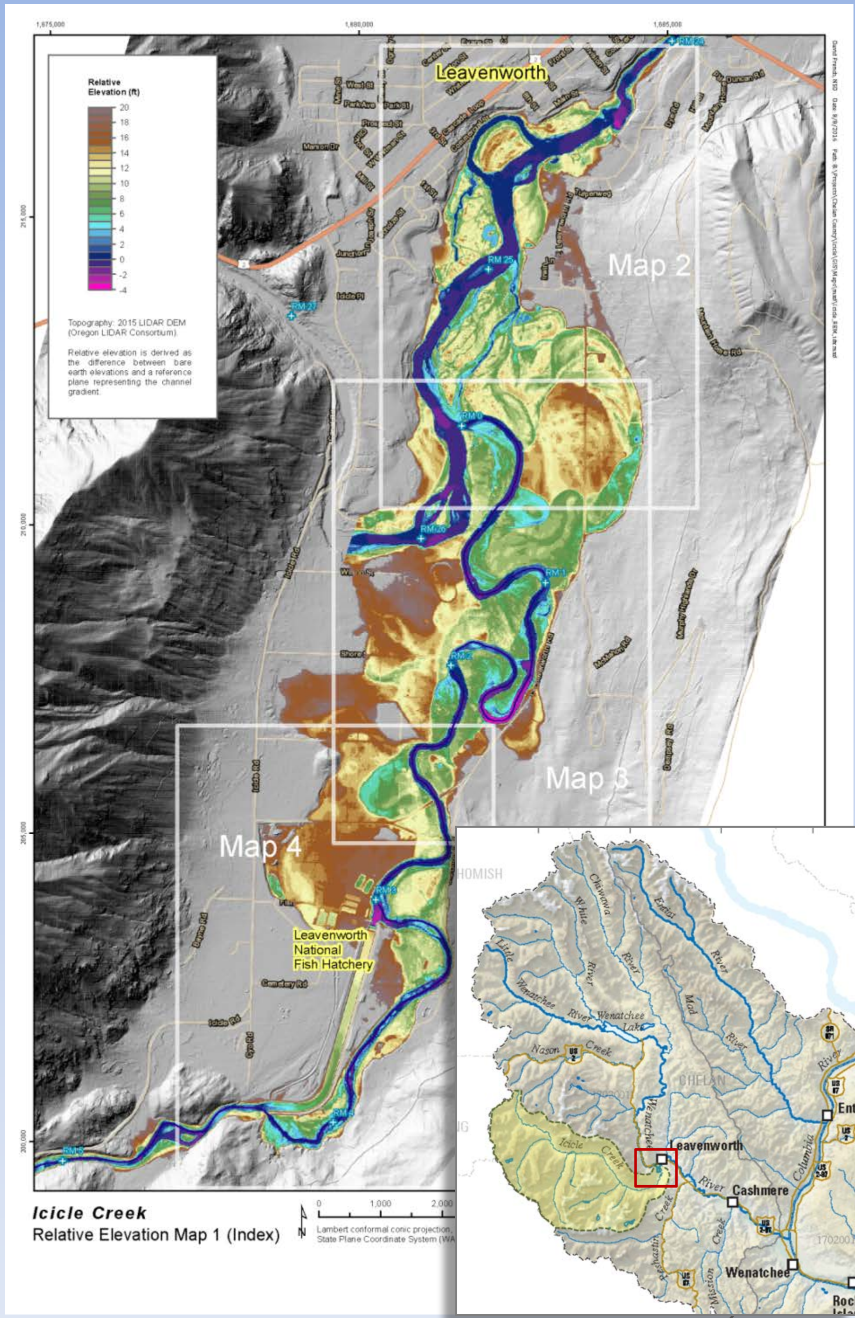
Lower Icicle Creek
Geomorphic and Hydraulic Assessment
January 5, 2017

Natural Systems Design

John M. Soden, PWS

Overview

- Review Key Questions/Assessment Results
    - Channel Incision and Floodplain Connectivity
    - Legacy of the Lamb-Davis Mill Dam
    - Effects of the LNFH on Lower Icicle Sediment Dynamics
    - Large Wood Dynamics
    - Habitat Conditions
- Overview of Restoration Opportunities

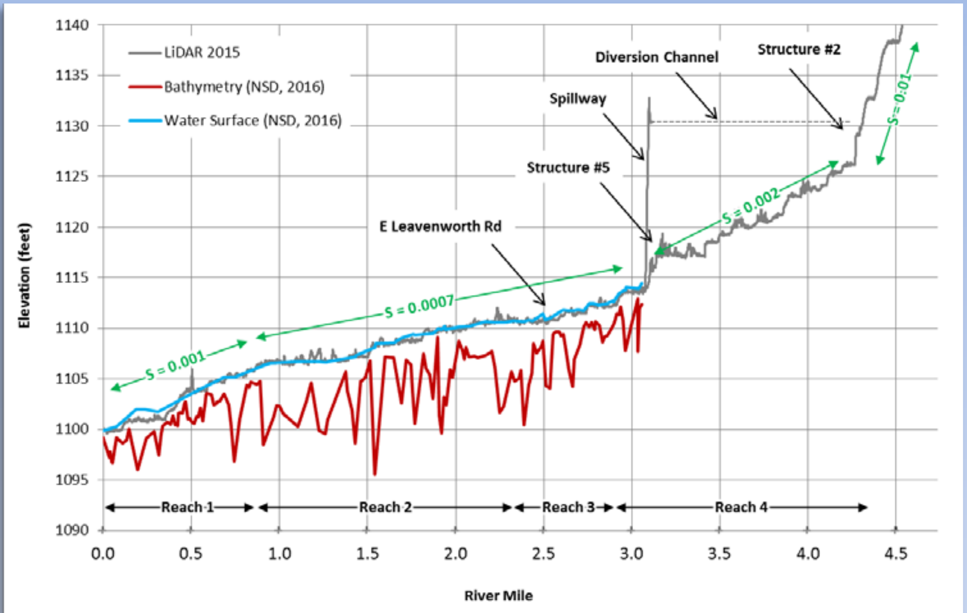


Assessment Data and Methods

Compiled Existing Data and Reports

Field Survey and Reconnaissance

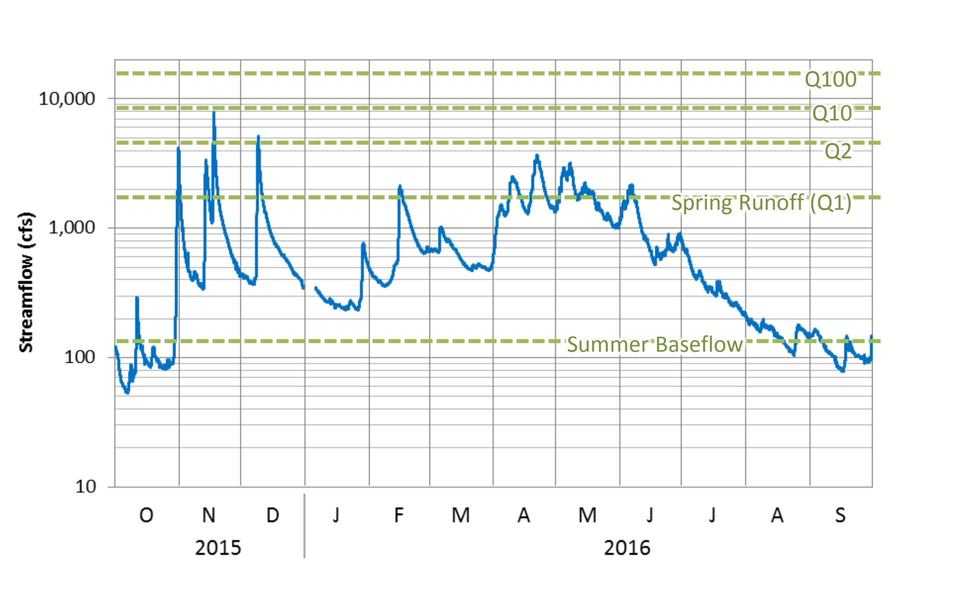
- Survey of channel bathymetry and water surface elevations;
- Bed material sampling (pebble counts and visual estimates of substrate size for channel unit areas);
- Inventory of wood pieces; and
- Inventory of streambank protection such as rip-rap bank armoring and rock barbs.

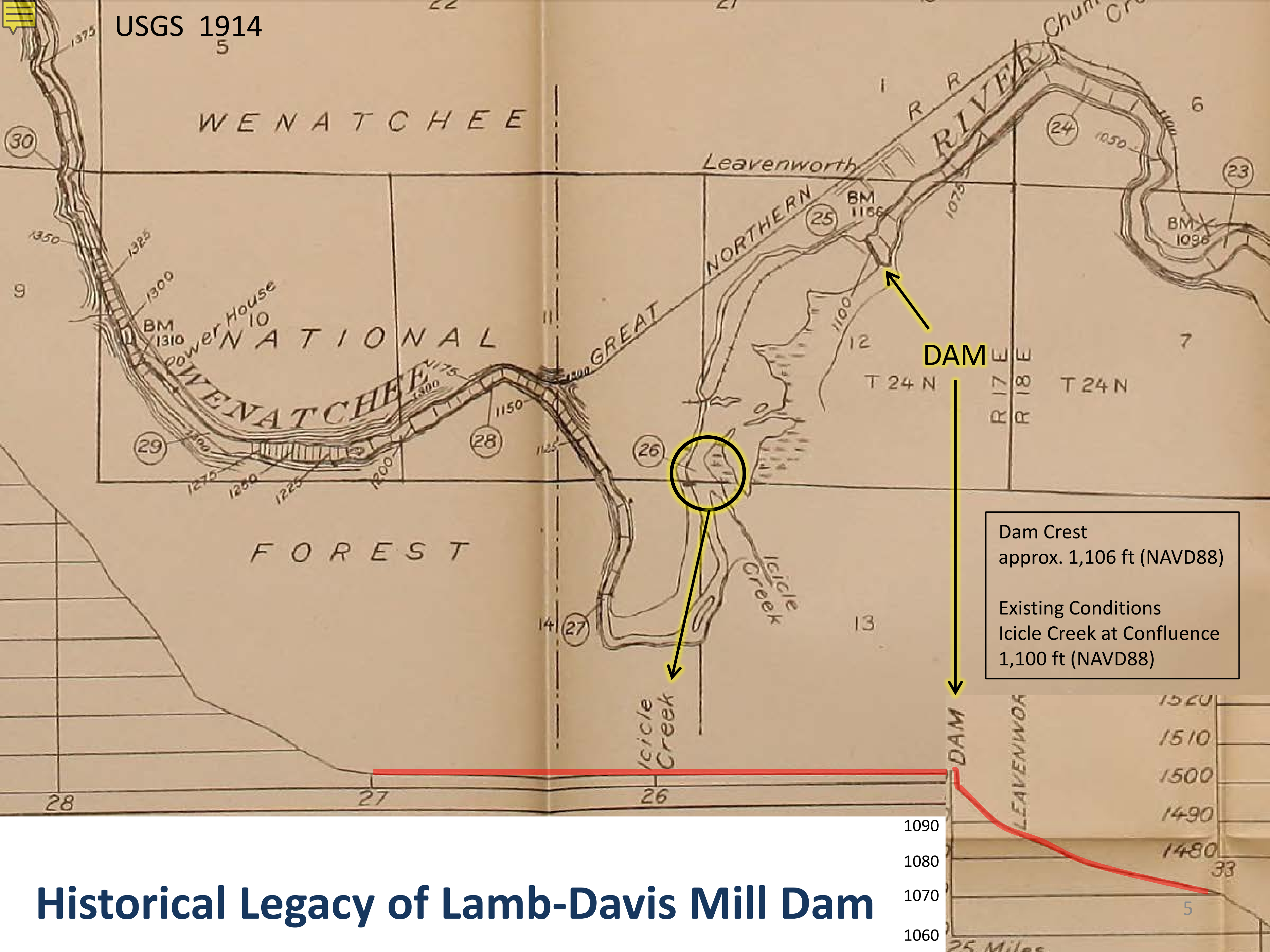


Assessment Data and Methods

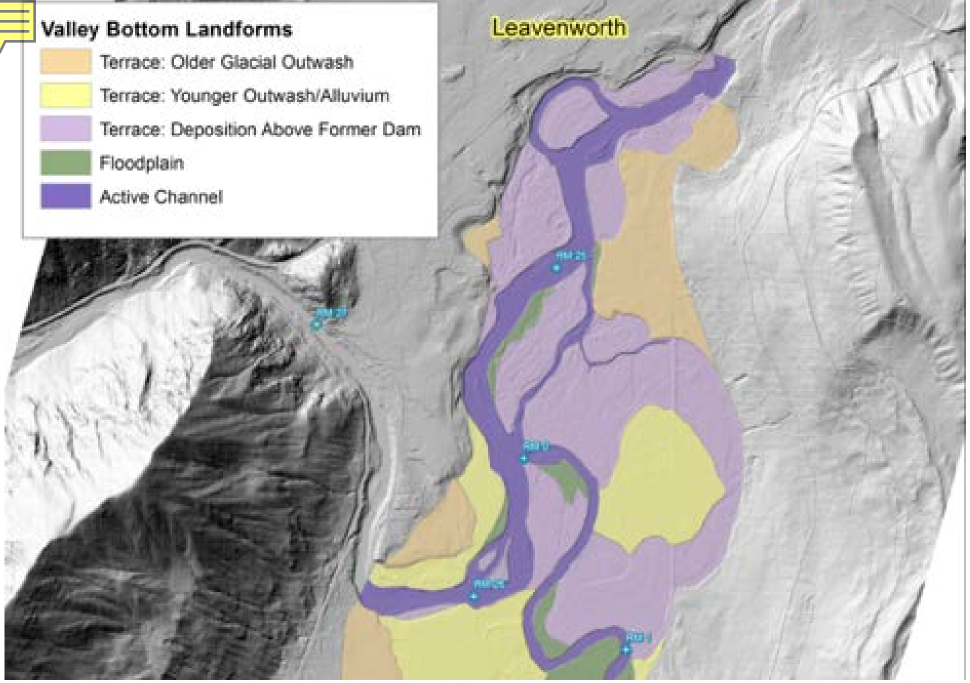
Hydraulic Analysis

- Previous modeling of Historical Channel by USFWS (2013)
- 2D-Model Developed for Reach Downstream of Hatchery (RM 0 – 3).
- Calibration
- Applications:
  - Floodplain Connectivity
  - Sediment Mobility
  - Habitat Suitability





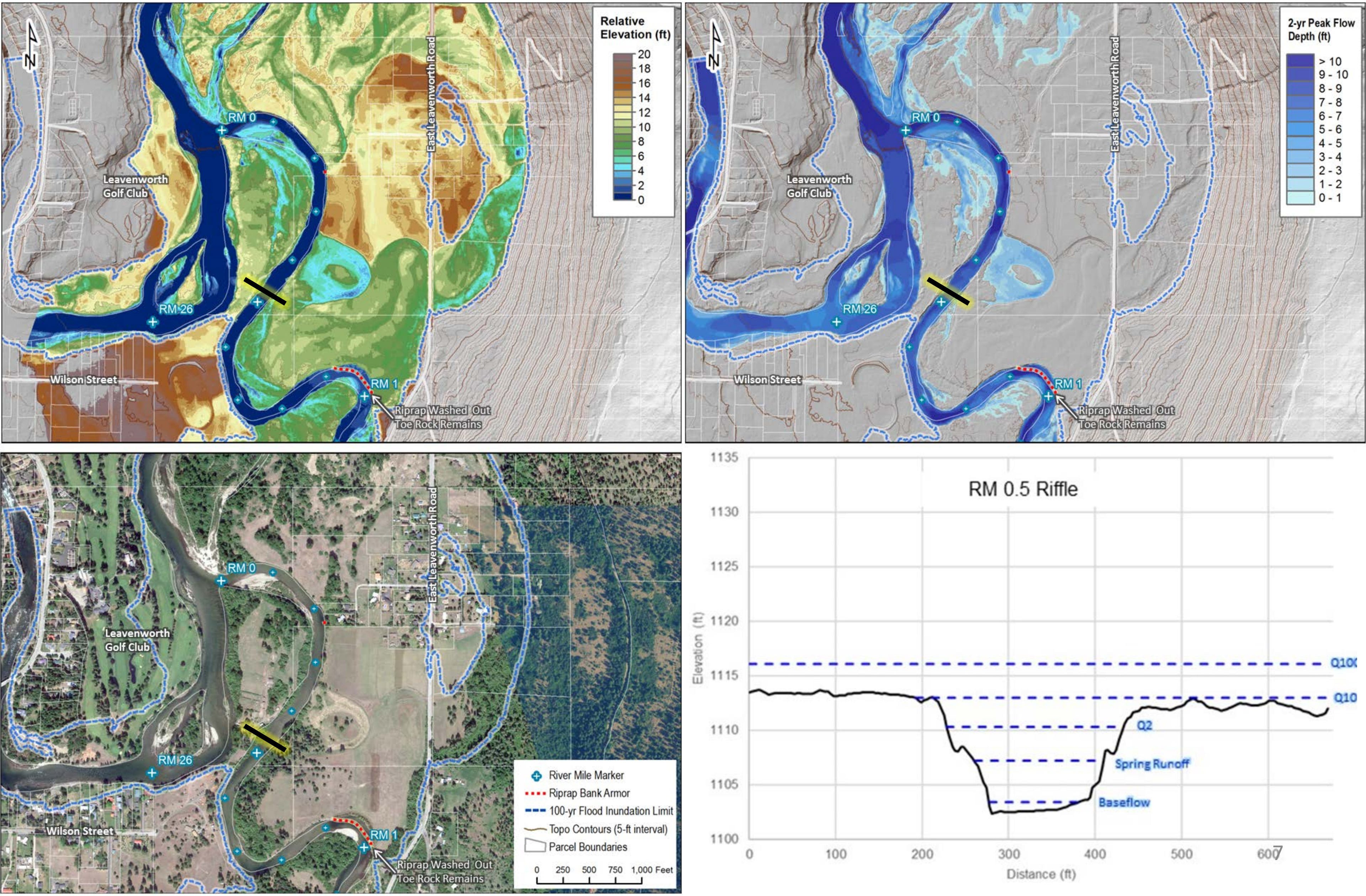
Historical Legacy of Lamb-Davis Mill Dam

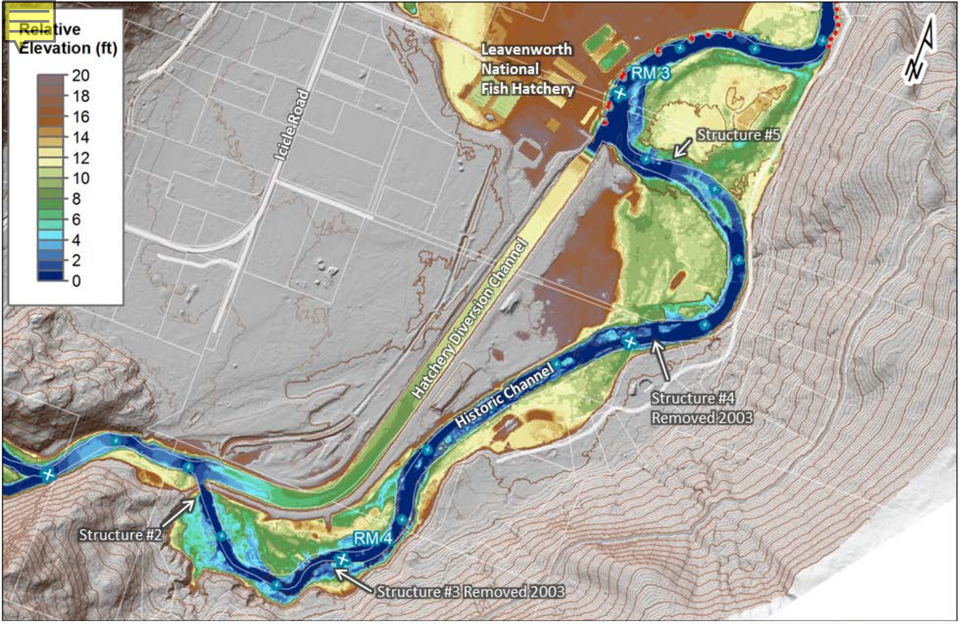


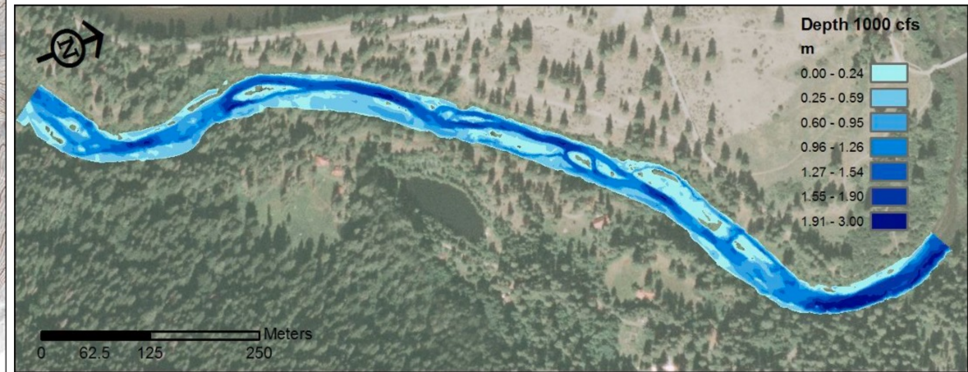
- Mapped area of impoundment and deposition.
- Raised Base Level 5 ft
- Influence extended >1 mile
- Has contributed to high terraces and channel incision.

