Quilcene-Snow Watershed Wetted Width Study

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Author: Terra Hegy
Habitat Program, Water Team

Abstract

Washington State Department of Fish and Wildlife (WDFW) staff used the wetted width, or wetted perimeter, method in the Quilcene-Snow watershed during 2003 and 2004 as part of watershed planning and instream flow setting. Data was gathered by representatives of WDFW and Jefferson County at 8 sites approximately once a month for a year in an attempt to determine adequate rearing and migration flows. At several transects an inflection point was clearly evident. This information helped state agencies and planning unit members develop instream flows which will eventually be incorporated into state regulation as directed by the Watershed Planning Act, RCW 90.82, and House Bill 2514 passed by the state Legislature.

Acknowledgements and thanks go to Hal Beecher who conceived the study and initiated it; Jefferson County staff David Christiansen, Gabrielle LaRoche, and Craig Schrader, who assisted with field time. Thanks also go to state employees Tiffany Hicks, Steve Boessow, Debby Sargeant, and Jim Pacheco who assisted with field work. Thanks also to landowners who generously gave us permission to access their land and to Department of Ecology for funding this project.

County staff take a wetted width measurement on Little Quilcene River, Nov. 26, 2003

Purpose of the Study

Upon request by the Watershed Planning Group for the Quilcene-Snow (WRIA 17; see WAC 173-500), WDFW initiated a wetted width study to attempt to obtain information on several small streams in the basin regarding fish habitat. The purpose was to develop levels of adequate rearing flows protective of larger juveniles such as one year old steelhead.

This method is used to evaluate the response of wetted width, a significant component of stream habitat, to changes in flow and has been used by many researchers (Annear et al, 2004). It involves measuring from water's edge to water's edge over a number of site visits. Stream width is then graphed versus flow. An inflection point indicates where habitat is stable and below which the width starts to rapidly decrease. The technique was modified by Dr. Hal Beecher (WDFW) who added a measurement of width where depth is at least 6 inches. This would indicate where the width was adequate for passage and rearing habitat. Yearling salmonids are seldom found in water shallower than 6 inches.
The streams were chosen by the planning group. The study was designed around the major water bodies in the basin, namely: Tarboo and Thorndyke, both draining into Dabob Bay and Hood Canal; Salmon and Snow Creeks, both of which drain into Discovery Bay; Little Quilcene and a tributary Leland Creek; and Chimacum Creek, which flows into Admiralty Inlet near Hadlock. Measured widths were also taken on the East Fork of Chimacum Creek and at 3 other locations on the main stem.

Methods

After initial project set up by Hal Beecher, Terra Hegy took the lead in the field work assisted by Jefferson County staff Gabrielle LaRoche and other WDFW and Ecology personnel.

Each time field crews went out, they measured the wetted width, which is the edge of the water to the opposite edge of the water at the same locations, marked by flags. Field personnel also measured the width of the stream that was equal to or greater than .5 ft. (six inches) deep. They also recorded the depth of the deepest pool in the vicinity and the maximum riffle depth nearby. Substrate was recorded at lower flow levels. If substrate was silt or sand or otherwise less than ideal, this fact would be noted.

Data was entered into an Excel spreadsheet after each trip. (See appendix for full data). After completion of the study, the author graphed flow along the x axis and width (either wetted or >.5 feet) along the y axis. Flow was determined using rating curves obtained from Department of Ecology's Stream Monitoring group in the Environmental Assessment Program. Since Ecology staff would examine the data once per water year (around October) curves were, for the most part, provisional.

Analysis of Data

Starting in March 2004, the planning unit at their monthly meetings received information and then discussed a stream in terms of instream flow recommendations. WDFW graphed and analyzed the data for that stream. WDFW and Ecology joined forces in developing a joint state instream flow recommendation for each stream (see Appendix). based on data analysis and consideration of fish habitat and life history.

At the various sites, an inflection point in the width vs. flow graph might be evident. Sometimes there was not a definitive inflection point, depending on the original transect selection or storm events occurring during winter of 03-04. Transects were chosen in an attempt to be representative of the reach, including the more flow-sensitive habitats, with some shallow gravel bar and some pools, and that had banks that were not almost vertical or overly undercut but gently sloping. An attempt was also made for data to be measured and recorded by the same people whenever possible to avoid small errors in measuring or recording.

Gathering data on Thorndyke Creek March 30, 2004.

Upon examining the data, it's interesting to note, for example, that Chimacum Creek near the mouth, the wetted width varied from 27.7 feet on Nov. 26, 2003 at higher flows, to 19.6 feet on July 29, 2003, the low flow season.

On the same dates, the width of the stream that had a depth of at least 6 inches decreased from 15.3 to 12.2 feet between high and low flow times.

Difficulties and Problems

Even though care was taken in measuring, some of the data showed nothing of interest. Some of the problems that were encountered during this study were:

Channel changes due to high flows. After the first three data measurements, two major storms came through the area (in October and November 2003). Even though the Hadlock/Chimacum area was not affected as much as other areas on the Olympic Peninsula, still there were notable changes to stream banks. In some cases such as Tarboo Creek, silt and gravel came in and significantly changed the cross section of the downstream transect. At transect B on Salmon, this also occurred.

At transect C on Salmon, a root wad was located on the left bank. During these storms, high flows scoured out the area below the root wad. Thus, even two transects which were very close together could be affected quite differently.

Recommendation:
Flows should be measured from the high flow going down to avoid channel changes due to storms.

2. Debris and other organic matter. The same above-mentioned storms brought in braches and woody debris that backed up water on East Fork Chimacum Creek. At H.J. Carroll Park on the mainstem Chimacum, a medium sized log backwatered Transect 1. In both cases, because of backwater effects, widths taken immediately above the debris jam were found to be excessively wide. At Salmon Creek, humans had built a small dam inside a culvert and across the creek. Field staff felt this probably altered the height of water on the staff gage which was located directly upstream of the culvert.

At the mouth of Chimacum, fern wads near the bank became problematic: did we measure over, under, or around, was asked almost each time. Markers set into banks at several sites went missing. Attempts were made to locate the exact spot each time, but sometimes measurements could have been off a few inches to the left or right, which made a difference in the measured wetted width.

Recommendation:
Transects should be chosen where they cannot be influenced by a culvert, bridge, at any flow. Root wads and other log debris may cause difficulty in assessing habitat-flow relationships, but are an important element of habitat, so decisions to place transects near them should be done with caution.

3. Tidal effect. At one site, Chimacum at the mouth (RM .1), where Ecology located a gage, was originally considered well above tidal influence. However, on one field visit, storms coupled with very high tide combined to make a fluctuating gage. Although Ecology attempted to adjust gage data to compensate for this effect, and

measurements were not gathered at high tide, some of the early measurements might have been made at times of high tide and could be suspect.

