Glendive – Yellowstone RB (NF)

Presenter Name: Jennifer Musilek, P.G.

Presenter Title: Geologist

Duty Location: Omaha District

Date of Presentation: November 2014

NLD System: 4705000120

NLD Segment: 4704000139

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Hydraulics Advisor: Jesse Brown

Geotech Advisor: Don Moses

Structural Advisor: Chelsea Wallis

Consequence Advisor: Blaine Remmick

Levee Overview

- Omaha District (NWO)
- Glendive – Yellowstone RB (NF)
- Single Segment Levee
- Segment ID: 4704000139
- Waterway: Yellowstone River
- County-Authorized Rural Special Improvement District, RSID #32
- Non-Federal Sponsor: Cottonwood Grove Levee Association
- Construction Complete: 1965 (raised in 1969)
- Population at Risk
  - Day: 42 Night: 58

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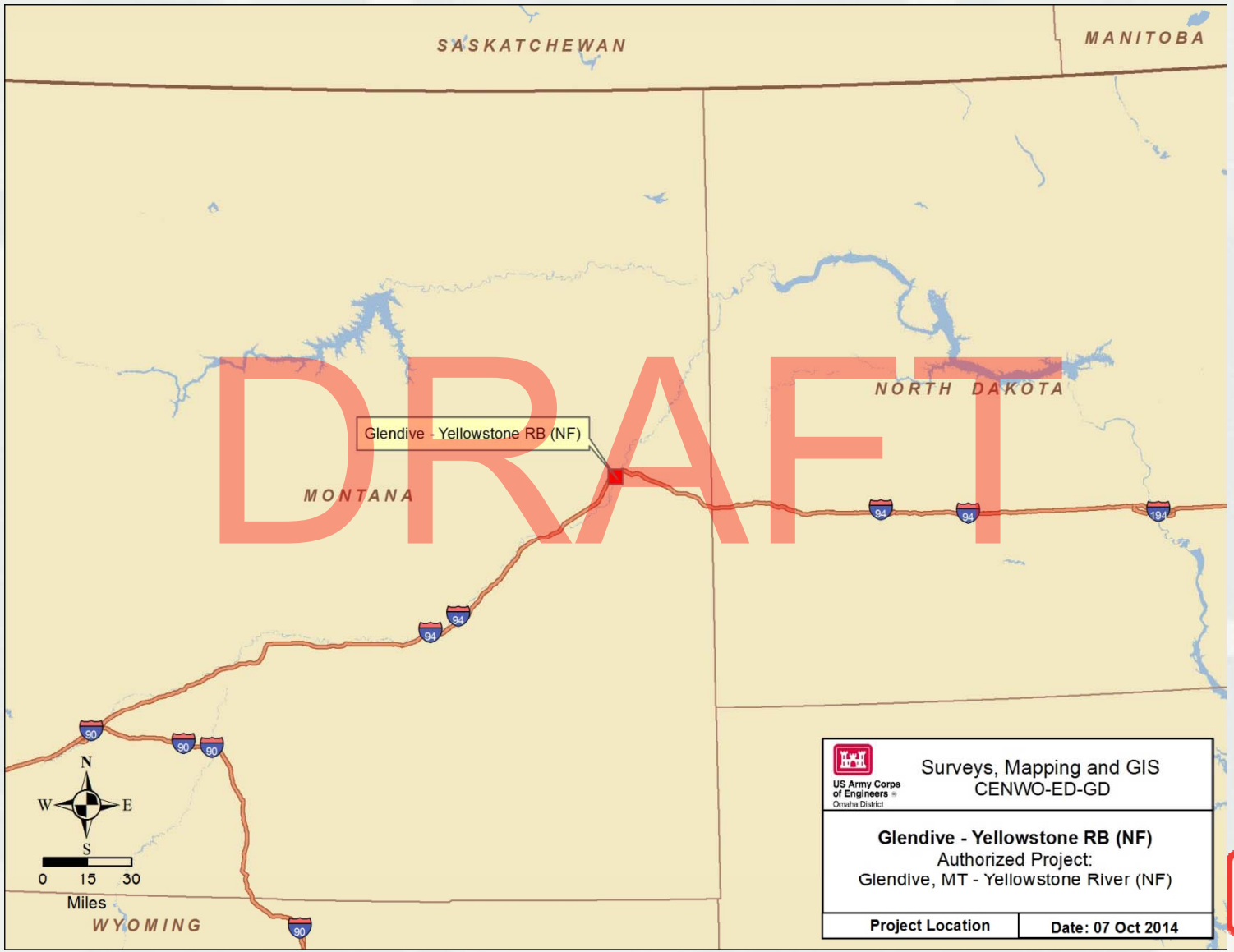
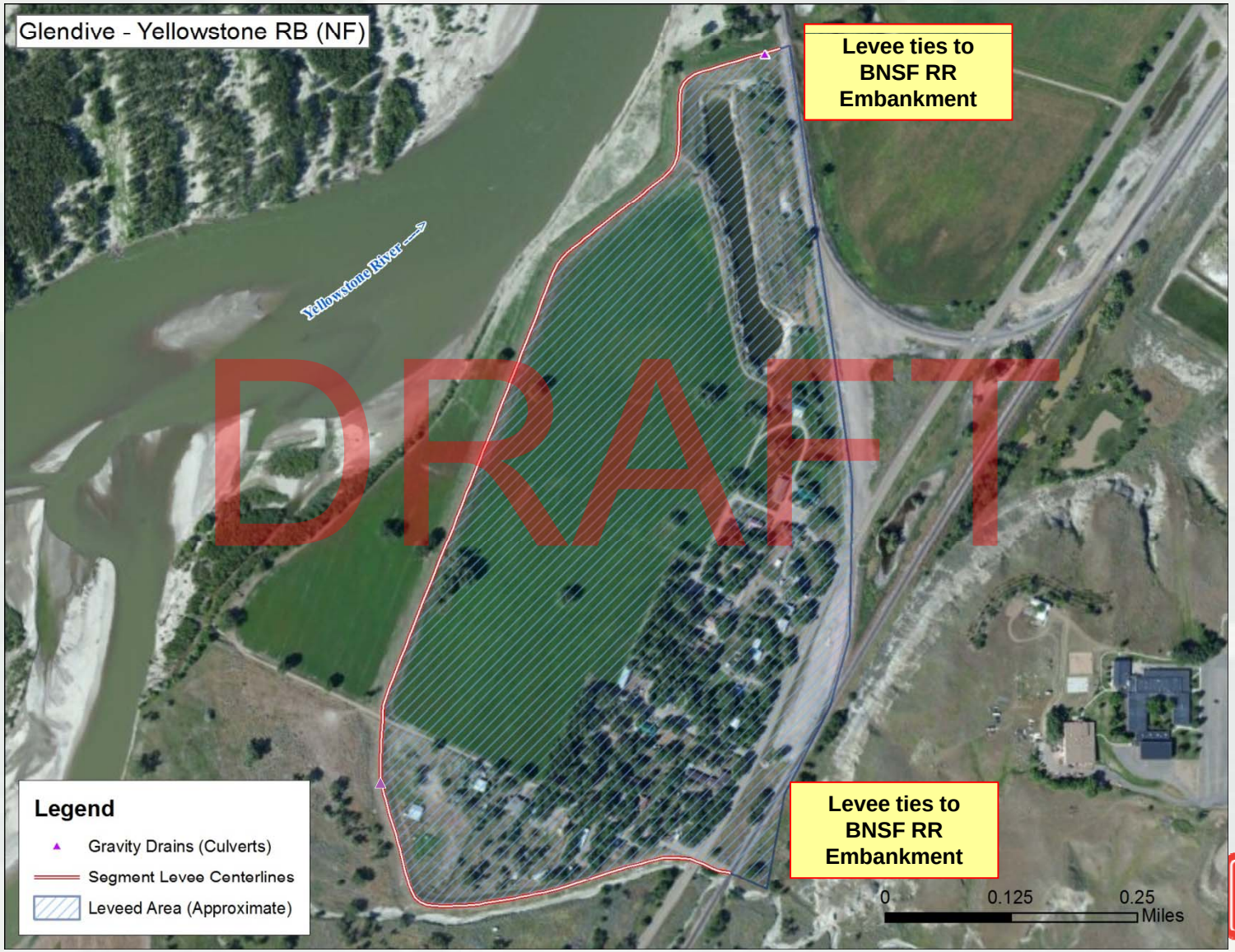
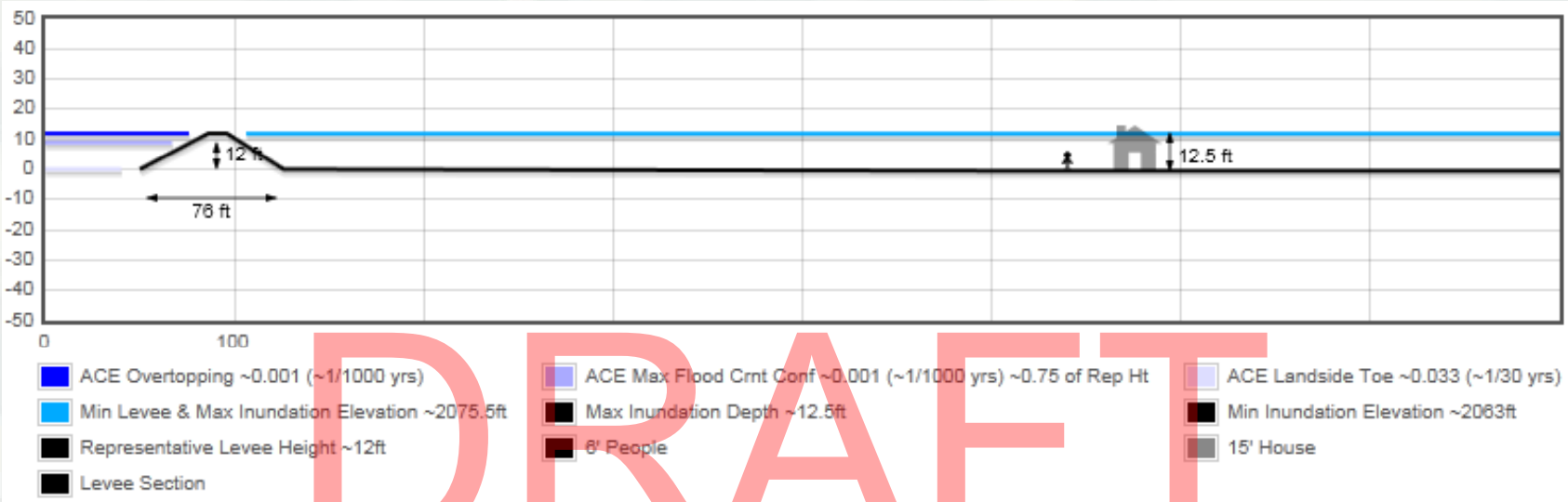
Site Location Map



