Modeling and Forecasting Working Group

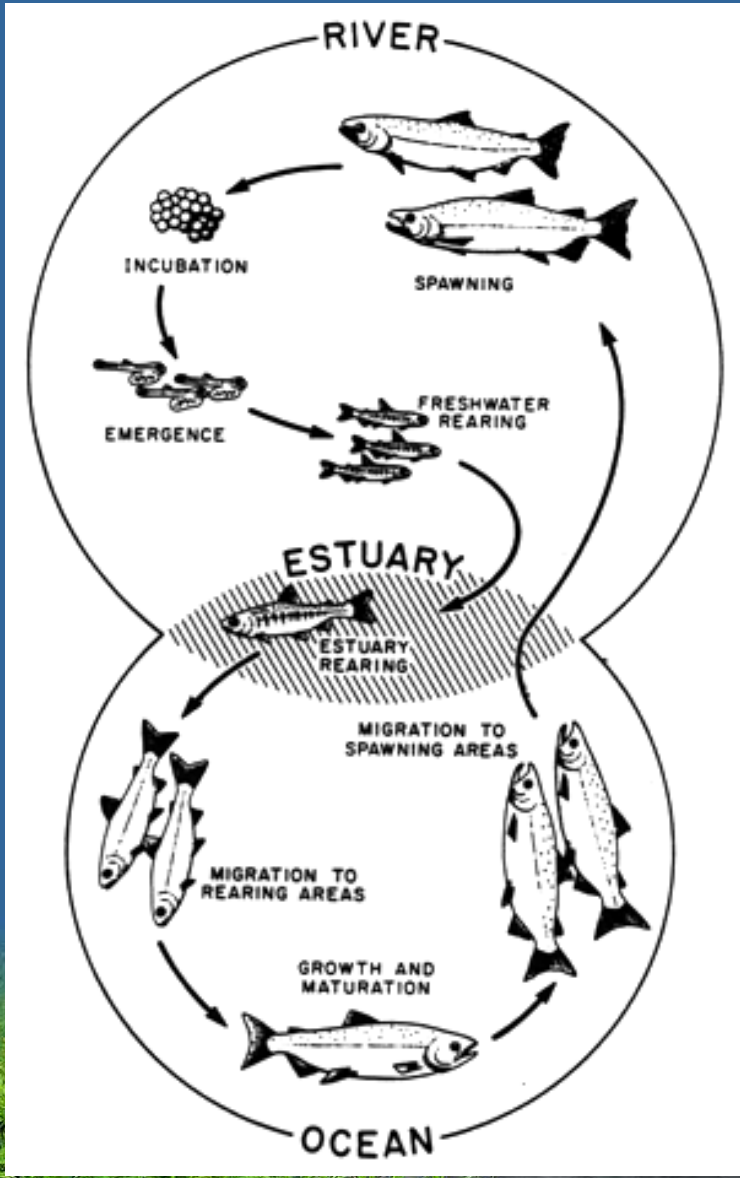
Bypass Flows for Fish

December 3, 2014

Overview

- Salmonid Life Cycles
- Salmonid Habitat
- Development of Predictive Flow-Habitat Models
- Use of Flow-Habitat Models to Set and Evaluate Bypass Flow Proposals

Salmonid Lifecycle



Life Stage Timing

Life Stage	Timing
Adult Migration	Dec-Apr (steelhead) Dec-Jan (coho) after flow threshold
Spawning	Dec-Apr (steelhead) Dec- Jan (coho) after migration event
Incubation	Dec-May For a few weeks following spawning
Rearing	1-3 years (steelhead) 1.5 years (coho) year round
Smolt Migration	Mar-June
Ocean Maturation	1-3 years (steelhead) 1.5 years (coho) year round

Habitat

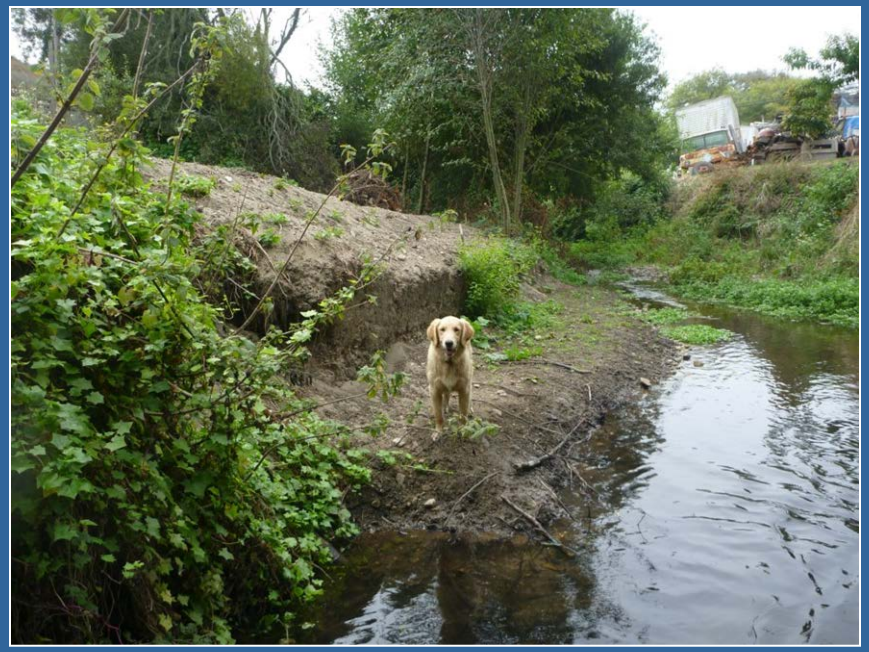
Habitat

Habitat

Habitat

Limiting Factors

- Altered flow
- Sedimentation
- Lack of large instream wood
- Water quality
- Altered lagoon habitat
- Anthropogenic riparian disturbance
- Ocean conditions
- Climate change



Riparian clearing/grading/dumping

Photo: Chris Berry

Flow = Habitat

City diversions may have substantial effects on local salmonid populations

How do diversions change habitat for steelhead and coho salmon?

Important Components of Habitat

- Cover
- Food
- Substrate
- Depth
- Flow Velocity

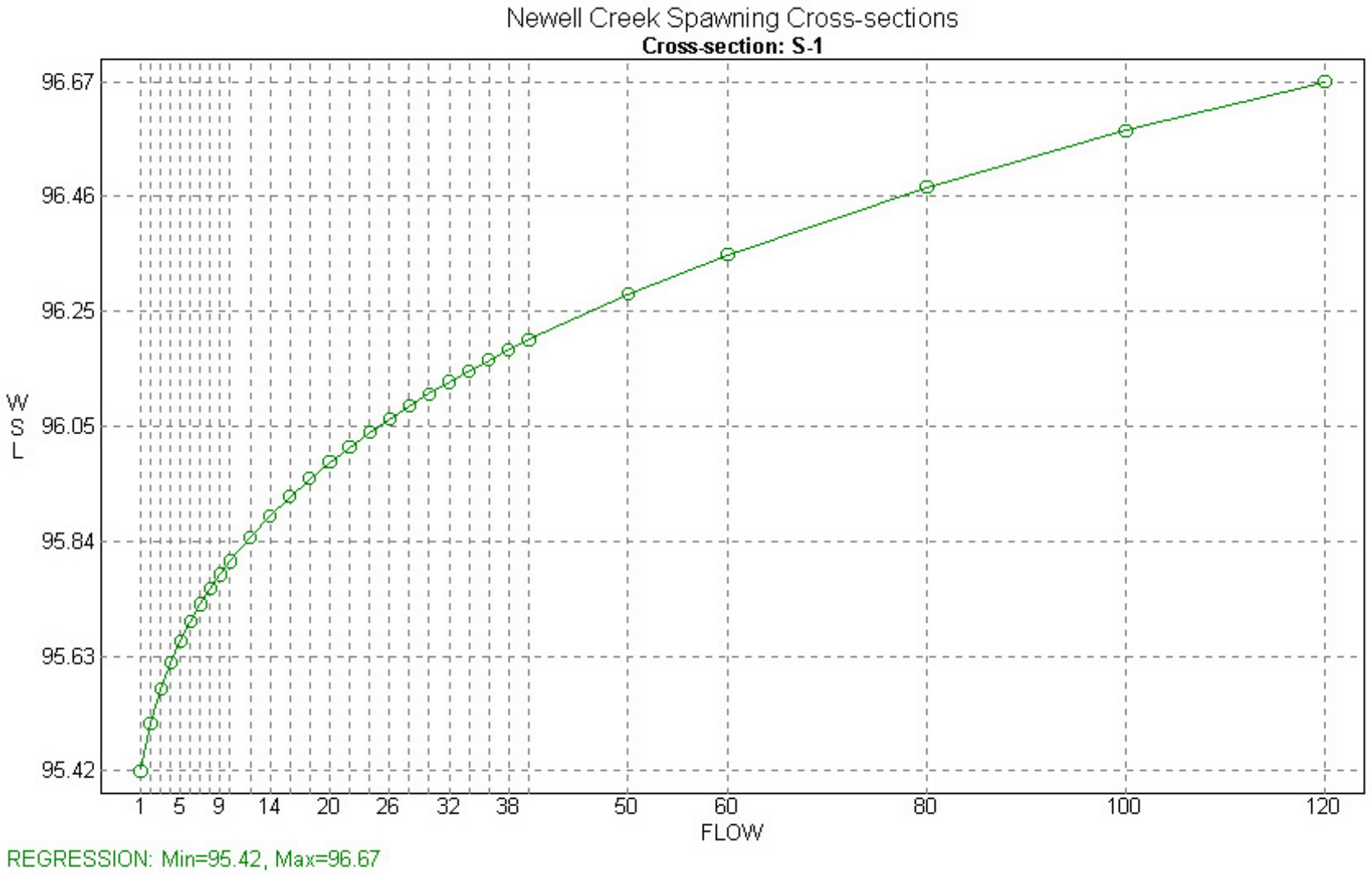
Physical Habitat Simulation (PHABSIM)