Recommendation: Locate all transects well above tidal influence.

4. Overtopping of gages. The same storm events noted in number 1 made it difficult to read the Ecology gauge on the Little Quilcene. The gauge was completely overtopped with water and field crews had to estimate the level and check back at a later date. After this, field crews would lower a weight down from the bridge. Near the end of the study, another gage was added and Ecology staff had to combine earlier and later readings. On some dates it appeared as though the bridge was settling since the flow measurements decreased for no apparent reason even though the widths were increasing. Even Ecology was baffled and concluded the bridge must be settling.

Recommendation: Locate a long enough staff gauge so that even at high flows it can be read. Alternatively, measure maximum flow within the capability of available equipment.

5. Flows at time of measuring. Ecology operates telemetered gages at most of the wetted width sites. These were downloaded and calibrated weekly by Jefferson County staff. WDFW would read the staff gauge and using the rating curve supplied by Ecology. At first WDFW tried to use the Ecology website, but those data were daily averages and may or may not be reflective of the flow at the exact time we measured the site. For example, a flow of 6 cfs could have varied that day between 4 and 8 cfs or even more. With analysis that dependant on a very minute change in flow, getting accurate flow information proved to be a difficulty with the wetted width graphs.

Recommendation:
Take flows 3 to 4 times and make your own rating curve to use along with the wetted width data. This would have added a lot of time to our study and involved more field time but may have yielded more inflection points. This should become less of a problem for a gage site that has been in operation for several years (these were newly installed so did not have a rating curve yet).

Other Measurements: Pool and Riffles

At each site, pool depths were taken on at least one transect. An attempt was made to take pool readings at the same place each time. However, after winter high flows, the channel could change, making it difficult to find the same location of pool (i e pools migrated). Pool depth does give an indication however of the minimum depth that pools do reach especially at low flows.

Maximum riffle depth was measured during summer low flows. This is the depth at which a fish would have to swim through to migrate upstream, the deepest part of the shallowest section. Riffle depth was not measured during high flows when depth was not a concern for migration.

Appendix A shows data for each site for pools and riffle depths with all other width measurements.

Reports to Planning Unit

Here follows a write up for each stream and summary graphs, problems encountered, and inflection points where indicated. This report was submitted to the planning unit as a State Proposal for Instream Flows on Thorndyke Creek on May 24, 2004. It is a sample of the type of information that submitted on each stream to the Planning Unit.

Author recording wetted width measurements July 29, 2003, on Chimacum Creek near mouth

example of discussion paper for instream flow development:

THORNDYKE CREEK

Background

Thorndyke Creek is fed by rainfall and drains an area of shallow lowland valleys with virtually no glacial or mountain snowmelt influence. Precipitation for the Thorndyke watershed's 6,904 acres is 31.5 inches a year. Stream length is 6.3 miles, with 8.2 miles of tributaries. Thorndyke enters Thorndyke Bay in upper Hood Canal in eastern portion Jefferson County.

Land use of the Thorndyke basin is largely undeveloped. Sandy Shore Lake lies at the headwaters. The lake along with other wetlands and seasonal lakes may act to moderate flows into Thorndyke Creek especially in the summer.

Fish species present are: coho, fall chum, winter steelhead, and coastal cutthroat. The Limiting Factors Report (WCC 2002) list 5.2 miles of known presence and 4.4 miles of presumed use for coho, fall chum, and winter steelhead. Bull trout spawning is unknown but unlikely in this stream.

Hydrographs/Exceedance Curves

The planning unit hired a consultant to research and write an Instream Flow Assessment (Golder 2003). The authors of the document considered Thorndyke to be "data-poor" and used flow data from a stream similar in elevation and precipitation with a longer record, namely, Dogfish Creek in WRIA 15 (Kitsap), to extrapolate Thorndyke exceedance curves.

It should be noted that there is a high degree of uncertainty with the consultant's hydrograph on Thorndyke Creek, since flow measurements were not available at the time from Thorndyke Creek. The state used actual flow measurements for Thorndyke Creek as measured by Ecology gauge data from April 2003 through March 2004 and 9 flow measurements from 1993-1998 taken by the Jefferson County Conservation District to develop this recommendation.

Instream Flow Studies

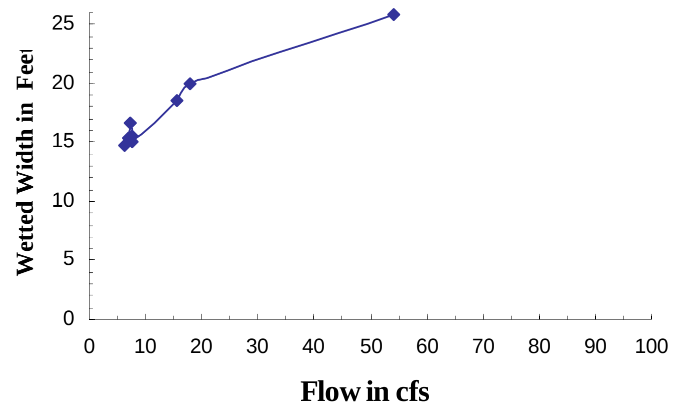
Washington Department of Fish and Wildlife conducted a wetted width study on Thorndyke Creek from July 2003 to April 2004. This method assumes that reductions in the wetted width are correlated with losses in habitat quality. Graphs are developed which indicate a relationship between actual flow and wetted width. The instream flow value is derived from the location of an inflection point on the wetted perimeter-discharge curve, or where the slope of the curve changes sharply.

This research showed an inflection point between 15 and 20 cfs for Thorndyke Creek after measurement on 8 dates at 6 different flows. The inflection point at approximately 17 cfs suggests a flow below which habitat for rearing of larger juvenile salmonids (such as steelhead) would decline fairly abruptly with any increment of flow reduction. However, because of the sparse data and the questionable high flow measurements on the Thorndyke gage, 17 cfs should be considered a rough and conservative estimate for rearing, for example, the inflection point could be at a higher flow, but it is unlikely to be lower than 15 cfs (Graph 1).

On each field visit, WDFW also measured what extent of the total wetted width was at, or more than, a depth that reached or exceeded .5 feet (six inches); rearing salmonids seldom use water shallower than this (Graph 2). This measurement is used to estimate suitability for rearing of larger juveniles and for adult trout habitat. The inflection point on the Thorndyke graph at approximately 17 cfs suggests that this instream flow would be adequate to protect food producing riffle habitats that are sufficient to maintain existing fish populations. Note that both graphs show a similar inflection point between 15 and 20 cfs, showing convergence, and thus tending to reinforce the other.

