

ALLUVIAL FAN HYDROPERIOD AS A CONTROL ON MIGRATORY FISH PASSAGE

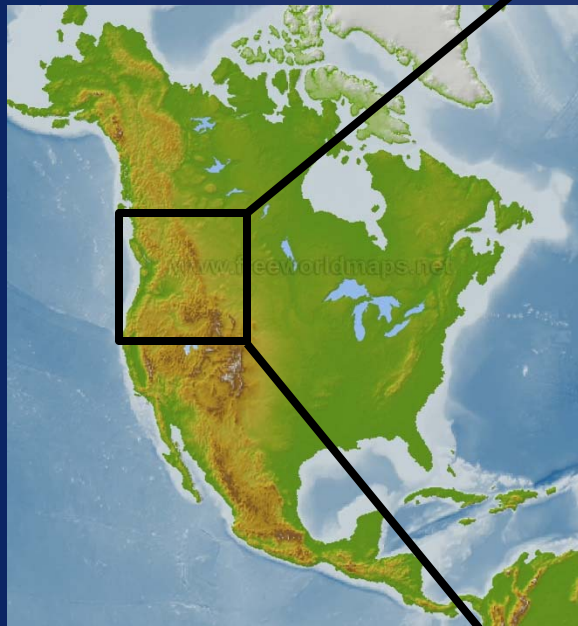
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Klickitat Field Office, Wahkiacus, Washington

Presented to:
5th International Conference on Alluvial Fans
Nov. 30 – Dec. 4, 2015
University of Canterbury, Christchurch, New Zealand

Presentation Outline

- Regional background
- Origins & objectives
- Preliminary findings
 - Integration of fisheries and hydrologic data
 - Using geospatial info to develop a profile 'rating'
- Contrast two tributary watersheds & fans

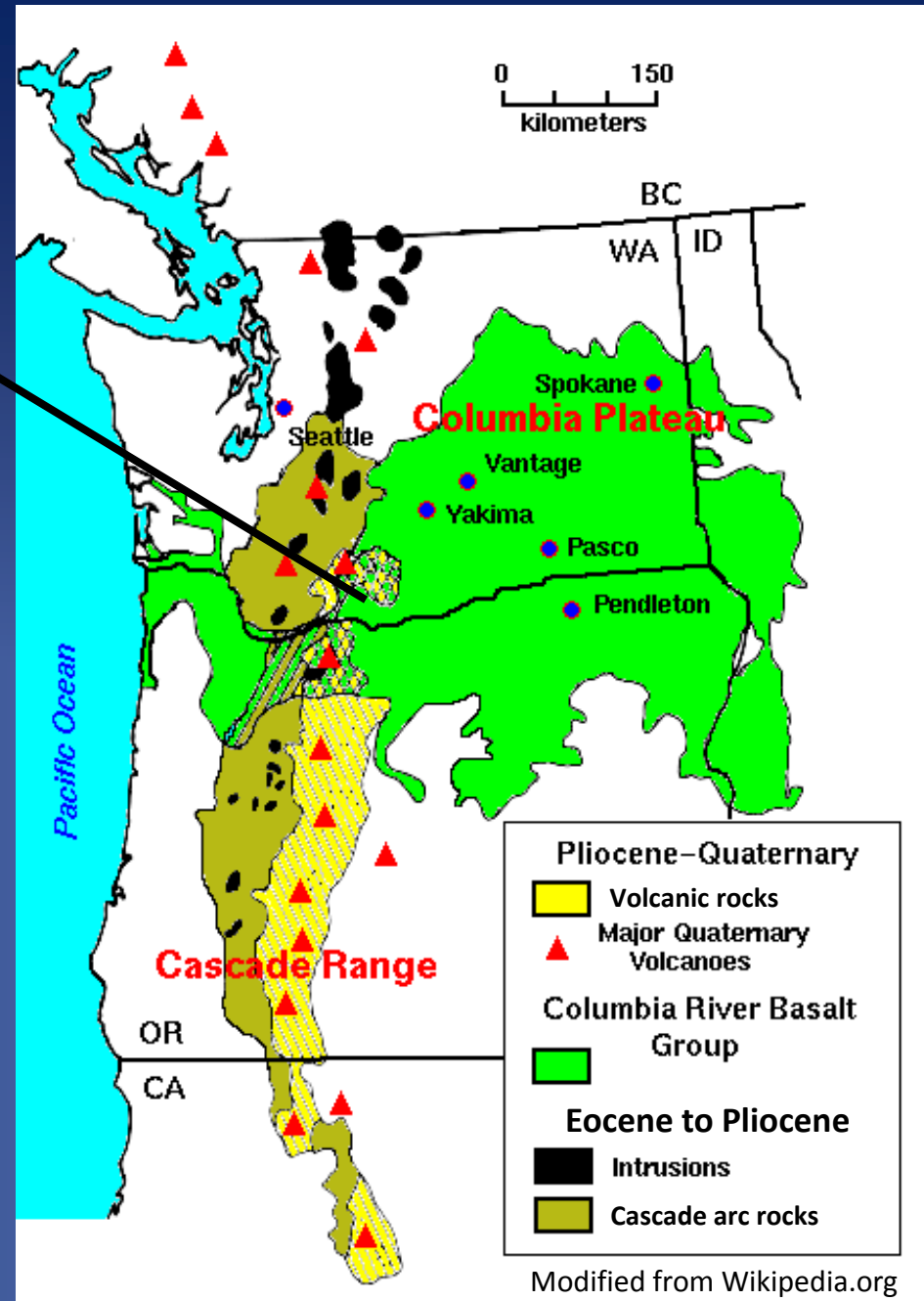
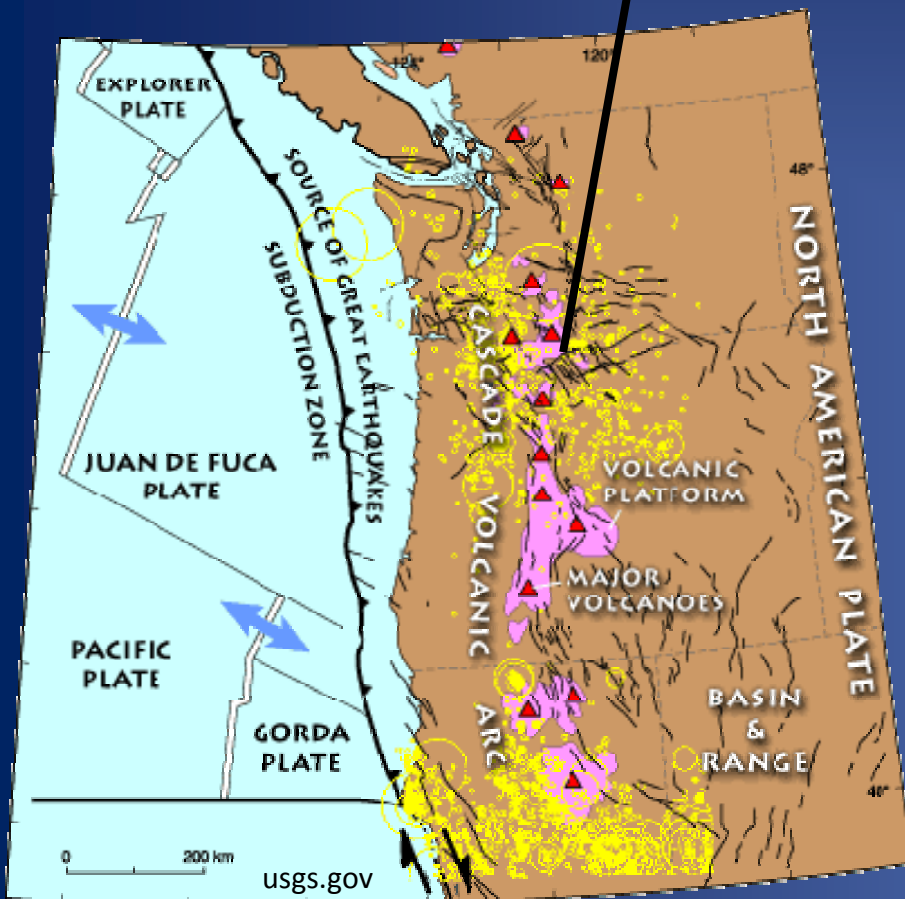
Columbia River Basin