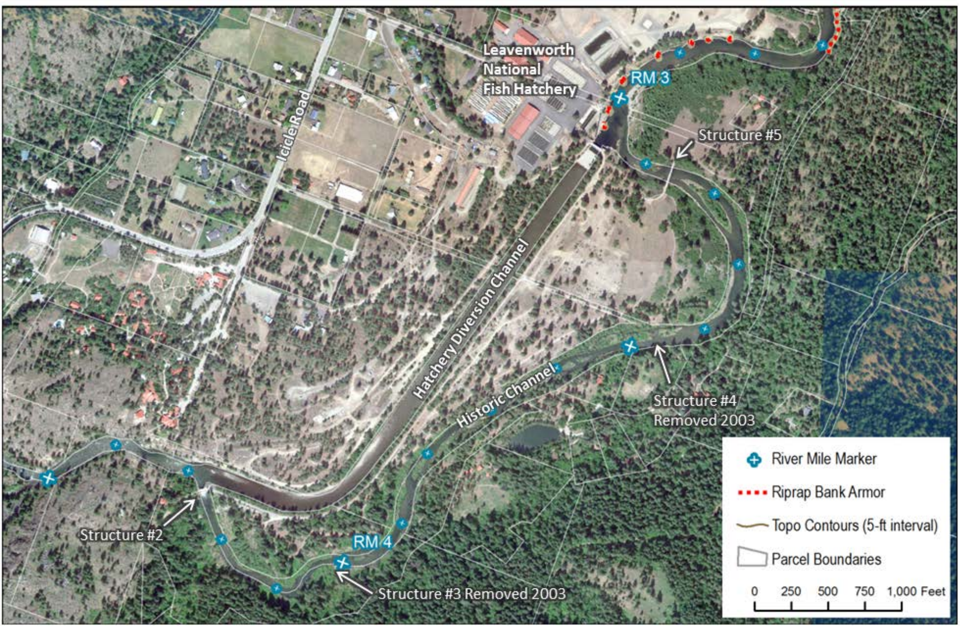
Historical Legacy of Lamb-Davis Mill Dam

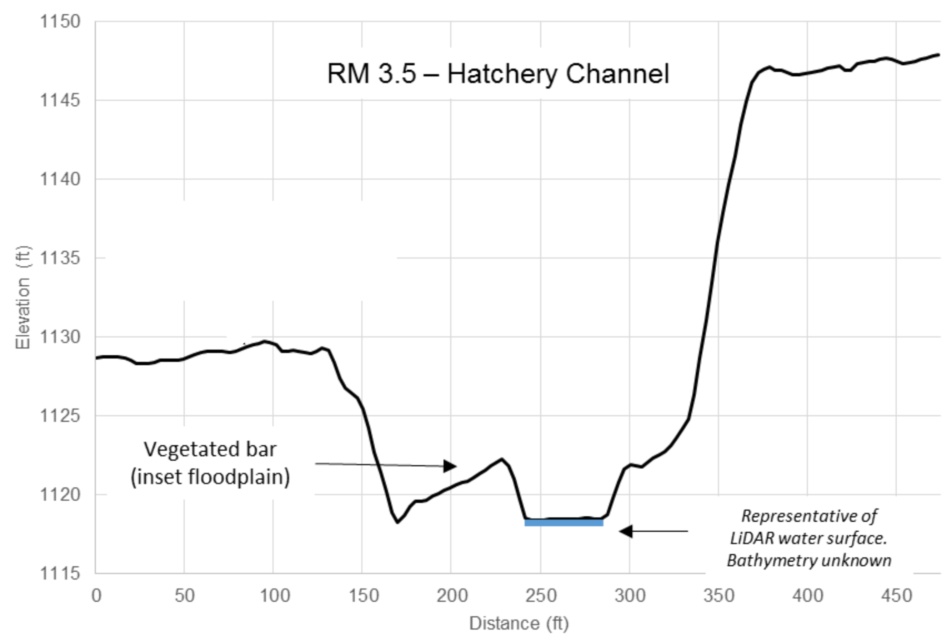
Results: Channel Incision/Floodplain Connectivity



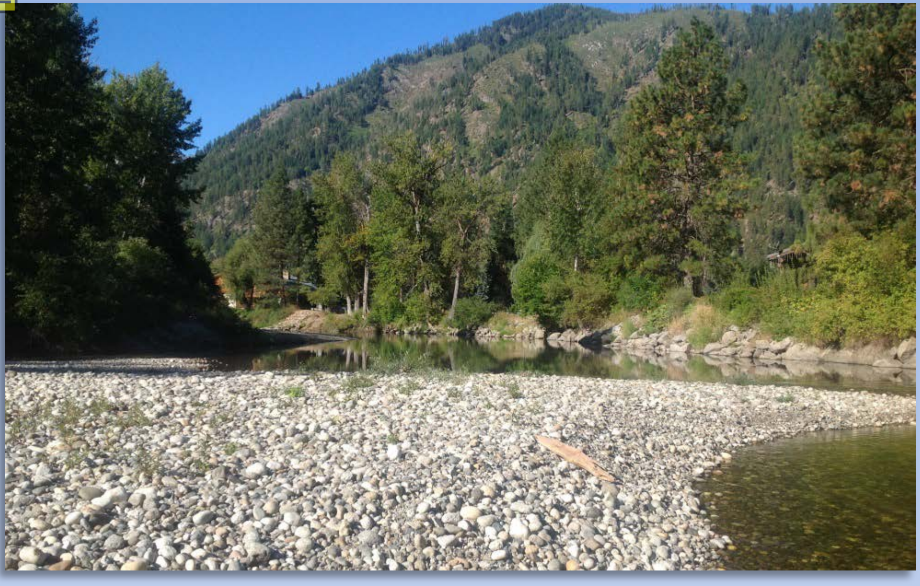






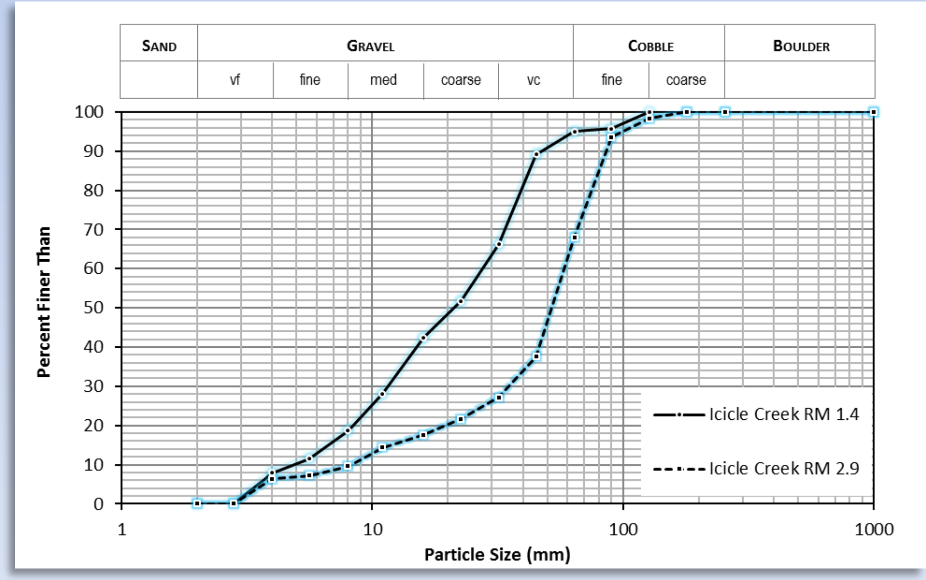


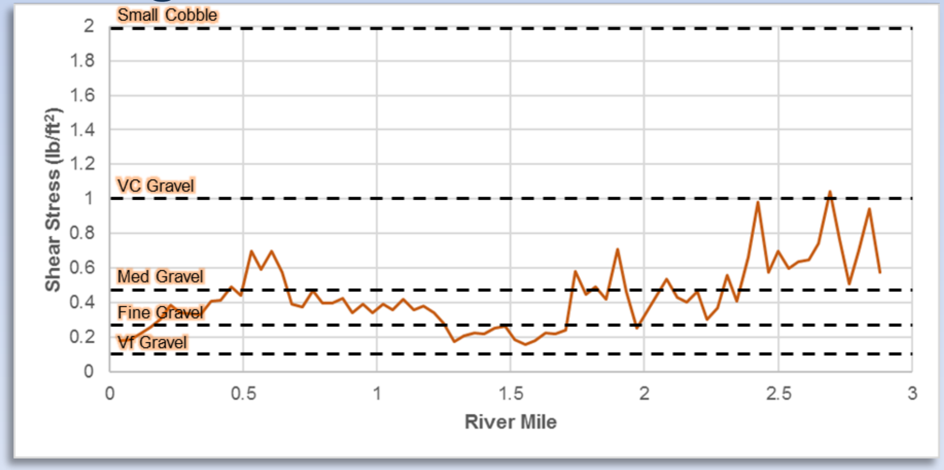
LNFH - Historical Channel



Downstream of LNFH

- Are the hatchery channels restricting gravel mobilization?
- Initial period:
  Sediment Input < Sediment Output
- Subsequent Quasi-Equilibrium
- Substrate near incipient motion at Q2
- High Sand Content





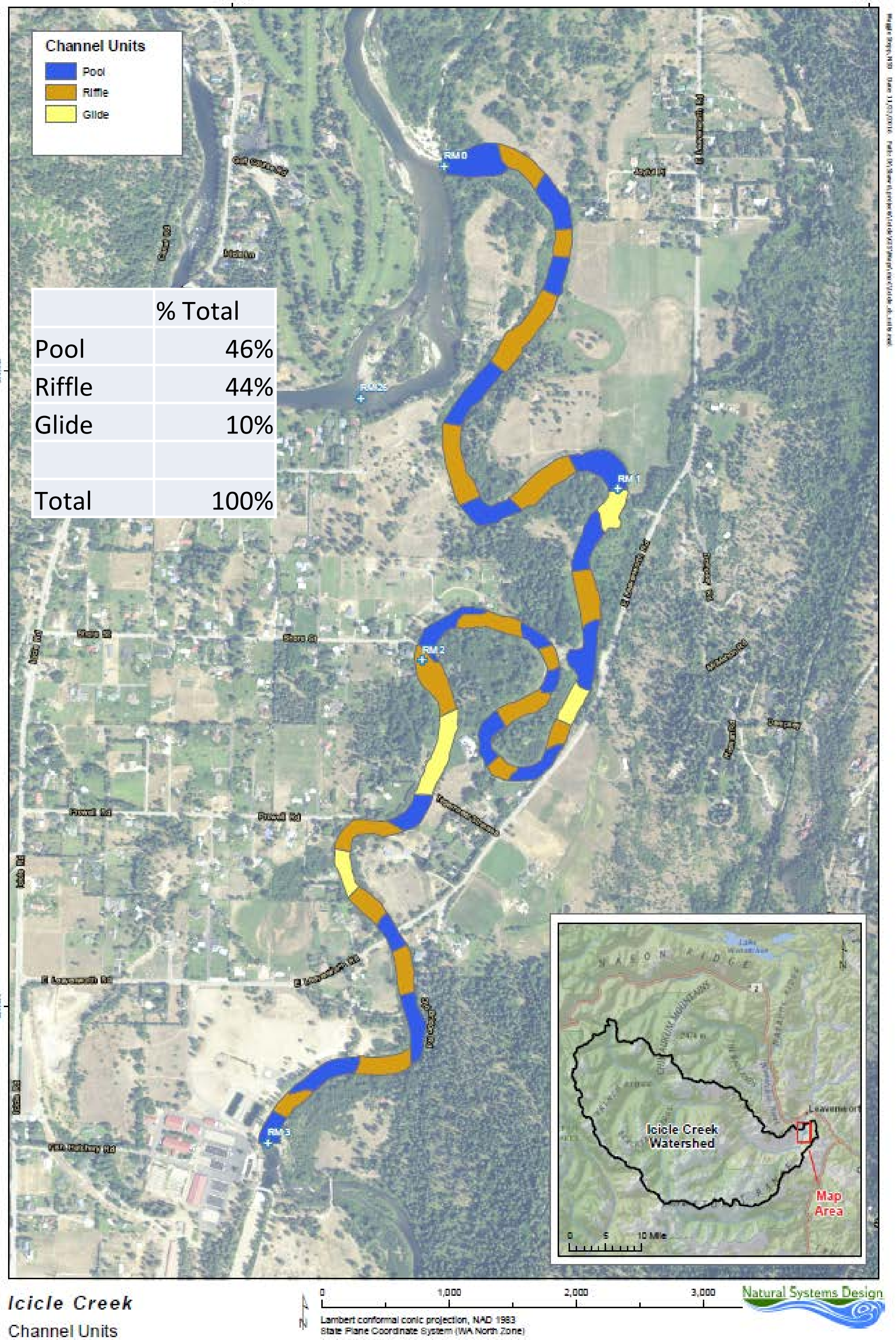
Results: Sediment Dynamics

Lower Icicle Creek		Fox and Bolton (2007)		
LARGE WOOD CLASSES	BASELINE CONDITIONS (#/100M)	75TH PERCENTILE (#/100M)	MEDIAN (#/100M)	25TH PERCENTILE (#/100M)
# Pieces*	**2.5**	> 35	17	<5
# Key Pieces	**0**	> 2	0.4	<0.5

*Qualifying wood piece: > 10 cm dia. and > 2m in length

- NMFS (1996) target 80 pieces/mile (>12" dia. and >35' length)
- Icicle Creek: 5 pieces/mile (>12" dia. and >35' length)

Wood Dynamics

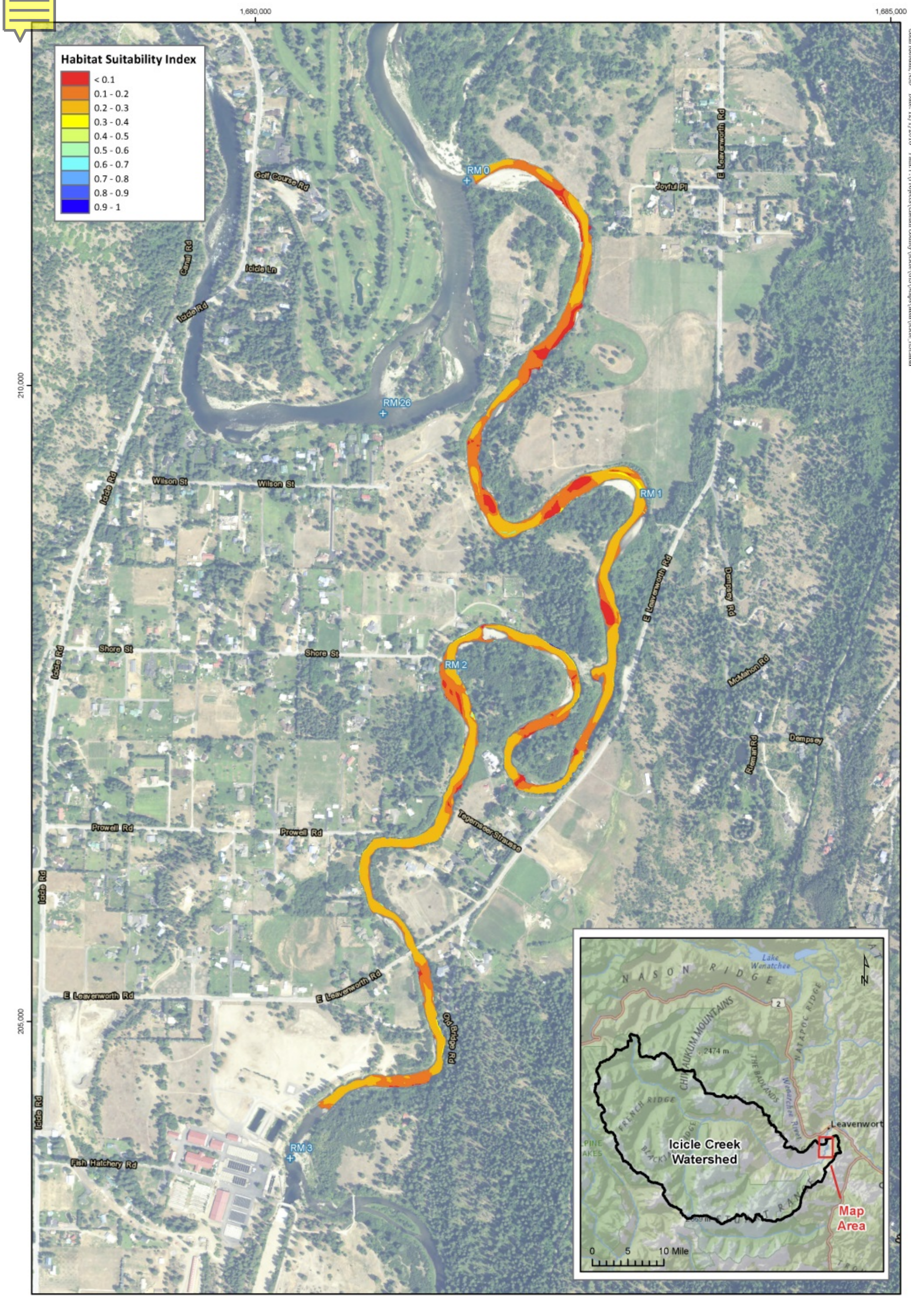


	% Total
Pool	46%
Riffle	44%
Glide	10%
Total	100%

Icicle Creek
Channel Units

Habitat Conditions

- Good abundance of pool and riffle habitat.
- Juvenile Chinook and steelhead rearing habitats are **poor** throughout the study area.
- Flow depth and velocity are generally good for rearing habitat conditions.
- **Lack of cover** is the primary driver of poor habitat values.
- Lack of connectivity to off-channel habitat limits the rearing habitat.
- **Spawning habitat is generally good**.



