FLUVIAL RECONNAISSANCE OF ROCK CREEK AND SELECTED TRIBUTARIES WITH IMPLICATIONS FOR ANADROMOUS SALMONID HABITAT MANAGEMENT

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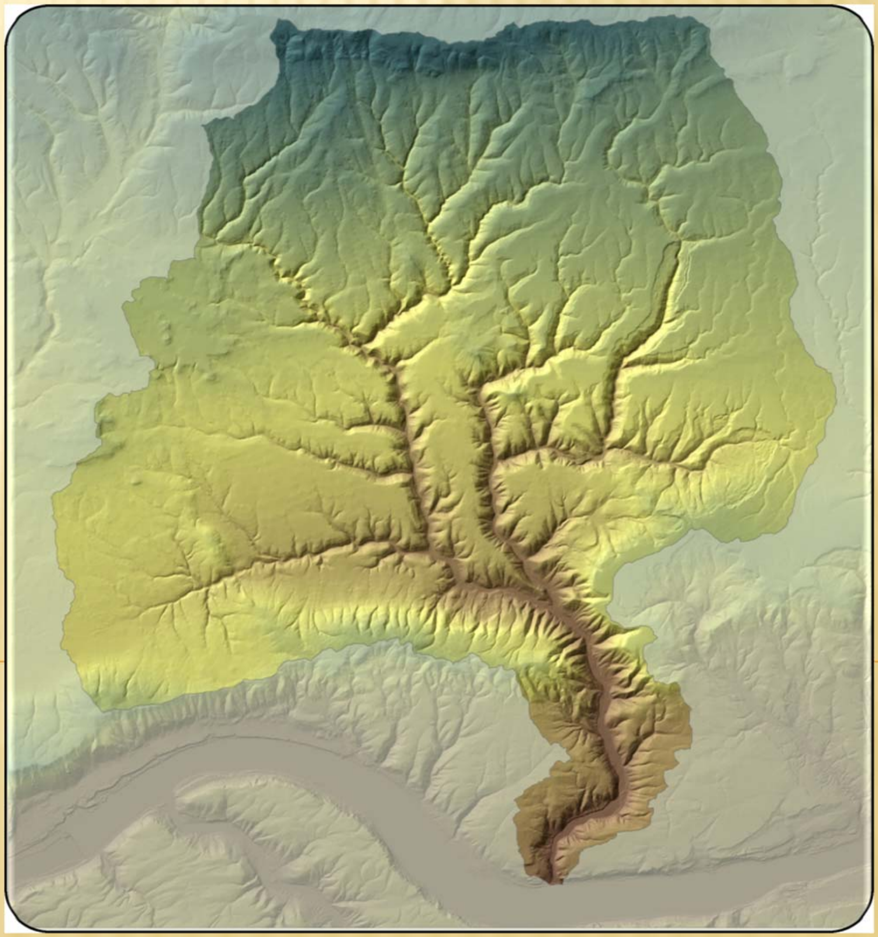
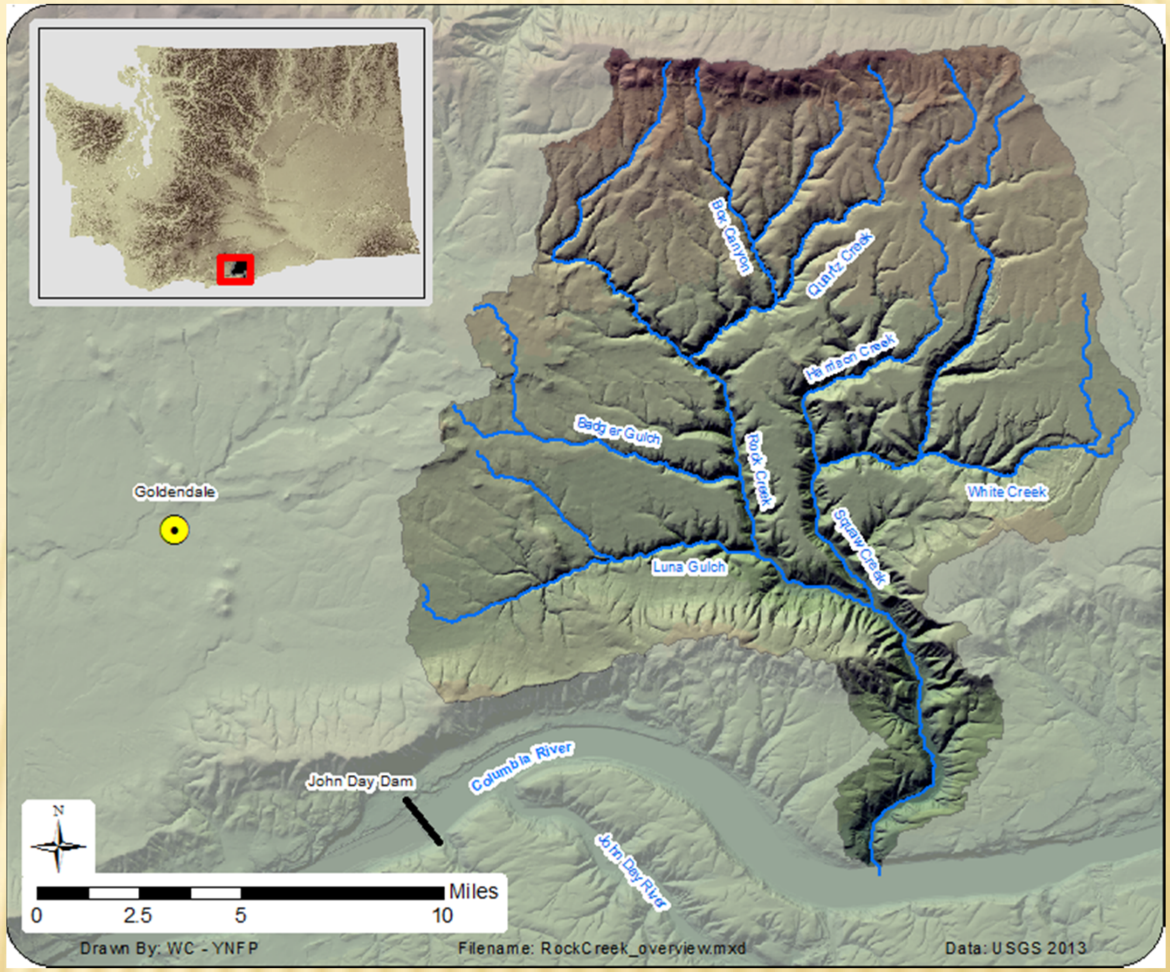


Columbia Gorge Fisheries and Watershed Science Conference
Gorge Discovery Center
The Dalles, OR
April 14, 2015

LOCATION

- 226 sq-mi watershed
- eastern Klickitat County
- Columbia R. tributary at River-Mile (RM) 230
- ~12 RM upstream of John Day Dam



Within the geographic region of the Mid-Columbia River DPS of steelhead trout (*Oncorhynchus mykiss*) [ESA threatened]

STUDY GOALS AND OBJECTIVES

Develop recommendations for stream restoration, protection, and enhancement potential for steelhead habitat in the Rock Creek watershed and identify areas needing further investigation.

Three components:

1) Synthesize existing literature and data - Compile and review existing data, maps, and reports related to the Rock Creek subbasin, with an emphasis on those related to steelhead habitat.

2) Fluvial Reconnaissance – Conduct spatial analyses, modeling, and interpretation of hydrogeomorphic and physical habitat data using combination of field observations, pre-existing habitat data, and remote sensing techniques.

3) Implications for Physical Habitat Management – Incorporate results from items 1 and 2 with findings from prior fisheries studies. Provide general suitability recommendations for stream protection, restoration and/or enhancement actions.

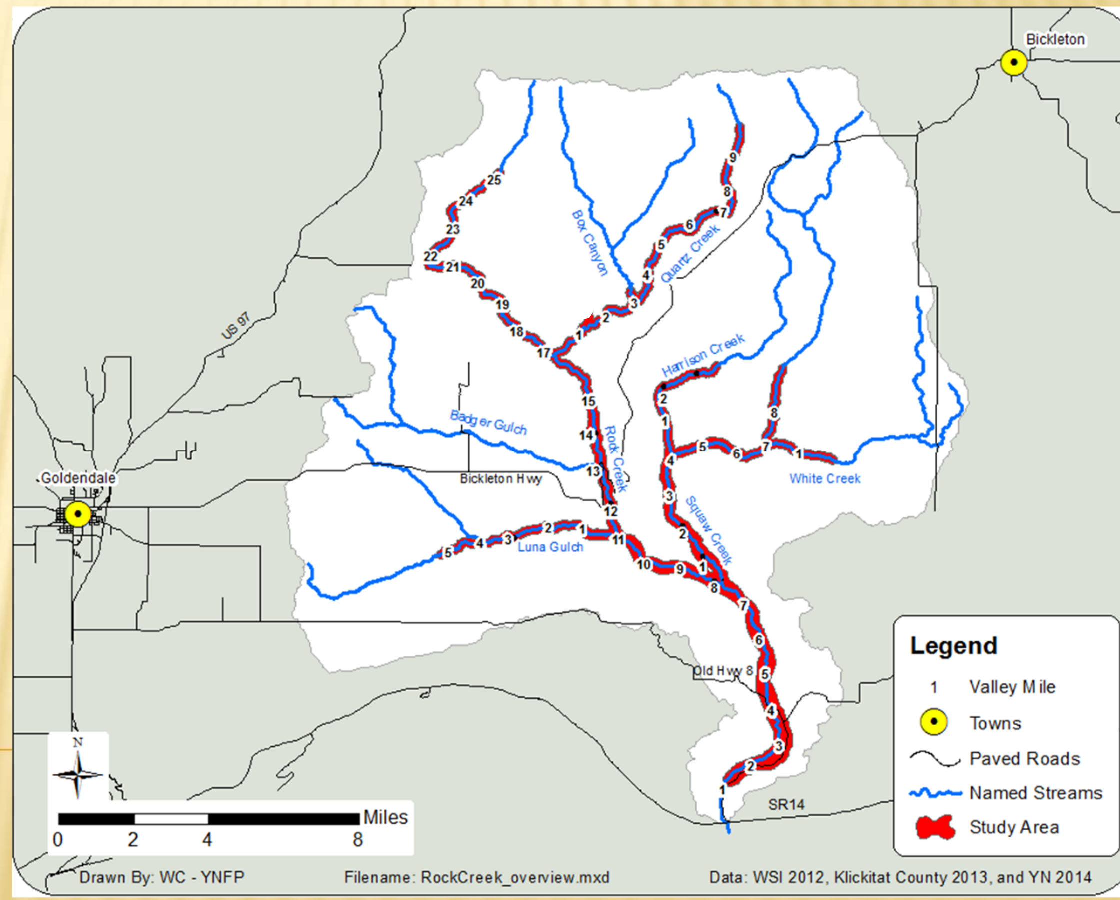
STUDY AREA

- Determined by availability of high resolution (LiDAR) topography and aerial photography.
- LiDAR extent partly based on stream reaches identified by local biologists likely to support anadromous salmonid production

Remote Sensing:

~58 miles (cumulative) of valley corridors, including:

- Rock Cr. 25.4 mi
- Quartz Cr. 10.4 mi
- Squaw Cr. 9.9 mi
- Luna Gulch 5.6 mi
- Harrison Cr. 3.8 mi
- White Cr. 2.2 mi
- Box Canyon 0.5 mi



Field:

