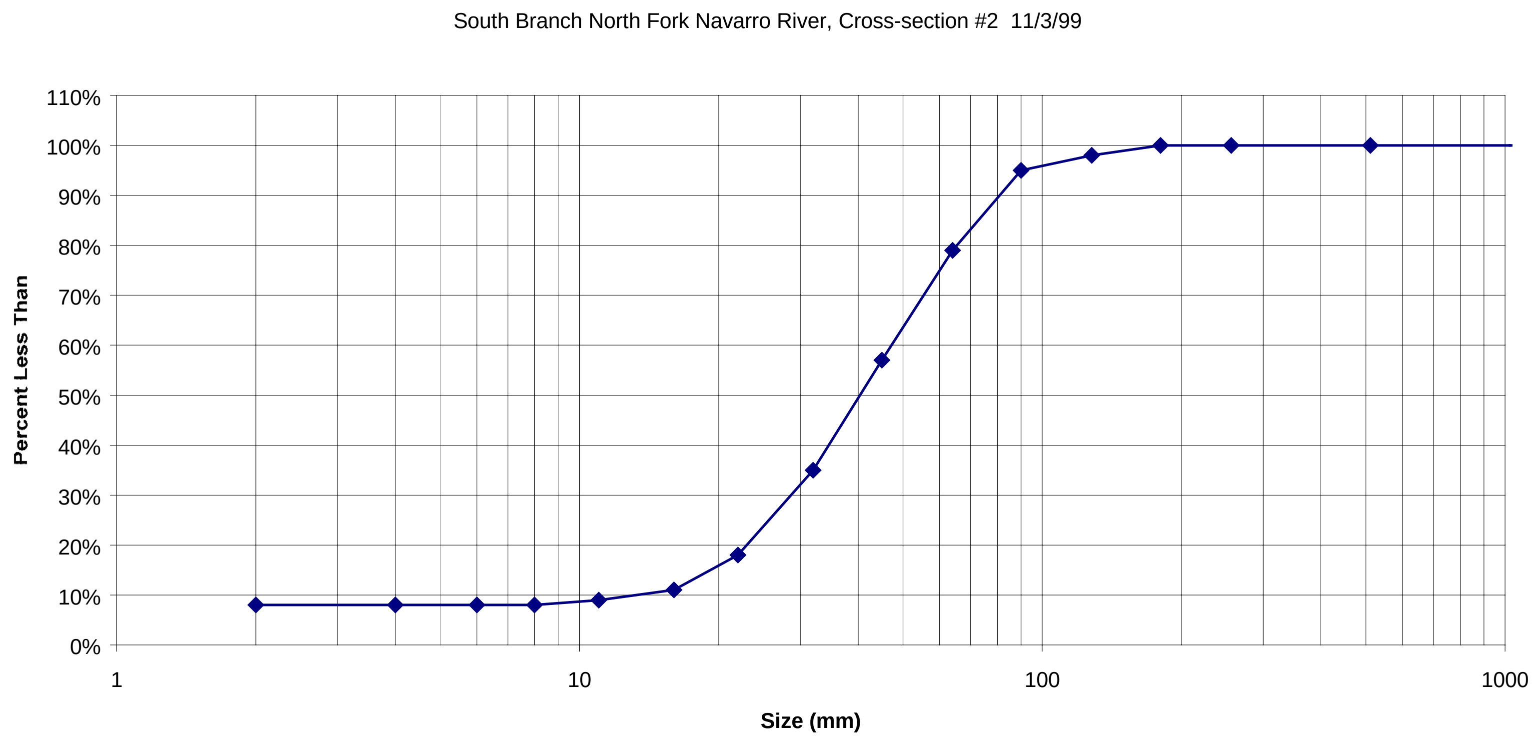
Lower South Branch Cross-section #1   11/7/99

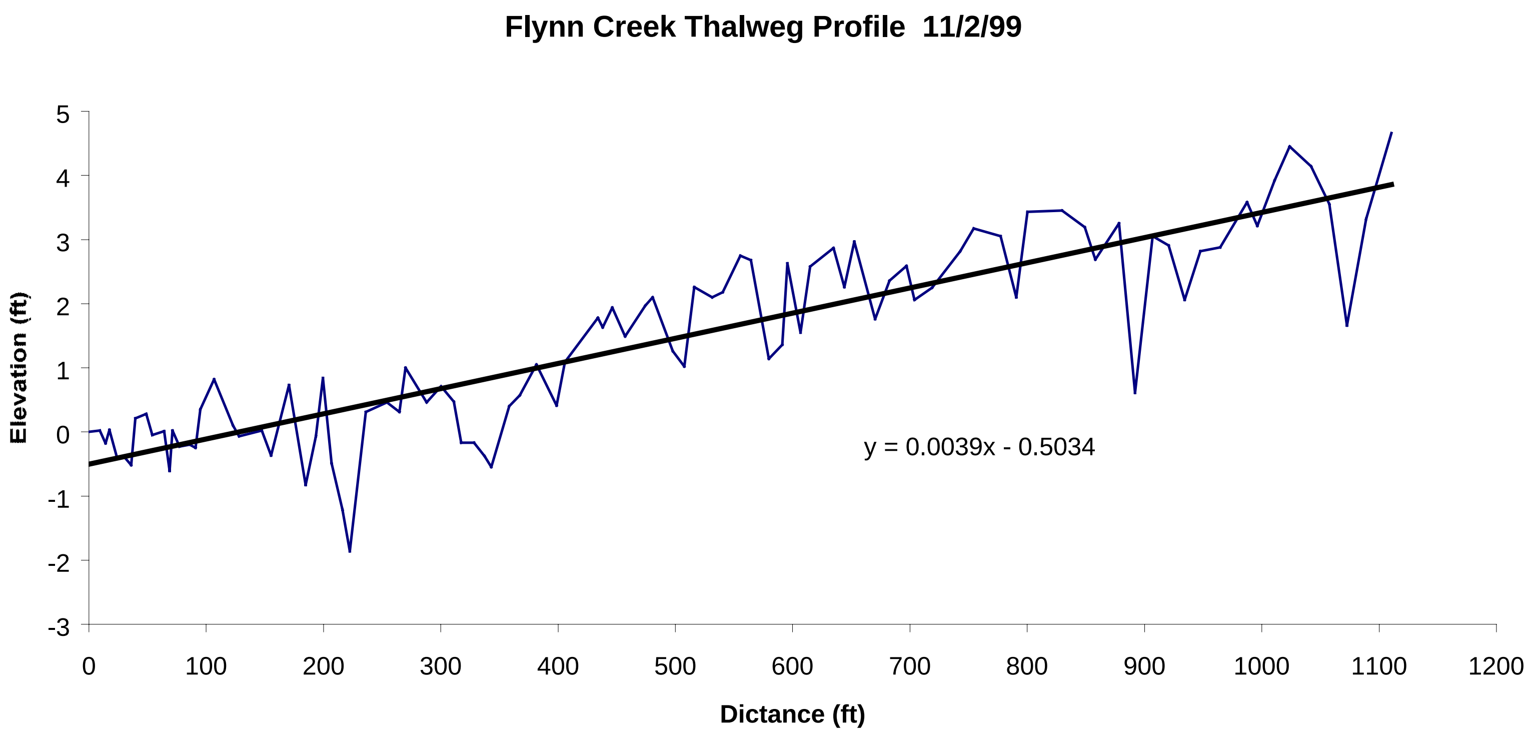


South Branch North Fork Navarro River, Cross-section #1 11/3/99




Lower South Branch Navarro River Cross-section #2 11/7/99
0
-2
-4
-6
-8
-10
-12
Elevation (ft)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Distance (ft)


South Branch North Fork Navarro River, Cross-section #2 11/3/99
Percent Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)



Flynn Creek Thalweg Profile 11/2/99
Elevation (ft)
5
4
3
2
1
0
-1
-2
-3
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Dictance (ft)
y = 0.0039x - 0.5034

Flynn Creek 1999 Residual Depth Statistics

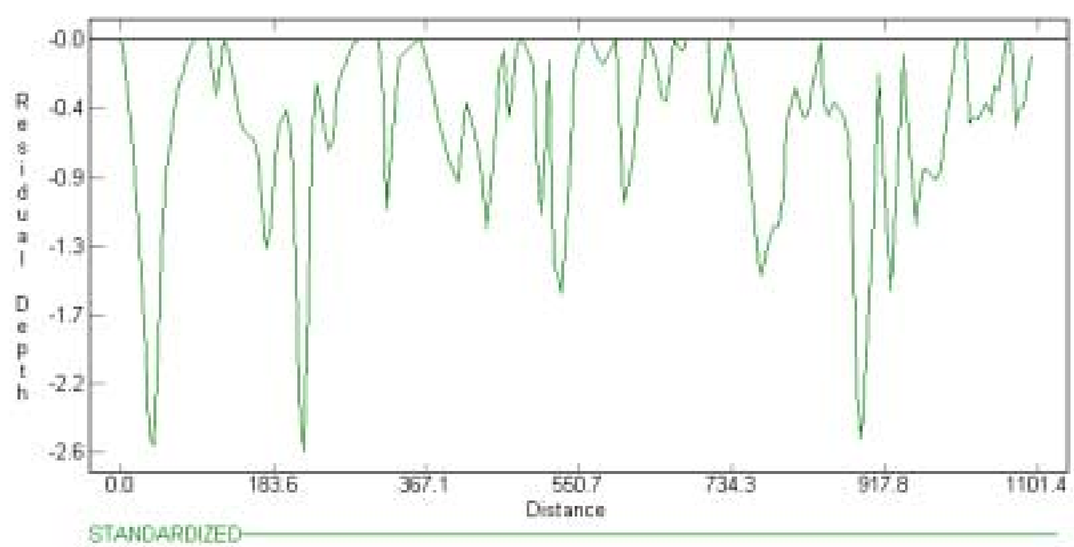
Top Elevation: 4.66
Bottom Elevation: -1.86
Reach Length: 1101.40

Standardized Statistics:
Number of data points in raw data: 94
Number of data points in Standardized data: 220