Levee Feature Map



Summary of Hydraulics, Section, General Geotechnical Conditions, Population, and Assets



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- Hydraulics
  - Toe and Overtopping ACE — ~3% (~30 yr) and ~0.1% (~1000 yr)
  - Max Flood w/ Current Configuration — ~75% of Levee Height / ACE ~0.2% (~500 yr)
  - Overtopped? Breached? — No (not since 1969 raise) & No
  - Times Loaded (events) — >25% -10 >50% -10 >75% -1
- Levee Section
  - Height, Crest Width, Slopes — ~12ft, ~10ft, WS ~3:1 and LS ~2.5:1
  - Embankment Materials — Loamy (silt, sand, and clay mixture)
  - Foundation Materials — Loamy materials overlying sands/gravels
- Population and Assets
  - Total Population — 42
  - Total Assets — $6,042,000

Performance History

Photos from the March 2014 Ice-Jam Event

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- Flooding due to ice jams
- Levee raised 4 ft after 1969 overtopping
- Major events in 1994 and 2003 (ice within 5-6 ft of levee crown)
- Major event in 2014 (ice within 3-5 ft of levee crown).

Gouge from ice on RS slope

Geologic Profile

- No boring information from Glendive RB levee
- Foundation material from West Glendive LB levee (opposite bank)
  - Alluvial deposits
  - Silts, clays, and silty sands overlying sand and gravels
  - Blanket material 0 to 10 ft thick
- Depth to bedrock (Fox Hills Fm Shaley Sandstone) >50 ft

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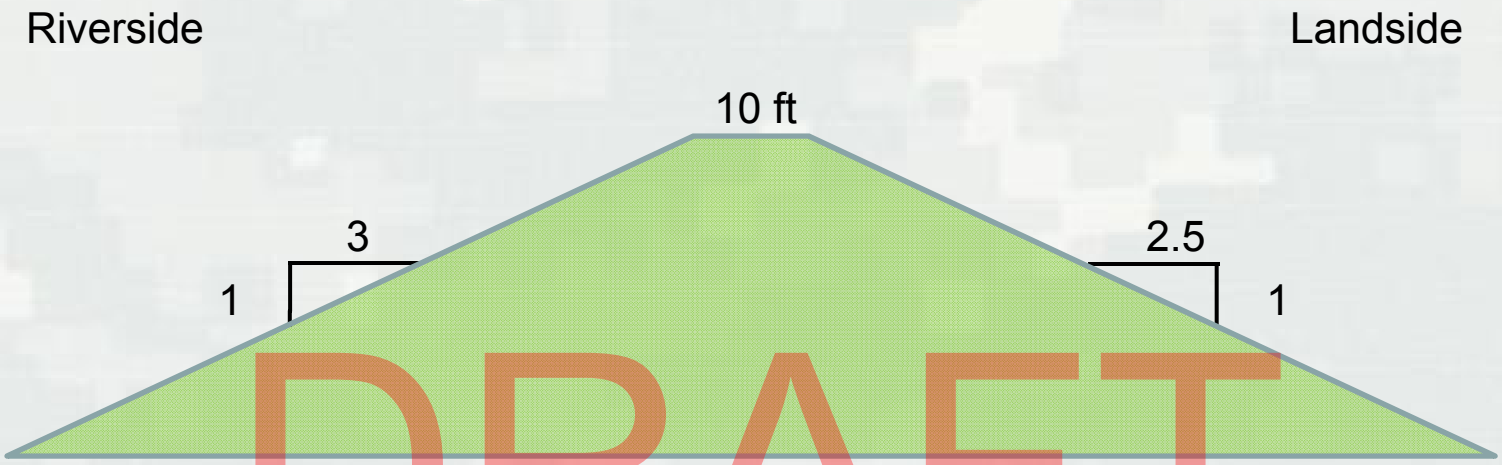
Embankment Typical Section



