Hydrogeologic Controls and Impacts of Quaternary Landslides Along the White Bluffs of the Columbia River, South-Central Washington

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and

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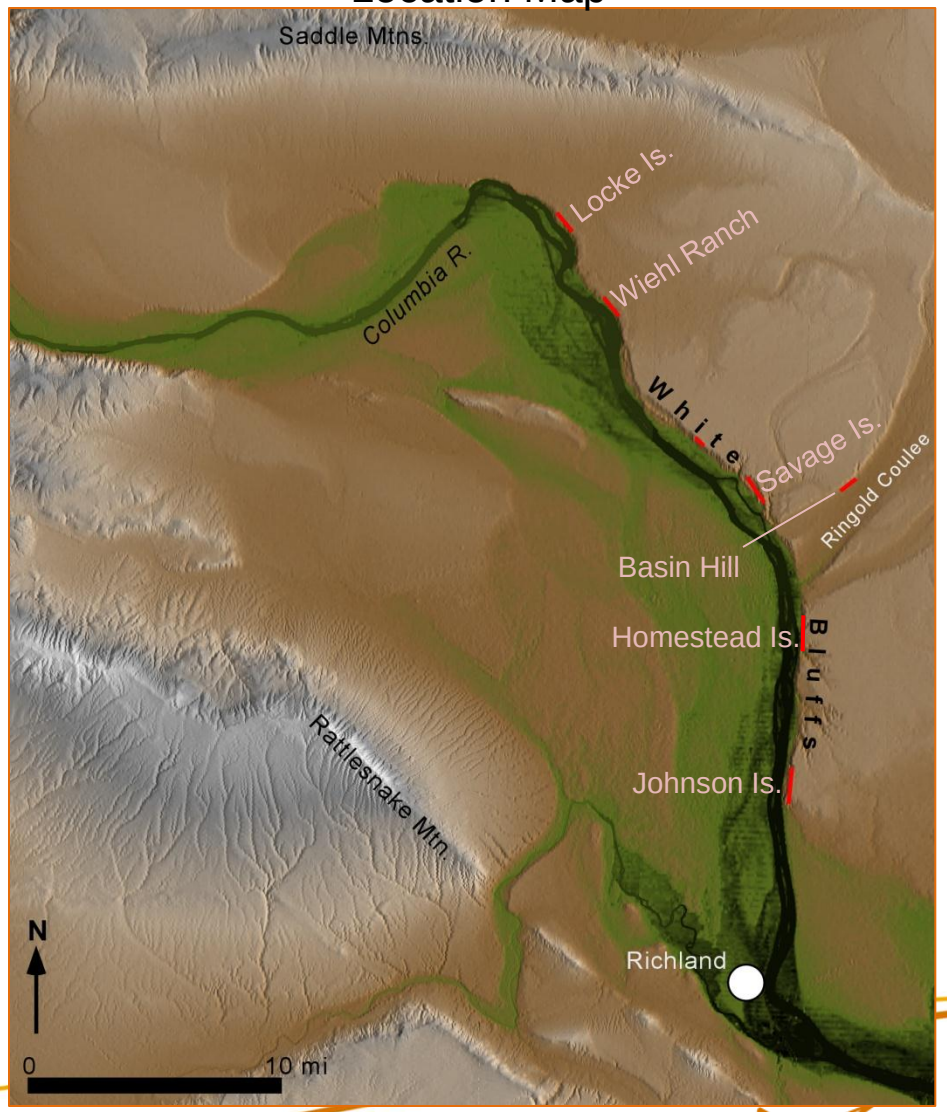
Background

- Landslides occur along the White Bluffs – a steep, erosional escarpment, up to 600 ft tall, composed of the well-stratified, weakly consolidated, fluvial-lacustrine, Ringold Formation (Pliocene).

- Water levels in the region have risen an average of 200 ft over the last 60 years, due to over-irrigation and seepage from an extensive network of unlined canals and wasteways, built for the Columbia Basin Irrigation Project.

- Except for a few old landslides associated with the Ice Age floods, barely any slumping occurred along the bluffs until the late 1960's.

Location Map



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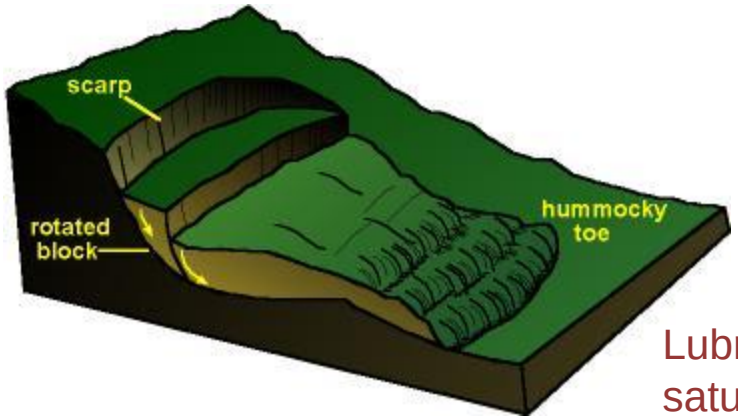
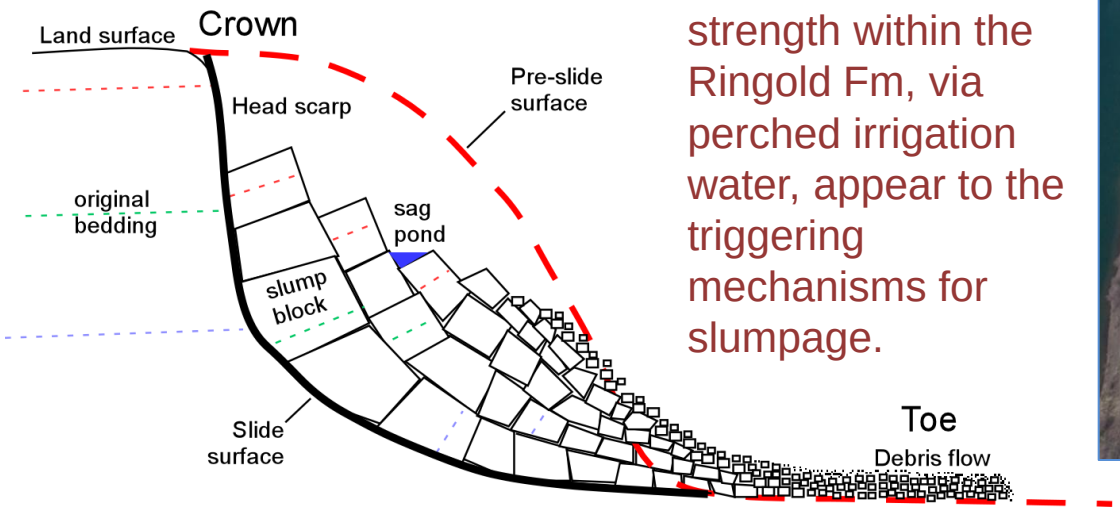
Anatomy of a Landslide