- Rock Cr VM 3.0 to 17.0

ELEVATION & MEAN ANNUAL PRECIPITATION

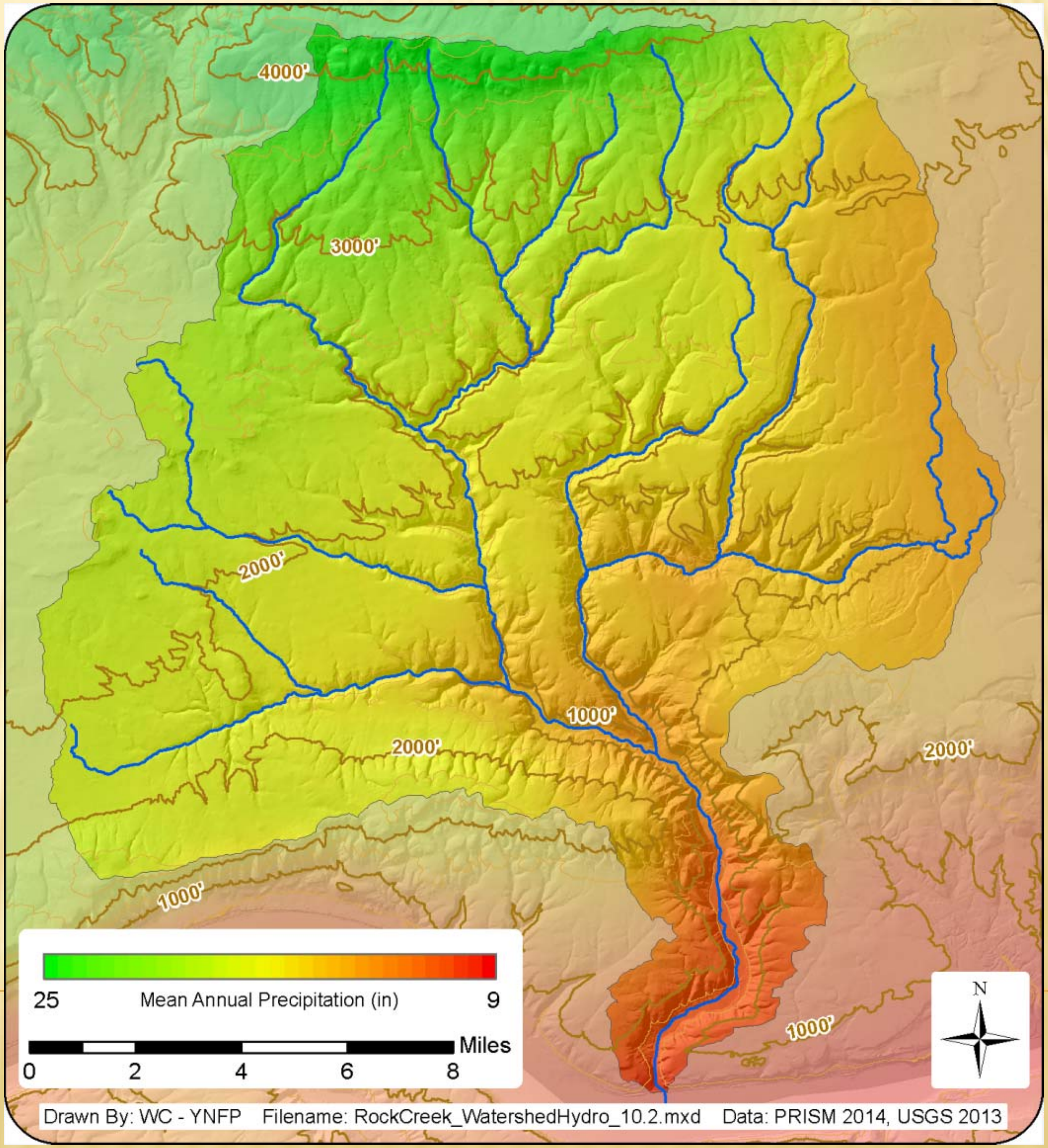
Basin elevation

- Mean = 2,293’
- Minimum = 264’
- Maximum = 4,730’

83% of watershed < 3,000’

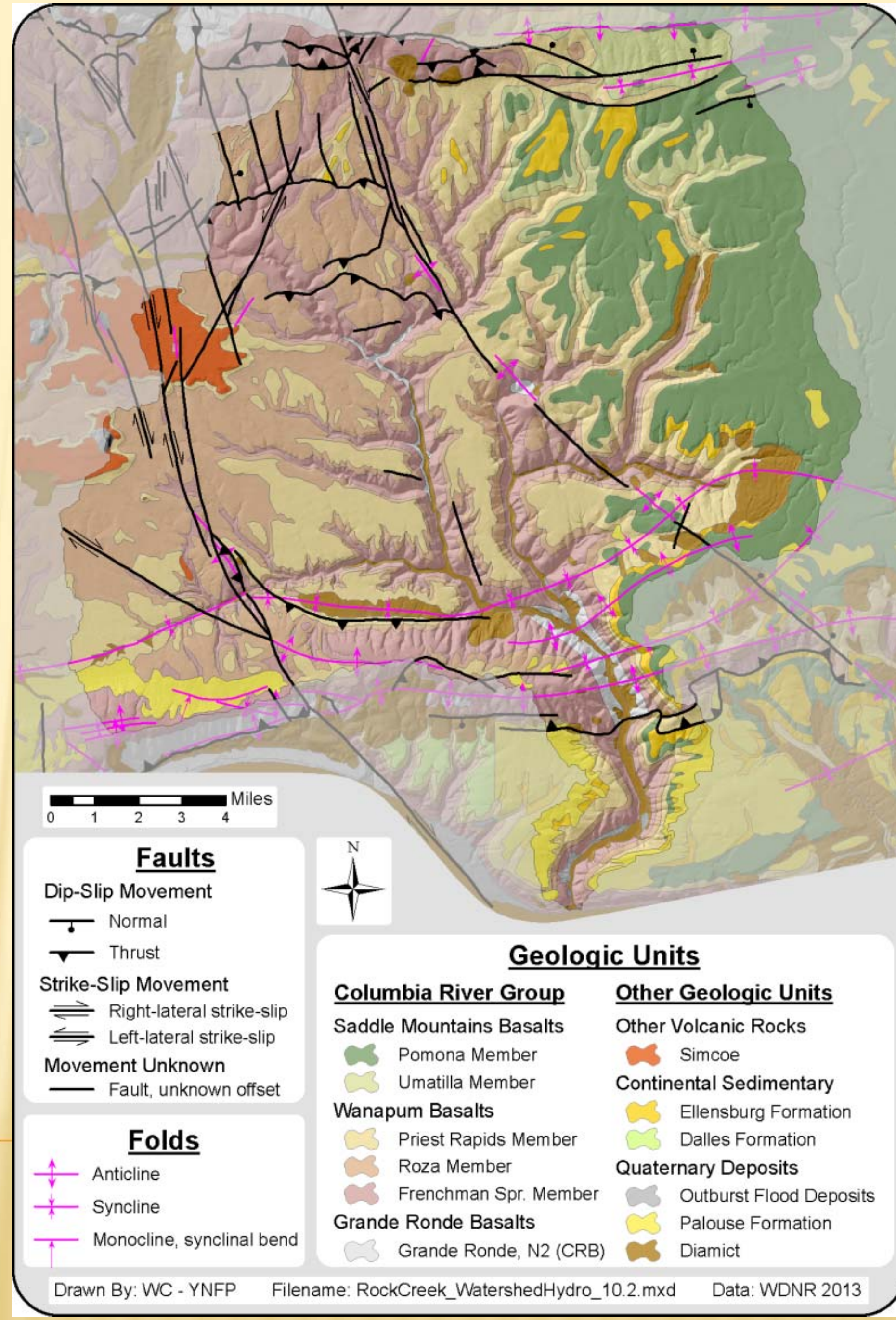
Mean annual precipitation

- Basin average = 16.6”
- Basin maximum = 25.5”
- Basin minimum = 9.5”

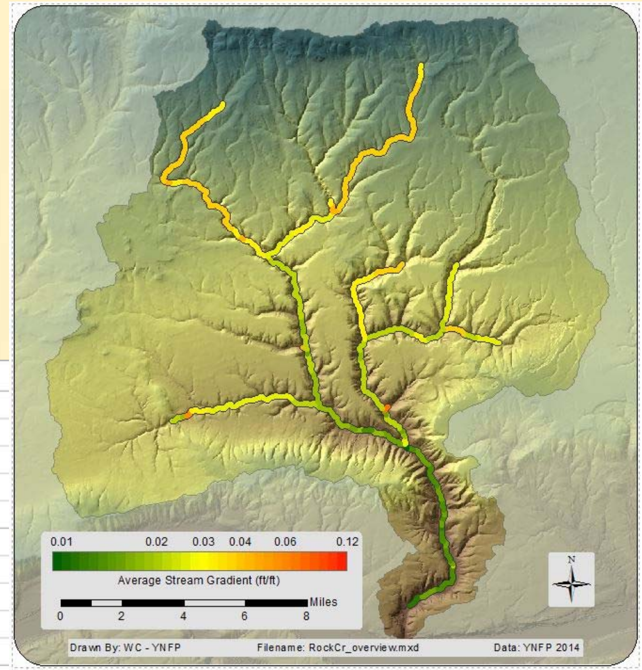


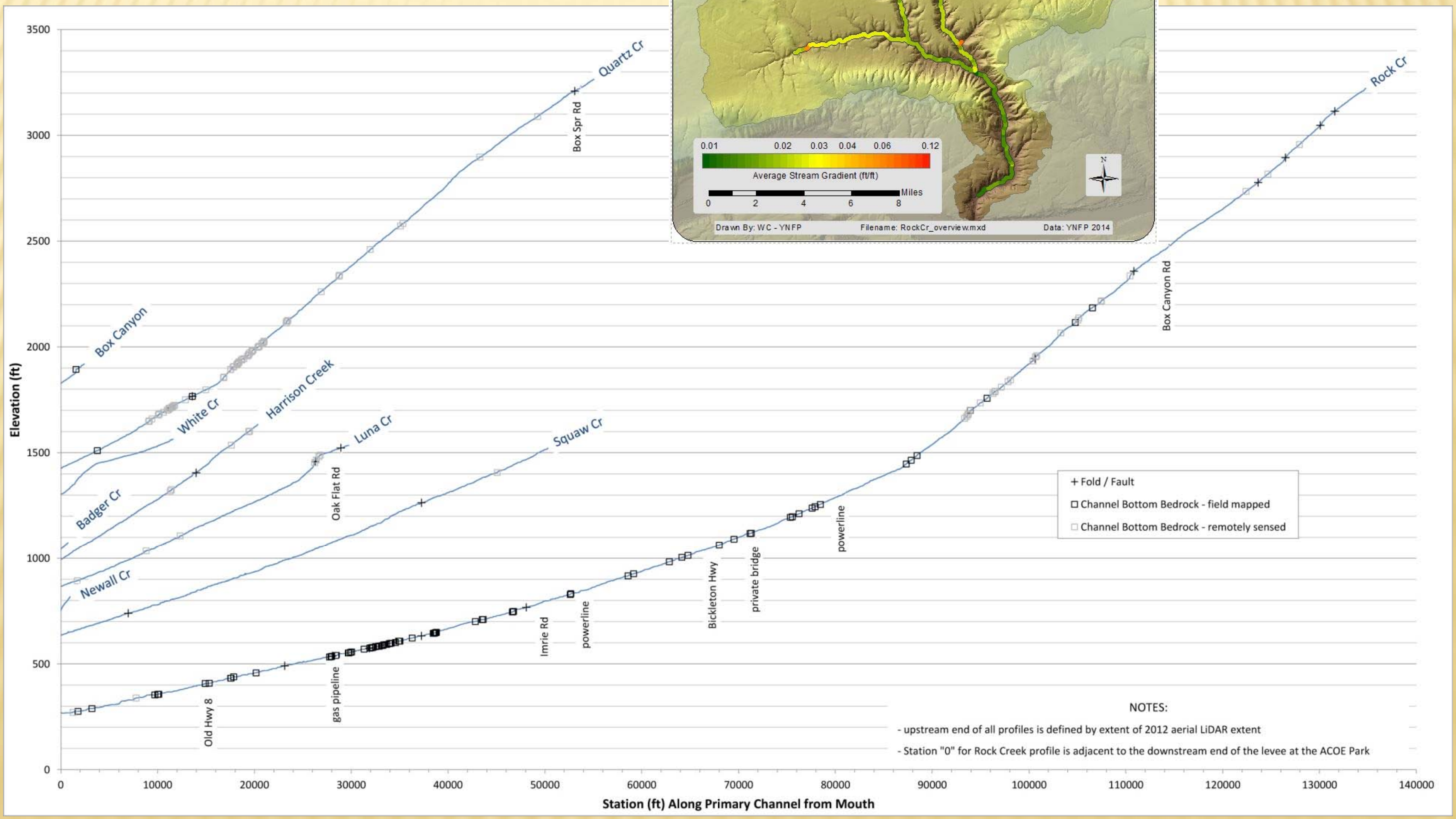
GEOLOGY

- 3 major units of CRB Group:
  - mostly Saddle Mountains and Wanapum basalts
  - Grand Ronde basalts:
    - Minor surficial basin area (~1%)
    - High frequency of stream contact:
      - >9.5 mi. of Rock Cr
      - >1.0 mi. of Quartz Cr
      - >0.8 mi. of Squaw Cr
      - >0.5 mi. of Harrison Cr
- Yakima Fold Belt
- Maximum inundation elevation of late-Pleistocene outburst floods ~1,115’ (Benito and O’Connor, 2003)