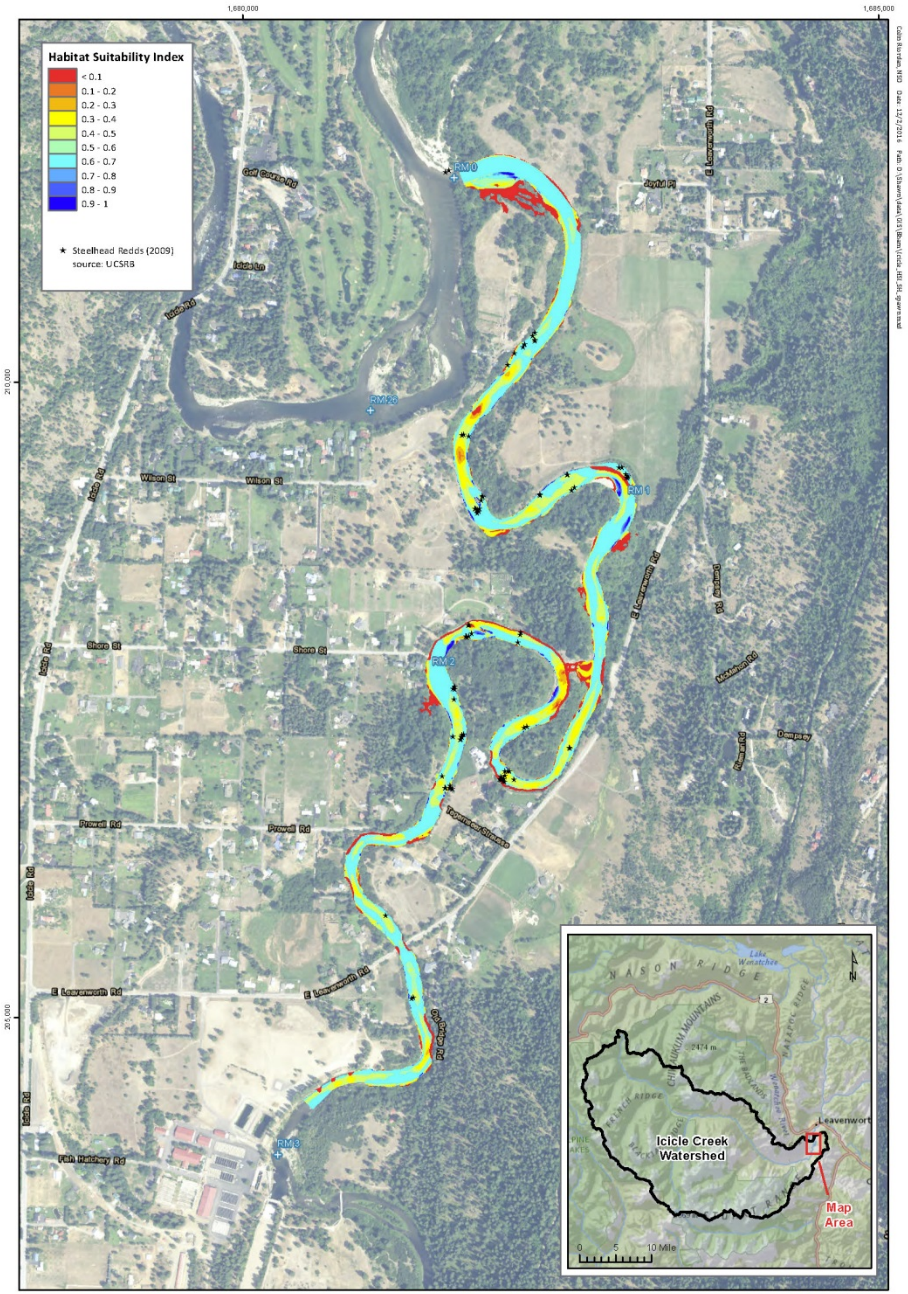
Icicle Creek

Steelhead juvenile rearing habitat
Summer base flow 130 cfs

0 1,000 2,000 Feet

Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design



Icicle Creek

Steelhead spawning habitat
Spring runoff flow (Q1) 1,830 cfs

0 1,000 2,000 Feet

Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design

Summary of Findings

- Channel Incision and Floodplain Connectivity
  - Widespread channel incision with disconnected floodplain at the 2-year flood.
- Historical Legacy of Lamb-Davis Mill Dam
  - Impoundment and deposition up to RM 1. Resulting in a “perched” floodplain.
- Effects of LNFH on Downstream Sediment Dynamics
  - Likely at equilibrium.
- Wood Dynamics
  - Very limited wood and wood recruitment. Critical factor in channel incision and low quality rearing habitat.
- Habitat Conditions
  - Very poor off-channel and pool rearing habitat; influenced by lack of cover.
  - High quantity and quality of steelhead spawning habitat.

Restoration Goals and Objectives

- Increase geomorphic and ecologic resilience to future disturbance and watershed changes
- Work with community to define and protect a stream corridor managed to sustain natural processes.
  - Preserve/protect existing floodplain.
- Increase rearing habitat for juvenile salmonids
  - Place large wood in existing pools.
  - Improve flow connectivity to existing off-channel habitats.
- Reduce Stream Temperatures
  - Restore riparian communities.

Sideboards

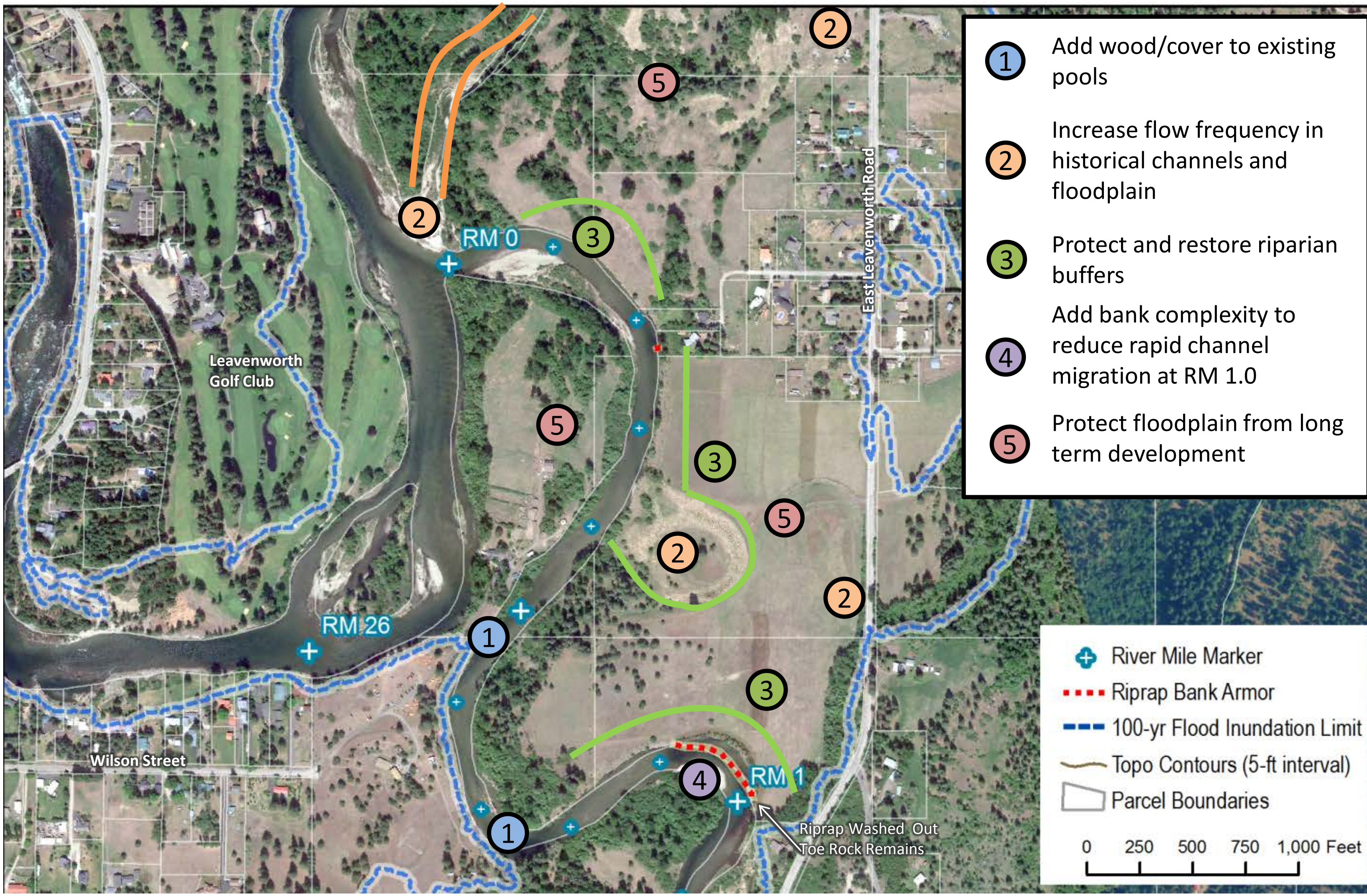
- Hatchery operations and infrastructure

- Tribal fishery
  - Protect pool and fishing area near LNFH.

- Close proximity of private property and human structures
  - Makes increasing floodplain connectivity challenging

- High volume of recreational users
  - Instream wood structures may increase risk for these users

Project Opportunities – Sub-reach 1



Project Opportunities – Sub-Reach 2

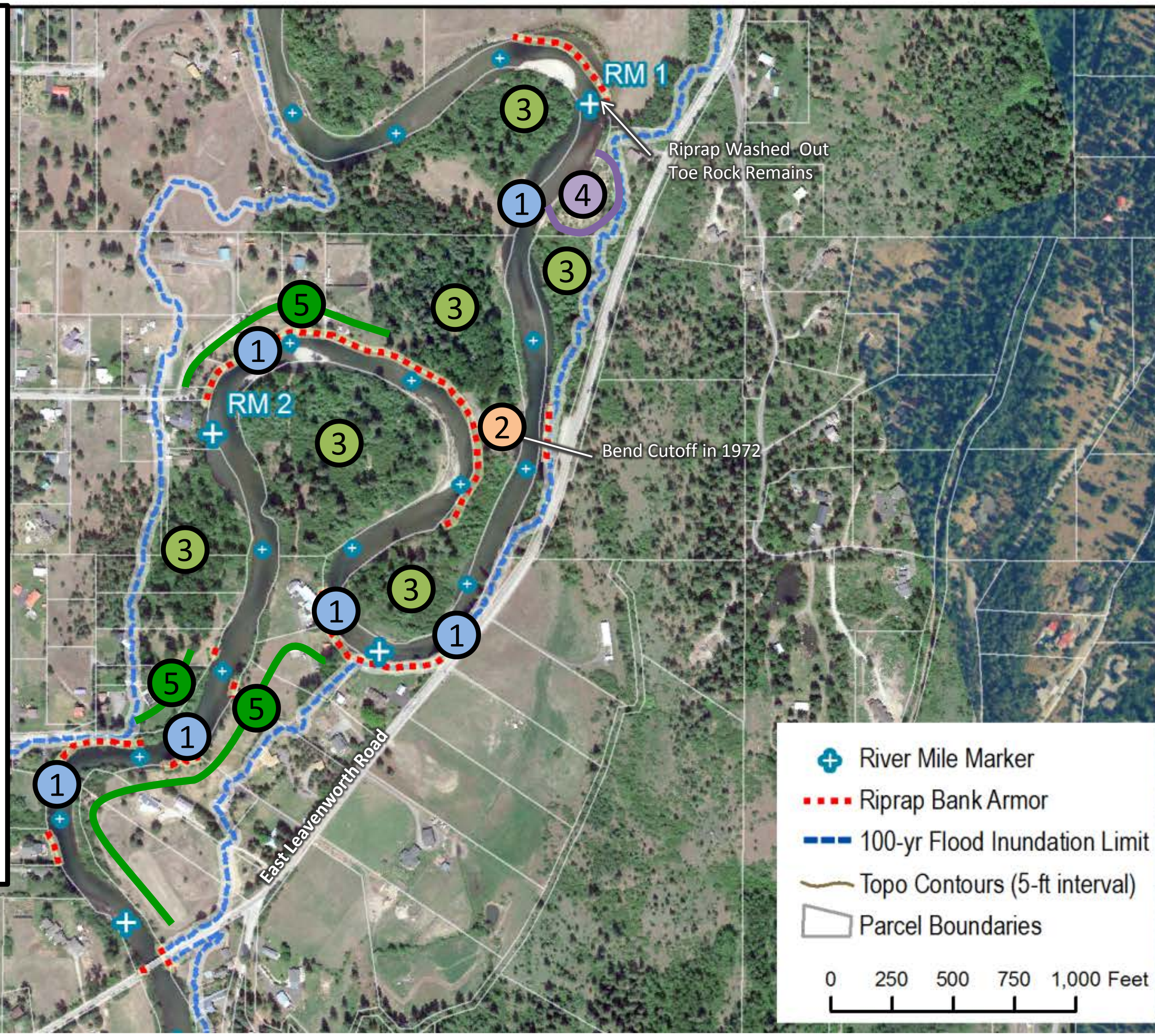
1 Add wood/cover to existing pools

2 Allow long-term erosion of meander cut-off at RM 1.3

3 Protect forested floodplain

4 Improve flow connectivity to low right bank floodplain at RM 1.1

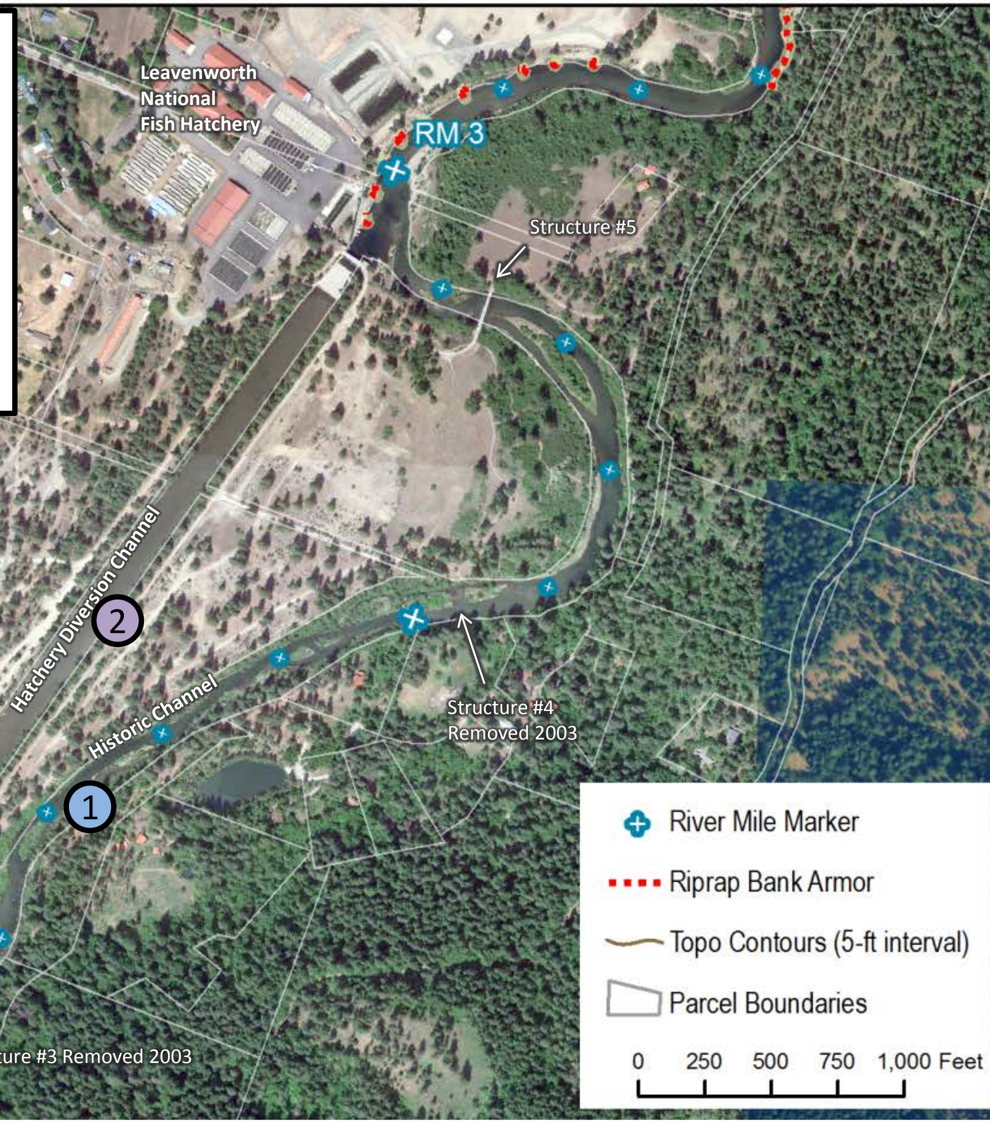
5 Protect and restore riparian buffer



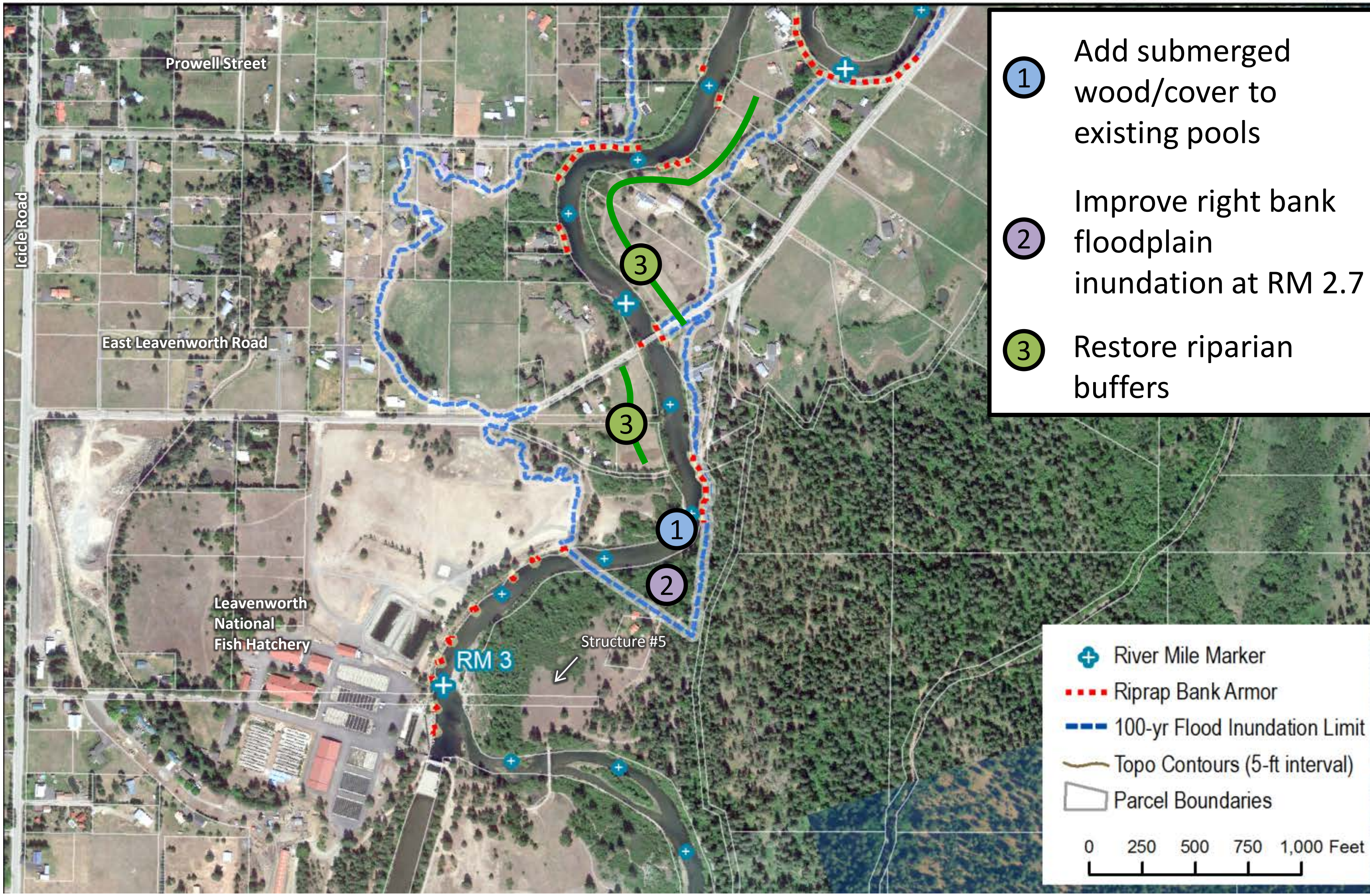
Project Opportunities @ LNFH

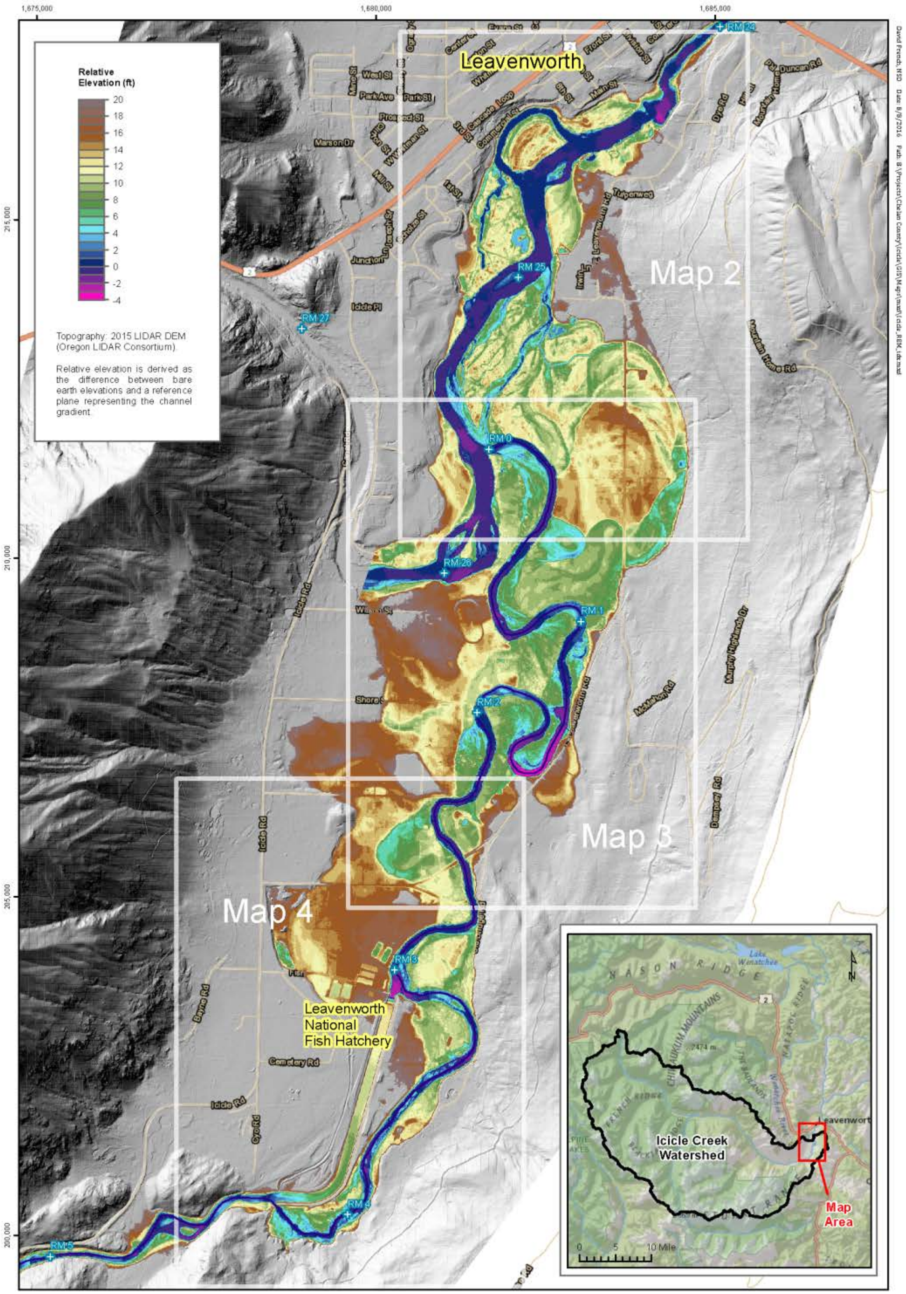
1. Add LWM to historical channel to improve cover, pool formation, and emphasize anabranching planform.