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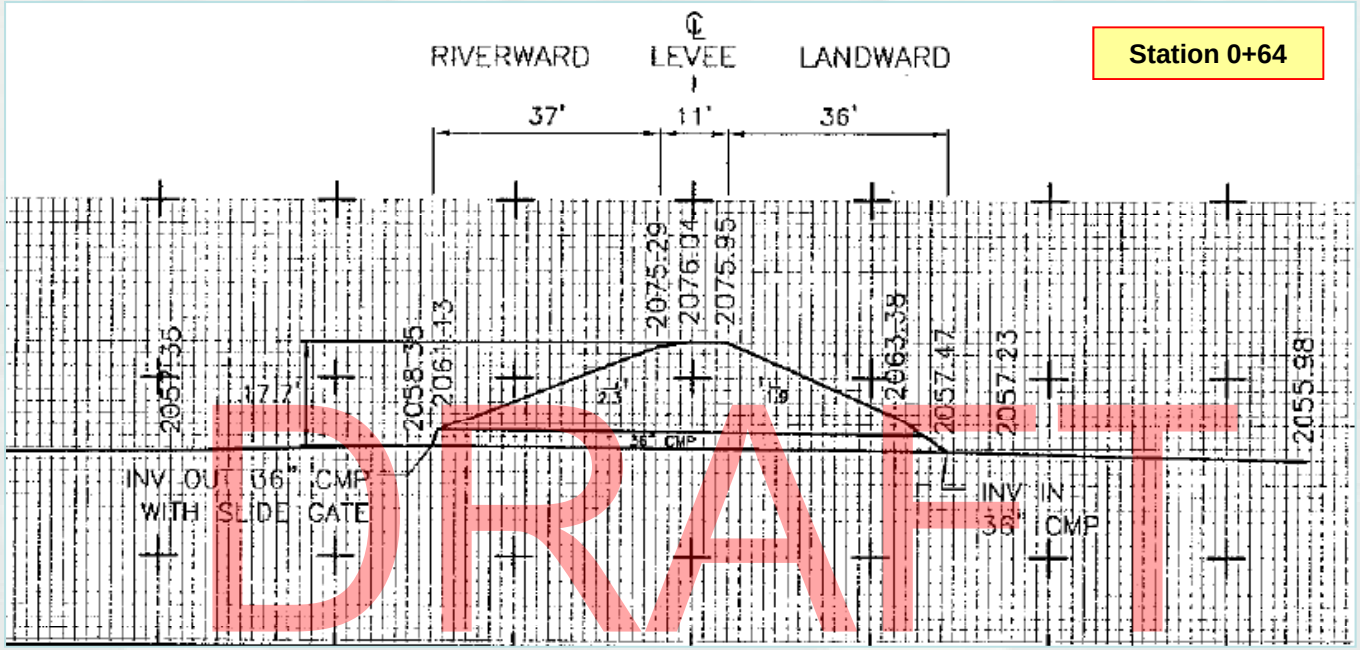
- Average Width (Levee Crest): 10 ft
- Average Height: 12 ft (ranges from 4 to 18 ft)
- Embankment Materials: Sponsor stated that materials were loams from the floodplain deposits (silt, clay, and fine sand mixture) and met all compaction test specifications

Typical Culvert Cross-Section



- 2 culverts
- 36” CMP at Sta. 0+64
- 15” CMP at Sta. 32+30
- Both have slide gates
- Bedding material unknown

Embankment Seepage Assessment Ratings

Performance Mode	ICW Rating	LST Rating	Justification
Embankment and Foundation Seepage and Piping			
Unwanted Vegetation Growth	M	LL	Vegetation consists of a few trees with branches encroaching on the levee slope and some small woody vegetation and sagebrush on the landside slope. Because the trees are outside of the right-of-way and the vegetation on the slope is minor, there is a low likelihood (LL) of significant seepage due to vegetation growth.
Encroachment	A	LL	Encroachments consist of power poles both in the right-of way (three poles) and in the levee slope (two poles). The sponsor removed junk and debris encroachments identified in the previous routine inspection. The only remaining encroachments are a few power poles and since the duration of flooding is typically less than a week, there is a low likelihood (LL) of significant seepage due to encroachments.
Settlement	A	LL	No settlement was observed. There is a low likelihood (LL) of significant seepage due to settlement.
Cracking	A	LL	No cracking was observed. There is a low likelihood (LL) of significant seepage due to cracking.
Animal Control	A	LL	No animal control issues were observed. Sponsor has active animal control program in place. There is a low likelihood (LL) of significant seepage due to animal control issues.

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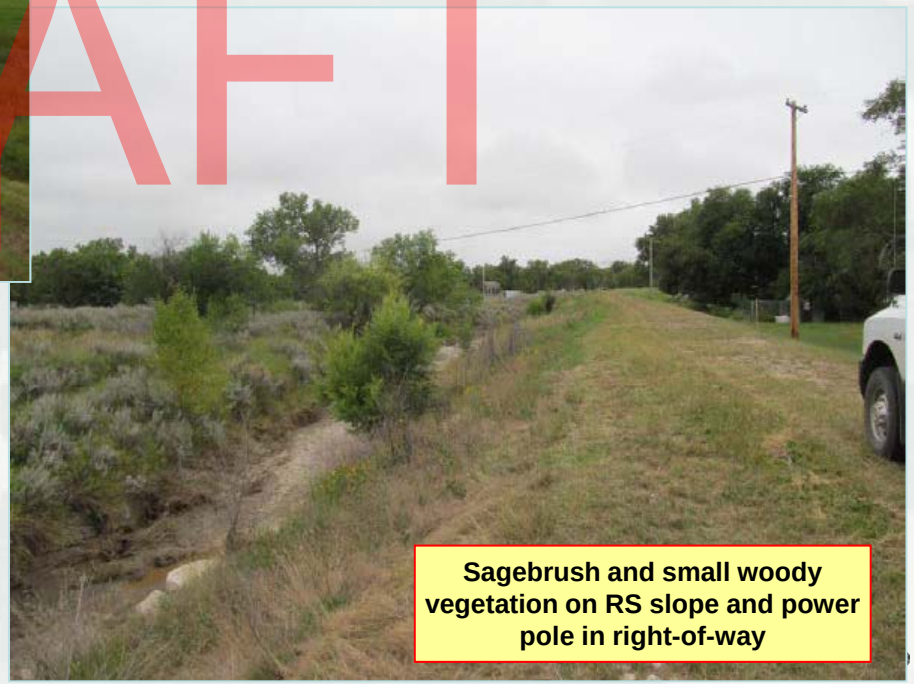
Embankment Seepage Supporting Photos – Vegetation/Encroachments

Trees outside right-of-way with overhanging branches and power pole LS slope



Sagebrush and small woody vegetation on RS slope and power pole in right-of-way

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Embankment Seepage Assessment Ratings (cont.)

Performance Mode	ICW Rating	LST Rating	Justification
Embankment and Foundation Seepage and Piping			
Culverts/Discharge Pipes	M	HL	The sponsor submitted culvert inspection videos in 2014. Both culverts showed some to heavy corrosion and a few small to medium joint separations with visible soil and localized deformations. The entire invert was not visible in the 36" pipe; therefore, a rating could not be assigned so the supplemental culvert assessment tool was also utilized (culverts received an HL rating). Due to the known corrosion and separation issues with the pipes, the fact that the invert was not visible in the video for the 36" pipe, and the rating given by the tool, it was determined that there is a high likelihood (HL) of seepage due to the culverts and discharge pipes.
Underseepage Relief Wells/Toe/Drainage Systems	N/A	N/A	There are no underseepage relief wells/toe/drainage systems on the levee.
Seepage	A	ML	There has been no evidence of seepage, saturated areas, or boils and there have been several major loading events on the levee. There are no soil borings but the embankment and foundation materials are likely overbank deposits of clay/silt/silty sand that overly sands and gravels at depth. There is a highway construction borrow pit ~30 ft from the toe on the landside of the levee that, according to the sponsor, was excavated to the lower sand/gravel layer. The borrow pit essentially acts like a large relief well; seepage exit gradients would not be an issue if modeled so it does not present a seepage issue. All performance modes other than culverts were rated LL. There has been no seepage associated with the culverts during any of the previous loading events; however, the HL rating for culverts combined with the uncertainties with the embankment materials were the key factors in determining that there is a moderate likelihood (ML) of seepage on this levee.