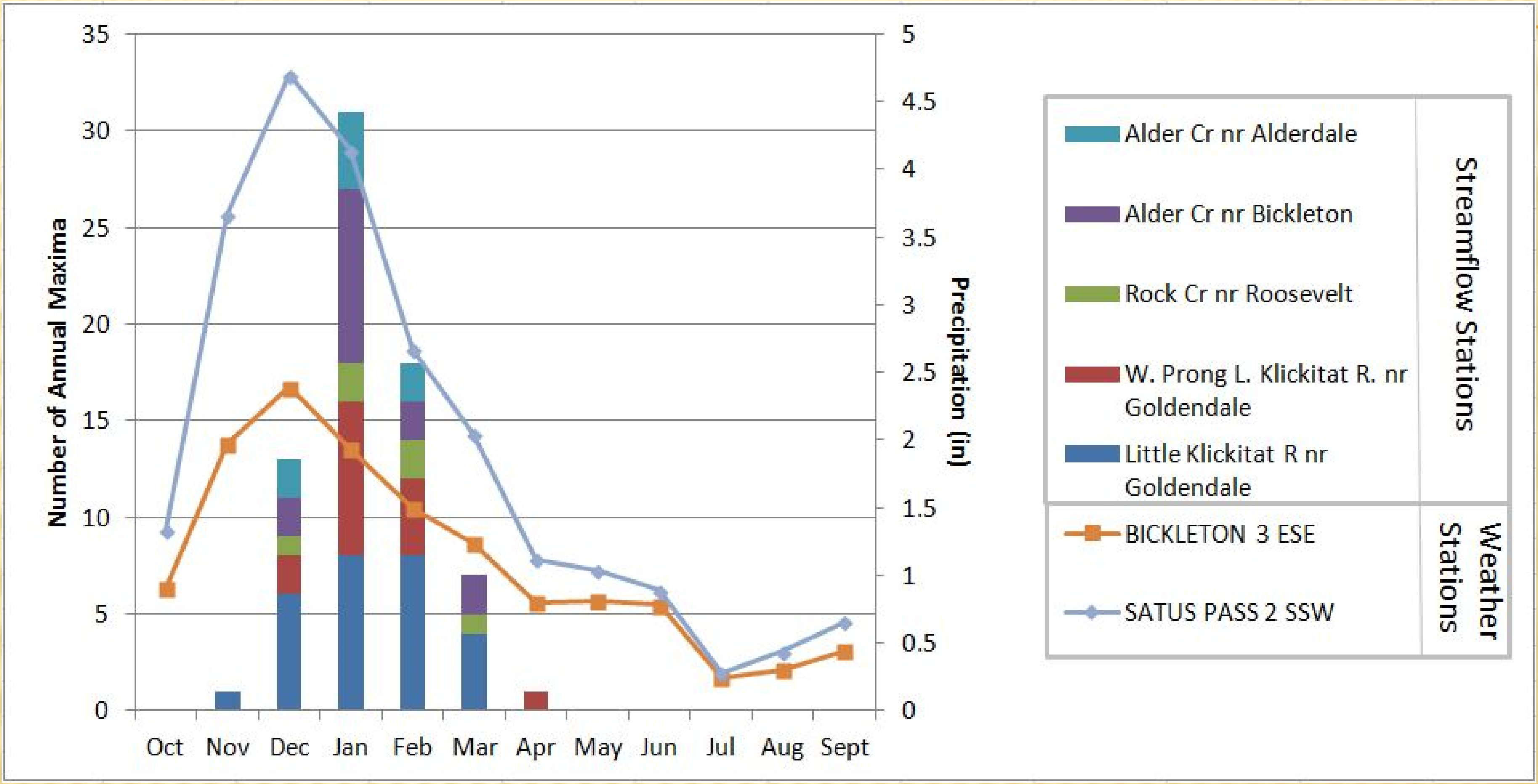


STREAM GRADIENT





PEAKFLOW HYDROLOGY - SEASONALITY



- precipitation and peakflow distributions are strongly seasonal
- annual maxima distribution lags ~1 month behind mean monthly precipitation

PEAKFLOW HYDROLOGY – CONCURRENCE

West ← ~30 Miles → East

Water Year	Little Klickitat R. nr Goldendale (83.5 mi^2)		W. Prong Little Klickitat R. nr G'dale (10.4 mi^2)		Rock Creek nr Roosevelt (213 mi^2)		Alder Creek nr Bickleton (8.35 mi^2)		Alder Creek nr Alderdale (197 mi^2)	
	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)
1946	12/15/46	1,330				2,658				
1948	1/7/48	1,760				3,894				
1949	2/17/49	888								
1950	2/24/50	1,360				2,744				
1958	2/15/58	1,020								
1959	1/11/59	526								
1960	3/29/60	511								
1961	**2/9/61**	**2,830**	**2/9/61**	**192**		6,970				
1962	**12/24/61**	**456**	**12/24/61**	**38**						
1963	**2/3/63**	**2,090**	**2/3/63**	**98**	**2/3/63**	**3,940**	**2/3/63**	**880**	**2/3/63**	**5,560**
1964	**1/25/64**	**760**	**1/25/64**	**37**	**1/25/64**	**912**	**1/25/64**	**58**	**1/26/64**	**68**
1965	**12/22/64**	**5,200**	12/22/64	569	**12/22/64**	**14,200** *	**12/22/64**	**973**	**12/22/64**	**17,600**
1966	**3/9/66**	**530**	4/1/66	[illegible]	**3/9/66**	**962**	**3/9/66**	**149**	1/6/66	670
1967	**1/28/67**	**673**	**1/28/67**	**77**	**1/29/67**	**1,570**	**1/28/67**	**110**	**1/28/67**	**154**
1968	**2/23/68**	**1,300**	**2/23/68**	**144**	**2/23/68**	**1,760**	1/15/68	137	2/3/68	513
1969	3/17/69	618	1/7/69	72			1/6/69	251		
1970	**1/23/70**	**1,760**	**1/23/70**	**182**		3,894	**1/23/70**	**164**		
1971	**1/16/71**	**1,340**	**1/16/71**	**105**		2,687	**1/16/71**	**234**		
1972	**1/20/72**	**3,290**	1/2[illegible]/72	1[illegible]		8,293	**1/20/72**	**293**		
1973	12/21/72	720	1/13/73	56			**1/13/73**	**240**		
1974	**1/15/74**	**4,800**	1/15/74	[illegible]		12,634	**1/16/74**	**992**		
1975	**2/12/75**	**418**	2/12/75	138			3/1/75	165		
1976	12/4/75	1,230				2,370	12/26/75	115		
1977	11/30/76	776					2/12/77	0.5		
1978	12/13/77	2,550				6,165				

Calculate Missing Values with Regression (1946–1962 and 1969–1978)

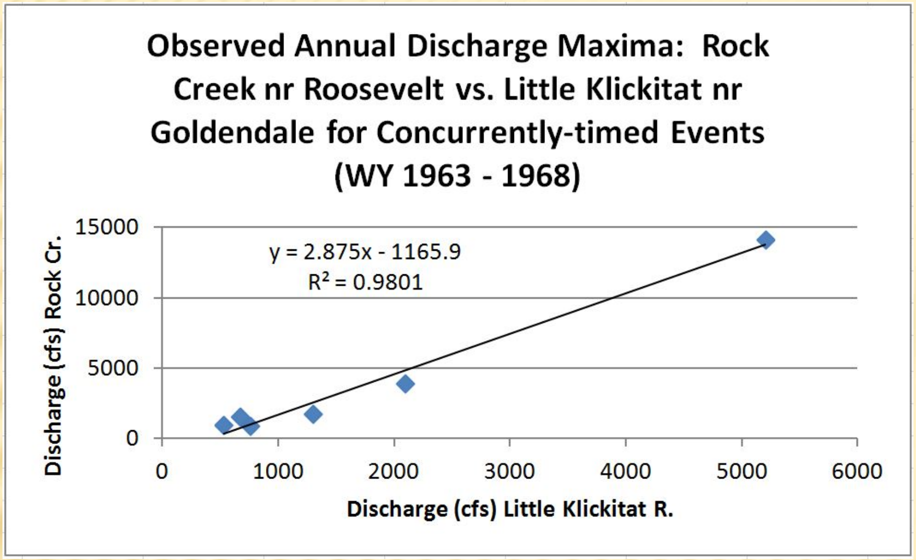
Develop Regression (1963–1968)

* USGS reports maximum daily average

Values in blue are calculated by regression with Little Klickitat gage

PEAKFLOW HYDROLOGY - FREQUENCY

Relationships



	Little Klickitat nr Goldendale (cfs)		Rock Creek nr Roosevelt (cfs)		
	Frequency Analysis (Gamma) Gage Observations		Excel Calculation Region 6 USGS Regressions	GIS Value Using Region 6 USGS Regressions	Calculated from Little Klickitat (Gamma) Using Local Regression
Q2	1,219		1,091	766	2,339
Q5	2,262		n/a	n/a	5,337
Q10	2,983		3,254	2,646	7,410
Q25	3,895		4,887	n/a	10,032
Q50	4,567		6,356	n/a	11,964
Q100	5,226		8,110	7,449	13,859

Field Interpretation of minimum high water surface:

- highest modern indicators = 1964 peakflow (~14-18kcfs; ~Q100)
  - mostly, old LWD and tree scars
- “fresh” indicators = March 2012 (~3,300 cfs; ~Q3)
  - fine-textured organic deposits, uncolonized fines, LWD, tree scars

MINIMUM HIGH WATER SURFACE: ~Q100


Bridge (left) that was washed off its piling foundation (right) by the 1964 flood.


Remains of different washed-out bridge (left) with accumulated sediment (right).

MINIMUM HIGH WATER SURFACE: Q25 - Q100

Woody debris buried by needle-cast (left, middle). Racked woody debris and scar on oak tree (right).

Fluvially re-worked walnut trees on (left) and tree with downstream lean (right) along high floodplain.