Graph 1:

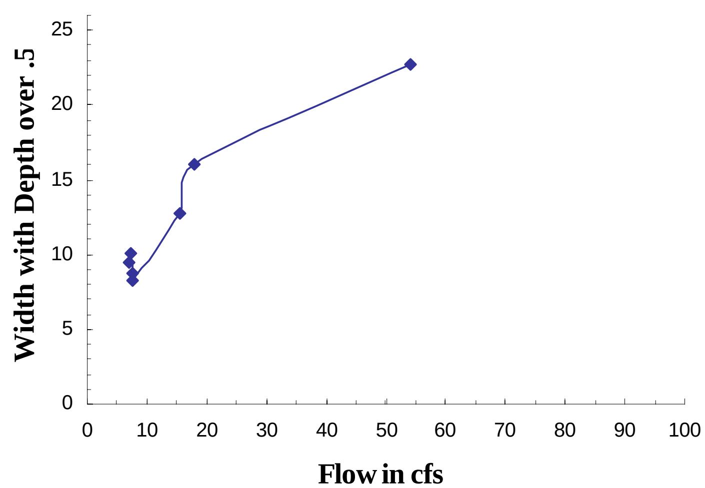
Thorndyke Creek near mouth: Wetted Width vs. Flow



gage ht	cfs	Wetted Width (feet)	date
0.88	6.46	14.7	9/5/03
0.88	6.84	15.3	7/7/03
0.89	7.31	16.7	10/29/03
0.88	7.49	15.6	7/29/03
0.84	7.55	15.0	4/27/04
0.94	15.6	18.6	2/25/04
1.02	17.9	19.9	12/16/03
1.48	54	25.8	10/20/03

Graph 2:

Thorndyke Creek near mouth: Depth over .5 feet vs. Flow



gage ht	cfs	Depth over .5 ft.	date
0.88	6.46	nd	9/5/04
0.88	6.84	9.5	7/7/03
0.89	7.31	10.1	10/29/03
0.88	7.49	8.7	7/29/03
0.84	7.55	8.3	4/27/04
0.94	15.6	12.8	2/25/04
1.02	17.9	16.0	12/16/03
1.48	54	22.7	10/20/03

Toe Width Study

An Ecology toe width study (Ecology 1999) provided additional information. The toe width method was developed in the 1970's as a quick and easy method to predict adequate spawning and rearing flows for salmon and steelhead (Swift 1979). The researchers developed a power function equation that, when one inputs an average width of a stream channel, flows are derived which are considered optimal for spawning and rearing salmonids. The following theoretical optimal instream flows were derived from the Ecology data:

Coho spawning	24.6
Chum spawning	49.7
Steelhead spawning	44.9
Steelhead rearing	10.1
Salmon rearing	9.1

Ecology now recommends using the same spawning optimal flows for chum as for coho spawning, due to the similarity of these species for habitat preferences.

Salmonid Life Stages

Knowledge of when fish are present and their life stage is an important component of setting instream flows. Table 1, below, summarizes fish present for each month of the year and the range of possible instream flows. The range of numbers is derived from data from the two instream flow methods, toe width and wetted width. For each month, a range of flows for each salmonid species and life history present is given. For example, in October, toe width data gave an optimal flow of 10.1 for steelhead rearing; wetted width data gave a flow of 18 cfs at the inflection point.

Fall

The water year begins in October when steelhead juvenile rearing is still in the active phase. Coho begin spawning in November but are probably present prior to this time, waiting for freshets in order to shoot upstream; they continue spawning into January. Fall chum spawning starts in early November and continues through December.

Therefore, during the months of November-January, optimal flows would be 24.6 cfs to protect coho and fall chum spawning, derived from the toe width method.

Winter

Winter steelhead begin spawning in mid February and continue into early June with the height of spawning during March and April. We recommend that during March and April, optimal flows of 44.9 cfs be used to protect steelhead spawning. The "shoulder" month of February can be less than the peak months to provide adequate incubation. May is one of the peak spawning months for steelhead, but incubation flows in June

Table 1

Fish life history and Range of Instream Flows

Month	Range of flows	Fall chum Spawning	Coho Spawn-ing	Winter steel-head spawn-ing	Steel-head Juvenile rearing	Coastal cutthroat Spawning	Coastal cutthroat Rearing	10% ex-ceedence (per Data Sum.)	Median flow (per Dogfish Cr. USGS)
Oct	10.1-18				x			~11	6.4
Nov	24.6-49.7	x	x		*				10.3
Dec	24.6-49.7	x	x		*				14.4
Jan	24.6-49.7	x	x mid Jan		*	x			18.2
Feb	44.9	Incubation		x mid Feb	*	x			16.2
Mar	44.9	Emergence		x	*	x			13.6
Apr	9.1-44.9	Emergence		x	x	x			8.6
May	9.1-44.9			x	x		x		6.0
Jun	9.1-44.9			x early June	x		x		4.6
Jul	10.1-18				x			~5	3.6
Aug	10.1-18				x			~6	3.6
Sep	10.1-18				x			~7	4.3

All numbers are cubic feet per second.
*Asterisks for winter inactivity of steelhead juveniles.

and July will decline. To protect the eggs of spring spawners so that they don't dry up with dropping flows we suggest a lower flow that will provide spawning habitat nearer the center of the channel and away from gravel that is prone to dewatering.

Through the winter, chum and coho incubation (Feb. through April) are an additional consideration, with low activity by juvenile steelhead and coho, which are present but avoid current and light.

Spring

Incubation and intragravel rearing of steelhead take place during March to June until fry emerge. Eggs need to be covered with water in order to survive. After emerging from the gravel, steelhead rear in the stream until they migrate out as 1, 2, or 3 year olds in spring. Biologists typically use a approximation of adequate incubation flow as 66% of the flow at which the fish spawned. Thus, 24.6 cfs will more than adequately protect incubating chum and chum eggs, as well as any coho still spawning.

Coastal cutthroat in Thorndyke are identified as part of the West Hood Canal stock in WDFW's Steelhead and Salmon Stock Inventory (Salmonscape 2004). Their spawning timing is unknown, but is thought to be January through April. Incubation and intra-gravel development take place March through May. As with steelhead, juveniles rear year-round for 1, 2, or 3 years until smolts migrate to the marine environment during spring of the following year or years. At this time, we have no data from the toe width method for suggesting instream flows for cutthroat. However, using steelhead rearing flows should protect cutthroat.

Summer/Rearing

Coho fry remain in the stream year round from the time of emergence through early June of the second year when they emigrate as yearling coho.