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Embankment Seepage Supporting Photos – Seepage

Embankment Stability Assessment Ratings

Performance Mode	ICW Rating	LST Rating	Justification
Embankment Stability			
Unwanted Vegetation Growth	A	LL	Vegetation consists of a few trees with branches encroaching on the levee slope and some small woody vegetation and sagebrush on the landside slope. Because the trees are outside of the right-of-way and the vegetation on the slope is minor, there is a low likelihood (LL) of significant stability issues due to vegetation growth.
Encroachment	A	LL	Encroachments consist of power poles both in the right-of way (two poles) and in the levee slope (three poles). The three poles on the slope are near the crest and are unlikely to cause any stability issues if they were to overturn; therefore there is a low likelihood (LL) of stability issues due to encroachments.
Slope Stability	A	LL	No slides or irregularities are present and the slopes are stable. There has been no historical or current evidence of tension cracks, depressions, or bulges and the levee has a loading history; therefore there is a low likelihood (LL) of slope stability issues.

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Embankment Stability Supporting Photos –Encroachments

Power poles on LS levee slope.

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Embankment Stability Assessment Ratings (cont.)

Performance Mode	ICW Rating	LST Rating	Justification
Embankment Stability			
Settlement	A	LL	No settlement was observed. There is a low likelihood (LL) of stability issues due to settlement.
Depressions/Rutting	A	LL	No depressions/rutting was observed. There is a low likelihood (LL) of stability issues due to depressions/rutting.
Cracking	A	LL	No cracking was observed. There is a low likelihood (LL) of stability issues due to cracking.
Underseepage Relief Wells/Toe/Drainage Systems	N/A	N/A	There are no underseepage relief wells/toe/drainage systems on this levee.

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Embankment Erosion Assessment Ratings

Performance Mode	ICW Rating	LST Rating	Justification
Embankment Erosion			
Sod Cover	A	LL	No issues with the sod cover were observed. There is a low likelihood (LL) of erosion issues due to sod cover.
Erosion/Bank Caving	M	LL	One area of minor erosion near the crest and the RS slope approximately 30 ft wide was noted in the last inspection. No significant erosion/bank caving issues were noted and the levee in general has good sod cover; therefore, there is a low likelihood (LL) of erosion issues caused by erosion/bank caving.
Riprap Revetments & Bank Protection	A	LL	No issues with the riprap were noted. There is a low likelihood (LL) of erosion issues due to riprap.
Revetments other than Riprap	N/A	N/A	There are no revetments other than riprap.

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Embankment Stability Supporting Photos – Erosion

Assessment Rating Summary
Primary Factors

- Embankment & Foundation Seepage – ML
- Embankment Stability – LL
- Embankment Erosion – LL

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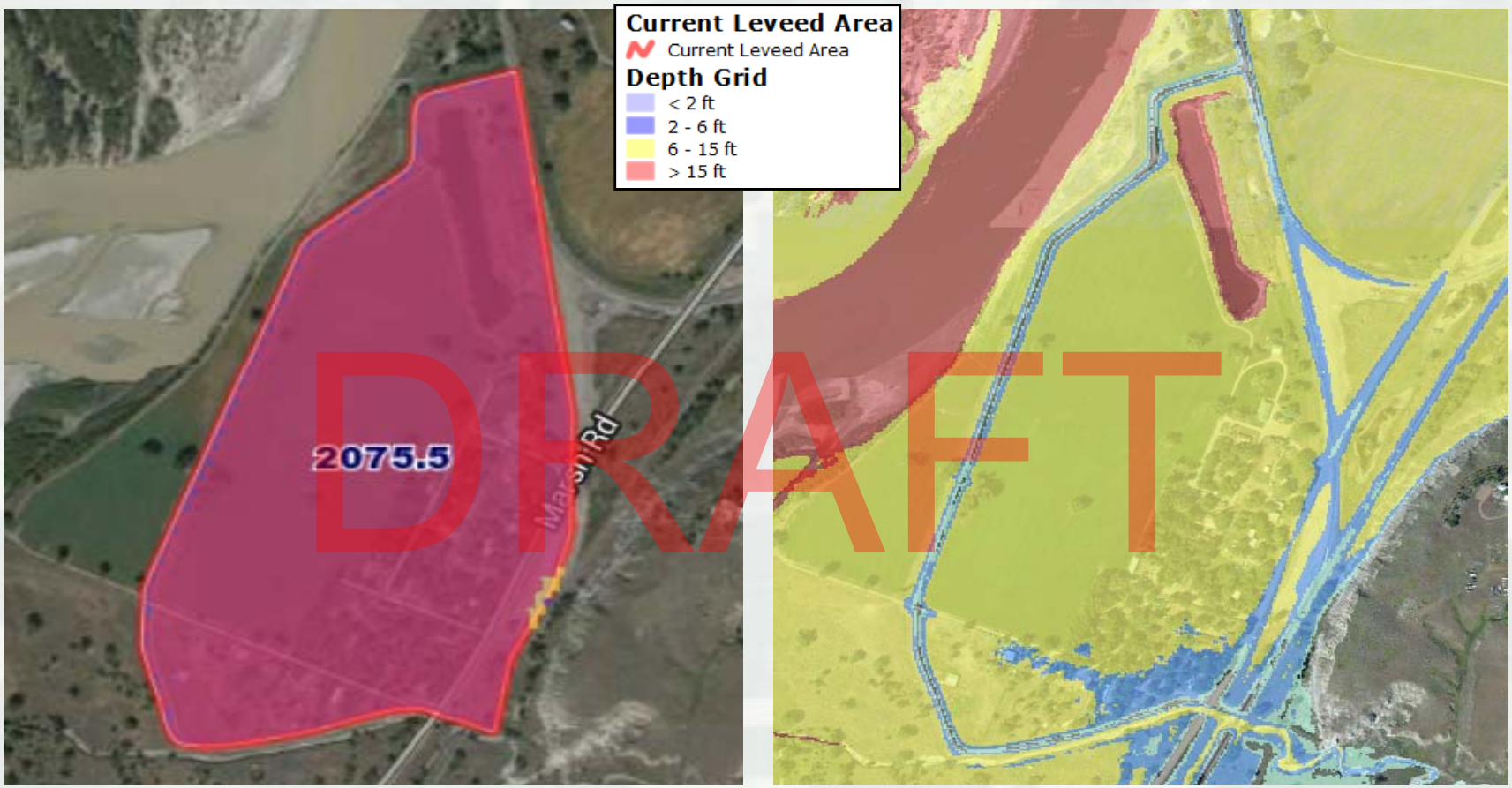
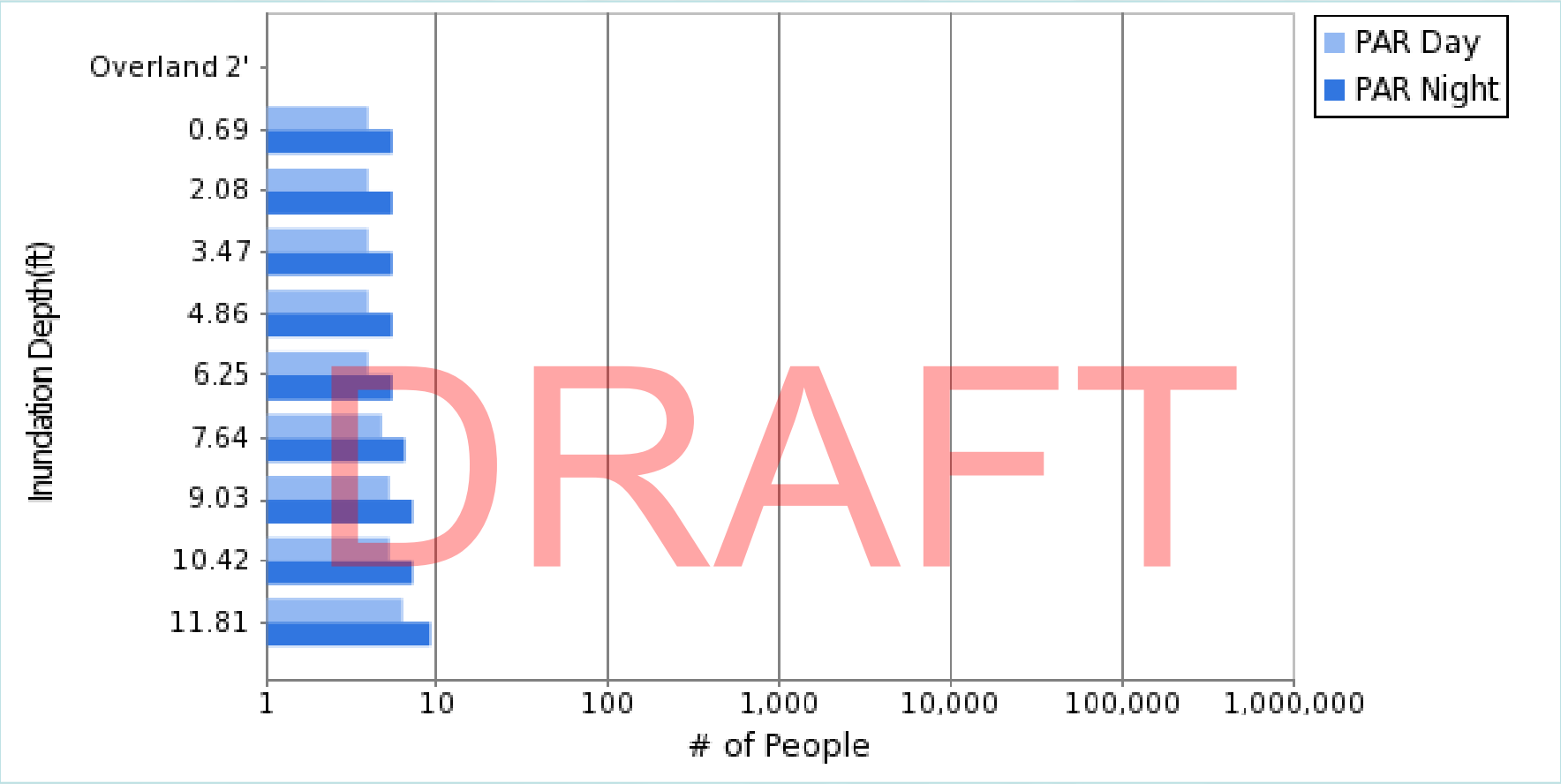
HAZUS Data Elevation Issues