Lubrication and saturation of low-K bedding surfaces and loss of soil strength within the Ringold Fm, via perched irrigation water, appear to the triggering mechanisms for slumpage.

Johnson Island Landslide Complex

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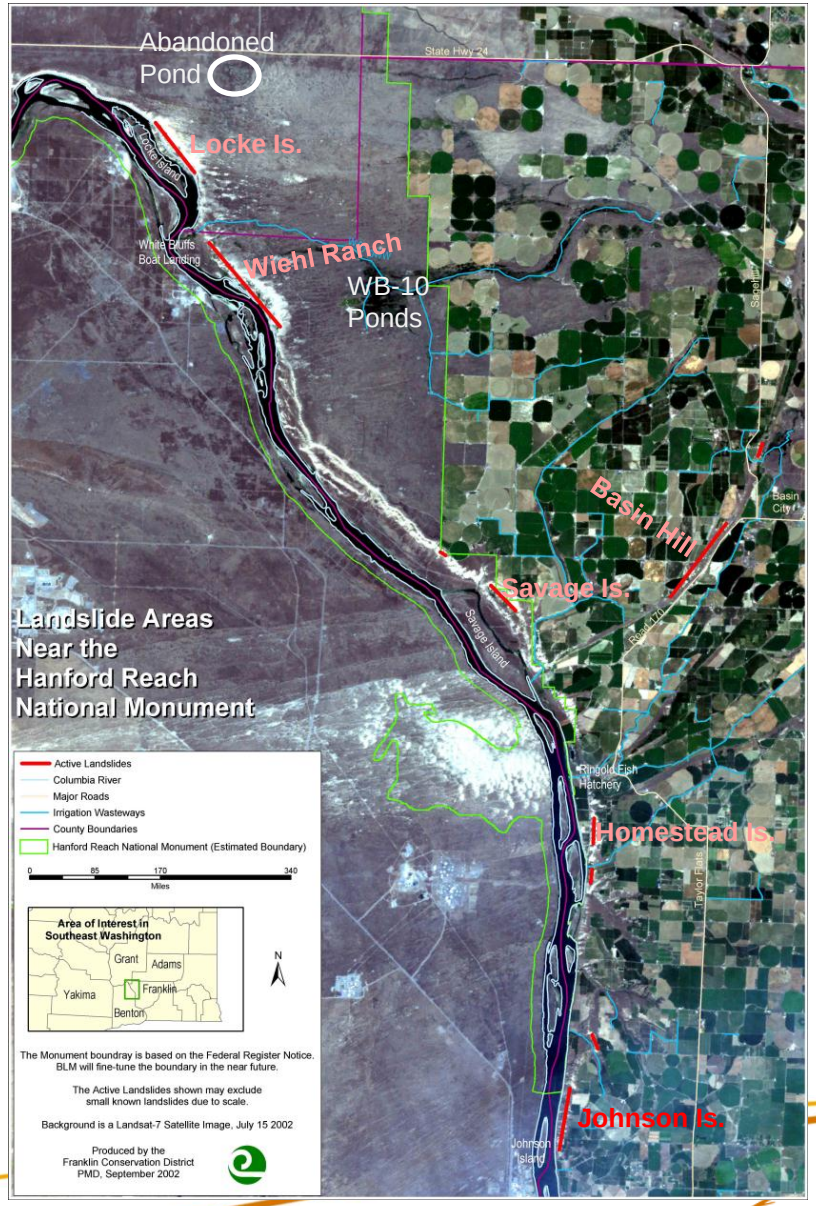
Water sources for landslides differ between the southern and northern portions of the White Bluffs

- South = unlined canals and irrigated farmlands up against bluff face
  (e.g., Savage Is., Basin Hill, Homestead Is., Johnson Is.)

- North = man-made, unlined, wastewater ponds and canals away from bluff edge
  (e.g., Locke Island and Wiehl Ranch)