In the summer months, July through October, steelhead and coho rearing are the main consideration. Toe width gives us 9.1 and 10.1 cfs respectively. The wetted width graph, as previously discussed, gives a value of between 10 and 20 cfs. Thus, a range of 9 to 15 cfs is available for summer months. Note that flows chosen as instream flows may not be present every year, but picking a higher flow would be more protective of rearing when those infrequent flows do happen to occur. Salmonid populations vary considerably among years. The benefits to production of a good water year (and the impact of a low water year) propagate through several generations, emphasizing the importance of infrequent good years.

Final Recommendations

Wetted width data is shown in Appendix 1 and the most informative graphs in Appendix 2.

Below is the recommendation that was presented by WDFW to the planning group for their consideration as a biologically defensible rationale.

Month	**Flow**	**Primary species to protect**
November thru February	24 cfs	Coho and chum spawning
March and April	45 cfs	Steelhead spawning
May and June	30 cfs	Incubation
July through October	15 cfs	Rearing

At a later point, hydrology was incorporated into the flow proposal by not going above the statistical measure of the 10% exceedance flow, indicative of an extremely wet and rarely occurring year.

Each stream in the study was analyzed similarly and wetted width curves were used when an inflection point was shown. The planning group discussed one stream a month until December 2004. These results are shown in Appendix 3.

References

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Comments or questions

Contact the author:

Terra Hegy, Instream Flow Biologist
Science Division, Habitat Program
Washington State Department of Fish and Wildlife
E-mail: hegytph@dfw.wa.gov
Phone: (360) 902-2608
Address: 600 Capital Way N
Olympia WA 98501-1091

Appendix A. Raw Data (July 2003-Sept. 2004)

Wetted Perimeter		**Habitat data for WRIA 17**			Date: July 7, 2003					
		Field crew: Beecher, Hegy, LaRoche								
					Width with					
Site	*Date*	*Total width*	*dth with co*	*Substrate*	*spawning habitat*	*Width >.5*	*Max D*	*Max Rif*	*distance from edge*	
Salmon Cr A	**07/07/2003**	13.7	0	SC, LG	13.7	0.1*				
Salmon Cr B	**07/07/2003**	16.2	0	G, silt	16.2	0.0				
Salmon Cr C	**07/07/2003**	19.2**	0.9	G, silt	12.8	13.1				
Leland Creek A	**07/07/2003**	13.2		C, B*	13.2	1.0	0.75			
Little Quil above conf B	**07/07/2003**	27.1		B*, S, LC MG	6.5	19.7	2.4			
Little Quil below conf C	**07/07/2003**	32.4	0.33	C	18.7	18.7		1.2		
Little Quil below conf D	**07/07/2003**	37.8	0	MC, LC	37.8	20.0				
Tarboo Creek A	**07/07/2003**	18.6	0.9	silt, MG	8.8	3.6		D/S		
Tarboo Creek B	**07/07/2003**	9.4	0	ND	9.2	5.3	1.1			
Thorndyke Creek	**07/07/2003**	15.3	0	SG, S-4.3*	11	9.5		0.45		
Chimacum EF	**07/07/2003**	12.45	0.25	G, silt, OD*	12.45	0.0				
Chimacum WF	**07/07/2003**	11.9		MG	11.9	2.2	1.8			
Chimacum park 1	**07/07/2003**	20.36	0.16	MG	11.9	0.0				
Chimacum park 2	**07/07/2003**	14.4		assume MG	14.4	8.2				
Chimacum Mouth	**07/07/2003**	21.8	1	S, silt, LG	21.8	13.0	1.65	0.3		
Line 12 minus boulder		**corrected 5-3-04								
Lines 13,23 gravel bar										
* indicates mixed substrate, are using the whole width					*changed Salmon A to .1 after review of data 4-15-04					

WRIA 17 wetted perimeter		Crew: Beecher, Hegy		Date: July 29, 2003					
					Width with		*Max pool*	*Max*	
Site	*Date*	*Total width*	*W with cover*	*Substrate*	*spawning hab*	*Width >.5*	*D*	*Rif*	*distance from edge*
Salmon Cr A	**07/29/2003**	13.9	0.2	silt-1.8	11.3	0.1			
Salmon Cr B	**07/29/2003**	13.6	0	G	13.6	0.0			
Salmon Cr C	**07/29/2003**	18.3	0.9	G, silt-5.4	12.9	8.0			
Leland Creek A	**07/29/2003**	15.4	0	C, B*	15.4	0.0	1.6		
Little Quil above conf B**	**07/29/2003**	26	0	B*, Silt 1.5, LC,M(	26	14.7			
Little Quil below conf C	**07/29/2003**	29.3	0.8	C	29.3	16.3			
Little Quil below conf D	**07/29/2003**	37.9	0	MC, LC, silt 1.2	36.7	16.7	1.1		
Tarboo Creek	**07/29/2003**	16	0.8	MG, S-3.5	12.5	3.0			
Tarboo Creek	**07/29/2003**	9	0.9	ND	9	4.6	1	0.3	
Thorndyke Creek	**07/29/2003**	15.6		SG, sa, S-4.2*	11.4	8.7	1.8		
Chimacum EF	**07/29/2003**	12.2	0.4	G, silt, OD*	12.2	0.0	0.25		
Chimacum WF	**07/29/2003**	11		MG	11	0.2			
Chimacum park 1	**07/29/2003**	19.1	0.1	MG, bar-3.3	19.1	0.0	1.6		
Chimacum park 2	**07/29/2003**	12		MG	12	6.5	1.2	0.25	
Chimacum Mouth	**07/29/2003**	19.6	0.8	S-.8, LG	18.8	12.2	1	0.8	
Big Quilcene	**07/29/2003**	54.6	0		37.6	37.6			
Big Quilcene	**07/29/2003**	38.9	0		21.8	21.8	1.5		
**minus boulder									
***minus gravel bar									
		* indicates mixed substrate, are using the whole width							

WRIA 17 wetted perimeter		Crew: Hegy, LaRoche			Date: Sept 5, 2003			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**09/05/2003**	13.6	0.2	silt-1.8	11.8	0.0		
Salmon Cr B	**09/05/2003**	13.6	0	G	13.6	0.0		
Salmon Cr C	**09/05/2003**	18	0	G, silt-5.4	7.2	9.4		
Leland Creek A	**09/05/2003**	14.1	0	LC	14.1	0.0	0.60	
Little Quil above conf B**	**09/05/2003**	24.6	0	B-1.9	24.6	7.7	2.00	
Little Quil Center Rd Bridge	**09/05/2003**	29.8	0.4	C	29.8	8.5		
Little Quil Center Rd Bridge	**09/05/2003**	37.7	0	C, S-2	35.7	6.7	0.70	0.30
Tarboo Creek	**09/05/2003**	16.6	0.8	MG, S	12.8	1.8		
Tarboo Creek	**09/05/2003**	8.7	0.9	S-1.6	7.1	2.4	0.95	0.28
Thorndyke Creek	**09/05/2003**	14.7	0	Org 4.8	14.7	n/a	0.65	0.35
Chimacum EF	**09/05/2003**	11.2	0.4	G, silt, OD	11.2	0.0	1.10	
Chimacum WF	**09/05/2003**	11.1	0	MG	11.1	0.0	1.65	
Chimacum park 1	**09/05/2003**	18.2	0	MG	18.2	0.0	1.50	
Chimacum park 2	**09/05/2003**	11.6	0	MG	11.6	6.5	1.20	0.25
Chimacum Mouth	**09/05/2003**	19.2	0.7	S, LG	19.2	10.4		0.70