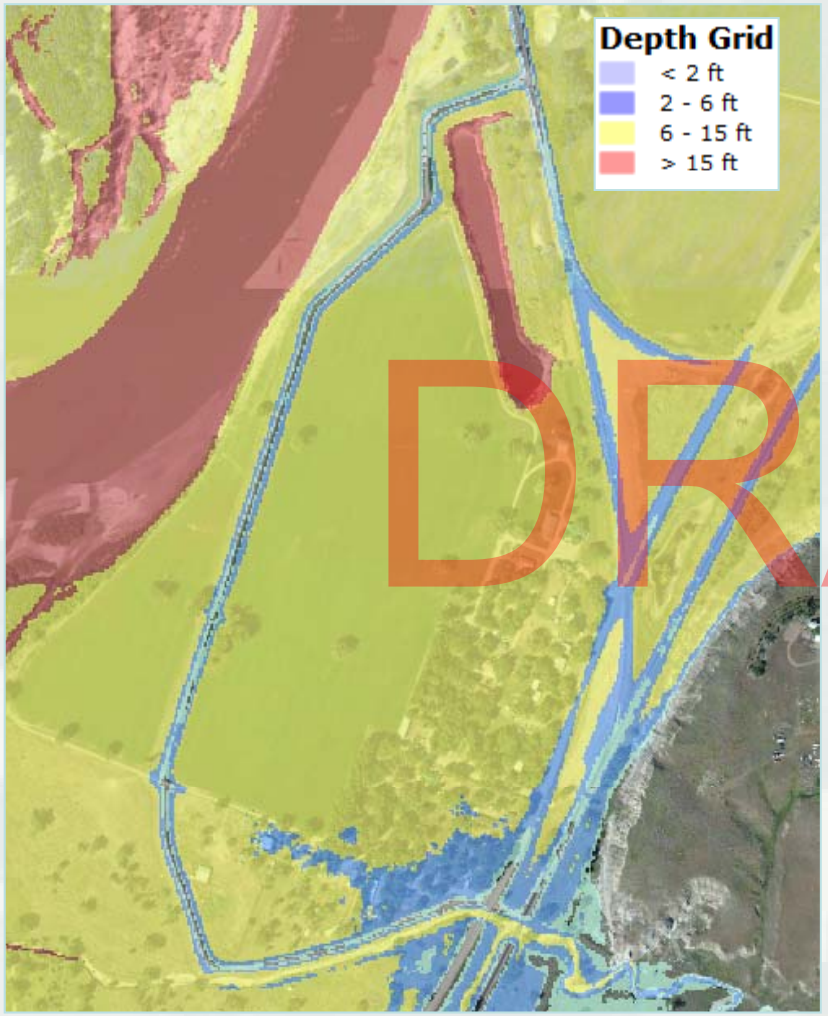
Inundation map based on incorrect HAZUS data in tool shows most of the area in the >15 ft zone (image on left). Actual depths should be in the 4-12.5 ft zone over most of the leveed area (image on right). Max depth is estimated at ~12.5 ft.

Population at Risk



Total PAR Day: 42
Total PAR Night: 58

Potential Flood Impacts



Depth of Flooding, feet	Population at Risk	# of Structures	Property Value ($1,000's)
0-2	4.0	2.9	$4.80
2-6	12.1	8.8	$570.64
6-15	25.6	19.1	$2,762.15
> 15	0.0	0.0	$0.00
TOTAL	41.7	30.8	$3,337.59

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Evacuation Effectiveness

- Evacuation Planning: A
  - Dawson County has an emergency plan with flood warning procedures that has been updated in the last five years. The sponsor coordinates extensively with the county disaster emergency services coordinator. The evacuation plan was exercised during the 2014 ice jam event (voluntary evacuations were enacted during that event).
- Community Awareness: A
  - The community has seen several ice jam events so they are very aware of the levee's role in flood protection and understand the vulnerability of flooding. During the most recent event in 2014, the community had voluntary evacuations.
- Flood Warning Effectiveness: A
  - Dawson County has an emergency plan with flood warning procedures for first responders and also has an Emergency Notification System (ENS) which is capable of providing the community with prerecorded information through mass phone calls of landline.