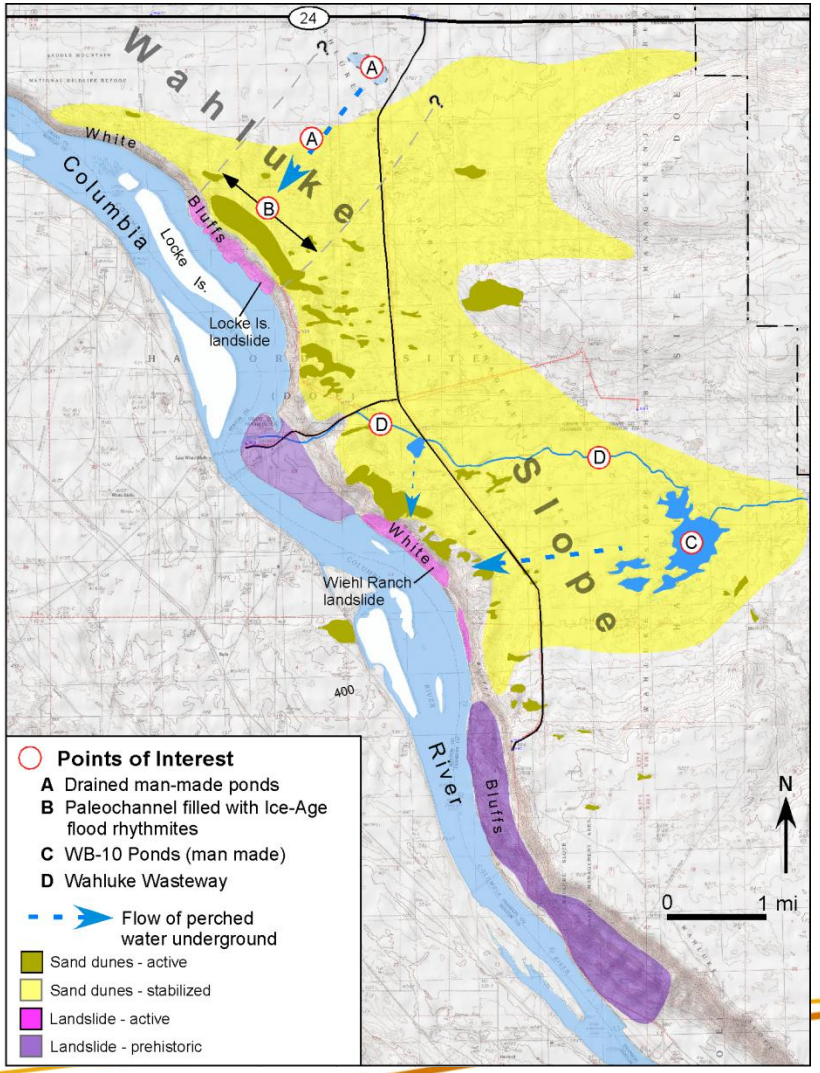


Triangle Associates (2003)

Northern White Bluffs

- Excess irrigation water was diverted to ponds (A + C) and unlined wasteways (D) beginning in the late 1960's. This water has percolated down through flood deposits to paleochannels (blue arrows), eroded into the low-K Ringold Fm. The perched, vadose water then flowed laterally to the bluff face, destabilizing the bluffs and triggering landslides.

- Pond water (A) responsible for the Locke Island landslide was drained in the mid 1990's, yet the slumping continues.



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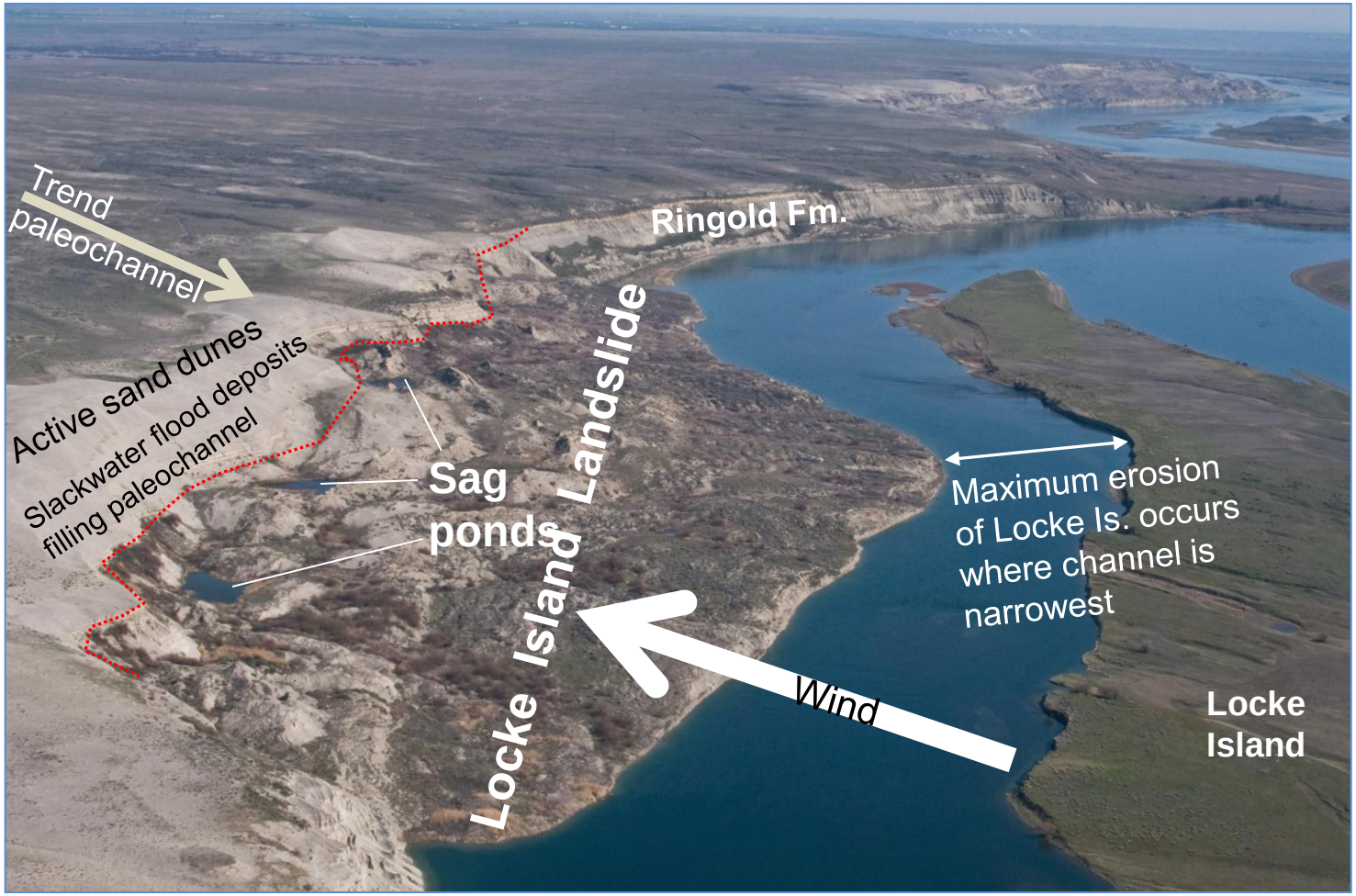
Locke Island Landslide Complex



