Examining the Functions and Forms of Restored Channel Outlets in Floodplains of the Lower Columbia River Estuary

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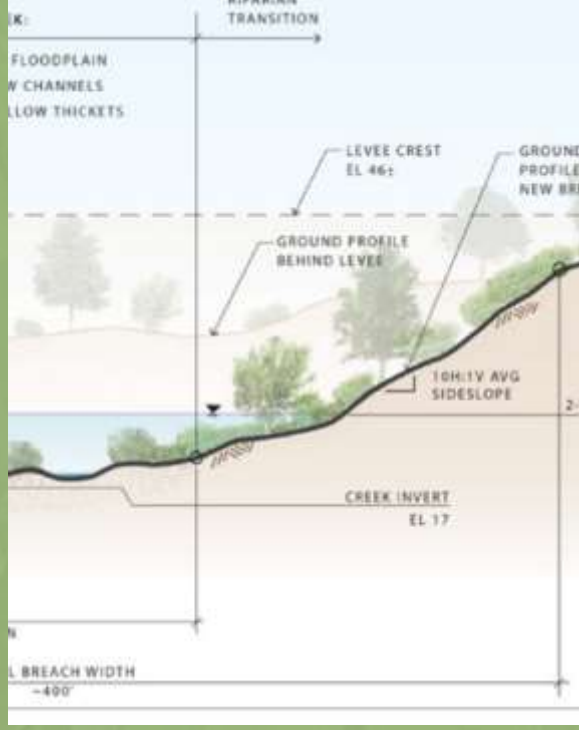
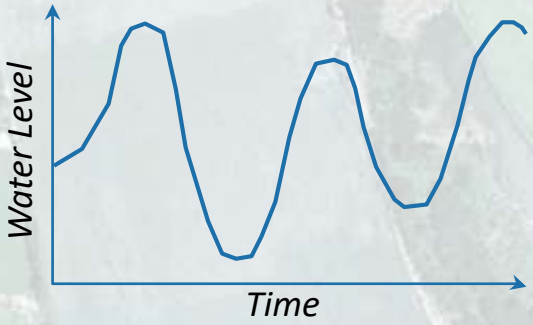


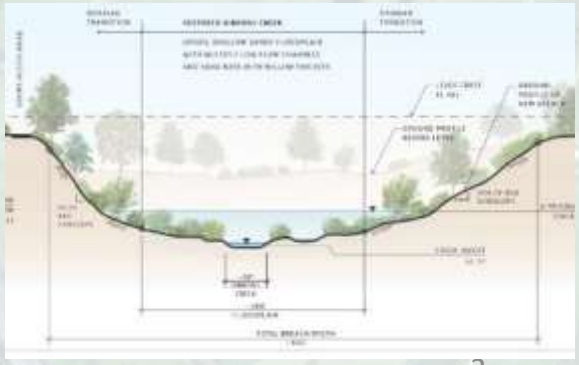
Salmonid recovery driving the need for advancements in restoration design

Salmonid recovery

Tidal / estuarine environments

Restoration design:
breaches, channels, outlets, connections





Why focus on connections?

- Fish and aquatic species ingress / egress
- Affect marsh geomorphology and ecology

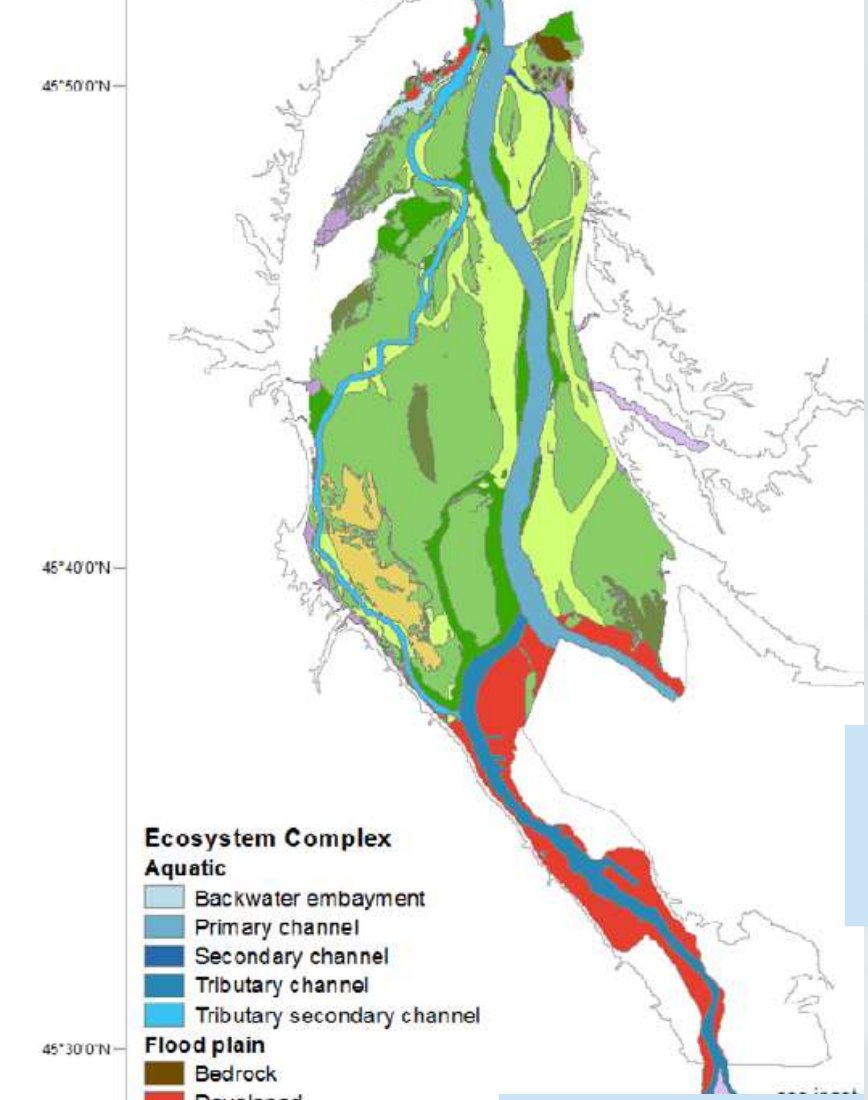
- Transport water, biota & nutrients, sediment

