Restoring Water Quality Through Rebuilding Hyporheic Function

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Natural Systems Design

Thornton Creek

COMMON PRACTICE

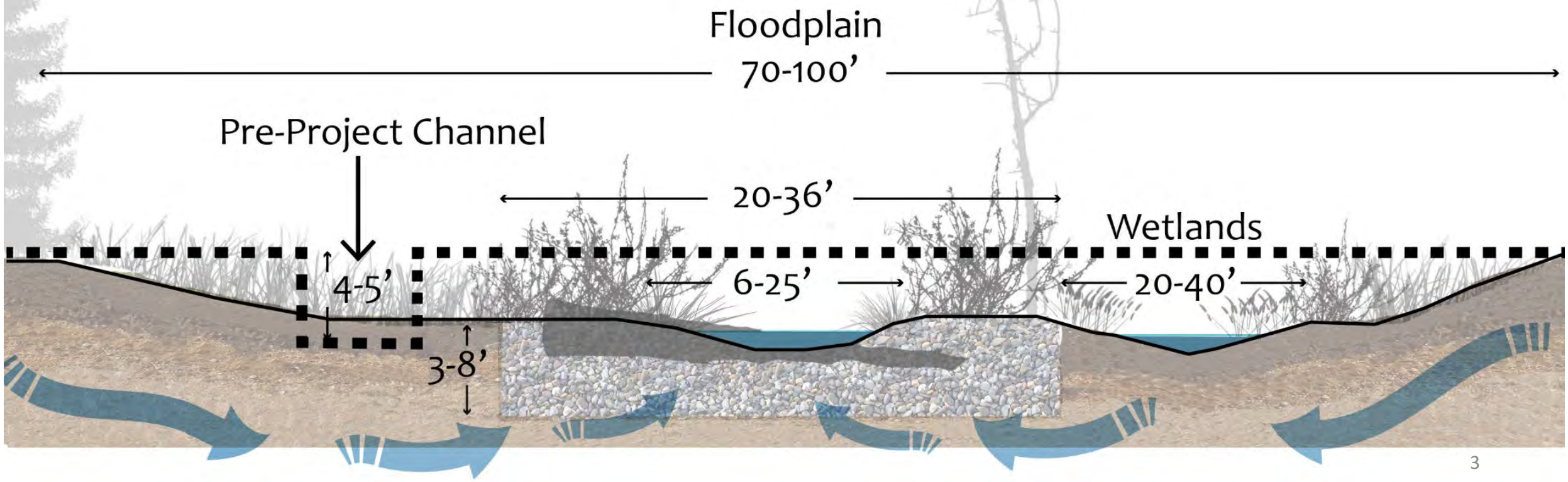
- Shade
- Cover
- Pools & Riffles
- Aeration