2. Restore full channel or channel forming flows to promote a dynamic/diverse system.



Project Opportunities – Sub-Reach 3





Icicle Creek
Relative Elevation Map 1 (Index)

0 1,000 2,000 3,000 4,000 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design

Icicle Creek
2015 Aerial Image

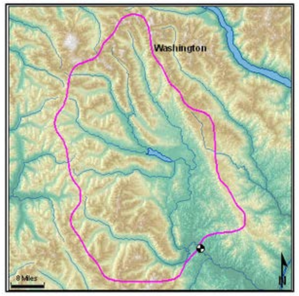
0 1,000 2,000 3,000 4,000 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design

WENATCHEE RIVER AT PESHASTIN

Site Info: WENPE (6053)

USGS Id: 12459000
Latitude (DMS): 47 35 00
Longitude (DMS): 120 37 06
Latitude (Decimal): 47.5833
Longitude (Decimal): -120.6183
Area: 1000 miles^2
Nash Sutcliffe Efficiency = 0.88



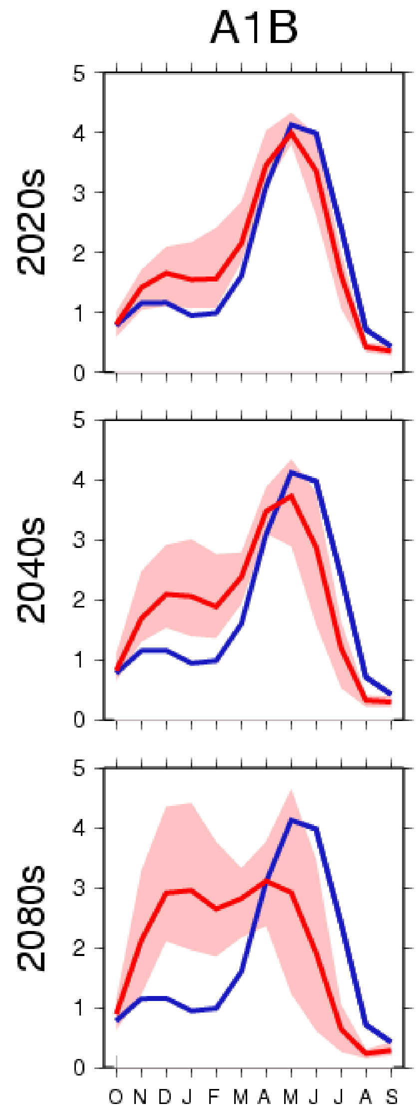
Effect of Climate Change On Hydrologic Regime

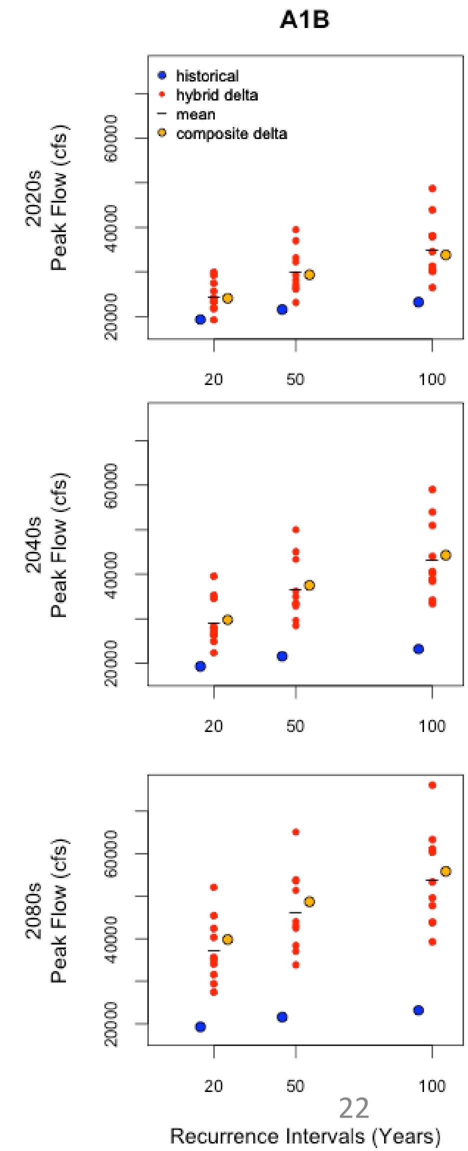
Projected Increase in Peak Flow

Recurrence Interval (yrs)	% Change	
	2040s	2080s
20	51%	94%
50	70%	115%
100	87%	132%

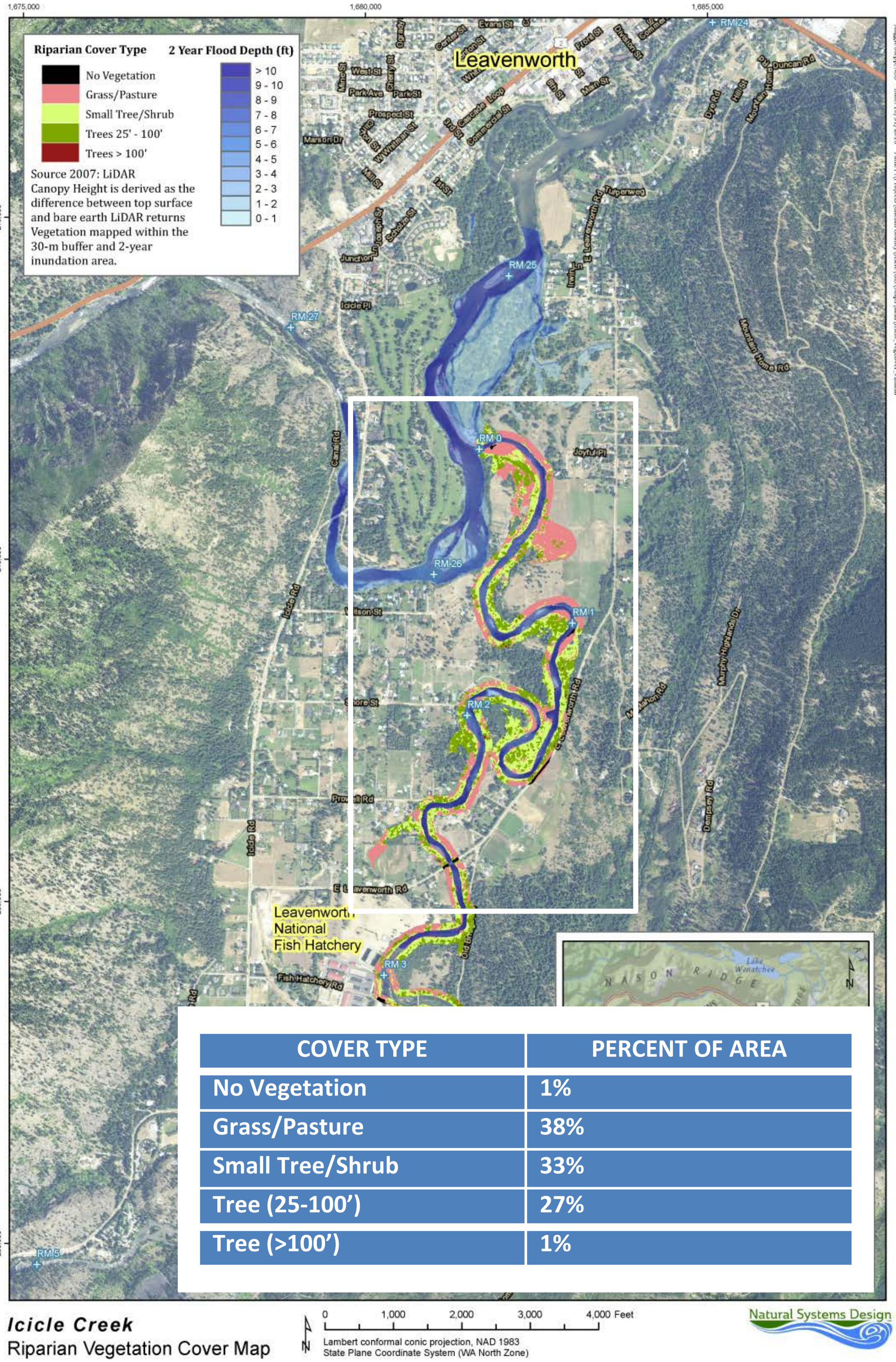
Projected Decrease in Low Flow

	% Change	
	2040s	2080s
7Q10	-23%	-28%

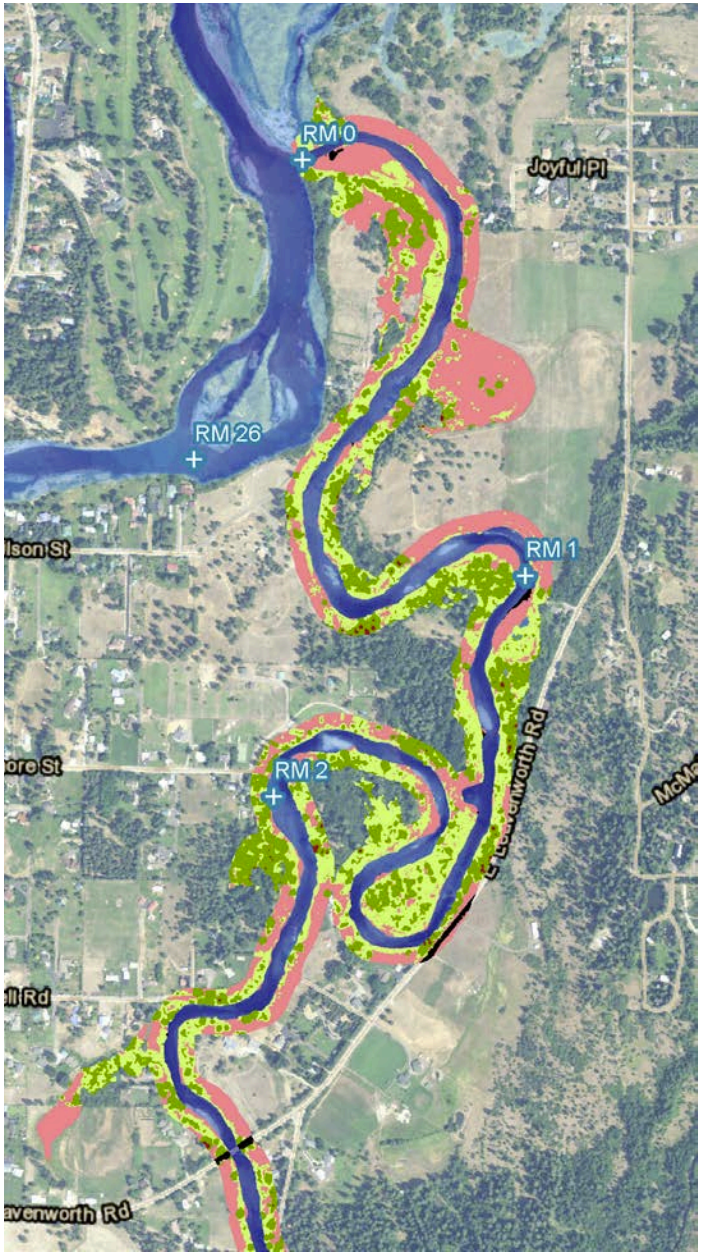




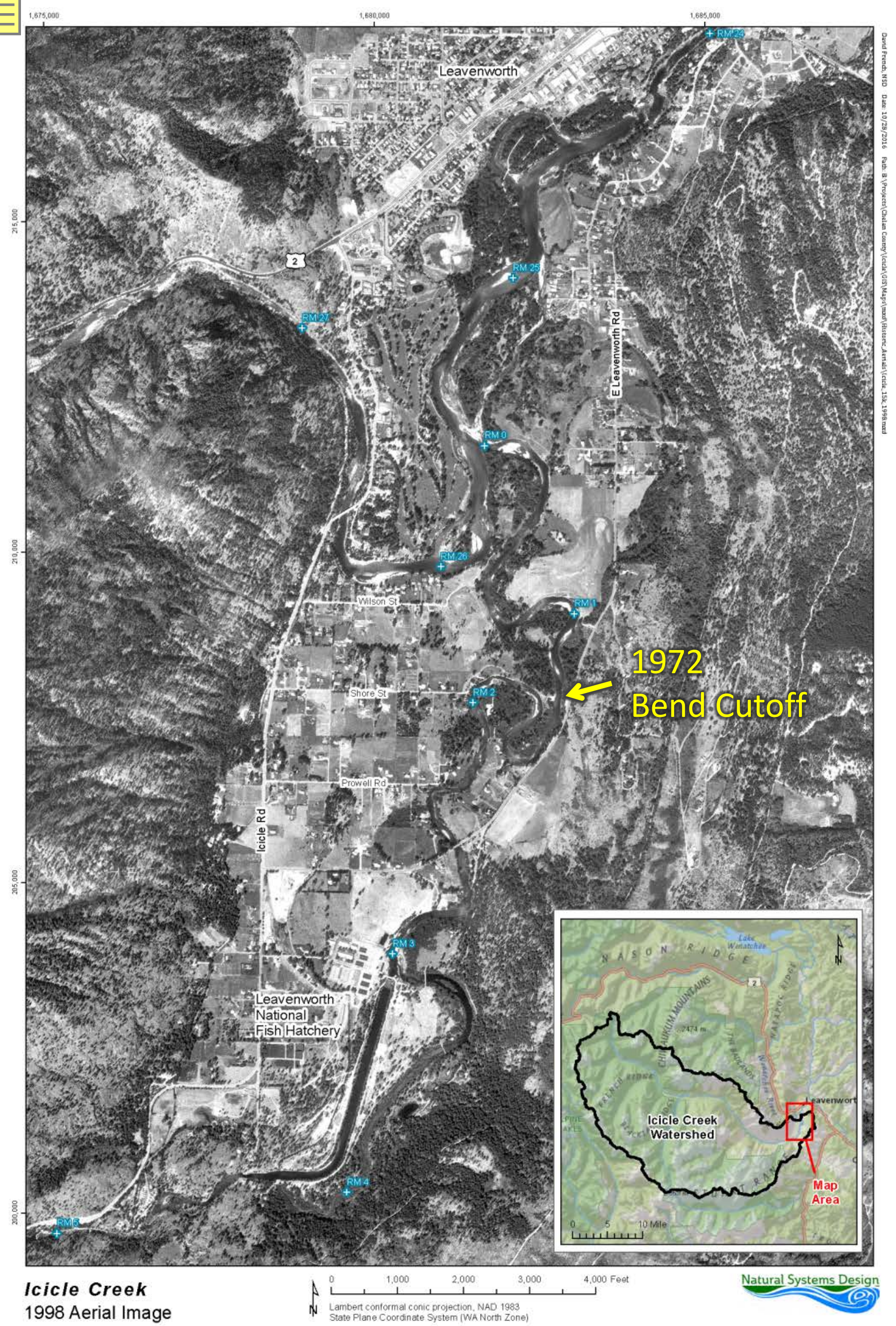
Hamlet, A.F., P. Carrasco, J. Deems, M.M. Elsner, T. Kamstra, C. Lee, S-Y Lee, G. Mauger, E. P. Salathe, I. Tohver, L. Whitely Binder, 2010, Final Project Report for the Columbia Basin Climate Change Scenarios Project, http://warm.atmos.washington.edu/2860/products/sites/?site=6053



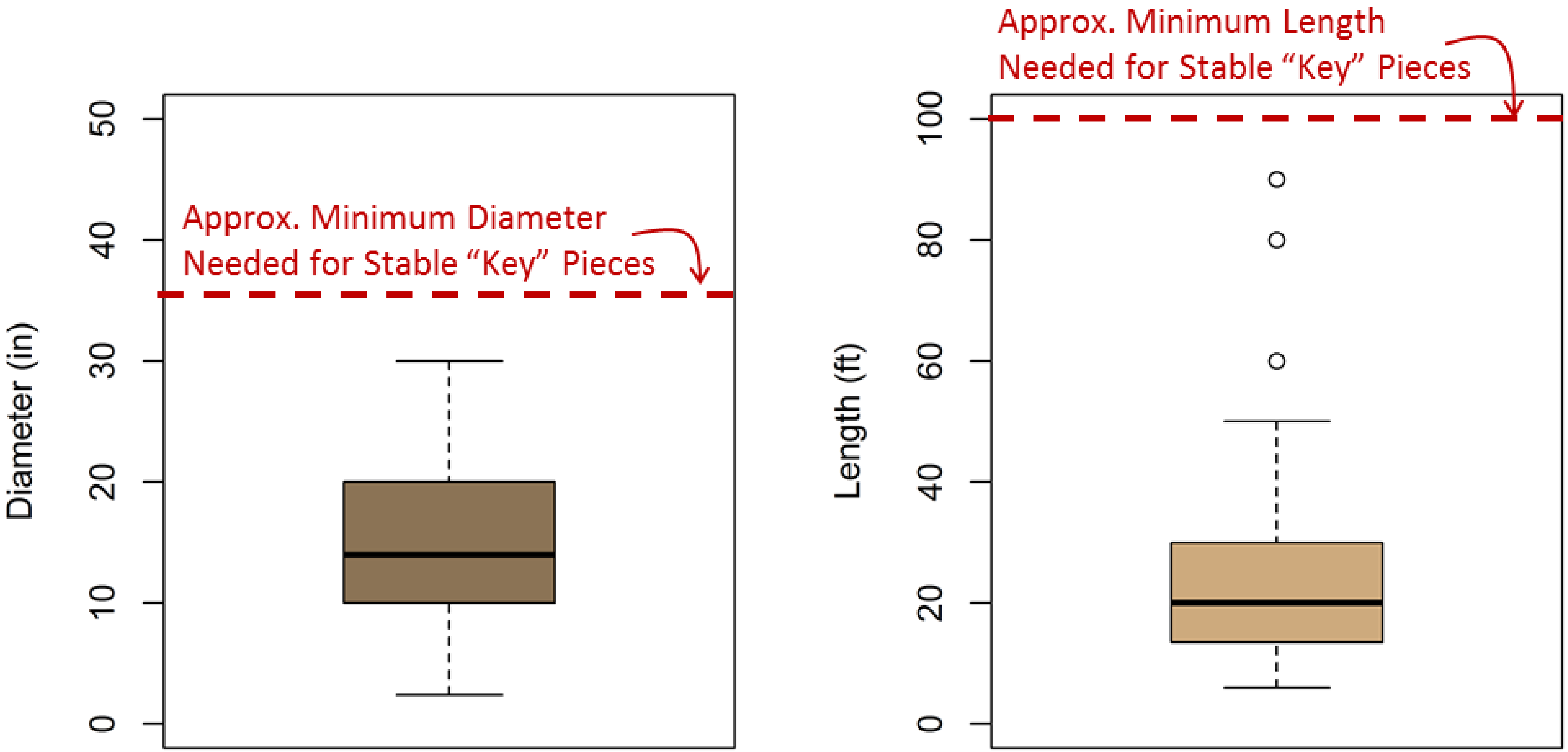
COVER TYPE	PERCENT OF AREA
No Vegetation	1%
Grass/Pasture	38%
Small Tree/Shrub	33%
Tree (25-100’)	27%
Tree (>100’)	1%