LCRE Connections

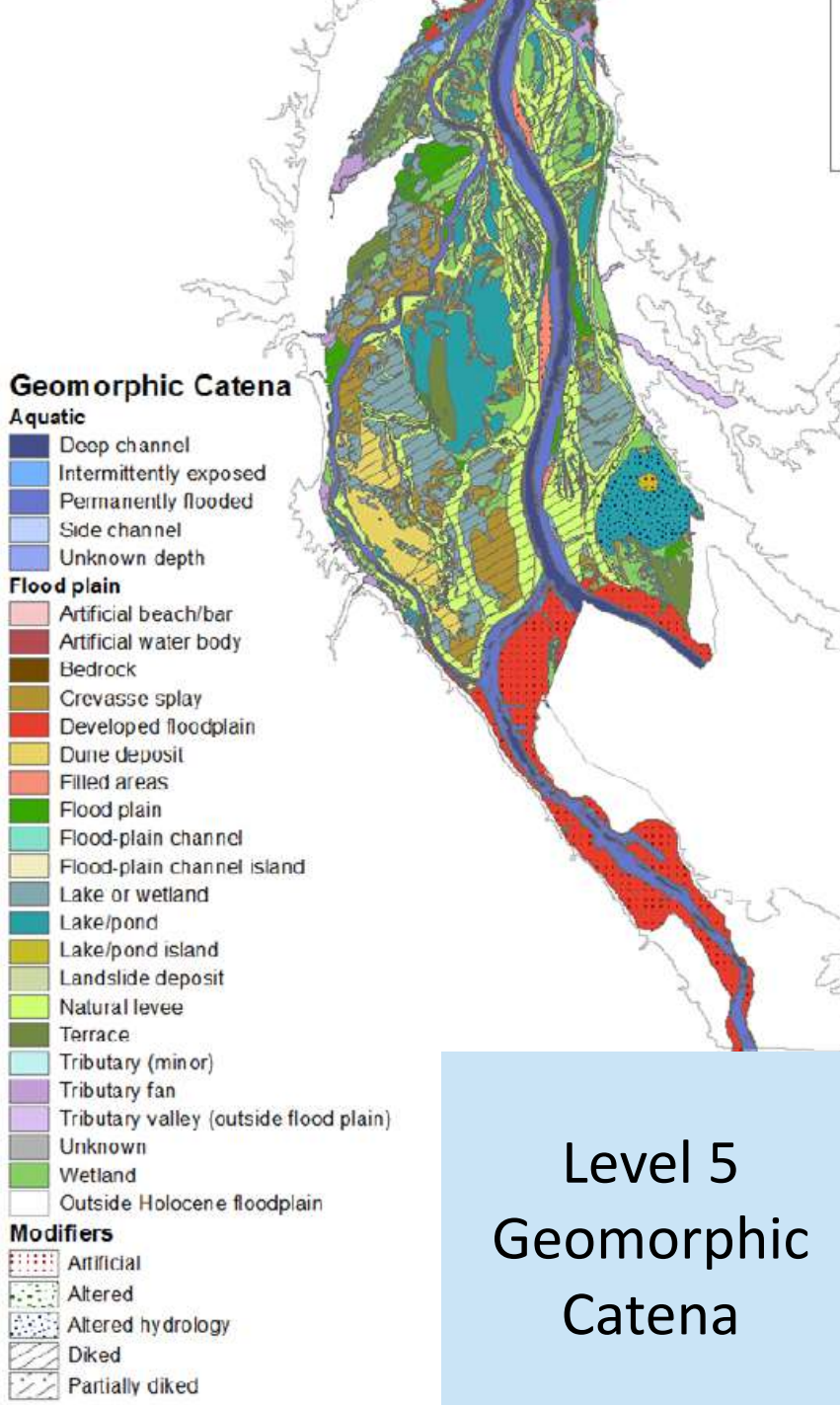
DOWNSTREAM *UPSTREAM*

HYDROGEMORPHIC REACH

A ← → *H*



Level 4 Ecosystem Complexes



Level 5 Geomorphic Catena

How to restore connectivity?

Remove.

the.

impairments…

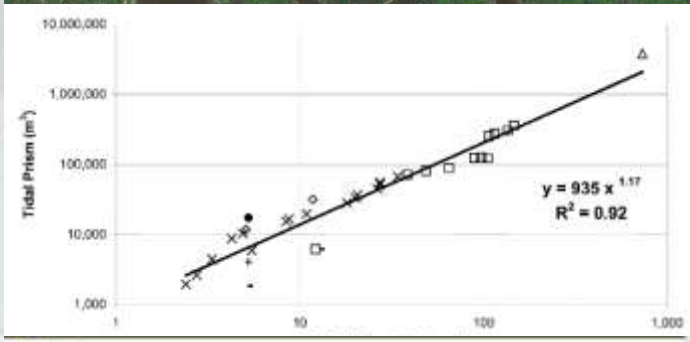
… RIP!

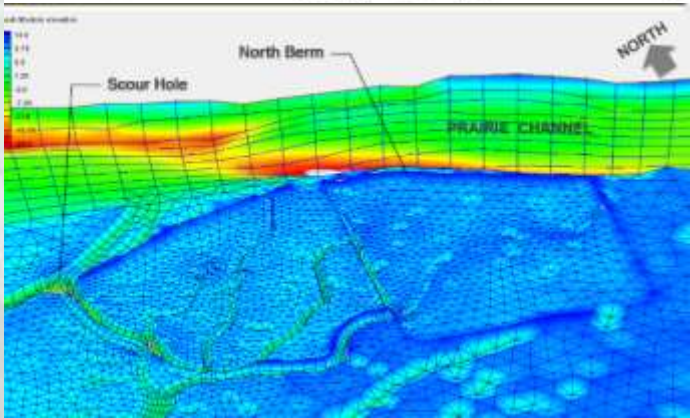
Evidence-based approach (multiple lines of evidence)

1. Least disturbed sites
2. Tidal hydraulic geometry
3. Hydrodynamic modeling

- Experience, constraints, costs

Sounds great…..!





Evidence-based approach – limitations?

- *Reference site?*
  Extensively disturbed, man-made

- *Hydraulic geometry guide?*
  Tidally challenged - above tidal range, combined fluvial/tidal (special cases, or “misfits”)

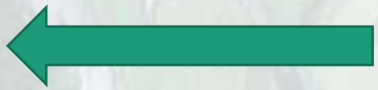
- *Modeling?*
  Difficult to survey, large, expensive

Evidence limitations?

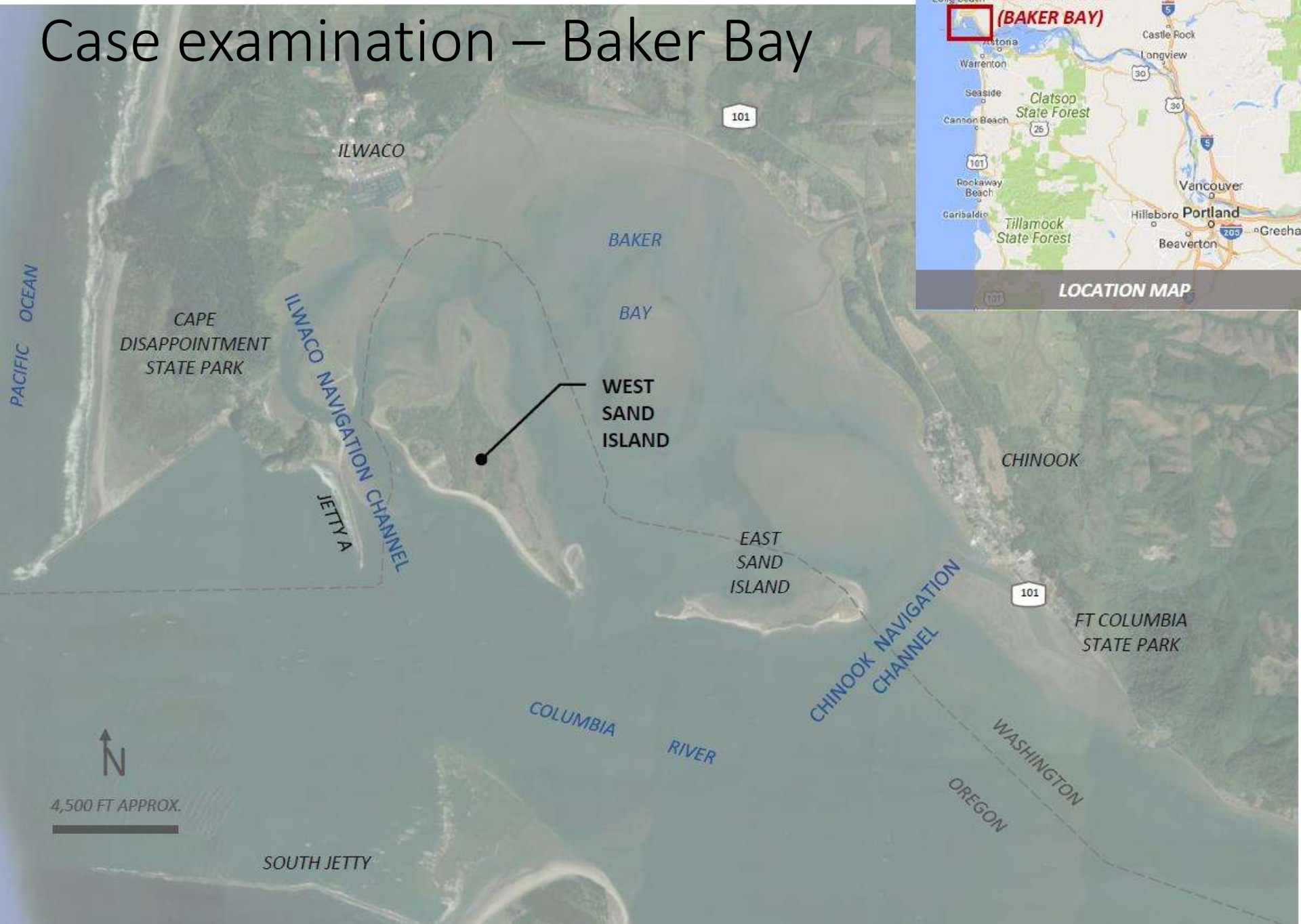
Location	Primary restored channel connection type
Sauvie Island - FE	**Upper tidal, redundant connections**
Sauvie Island – NU (multiple)	*Muted tidal channel*
Sauvie Island - Sturgeon	**Upstream-island / redundant channel connection**
Multnomah Channel - bottomlands	**Creek tributary; muted tidal**
Multnomah Channel - Scappoose	**Creek tributary, high floodplain, above MHHW**
Multnomah Channel – Mult. Co.	**Creek tributary, high floodplain, above MHHW**
Sandy R. Delta Natural Area	**Creek tributary, high floodplain, above MHHW**
Columbia floodplain – Washougal	**Alluvial fan, high wetland channels, above MHHW**
Dibblee – Rainier	*Muted tidal channel*
Tongue Point	*Tidal channel*
Cathlamet Bay Island	*Tidal & fluvial-surge channels*
Youngs River	*Tidal channel*
Fort Clatsop	*Tidal channel*
Columbia Passage Connection 1	**River distributary / passive restoration**
Baker Bay - WSI	**Vegetation removal with high tidal zone connections**
Columbia Passage Connection 2	**Creek tributary / tidal inlet**
Willamette River – Oaks	**Bluff seeps, high floodplain**
Miller Creek	**Creek tributary, high floodplain**