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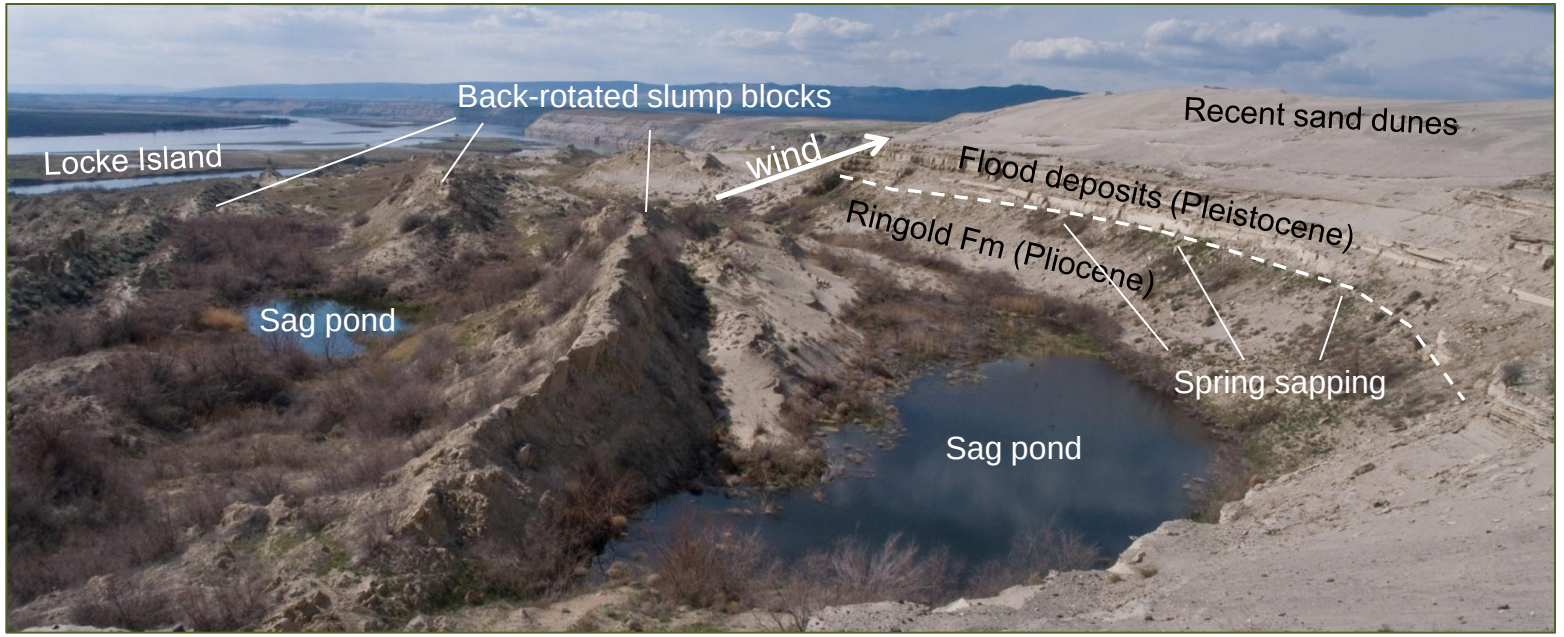
Locke Island Landslide Complex