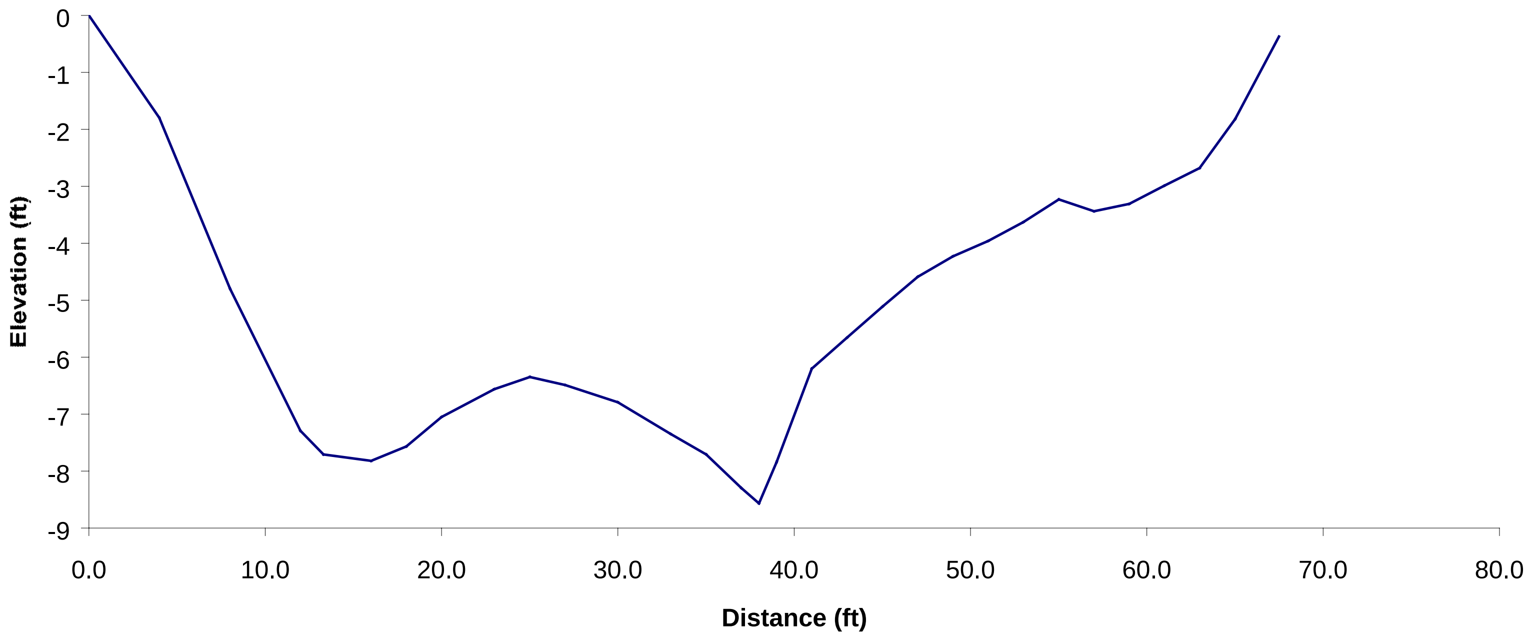
Reach Step Distance: 5.00

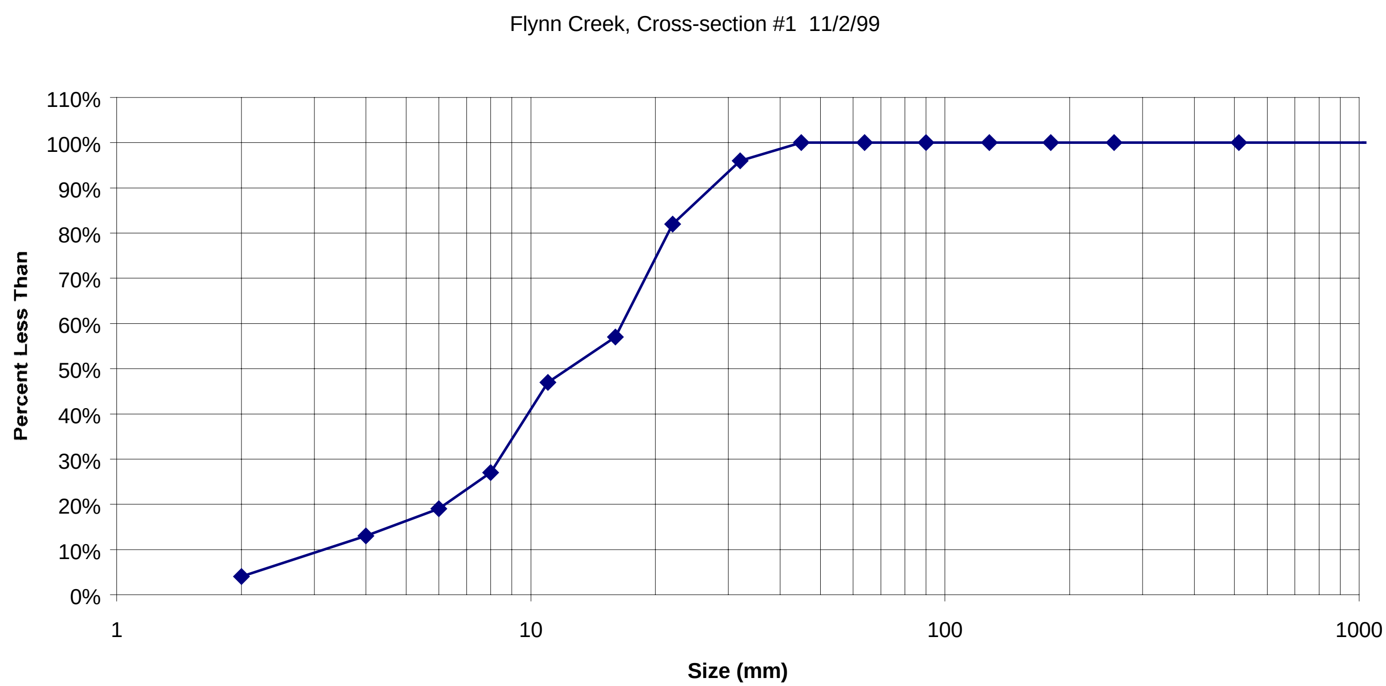
Max Residual Depth: 2.59
Mean Residual Depth: 0.54
Standard Deviation: 0.55

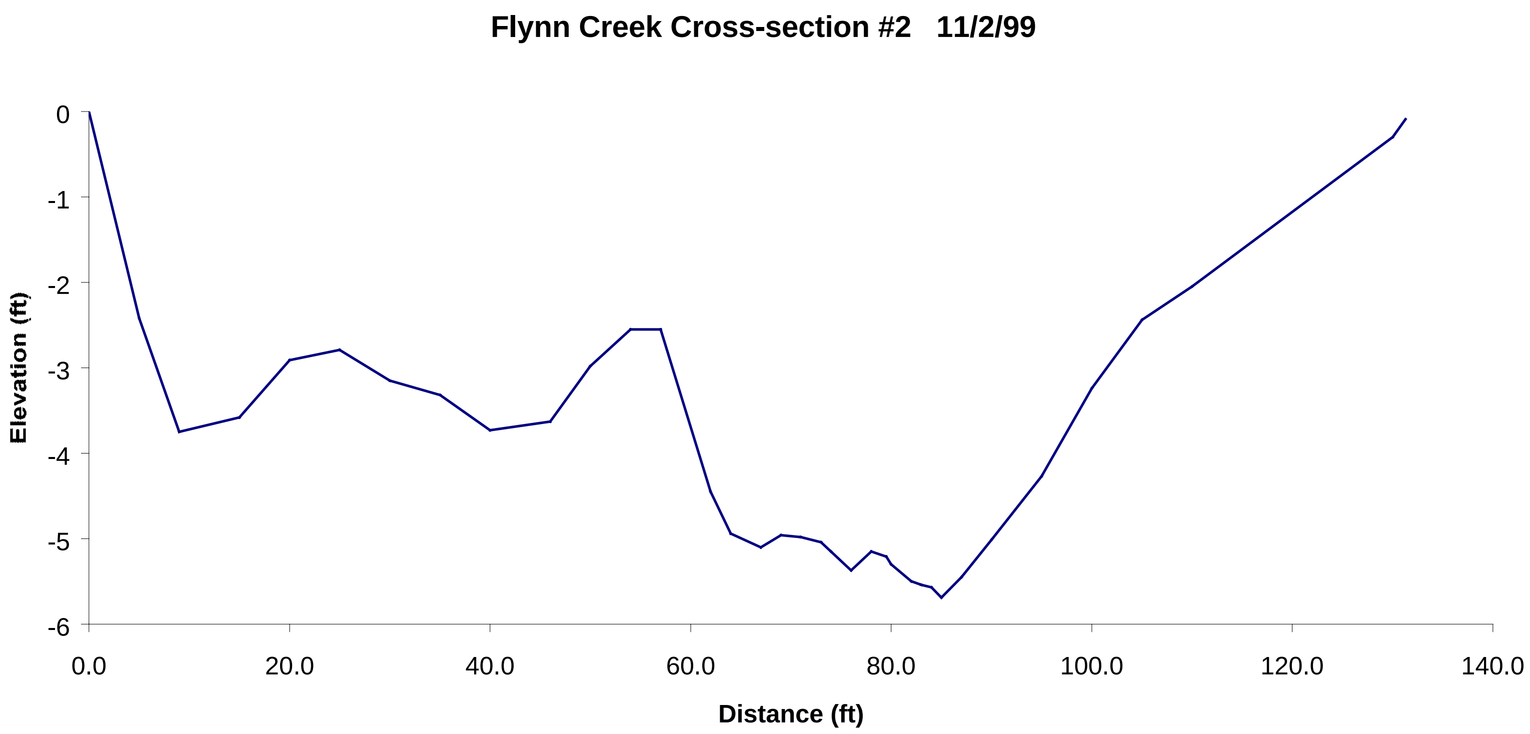
Number of non-zero Residual Depths: 188
Percent of Reach as pool: 85.45
Percent of Reach as riffle: 14.55