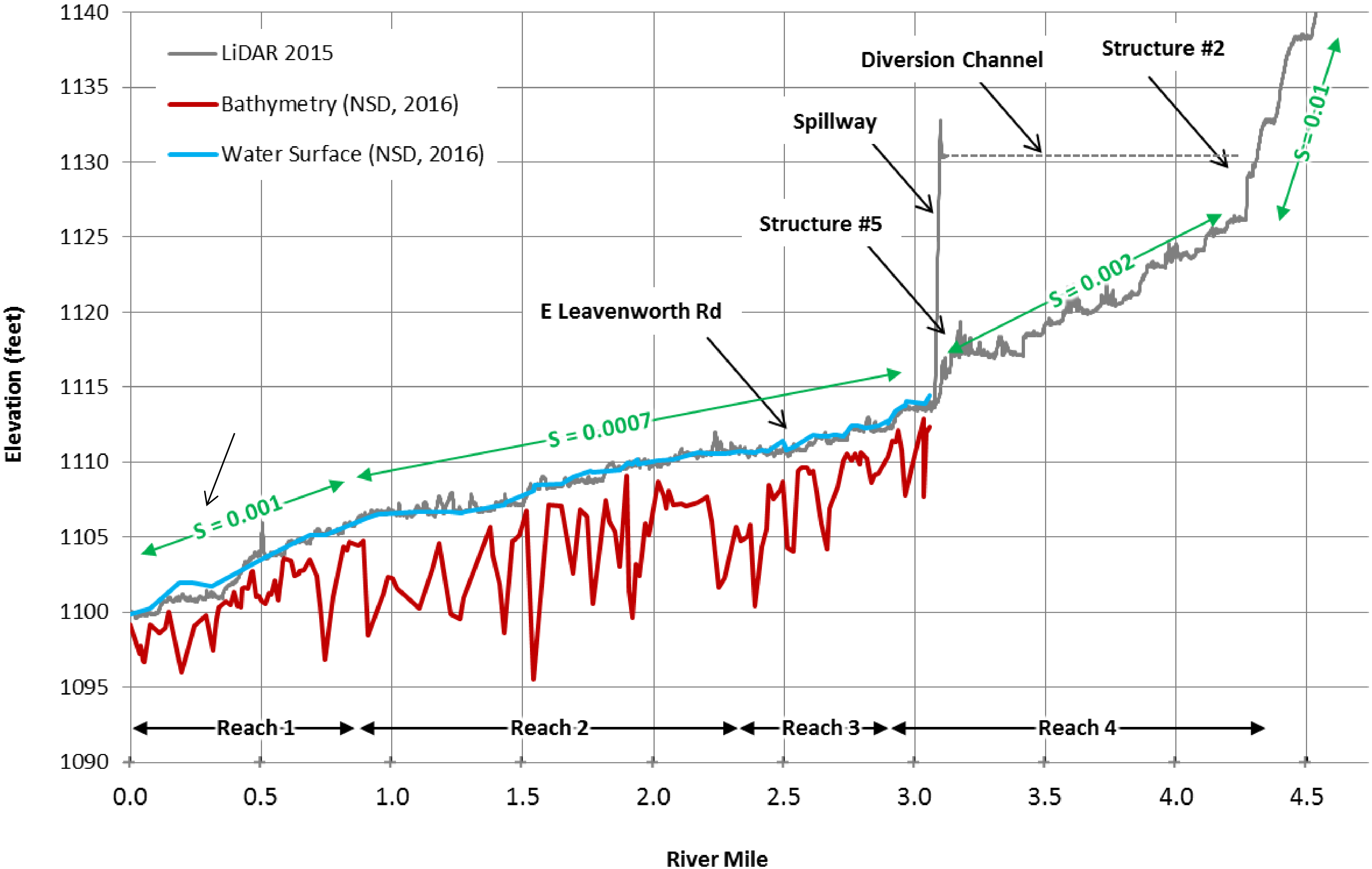
Channel Migration Potential/Bank Armor


Leavenworth
E Leavenworth Rd
Wilson St
Shore St
Prowell Rd
Icicle Rd
1972
Bend Cutoff
Leavenworth
National
Fish Hatchery
Icicle Creek
Watershed
Map
Area
Icicle Creek
1998 Aerial Image
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)
Natural Systems Design


Leavenworth
E Leavenworth Rd
Bend
Erosion
Bend
Erosion
Wilson St
Shore St
Prowell Rd
Icicle Rd
Leavenworth
National
Fish Hatchery
Icicle Creek
Watershed
Map
Area
Icicle Creek
2015 Aerial Image
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)
Natural Systems Design

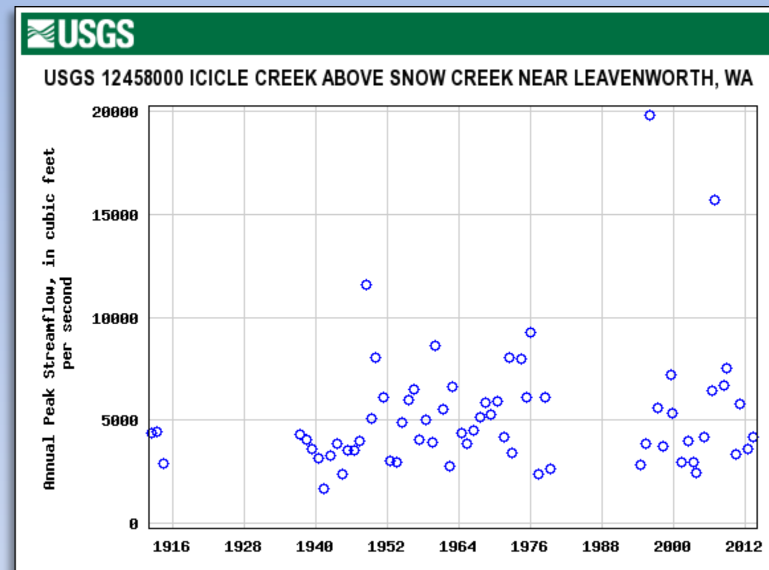


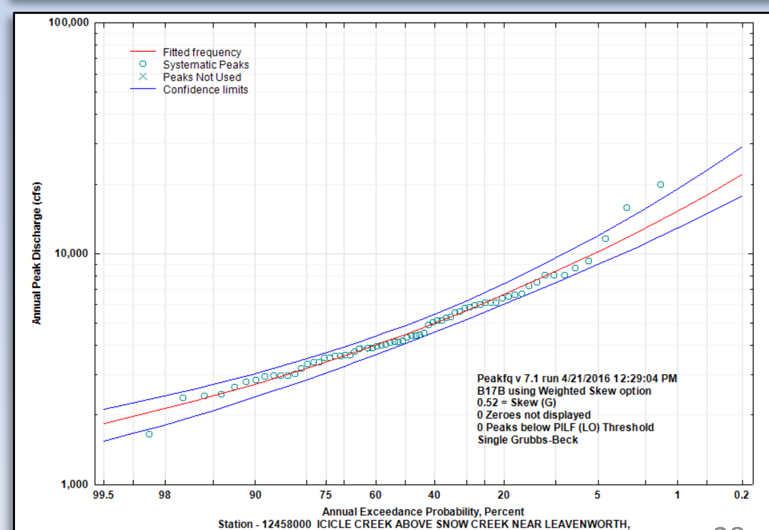
Box and whisker diagrams illustrating the range and variability of wood characteristics in the project reach. Boxes bracket the interquartile range (25th to 75th percentile) and whiskers extend to min/max values observed excluding statistical outliers. Points represent values of statistical outliers. Total sample = 119 pieces. There were no pieces in the inventory that have sufficient diameter or length to provide functions of stable "key" pieces that affect geomorphic processes in the reach.

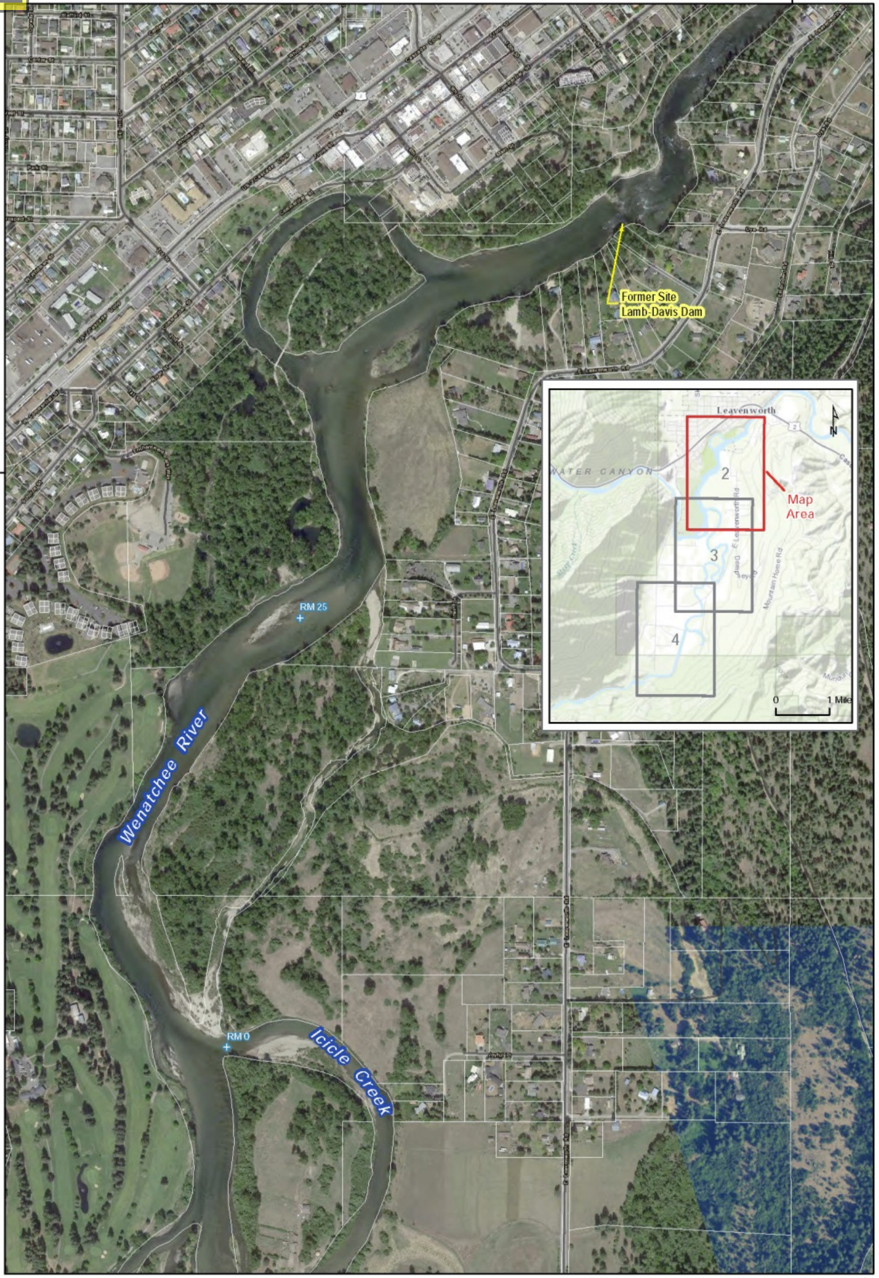

LiDAR 2015
Bathymetry (NSD, 2016)
Water Surface (NSD, 2016)
Elevation (feet)
River Mile
Diversion Channel
Structure #2
Spillway
Structure #5
E Leavenworth Rd
S = 0.001
S = 0.0007
S = 0.002
S = 0.01
Reach 1
Reach 2
Reach 3
Reach 4
1140
1135
1130
1125
1120
1115
1110
1105
1100
1095
1090
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

Historical Flood Peaks
USGS Gaging Station above Snow Creek

RANK	DATE	PEAK FLOW (CFS)
1	11/29/1995	19,800
2	11/6/2006	15,700
3	5/28/1948	11,600
4	12/4/1975	9,250
5	11/23/1959	8,620
6	6/10/1972	8,040
7	11/27/1949	8,020
8	6/17/1974	8,000
9	11/12/2008	7,510
10	6/16/1999	7,230





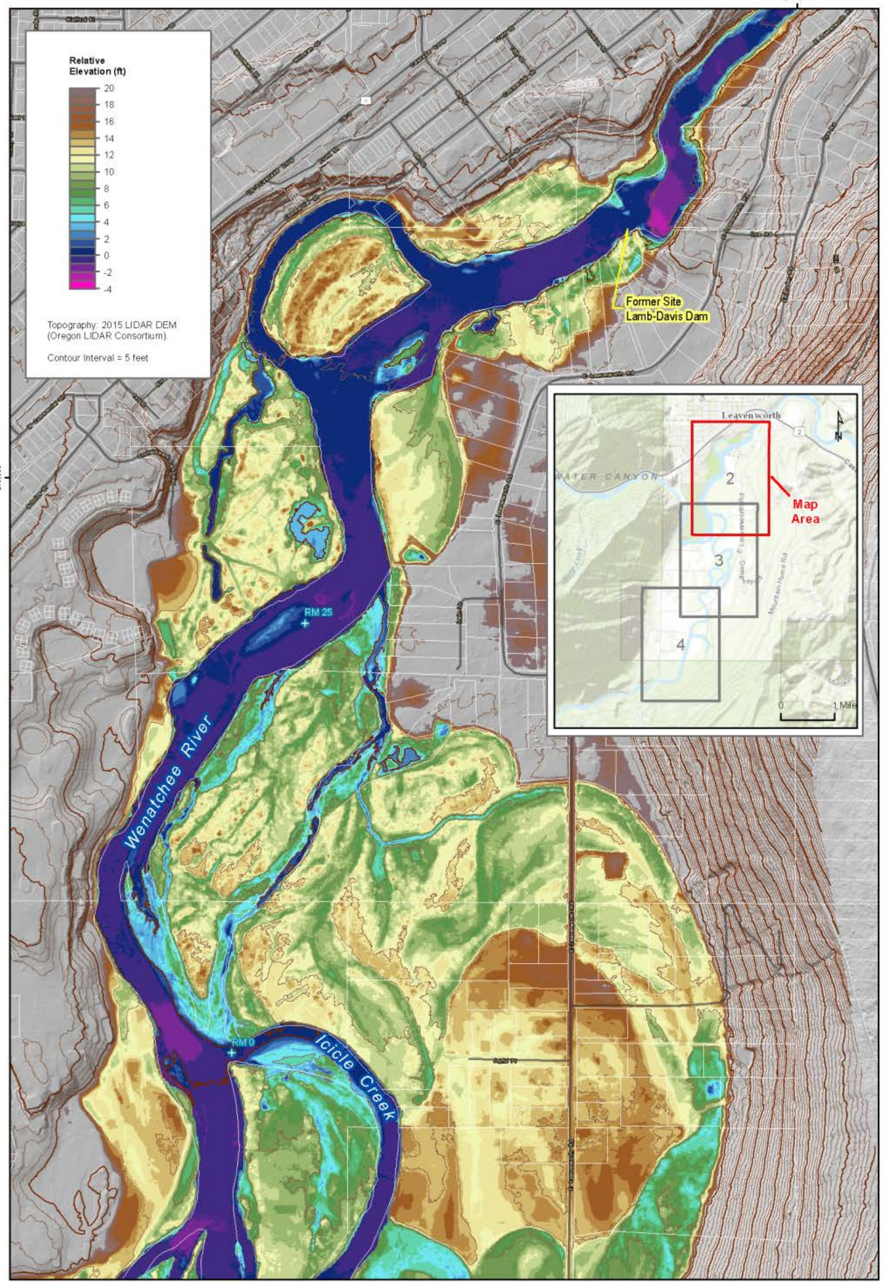


Icicle Creek
2015 Aerial Image - Map 2

0 500 1,000 1,500 Feet

Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design



Icicle Creek
Relative Elevation Map 2

0 500 1,000 1,500 Feet

Lambert conformal conic projection, NAD 1983
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Natural Systems Design

Habitat Suitability Index Modeling

Used to help establish a baseline for species and life history stage habitat preferences using hydraulic and habitat inputs.

Targeted Species:

- **Juvenile steelhead rearing habitat at baseflow (130 cfs)**
- **Juvenile steelhead rearing habitatat Q1 (1,830 cfs)**
- **Adult steelhead spawning at Q1 (1,830**)
- Juvenile spring Chinook rearing habitat at baseflow (130 cfs)
- Juvenile spring Chinook rearing habitatat Q1 (1,830 cfs)

Inputs:

- 2d hydraulic outputs (flow depth & velocity).
- Substrate class
- Cover class

Output:
- 0.0 – 0.5 considered poor habitat
- 0.5 – 1.0 considered good habitat

Juvenile steelhead at baseflow (130 cfs)

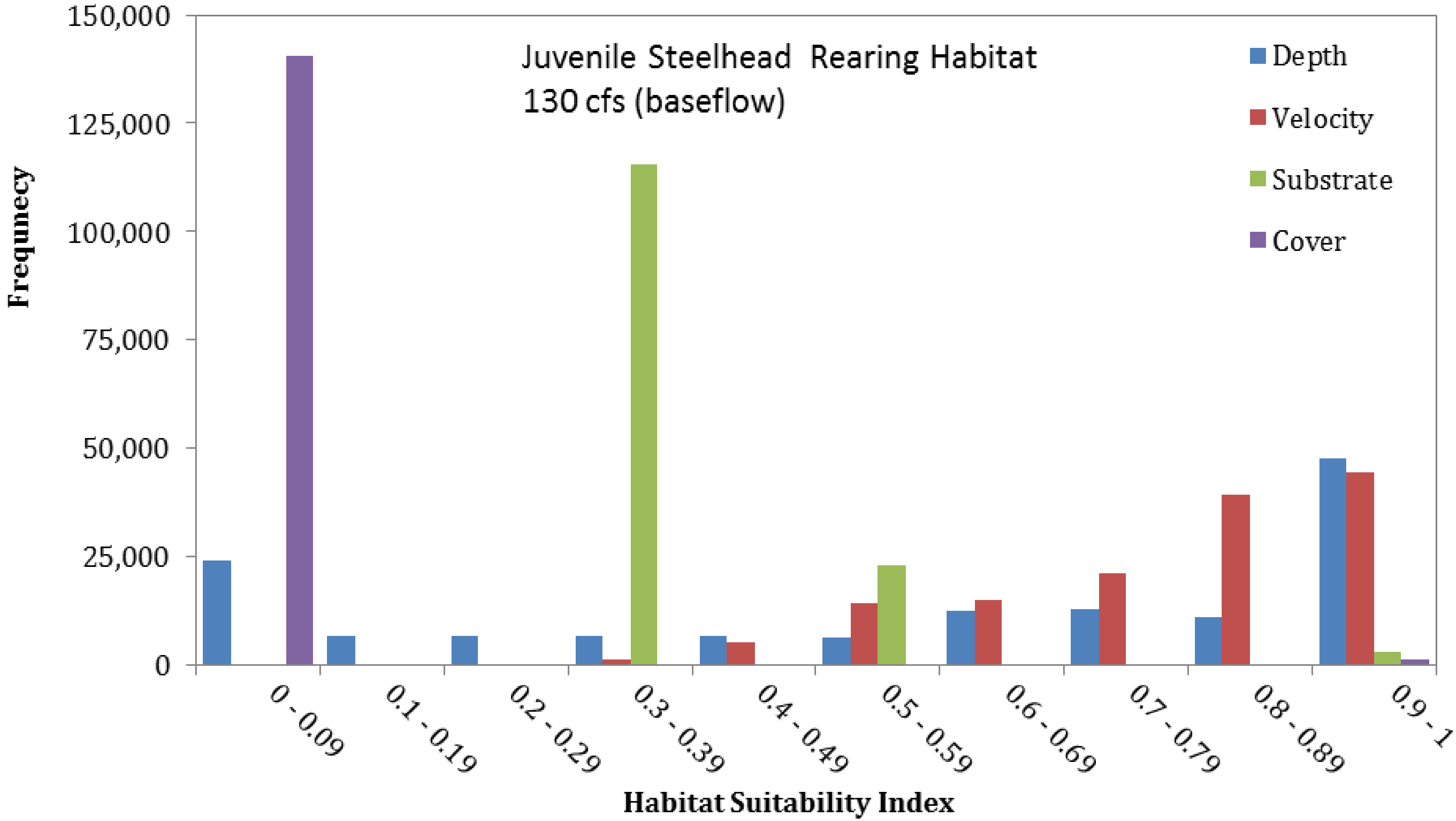
- Depth and velocity are well distributed with most of the study area in the favorable range for habitat suitability
- Substrate is relatively uniform and not very good for rearing habitat
- Cover is uniformly poor
- Cover is extremely limited and index values would benefit substantially from additional cover