*****may not be accurate
**minus boulder
***minus gravel bar

WRIA 17 wetted perimeter		Crew: Beecher, Hegy			Date: Oct 20 2003			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**10/20/2003**	15.8			15.8	13.2		
Salmon Cr B	**10/20/2003**	18.8				12.3		
Salmon Cr C	**10/20/2003**	21.1		silt-3.8	17.3	15.5		
Leland Creek A	**10/20/2003**	16.5			16.5	11.8	1.10	
Little Quil above conf B**	**10/20/2003**	37E			37	37.0		
Little Quil Bridge A	**10/20/2003**	43E			43	43.0	2.20	
Little Quil Bridge B	**10/20/2003**	40.6			40.6	40.6	2.00	0.30
Tarboo Creek	**10/20/2003**	26.3	1.6		26.3	15.3		
Tarboo Creek	**10/20/2003**	14.1	0.5		14.1	9.5	1.70	0.28
Thorndyke Creek	**10/20/2003**	25.8			25.8	22.7	2.80	1.00
Chimacum EF	**10/20/2003**	12.3			12.3	7.8	1.40	
Chimacum WF	**10/20/2003**	13.3			13.3	10.6	1.85	0.30
Chimacum park 1	**10/20/2003**	23.1			23.1	2.1	1.95	0.40
Chimacum park 2	**10/20/2003**	16.2			16.2	8.7		0.50
Chimacum Mouth	**10/20/2003**	28.9	0.7		28.9	27.9	2.30	1.60

WRIA 17 wetted perimeter:		Crew: Hegy, LaRoche			Date: Oct 29, 2003			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**10/29/2003**	14.6			14.6	7.3		
Salmon Cr B	**10/29/2003**	14.6			14.6	0.0		
Salmon Cr C	**10/29/2003**	19.4		silt-3.8	15.6	12.2		
Leland Creek A	**10/29/2003**	16.5			16.5	3.5	0.90	
Little Quil above conf B	**10/29/2003**	26.8			26.8	15.6	2.20	
Little Quil Bridge A	**10/29/2003**	32.3	0.2		32.3	13.3	1.20	
Little Quil Bridge B	**10/29/2003**	37.5			37.5	17.7		0.60
Tarboo Creek	**10/29/2003**	23.2		mud-2.5	20.7	7.3		
Tarboo Creek	**10/29/2003**	9.4			9.4	1.6	1.00	0.45
Thorndyke Creek	**10/29/2003**	16.7			16.7	10.1	2.10	0.60
Chimacum EF	**10/29/2003**	12.5	0.4		12.5	11.6	1.50	
Chimacum WF	**10/29/2003**	13.5	0.5		13.5	10.4	1.90	0.35
Chimacum park 1	**10/29/2003**	22.9			22.9	0.0	1.90	0.40
Chimacum park 2	**10/29/2003**	18.8			18.8	10.7		0.65
Chimacum Mouth	**10/29/2003**	26.2	0.4		26.2	14.6	1.25	0.45

WRIA 17 wetted perimeter:		Crew: Hegy, LaRoche			Date: Nov. 26, 2003			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**11/26/2003**	14.7		-1.9	12.8	5.5		
Salmon Cr B	**11/26/2003**	15.6			15.6	0.7		
Salmon Cr C	**11/26/2003**	19.2		-10.7	8.5	9.5		
Leland Creek A	**11/26/2003**	17.3			17.3	12.5	not done	
Little Quil above conf	**11/26/2003**	27.4		-1.7	25.7	19.2	2.10	
Little Quil Bridge 1	**11/26/2003**	35.4		-3.2	32.2	23.3	1.30	
Little Quil Bridge 2	**11/26/2003**	38.5			38.5	24.6	1.20	none
Tarboo Creek								
Tarboo Creek								
Thorndyke Creek								
Chimacum EF	**11/26/2003**	12.0	0.2		12.0	11.7	1.60	
Chimacum WF	**11/26/2003**	13.9			13.9	3.8	2.10	0.70
Chimacum park 1	**11/26/2003**	23.6			23.6	4.1	1.75	0.60
Chimacum park 2	**11/26/2003**	20.7	0.3		20.7	15.7	2.30	none
Chimacum Mouth	**11/26/2003**	27.7	0.4		27.7	15.3	1.50	1.00

WRIA 17 wetted perimeter:		Crew: Hegy, T. Hicks			Date: Dec 16, 2003			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**12/16/2003**	15.7		-2.2	13.5	11.2		
Salmon Cr B	**12/16/2003**	21.4			21.4	5.2		
Salmon Cr C	**12/16/2003**	21.2	0.3	-5.2	16	14.7		
Leland Creek A	**12/16/2003**	19			19	16.8	1.40	
Little Quil above conf	**12/16/2003**	33.3			33.3		nd	
Little Quil Bridge 1	**12/16/2003**	42.8			42.8		1.50	
Little Quil Bridge 2	**12/16/2003**	39.8	0.2		39.8		1.50	
Tarboo Creek	**12/16/2003**	26.9	1.8	(muck 3.6)	26.9	14.2		
Tarboo Creek	**12/16/2003**	14.5	0.5		14.5	8.5	1.15	
Thorndyke Creek	**12/16/2003**	19.9	0.3		19.9	16.0	2.30	
Chimacum EF	**12/16/2003**	12.7	0.4		12.7	11.9	nd	
Chimacum WF	**12/16/2003**	14			14	0.9	2.00	
Chimacum park 1	**12/16/2003**	22.6	0.2		22.6	2.0	1.20	
Chimacum park 2	**12/16/2003**	20.1			20.1	15.8	nd	1.20
Chimacum Mouth	**12/16/2003**	gage covered by tide; did not do					nd	