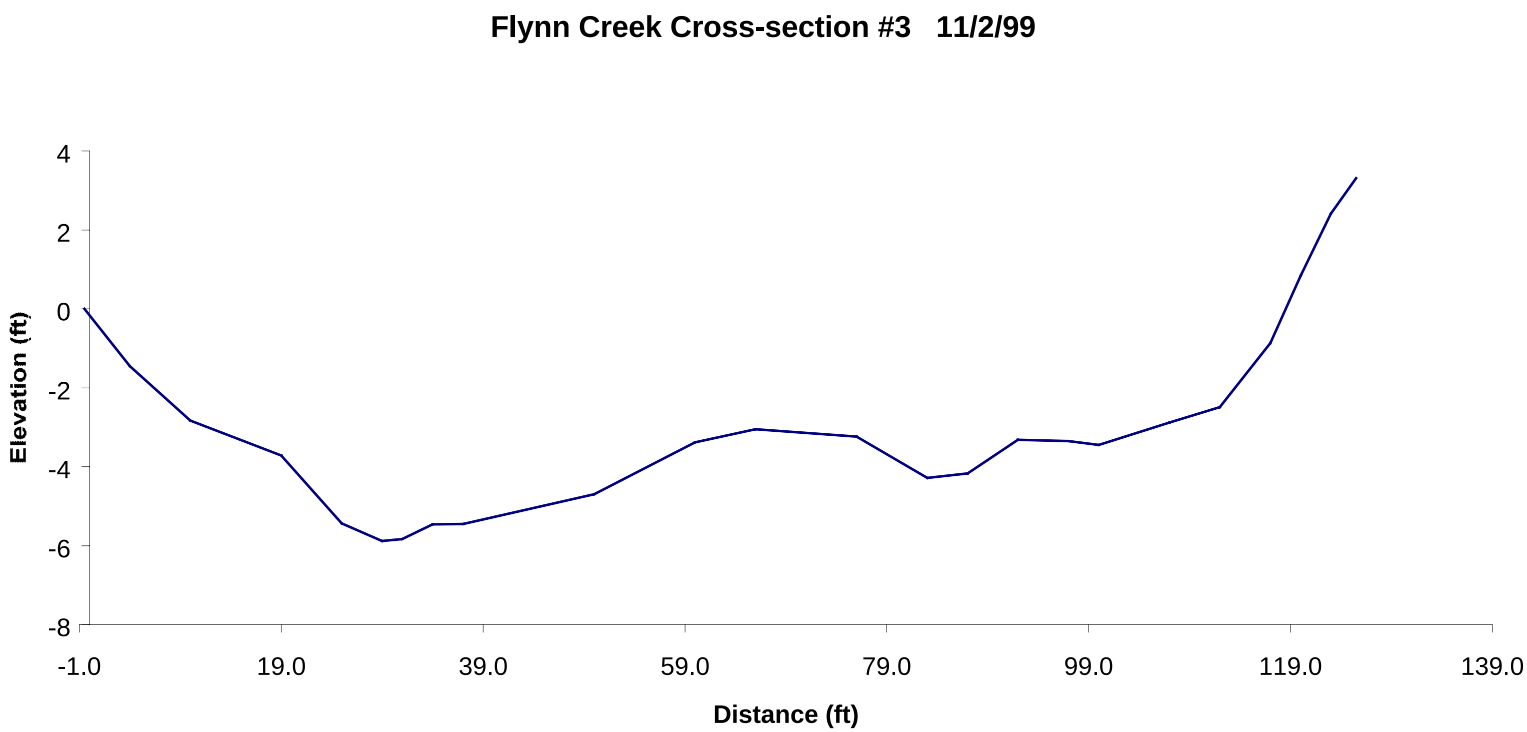
Flynn Creek Cross-section #1   11/2/99



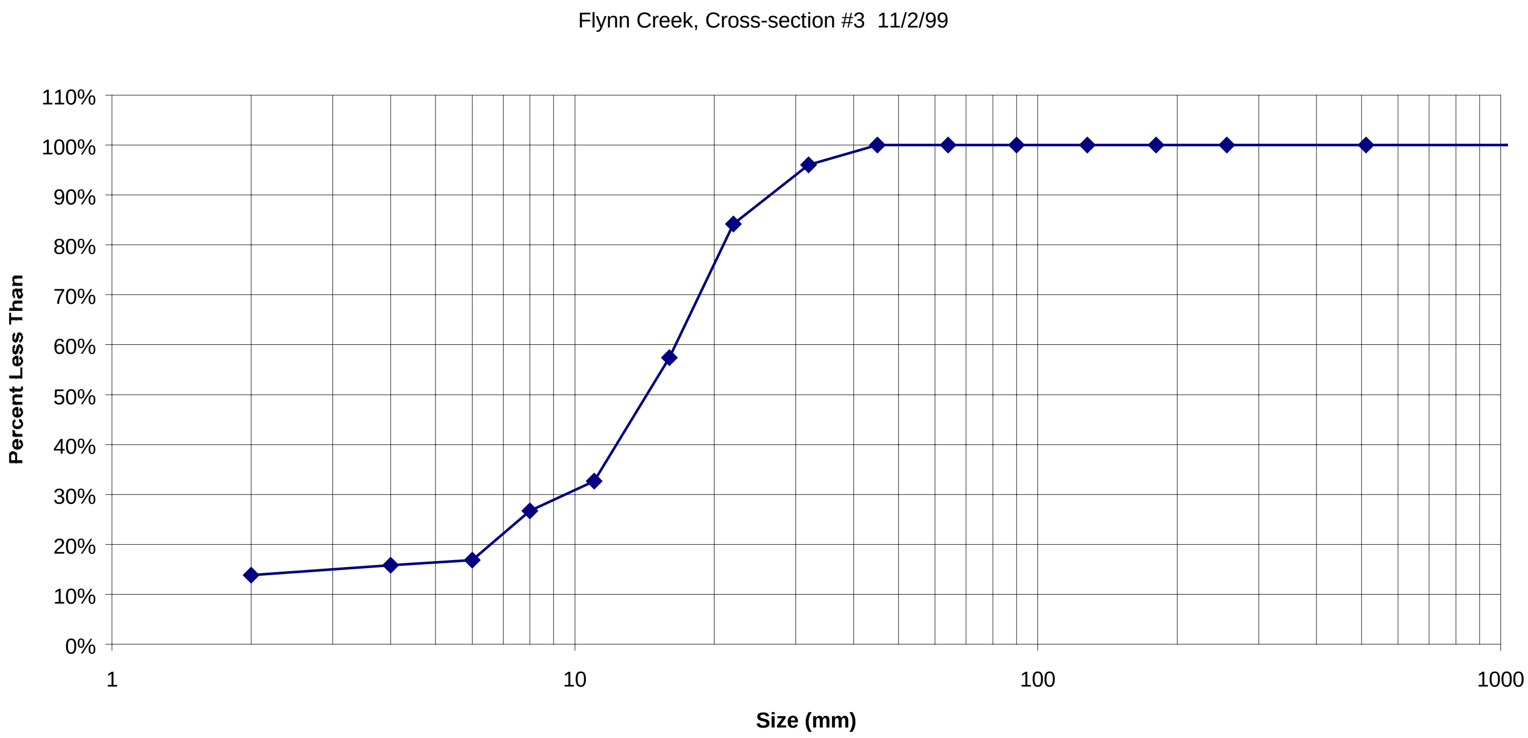

Flynn Creek, Cross-section #1 11/2/99
Percent Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)

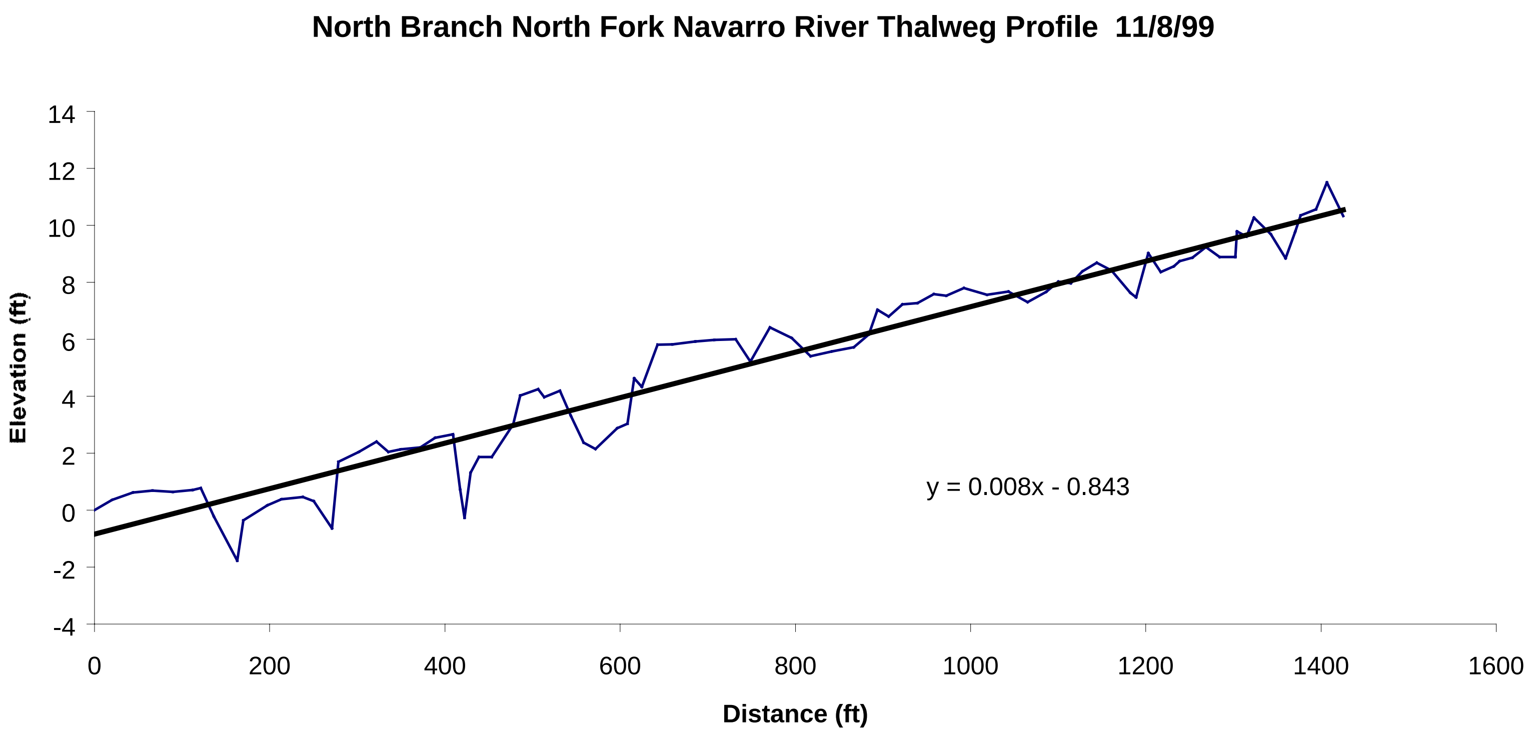

Flynn Creek Cross-section #2 11/2/99
0
-1
-2
-3
-4
-5
-6
Elevation (ft)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
Distance (ft)


Flynn Creek, Cross-section #2 11/2/99
Percent Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)



Flynn Creek Cross-section #3 11/2/99
4
2
0
-2
-4
-6
-8
Elevation (ft)
-1.0
19.0
39.0
59.0
79.0
99.0
119.0
139.0
Distance (ft)


Flynn Creek, Cross-section #3 11/2/99
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Less Than
1
10
100
1000
Size (mm)


North Branch North Fork Navarro River Thalweg Profile 11/8/99
Elevation (ft)
14
12
10
8
6
4
2
0
-2
-4
0
200
400
600
800
1000
1200
1400
1600
Distance (ft)
y = 0.008x - 0.843

North Branch North Fork Navarro River Residual Depth Statistics 1999

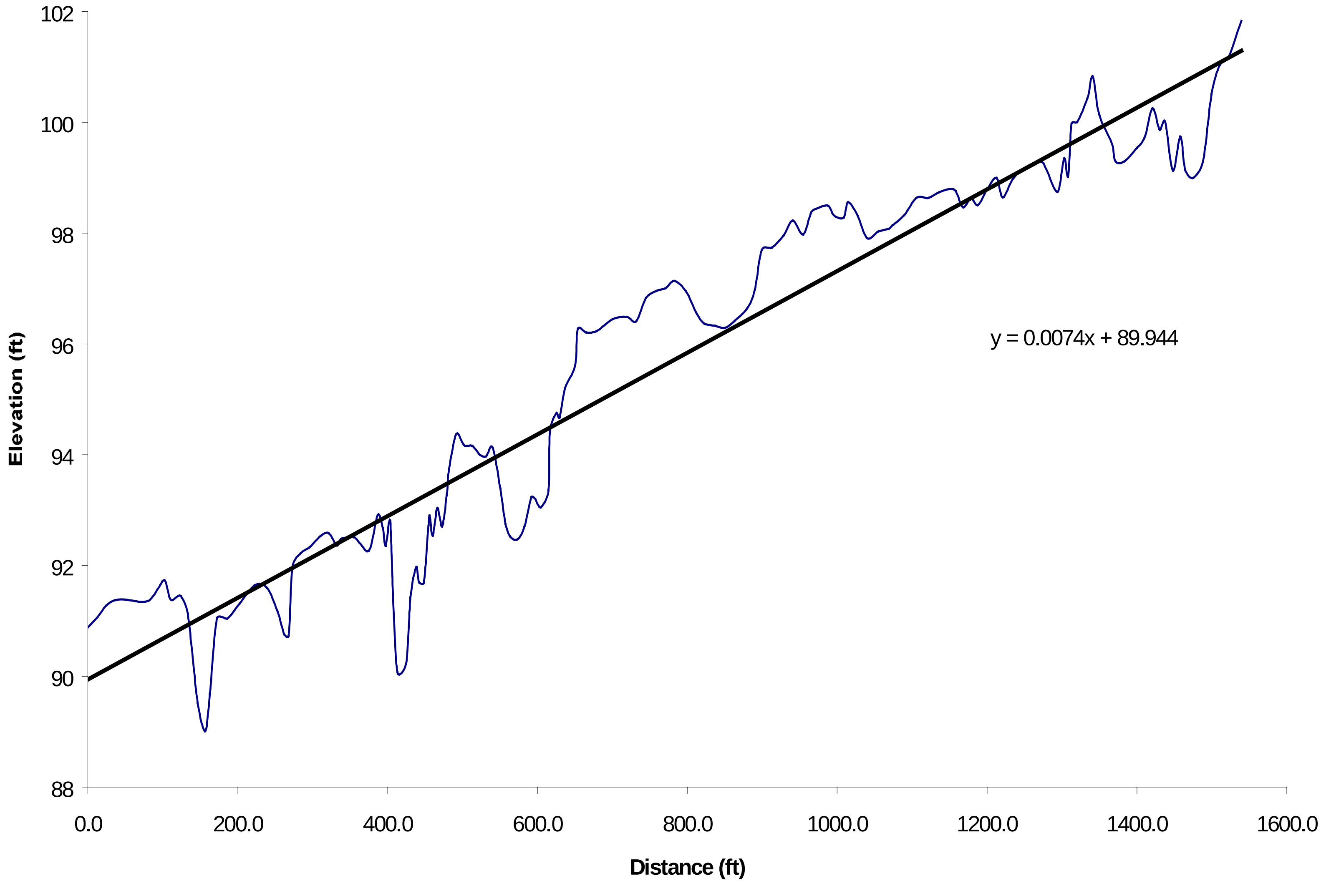
Top Elevation: 11.51
Bottom Elevation: -1.78
Reach Length: 1405.27