Gray – evidence non-limited (reference/design guidance applicable)

Black – special cases (misfit connections)



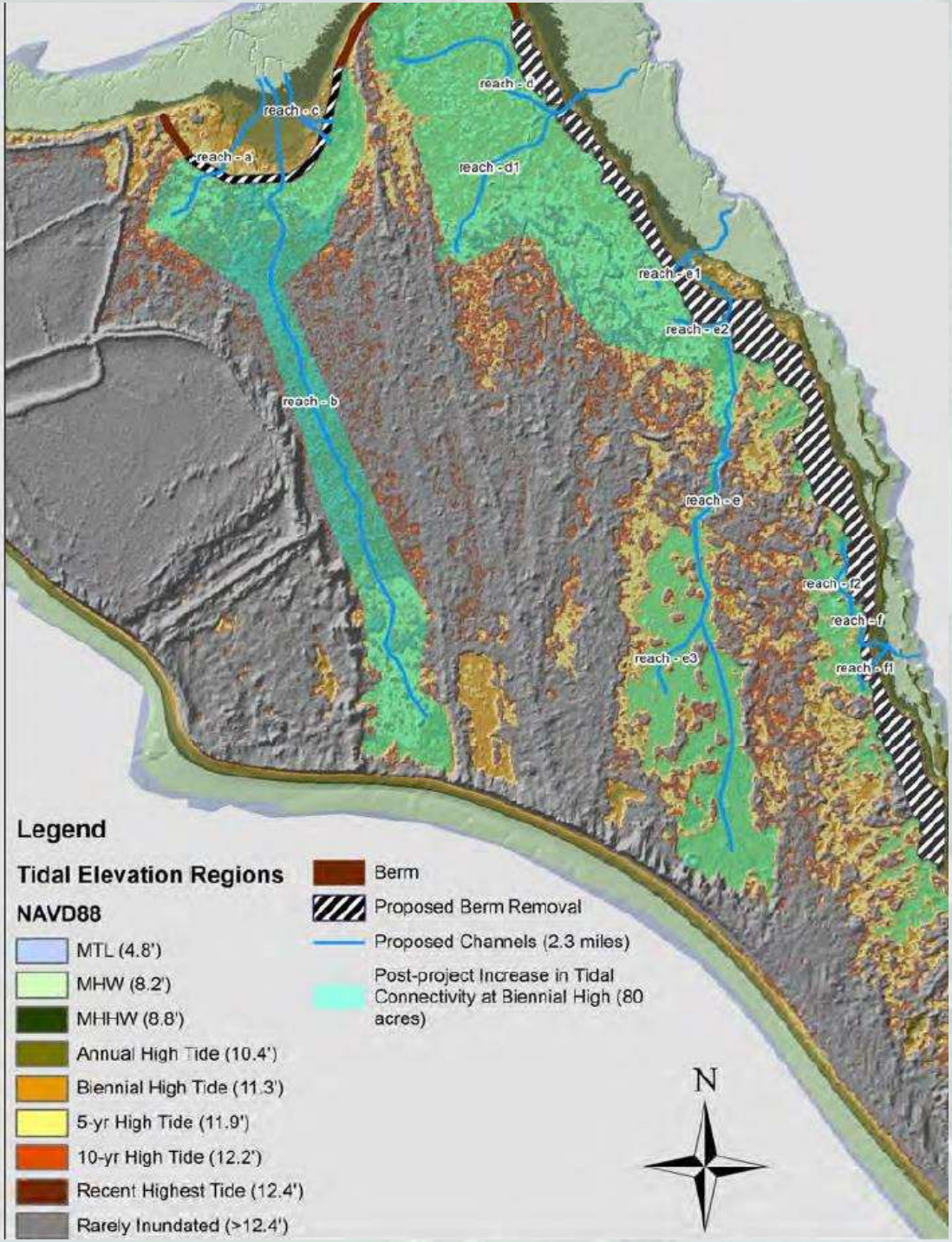
Case examination – Baker Bay



Case examination – Baker Bay

- Subject to numerous human activities
- Large, unique, wild habitats remain
- Recommended for Natural Heritage Conservation Area

Initial conceptual design



- Invasive veg. removal & revegetation
- Numerous connections & long channels
- Biennial high tide connectivity increase

- Preliminary reviews → additional analysis warranted

Field reconnaissance

EAST·SHORELINE·CHANNEL·D·REGION—·EXTERIOR·AND·INTERIOR·WETLANDS¶

¶

Not visible on aerials / LiDAR

Numerous small flow paths

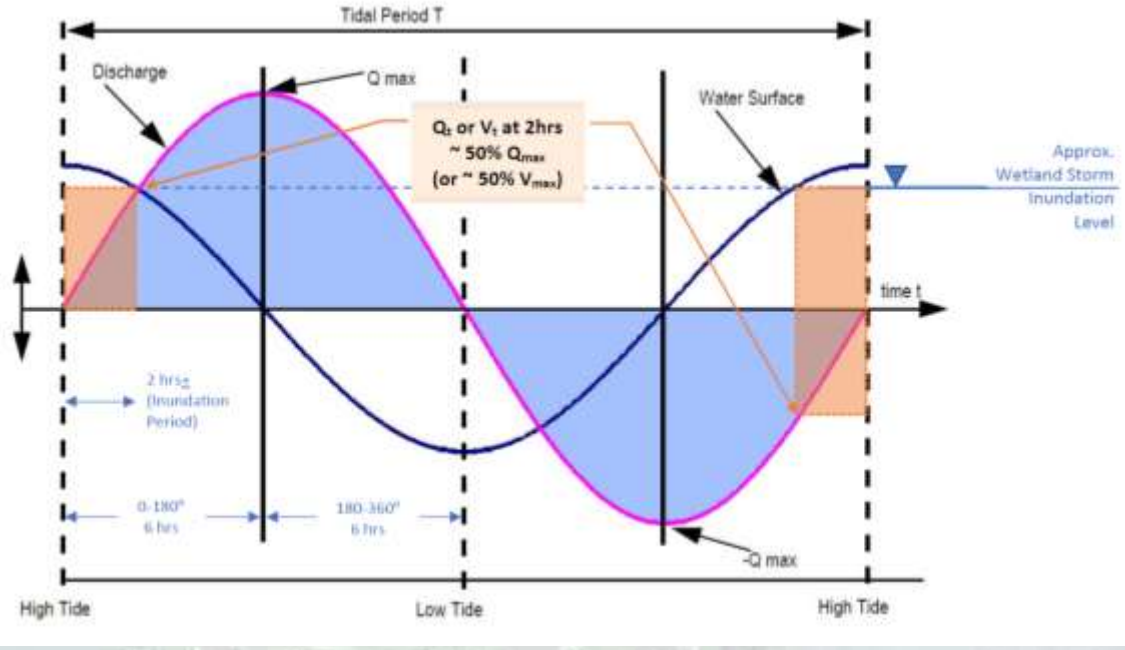
Hydraulic evaluation of erosion

- Tidal prism approach - max. theoretical flow (USFHA 2004, HEC-25)