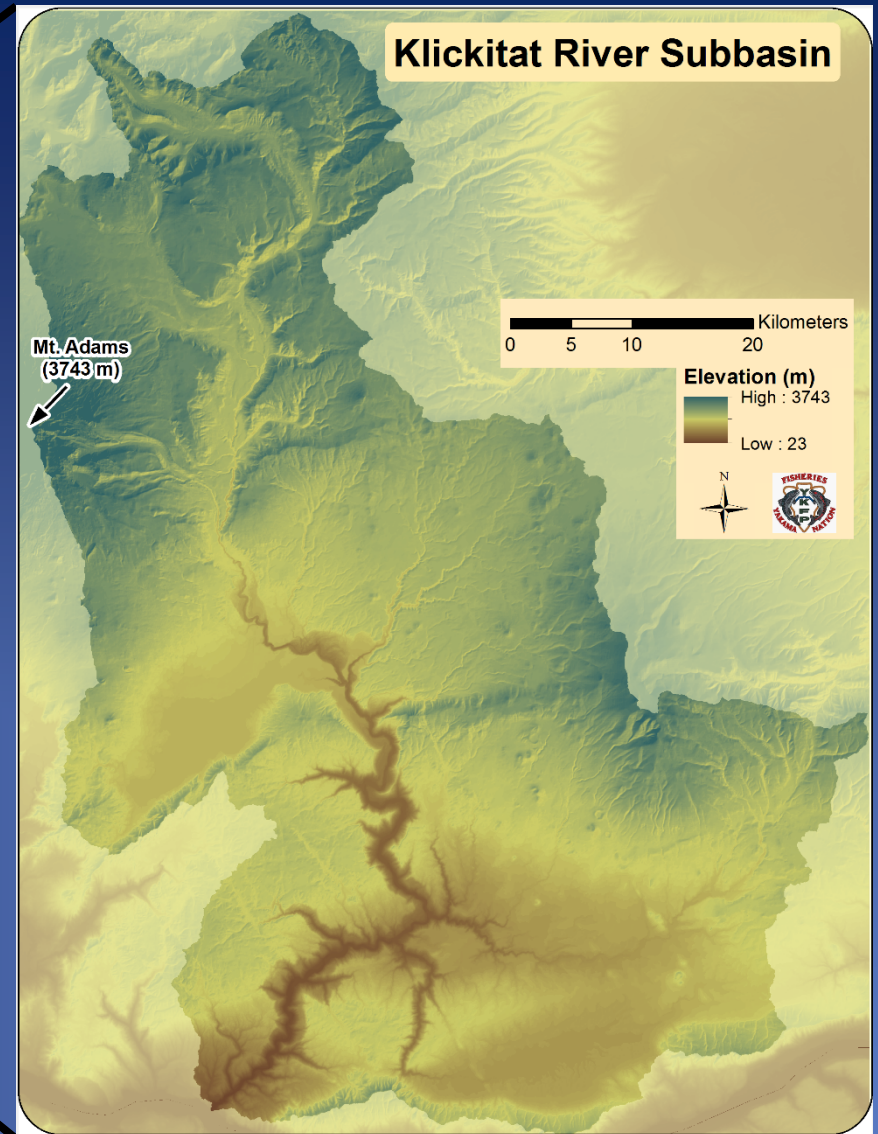
- Drains 671,000 km² (259,100 mi²) of 1 Canadian province and 7 U.S. states
- Average discharge at the mouth of about 7,500 m³/s (265,000 cfs)

Regional Geology

Klickitat Subbasin



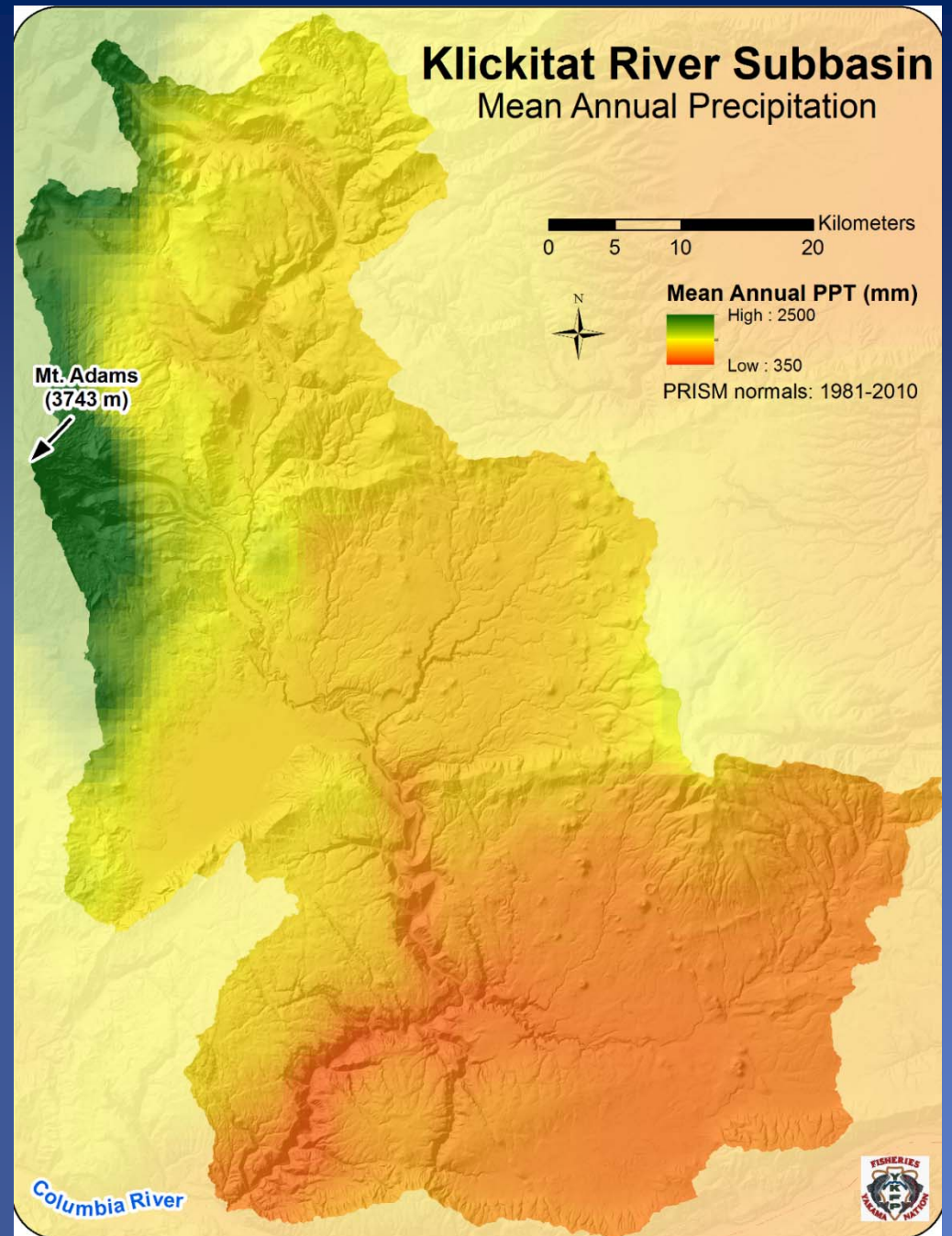
Klickitat River Subbasin



- south-central Washington State
- drainage area: 3,501 km² (1,352 mi²)
- mean annual Q: 41.9 m³/s (1,479 cfs)
- Columbia River Tributary at river-km 290.3 (river-mile 180.4)
- 55.2 km (34.3 mi) upstream of Bonneville Dam

Sharp Ecological Gradients

- Elevational
(north to south)
- Rain shadow of
Cascade Mtns
(west to east)



Klickitat Subbasin Fisheries Context

- Anadromous *Oncorhynchus mykiss* (aka “steelhead”) listed as Endangered Species Act “Threatened”
- Steelhead, salmon, and other fish species have very high cultural importance to Yakama People
- 7 of 10 tributaries supporting steelhead use in lower 45 miles are seasonally disconnected at mouth (subsurface flow through alluvial fans)

Qualitative Origins

- 1990s – “stranding” of salmonids observed annually in seasonal stream reaches
- 1990s to early 2000s – annual fish rescues in tributary alluvial fan reaches
 - captured and relocated salmonids that would otherwise perish
 - routinely found species that had swam upstream into tributary
- 2001 and 2005 (drought years) suggested, in some years:
 - discharges suitable for adult in-migrants might not occur for some tributary fans
 - cumulative duration of flows suitable for juvenile out-migrants might be measured in hours or several days

A composite of multiple monitoring efforts:

Goal: Quantify streamflow characteristics for tributary watersheds inhabited by migratory salmonids

Goal: Document a baseline of fish migration linkages in seasonally disconnected tributaries

Objectives

- Document stream hydrology to:
 - characterize environmental “envelope” for migratory behaviors
 - Inform modeling of channel processes
- Quantify the proportion of *O. mykiss* displaying anadromy
- Document temporal fish movements and identify patterns

Instrumentation – Fisheries



- Each PIT tagged fish geo-referenced
- Each detection record includes date and time stamp
- At least 2 antennae per stream (directionality)
- Solar powered to reduce site maintenance

PIT Tag Methods

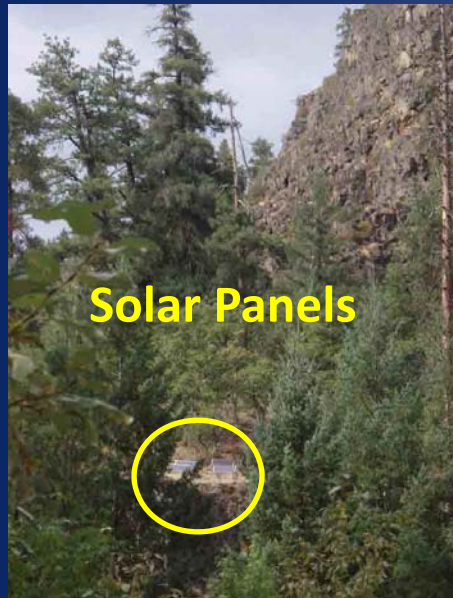


PIT Tag



Data Output

	01	05/12/10	10:11:42	3D9.1C2CBC4456	FF 02
	01	05/12/10	10:17:32	3D9.1C2CBC4456	FF 04
	01	05/12/10	10:19:30	3D9.1C2CBC4456	FF 06