- Hydraulic Simulation
- Habitat Suitability Simulation

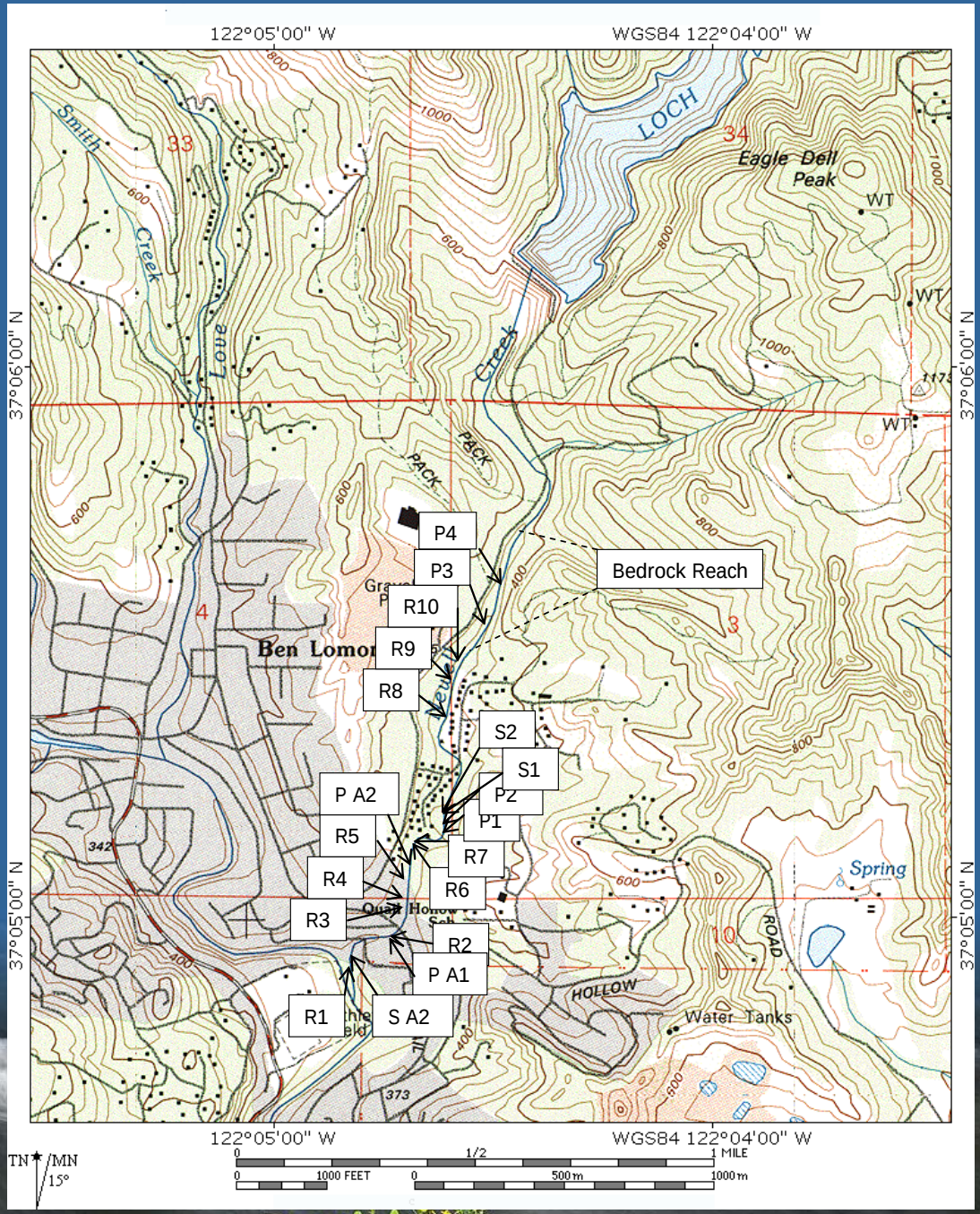
"Assessment of Streamflow Effects on Migration, Spawning, and Rearing Habitat for Anadromous Salmonids in Streams Influenced by City of Santa Cruz Water Diversions including Newell Creek"