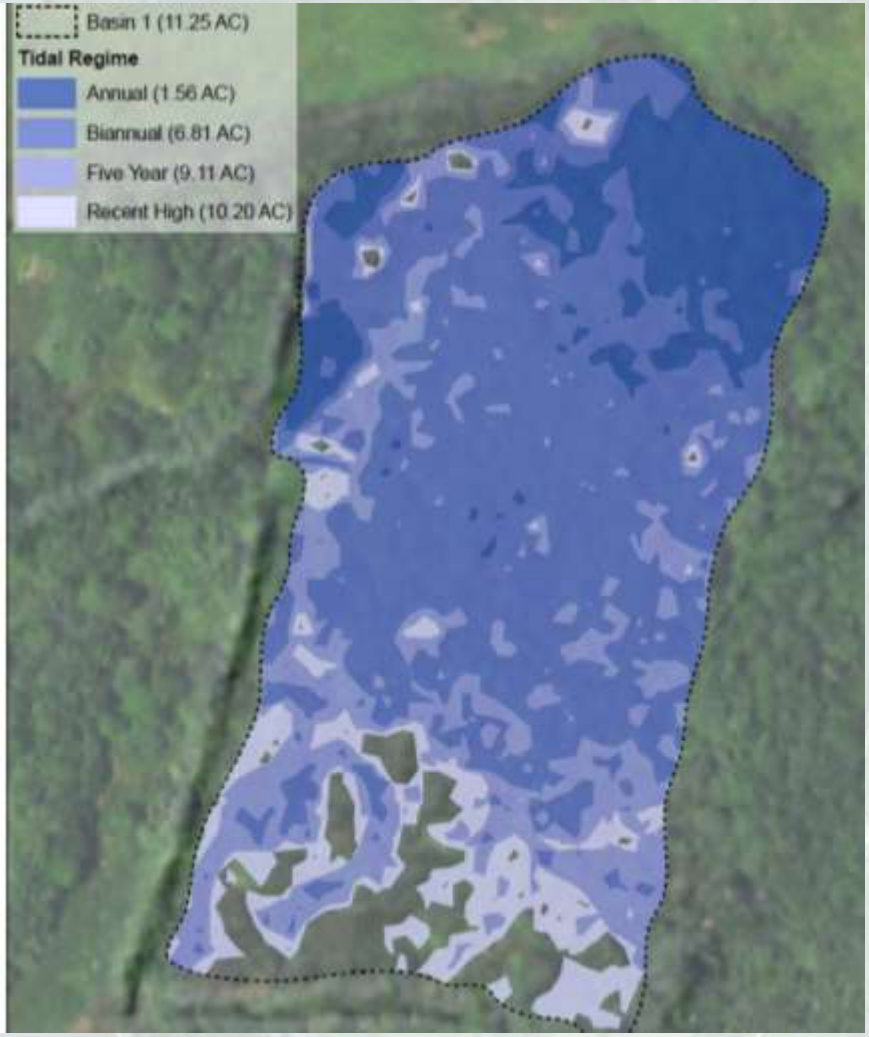
$$Q_{max} = \frac{\pi Vol}{t}$$

where:

Q_{max}	=	Maximum discharge during a tidal cycle (cfs)
π	=	Constant, 3.1416
Vol	=	Volume of tidal prism (inundated volume) (ft^3)
t	=	Time between successive high tides (sec.)



Basin delineation & hypsometry

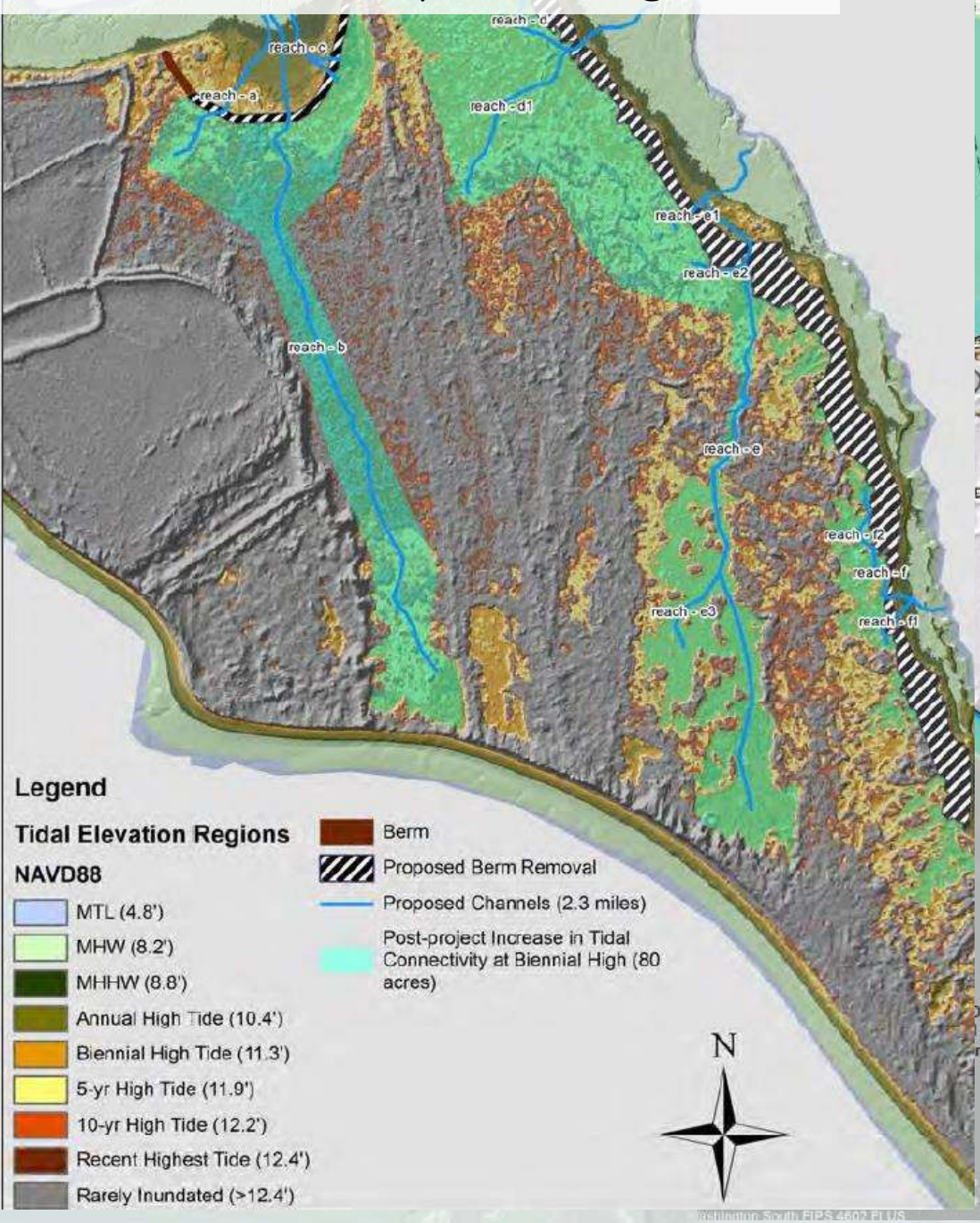


Initial hydraulic results

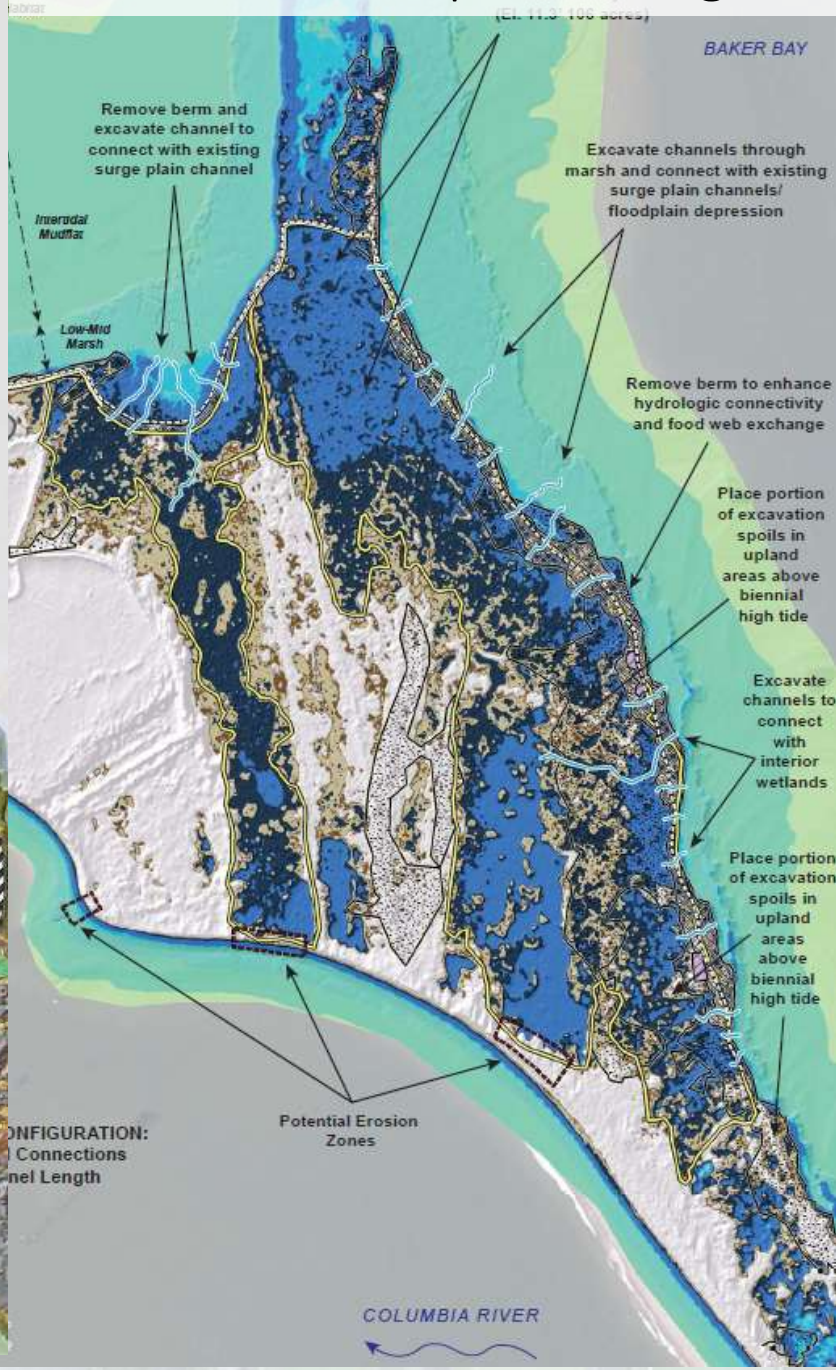
Water Level / Datum	Elev. (Feet NAVD88)	Wetland Area (AC)	Wetland Vol. (AF)	Max Theor. Flow (CFS)	Max Theor. Vel. (FT/S)	Actual Vel. (FT/S)
Basin 1						
No. Channels to Basin:	*2*					
Recent Highest Tide	12.4	10.2	14.0	22.2	11.1	5.6
5-yr Water Level	11.9	9.1	9.2	14.6	7.3	3.7
Biennial High Tide	11.3	6.8	4.2	6.7	3.3	1.7
Annual High Tide					0.7	0.4
MHHW					0.0	0.0
Basin 2						
No. Channels to Basin:						
Recent Highest Tide					26.2	13.1
5-yr Water Level					17.4	8.7
Biennial High Tide					8.7	4.4
Annual High Tide					2.2	1.1
MHHW	8.8	0.36	0.12	0.2	0.1	0.0