MOVING FORWARD

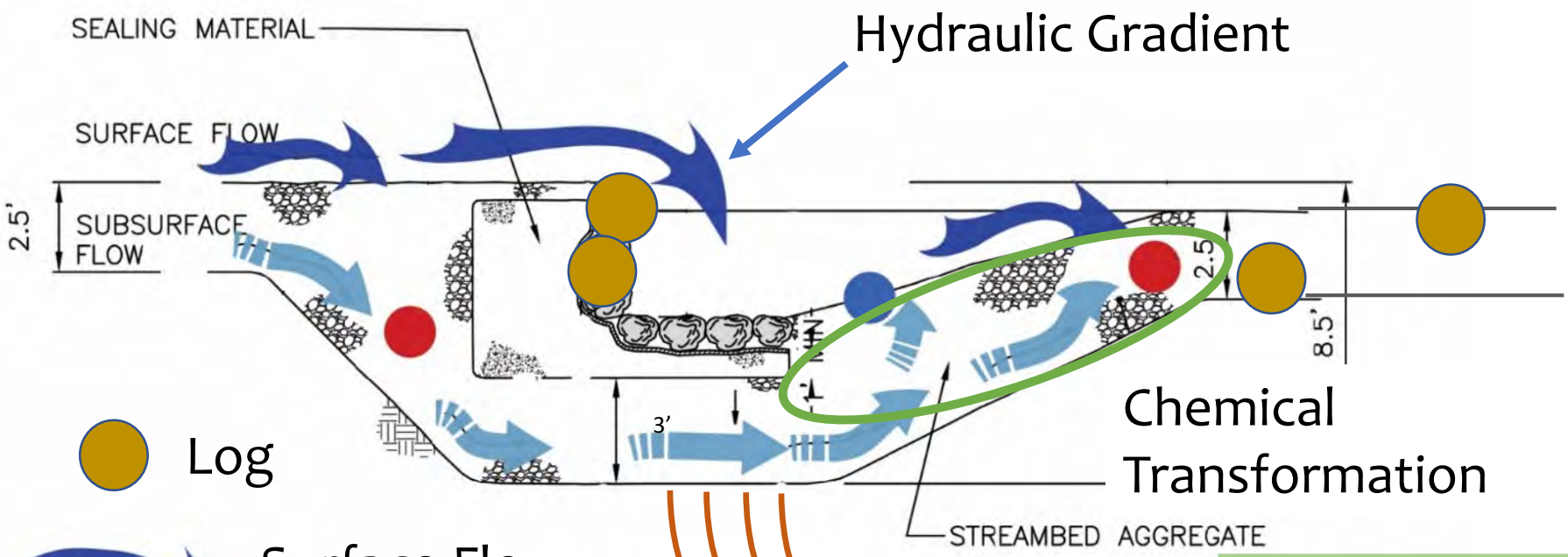
- Rebuild alluvial layer
- Hyporheic function
- Subsurface mixing
- Water treatment

Restoring hyporheic - inset floodplain

- Gravel lenses to route groundwater
- Over-excavate & gravel proximate to channel
- Vary gravel depth & buried logs promote mixing