Reach Step Distance: 5.00

Max Residual Depth: 2.54
Mean Residual Depth: 0.38
Standard Deviation: 0.52

Number of non-zero Residual Depths: 191
Percent of Reach as pool: 67.97
Percent of Reach as riffle: 32.03

North Branch North Fork Navarro Thalweg Profile 10/15/01



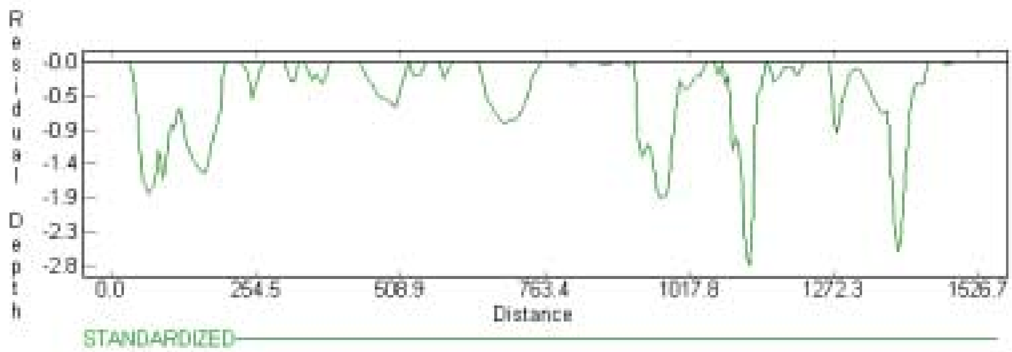
North Branch North Fork Navarro River Residual Depth Statistics 2001

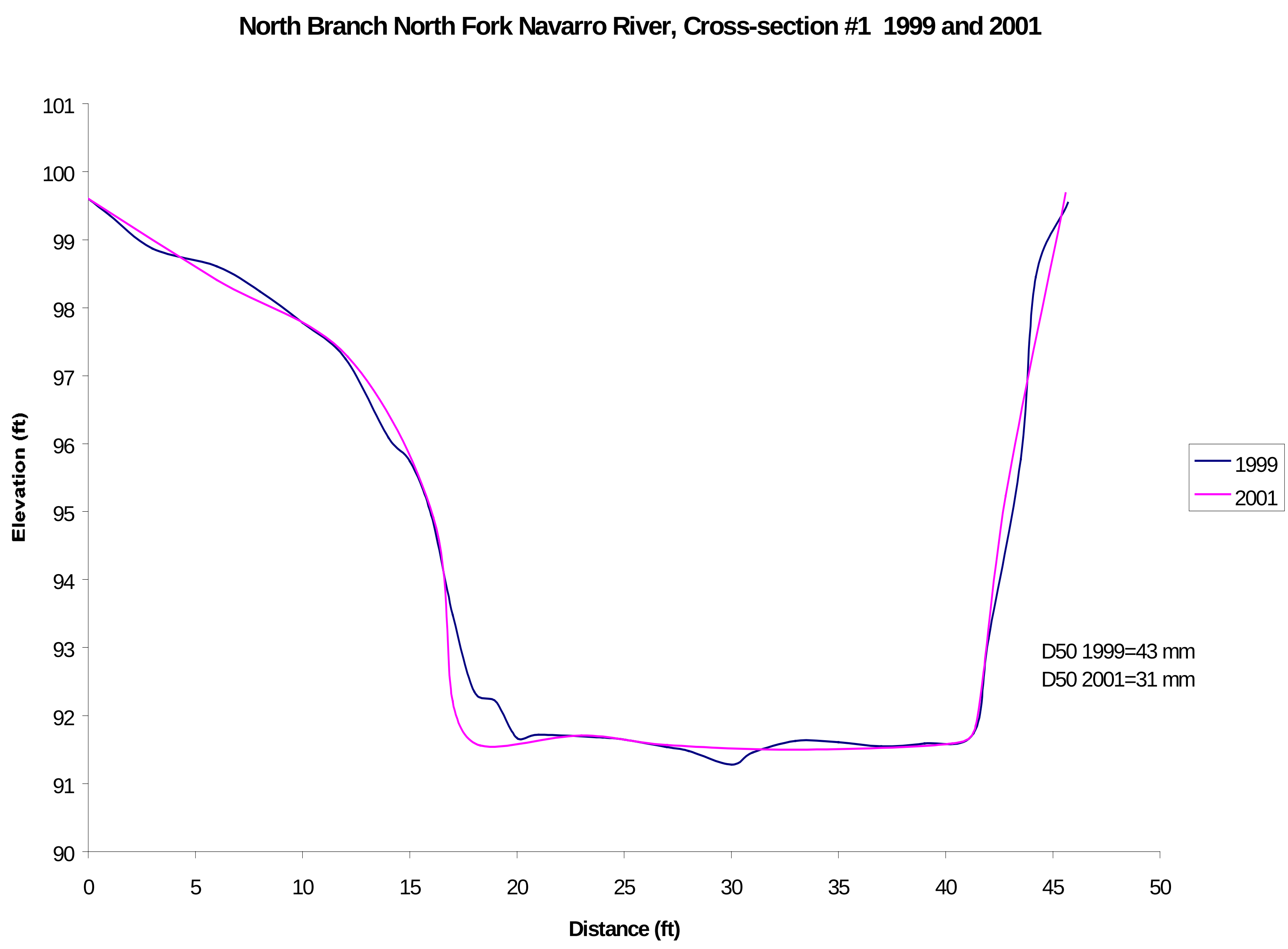
Top Elevation: 101.83
Bottom Elevation: 89.01
Reach Length: 1526.70