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Evacuation Effectiveness

- Transportation System Congestion Factor
  - Day: 1
  - Night: 1
- Computed Evacuation Effectiveness Factor
  - Breach prior to overtopping: 83% Day (83% Night)
  - Overtopping: 98% Day (98% Night)

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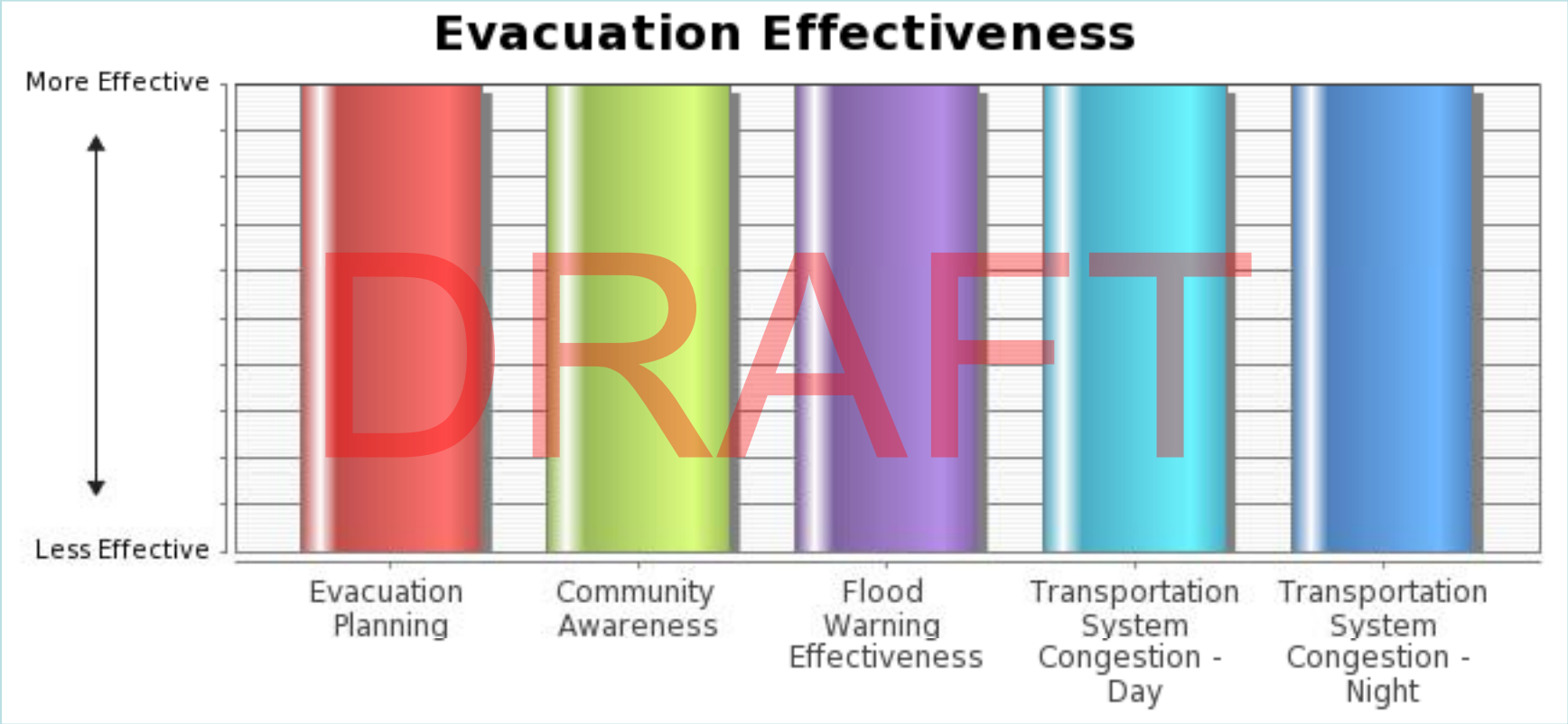
Contribution to Risk: Evacuation Effectiveness



Critical Infrastructure

There is no critical infrastructure in the leveed area.

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Consequences Narrative

- The loss of life for the Glendive – Yellowstone RB segment would be essentially 0 for breach prior to overtopping and for overtopping. The leveed area has a low population (42 day and 58 night) and residents are very flood aware due to several historic ice-jam flood events, which are the primary threat on this levee. The county has a recently updated emergency plan and the community had voluntary evacuations during the 2014 flood. Evacuation routes are not anticipated to be congested due to the low population and relatively small area (~80 acres); however, evacuation routes for residents that do not evacuate can become flooded and impassable. (Note that residents could still evacuate by foot to the bluffs east of the community.) While the warning times can be measured in days for general ice jam flooding on the Yellowstone River, warning times at specific locations can be quite short allowing much less time for evacuation, especially when an upstream ice jam breaks loose and moves toward Glendive (1994 event).
- It is anticipated that flooding of this segment would begin inundating the leveed area within minutes of levee overtopping or breach prior to overtopping. A breached area may widen fairly quickly since the levee embankment is likely loamy material (clay/silt/fine sand). Inundation depths for a majority of the population are between 4 and 12.5 feet. The potential for life loss for people that do not evacuate would be elevated.
- There are about 40 acres of alfalfa crops in the leveed area not captured by the tool.

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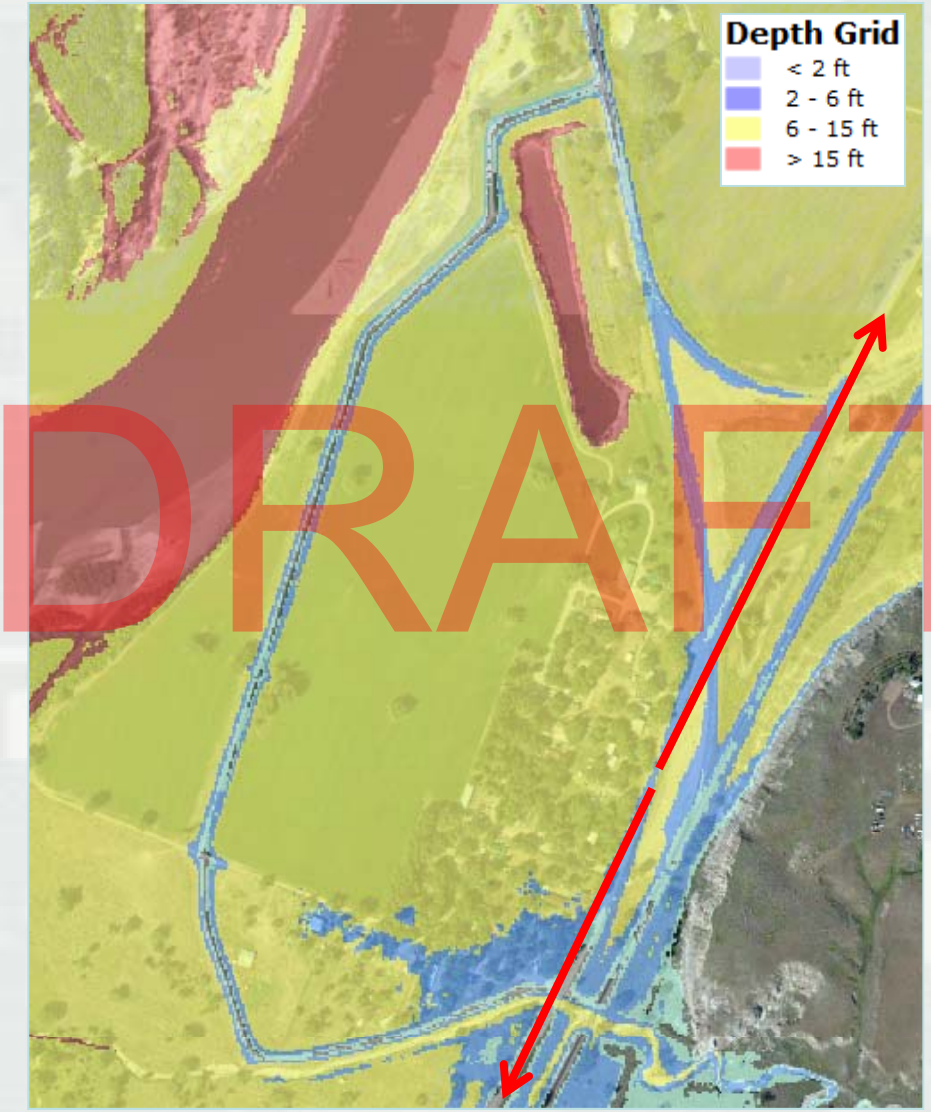
Screening-Level Depth Grid



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Residents could evacuate by vehicle to the north or south along Highway 335 or by foot into the bluffs east of the levee.