Maximize Hyporheic Function – Bioreactor



Hydraulic Gradient

Chemical Transformation

Log

Surface Flow

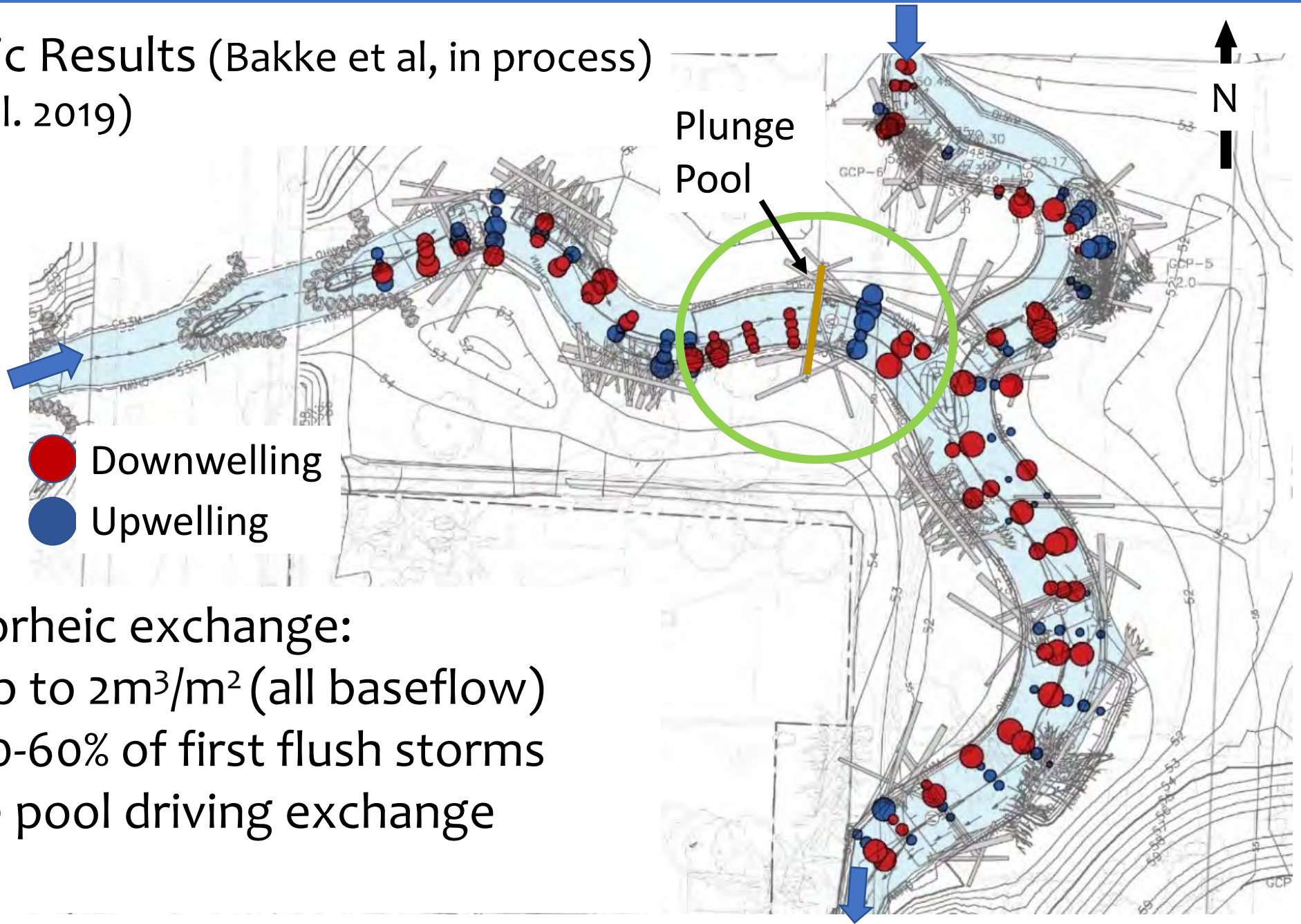
Subsurface Flow

Heat Exchange

Downwelling

Upwelling

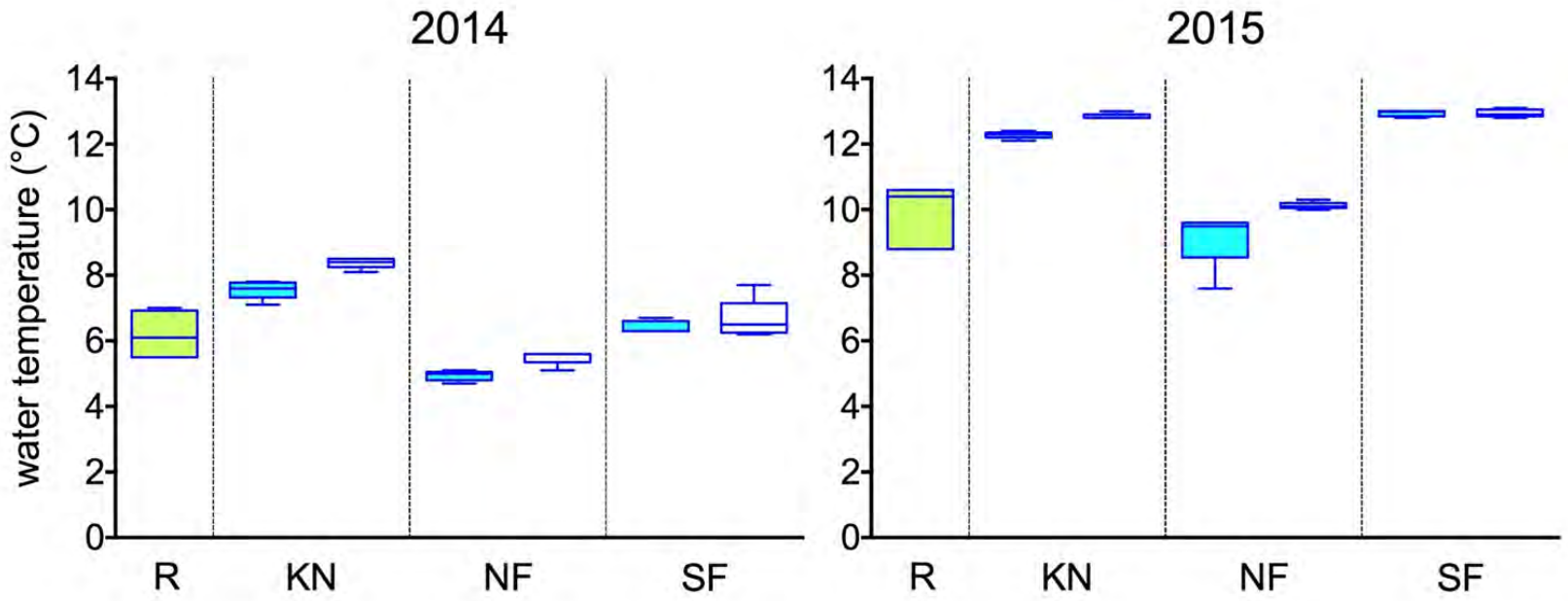
Hyporheic Results (Bakke et al, in process) (Peter et al. 2019)