Hagar Environmental Science 2014

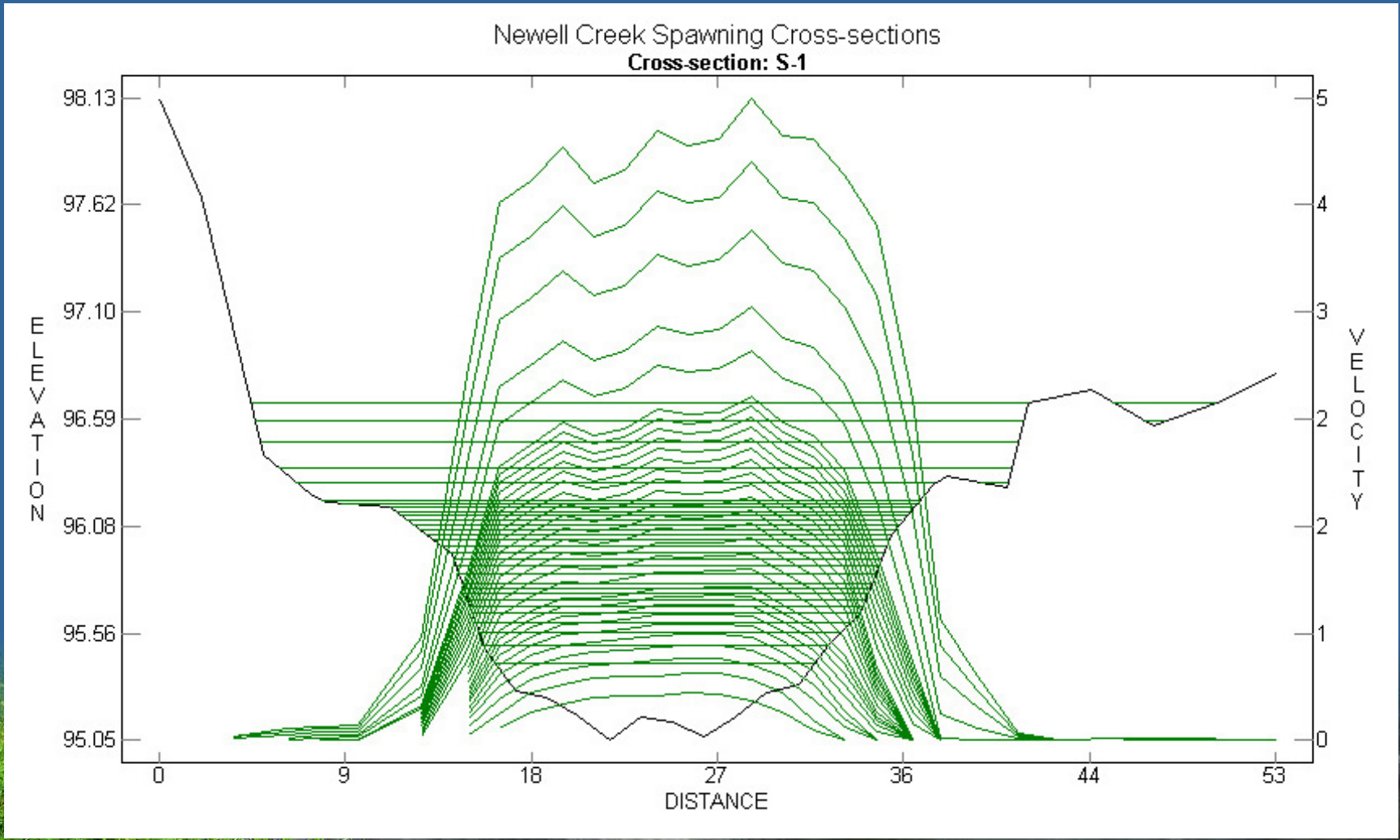
Rating Curve Site 1



PHABSIM
Study Sites
Newell Creek

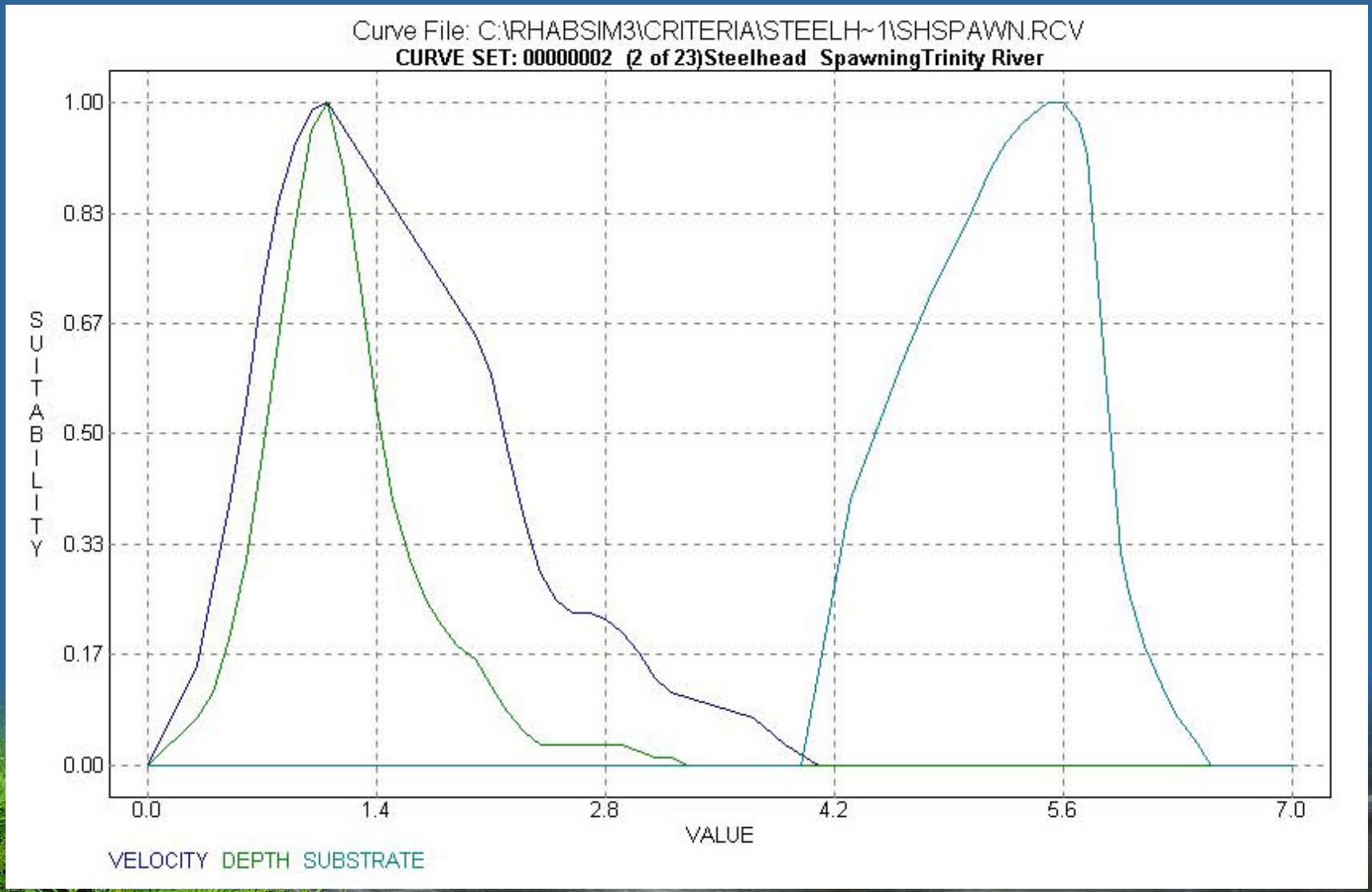


Hydraulic Simulation Site 1

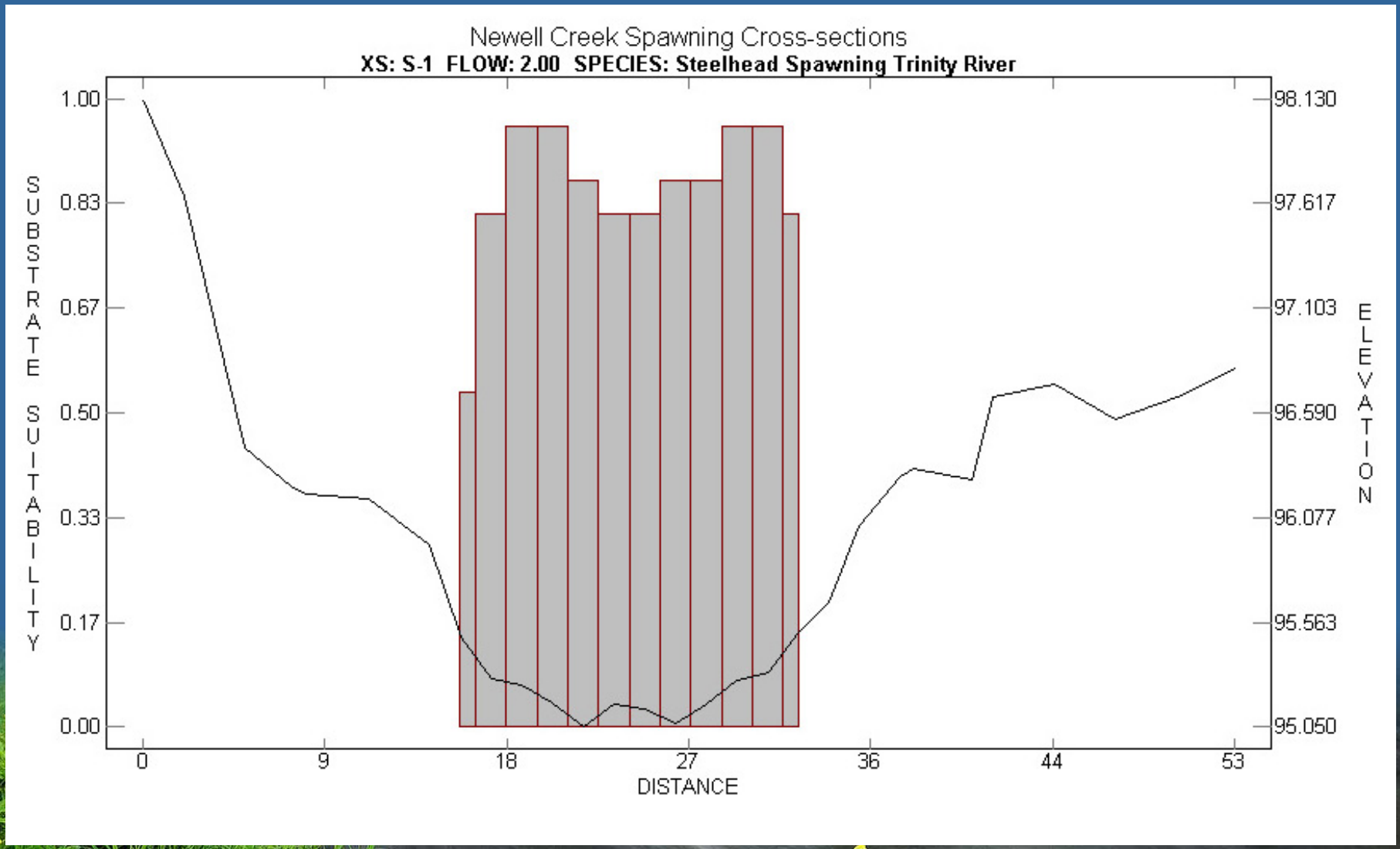


Habitat Suitability