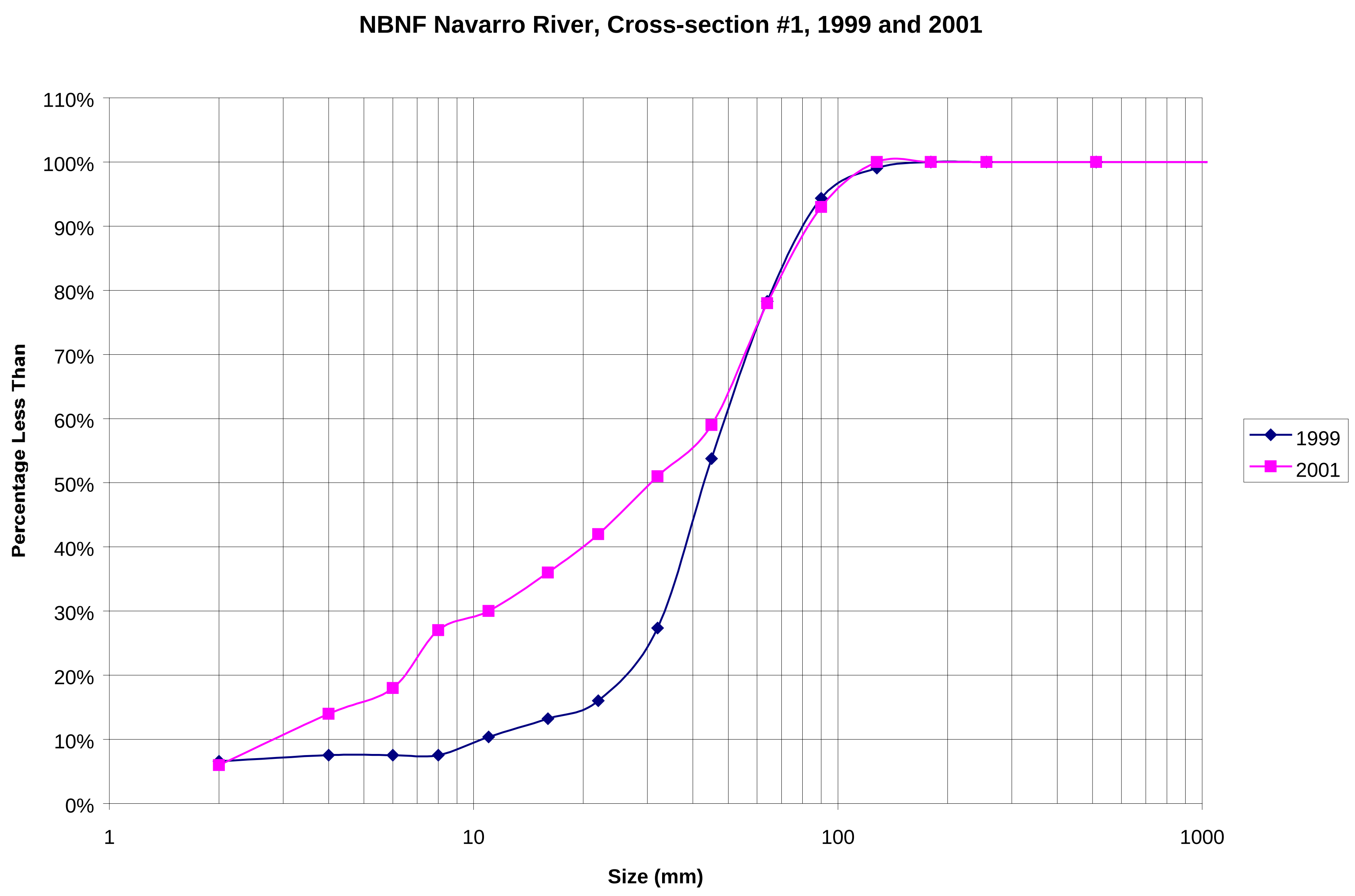
Reach Step Distance: 5.00

Max Residual Depth: 2.82
Mean Residual Depth: 0.43
Standard Deviation: 0.60

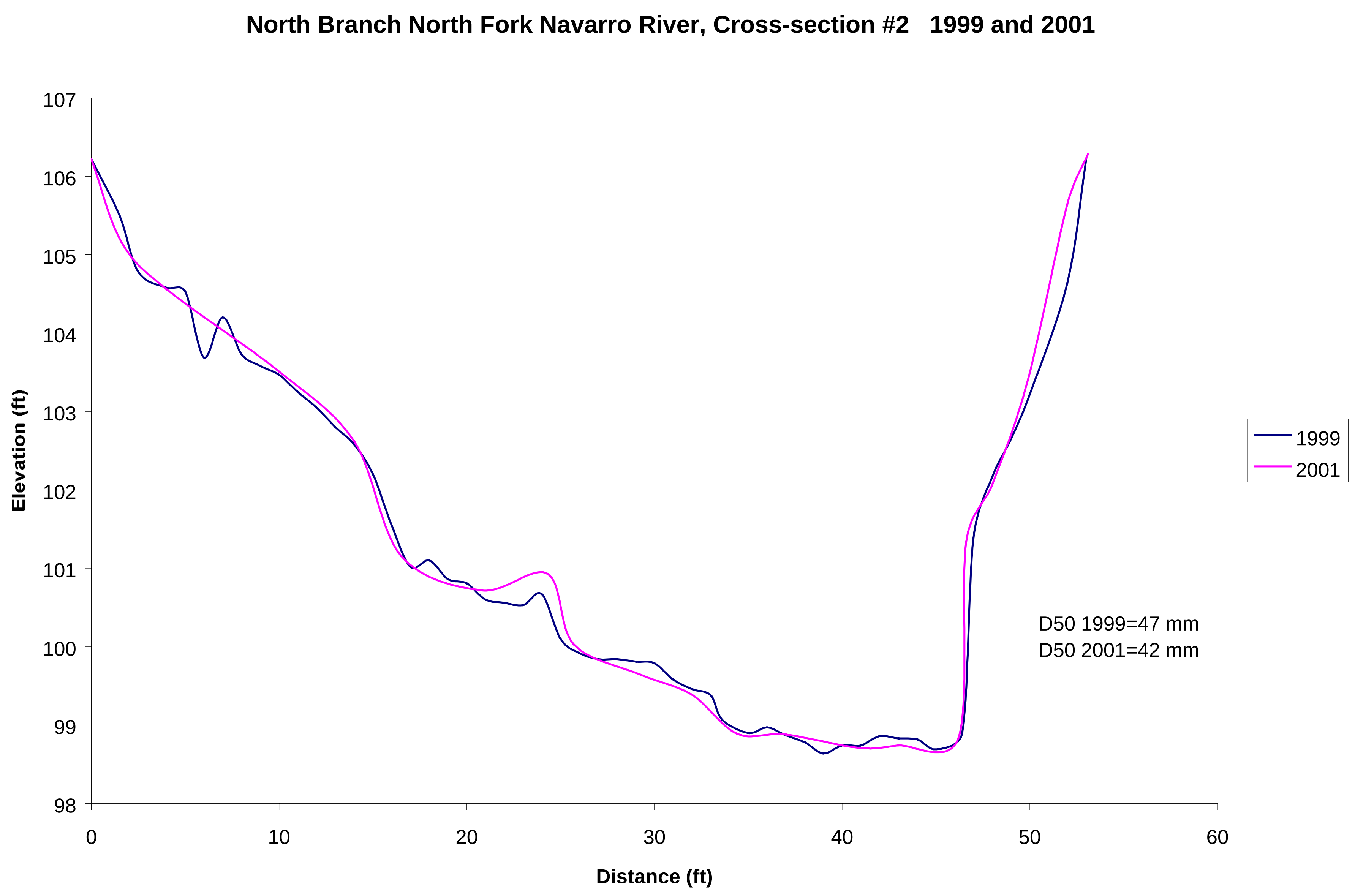
Number of non-zero Residual Depths: 209
Percent of Reach as pool: 68.52
Percent of Reach as riffle: 31.48

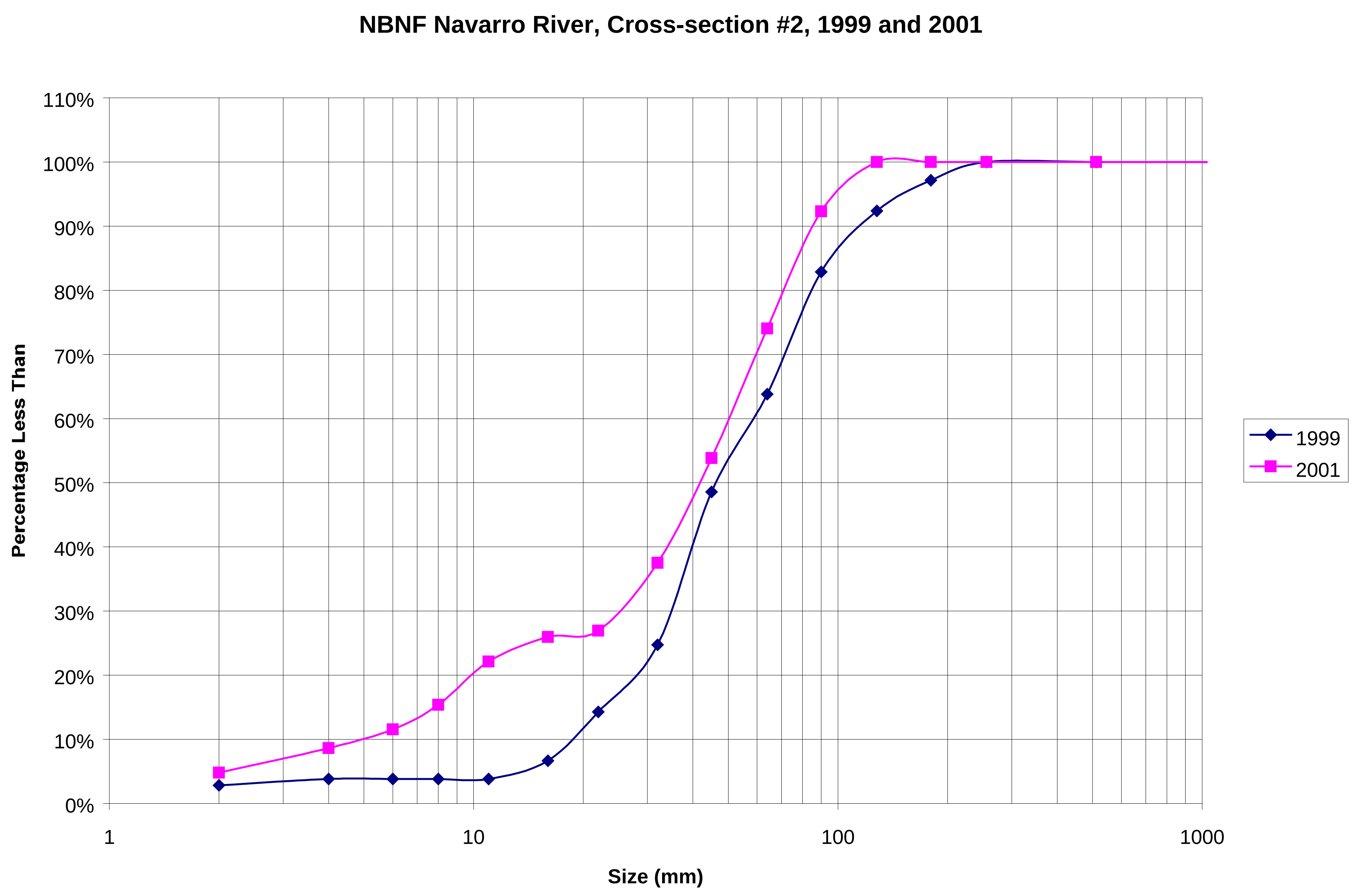



North Branch North Fork Navarro River, Cross-section #1 1999 and 2001
Elevation (ft)
101
100
99
98
97
96
95
94
93
92
91
90
0
5
10
15
20
25
30
35
40
45
50
Distance (ft)
1999
2001
D50 1999=43 mm
D50 2001=31 mm

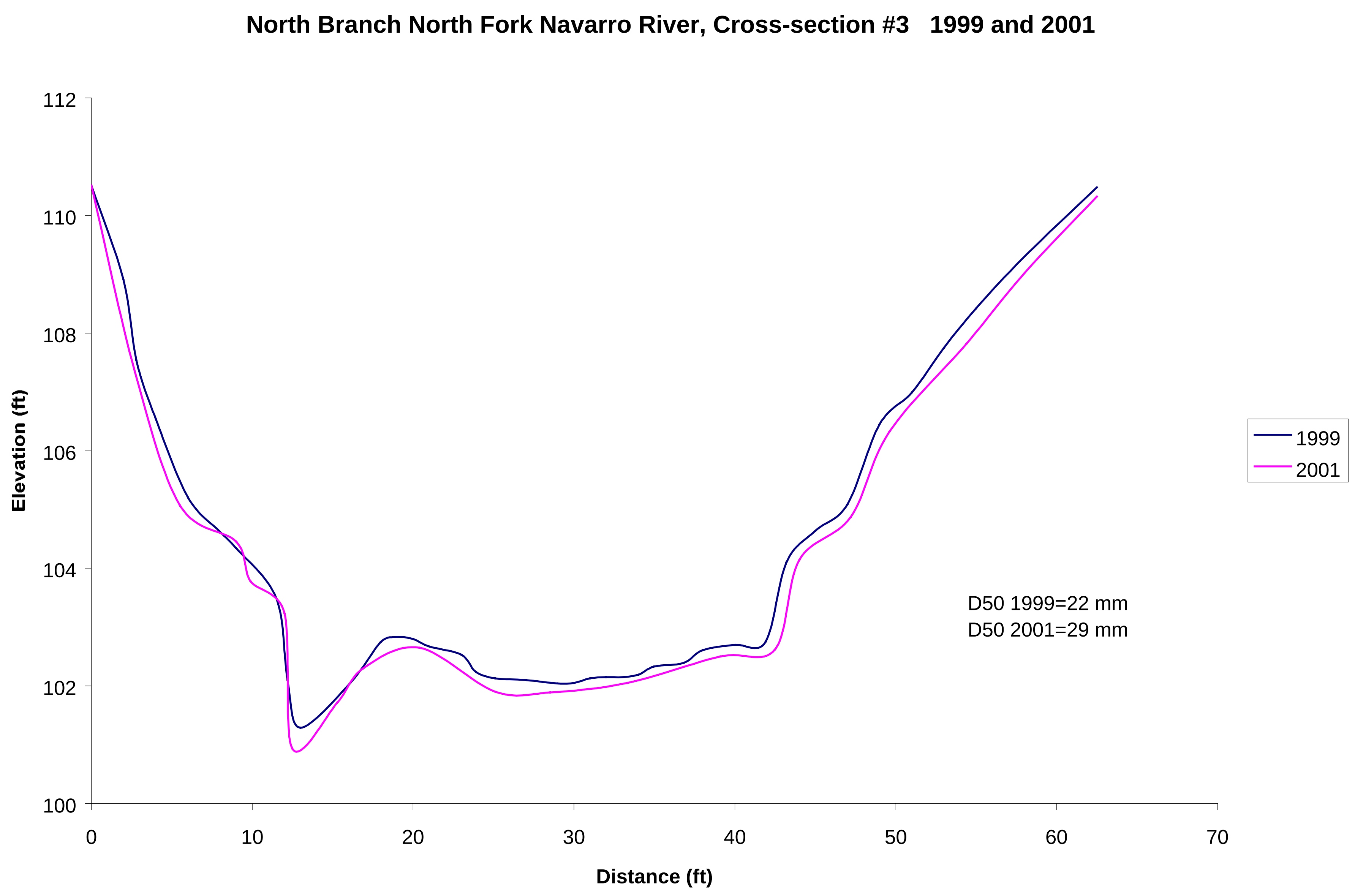


NBNF Navarro River, Cross-section #1, 1999 and 2001
Percentage Less Than
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
110%
1
10
100
1000
Size (mm)
1999
2001