- Hyporheic exchange:
  - up to 2m³/m² (all baseflow)
  - 20-60% of first flush storms
- Plunge pool driving exchange

Hyporheic Temperature (Morley et al. in process)

- As much as 2° Celsius cooler in restored reaches
- Add'l cooling expected as veg grows (shade)



Reference
Treated
Control

Forested
(R) = Reference

Urban
(KN) = Kingfisher
(NF) = Confluence North Fork
(SF) = Confluence South Fork

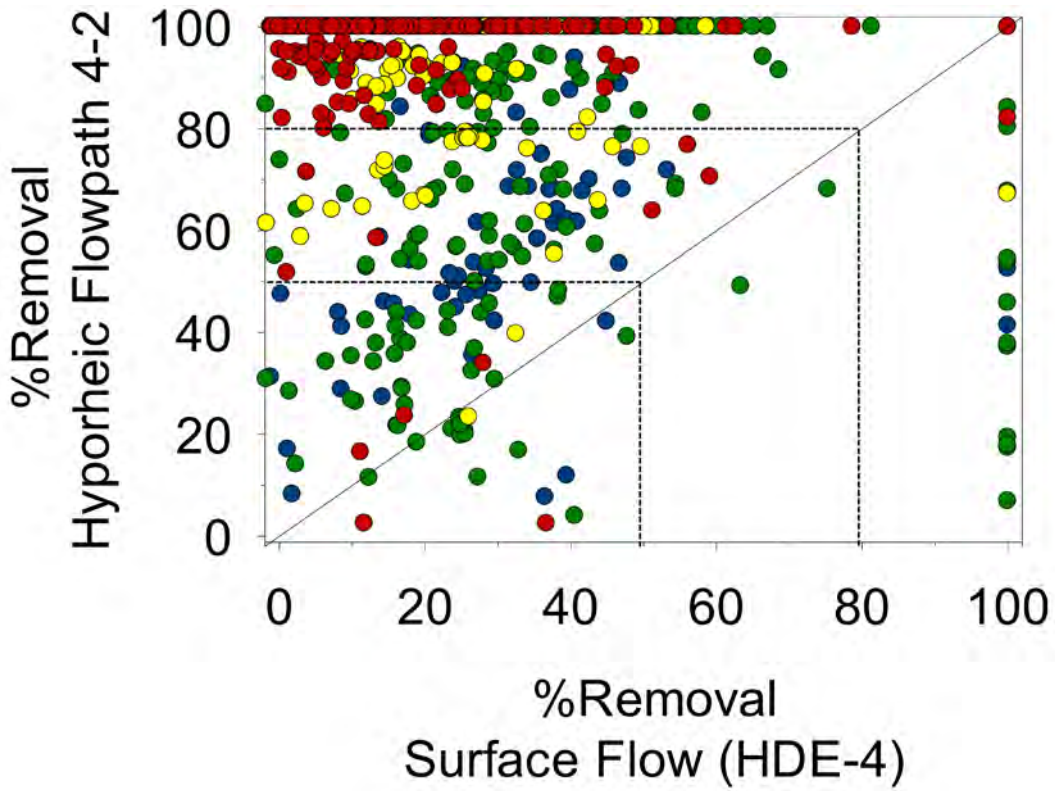
Contaminant Removal (Peter et al. 2019)

- Coho Mortality Signature Chem's
  - Base Q: 51 - 84% Removal
  - Storm Q: 15 – 50% Removal
- Hyporheic removal >>> surface removal
- Removal ≈ Hydraulic Residence Time

- 1 Bioreactor (Plunge Pool)
  - Base Flow – treats 100%
  - Storm flow – treats 20-60%