Consequence Data Summary

- Life Loss as Percentage of PAR: 0.22%
- Threatened Population with Breach prior to Overtopping: Day- 7 Night- 10
- Threatened Population with Overtopping: Day- 1 Night- 1
- Estimated Loss of Life with Overtopping: 0.01
- Estimated Loss of Life Breach Prior to Overtopping: 0.11
- Number of Structures Inundated: 31
- Economic Damages (in 1000s): $3,348.63

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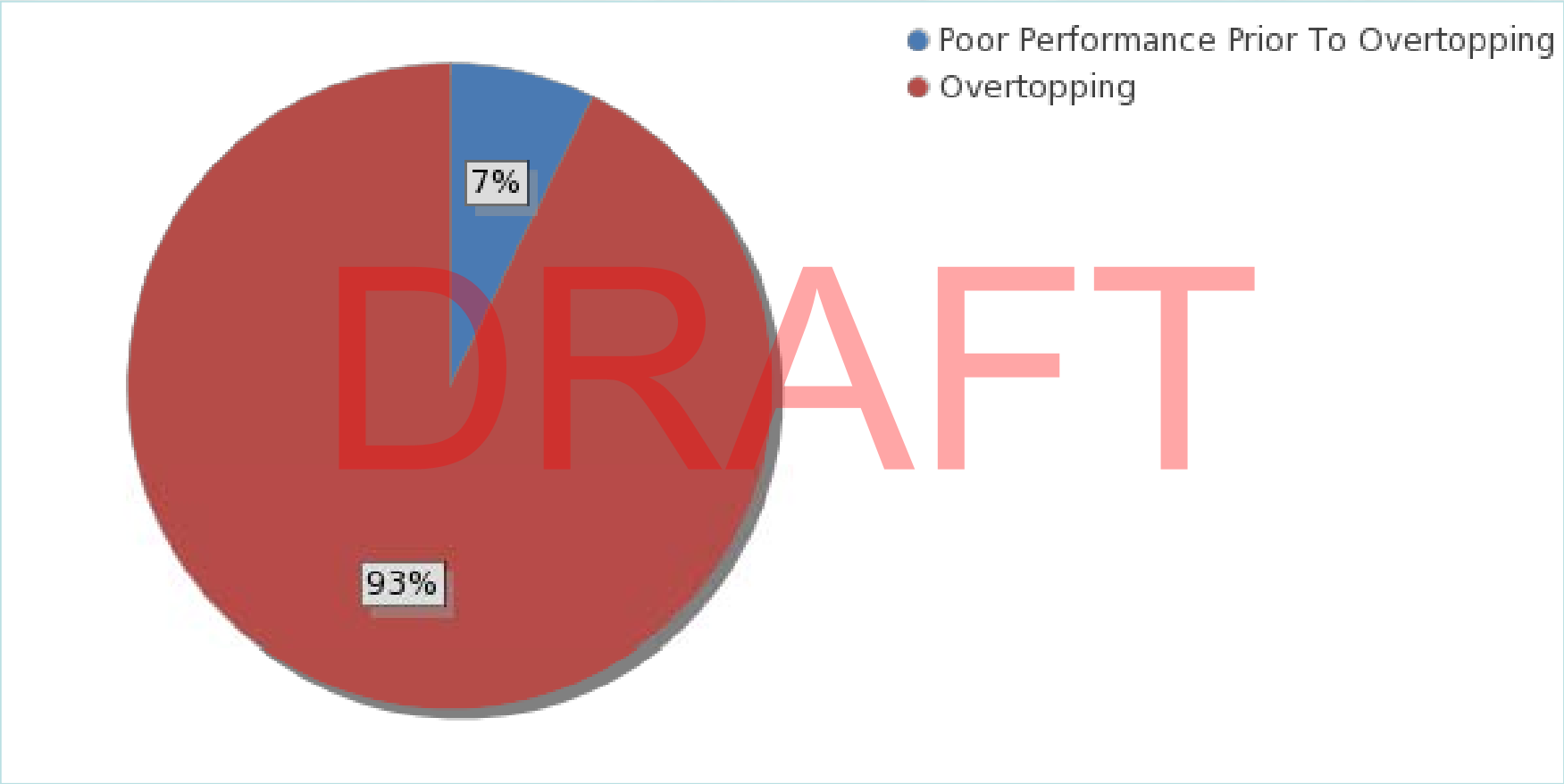
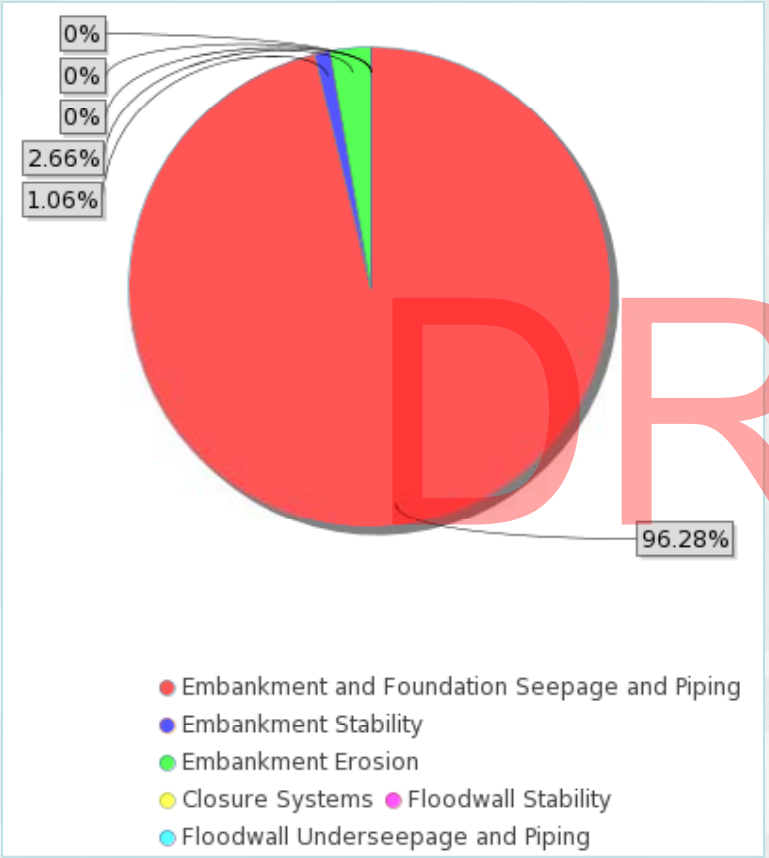
Contribution to Life Risk by Flood Scenario



Contribution to Likelihood of Breach Prior to Overtopping



Performance Type	Performance Index	Life Safety Index	Economic Index
Embankment and Foundation Seepage and Piping	96.28%	96.28%	96.28%
Embankment Stability	1.06%	1.06%	1.06%
Embankment Erosion	2.66%	2.66%	2.66%
Closure Systems	N/A	N/A	N/A
Floodwall Stability	N/A	N/A	N/A
Floodwall Underseepage and Piping	N/A	N/A	N/A