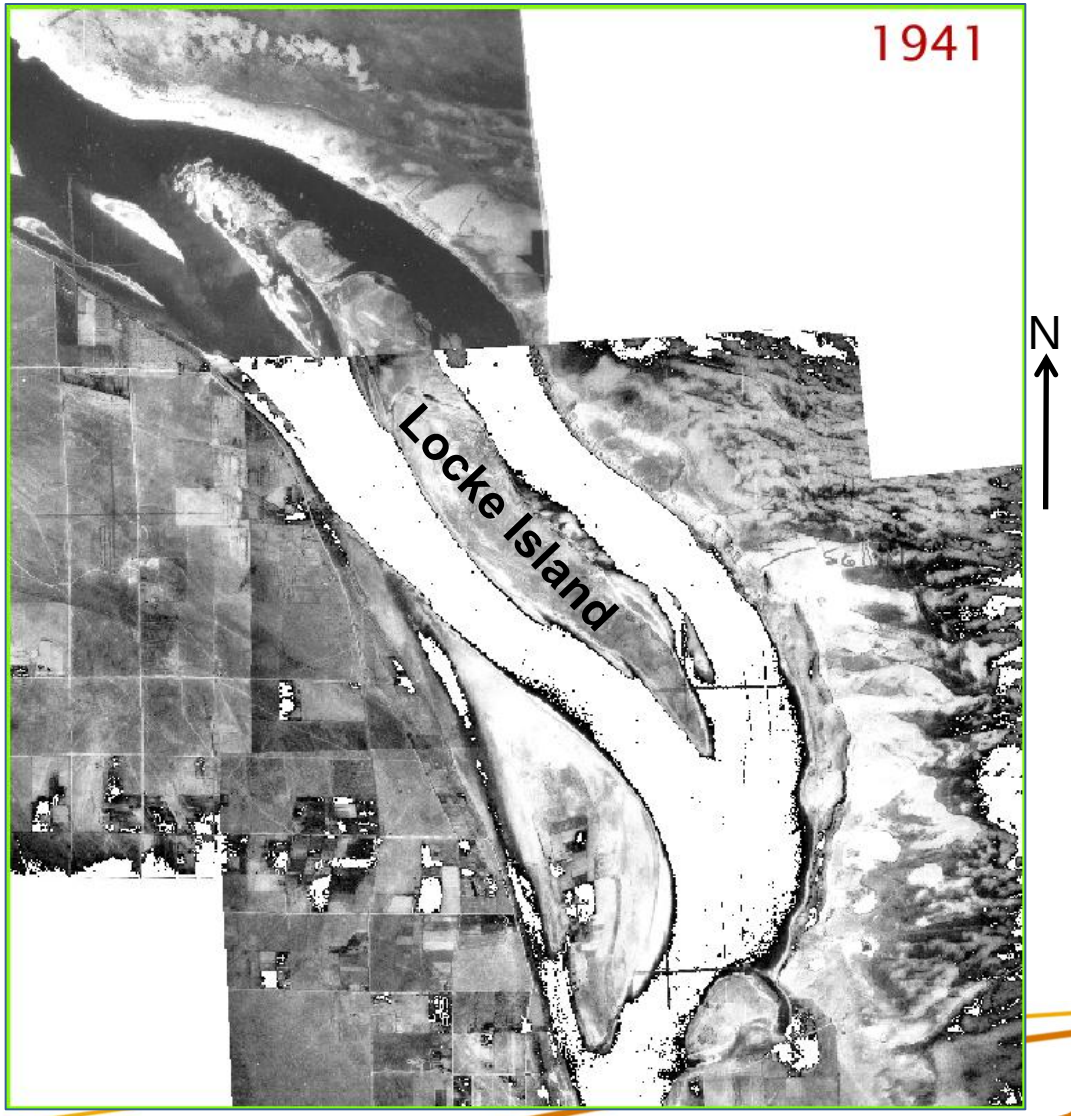


Recent sand dunes on top of bluffs above landslide

Timelapse for Locke Island Landslide Complex

- Irrigation water was diverted to a wastewater pond about 2 miles NE of the Locke Is. in late 1960's to enhance wildlife habitat.

- Slumping began in mid 1970's, peaked around 1985, but continues to present - even though the pond was drained in the mid 1990's.



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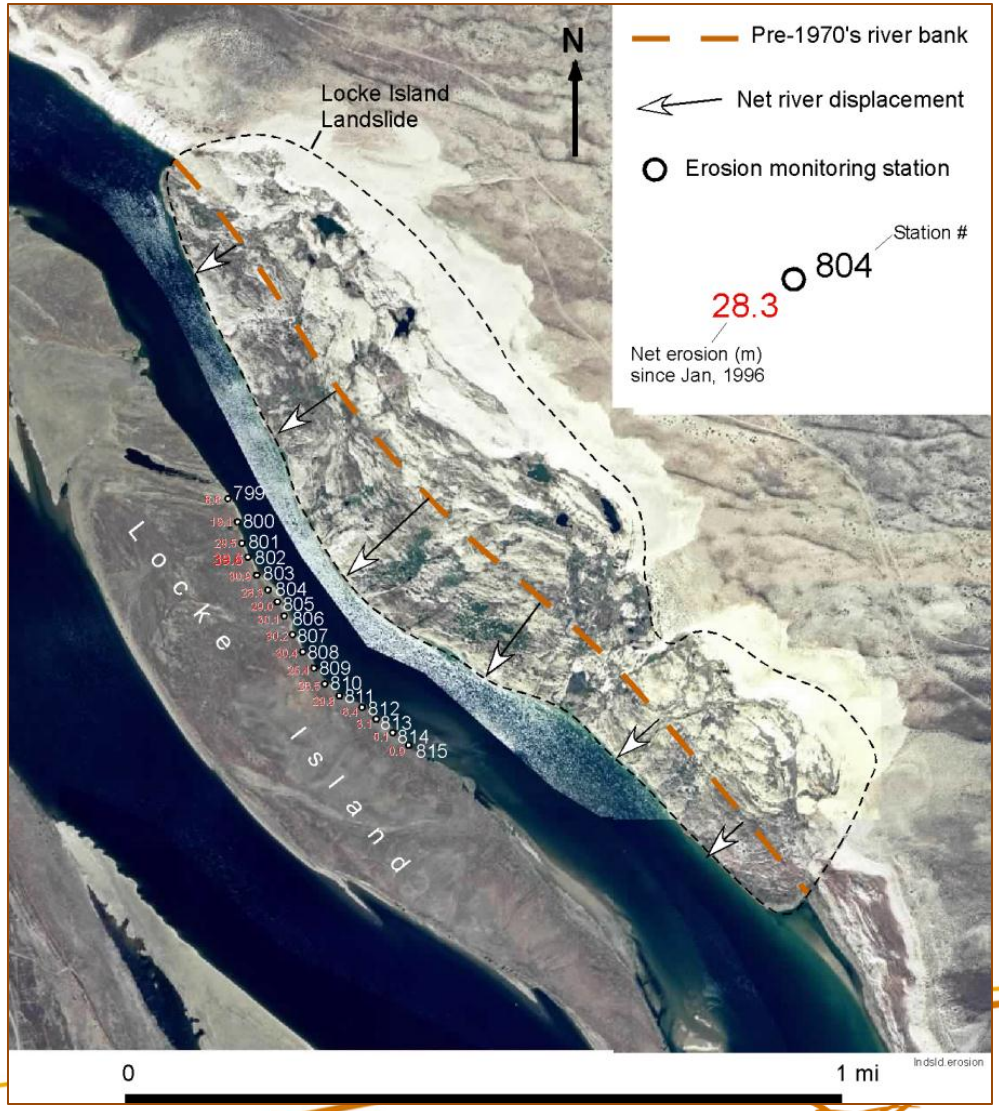
Adverse Effects at Locke Island