Apparent inconsistency in hydraulic regime – maybe reviewers were right

Initial conceptual design



Revised conceptual design



Revised hydraulic results

Water Level / Datum	Elev. (Feet NAVD88)	Wetland Area (AC)	Wetland Vol. (AF)	Max Theor. Flow (CFS)	Max Theor. Vel. (FT/S)	Actual Vel. (FT/S)
Basin 1						
No. Channels to Basin:	*2*					
Recent Highest Tide	12.4	10.2	14.0	22.2	3.7	1.9
5-yr Water Level	11.9	9.1	9.2	14.6	2.4	1.2
Biennial High Tide	11.3	6.8	4.2	6.7	1.1	0.6
Annual High Tide	10.4	1.6	0.9	1.4	0.2	0.1
MHHW					0.0	0.0
Basin 2						
No. Channels to Basin:						
Recent Highest Tide					5.8	2.9
5-yr Water Level	11.9	21.3	21.9	23.2	3.9	1.9
Biennial High Tide	11.3	13.6	11.0	11.6	1.9	1.0
Annual High Tide	10.4	4.0	2.8	3.0	0.5	0.2
MHHW	8.8	0.36	0.12	0.1	0.0	0.0

Hydraulics consistent w/ field observations

Findings and recommendations

- Common tools/approaches are usually necessary but not necessarily sufficient
- LiDAR and historical depictions may not tell the story well enough
- Technical staff lead ground survey & observations
- Incorporate remote sensing/survey technology

Findings and recommendations

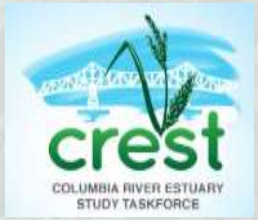
- Incorporate higher resolution data – UAV, ground survey

Findings and recommendations

- Moderate design modifications → significant habitat improvements
- Numerous small connections >> few large connections (don't just go big, go small too!)
- In LCRE, the habitat forming processes vary…

  …the preceding may or may not apply to your site!