Instrumentation – Hydrology

- INW PT2X pressure-transducers
 - stage and temperature in 15 minute increments
 - on-board data logger
 - vented cable



Instrumented Fans - Periods of Record

<u>Watershed</u>	<u>Stream Gage</u>		<u>PIT Tag Array</u>	
	<u>From</u>	<u>To</u>	<u>From</u>	<u>To</u>
Dillacort Cr*	1/14/2014	Present	12/11/2013	Present
Logging Camp Cr*	1/24/2013	Present	10/15/2012	Present
Snyder Cr*	10/14/2014	Present	11/03/2014	Present
Summit Cr	3/31/2007	Present	10/31/2014	Present
Swale Cr*	4/18/2006	Present	11/21/2013	Present
Wheeler Cr*	4/13/2013	Present	4/16/2012	Present
White Cr	4/3/2007	Present	08/01/2009	Present

* Seasonally disconnected from Klickitat River

Oncorhynchus mykiss

- Also known as rainbow trout
- As a species, exhibits very high diversity of life histories
- High phenotypic plasticity

Adult Migrant

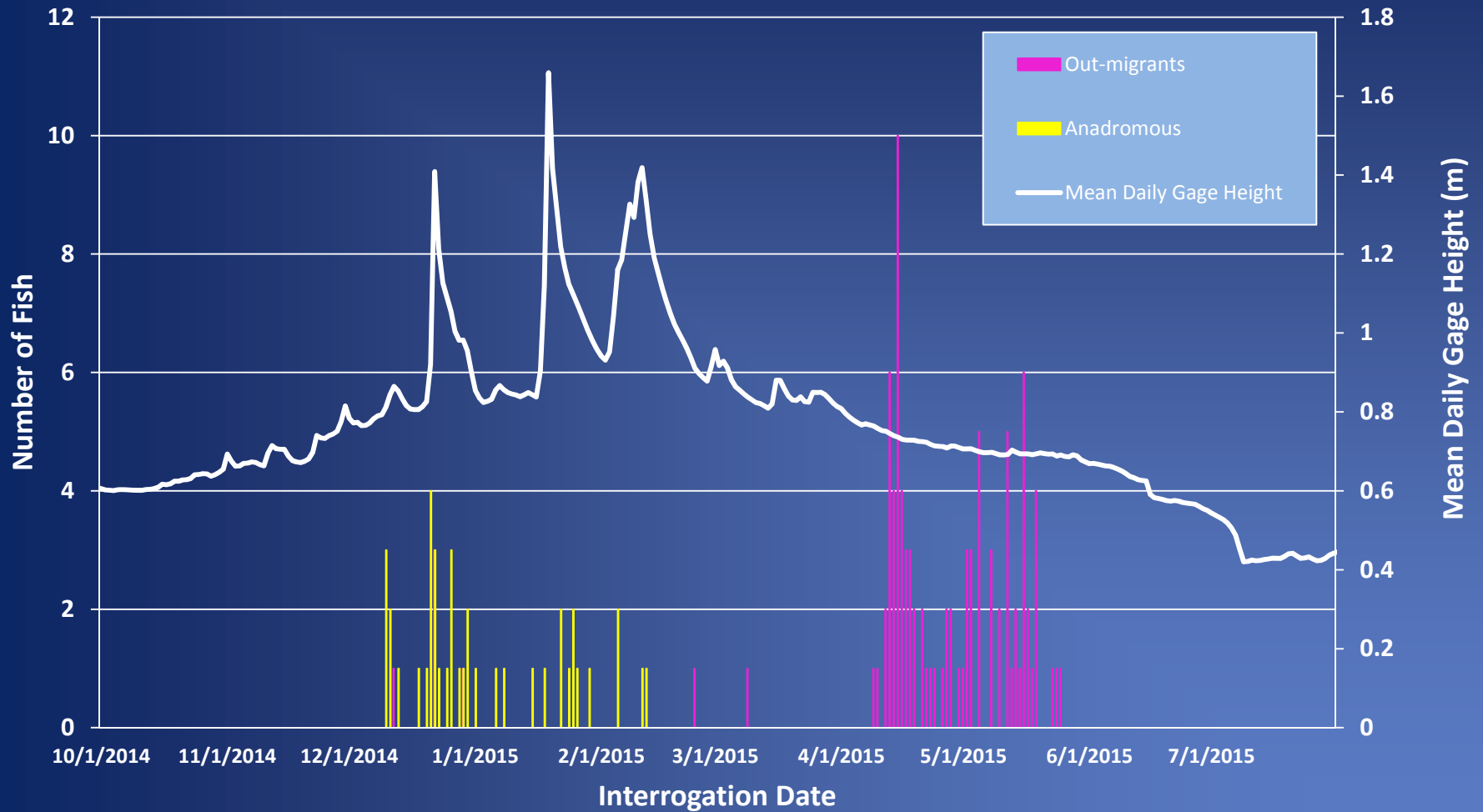


Juvenile Migrant



Integrating Hydrology and Fisheries Data

Swale Creek WY2015



Flow Distribution 'Rating'

- Intent: correlates gage height with surface flow conditions that are not distributed uniformly along fan profile
- Function: facilitates development of a continuous time series of profile conditions based on gage records
- Field Method: series of repeat field surveys at different discharges during late-spring (drying)
 - Trimble GeoXT6000 GPS (~0.5-1.5m acc.)
 - Gage height noted
 - Same length of stream walked
- Office Method: develop 'rating' table
 - Use field data and proxy records
 - Develop index of surface flow state
 - Assign an flow state index value to each channel unit for each gage record
 - 1.34 million records per 9-months of hourly data for a 610m (2,000') segment in 3.0m (10') units



Likely passable to all life stages



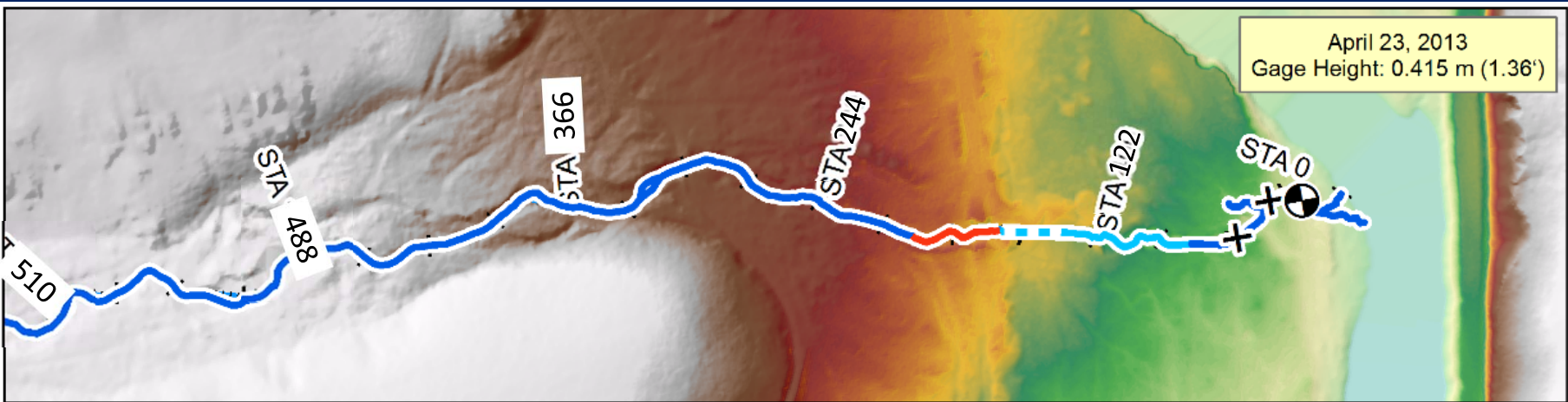
Generally passable to juveniles only



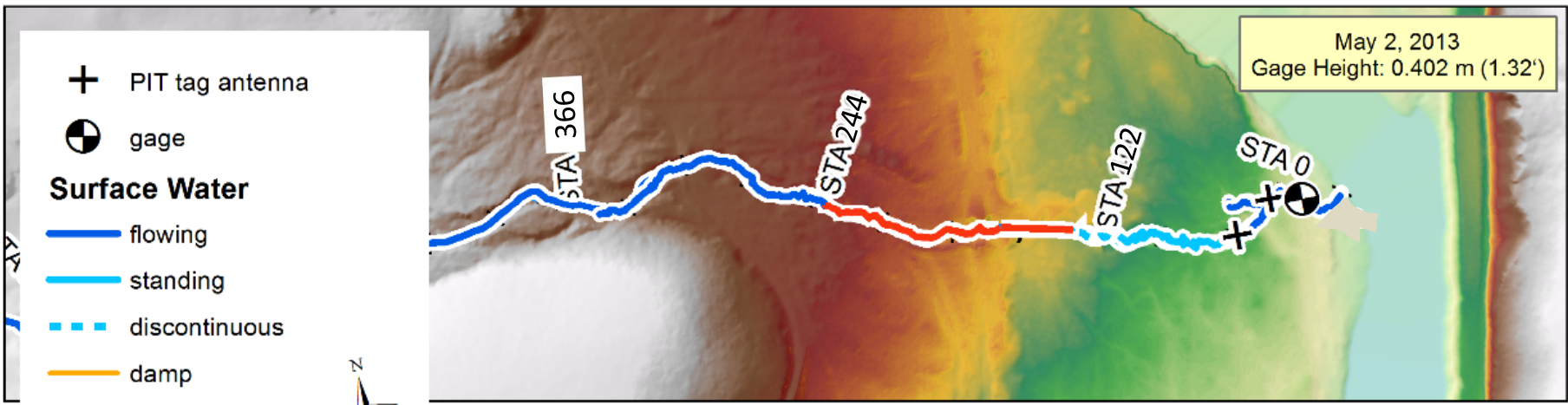
Flowing but not passable to any life stage