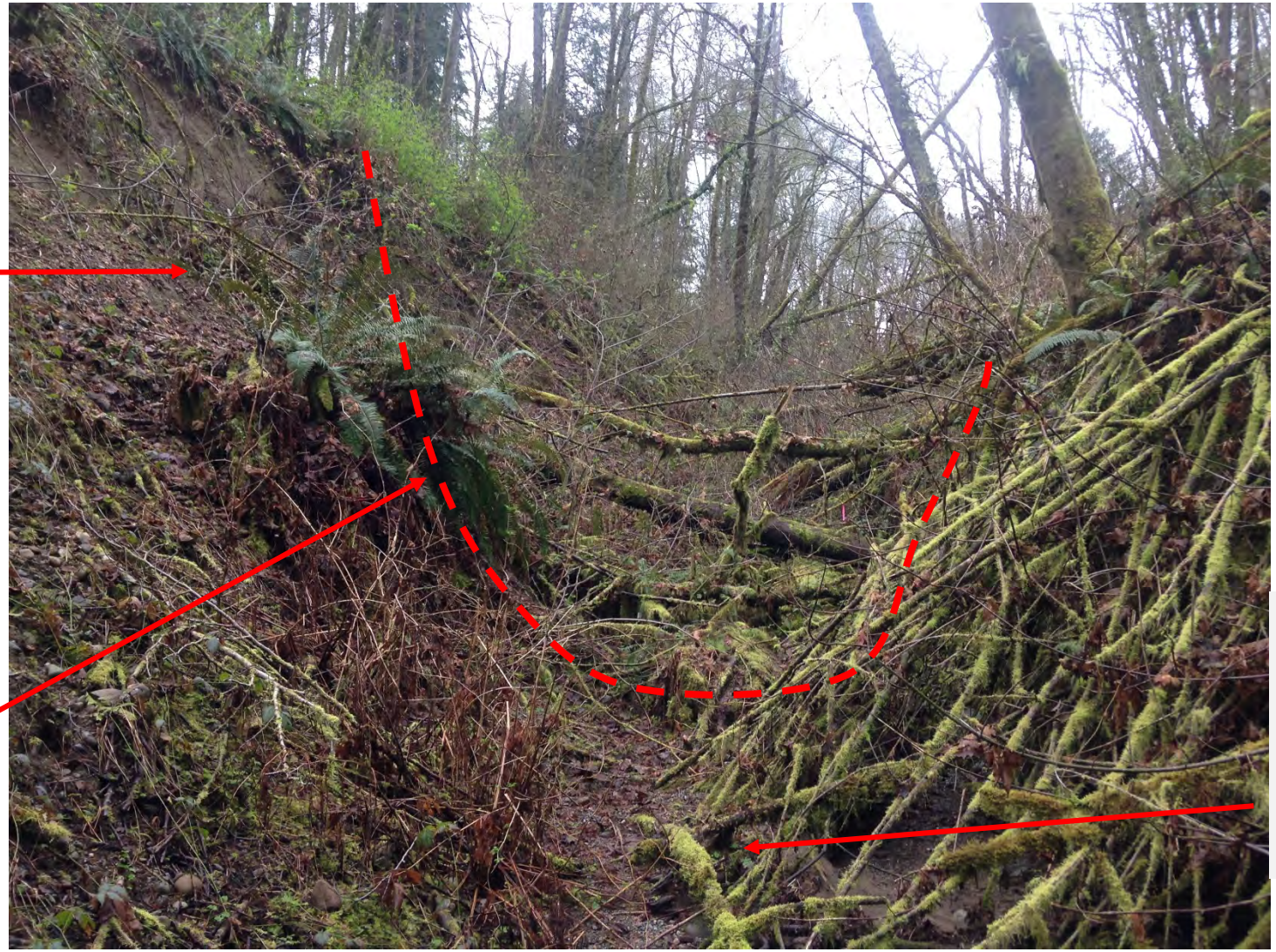
- AND: 1 project = 500 LF = 6 Plunge Pools

Base flow (non-target chem's)



Clarks Creek – sediment treatment

Eroding banks



Eroded Ravine profile

Eroding bed
There is no "bottom"