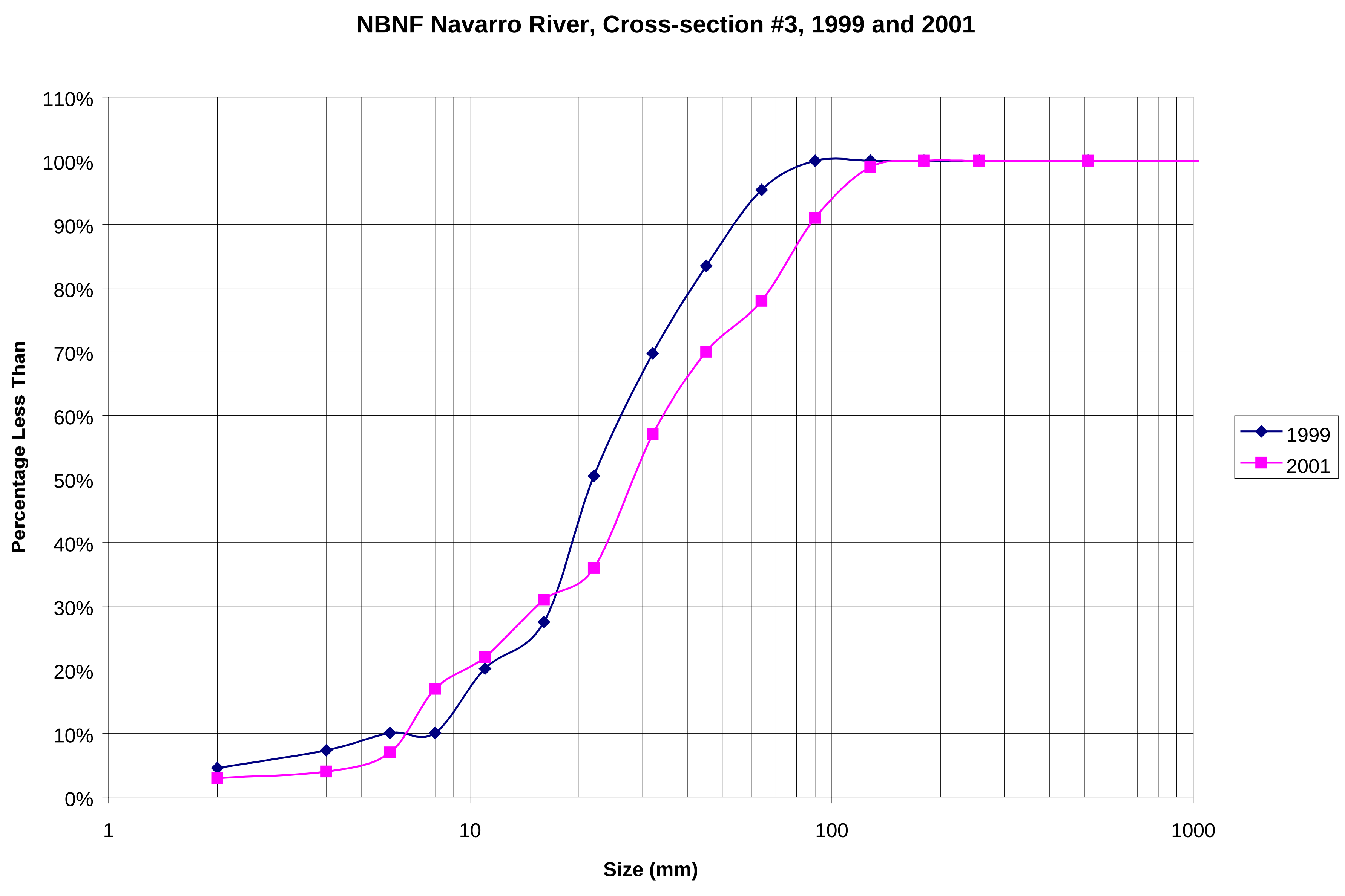

North Branch North Fork Navarro River, Cross-section #2 1999 and 2001
Elevation (ft)
107
106
105
104
103
102
101
100
99
98
0
10
20
30
40
50
60
Distance (ft)
1999
2001
D50 1999=47 mm
D50 2001=42 mm

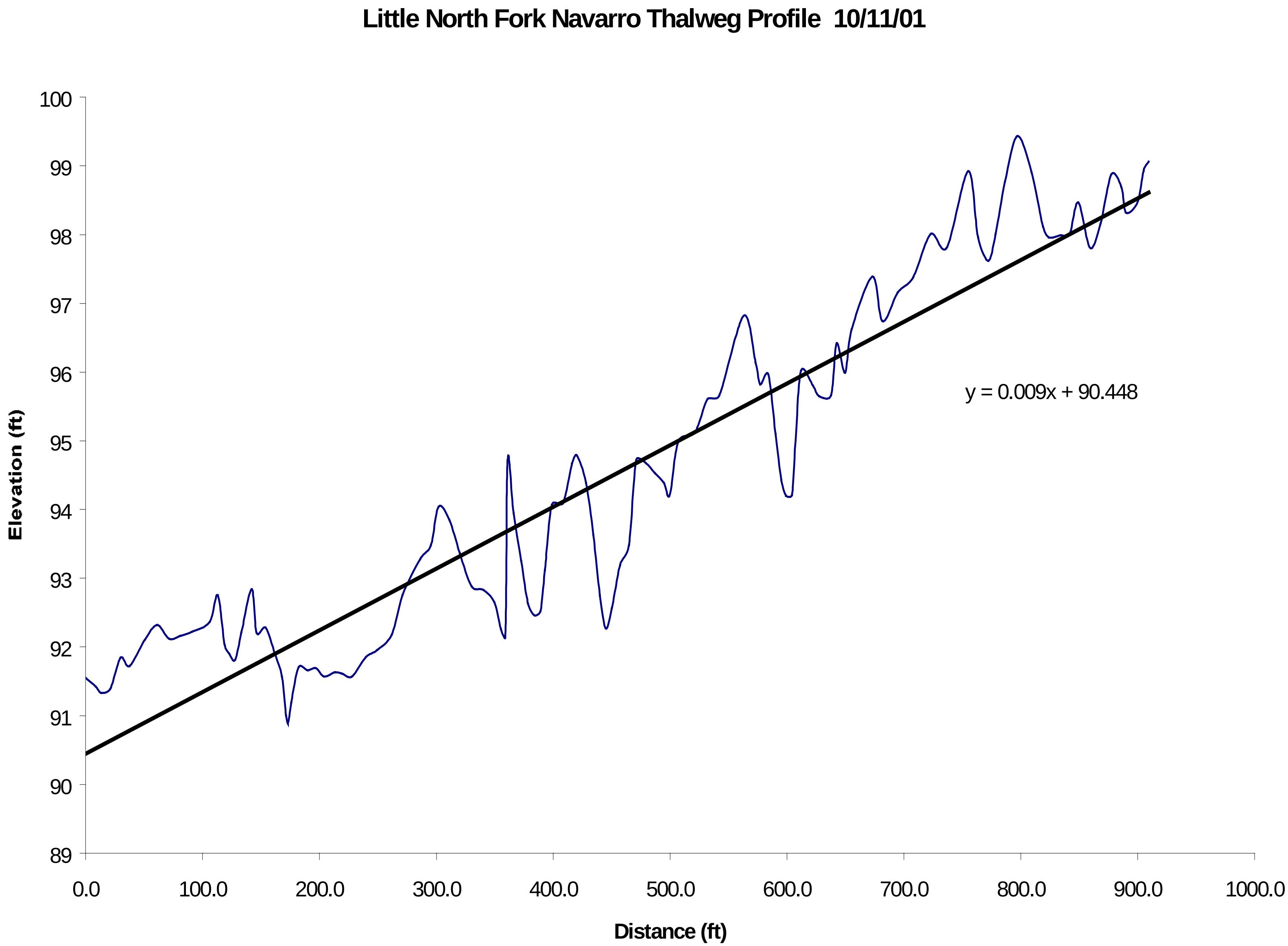


NBNF Navarro River, Cross-section #2, 1999 and 2001
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage Less Than
1
10
100
1000
Size (mm)
1999
2001



North Branch North Fork Navarro River, Cross-section #3 1999 and 2001
Elevation (ft)
112
110
108
106
104
102
100
0
10
20
30
40
50
60
70
Distance (ft)
1999
2001
D50 1999=22 mm
D50 2001=29 mm


NBNF Navarro River, Cross-section #3, 1999 and 2001
Percentage Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)
1999
2001



Little North Fork Navarro Thalweg Profile 10/11/01
100
99
98
97
96
95
94
93
92
91
90
89
Elevation (ft)
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1000.0
Distance (ft)
y = 0.009x + 90.448

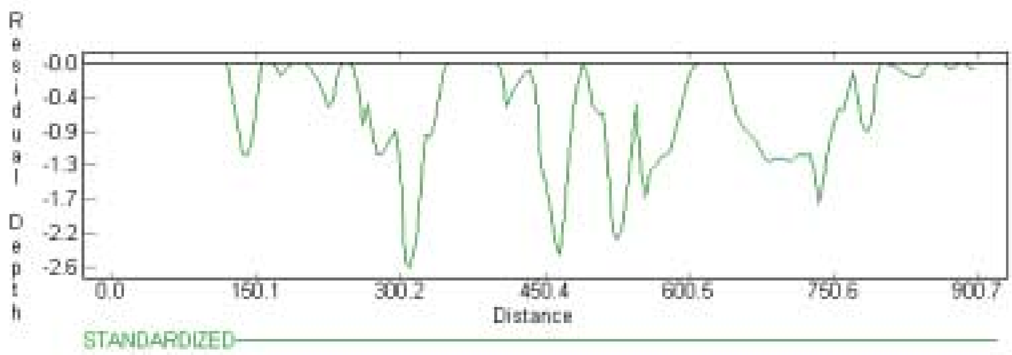
Little North Fork Navarro River Residual Depth Statistics 2001