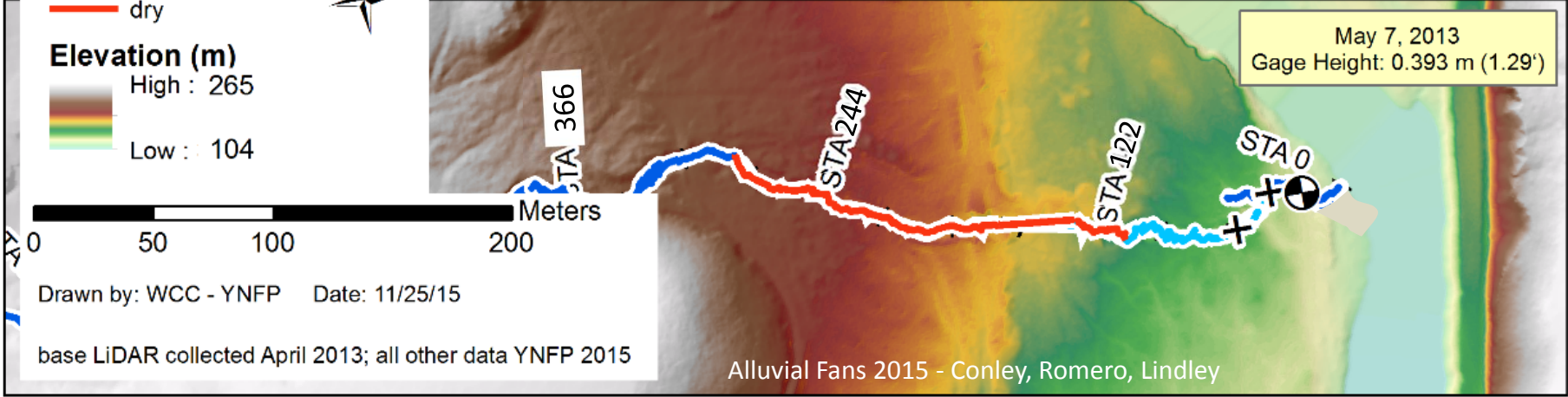
April 23, 2013
Gage Height: 0.415 m (1.36')



May 2, 2013
Gage Height: 0.402 m (1.32')



May 7, 2013
Gage Height: 0.393 m (1.29')

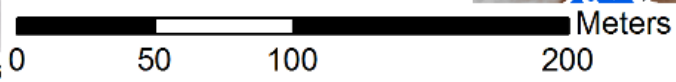


- + PIT tag antenna
- ⊙ gage

Surface Water

- flowing
- standing
- - - discontinuous
- damp
- dry

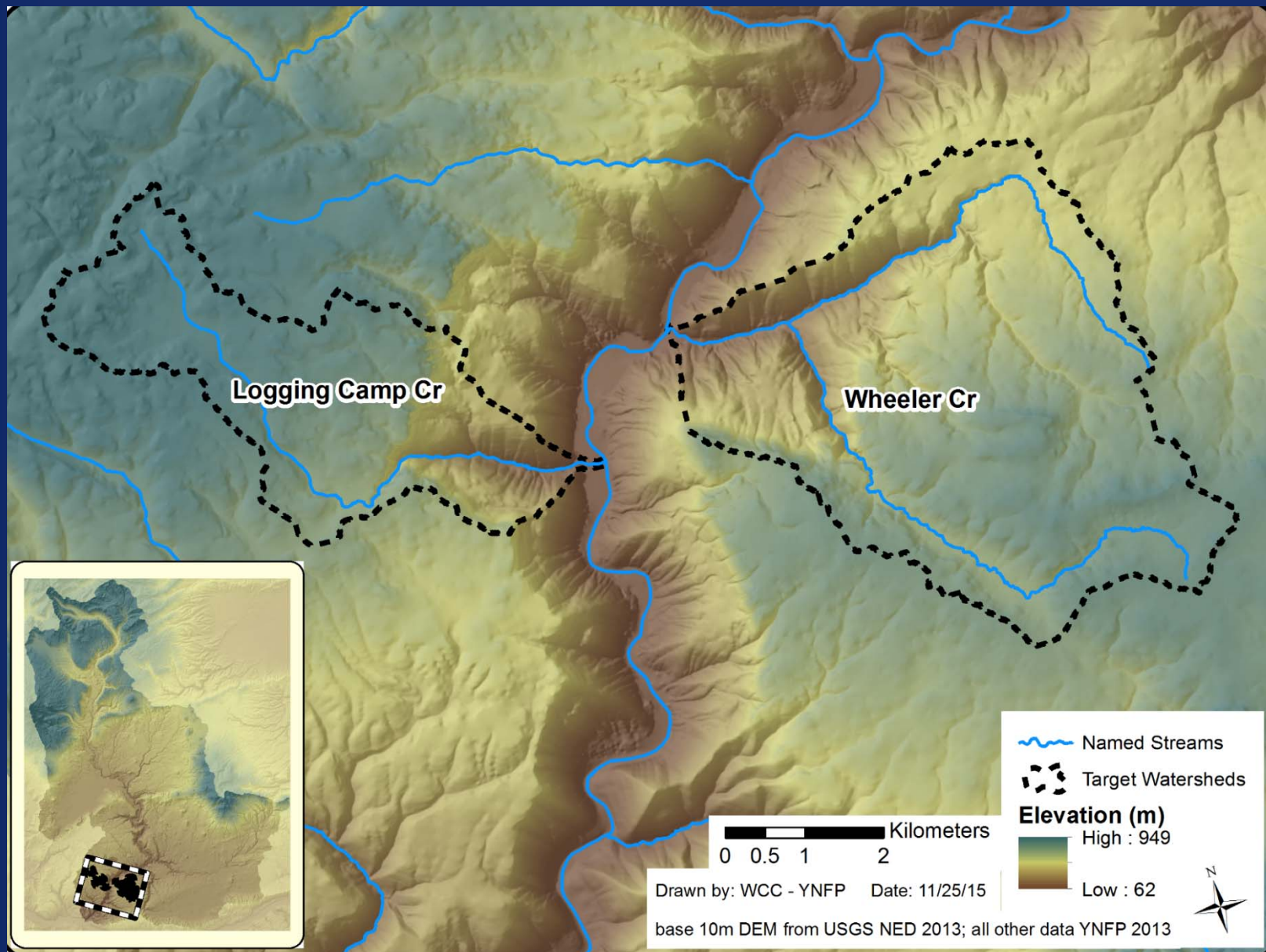
Elevation (m)
 High : 265
 Low : 104



Drawn by: WCC - YNFP Date: 11/25/15

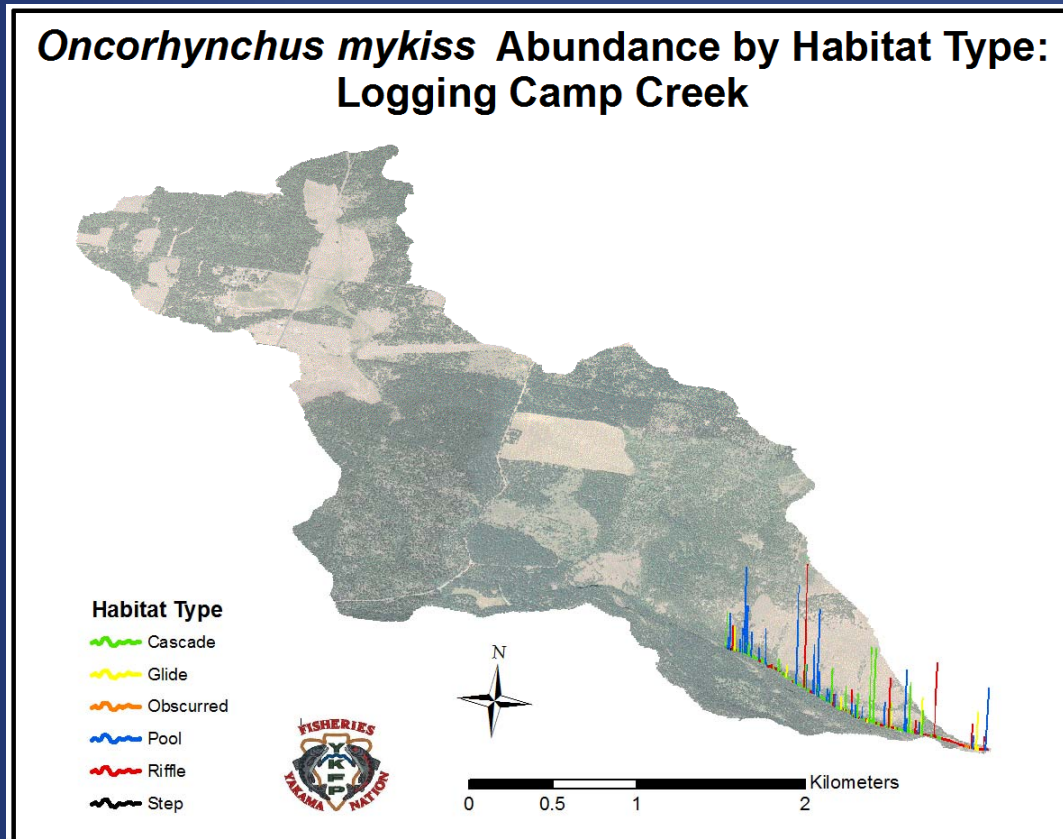
base LiDAR collected April 2013; all other data YNFP 2015