MINIMUM HIGH WATER SURFACE: ~Q3

Fresh woody debris jam and tree scars

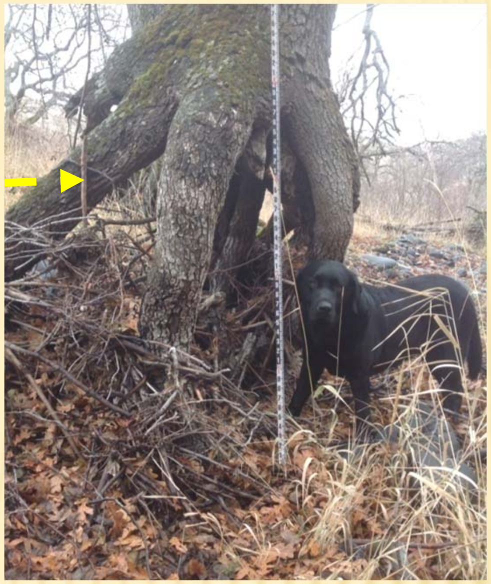
Fresh woody debris and detritus

Band of detritus

Gravel sheet with detritus patches

Fresh sand deposit

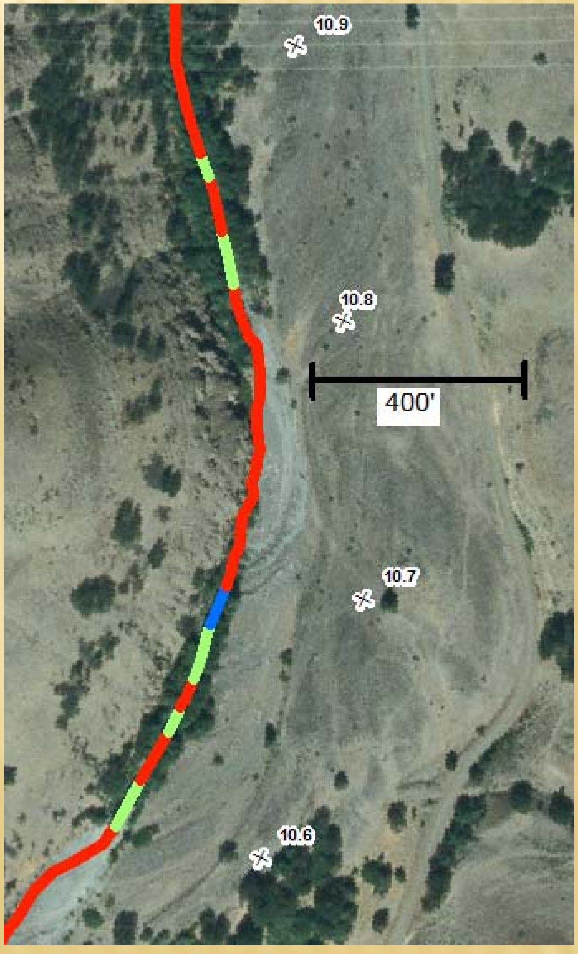
MINIMUM HIGH WATER SURFACE: MULTIPLE


MINIMUM HIGH WATER SURFACE: INDETERMINATE


PERENNIAL STEELHEAD HABITAT

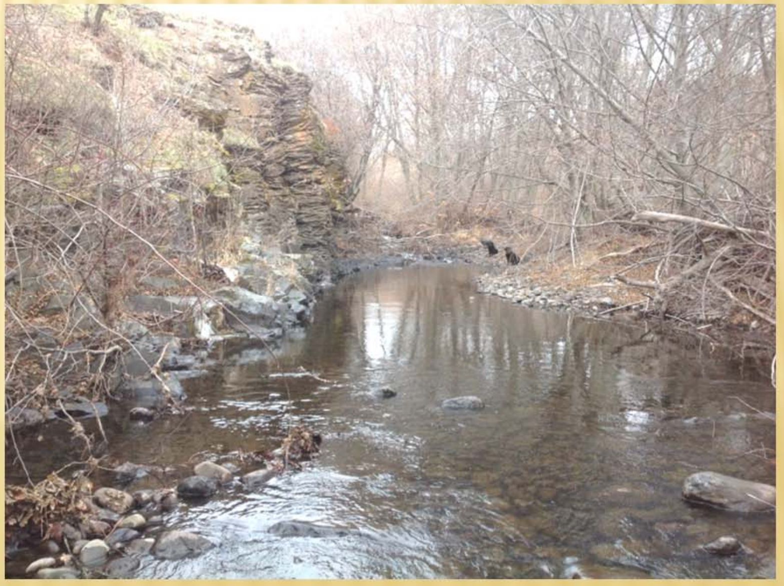
- baseflow habitat censuses 2009 – 2012 (Allen et al. 2014)
- 14 miles of Rock and Squaw creeks (77% of total subbasin stream length < 0.025 ft/ft gradient).
- Underwater cover limited juvenile survival during summer baseflow in all years.
- Surveys conducted during baseflow (Sept.)
  - average across years (by total length):
    - 17% "pool" (wetted at time of survey)
    - 47% "non-pool wet"
    - 36% "dry" (dries-up seasonally)
  - 2012 (a very dry summer/fall):
    - mapped to LiDAR topography (right)
    - 14% perennial pools (blue in map)
    - 40% "non-pool wet" (light green in map)
    - 46% dries-up seasonally (red in map)



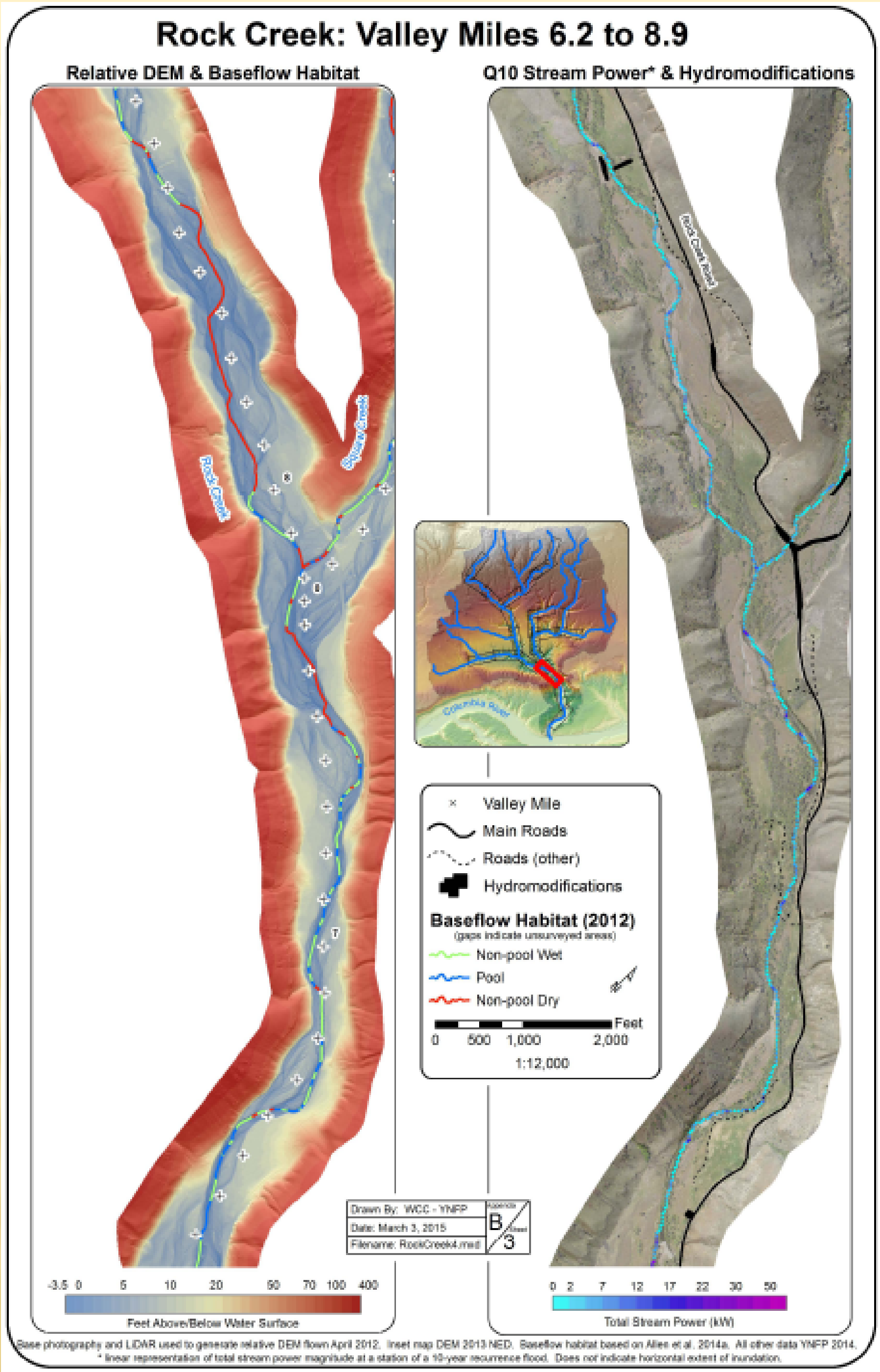
TYPICAL WINTER HABITAT

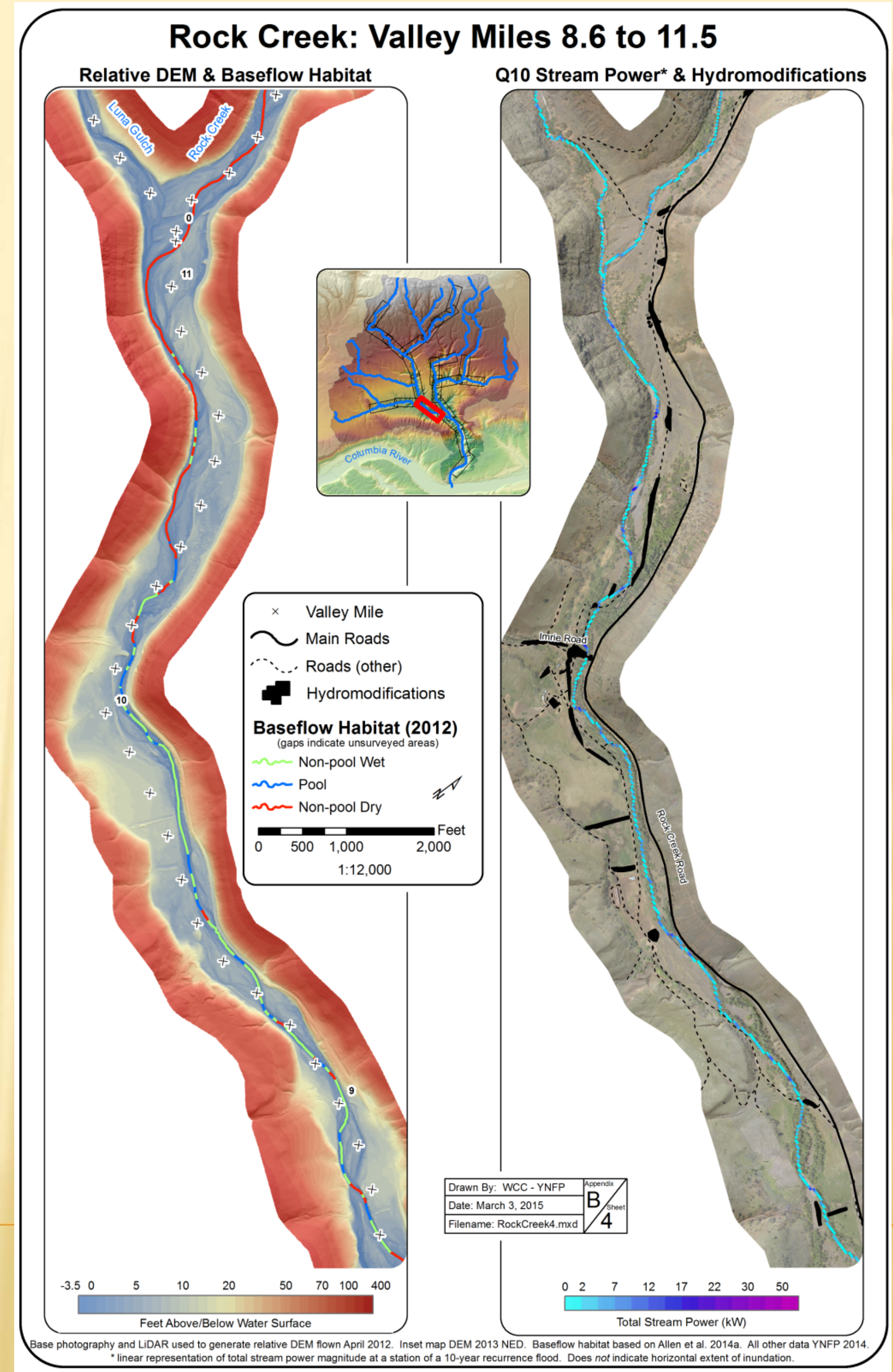
photos: January 2014


Simple, shallow plane-bed habitat conditions predominate throughout much of Rock Creek.