- Riverbank erosion (up to 42 m since 1994), especially during peak flows of Columbia R.
- Destruction of sensitive cultural resources
- Downriver siltation of salmon-spawning areas



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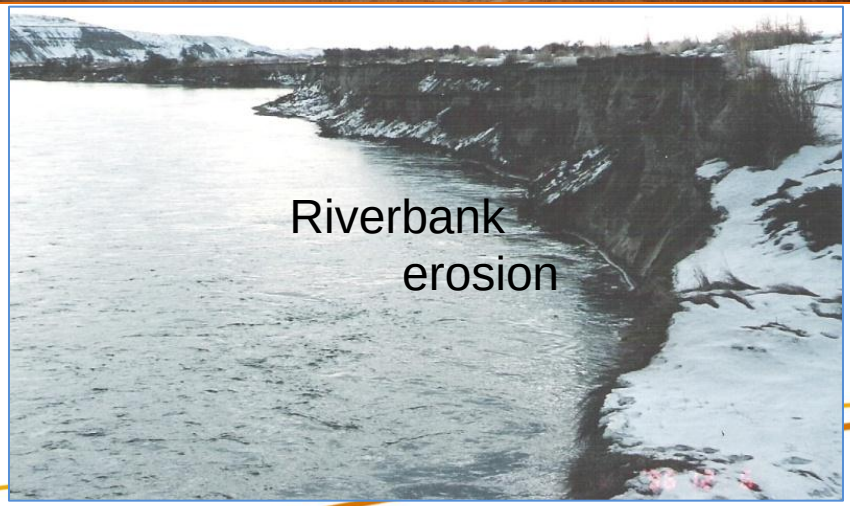

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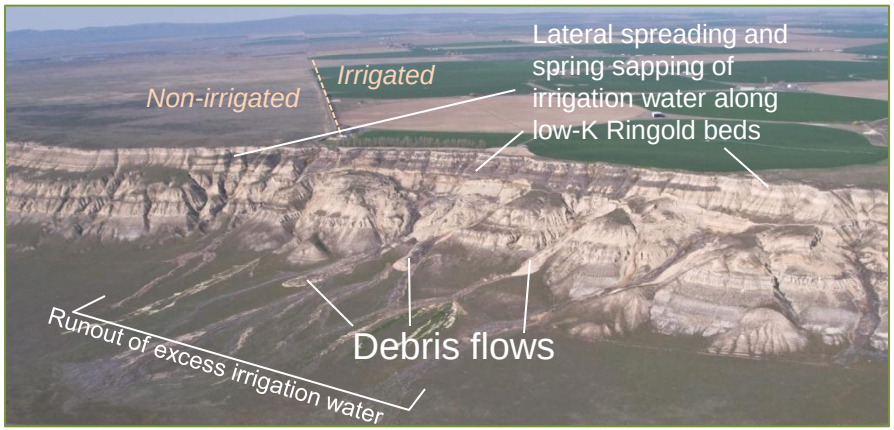
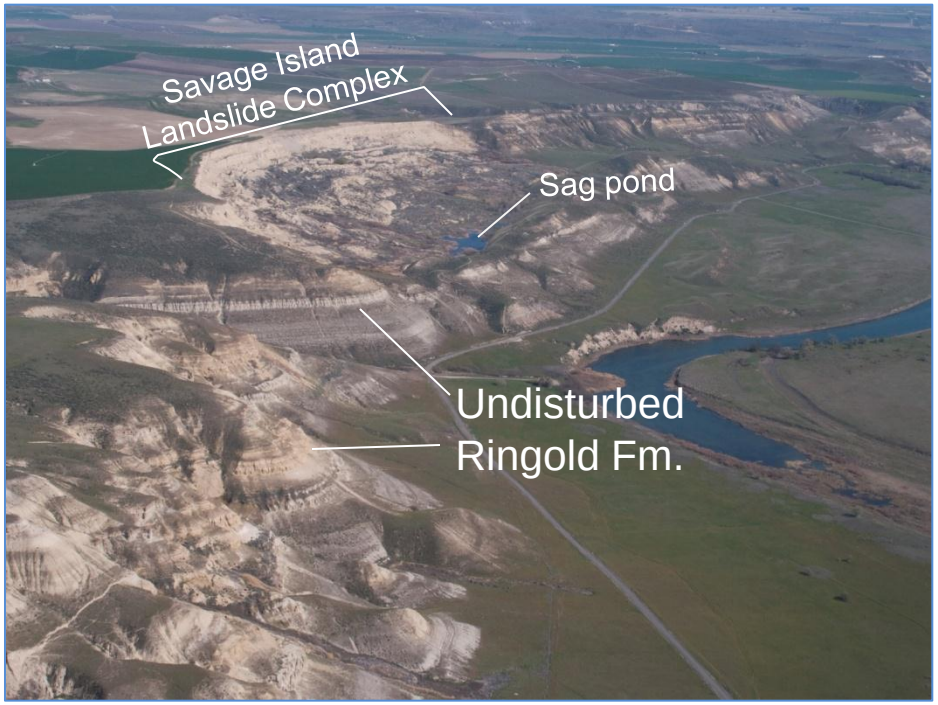
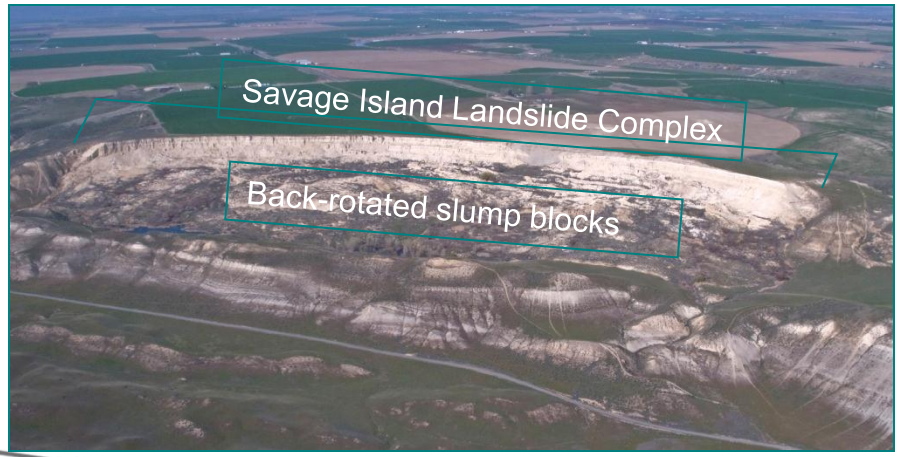
Southern White Bluffs