WRIA 17 wetted perimeter:		Crew: Hegy, LaRoche			Date: Jan 15, 2004			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**01/15/2004**	15.8	0.2	-2.2	13.6	12.8		
Salmon Cr B	**01/15/2004**	21.6			21.6	9.5		
Salmon Cr C	**01/15/2004**	21.4	0.5	-5.2	16.2	13.5		
Leland Creek A	**01/15/2004**	19.2			19.2	4.9		
Little Quil above conf	**01/15/2004**	32.5			32.5	25.7	2.90	
Little Quil Bridge 1		nd						
Little Quil Bridge 2		nd						
Tarboo Creek								
Tarboo Creek								
Thorndyke Creek								
Chimacum EF								
Chimacum WF								
Chimacum park 1								
Chimacum park 2								
Chimacum Mouth	**01/15/2004**	27.8	0.3		27.8	16.0	2.00	

WRIA 17 wetted perimeter:		Crew: Hegy, LaRoche			Date: Jan 15, 2004			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**01/15/2004**	15.8	0.2	-2.2	13.6	12.8		
Salmon Cr B	**01/15/2004**	21.6			21.6	9.5		
Salmon Cr C	**01/15/2004**	21.4	0.5	-5.2	16.2	13.5		
Leland Creek A	**01/15/2004**	19.2			19.2	4.9		
Little Quil above conf	**01/15/2004**	32.5			32.5	25.7	2.90	
Little Quil Bridge 1		nd						
Little Quil Bridge 2		nd						
Tarboo Creek								
Tarboo Creek								
Thorndyke Creek								
Chimacum EF								
Chimacum WF								
Chimacum park 1								
Chimacum park 2								
Chimacum Mouth	**01/15/2004**	27.8	0.3		27.8	16.0	2.00	

WRIA 17 wetted perimeter:		Crew: Hegy, LaRoche			Date: Feb 25, 2004			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**02/25/2004**	13			13	11.5		
Salmon Cr B	**02/25/2004**	21.6			21.6	6.8		
Salmon Cr C	**02/25/2004**	21.1	0	-6.4	21.1	13.4		
Leland Creek A	**02/25/2004**	19.3			19.3	15.1	2.20	
Little Quil above conf	**02/25/2004**	31			31	24.4	2.80	
Little Quil Bridge 1	**02/25/2004**	43	0.3		43	27.7	1.50	
Little Quil Bridge 2	**02/25/2004**	39.7			39.7	37.7		
Tarboo Creek	**02/25/2004**	19.6	1		19.6	12.5	0.90	
Tarboo Creek	**02/25/2004**	12	1		12	6.6		
Thorndyke Creek	**02/25/2004**	18.6			18.6	12.8		
Chimacum EF	**02/25/2004**	12.2	0.1		12.2	10.1		
Chimacum WF	**02/25/2004**	13.5	0		13.5	5.2	2.00	
Chimacum park 1	**02/25/2004**	23.7	0.2		23.7	1.5	2.10	
Chimacum park 2	**02/25/2004**	19.8			19.8	15.6	2.00	
Chimacum Mouth	**02/25/2004**	27.8	1.1		27.8	15.6	2.00	

WRIA 17 wetted perimeter:		Crew: Hegy, LaRoche, Pacheco, Ensenat				Date: Mar 30, 2004		
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**03/30/2004**							
Salmon Cr B	**03/30/2004**							
Salmon Cr C	**03/30/2004**							
Leland Creek A	**03/30/2004**							
Little Quil above conf	**03/30/2004**							
Little Quil Bridge 1	**03/30/2004**							
Little Quil Bridge 2	**03/30/2004**							
Tarboo Creek	**03/30/2004**	20.5	0.5		20.5	12.8	1.10	
Tarboo Creek	**03/30/2004**	11			11	4.0		
Thorndyke Creek	**03/30/2004**							
Chimacum EF	**03/30/2004**	12.3	0.3		12.3	10.1	1.20	
Chimacum WF	**03/30/2004**	14.5	0.5		14.5	10.3	2.20	
Chimacum park 1	**03/30/2004**	23.5	0.1		23.5	3.6	2.20	
Chimacum park 2	**03/30/2004**	20.1			20.1	17.1	2.10	
Chimacum Mouth	**03/30/2004**	28.5	0.9		28.5	16.5	2.10	

WRIA 17 wetted perimeter:		Crew: Hegy, LaRoche			Date: April 27, 2004			
			Width with		Width with		Max pool	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**04/27/2004**							
Salmon Cr B	**04/27/2004**							
Salmon Cr C	**04/27/2004**							
Leland Creek A	**04/27/2004**							
Little Quil above conf	**04/27/2004**							
Little Quil Bridge 1	**04/27/2004**							
Little Quil Bridge 2	**04/27/2004**							
Tarboo Creek	**04/27/2004**	17.4			17.4	0.0		
Tarboo Creek	**04/27/2004**	8.6	0.3		8.6	0.0	0.70	0.35
Thorndyke Creek	**04/27/2004**	15	1.5		15	8.3		
Chimacum EF	**04/27/2004**							
Chimacum WF	**04/27/2004**							
Chimacum park 1	**04/27/2004**							
Chimacum park 2	**04/27/2004**							
Chimacum Mouth	**04/27/2004**							

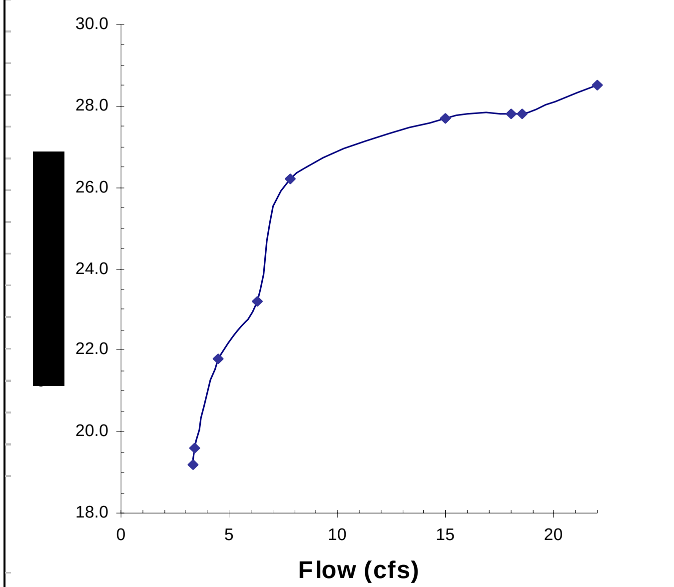
WRIA 17 wetted perimeter:		Crew: Hegy, Boessow			Date: July 13, 2004				
			Width with		Width with		Max pool		
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*	
Salmon Cr A	**07/13/2004**	14.5			14.5	3.9			
Salmon Cr B	**07/13/2004**	nd							
Salmon Cr C	**07/13/2004**	nd							
Leland Creek A	**07/13/2004**	17.3			17.3	0.6			
Little Quil above conf *	**07/13/2004**	27.5			27.5	16.3			
Little Quil Bridge 1**	**07/13/2004**	32	0.2		32	15.6	1.00		"+/- 1"
Little Quil Bridge 2	**07/13/2004**	37.9			37.9	20.2			"+/- 1"
Tarboo Creek	**07/13/2004**	nd							
Tarboo Creek	**07/13/2004**	nd							
Thorndyke Creek	**07/13/2004**	nd							
Chimacum EF	**07/13/2004**	nd							
Chimacum WF	**07/13/2004**	nd							
Chimacum park 1	**07/13/2004**	23.4			23.4	0.0			
Chimacum park 2	**07/13/2004**	13.6			13.6	7.7			
Chimacum Mouth	**07/13/2004**	nd							
*minus boulder									
**minus gravel bar									