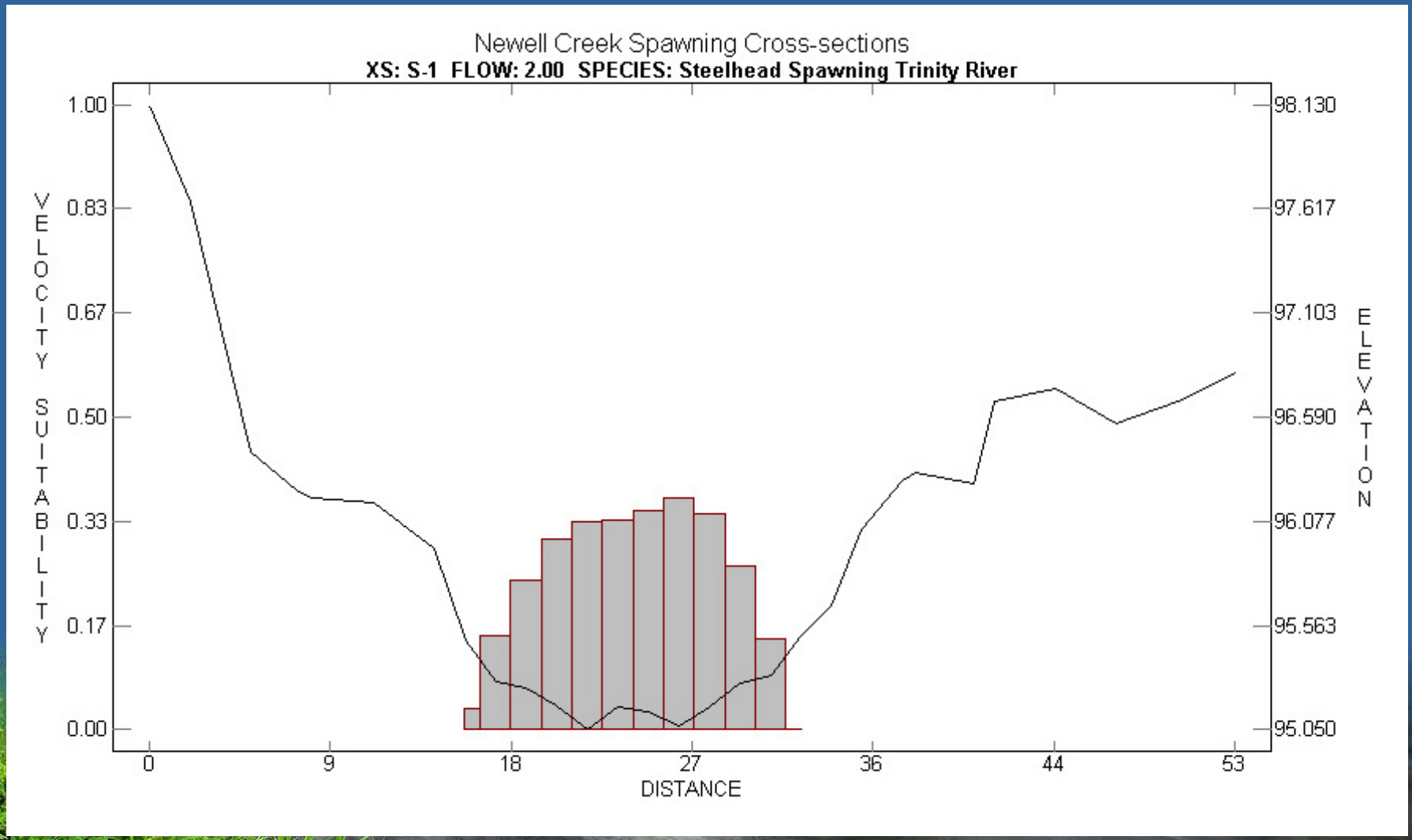
Spawning Steelhead



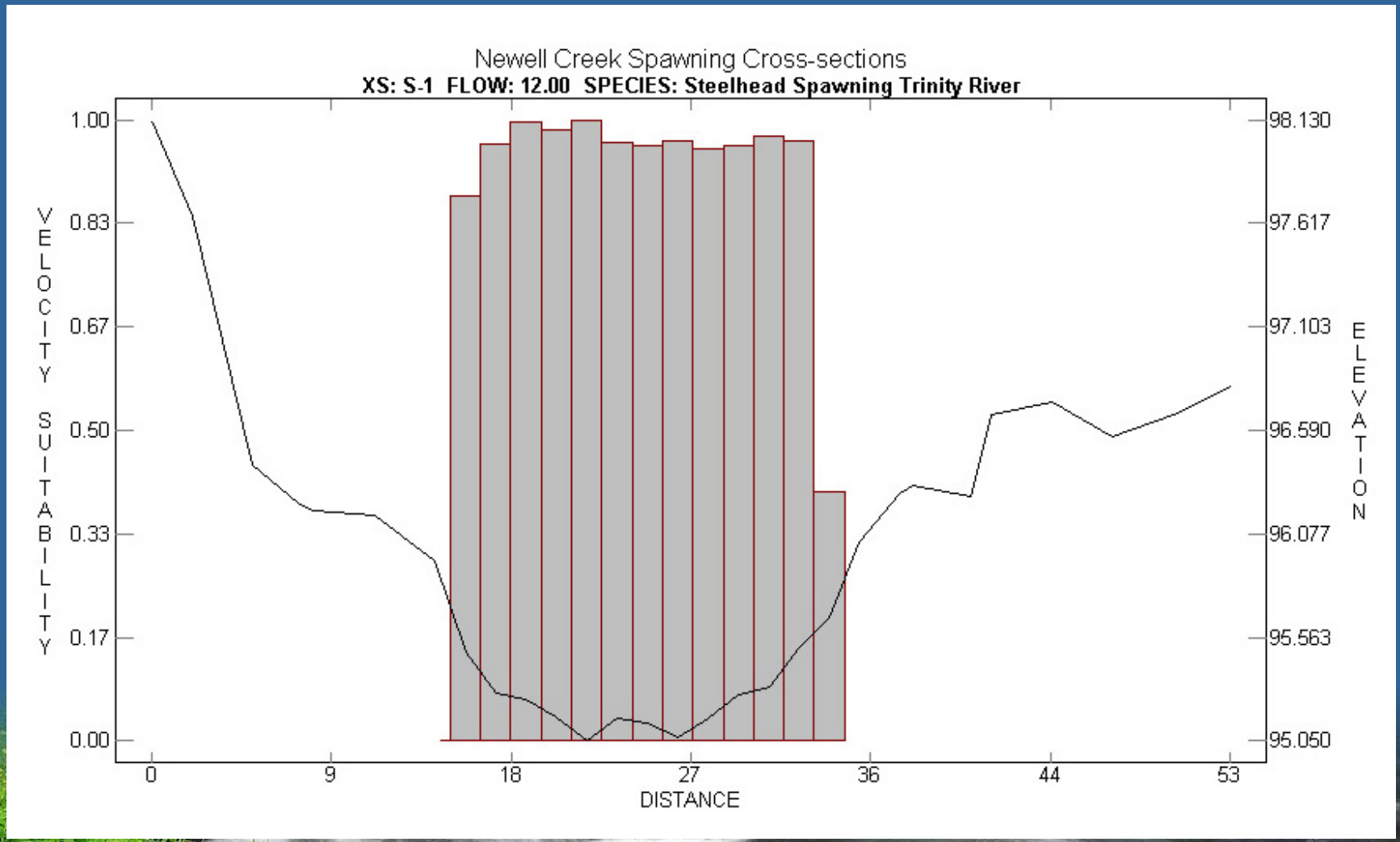
Substrate Suitability at Site 1



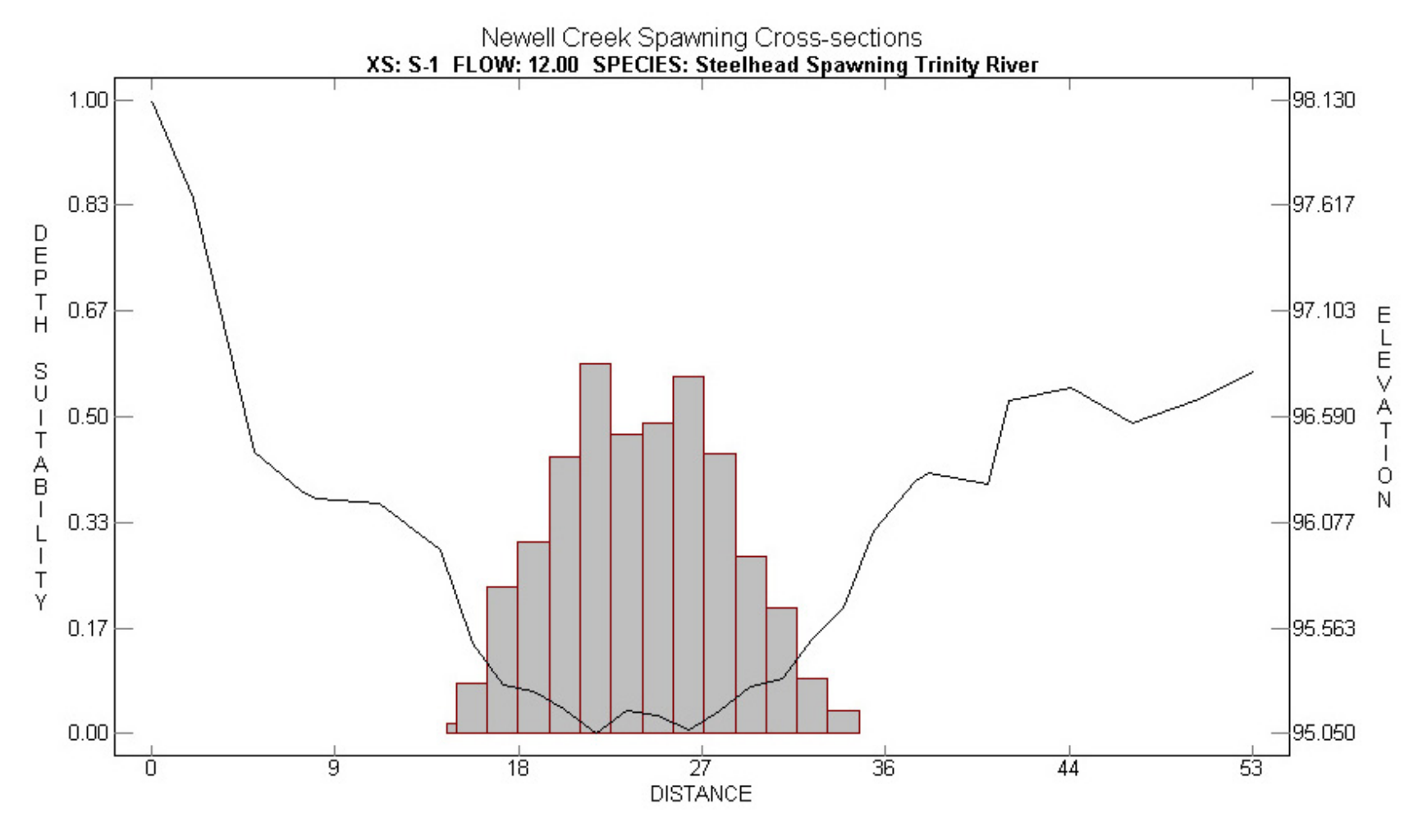
Velocity Suitability at Site 1
2 cfs



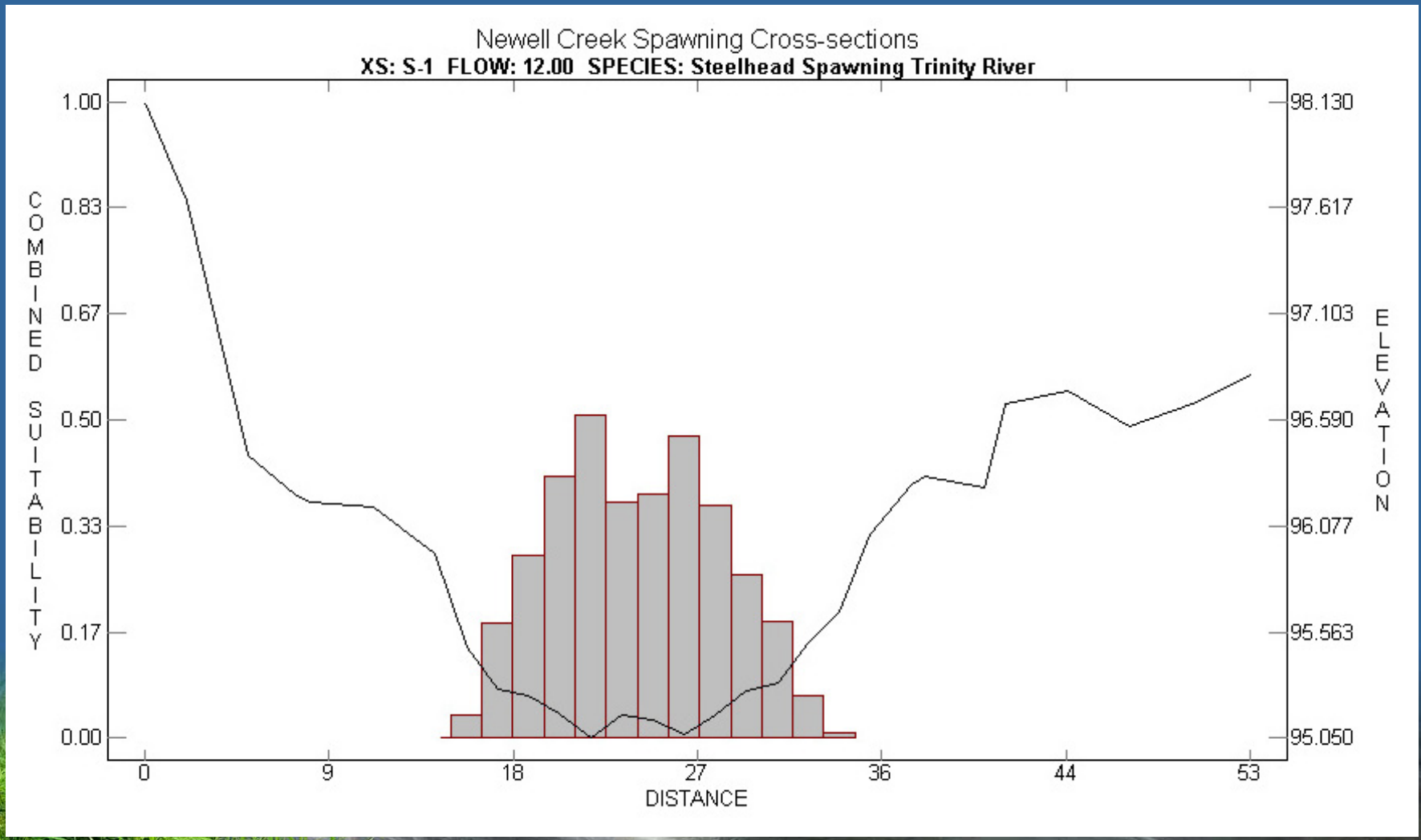
Velocity Suitability at Site 1