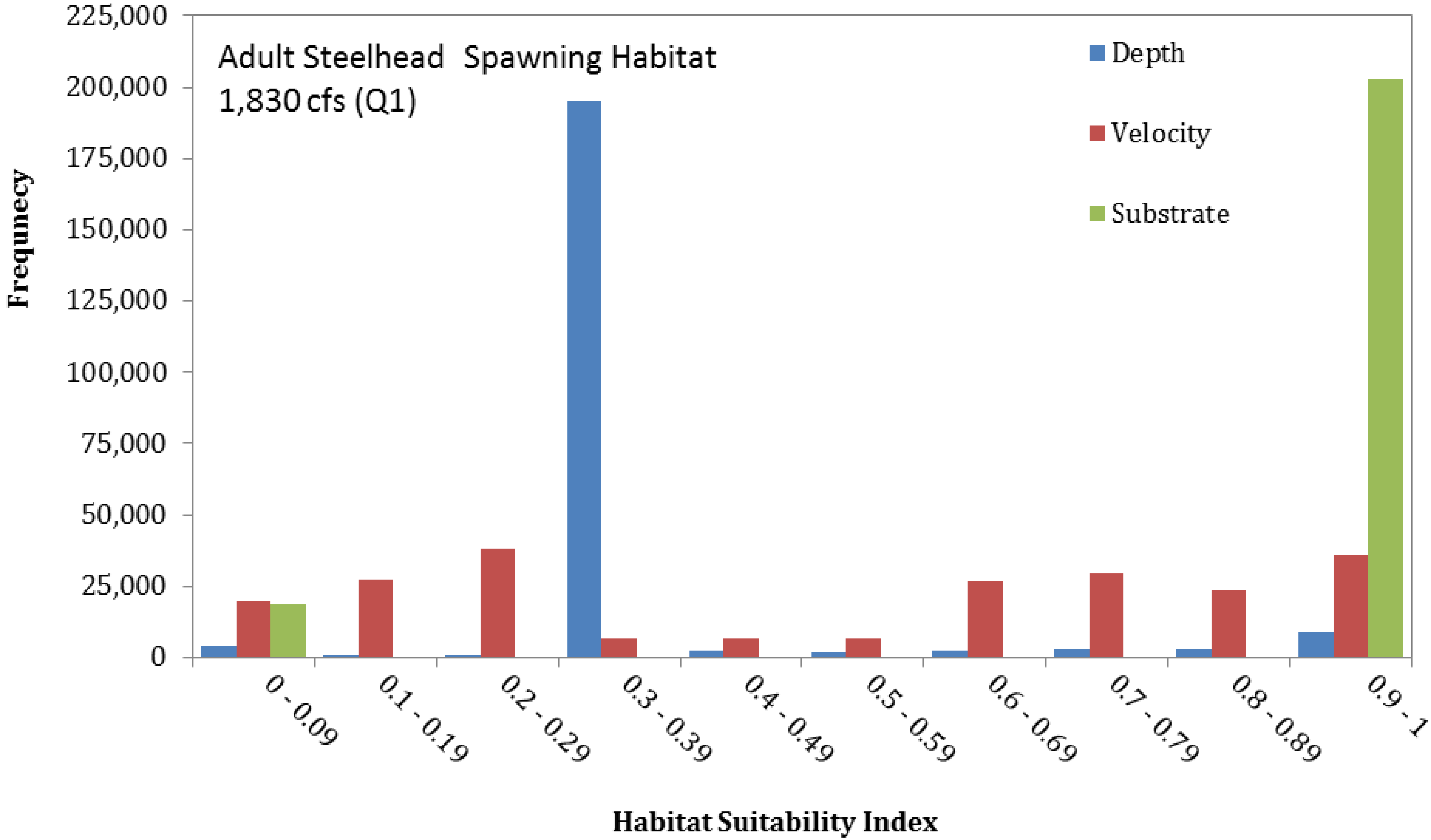
Juvenile steelhead at Q1 (1,830 cfs)

- Generally same results as at baseflow except that velocity is less favorable for rearing habitat
- Limited off-channel refugia
- HSI values for rearing go down at Q1 compared to baseflow
- Project opportunities that create areas of lower velocity with additional cover at Q1 would bump up index values

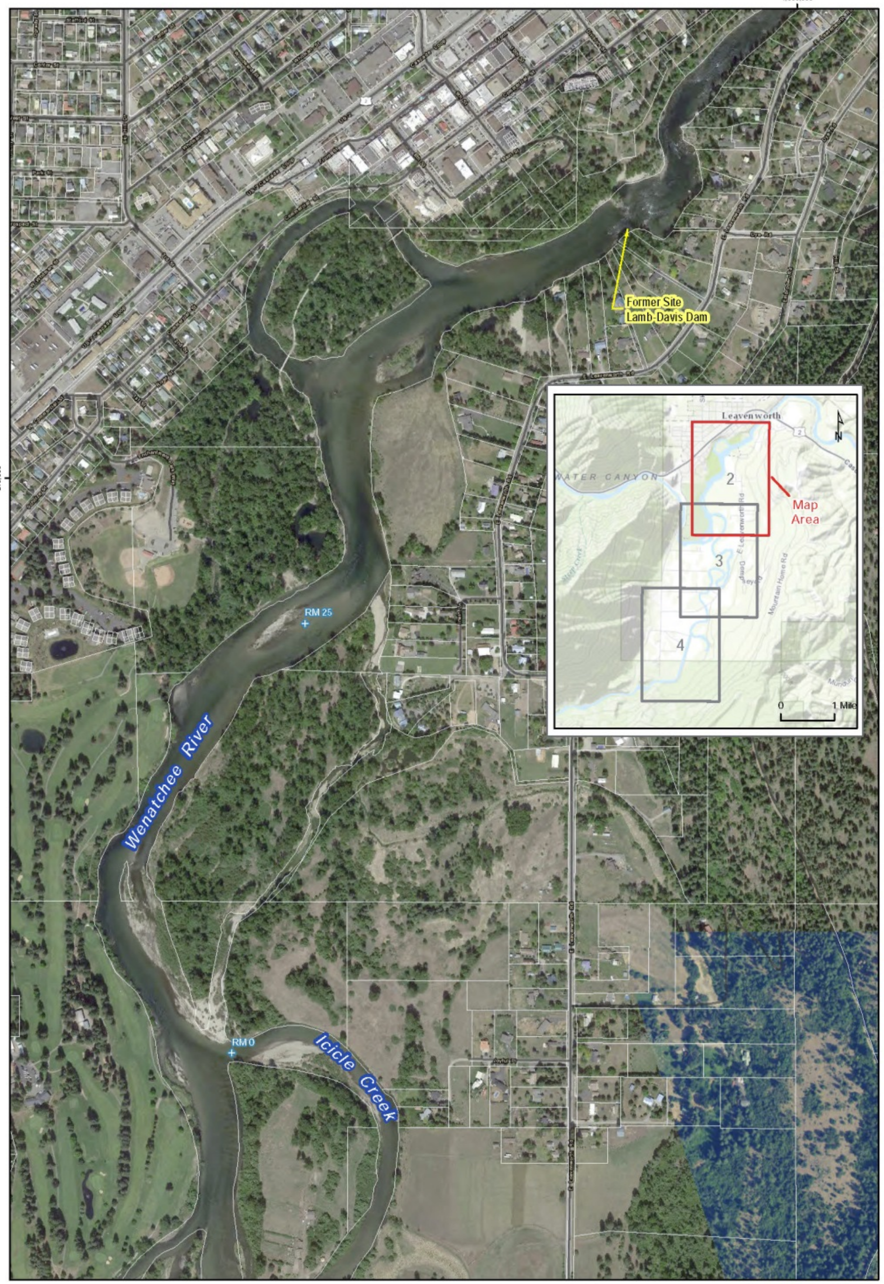
Adult steelhead spawning at Q1 (1,830)

- Substrate is generally favorable for spawning
- Many areas too deep for favorable spawning conditions at this Q
- Velocity well distributed
- Overall, spawning HSI values (~0.5-0.6) are much better than index values for rearing habitat (~0.1-0.2)


Juvenile Steelhead Rearing Habitat
130 cfs (baseflow)
Depth
Velocity
Substrate
Cover
Frequnecy
150,000
125,000
100,000
75,000
50,000
25,000
0
0 - 0.09
0.1 - 0.19
0.2 - 0.29
0.3 - 0.39
0.4 - 0.49
0.5 - 0.59
0.6 - 0.69
0.7 - 0.79
0.8 - 0.89
0.9 - 1
Habitat Suitability Index



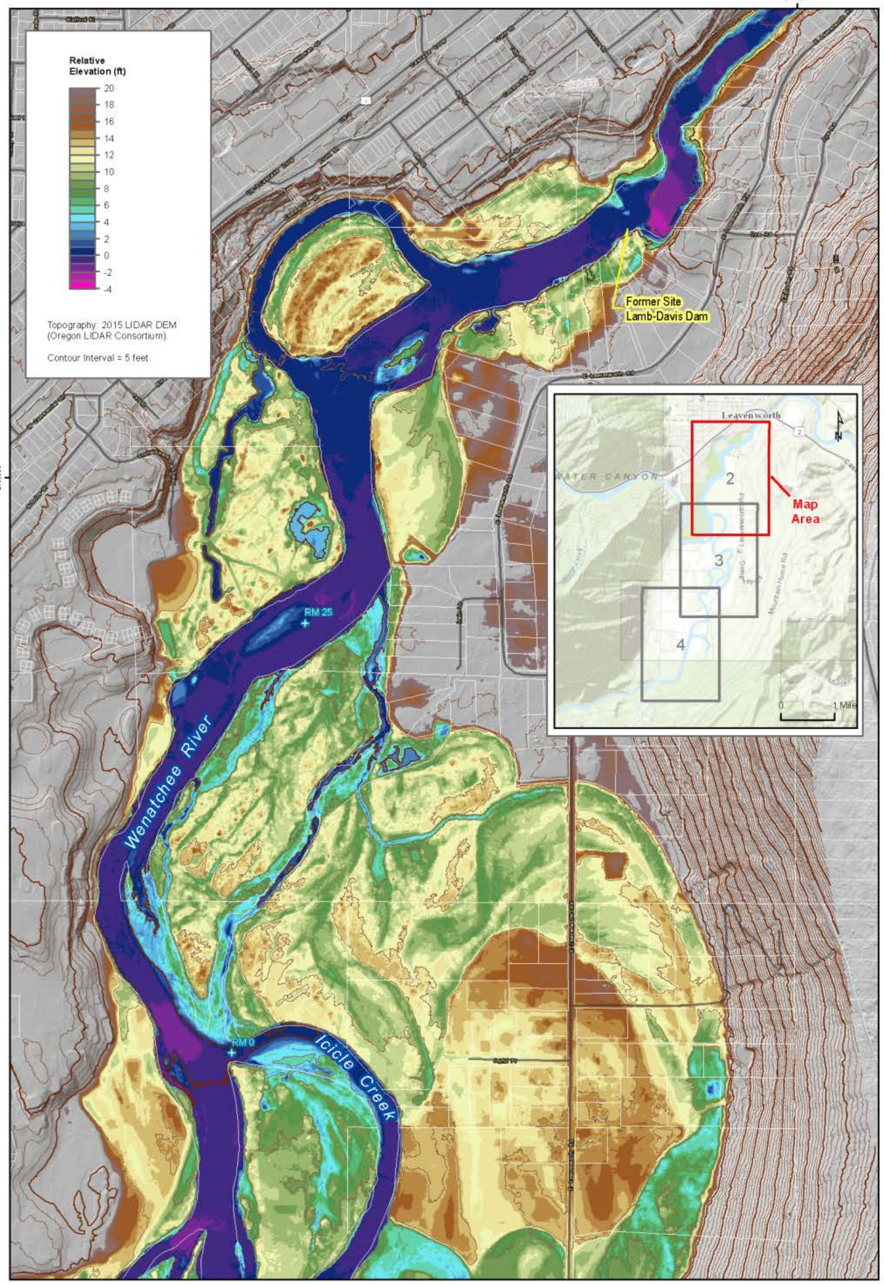
Adult Steelhead Spawning Habitat
1,830 cfs (Q1)
Depth
Velocity
Substrate
Frequnecy
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
0
0 - 0.09
0.1 - 0.19
0.2 - 0.29
0.3 - 0.39
0.4 - 0.49
0.5 - 0.59
0.6 - 0.69
0.7 - 0.79
0.8 - 0.89
0.9 - 1
Habitat Suitability Index



Icicle Creek
2015 Aerial Image - Map 2

0 500 1,000 1,500 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design



Icicle Creek
Relative Elevation Map 2

0 500 1,000 1,500 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design

Icicle Creek
2015 Aerial Image - Map 3

0 500 1,000 1,500 Feet
Lambert conformal conic projection, NAD 1983
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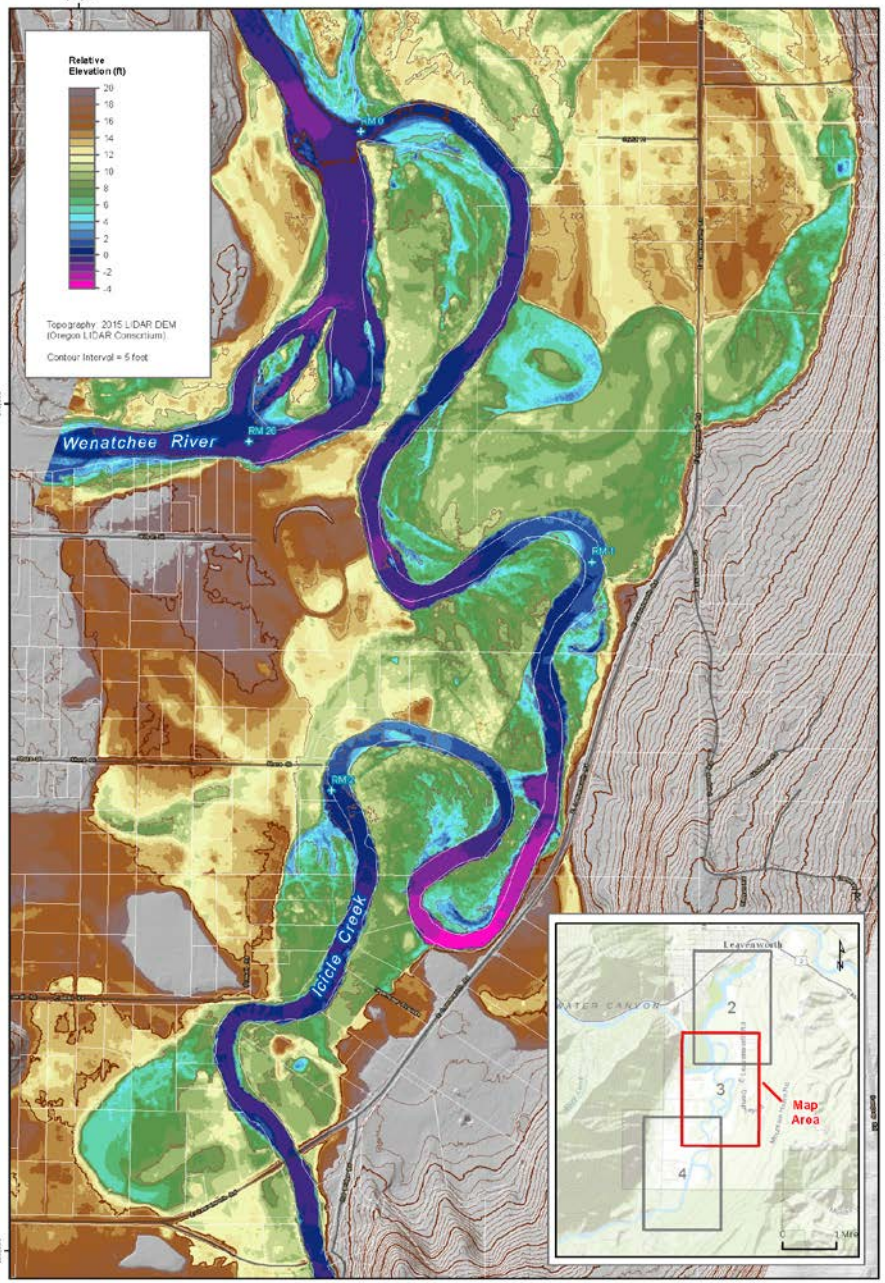
Natural Systems Design



Icicle Creek
Relative Elevation Map 3

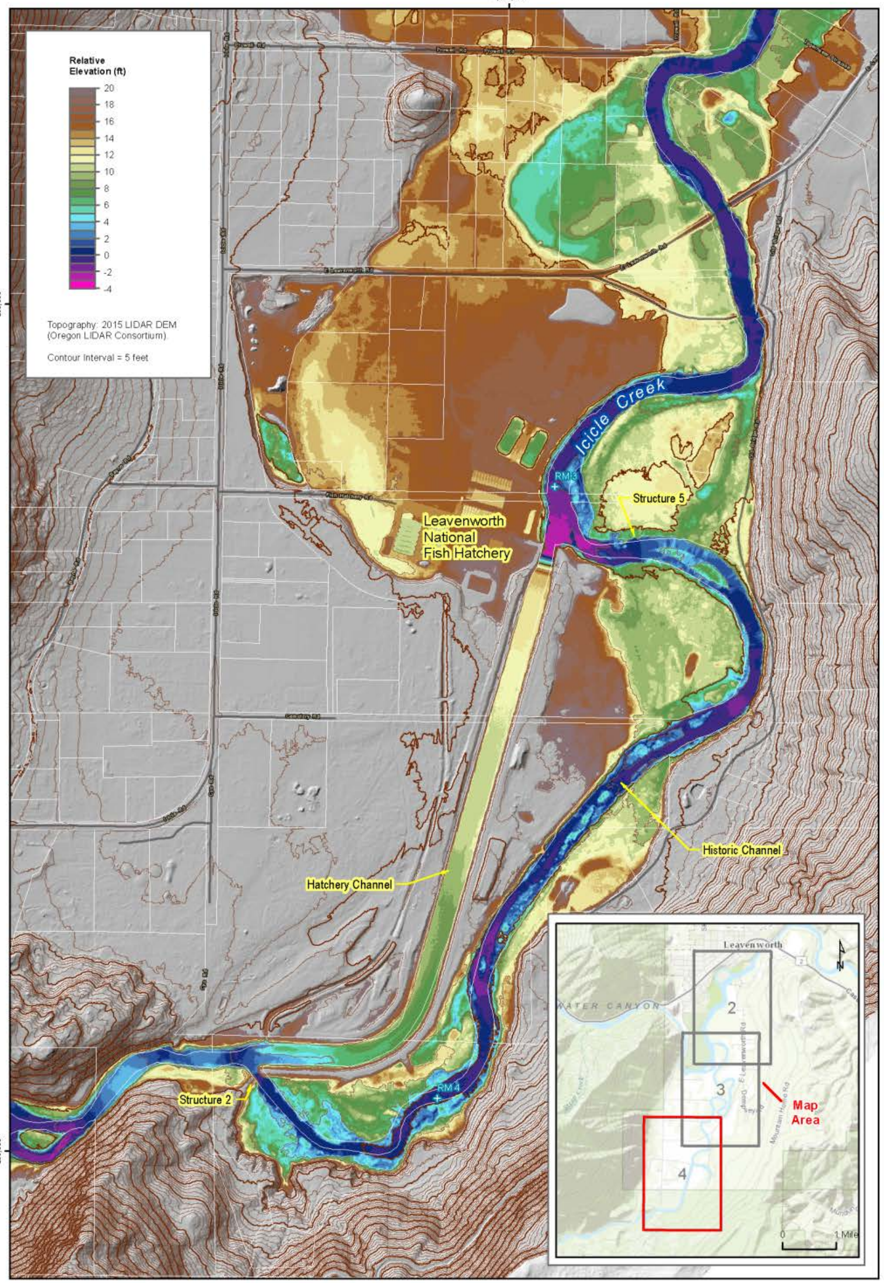
0 500 1,000 1,500 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