Thank you
contributors & partners



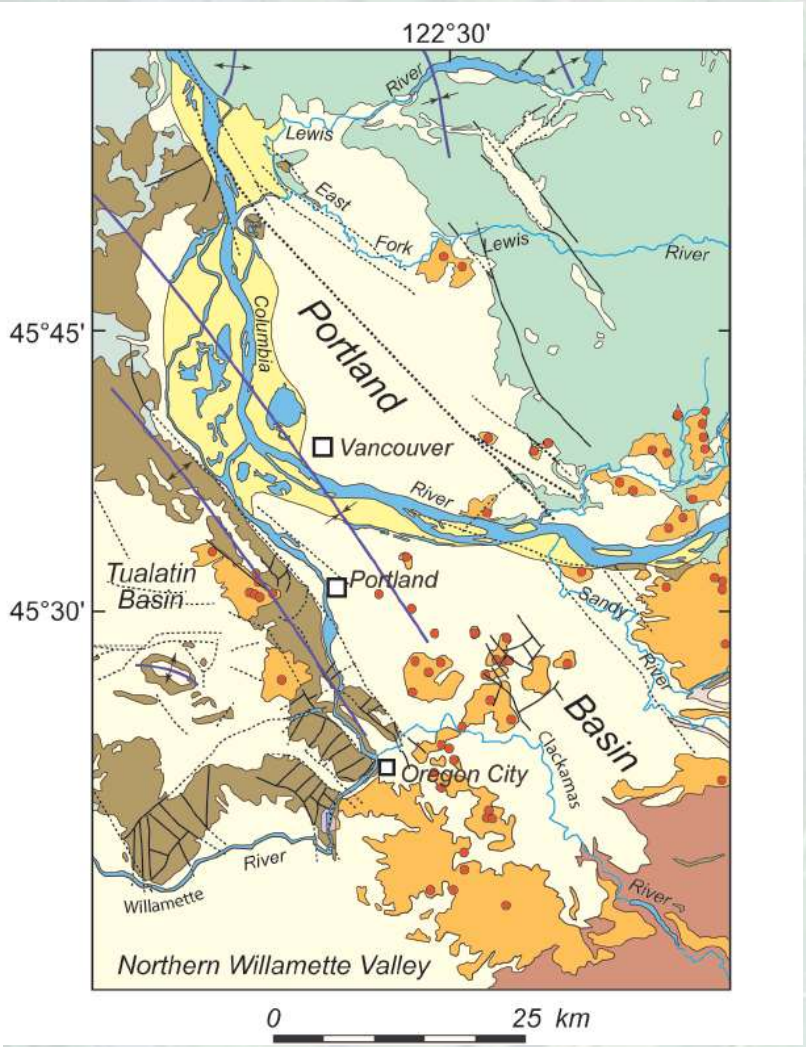
Reference slides

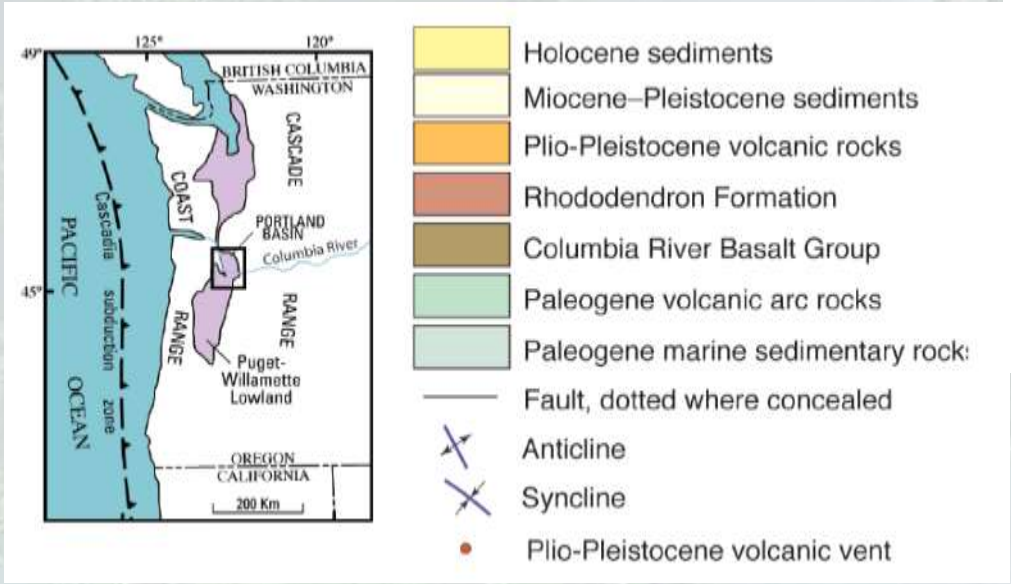
Challenges

The LCRE middle reach…

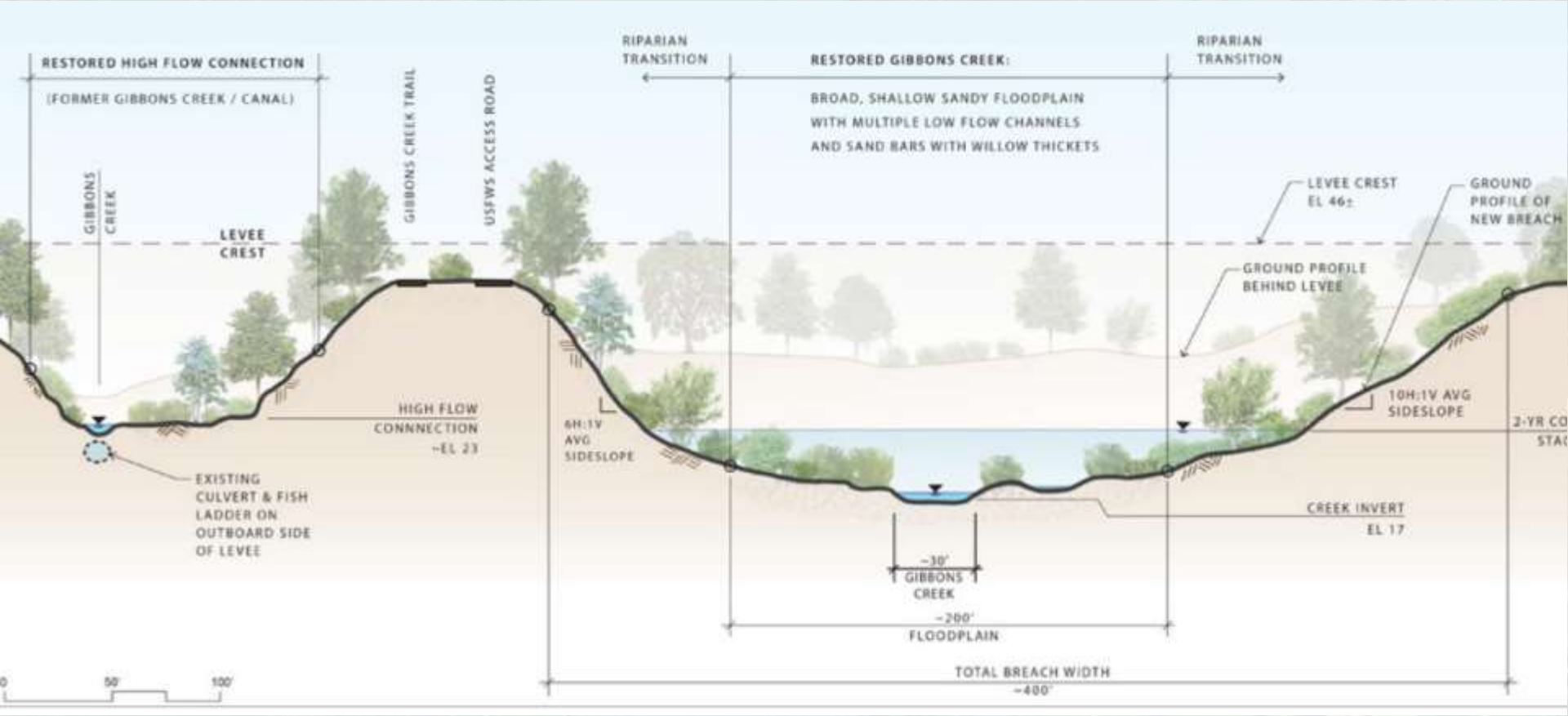
…“occupies the globally exceptional situation of a forearc basin bisected by a large continental river – a unique juxtaposition of local and regional geologic processes.”