12 cfs



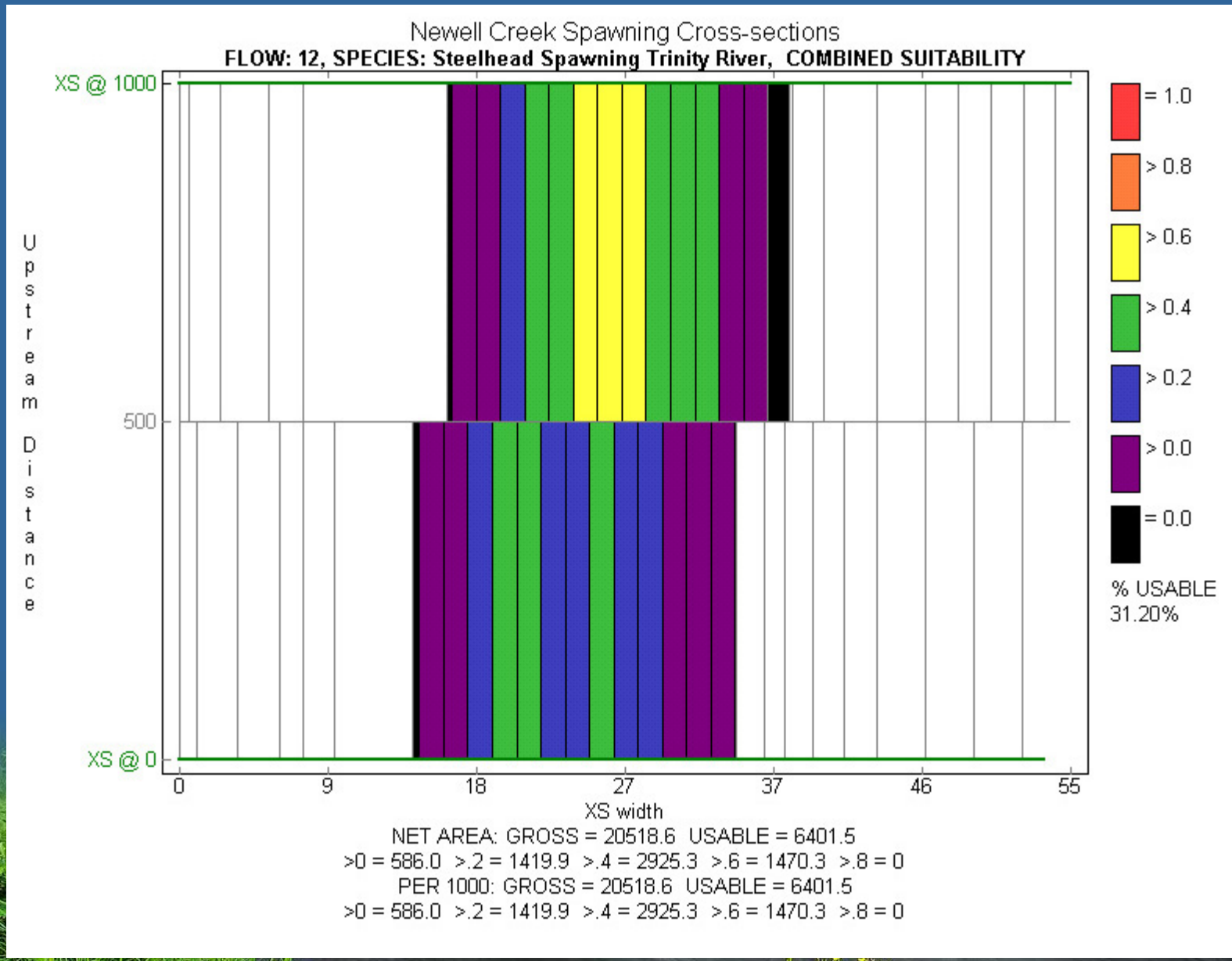
Depth Suitability at Site 1
12 cfs



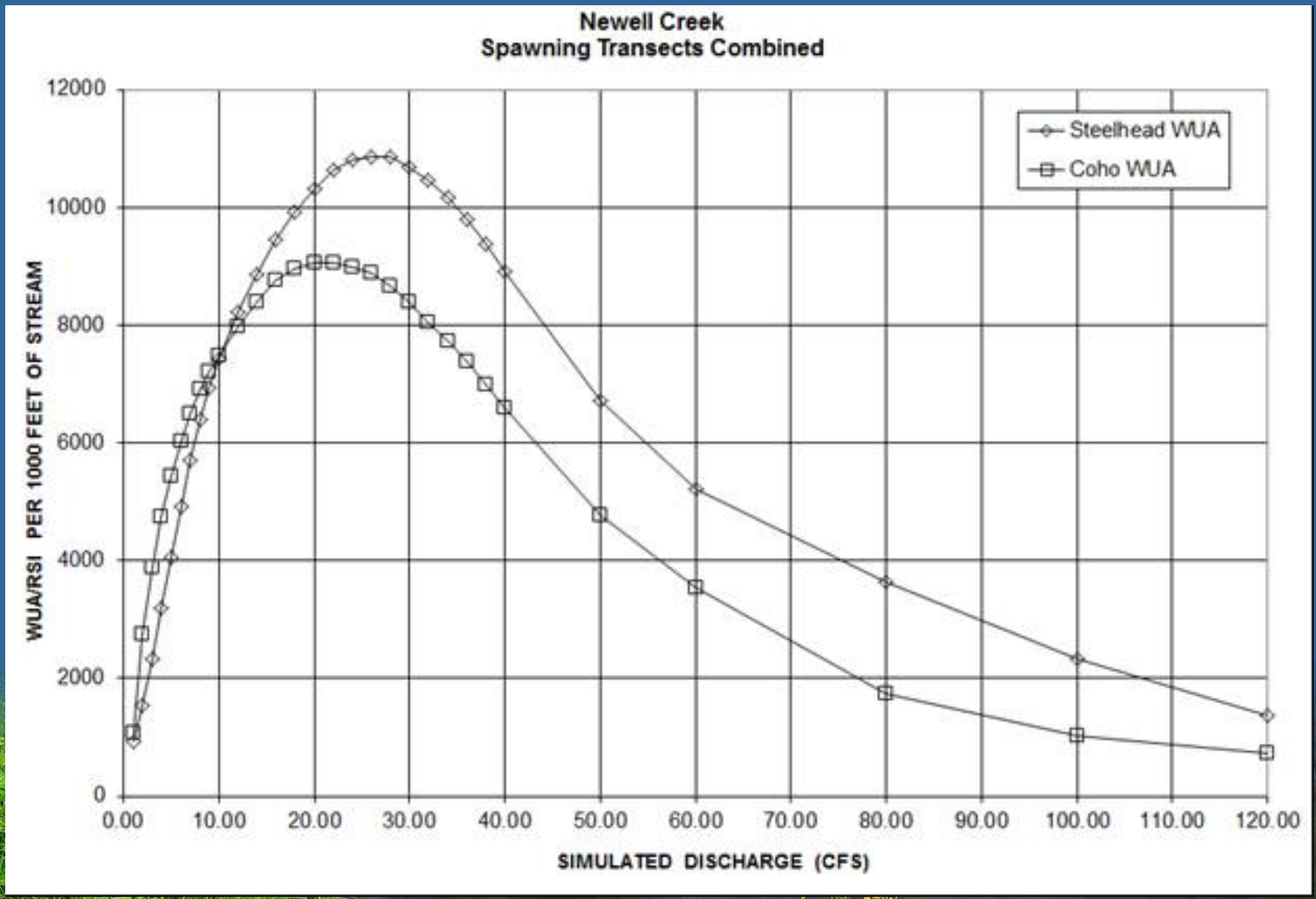
Combined Suitability at Site 1
12 cfs



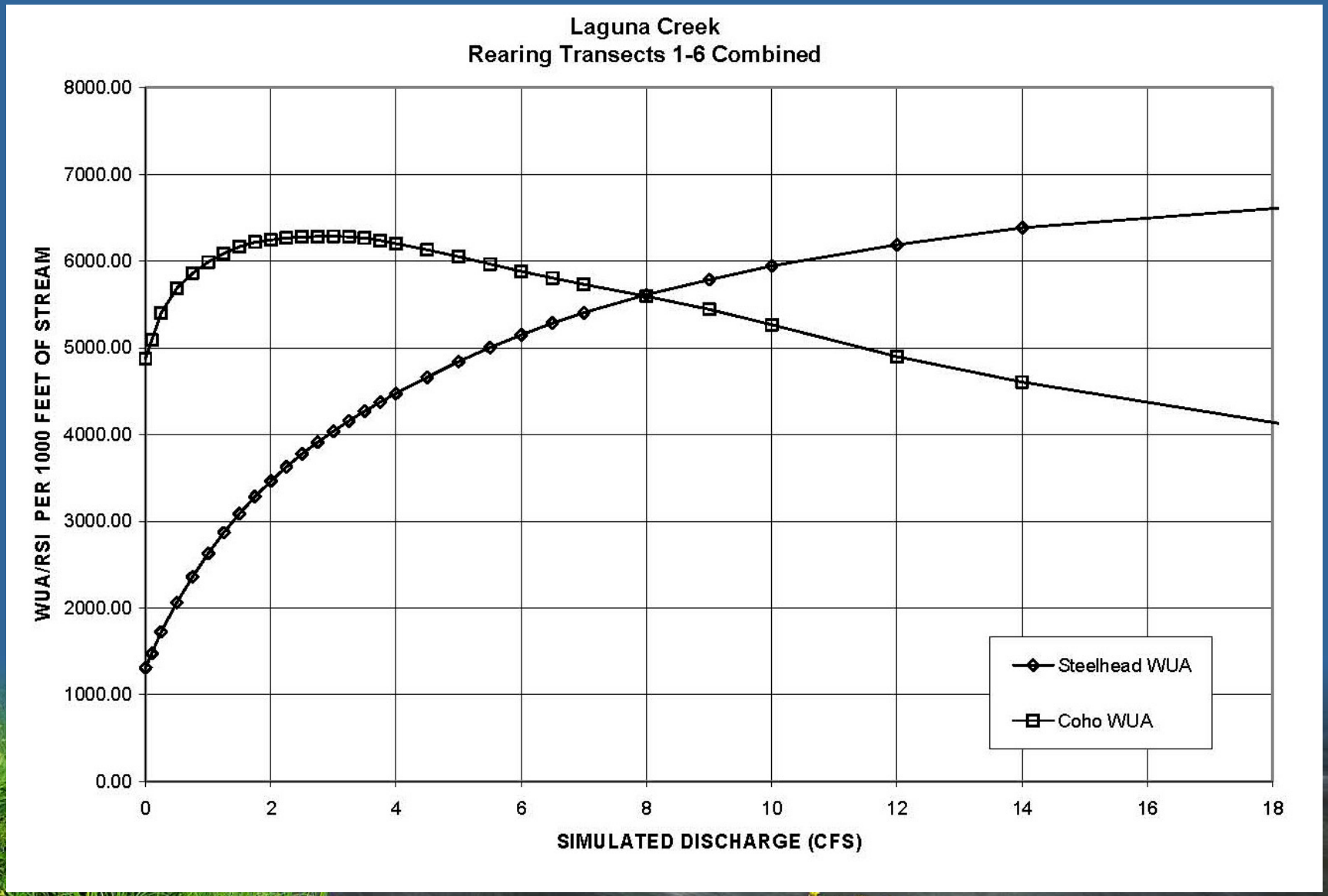
Suitability for Steelhead Spawning by Transect