Watershed Contrasts



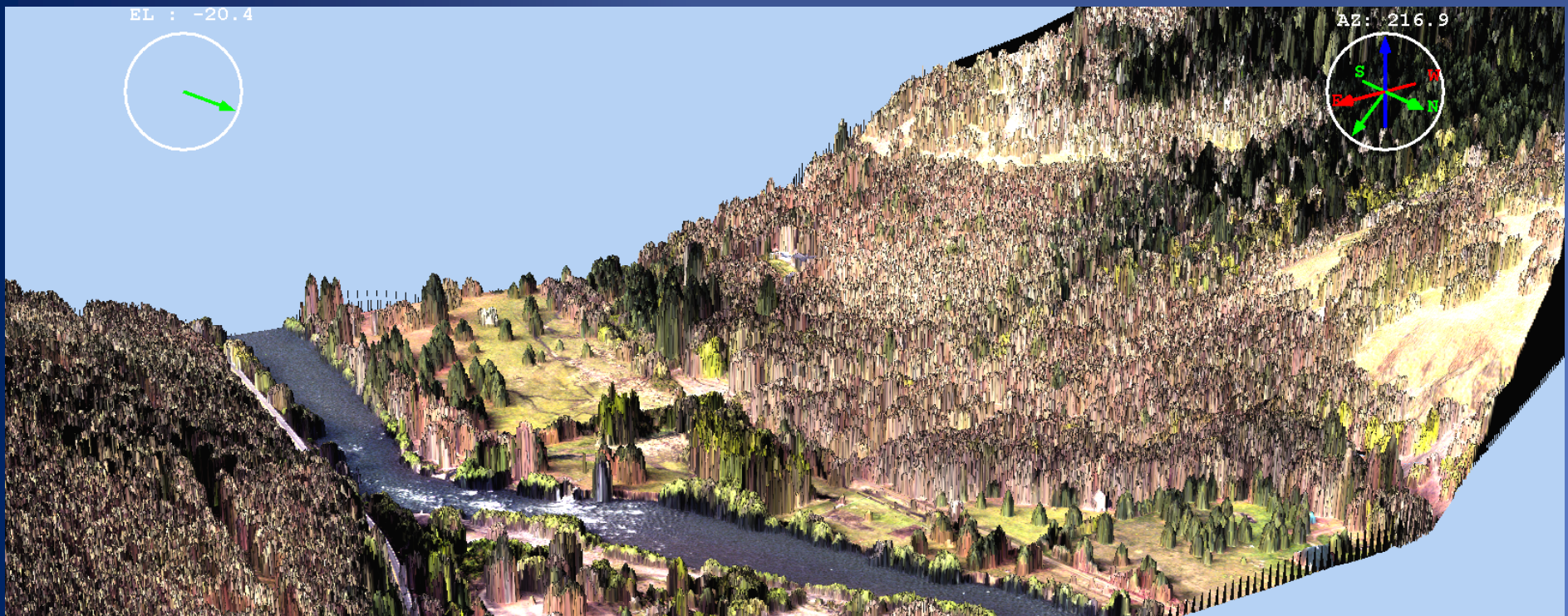
Logging Camp Creek - Watershed

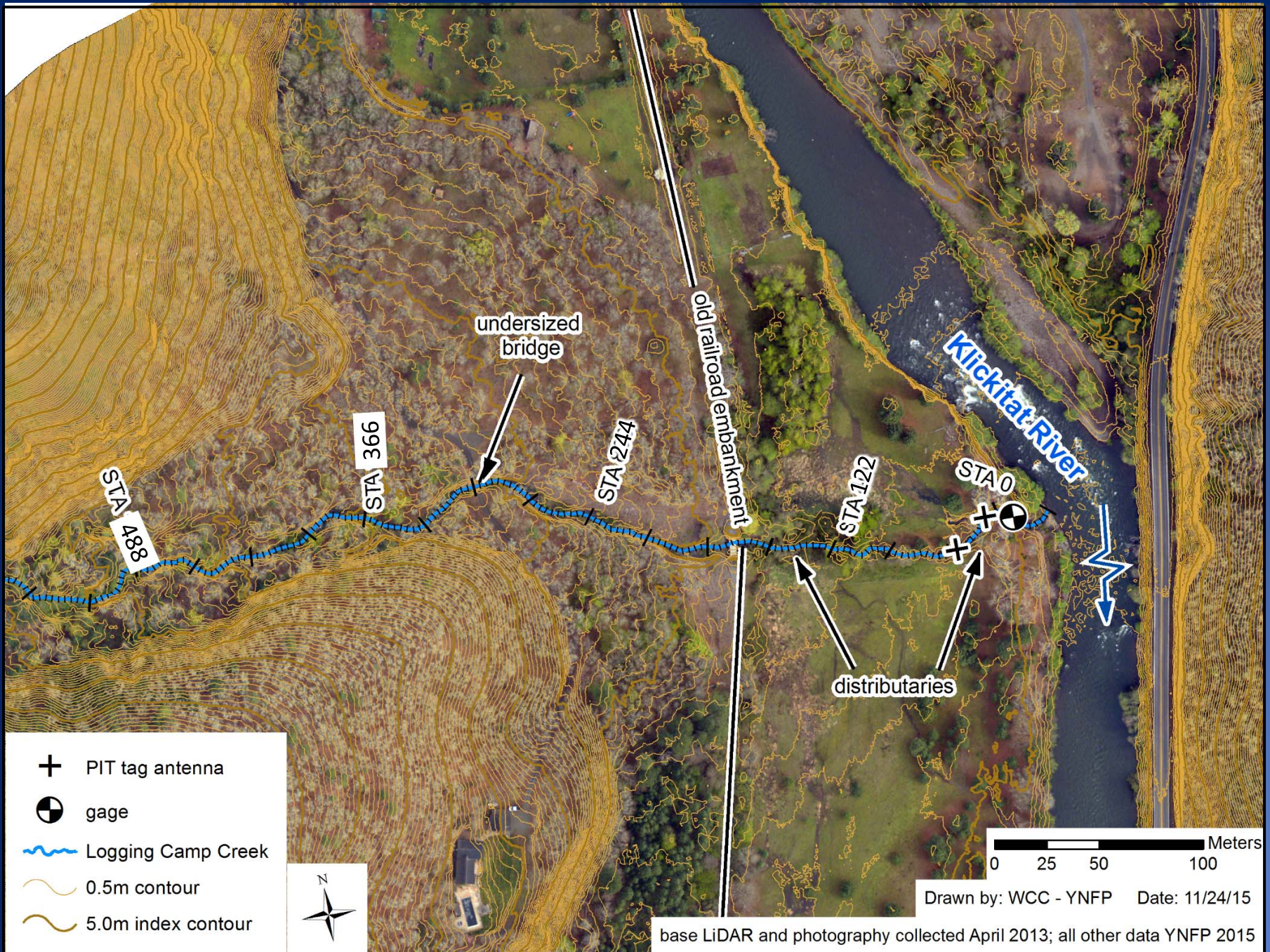
- Drainage Area 12.3 km² (4.8 mi²)
- Mean Basin Elev.: 619 m (2,030')
- Mean Annual PPT: 785 mm (30.9")
- Relief: 664 m (2,180')
- Forest Canopy: 48.2%
- Mean Basin Slope: 14.5%
- Reaches accessible to anadromous salmonids are mostly (> ~60%) perennial



Logging Camp Creek – Alluvial Fan

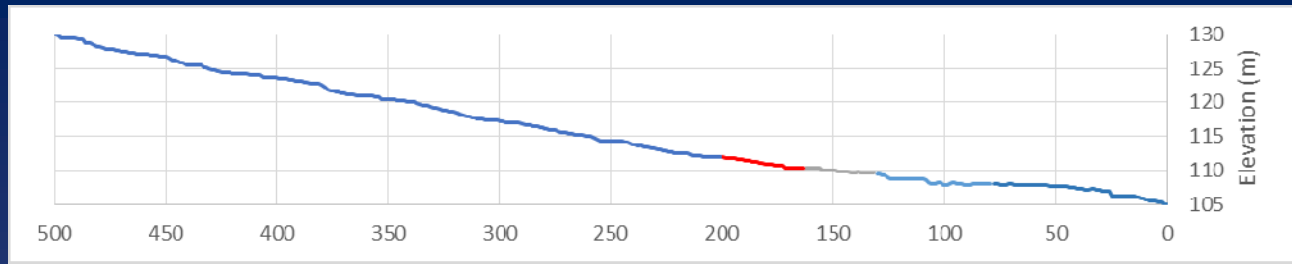
- Disconnected from Klickitat River
- Prograding onto mix of:
 - matrix-supported floodplain deposits (large, upvalley landslide)
 - Klickitat River alluvium
- Hydromodifications: railroad embankment, undersized bridge