Evarts, O’Conner, Wells, Madin. 2009 GSA Today





Types of Connections



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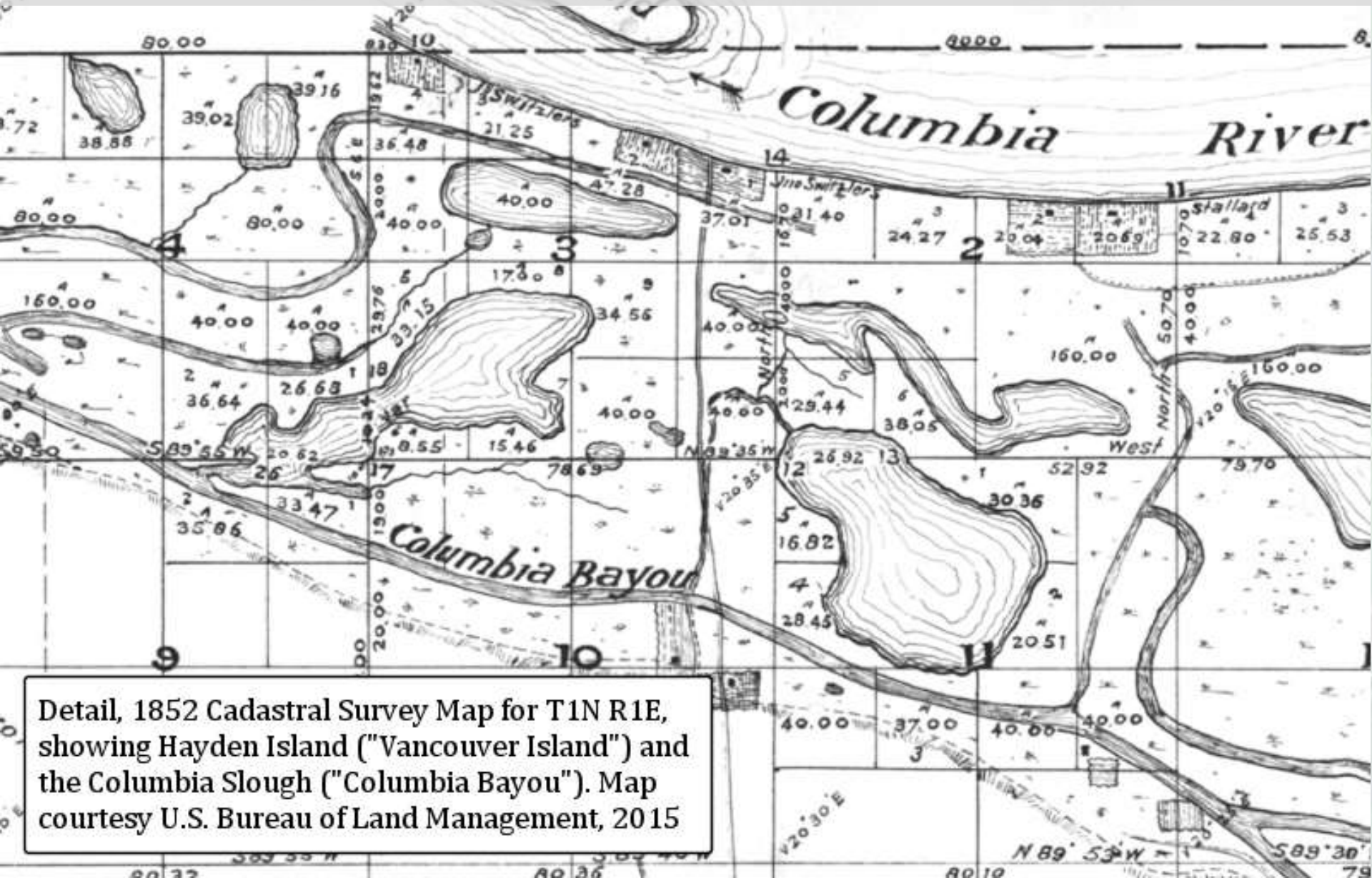
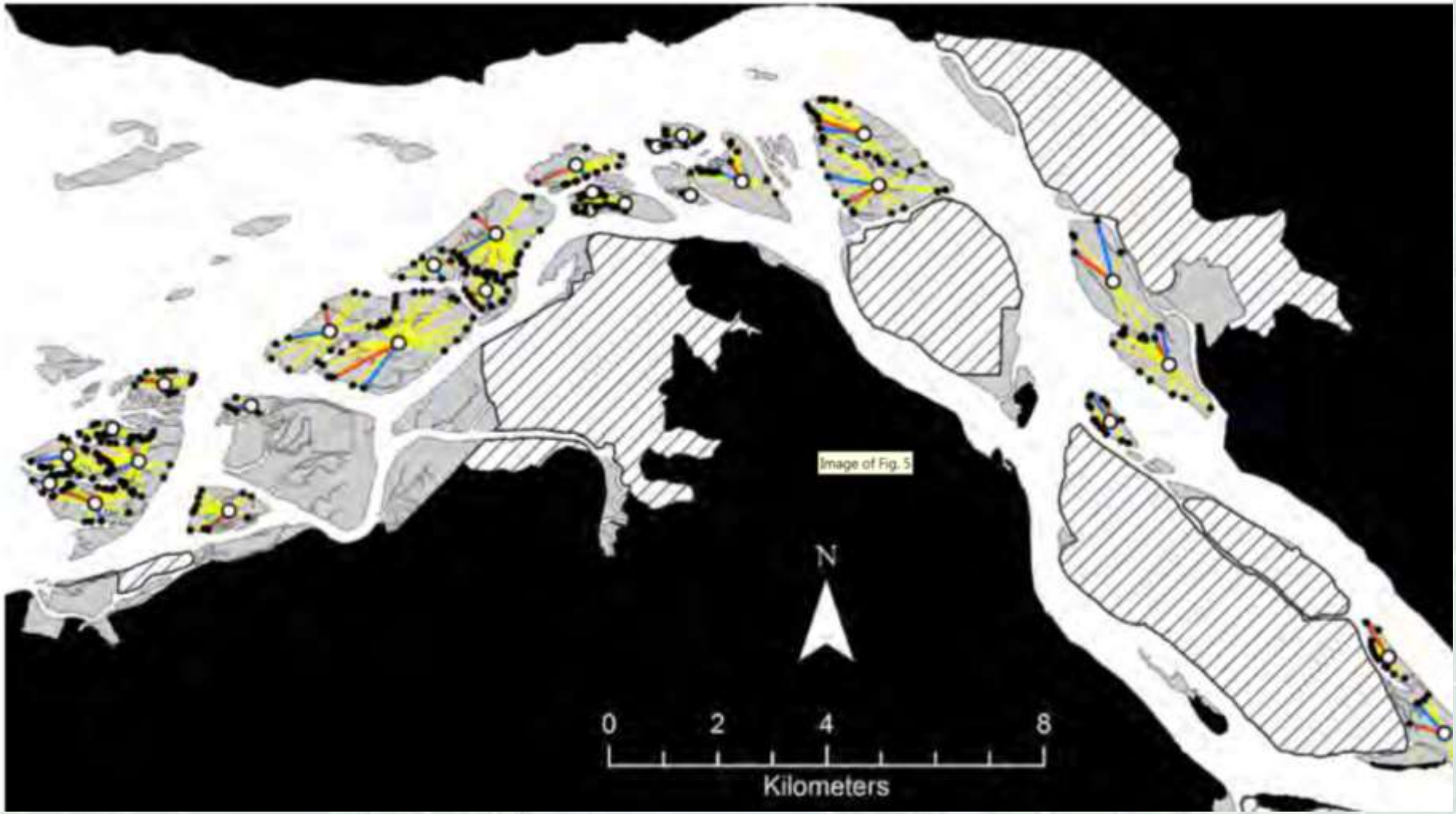
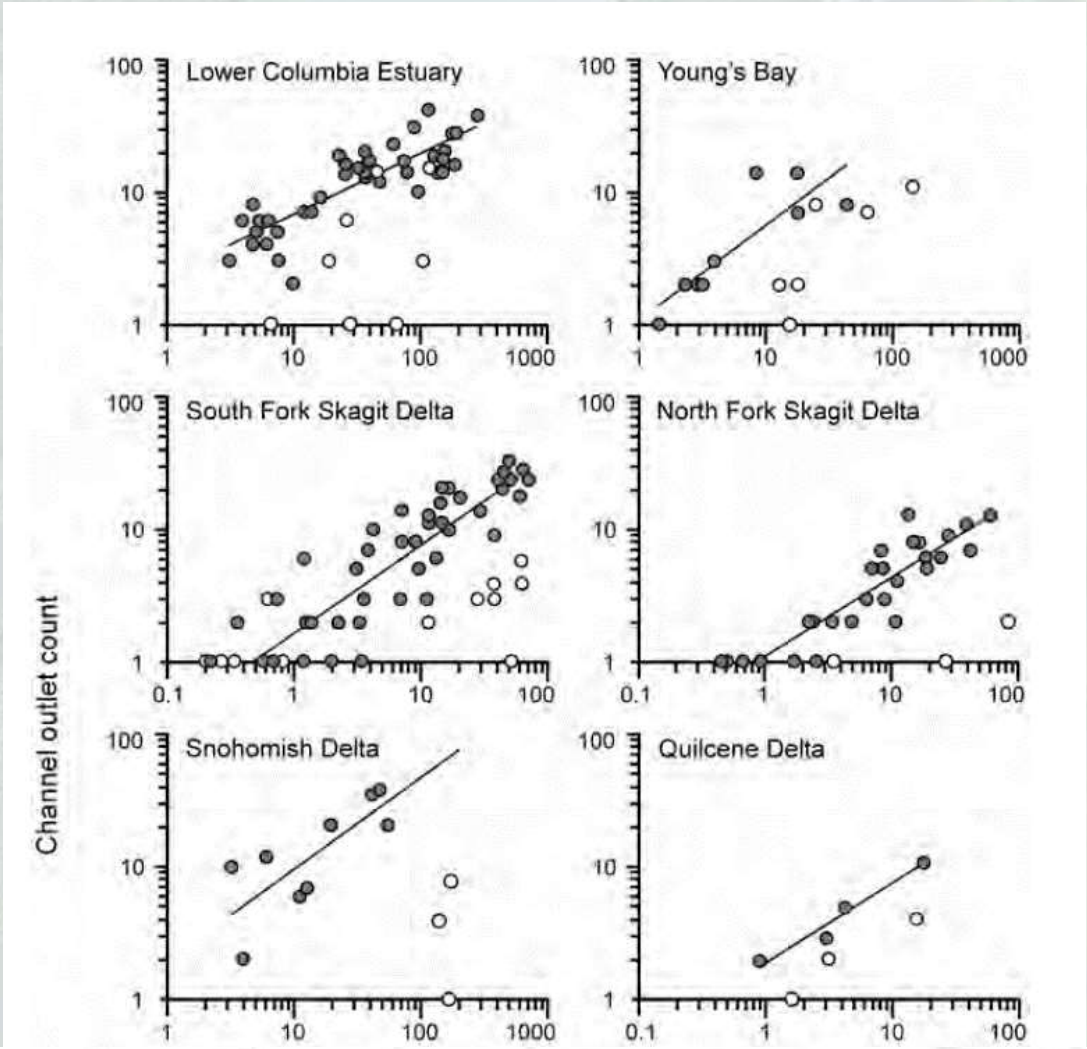


Detail, 1852 Cadastral Survey Map for T1N R1E, showing Hayden Island ("Vancouver Island") and the Columbia Slough ("Columbia Bayou"). Map courtesy U.S. Bureau of Land Management, 2015