Natural Systems Design

Icicle Creek
2015 Aerial Image - Map 4

0 500 1,000 1,500 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

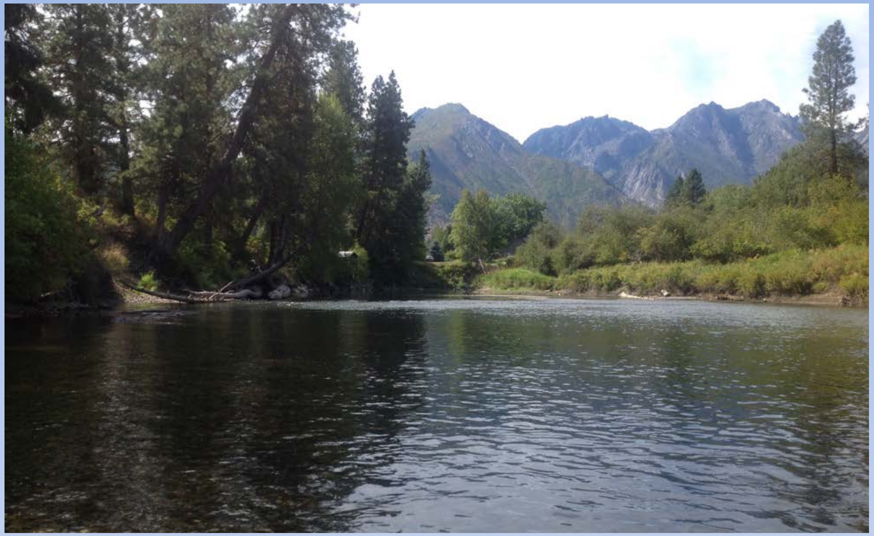
Natural Systems Design



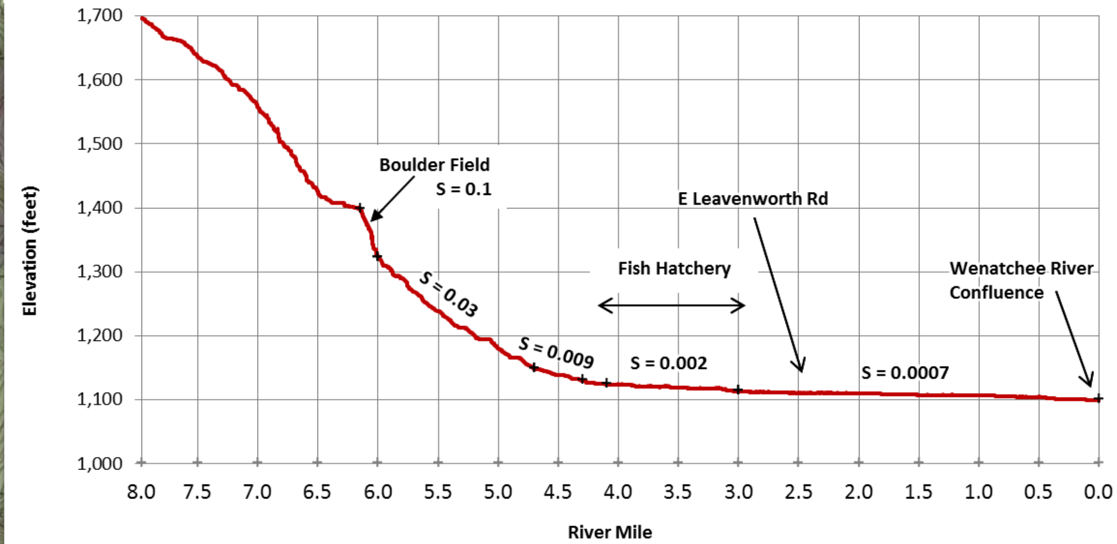
Icicle Creek
Relative Elevation Map 4

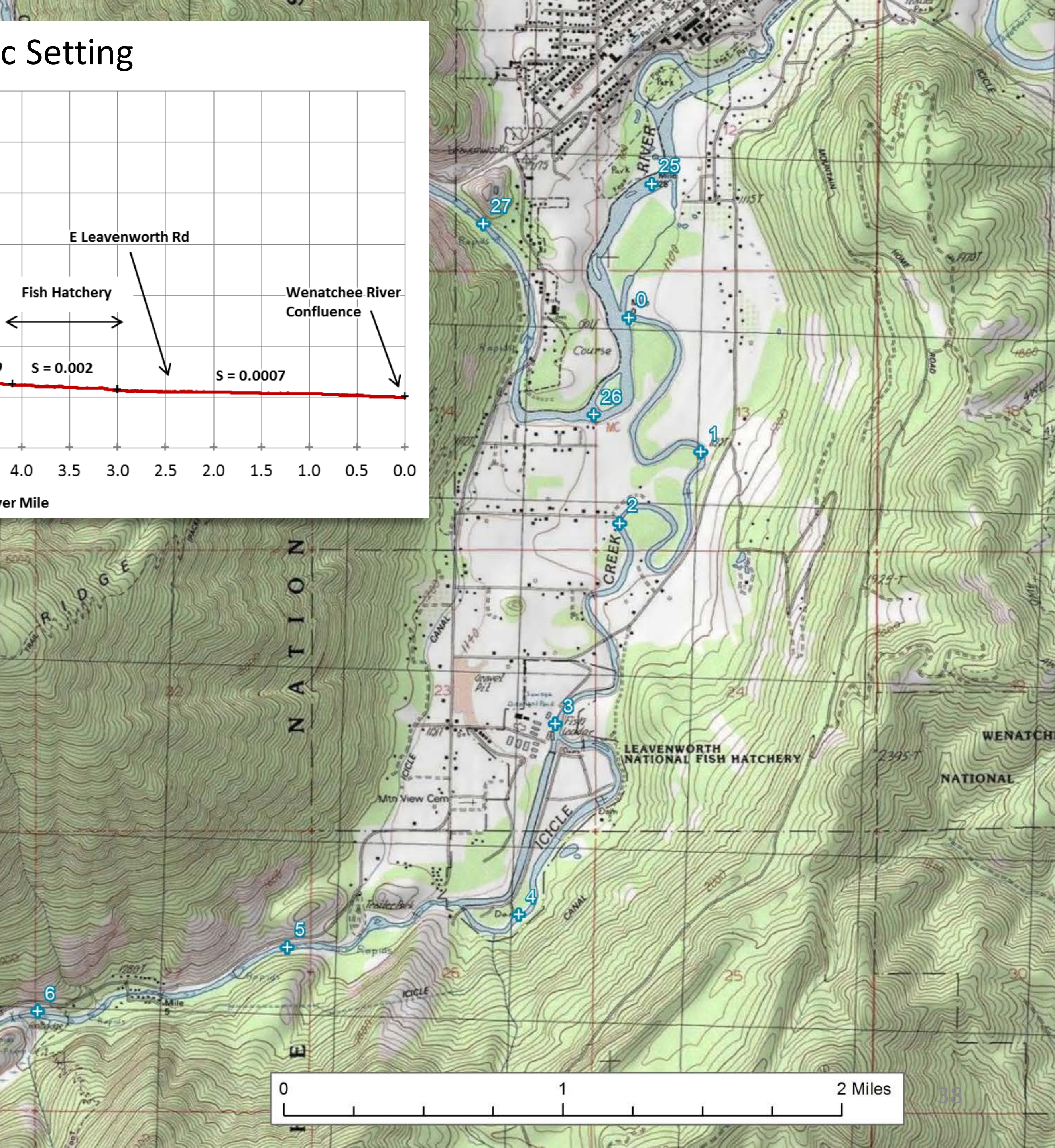
0 500 1,000 1,500 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

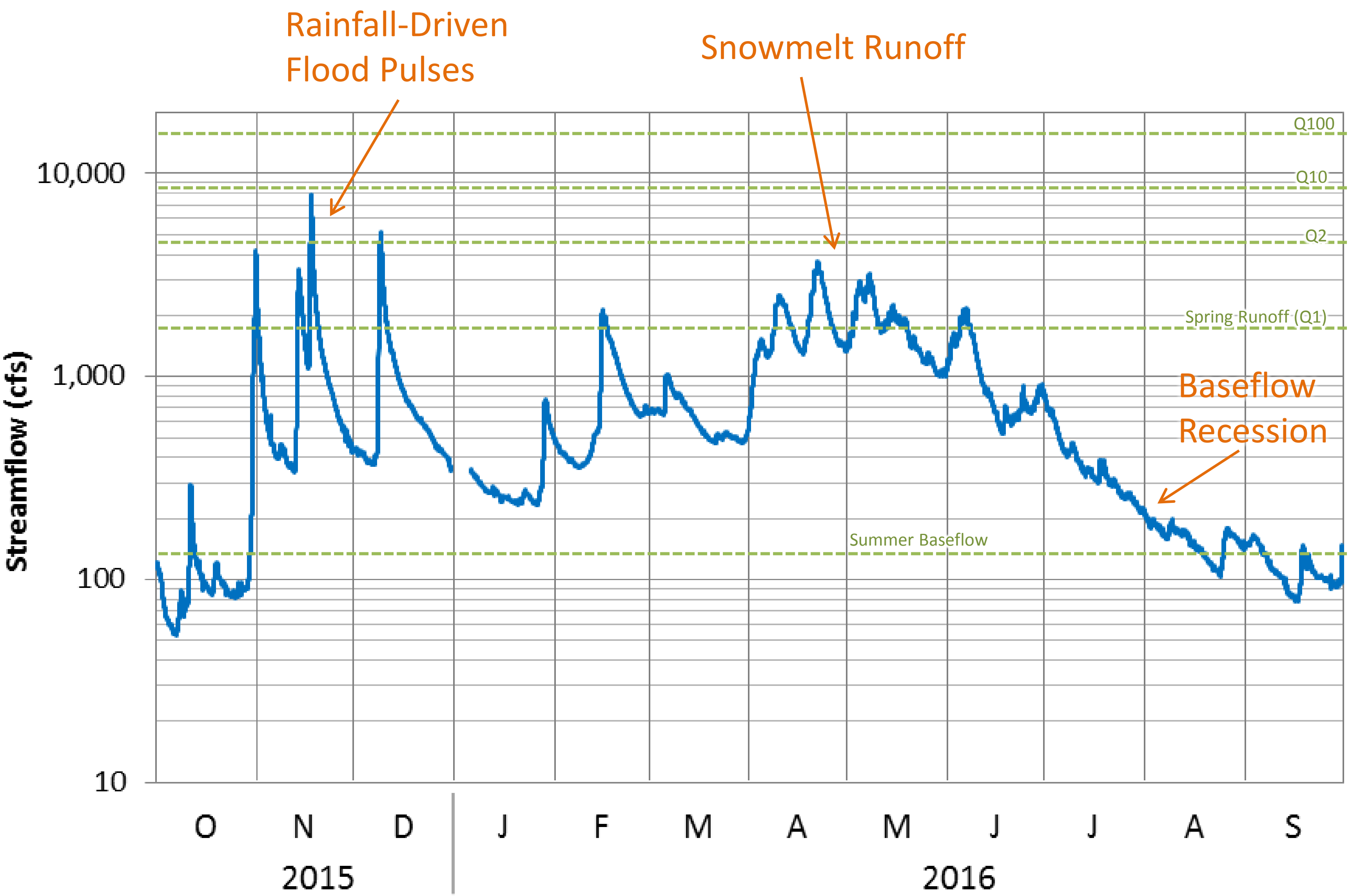
Natural Systems Design

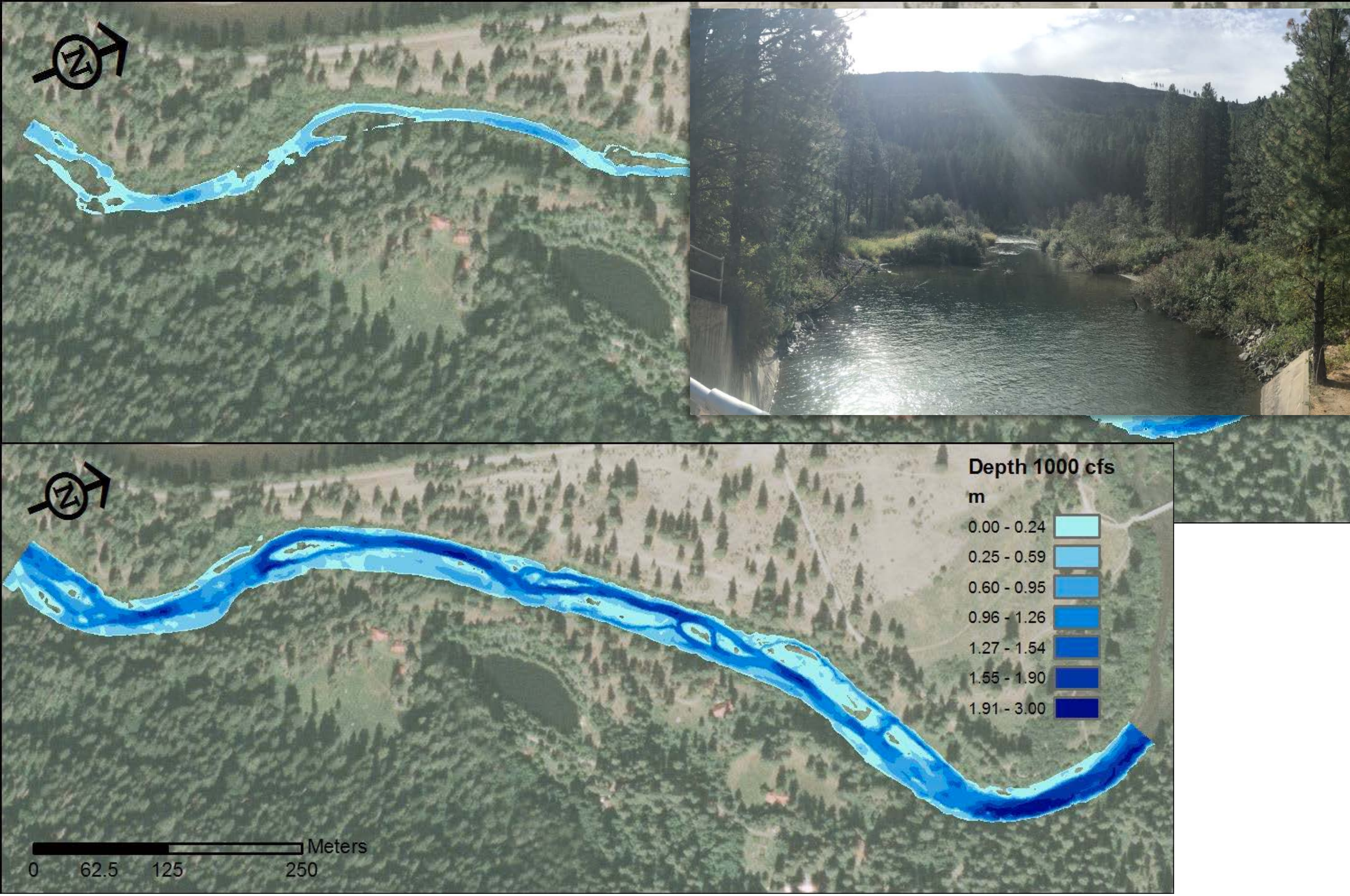


Geomorphic Setting



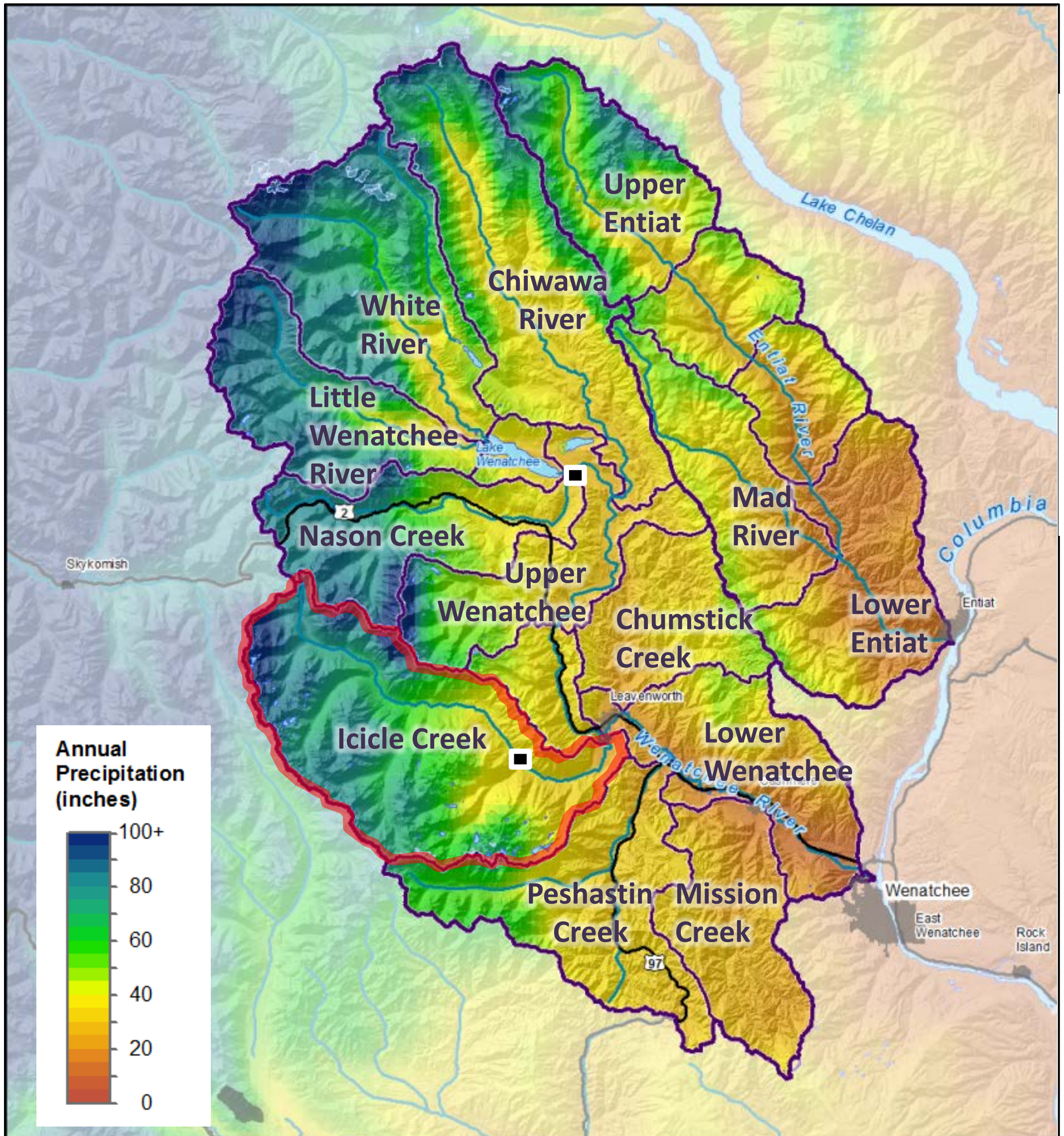



Rainfall-Driven Flood Pulses
Snowmelt Runoff
Baseflow Recession
Q100
Q10
Q2
Spring Runoff (Q1)
Summer Baseflow
Streamflow (cfs)
10,000
1,000
100
10
O
N
D
J
F
M
A
M
J
J
A
S
2015
2016

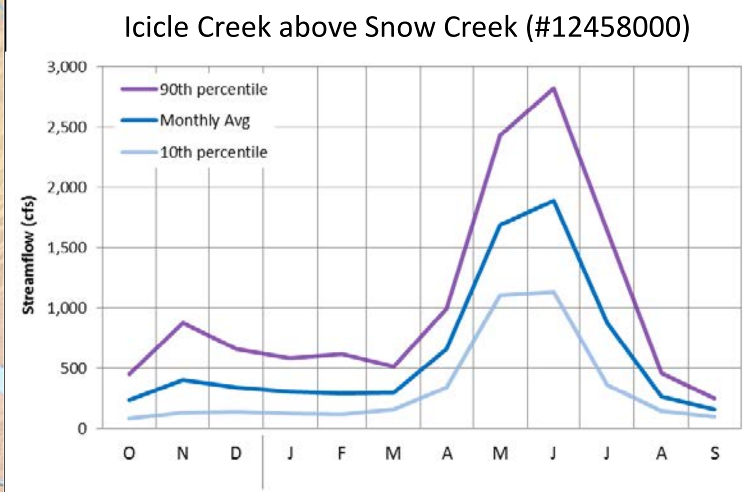


Skalicky, J.J., Hines, D., Anglin, D., Jones, N., 2013. Icicle Creek Instream Flow and Fish Habitat Analysis for the Leavenworth National Fish Hatchery, U.S. Fish and Wildlife Service.