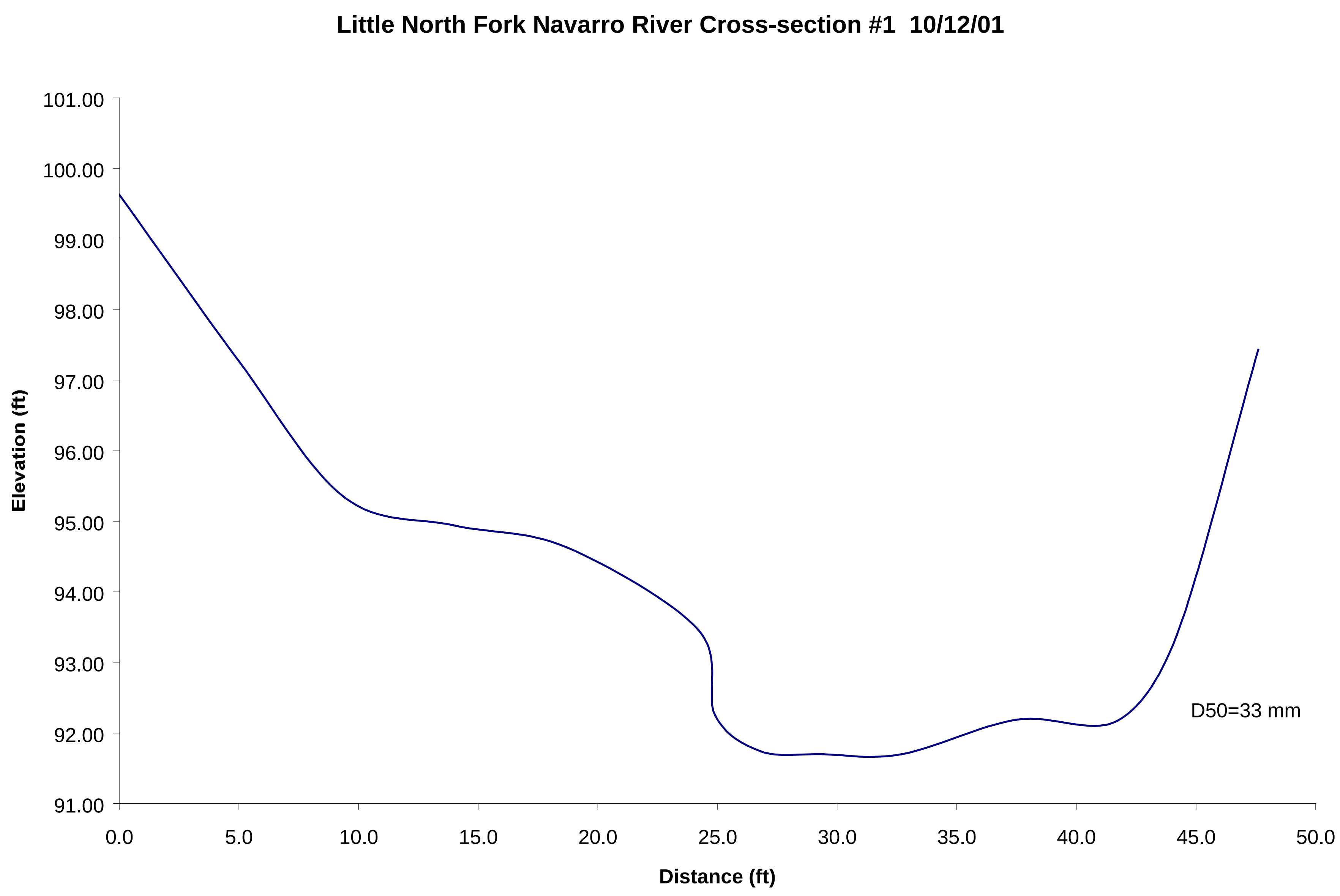
Top Elevation: 99.43
Bottom Elevation: 90.89
Reach Length: 900.70

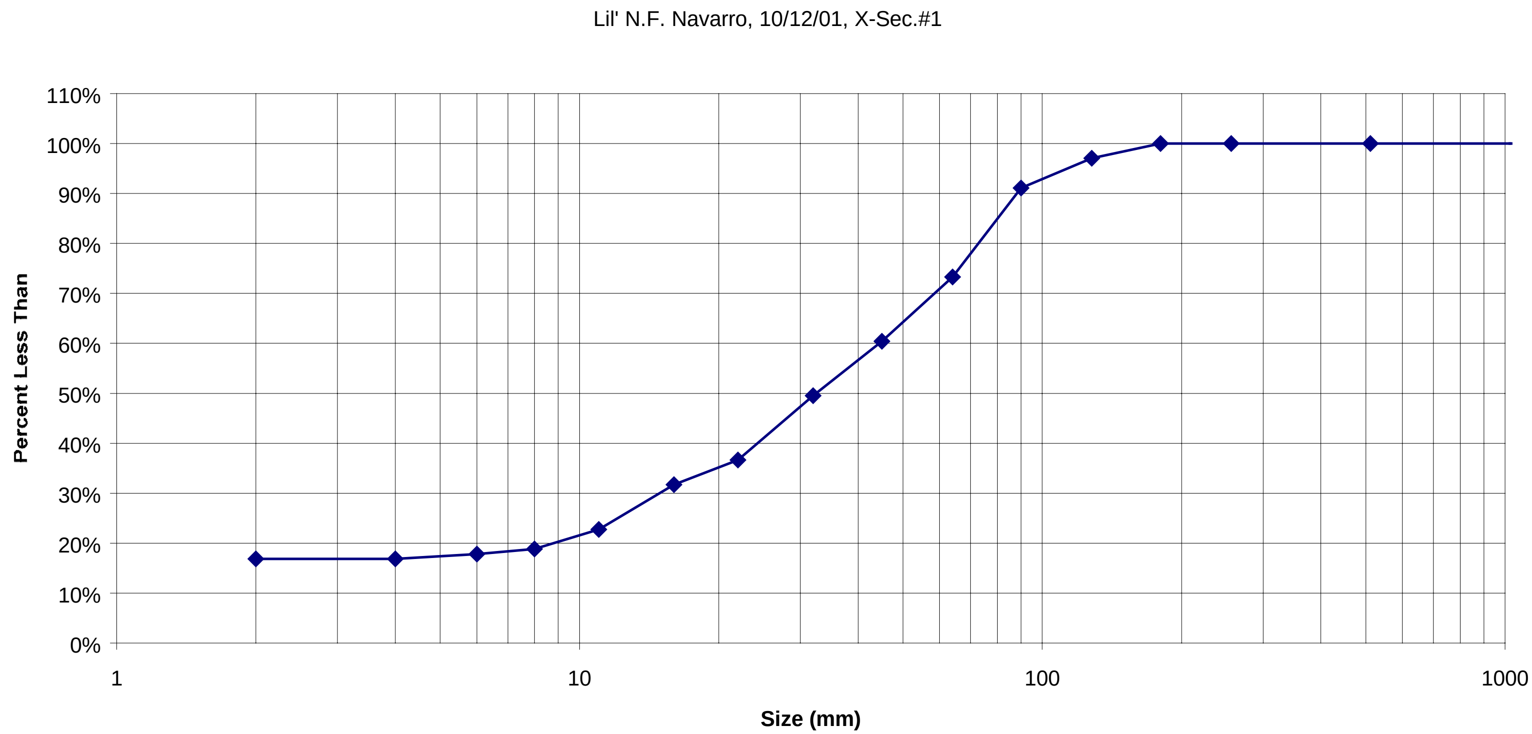
Reach Step Distance: 5.00

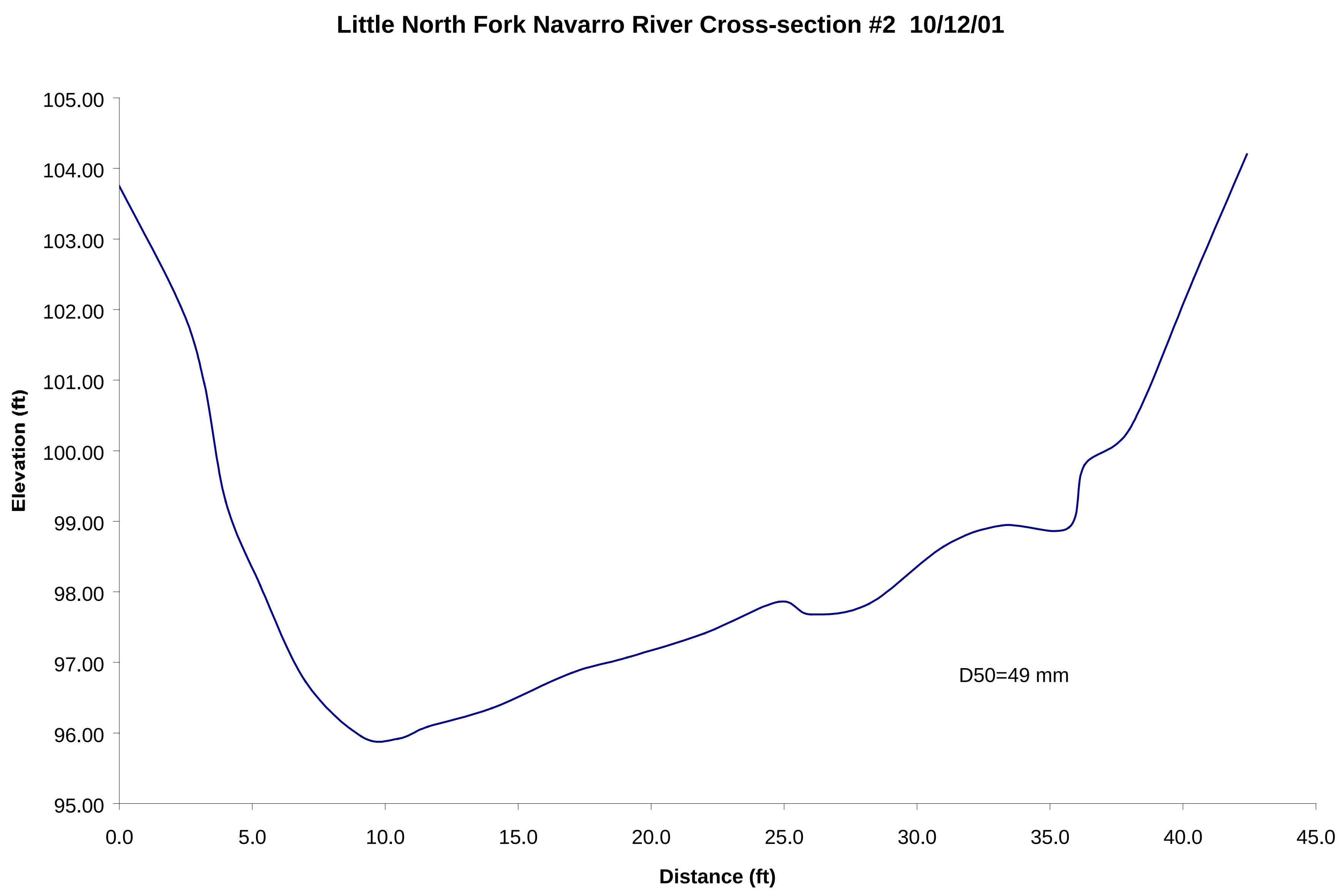
Max Residual Depth: 2.62
Mean Residual Depth: 0.55
Standard Deviation: 0.65

Number of non-zero Residual Depths: 121
Percent of Reach as pool: 67.22
Percent of Reach as riffle: 32.78