WRIA 17 wetted perimeter:		Crew: Hegy, Schrader			Date: 9/28/04			
			Width with		*Width with*		*Max pool*	
Site	*Date*	*Total width*	*cover (U/C)*	*Substrate*	*spawning hab*	*Width >.5*	*D nearby*	*Max riffle D*
Salmon Cr A	**09/28/2004**							
Salmon Cr B	**09/28/2004**							
Salmon Cr C	**09/28/2004**							
Leland Creek A	**09/28/2004**							
Little Quil above conf *	**09/28/2004**							
Little Quil Bridge 1**	**09/28/2004**							
Little Quil Bridge 2	**09/28/2004**							
Tarboo Creek	**09/28/2004**							
Tarboo Creek	**09/28/2004**							
Thorndyke Creek	**09/28/2004**							
Chimacum EF	**09/28/2004**	12.3	0.2	silt	12.3	3.1		
Chimacum WF	**09/28/2004**	12.8	0.7	gravel	12.8	6.7		
Chimacum park 1	**09/28/2004**	22.5			22.5	0.0		
Chimacum park 2	**09/28/2004**	17.2		med-LG	17.2	9.4		
Chimacum Mouth	**09/28/2004**	23.2		med-LG	23.2	13.5		

Appendix B. Wetted Width Graphs (selected)

Chimacum Creek nr mouth --Flow vs. Wetted Width

gage nr. Mouth, RM .1



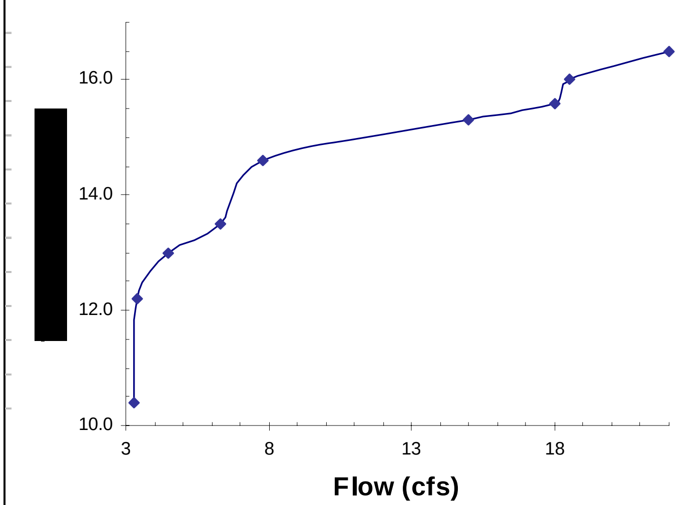
date	cfs*	Wetted width
9/5/03	3.3	19.2
7/29/03	3.4	19.6
7/7/03	4.5	21.8
9/28/04	6.3	23.2
10/29/03	7.8	26.2
11/26/03	15	27.7
2/25/04	18	27.8
1/15/04	18.5	27.8
3/30/04	22	28.5

Flow from Ecology rating curve.

deleted 10-20-03 at high flow

Chimacum Creek nr mouth --Flow vs. Habitat Width

gage nr. Mouth, RM .1

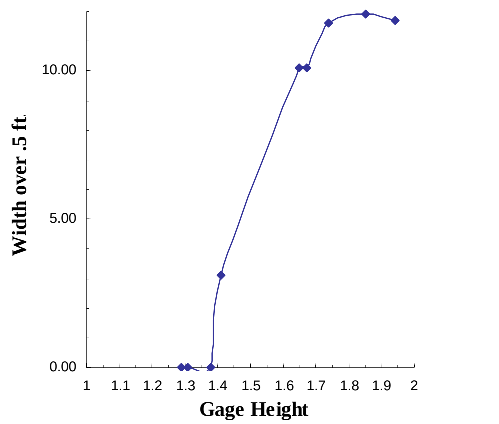


date	cfs	Width >=.5 ft.
9/5/03	3.3	10.4
7/29/03	3.4	12.2
7/7/03	4.5	13.0
9/28/04	6.3	13.5
10/29/03	7.8	14.6
11/26/03	15	15.3
2/25/04	18	15.6
1/15/04	18.5	16.0
3/30/04	22	16.5

Flow from Ecology rating curve.

Chimacum Creek, East Fork: Gage Ht. vs. Habitat Width

at wooden bridge, RM .2

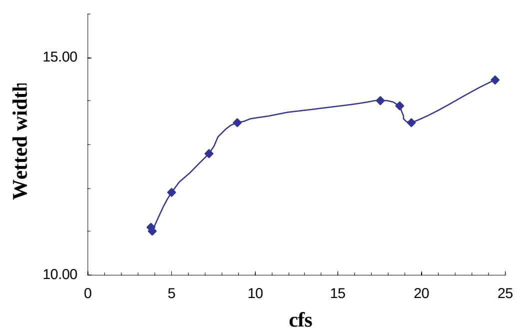


date	gage ht.	Width >=.5 ft.	
7/29/03	1.29	0.0	
9/5/03	1.31	0.0	indicates undercut bank?
7/7/03	1.38	0.0	
9/28/04	1.41	3.1	
2/25/04	1.65	10.1	
3/30/04	1.67	10.1	
10/29/03	1.74	11.6	
12/16/03	1.85	11.9	
11/26/03	1.94	11.7	indicates overhanging bank?

Data point from 10/20/03 not used because flows had been very high that day and it appears that the bed had been lowered due to scouring.

Inflection point at 1.74 which equates to ~2 cfs.