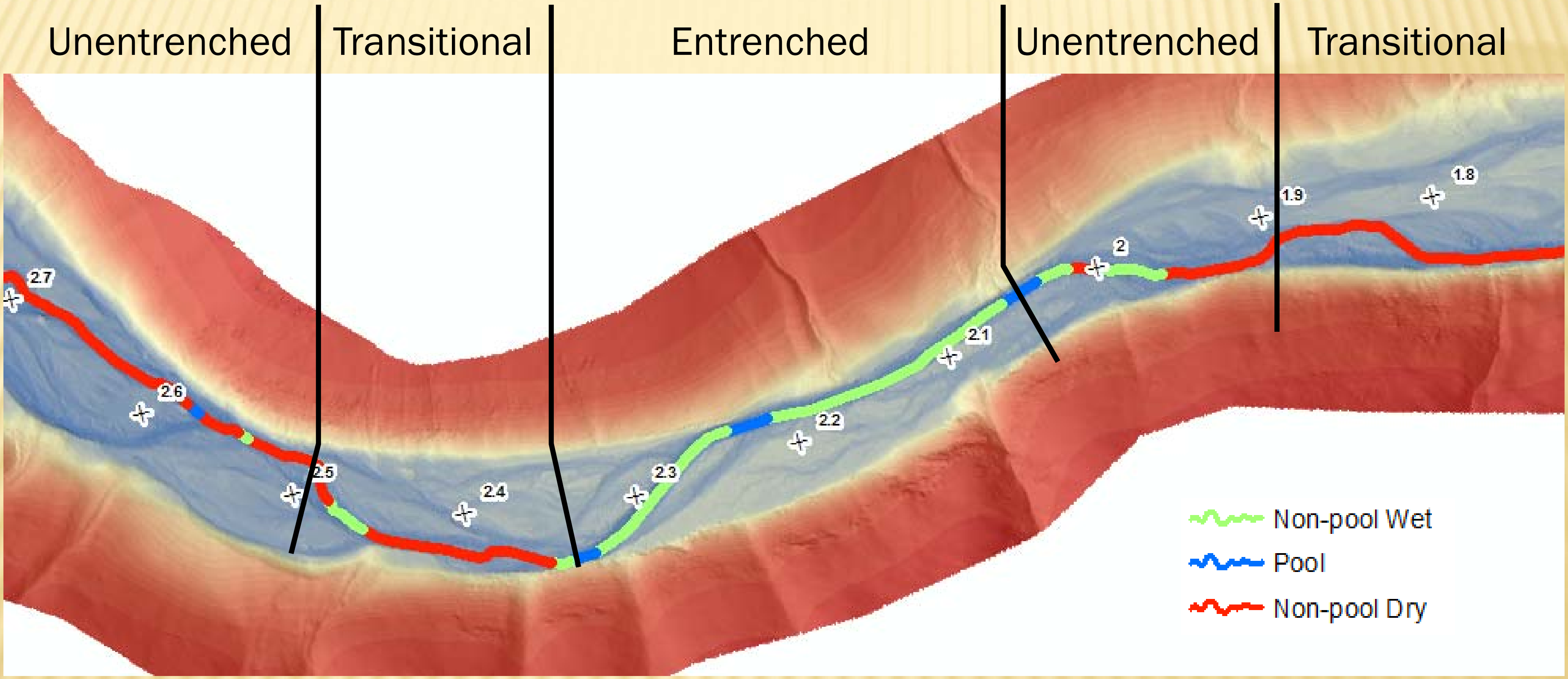
Higher-quality habitat is uncommon and tends to be forced, typically by bedrock or riparian trees.


Rock Creek: Valley Miles 6.2 to 8.9
Relative DEM & Baseflow Habitat
Q10 Stream Power* & Hydromodifications
Rock Creek
Squaw Creek
Rock Creek Road
Columbia River
Valley Mile
Main Roads
Roads (other)
Hydromodifications
Baseflow Habitat (2012)
(gaps indicate unsurveyed areas)
Non-pool Wet
Pool
Non-pool Dry
Feet
0 500 1,000 2,000
1:12,000
Drawn By: WCC - YNFP
Date: March 3, 2015
Filename: RockCreek4.mxd
Appendix B
Sheet 3
-3.5 0 5 10 20 50 70 100 400
Feet Above/Below Water Surface
0 2 7 12 17 22 30 50
Total Stream Power (kW)
Base photography and LiDAR used to generate relative DEM flown April 2012. Inset map DEM 2013 NED. Baseflow habitat based on Allen et al. 2014a. All other data YNFP 2014.
* linear representation of total stream power magnitude at a station of a 10-year recurrence flood. Does not indicate horizontal extent of inundation.


Rock Creek: Valley Miles 8.6 to 11.5
Relative DEM & Baseflow Habitat
Q10 Stream Power* & Hydromodifications
Luna Gulch
Rock Creek
Columbia River
Imrie Road
Rock Creek Road
Valley Mile
Main Roads
Roads (other)
Hydromodifications
Baseflow Habitat (2012)
(gaps indicate unsurveyed areas)
Non-pool Wet
Pool
Non-pool Dry
Feet
0 500 1,000 2,000
1:12,000
Drawn By: WCC - YNFP
Date: March 3, 2015
Filename: RockCreek4.mxd
Appendix B
Sheet 4
-3.5 0 5 10 20 50 70 100 400
Feet Above/Below Water Surface
0 2 7 12 17 22 30 50
Total Stream Power (kW)
Base photography and LiDAR used to generate relative DEM flown April 2012. Inset map DEM 2013 NED. Baseflow habitat based on Allen et al. 2014a. All other data YNFP 2014.
* linear representation of total stream power magnitude at a station of a 10-year recurrence flood. Does not indicate horizontal extent of inundation.

BASEFLOW INTERMITTENCY

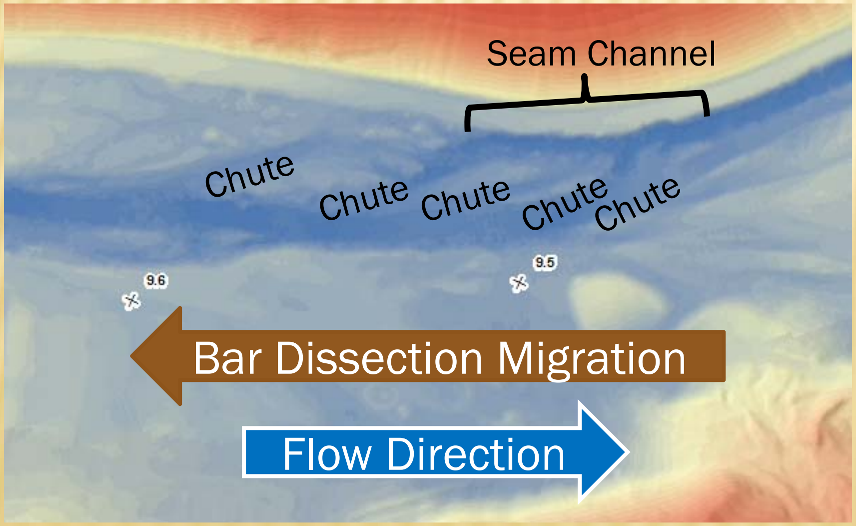
- Perennial reaches often entrenched
- Seasonal reaches often unentrenched, may be important for recharge
- Entrenchment sometimes correlated with valley confinement



- Other likely controls
  - Proximity to groundwater inflow
  - Subsurface hydraulic conductivity
  - Cumulative evapotranspiration

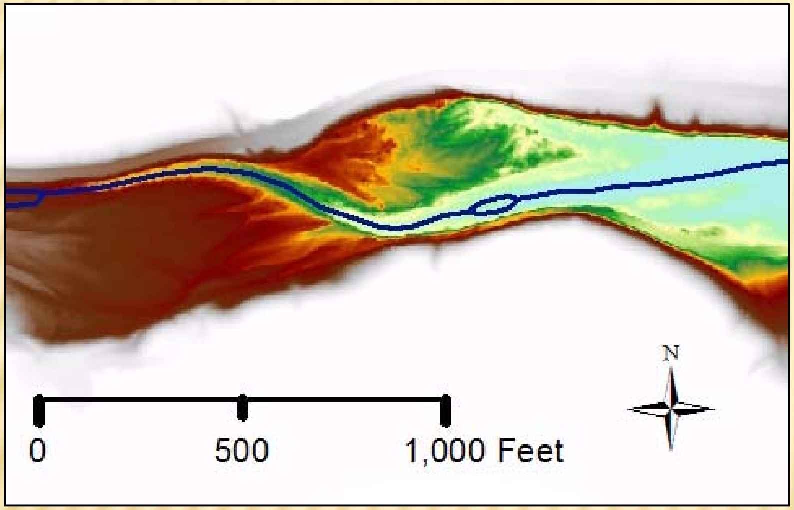
HIGH RELIEF DIAGONAL BARS

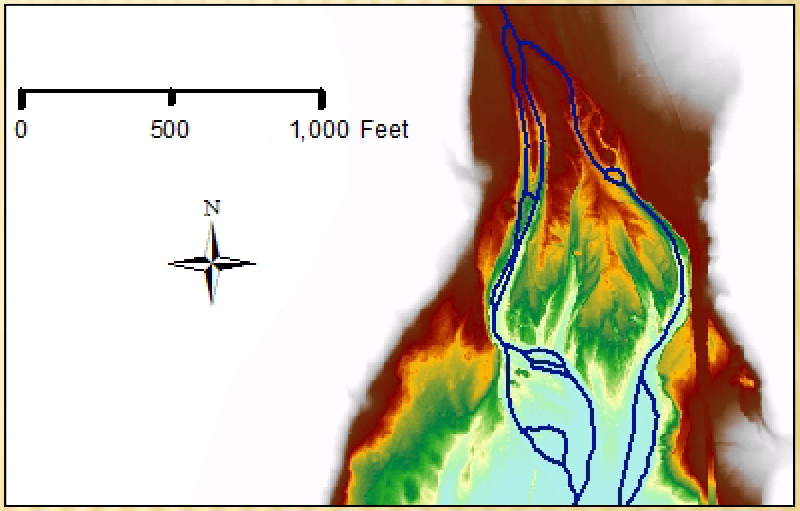
- Arrive as sediment slugs during high magnitude peakflows (>Q25)
- Get re-worked by lower magnitude peaks (<Q10)
- "seam" channel migrates headward along resistant boundary
- "chute" channels carry cross-over flow



TORRENTS?

- Air photos indicate the 1964 peakflow was a signature event
- 1974 and 1996 peakflows also caused morphologic shifts
- Valley-scale lobate features (below) and poorly-sorted floodplain deposits (bottom) suggest a history of torrents or debris flows, though were not specifically correlated with a particular event.