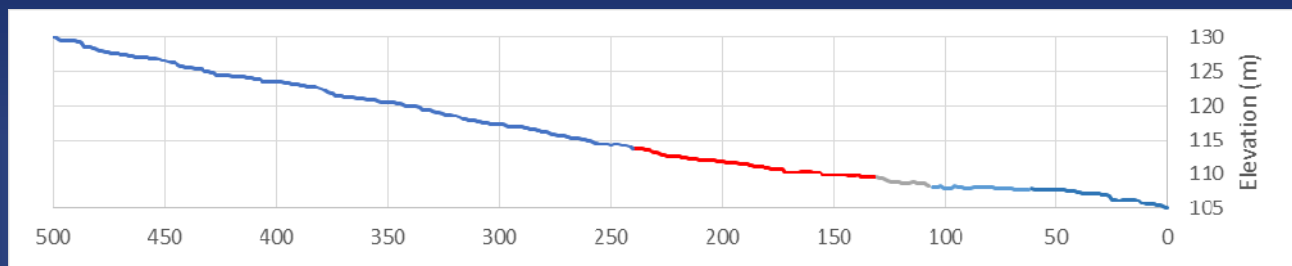


Alluvial Fans 2015 - Conley, Romero, Lindley

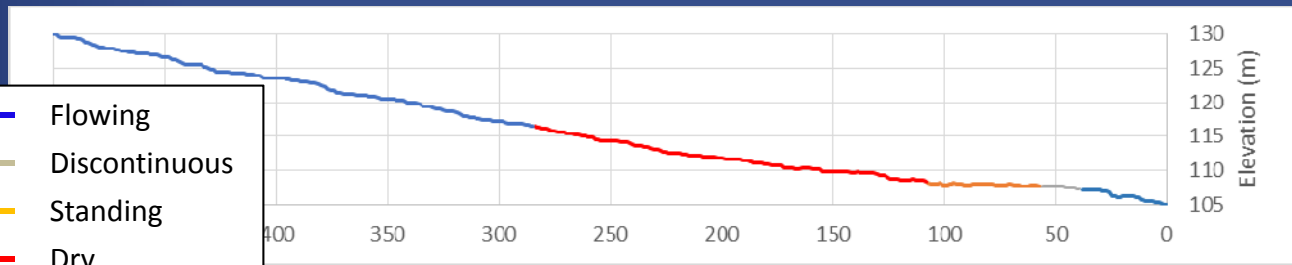
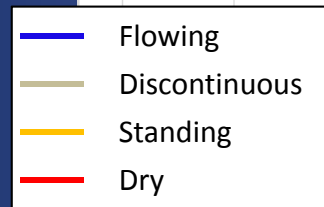
April 23, 2013
Gage Height:
0.415 m (1.36')



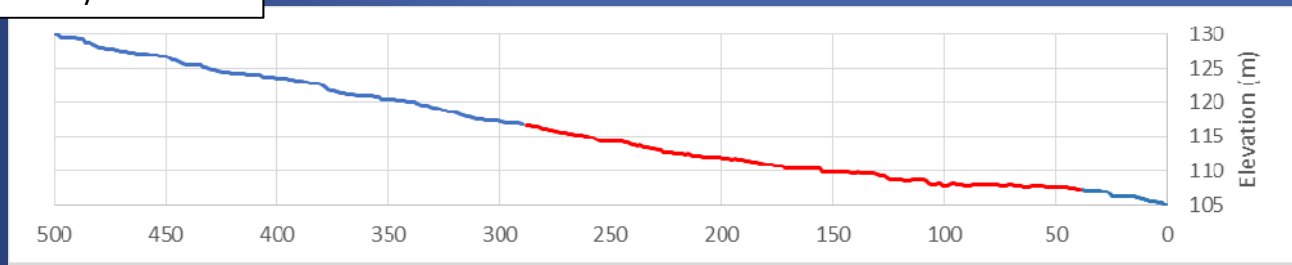
May 2, 2013
Gage Height:
0.402 m (1.32')



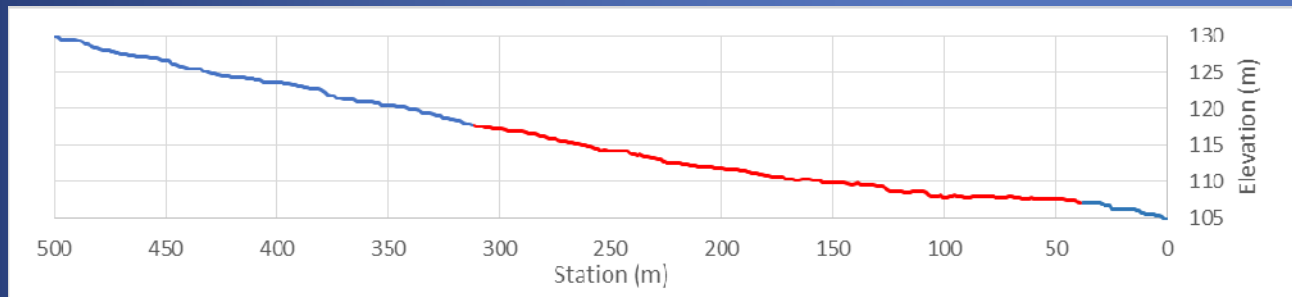
May 7, 2013
Gage Height:
0.393 m (1.29')



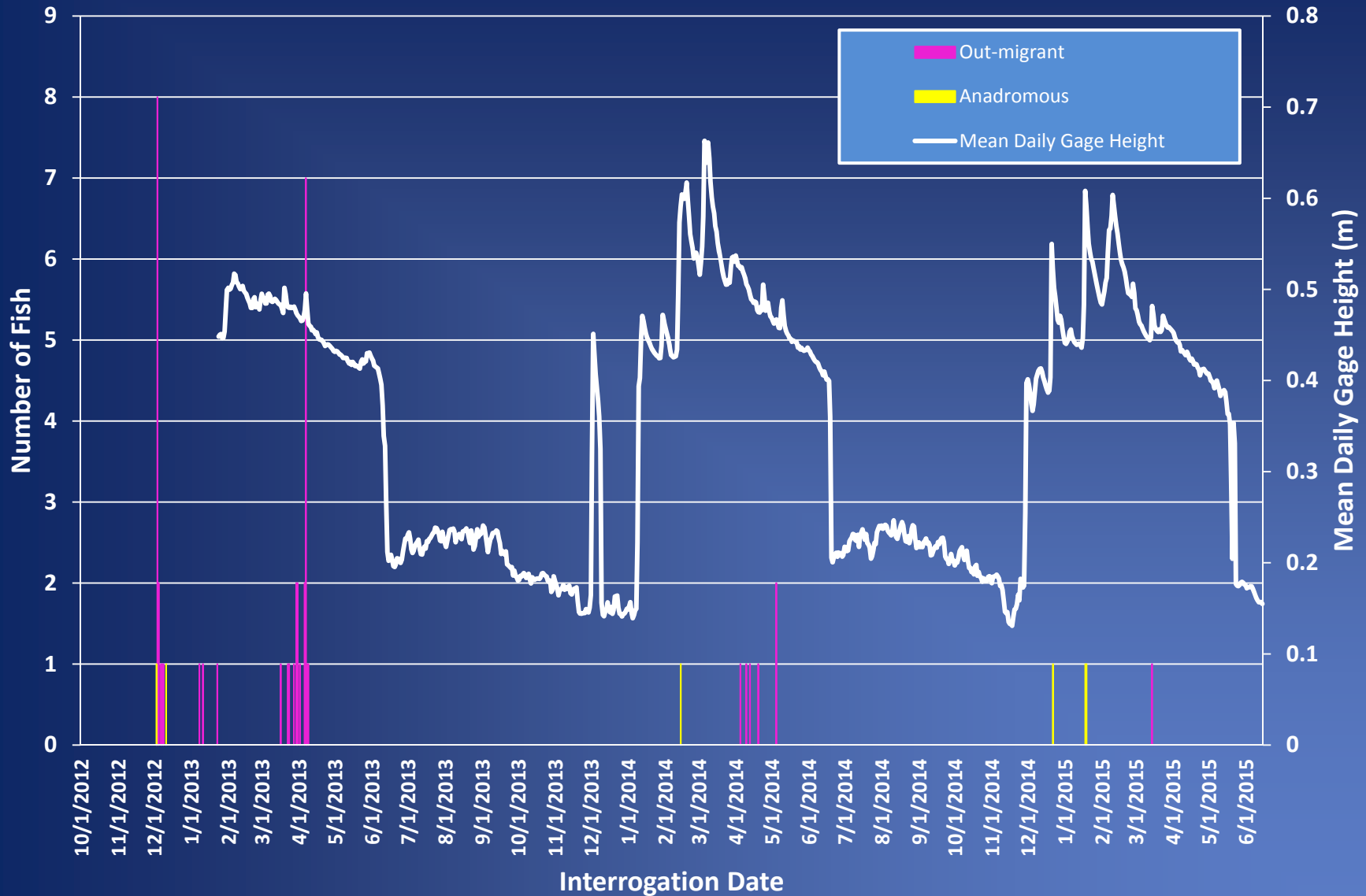
May 15, 2013
Gage Height:
0.384 m (1.26')