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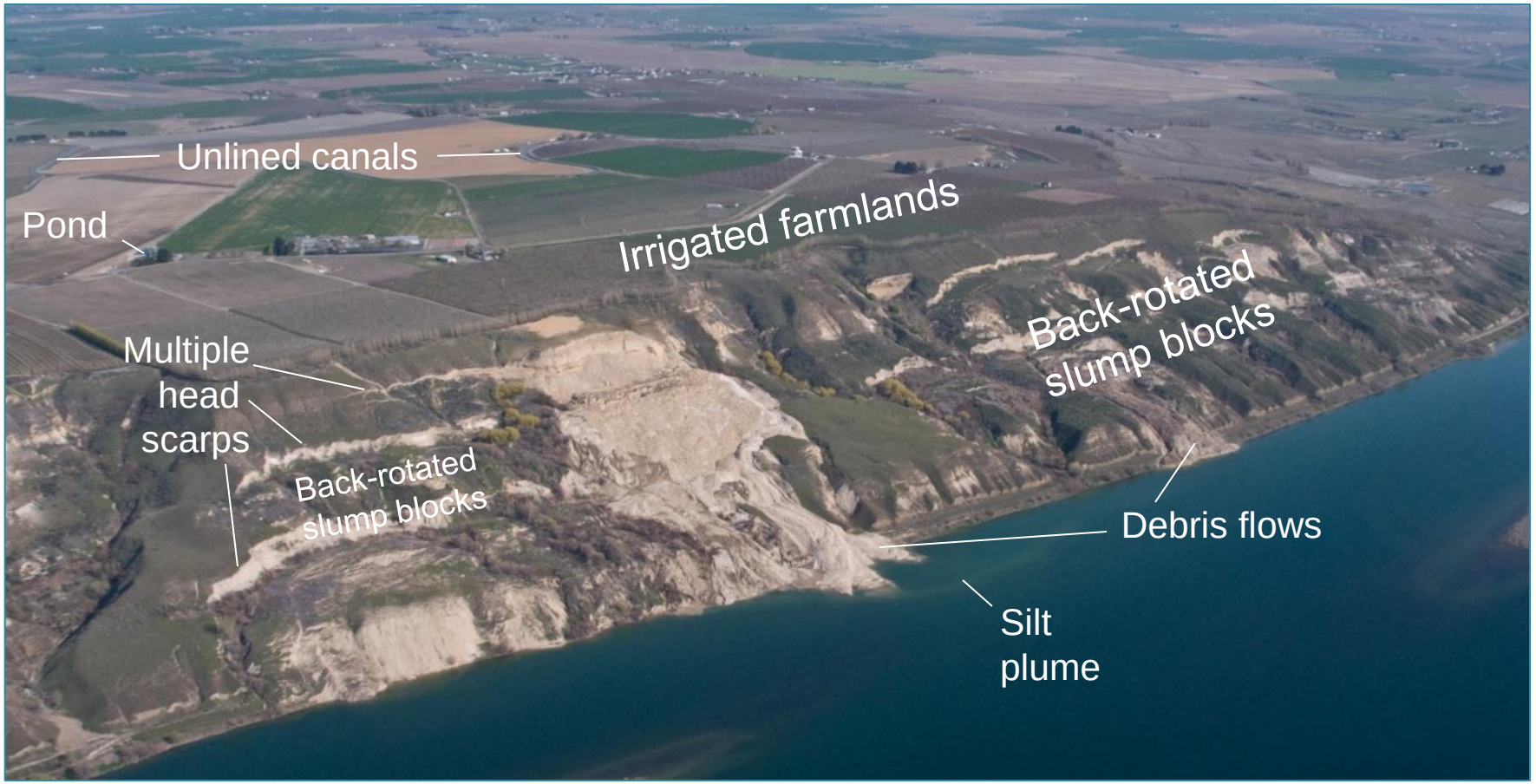
Johnson Island Landslide Complex