Spawning Habitat Suitability As A Function of Flow



Rearing Habitat Suitability As A Function of Flow



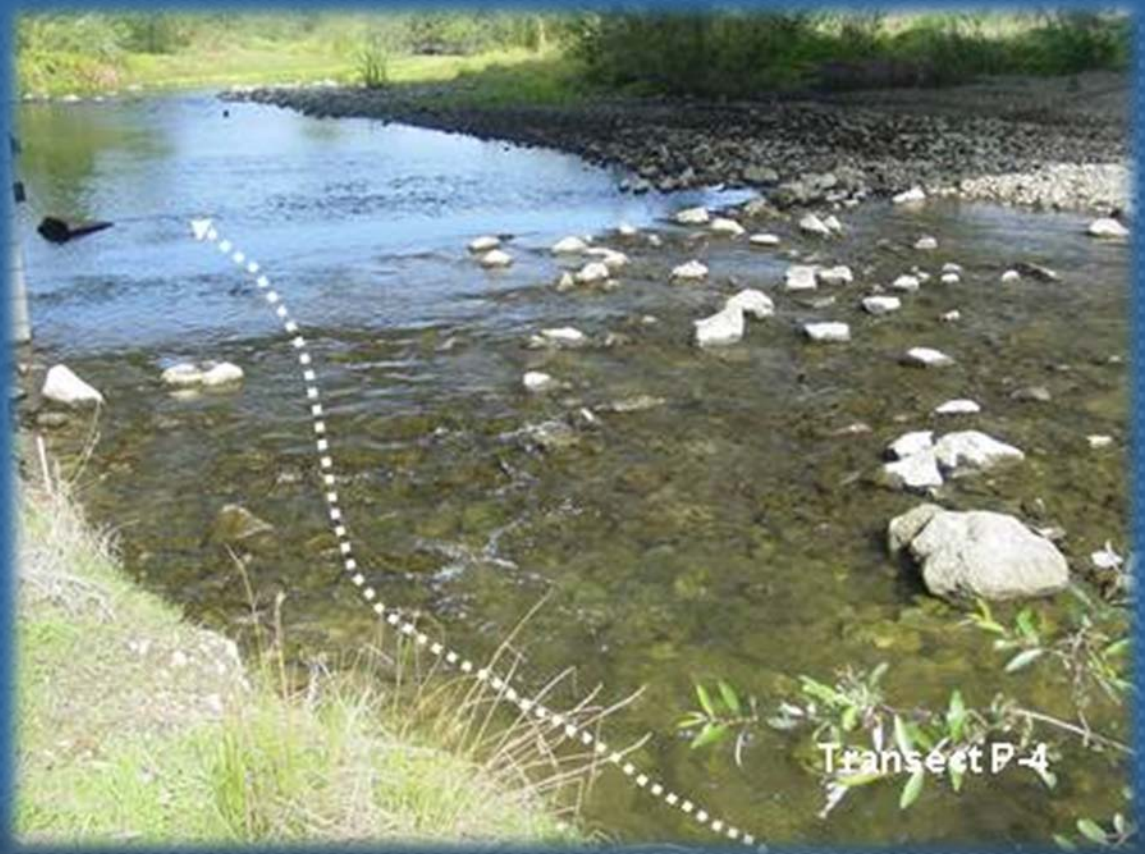
Passage at Critical Riffles

25% of cross-section => depth criterion

10% contiguous section => depth criterion

Criterion = 0.6 ft. for adults

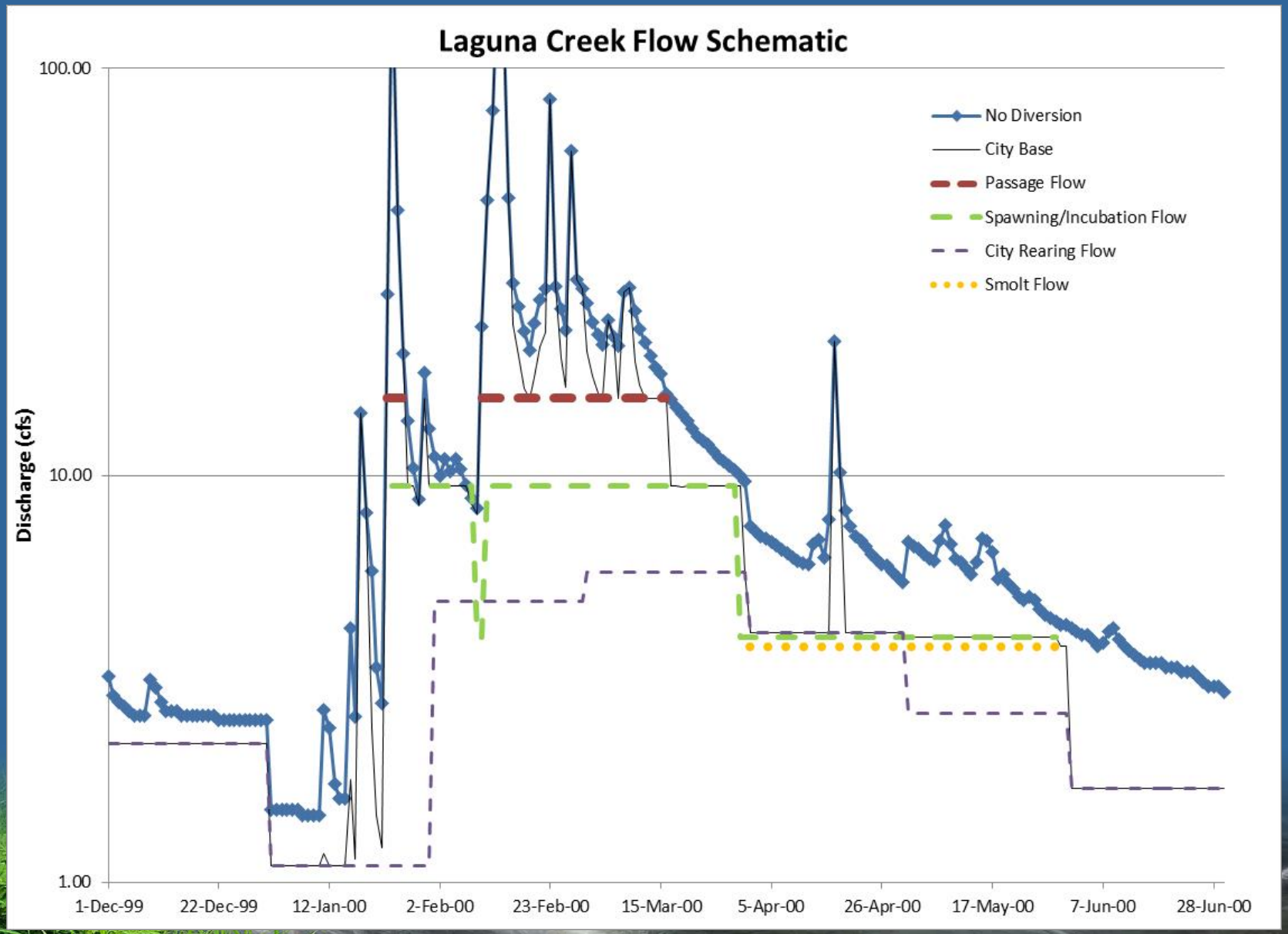
Criterion = 0.4 ft. for smolts

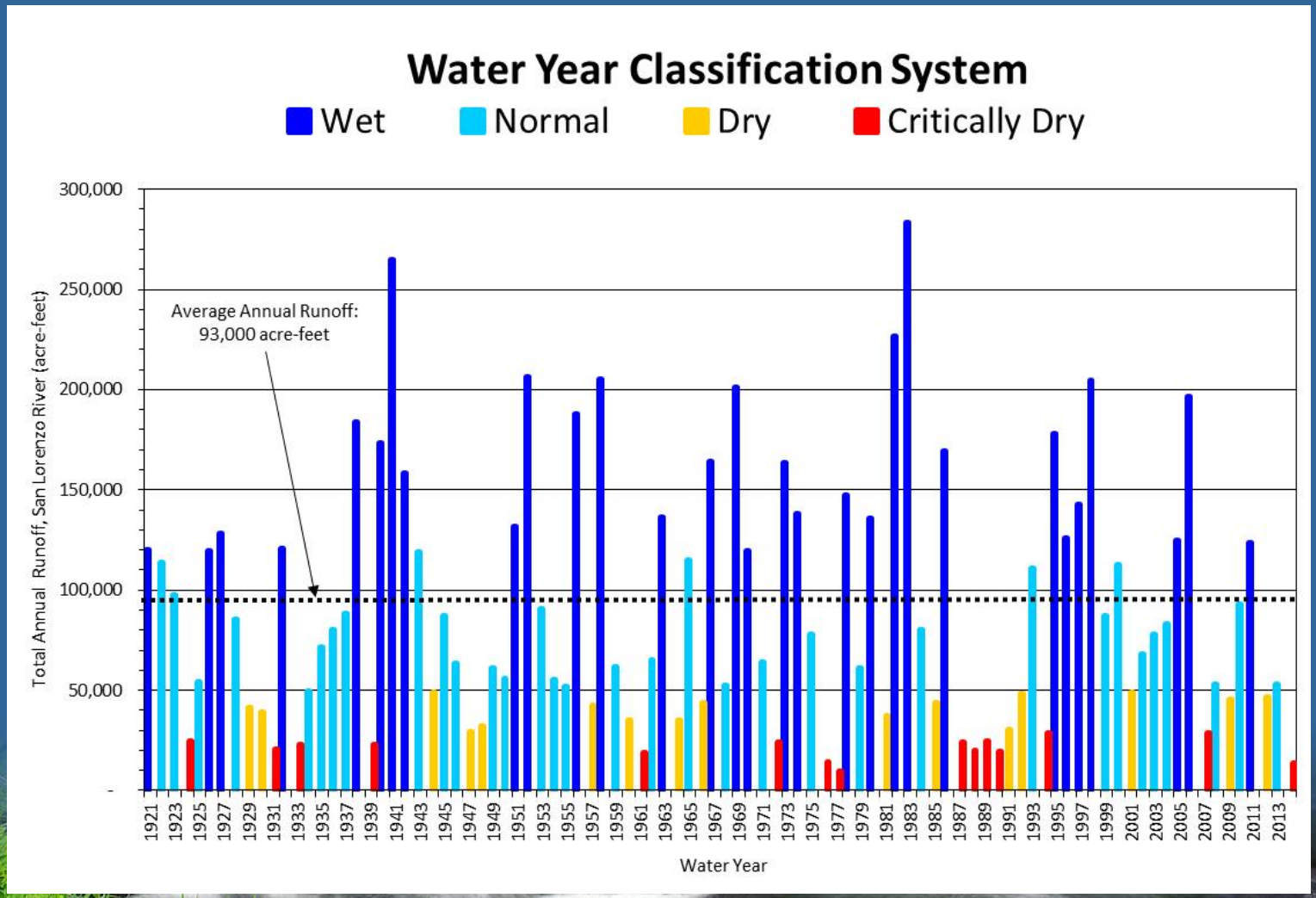


Developing Flow Targets

Lifestage	Timing	Flow Needed	
		San Lorenzo below Tait	Laguna
Adult Migration	Dec-Apr (steelhead) Dec-Jan (coho) after flow threshold	25	16
Spawning (Steelhead)	Dec-Apr for 14 days after migration	--	10-16
Spawning (coho)	Dec-Jan for 14 days after migration	--	6-12
Incubation	Dec-May for 60 days after spawning	--	4
Rearing (Steelhead)	1-3 years year round	8-19 (good) 19-45 (opt)	3-7 (good) 7-18+ (opt)
Rearing (coho)	1.5 years	1-20+ 5 (opt)	0.1-11 (good) 3 (opt)
Smolt Migration	Mar-June	10	4