Chimacum Creek,West Fork: Synthesized flow vs. Wetted Width



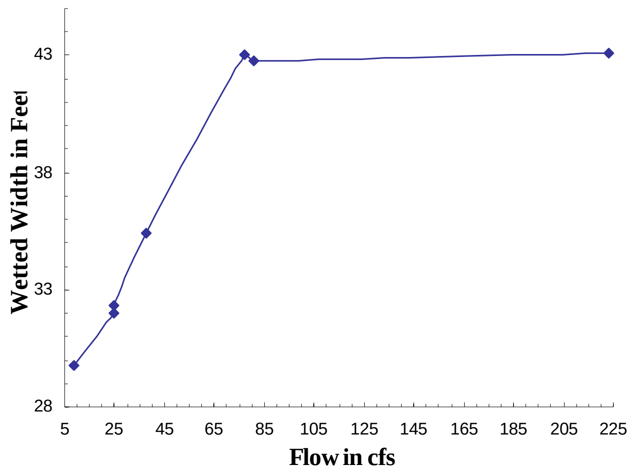
date	gauge ht.	cfs*	Wetted width
9/5/03	1.03	3.75	11.1
7/29/03	1.04	3.86	11.0
7/7/03	1.1	5.02	11.9
9/28/04	1.35	7.26	12.8
10/29/03	1.28	8.94	13.5
12/16/03	1.5	17.55	14.0
11/26/03	1.45	18.68	13.9
2/25/04	1.58	19.35	13.5
3/30/04	1.65	24.41	14.5
10/20/03	1.3		13.3

Appeared to be a lot of change in the channel at times, esp. in amounts of gravel.

*estimated using Jefferson Co. Conservation District flow measurements and gage at mouth of Chimacum.

Inflection point ~9 cfs.

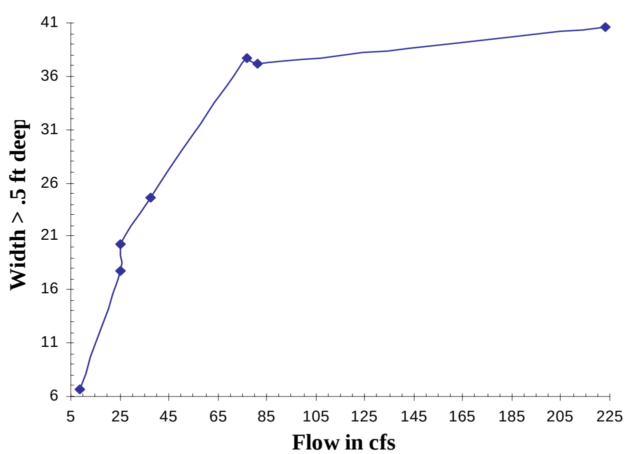
Little Quilcene Transect 1 at Bridge: Wetted Width vs Flow



gage ht.	cfs	Wetted Width (feet)	date
2.83	8.79	29.8	9/5/03
3.13	25	32.0	7/13/04
3.13	25	32.3	10/29/03
3.26	37.5	35.4	11/26/03
3.49	76.9	43.0	2/25/04
3.49	81.1	42.8	12/16/03
5.69	223	43.1	10/20/03

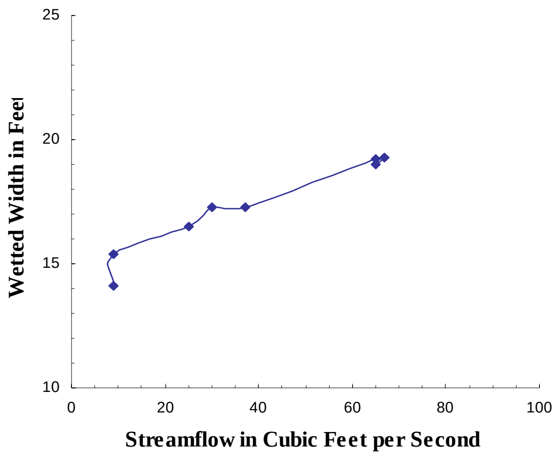
Little Quilcene Transect 2 at Bridge: Habitat Width vs Flow

by red ball swing



gage ht.	cfs	Width where depth => .5 ft	date
2.83	8.79	6.7	9/5/03
3.13	25	17.7	10/29/03
3.13	25	20.2	7/13/04
3.26	37.5	24.6	11/26/03
3.49	76.9	37.7	2/25/04
3.49	81.1	37.2	12/16/03
5.69	223	40.6	10/20/03

Leland Creek **(using Little Quilcene gauge)** **8/27/04**

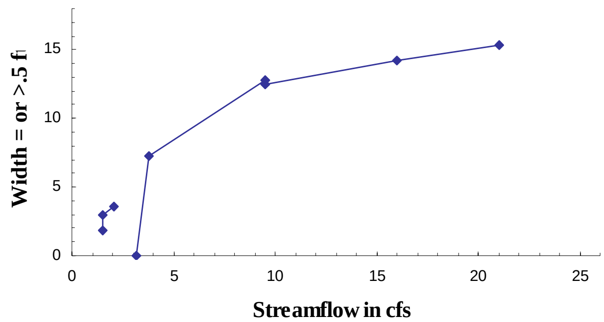


gauge	cfs	Wetted Width (feet)	date	water year
2.83	8.93	14.1	9/5/03	0.03
2.9	8.94	15.4	7/29/03	0.03
3.13	25.00	16.5	10/29/03	.04a
3.18	30.00	17.3	7/13/04	.04a
3.26	37.00	17.3	11/26/03	.04a
3.48	65.00	19.2	1/15/04	.04a
3.48	65.00	19.0	12/16/03	.04a
3.49	67.00	19.3	2/25/04	.04a

discarded 7/7/03;and 10/20/03 high flows

Tarboo Creek, Trans. A: Width over .5' vs. Flow

01/04/2005



gage ht.	cfs	Width of rearing habitat	date
1.16	1.5	1.8	7/29/03
1.16	1.5	3.0	9/5/03
1.18	2.1	3.6	7/7/03
1.01	3.2	0.0	4/27/04
1.24	3.8	7.3	10/29/03
1.22	9.5	12.8	3/30/04
1.22	9.5	12.5	2/25/04
1.35	16	14.2	12/16/03
1.58	21	15.3	10/20/03

Ecology data on flow provisional & subject to change.
Data spans 2 water years;each shown separately.
Inflection point between 5 and 10 cfs.

Appendix C. Final State Flow Recommendations

Joint Flows proposed by Dept. of Ecology and Fish & Wildlife
Quilcene-Snow Watershed Planning based on wetted width and toe width
Dec. 8, 2004

	Thorndyke	Tarboo	Salmon	Snow*	Big Quilcene	Little Quilcene	Chimacum
Jan	24	20	21	35	120	61	25
Feb	24	20	21	35	120	61	25
Mar	45	25	40	50	190	100	46
Apr	45	16	35	50	190	100	46
May	30	8	26	50	190	92	32
June	30	8	26	35	190	66	10
July	12	8	9	17	190	66	10
Aug	12	8	9	15	167	27	10
Sept	12	8	9	20	94	30	12
Oct	12	8	12	35	180	48	20
Nov	24	20	21	35	120	61	25
Dec	24	20	21	35	120	61	25

*Snow Creek had a PHABSIM study done by WDFW which was also used.