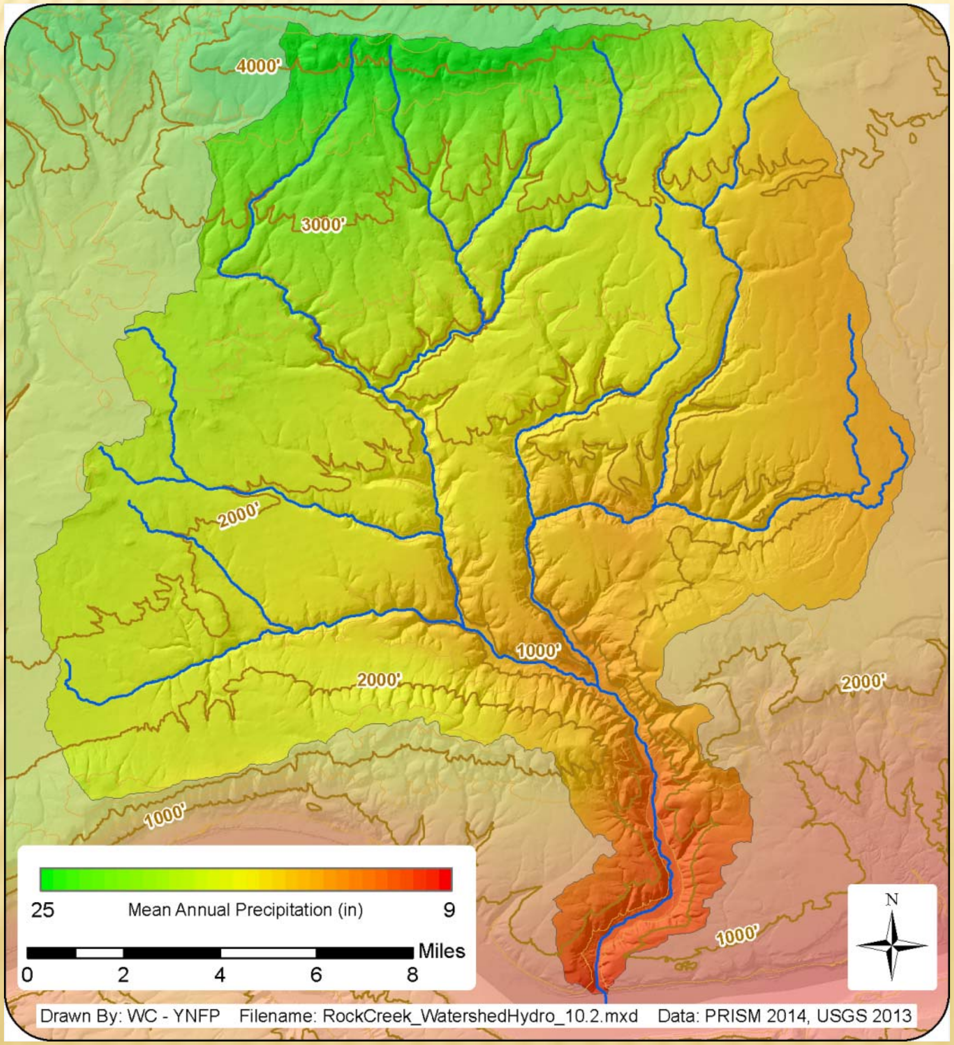


LANDSCAPE AND TEMPORAL CONTEXTS

- Intrinsic watershed characteristics
- Groundwater development
- Climate forecasts

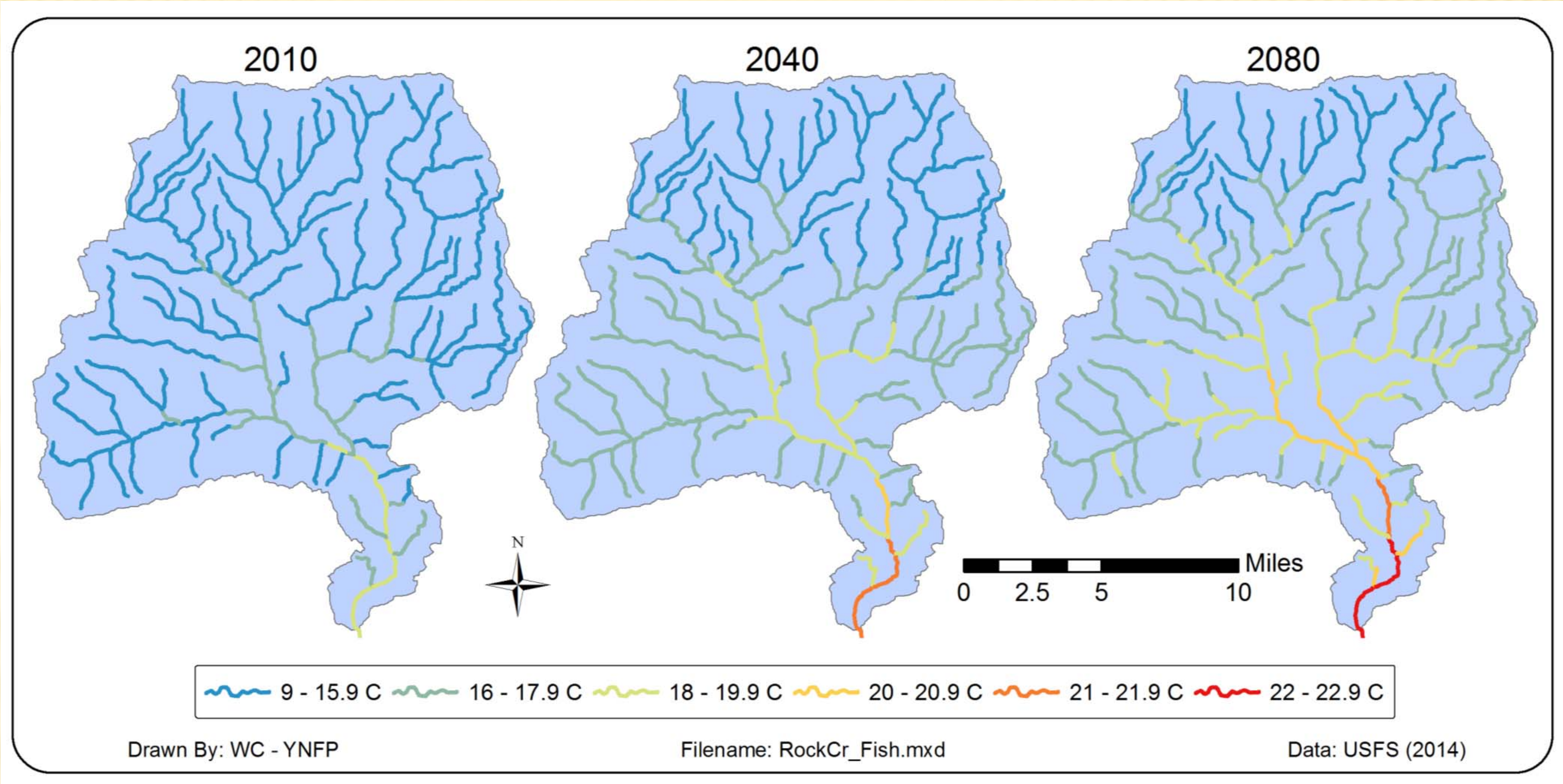
Watershed Characteristics

Dynamic stream behavior is largely a function of intrinsic watershed characteristics, including:



- equant shape
- low elevation
- south-facing aspect
- low annual precipitation
- no appreciable surface storage
- low infiltration rates
- moderately-high relief

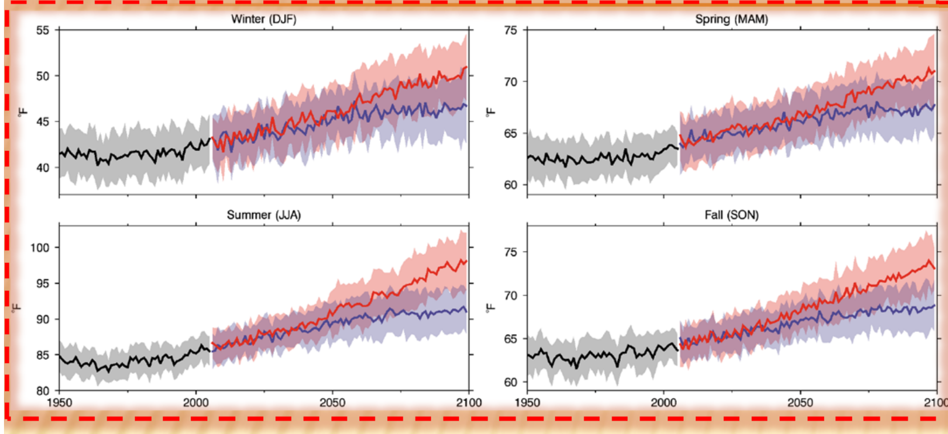
STREAM TEMPERATURE



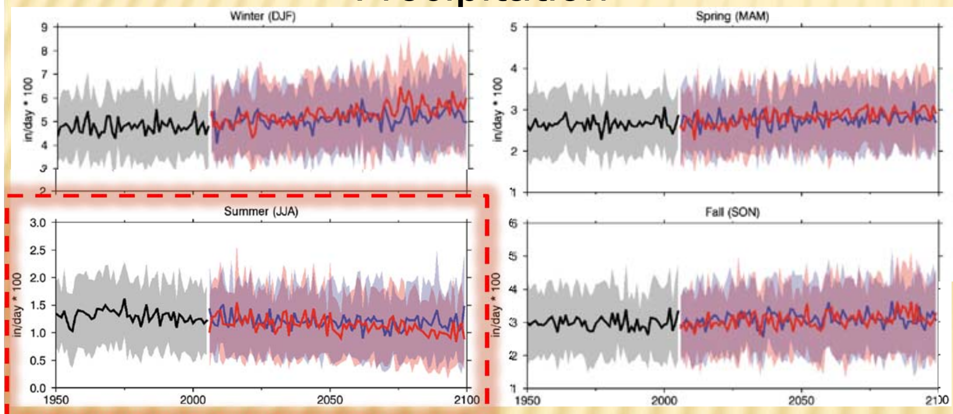
- 2080 temperatures already being observed at multiple stations
- Model over-represents summer flow network
- Important take-home message: general warming trend