The BIG IDEA – rebuild the alluvial valley

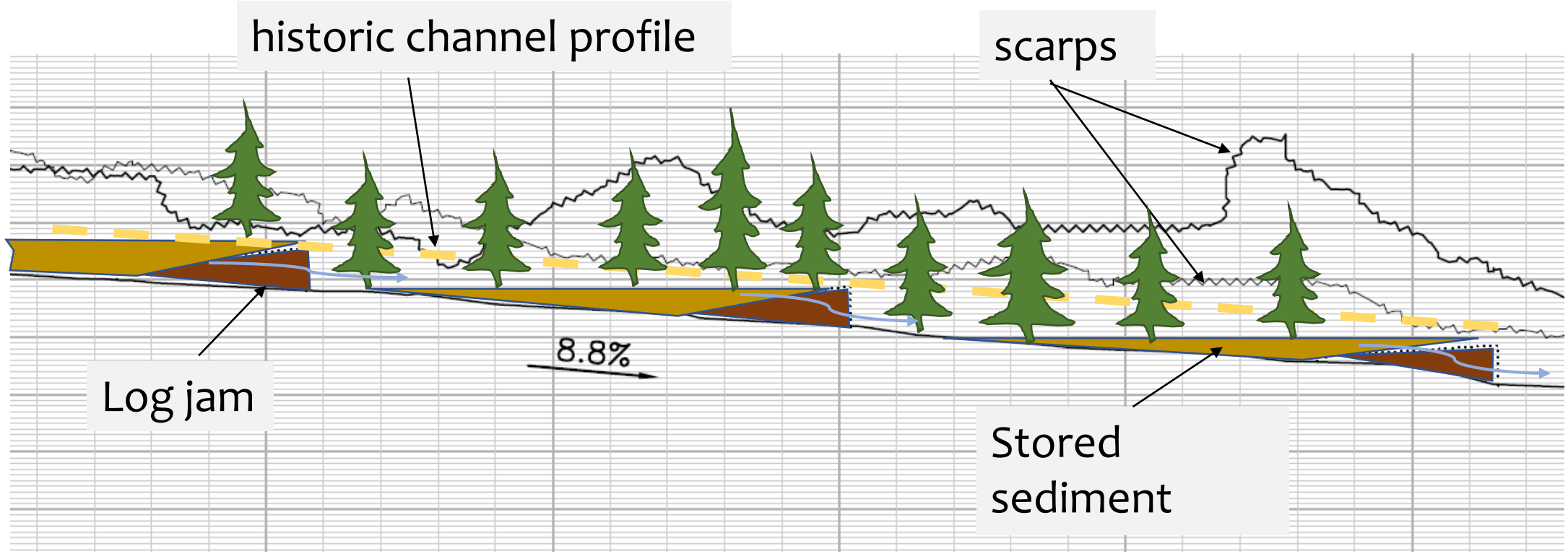
historic valley slope

Log Jam

Eroded ravine

2'–5' of Slash

Log jams retain sediment, restore valley



- Porous structures – reduce water velocity
- Collect incoming sediment – rebuild alluvial valley bottom
- Vegetate to retain sediment
- Restore hyporheic (subsurface) flow, cooler, boost base Q