June 4, 2013
Gage Height:
0.372 m (1.22')



Logging Camp Creek Fish Detections



Logging Camp Creek – Passage Duration

Adults [\sim gage heights $> 0.50\text{m}$ (1.65')]*

Water-Year	Passage Days	Period
2014	~ 58	mostly mid-Feb to mid-Apr
2015	~ 33	mostly mid-Jan to Late-Feb

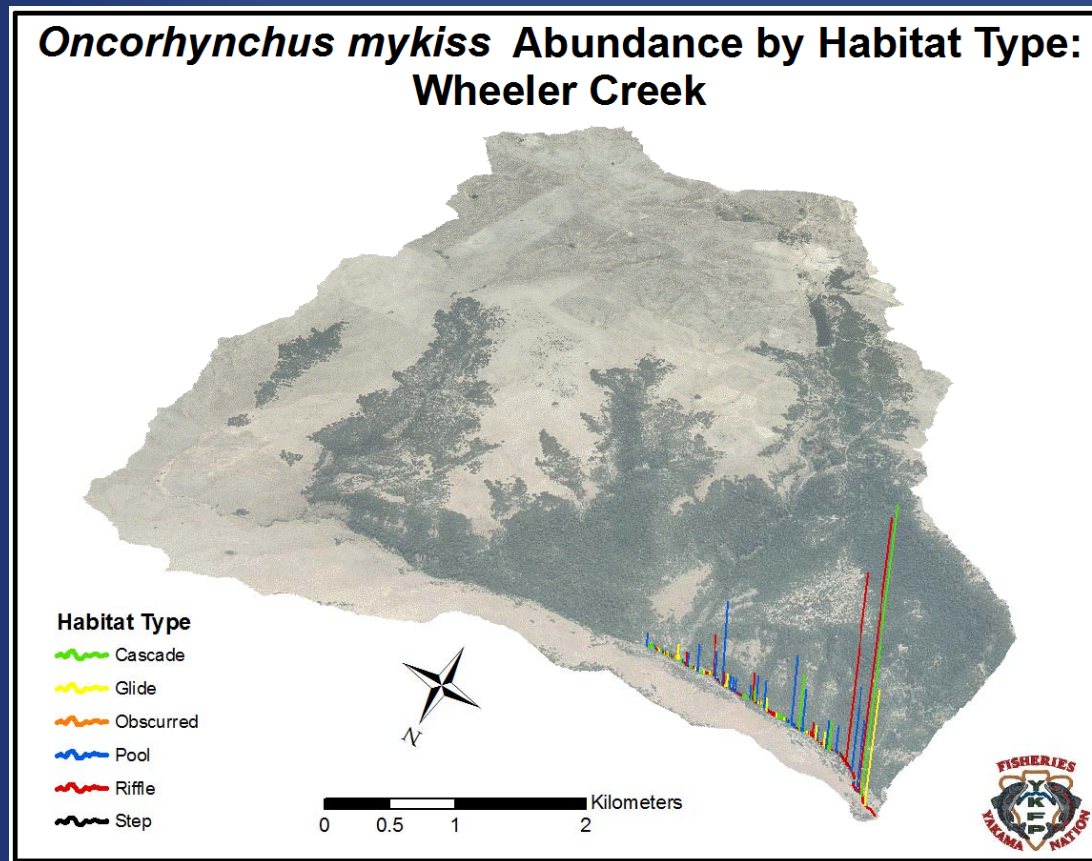
Juveniles [\sim gage heights $> 0.44\text{m}$ (1.45')]*

Water-Year	Passage Days	Period
2014	~ 115	mostly mid-Jan to mid-May
2015	~ 97	mostly mid-Dec to mid-Apr

*preliminary, minimum values in terms of depth only. While discharges at these stages have been observed to pass fish, they may not be adequate to stimulate migratory behavior.

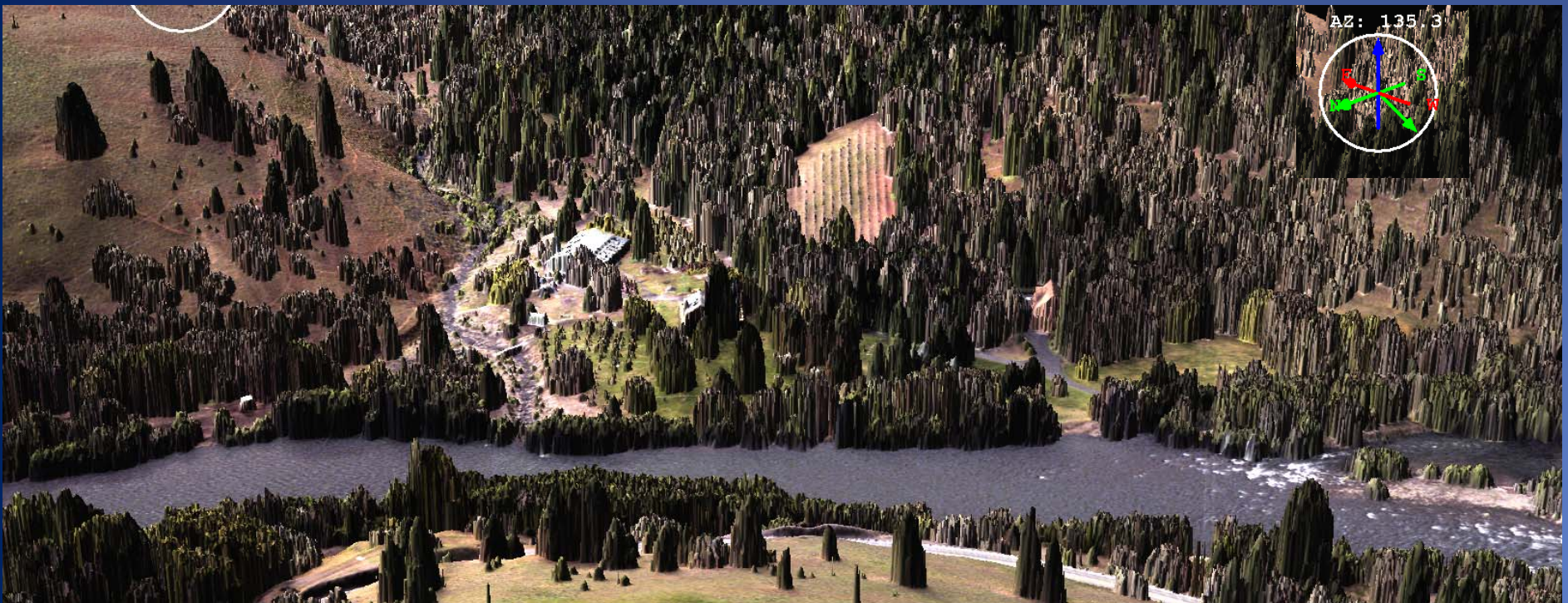
Wheeler Creek - Watershed

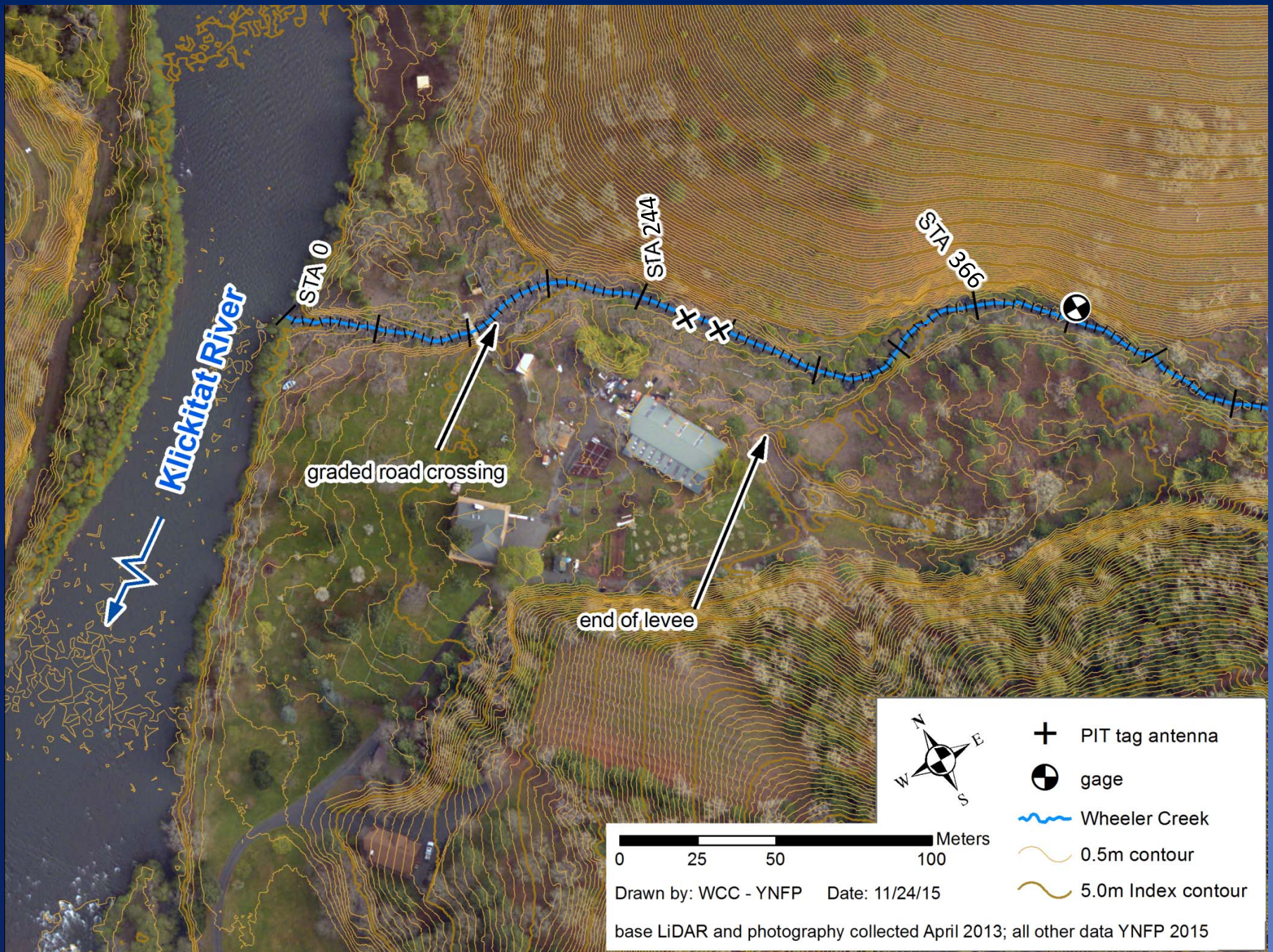
- Drainage Area 25.1 km² (9.7 mi²)
- Mean Basin Elev.: 558 m (1,830')
- Mean Annual PPT: 483 mm (19.0")
- Relief: 570 m (1,870')
- Forest Canopy: 12.7%
- Mean Basin Slope: 16.3%
- Reaches accessible to anadromous salmonids are entirely seasonal in most years