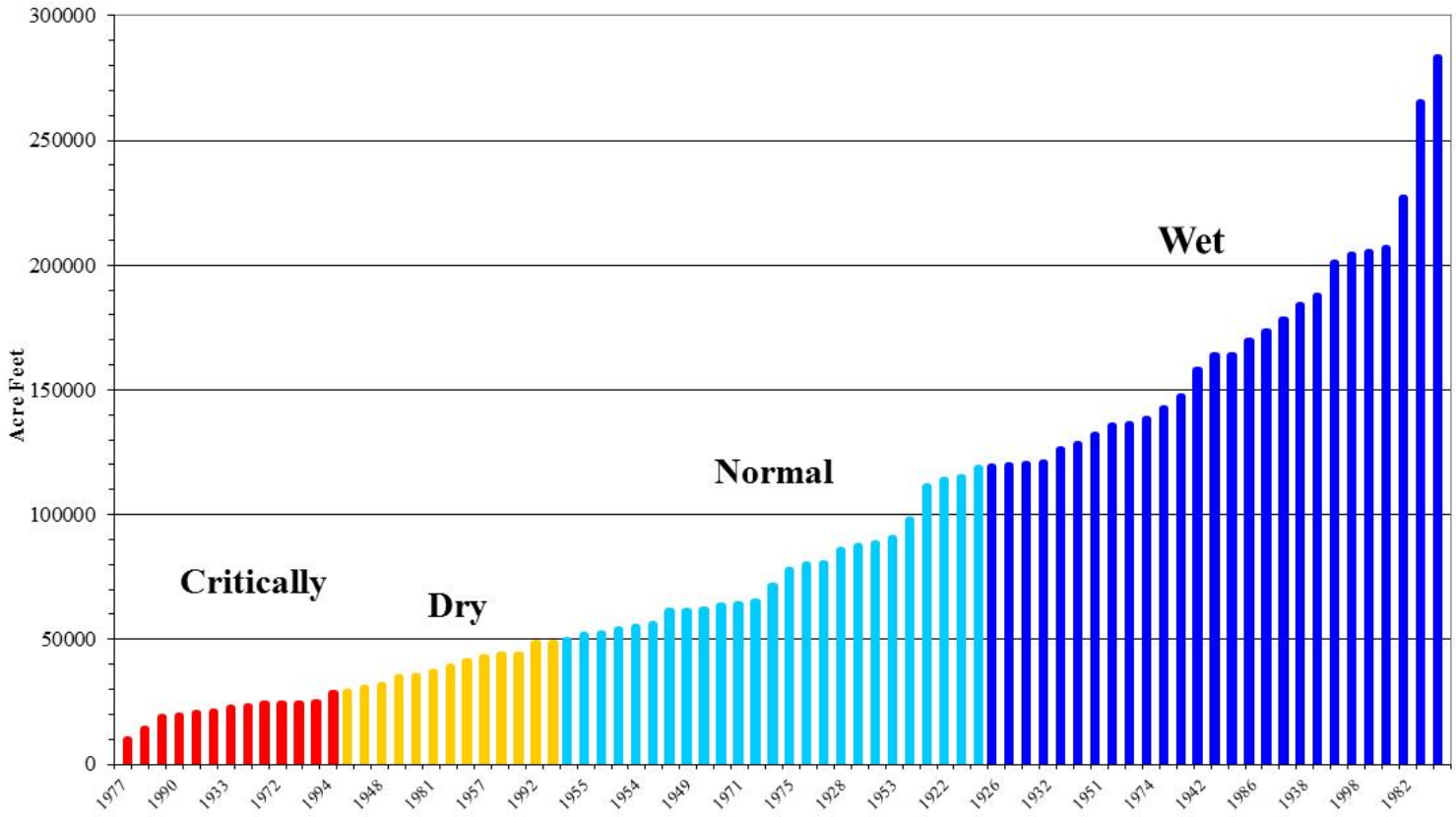
- Flow Bypass Targets set by month
  - Rearing- Year-round base flow set by month and year type
  - Adult Migration- triggered by flow exceeding minimum passage level, maintain at all times it would occur without City diversion
  - Spawning- initiated by migration event, ~80% of peak WUA for 2 weeks following last passage event
  - Incubation- initiated by spawning flows, maintain wetted channel at spawning sites for 60 days or end of incubation period
  - Smolt Migration- set level, April-May
- Daily Bypass Flow Target = Max (migration target, spawning target, incubation target, rearing target, smolt migration target)
- In supply modelling (Confluence) DBFT subtracted from flow available for diversion

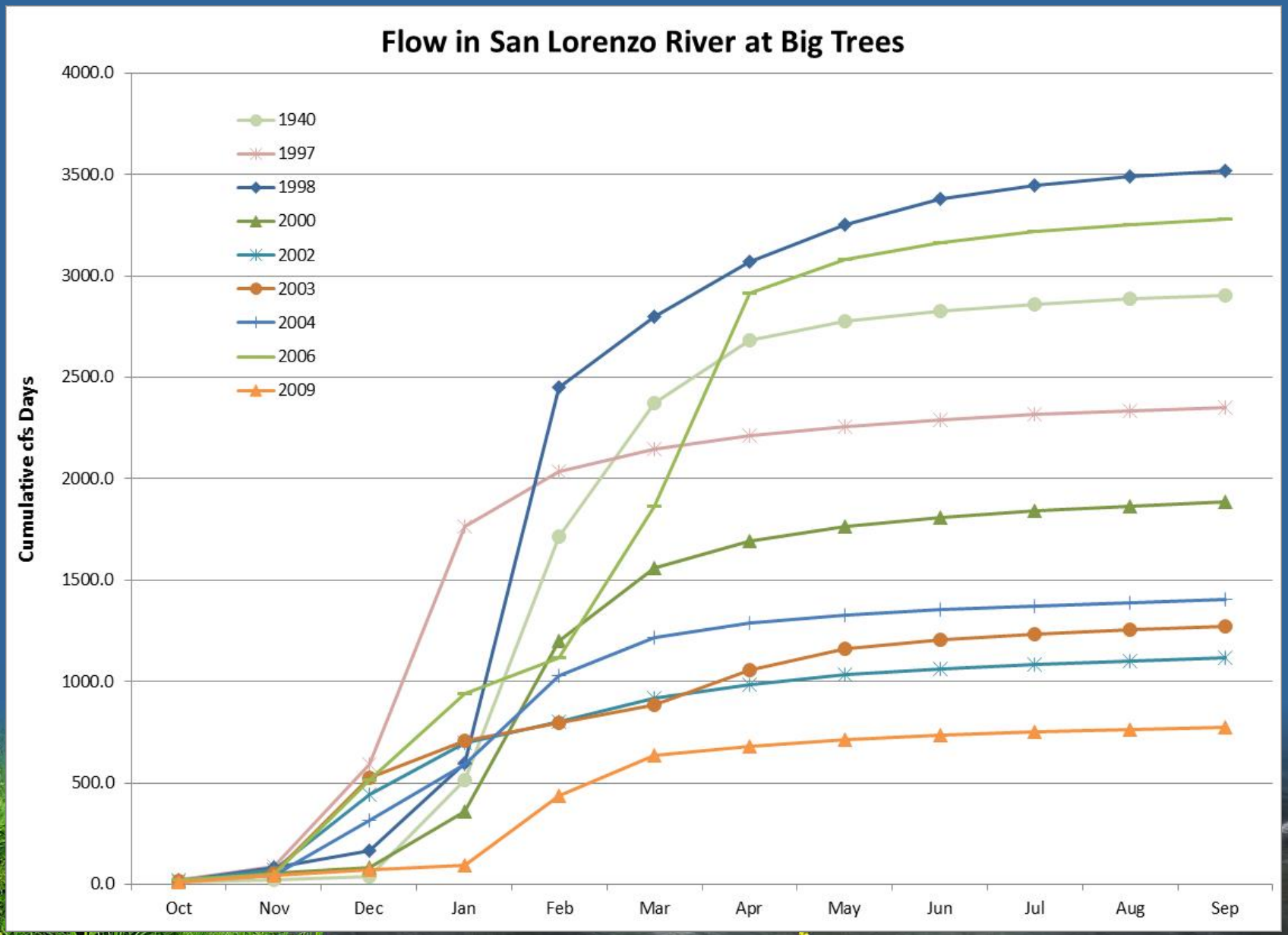

Laguna Creek Flow Schematic
100.00
10.00
1.00
Discharge (cfs)
No Diversion
City Base
Passage Flow
Spawning/Incubation Flow
City Rearing Flow
Smolt Flow
1-Dec-99
22-Dec-99
12-Jan-00
2-Feb-00
23-Feb-00
15-Mar-00
5-Apr-00
26-Apr-00
17-May-00
7-Jun-00
28-Jun-00


Water Year Classification System
Wet
Normal
Dry
Critically Dry
Average Annual Runoff:
93,000 acre-feet
Total Annual Runoff, San Lorenzo River (acre-feet)
300,000
250,000
200,000
150,000
100,000
50,000
-
1921
1923
1925
1927
1929
1931
1933
1935
1937
1939
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Water Year

Water Year Classification System

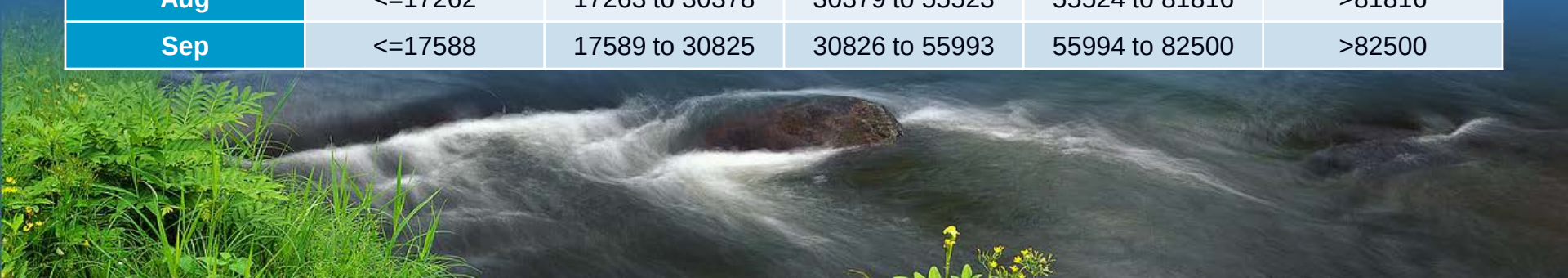
Based on San Lorenzo River Runoff




Flow in San Lorenzo River at Big Trees
Cumulative cfs Days
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
1940
1997
1998
2000
2002
2003
2004
2006
2009
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