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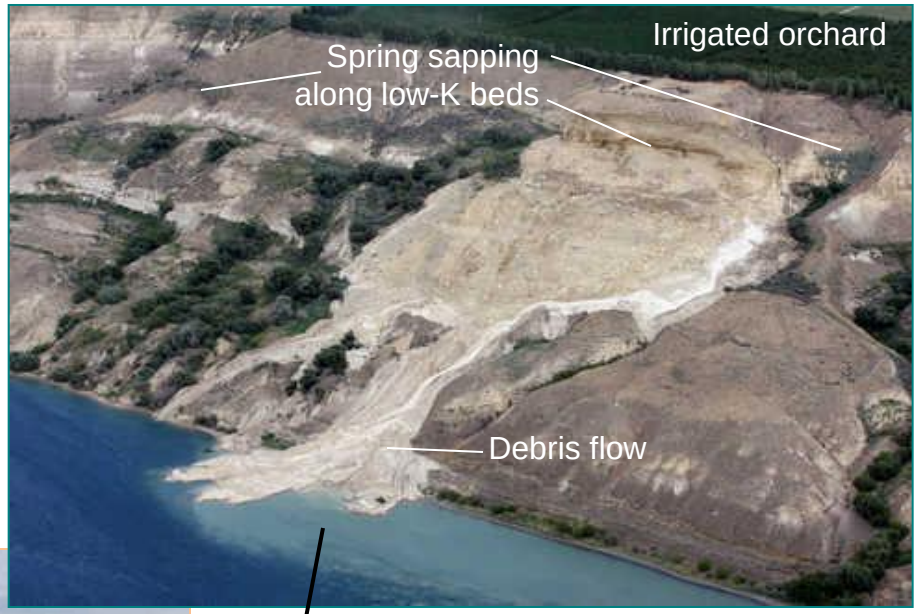
Johnson Island Landslide Complex- Then and Now

View looking northeast over the Hanford-Site 300 Area

Recent Landslide Events: Johnson Island – August 20, 2008



Silt plume

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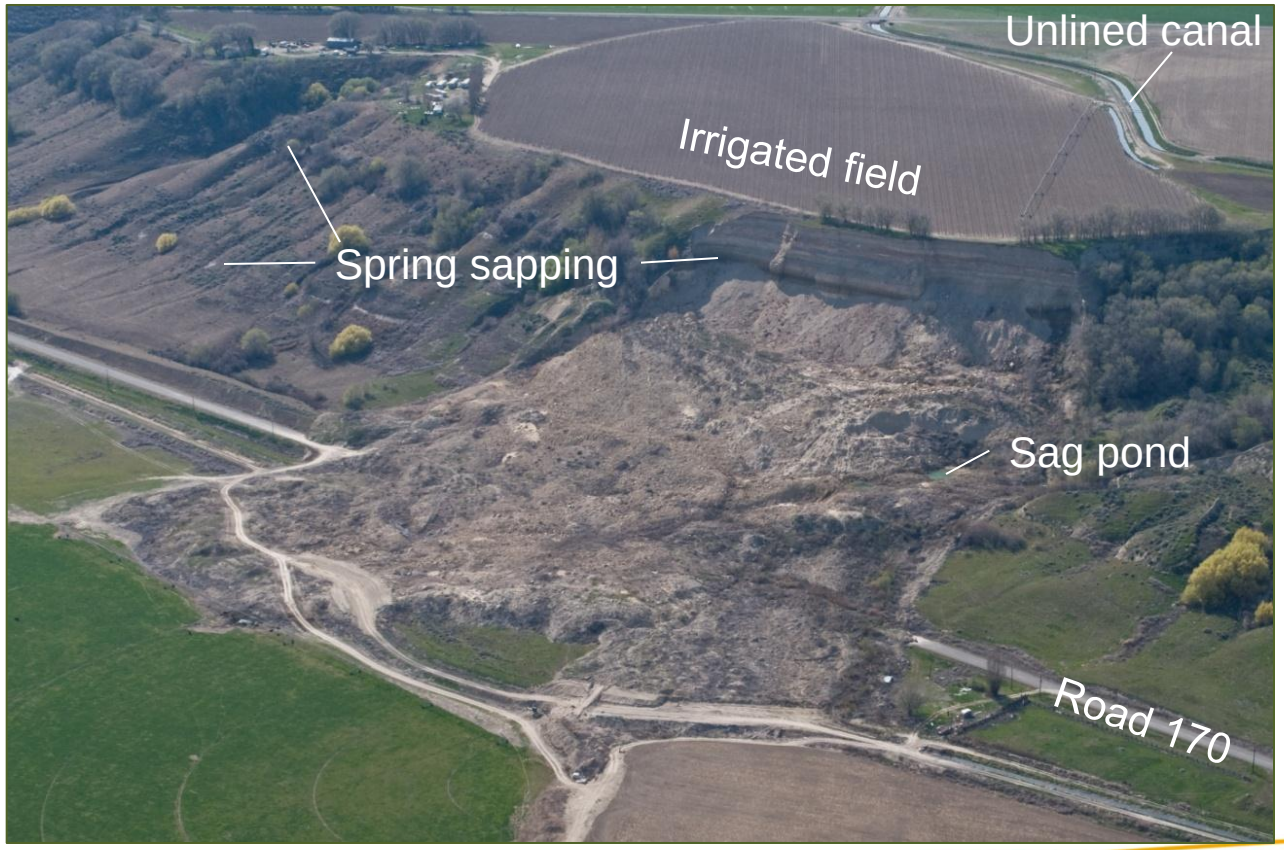
Basin Hill Event, May 13, 2006

- Most of the slump failed and moved in a single evening
- A busy county road, an irrigation canal, and acres of productive farmland were buried beneath landslide debris
- Farm worker's home almost wiped out



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Summary

- Some landslides occurred during or immediately following Ice Age floods, but most slumping of the White Bluffs has occurred in the last 30-40 yrs.

- Rising water levels due to over-irrigation and seepage from an extensive network of unlined canals and wastewater ponds weaken the soil and promote slumping.

- Unlike the southern White Bluffs, landslides along the northern bluffs occur on non-irrigated farmland away from any nearby water sources. The water for these landslides moves along paleochannels, atop the Ringold Fm. from distant unlined ponds and canals.

- Some landslides may also be induced by rapid raising and lowering of river levels below Priest Rapids Dam.

- Adverse effects from landsliding include loss of valuable farmland, accelerated riverbank erosion and loss of sensitive cultural resources, siltation of salmon-spawning habitat, disruption in transportation and irrigation networks, as well as threatened stability of farms and homes along the White Bluffs.