Wheeler Creek – Alluvial Fan

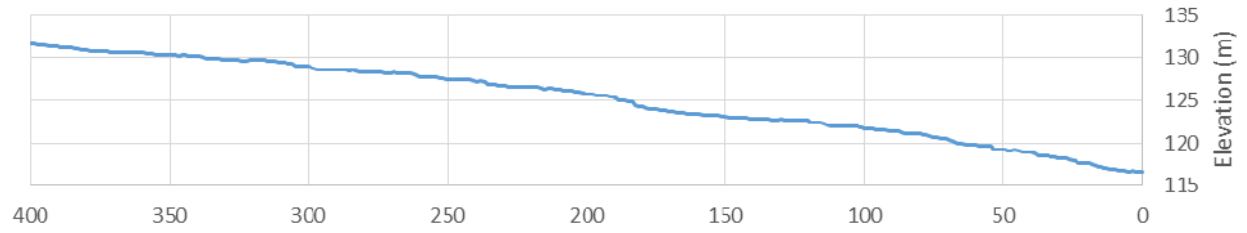
- Fan is less well-defined than Logging Camp
 - probable debris flow history
 - re-working by Klickitat River (and alluvial deposits)
- Hydromodifications:
 - Levee occludes ~58% of valley bottom near fan apex
 - residential development



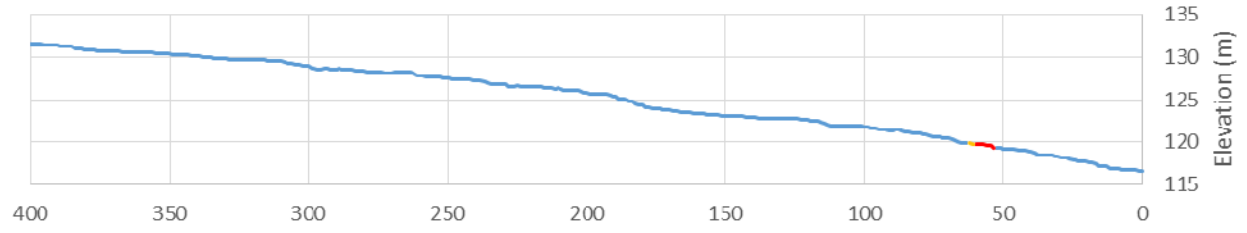


Alluvial Fans 2015 - Conley, Romero, Lindley

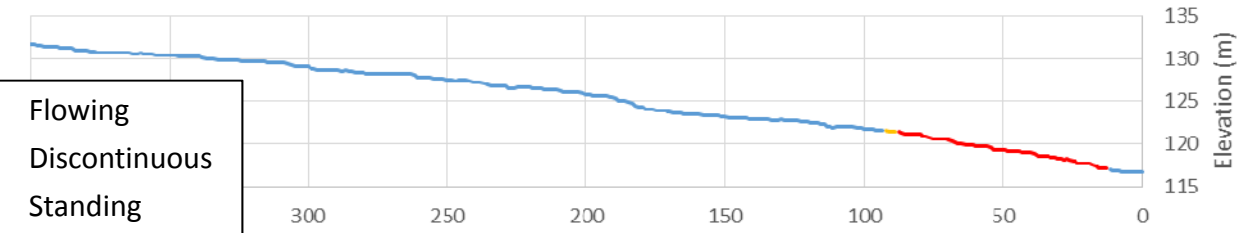
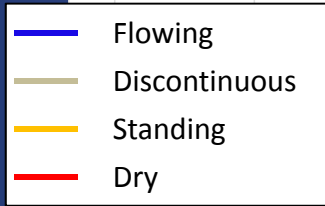
April 22, 2013
Gage Height:
0.293 m (0.96')



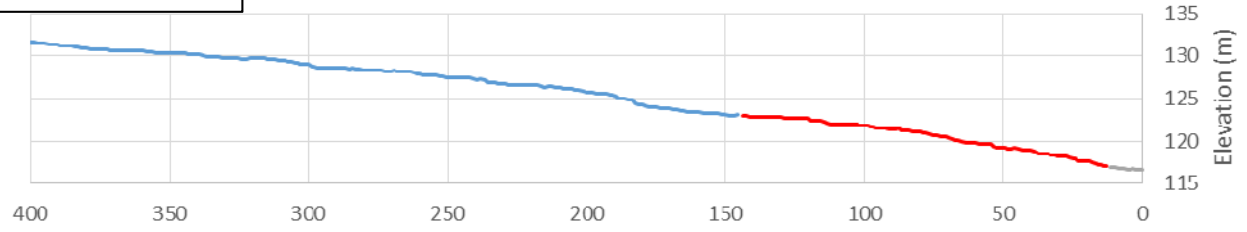
April 29, 2013
Gage Height:
0.265 m (0.87')



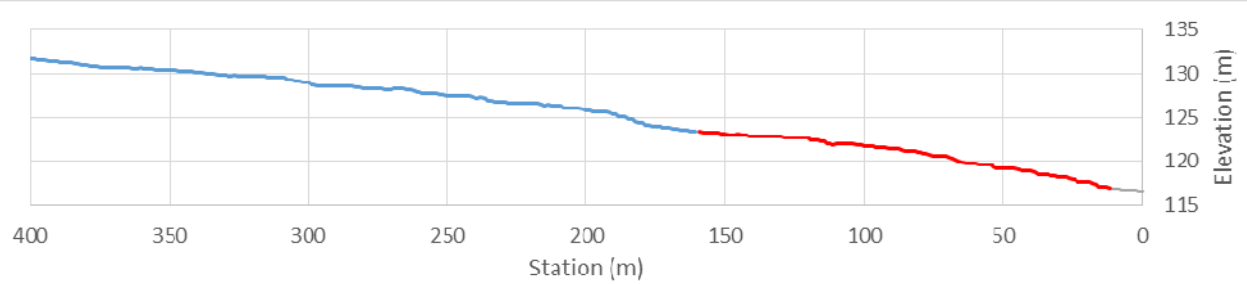
May 6, 2013
Gage Height:
0.253 m (0.83')



May 16, 2013
Gage Height:
0.232 m (0.76')



June 3, 2013
Gage Height:
0.224 m (0.73')



Wheeler Creek Fish Detections



Wheeler Creek – Passage Duration

Adults [\sim gage heights $> 0.34\text{m}$ (1.12')]*

Water-Year	Passage Days	Period
2014	~ 79	mostly mid-Feb to mid-Apr
2015	~ 96	mostly mid-Jan to Late-Feb

Juveniles [\sim gage heights $> 0.28\text{m}$ (0.92')]*

Water-Year	Passage Days	Period
2014	~ 129	mostly mid-Jan to mid-May
2015	~ 148	mostly mid-Dec to mid-Apr

*preliminary, minimum values in terms of depth only. While discharges at these stages have been observed to pass fish, they may not be adequate to stimulate migratory behavior.

Management Applications

- Refine fish survival and population models
- Evaluate habitat usage, growth, and survival
- Inform land-use decision making
 - instream-flow
 - channel and floodplain manipulation

Further Investigation

- More field observations
 - Develop stage:discharge ratings
 - Improve resolution of flow distribution ratings
- Synoptic discharge measurements
 - quantify loss rates
 - characterize seasonal hysteresis

Stay tuned:

<http://www.ykfp.org/klickitat/>

Acknowledgements

- Nicolas Romero
- David Lindley
- Confederated Tribes and Bands of the Yakama Nation
- Bonneville Power Administration
 - Klickitat Watershed Enhancement Project
 - Project # 1997-056-00
 - Klickitat Monitoring and Evaluation Project
 - Project # 1995-063-35