Hydrologic Regime

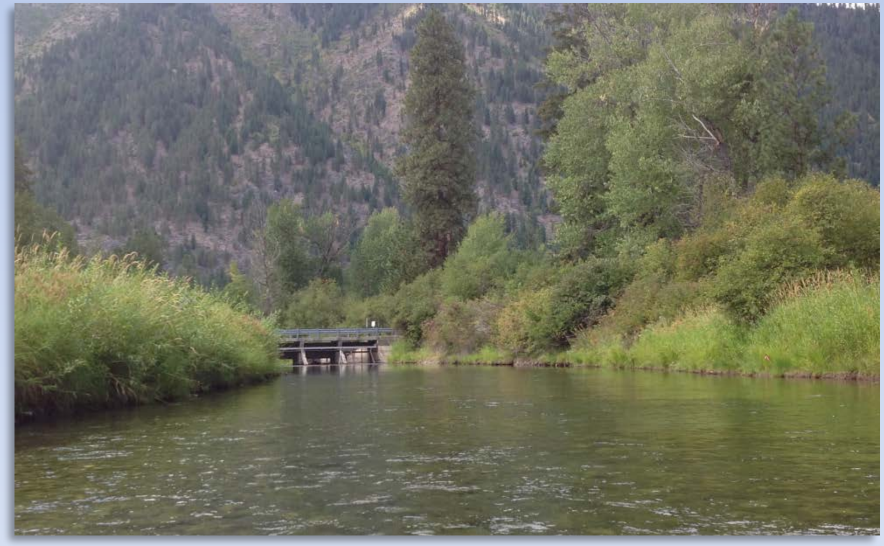


Data source: PRSIM (2013)



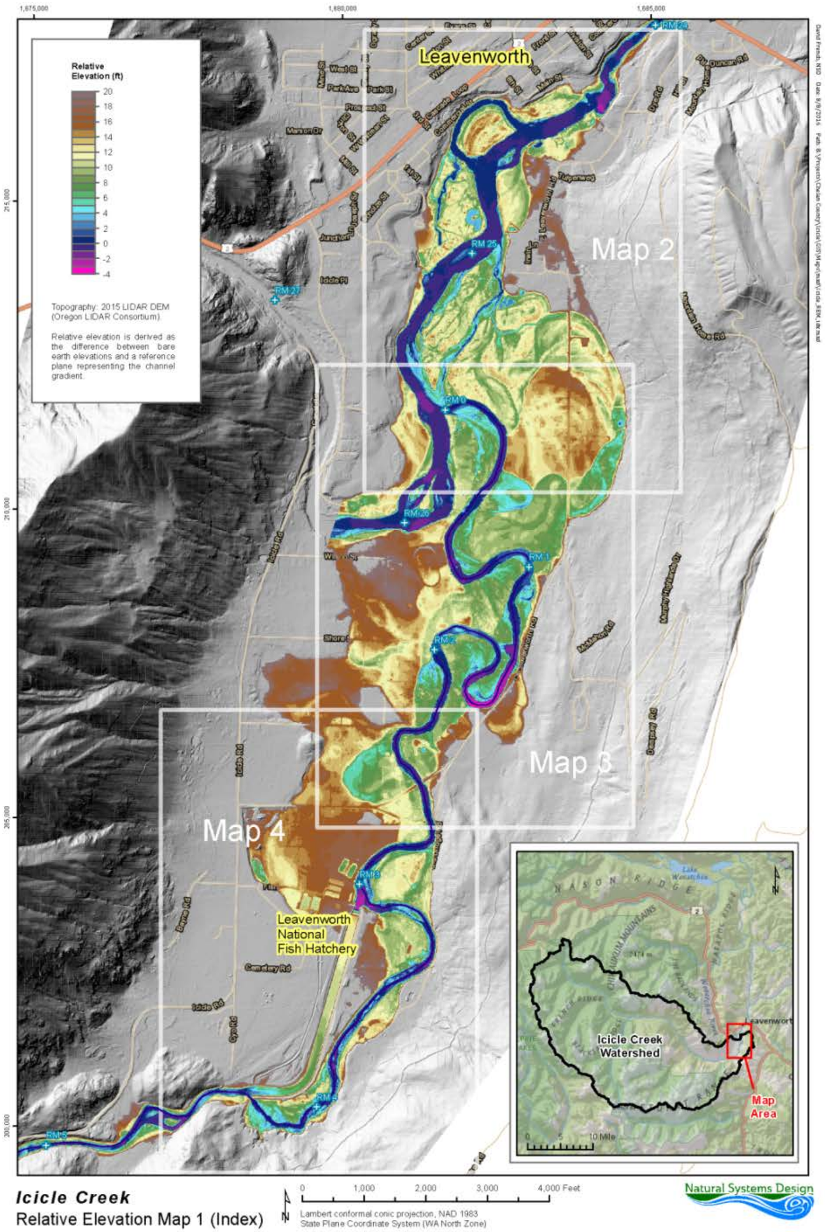
Flood frequency statistics calculated for at USGS gage #12458000.

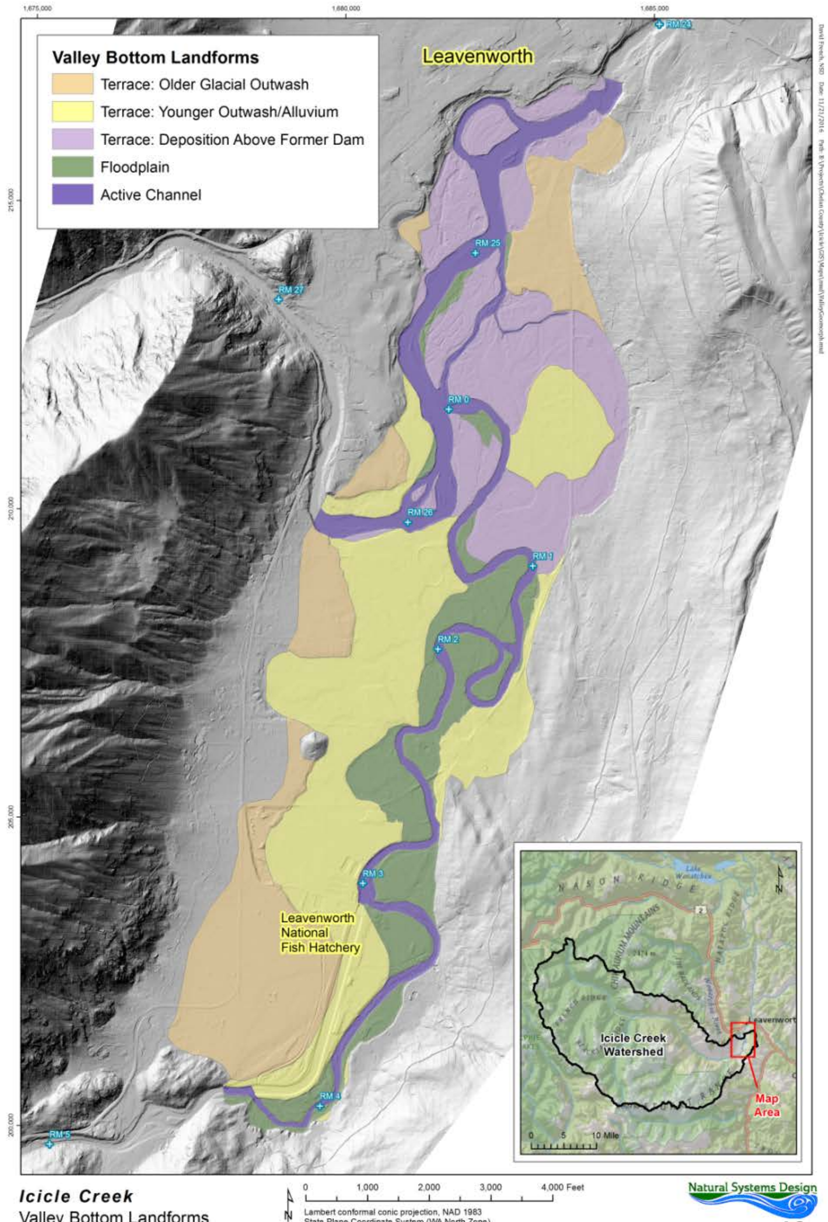
RECURRENCE INTERVAL (YEARS)	PEAK FLOW (CFS)
1.01	1,960
1.25	3,160
2	4,450
5	6,600
10	8,290
25	10,770
50	12,880
100	15,230

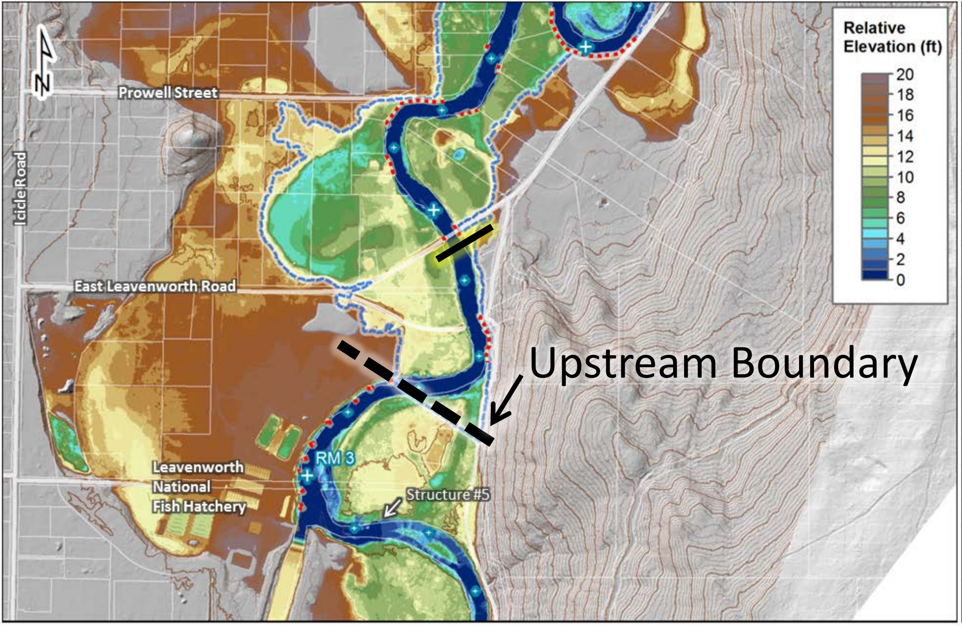


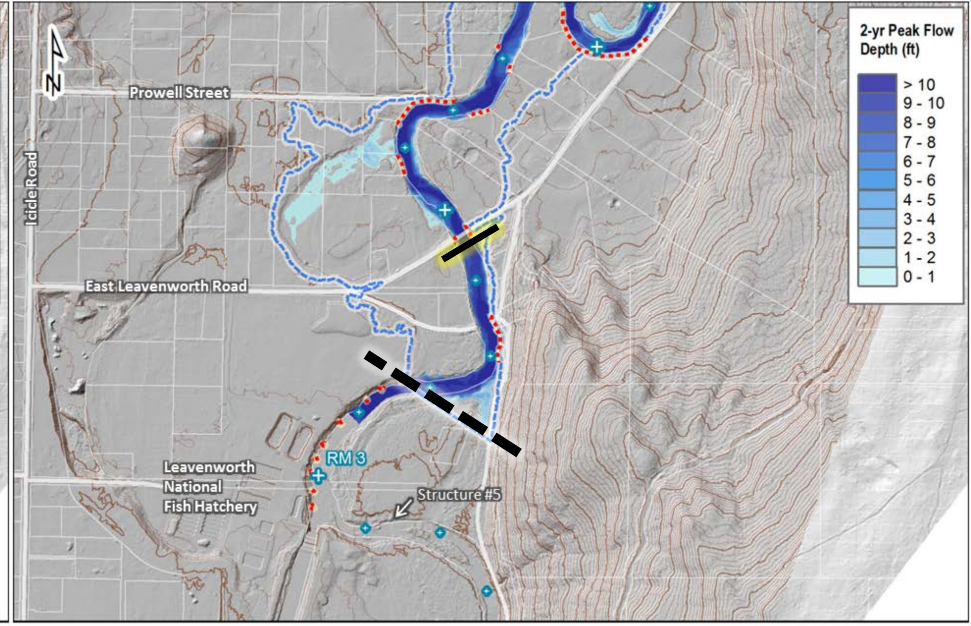

Sediment Dynamics

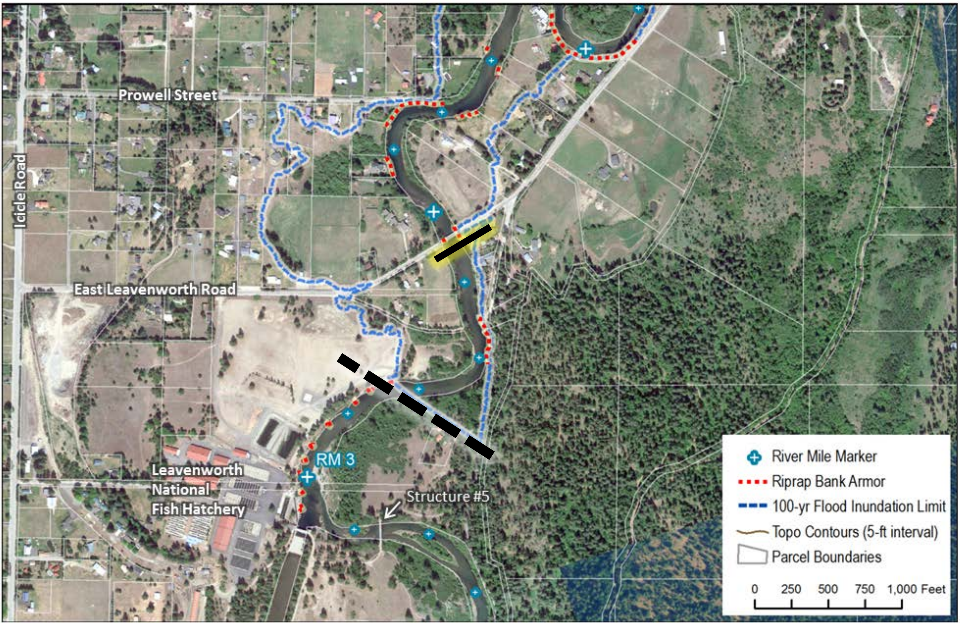
Overview - Valley Topography and Landforms

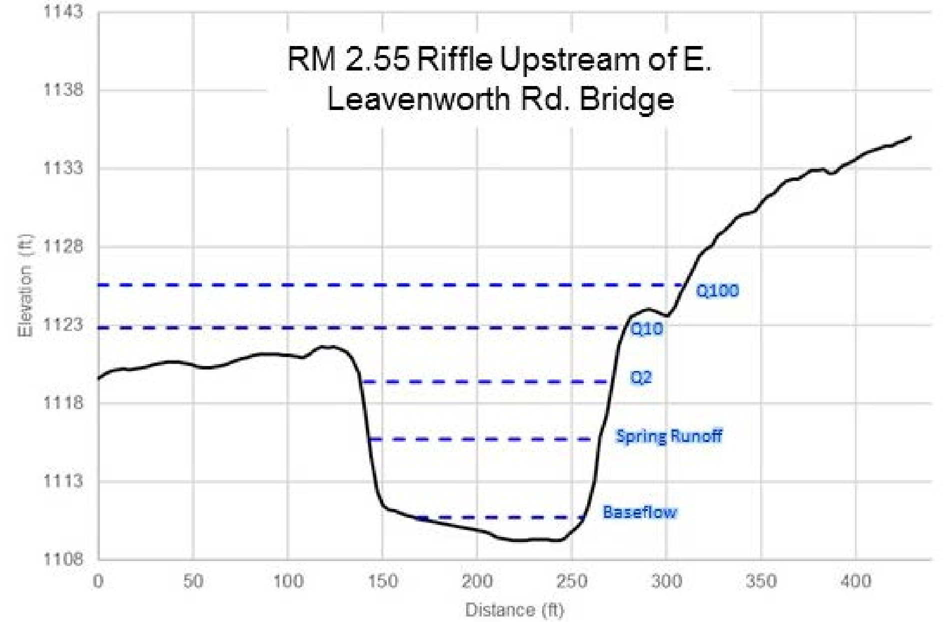


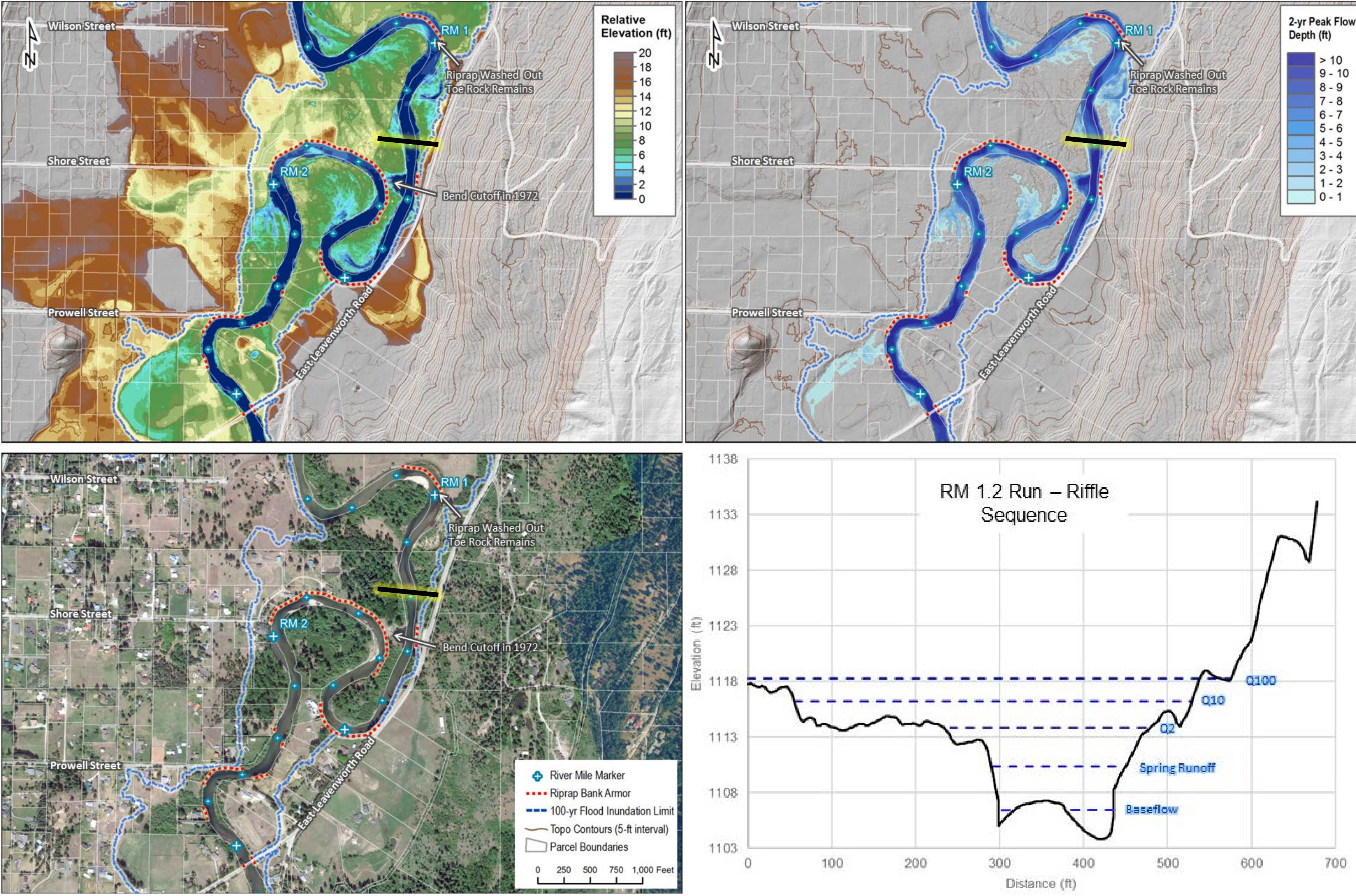



Relative Elevation (ft)
20
18
16
14
12
10
8
6
4
2
0
Prowell Street
Icicle Road
East Leavenworth Road
Upstream Boundary
RM 3
Leavenworth National Fish Hatchery
Structure #5


2-yr Peak Flow Depth (ft)
> 10
9 - 10
8 - 9
7 - 8
6 - 7
5 - 6
4 - 5
3 - 4
2 - 3
1 - 2
0 - 1
Prowell Street
Icicle Road
East Leavenworth Road
RM 3
Leavenworth National Fish Hatchery
Structure #5


Prowell Street
Icicle Road
East Leavenworth Road
RM 3
Leavenworth National Fish Hatchery
Structure #5
River Mile Marker
Riprap Bank Armor
100-yr Flood Inundation Limit
Topo Contours (5-ft interval)
Parcel Boundaries
0 250 500 750 1,000 Feet


RM 2.55 Riffle Upstream of E. Leavenworth Rd. Bridge
Elevation (ft)
Distance (ft)
1143
1138
1133
1128
1123
1118
1113
1108
0
50
100
150
200
250
300
350
400
Q100
Q10
Q2
Spring Runoff
Baseflow



River Mile 1.2