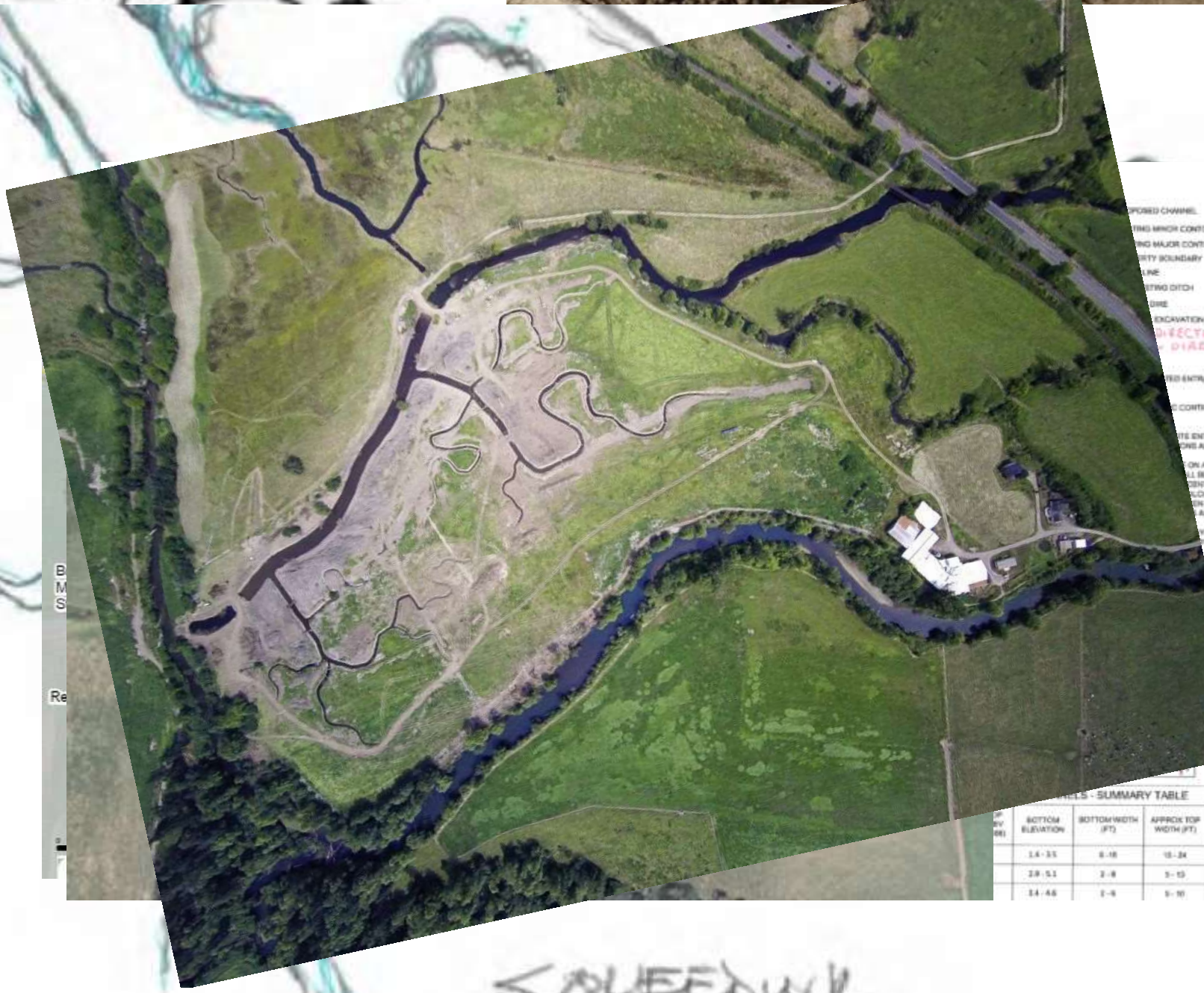
Hood, 2015



How to restore?



Late 1800s Marsh Mapping



Geomorphic & feasibility assessment

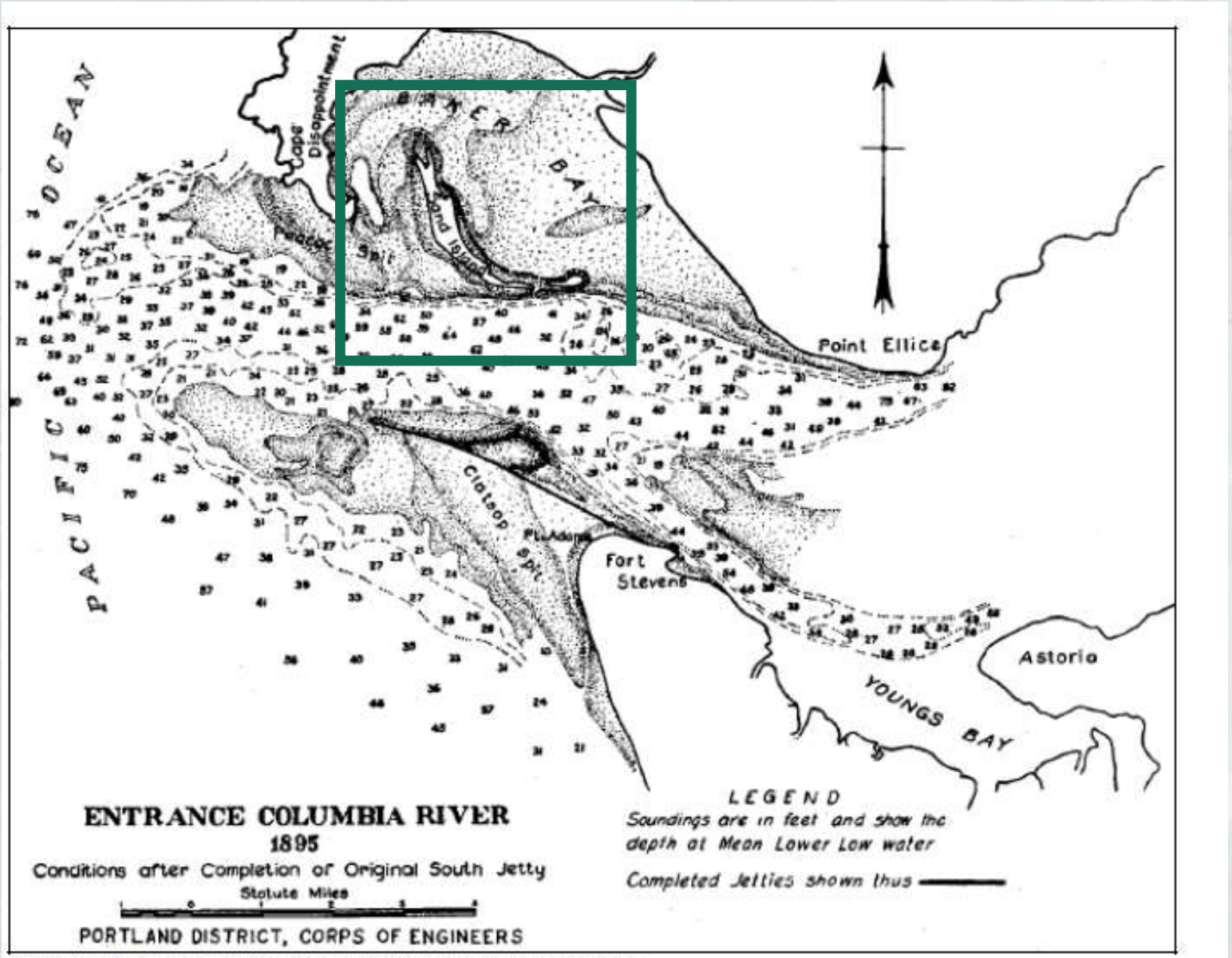
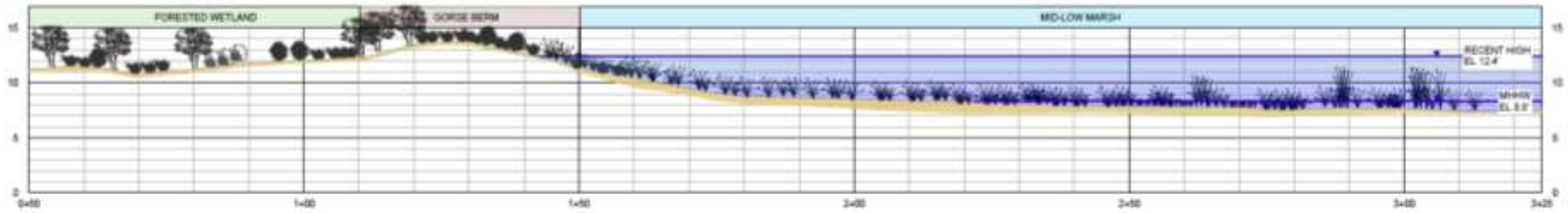
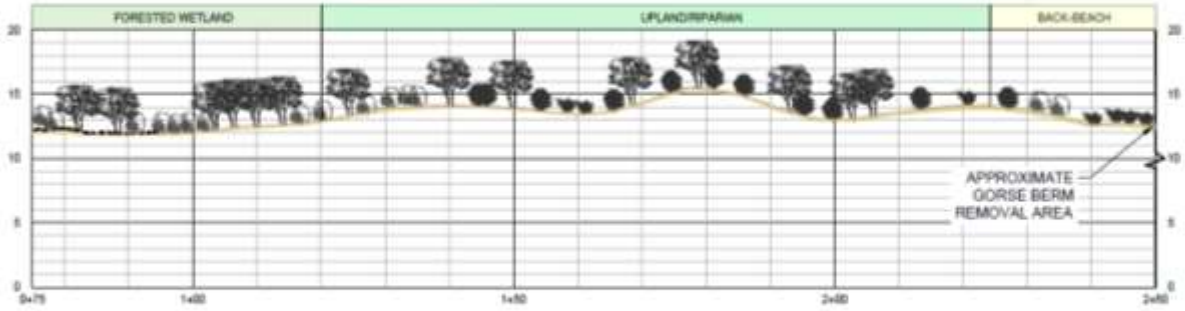


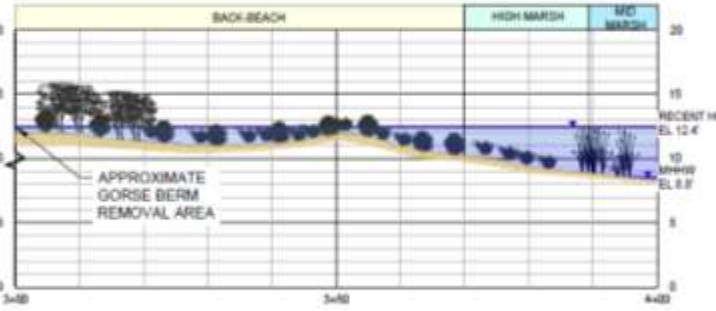
Figure 6. 1895 survey showing the south jetty and adjacent accretion.

Survey results



D SECTION - NORTH BERM





E SECTION - SOUTH BERM