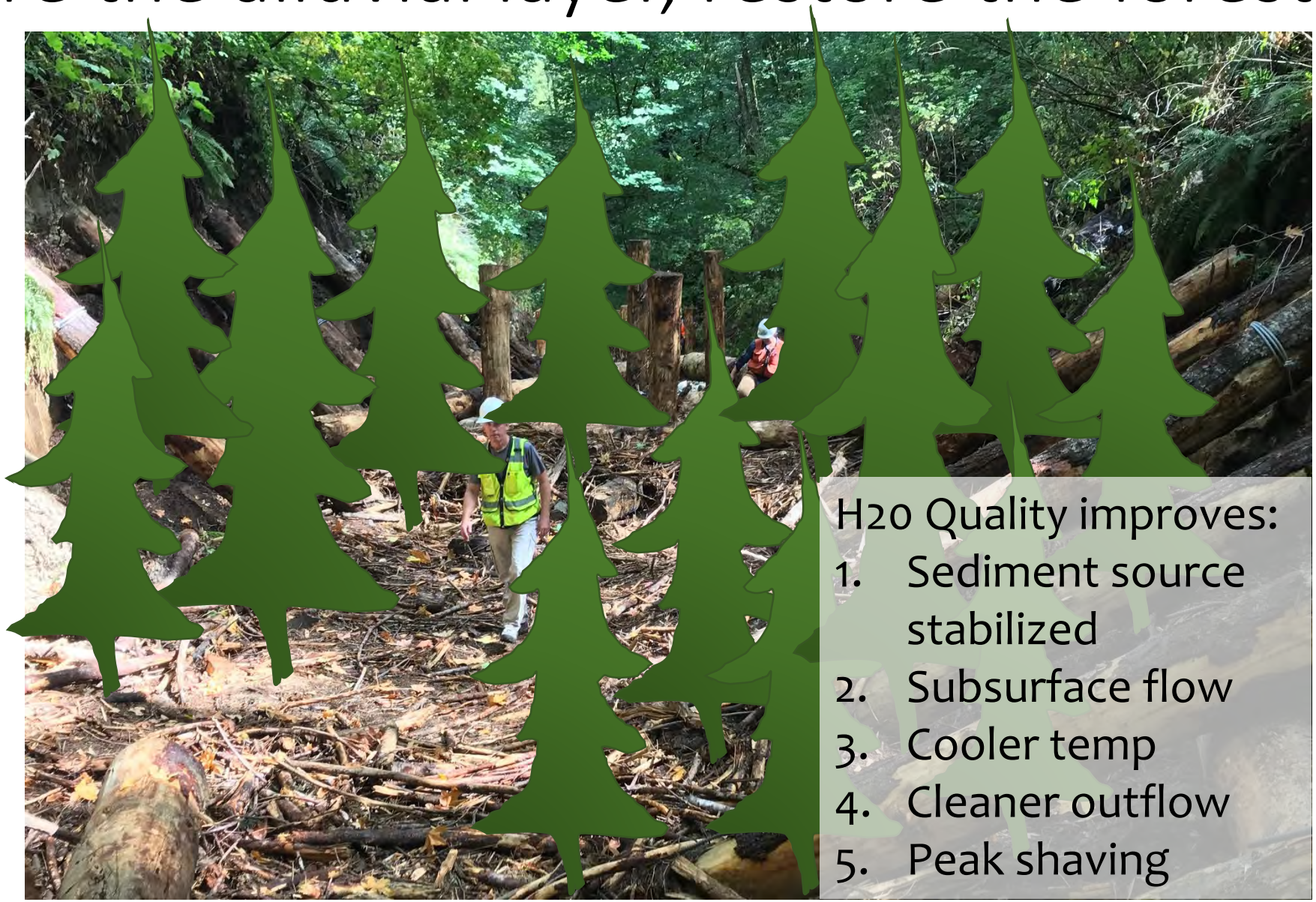
Bed Stabilization – log jams – install piles

Energy dissipation - cobble splash pad

Retain slash with log jam

Store incoming sediment in 5 ft of slash

Restore the alluvial layer, restore the forest



H20 Quality improves:

1. Sediment source stabilized
2. Subsurface flow
3. Cooler temp
4. Cleaner outflow
5. Peak shaving

Hyporheic Restoration Approaches

Thornton – highly engineered

- Traditional: 1’ gravel

- Over-excavate, designed aggregate
- Design - vertical/lateral mixing
- Chemical treatment, cooling
- Fish passable
- 3’ – 8’ gravel

- Finished surface – at construction

Clarks – low-tech

- Traditional – surface stabilization

- Retain incoming sediment
- Maximize subsurface flow
- Sediment removal, cooling
- Not fish passable
- Aggrade bed up to 5’

- Finished surface - future

Restored Hyporheic = Clean Water

The Puyallup Tribe of Indians

Northwest Indian Fisheries Commission

Seattle Public Utilities

"Engineering With Nature"

June 8

NOAA

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Natural Systems Design

LEAPING FROG FILMS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CITY OF PUYALLUP STATE OF WASHINGTON

Acknowledgements/References:

Paul Bakke, (Ret.) – Thornton Creek Hyporheic Concept

Sarah Morley, Linda Rhodes, Anne Baxter - NOAA – Water Quality Monitoring

Peter et al. 2019, Evaluating emerging organic contaminant removal in an engineered hyporheic zone using high resolution mass spectrometry