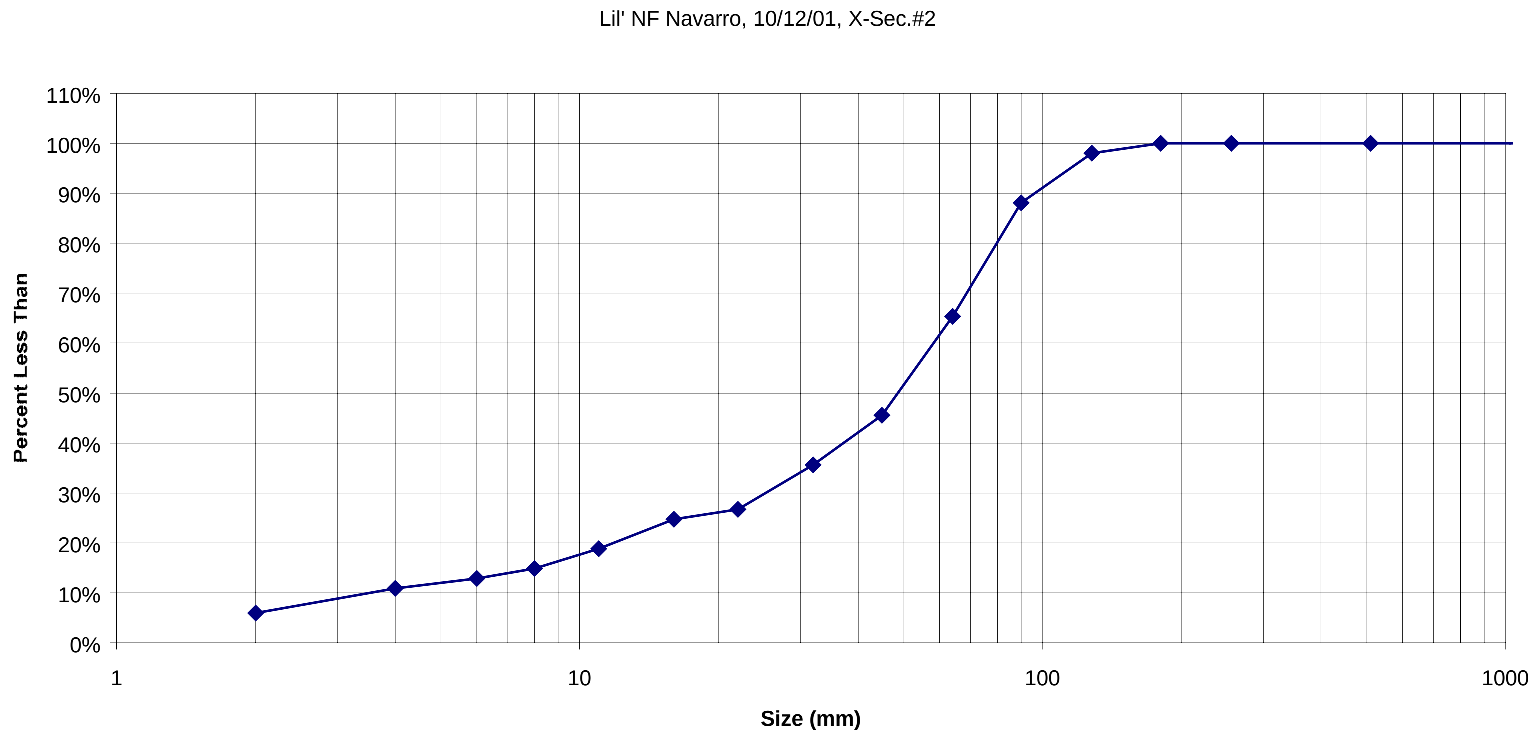



Little North Fork Navarro River Cross-section #1 10/12/01
Elevation (ft)
101.00
100.00
99.00
98.00
97.00
96.00
95.00
94.00
93.00
92.00
91.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
Distance (ft)
D50=33 mm

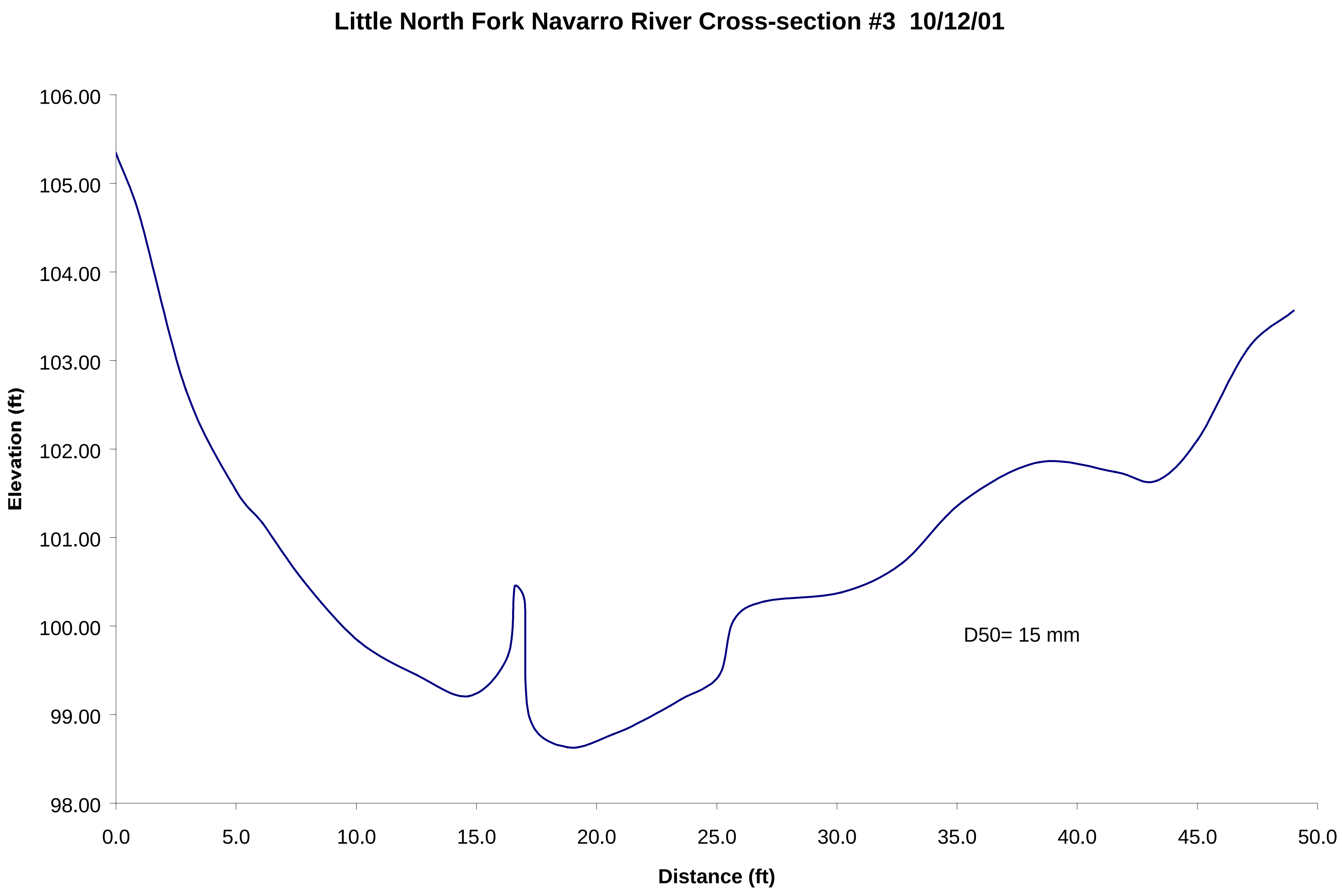

Lil' N.F. Navarro, 10/12/01, X-Sec.#1
Percent Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)

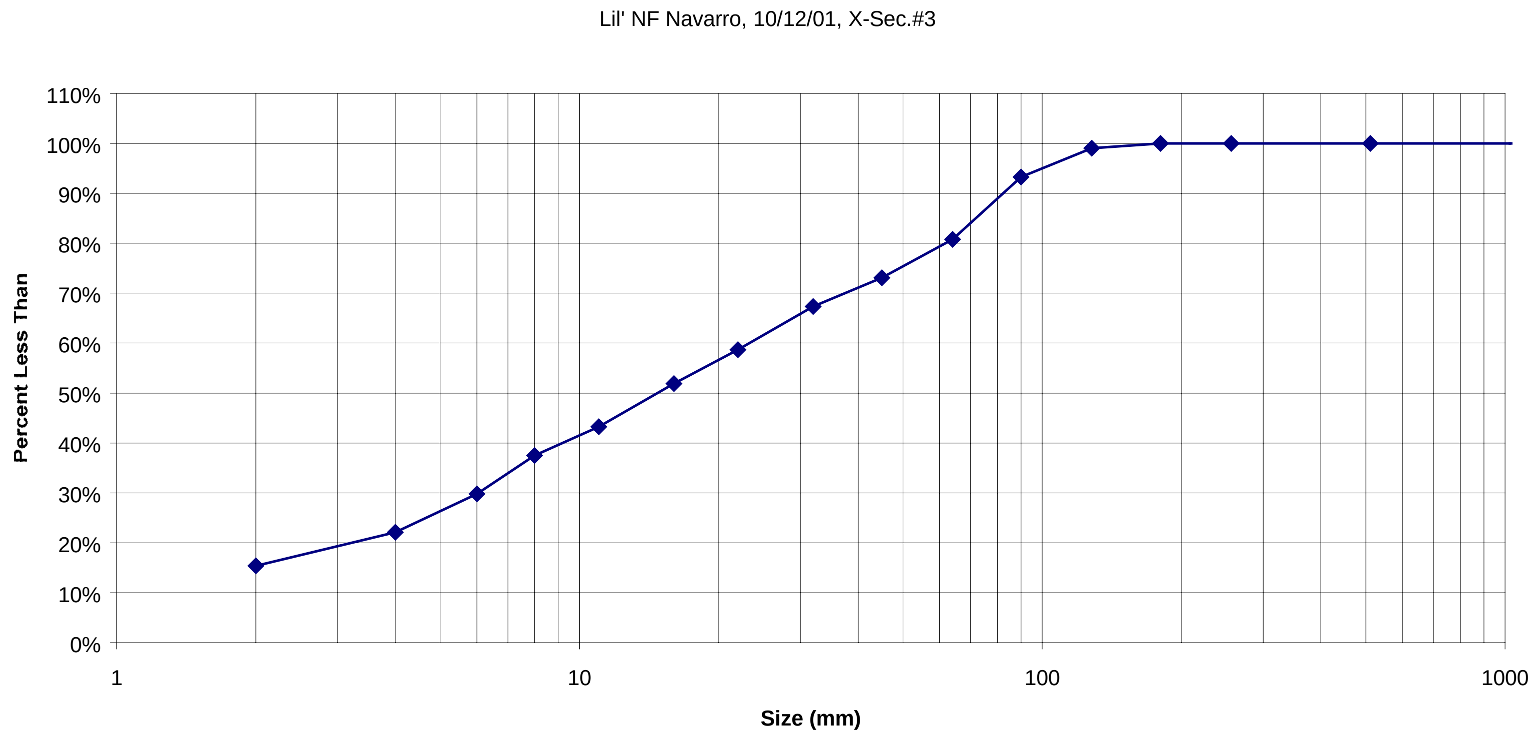


Little North Fork Navarro River Cross-section #2 10/12/01
105.00
104.00
103.00
102.00
101.00
100.00
99.00
98.00
97.00
96.00
95.00
Elevation (ft)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
Distance (ft)
D50=49 mm



Lil' NF Navarro, 10/12/01, X-Sec.#2
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Less Than
1
10
100
1000
Size (mm)


Little North Fork Navarro River Cross-section #3 10/12/01
Elevation (ft)
106.00
105.00
104.00
103.00
102.00
101.00
100.00
99.00
98.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
Distance (ft)
D50= 15 mm


Lil' NF Navarro, 10/12/01, X-Sec.#3
Percent Less Than
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
10
100
1000
Size (mm)