CLIMATE BY SEASON

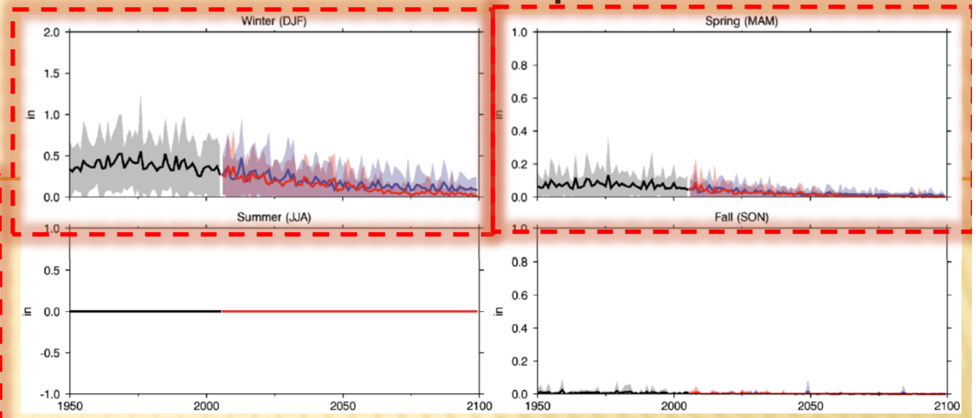
Air Temperature - Maximum



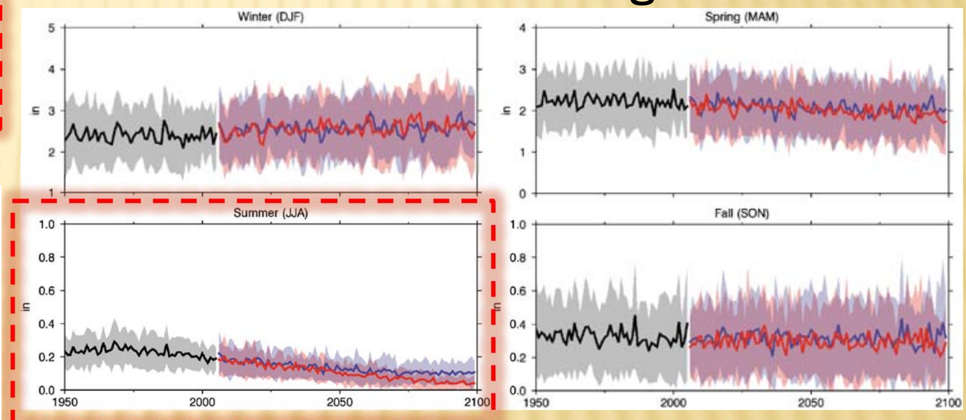
Precipitation



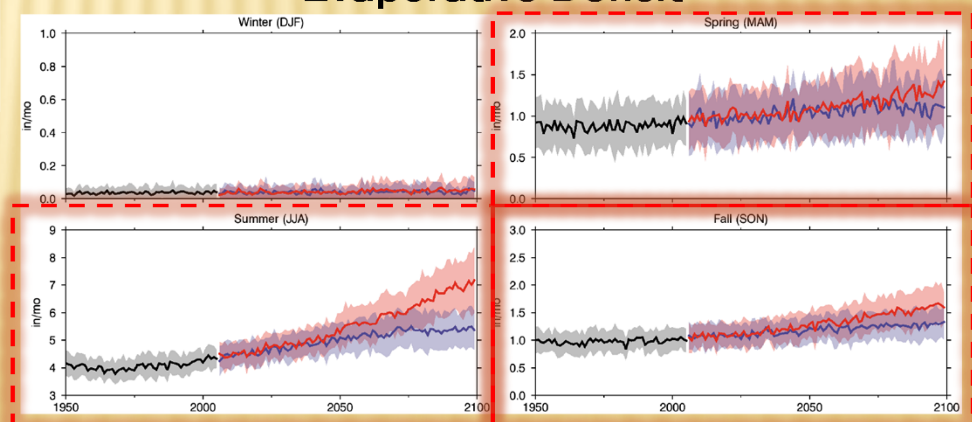
Snow Water Equivalent



Soil Water Storage



Evaporative Deficit



Location: Mid-Columbia – Lake Walulla

Dataset: NASA NEX-DCP-30

Model: MeanModel

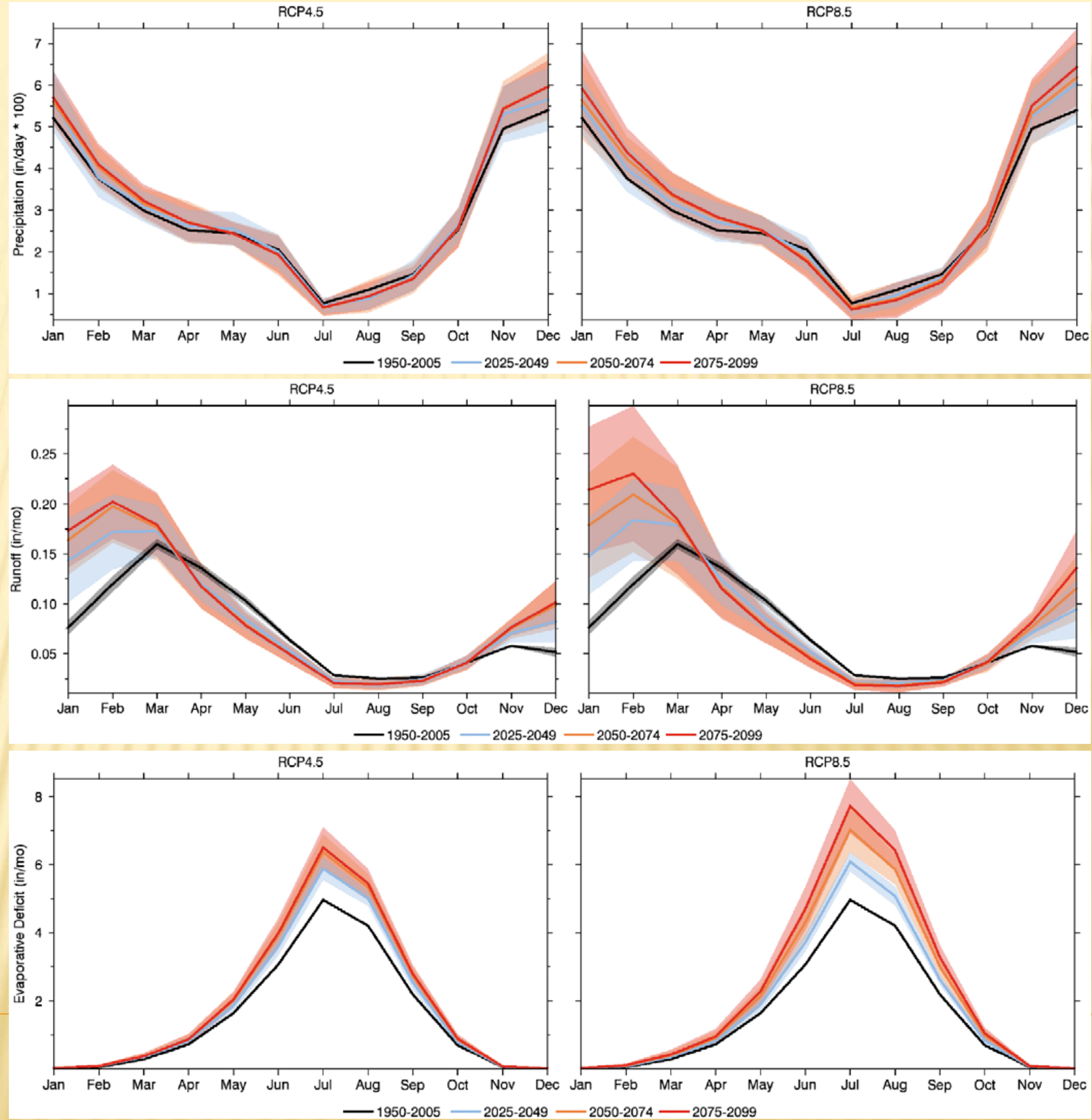
Time Period: Annual Average

http://www.usgs.gov/climate_landuse/clu_rd/apps/nccv_viewer.asp

PRECIPITATION

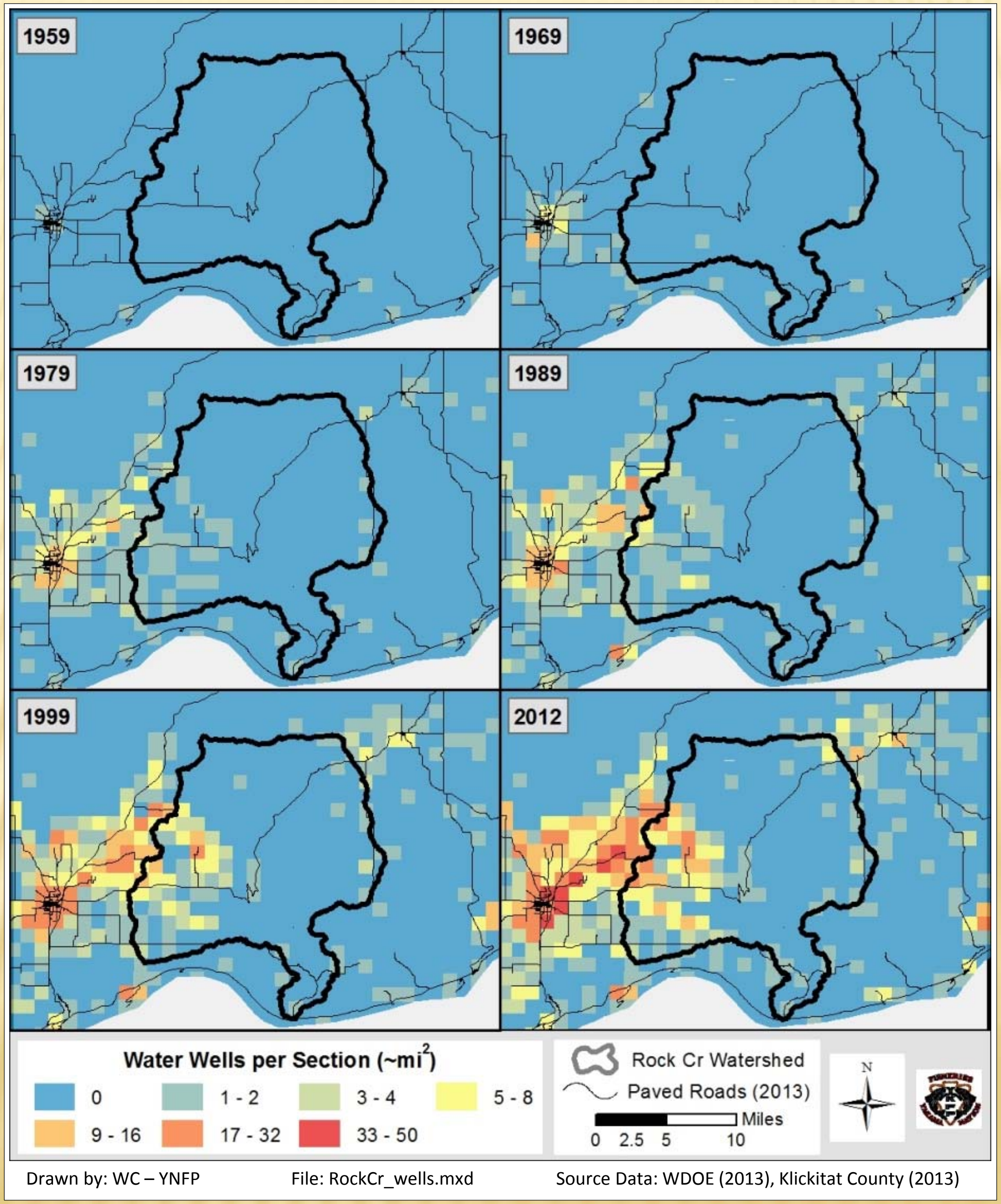
RUNOFF

EVAPORATIVE DEFICIT



http://www.usgs.gov/climate_landuse/clu_rd/apps/nccv_viewer.asp

GROUNDWATER DEVELOPMENT



FISHERIES CONTEXT

- Recovery Plan
- Spawning surveys
- PIT-tagging
- Genetics

RECOVERY PLAN

NMFS (2009) and ICTRT (2003, 2009):

- single Major Spawning Area (MaSA) for Rock Cr. Subbasin
- within Washington Gorge Management Unit
  - White Salmon
  - Klickitat
  - Rock Creek
  - Alder Creek
  - Chapman Cr.
  - Wood Gulch
  - Pine Creek
  - Glade Creek
- within Cascades Eastern Slope Tributaries Major Population Group (MPG)
  - Klickitat
  - Deschutes
  - Rock Creek
  - Fifteenmile
  - White Salmon
- Small tributaries east of Rock Creek (Chapman, Pine, & Wood)
  - Part of extirpated Willow Creek MPG
  - Current production likely either ephemeral, linked with upstream tributary (in Umatilla MPG), or result of straying

STEELHEAD POPULATION CHARACTERISTICS

Spawner surveys suggest good spawner abundance:

	Live Adults		Redds		Miles Surveyed		Redds/Mile		Estimated Adults	
Year	Rock Cr	Tribs	Rock Cr	Tribs	Rock Cr	Tribs	Rock Cr	Tribs	ODFW[a]	WDFW[b]
2009	7	30	12	33	5.0	7.5	2.4	4.4	81	73
2010	84	20	89	38	9.2	5.5	9.7	6.9	220	204
2011	73	81	187	100	20.8	6.0	9.0	16.7	492	461
2012	38	21	159	99	29.8	27.1	5.3	3.7	443	414
2013	36	6	84	22	20.8	22.0	4.0	1.0	184	170

[a] ODFW (2013) [b] Miller et al. (2014)

PIT-tag based metrics paint a more tempered picture:

Smolt-to-Adult ratio (SAR; based on data presented in Harvey 2014, above):