End of Month Cumulative Water Year Flow (cfs) at San Lorenzo River Big Trees Gage (*source: Balance*)

	Exceedence Category Limits (End of Month Cumulative Daily Flow from October 1 in cfs)				
	Category 5 80-100 %	Category 4 60-80%	Category 3 40-60%	Category 2 20-40%	Category 1 0-20%
Oct	<=464	465 to 554	555 to 734	735 to 870	>870
Nov	<=1211	1212 to 1509	1510 to 1840	1841 to 2500	>2500
Dec	<=2490	2378 to 3246	3247 to 5652	5653 to 10245	>10245
Jan	<=4344	4345 to 8435	8436 to 18409	18410 to 29133	>29133
Feb	<=8592	8593 to 16755	16756 to 31476	31477 to 48944	>48944
Mar	<=12163	12164 to 24047	24048 to 42200	42201 to 58798	>58798
Apr	<=14005	14006 to 26559	26560 to 50534	50534 to 71427	>71427
May	<=15831	15832 to 28210	28211 to 52798	52799 to 76720	>76720
Jun	<=16509	16510 to 29115	29116 to 54151	54152 to 79275	>79275
Jul	<=16927	16928 to 29741	29742 to 54924	54925 to 80740	>80740
Aug	<=17262	17263 to 30378	30379 to 55523	55524 to 81816	>81816
Sep	<=17588	17589 to 30825	30826 to 55993	55994 to 82500	>82500



Flow Proposal – Laguna Creek

	Minimum Flow at Laguna Creek Anadromous Gage									
	Rearing Baseflow						Migration		Spawning	
	Exception Minimum	Exceedance Category 5 80-100%	Exceedance Category 4 60-80%	Exceedance Category 3 40-60%	Exceedance Category 2 20-40%	Exceedance Category 1 0-20%	Adult	Smolt Migration	Spawn	Incubate
Oct	0.4	0.6	0.7	1.2	1.4	1.7				
Nov	0.4	0.8	0.9	1.7	1.9	2.4				
Dec	0.6	0.9	1.1	2.2	2.8	4.5	15.5		9.4	4
Jan	0.6	1.1	1.4	3.7	4.8	6.5	15.5		9.4	4
Feb	0.9	1	1.9	4.9	5.8	6.5	15.5		9.4	4
Mar	1.2	1.1	2.1	4.5	5.8	6.5	15.5		9.4	4
Apr	0.4	1.2	2	2.8	4.1	6.3	15.5	3.8	9.4	4
May	0.4	0.8	1.7	2.6	3.5	4.9		3.8	9.4	4
Jun	0.3	0.6	1.1	1.7	2.4	3.5				
Jul	0.1	0.3	0.4	1	1.5	2.4				
Aug	0.1	0.2	0.3	0.8	1.1	1.7				
Sep	0.1	0.2	0.4	0.7	1	1.4				

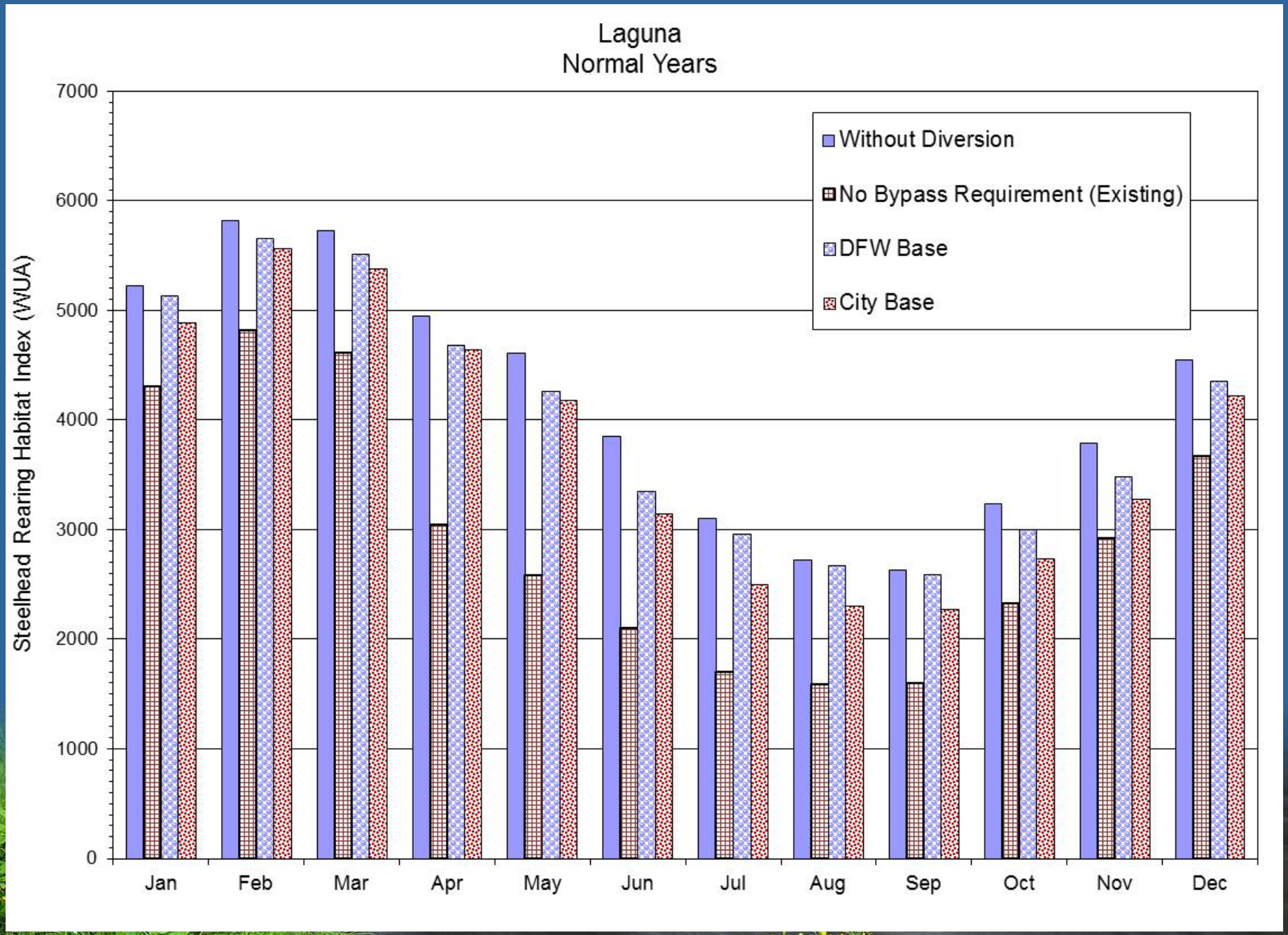
Flow Scenarios Evaluated

- Tier 1 - Existing Condition
- Tier 2 - Improved Habitat Conditions with more aggressive use of storage but compliance with supply shortage criteria
- Tier 3 – Approximately 80% of Optimum Habitat for all Life Stages
- Tier 2/3 Hybrid – Tier 3 in wetter years, Tier 2 in drier years
- City Proposal – Tier 2/3 Hybrid with Tier 1 in driest years (~5% of years)
- DFW 5 – Modifications to City Proposal for Additional Habitat Benefits

Comparison of City and DFW Proposals

Lifestage	City	DFW
Adult Migration	• Threshold is for most critical riffle • Not provided below Tait St in 60-100% Exceedance Years • Not provided in Majors or Liddell in December of 60-100% Exc. Yrs.	• Threshold is for least critical riffle • Always provided below Tait St • Not provided in Majors or Liddell in 60-100% Exc. Yrs.
Spawning	• Starts after 2 migration days	• Starts after 1 migration day
Rearing	• Minimum rearing flows 0.1-2.1 cfs in Laguna and 1-15 cfs below Tait in driest years/months • Minimum rearing flow 0.2 cfs in Liddell and 0.1 cfs in Majors in critically dry years	• Minimum of 2 cfs in Laguna and 8 cfs below Tait St. in driest years • Minimum rearing flow 0.25 cfs in Liddell and Majors in critically dry years
Smolt Migration	• Provided in April and May • Not provided in 60-100% exc. cond. in Laguna or 80-100% exc. cond. in San Lorenzo	• Provided January through May • Provided 3 days per week March-May in 80-100% exc. cond. in Laguna and San Lorenzo


Laguna Creek
Average During Potential Spawning Periods
Average of Spawning Habitat Index (WUA)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Without Diversion
No Bypass Requirement (Existing)
DFW Base
City Base
Wet
Normal
Dry
Critical


Laguna
Normal Years
Steelhead Rearing Habitat Index (WUA)
7000
6000
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Without Diversion
No Bypass Requirement (Existing)
DFW Base
City Base

What is Being Proposed as a Conservation Strategy?

- The Conservation Strategy is based on providing flows that will support the species within the practicability constraints of the City's water supply.
- The principal goal of the proposed flows is to minimize the potential effects of City activities on the species.
- Residual effects that could not be minimized would be offset through a mitigation fund that could be directed at species conservation actions.

Table 8-1. Definition of Viable Salmonid Population Attributes
Source: McElhany et al. 2000.

Attribute	Definition
Abundance	The average number of fish of any life stage in a given stream, watershed, or basin; the more fish in the population the lower the extinction risk. Abundance is determined by the amount (capacity) and quality (productivity) of the habitat present in the basin.
Productivity	The maximum number of recruits (adults) produced by a single spawner. Productivity determines population resilience to mortality pressures, such as from fishing, dams, and further habitat degradation. Habitat quality (including water quality) is a major determinant of a population's productivity. This parameter is especially important when efforts are being made to reverse long-term downward trends in population abundance.
Diversity	The number of possible self-sustaining life histories exhibited by a population and the robustness of the genetic and environmental conditions that determine life history diversity. Populations that can sustain a wide variety of life-history patterns are likely to be more resilient to the influences of environmental change.
Spatial Structure	The number and location (distribution) and timing of salmon populations in the ESU or the basin. Wider distribution of fish abundance reduces fish susceptibility to catastrophic events such as flooding, chemical spills, or geologic disturbance.

Steelhead and Coho Salmon Life Stages

- Adult Migration
- Spawning and Incubation
- Rearing
- Smolt Migration
- Ocean Maturation