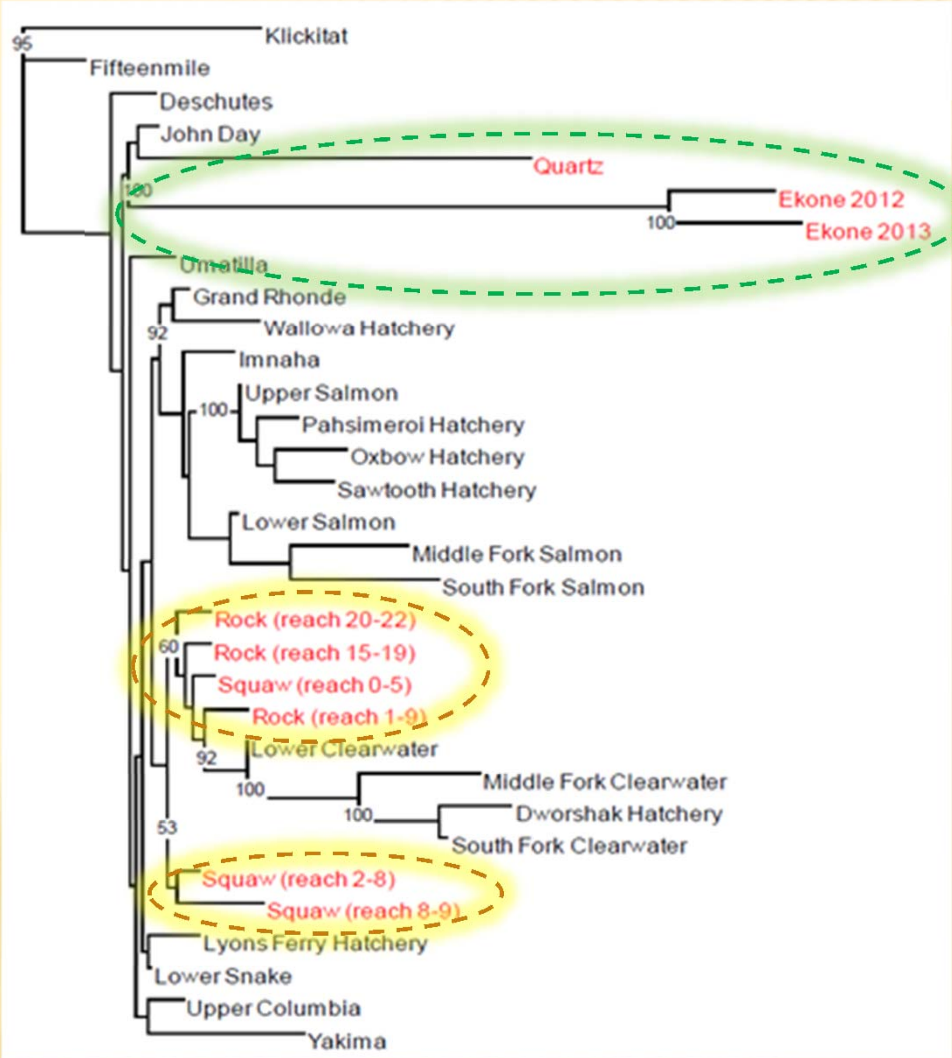
- most native populations: 2% to 3% considered adequate for replacement
- Rock Creek (2011-2013): 16.1% to 17.2%.
- Suggests a substantial immigration component in Rock Creek population

Origin (Allen et al. 2014a):

- 85% of unique adult detections of known juvenile origin from Snake R. basin
- Of these, 55% were known to have been transported downstream by barge

STEELHEAD GENETICS

- Genetic sampling indicates the steelhead run (yellow ovals) to be highly introgressed with the Snake River DPS (Matala 2014).
- *O. mykiss* samples from sites upstream of extended higher-gradient reaches group where expected (green oval).
- Currently unclear if steelhead in Rock Creek are a viable naturalized Snake River DPS subpopulation or sustained solely by routine straying.

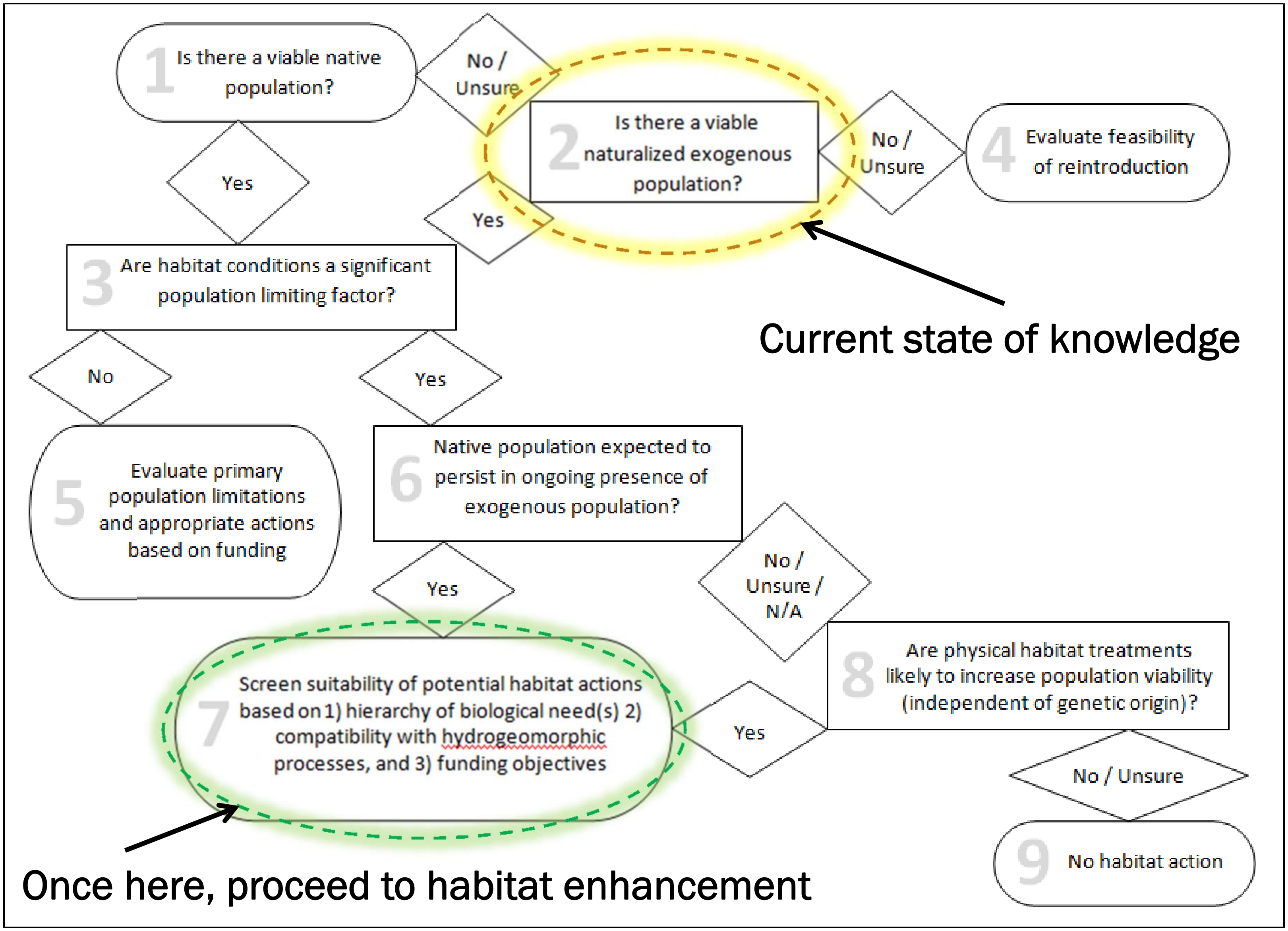


Whether or not the watershed is a meta-population "sink" is important to ensure that habitat actions are necessary and potentially effective.

WHAT DOES IT ALL MEAN?

- Dynamic stream and watershed behavior
- Marginal conditions for steelhead persistence
- Future conditions likely to become more marginal
- Uncertain viability of existing steelhead population

TO ENHANCE STEELHEAD HABITAT (OR NOT)?



(balancing benefit and effort)

SYNOPSIS

- Marginal conditions for population persistence
- MANY, substantial uncertainties, but….
  - Future habitat conditions likely to become more marginal
- No apparent fisheries benefit treating seasonal reaches
- Extended duration of post-disturbance response (‘64, ‘74, ‘96) combined with expected recurrence frequency of such disturbances suggest many of Rock Creek’s alluvial reaches can be expected to be in a nearly continual state of geomorphic adjustment.
- High potential for well-intended in-stream actions to:
  - do harm or have unintended consequences
  - have short service-life
- Uncertain population status could result in no benefit to population or Mid-Columbia DPS

WHILE ANSWERING POPULATION VIABILITY QUESTIONS…

Some interim habitat actions could be pursued, including:

- securing senior protections for instream flow & physical habitat,
- passive techniques:
  - allowing / encouraging beaver colonization
- Limited implementation of manual additions of locally-sourced woody debris (branches and tops) to improve instream cover.
- Re-frame efforts to be more watershed focused:
  - Invasive species

All actions should be organized hierarchically with baseflow protections above all other actions.

ADDITIONAL INFORMATION NEEDS

- document geographic distribution of perennial habitats
- groundwater / surface water relationships
- effectiveness monitoring of manual woody debris additions on summer survival
- ongoing PIT-tagging to address questions of productivity and population status

ACKNOWLEDGEMENTS

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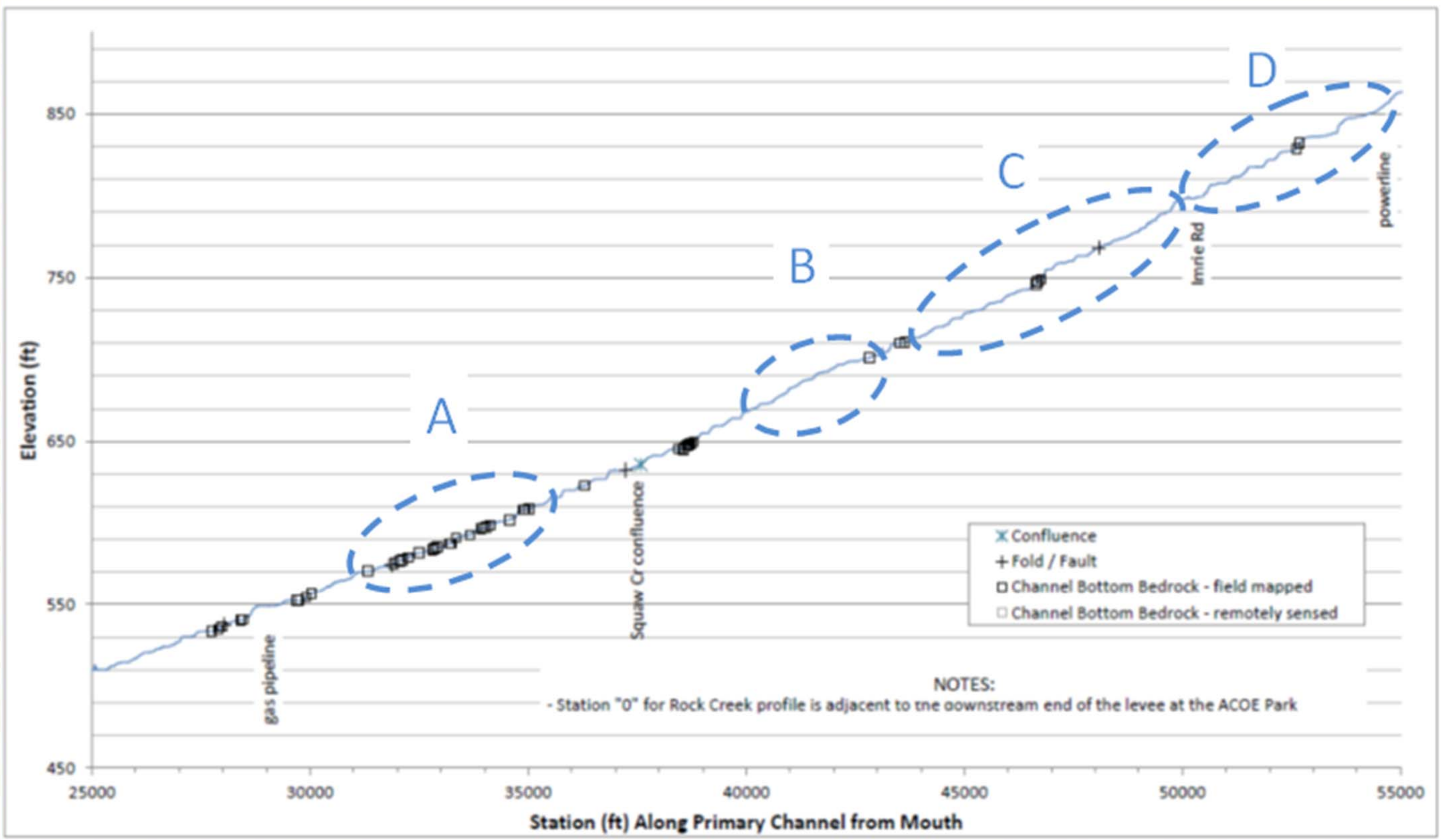
Questions?



Elevation (ft)
850
750
650
550
450
25000
30000
35000
40000
45000
50000
55000
Station (ft) Along Primary Channel from Mouth
A
B
C
D
gas pipeline
Squaw Cr confluence
Imrie Rd
powerline
Confluence
Fold / Fault
Channel Bottom Bedrock - field mapped
Channel Bottom Bedrock - remotely sensed
NOTES:
- Station "0" for Rock Creek profile is adjacent to the downstream end of the levee at the ACOE Park