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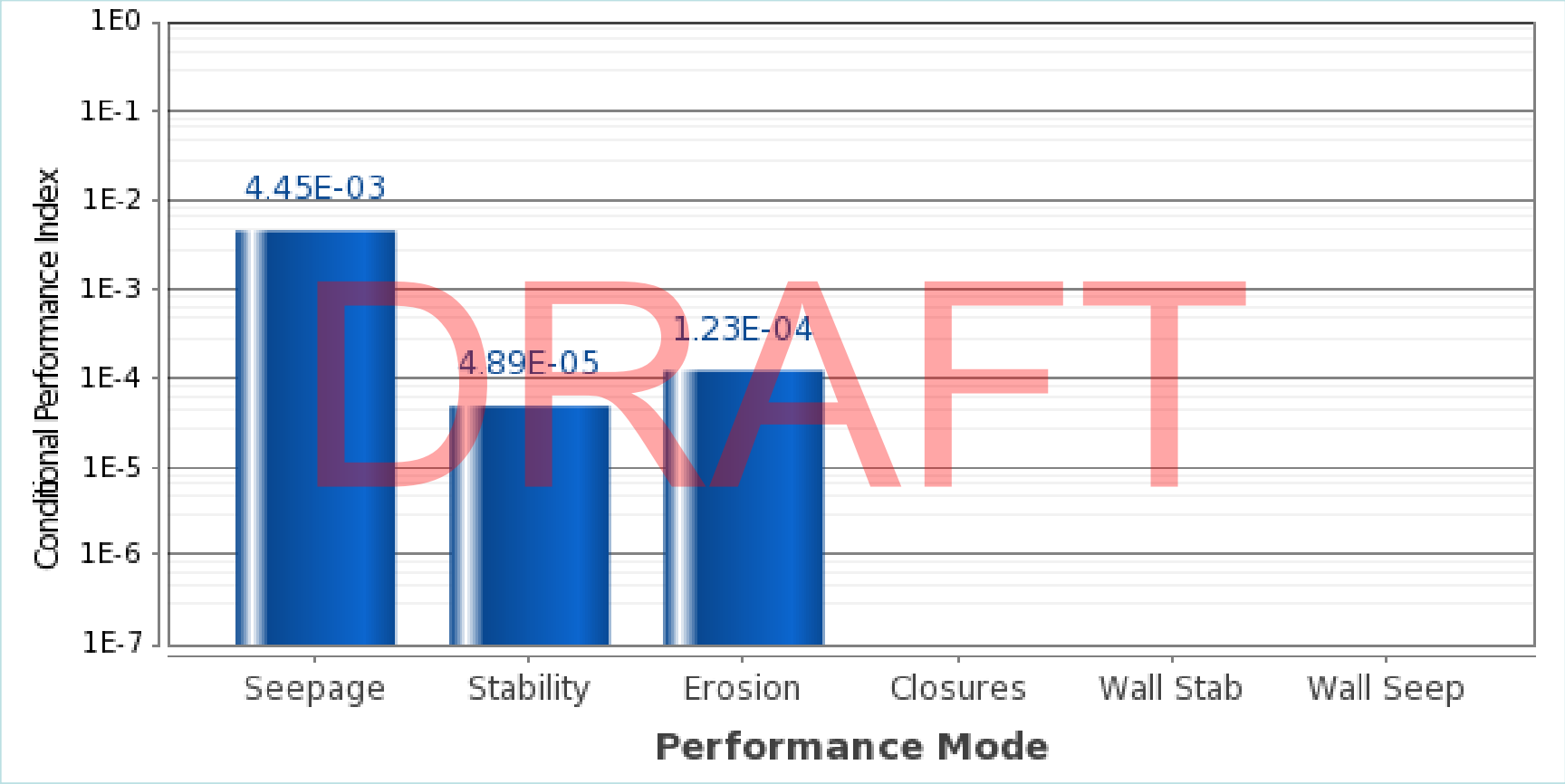
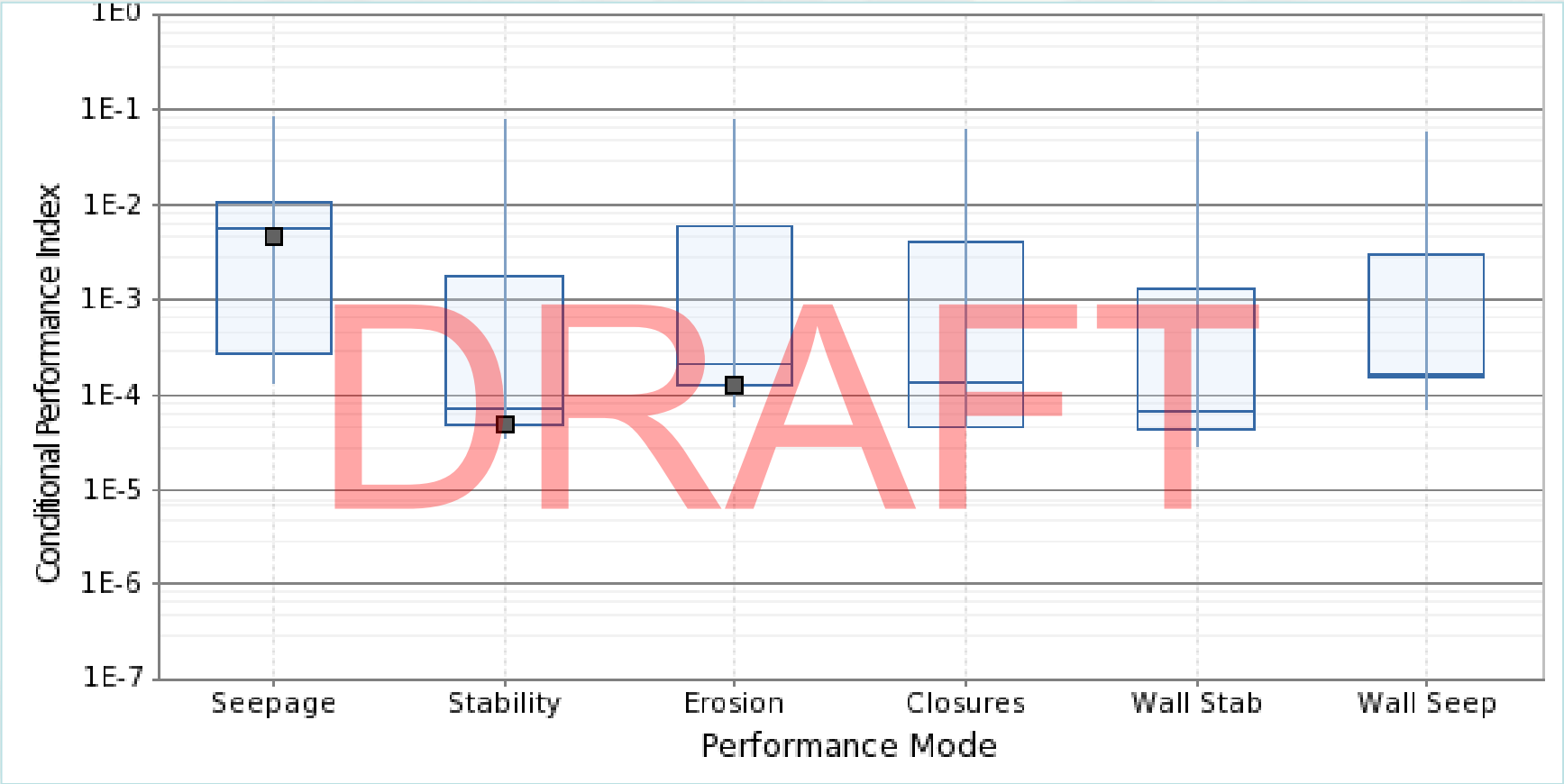
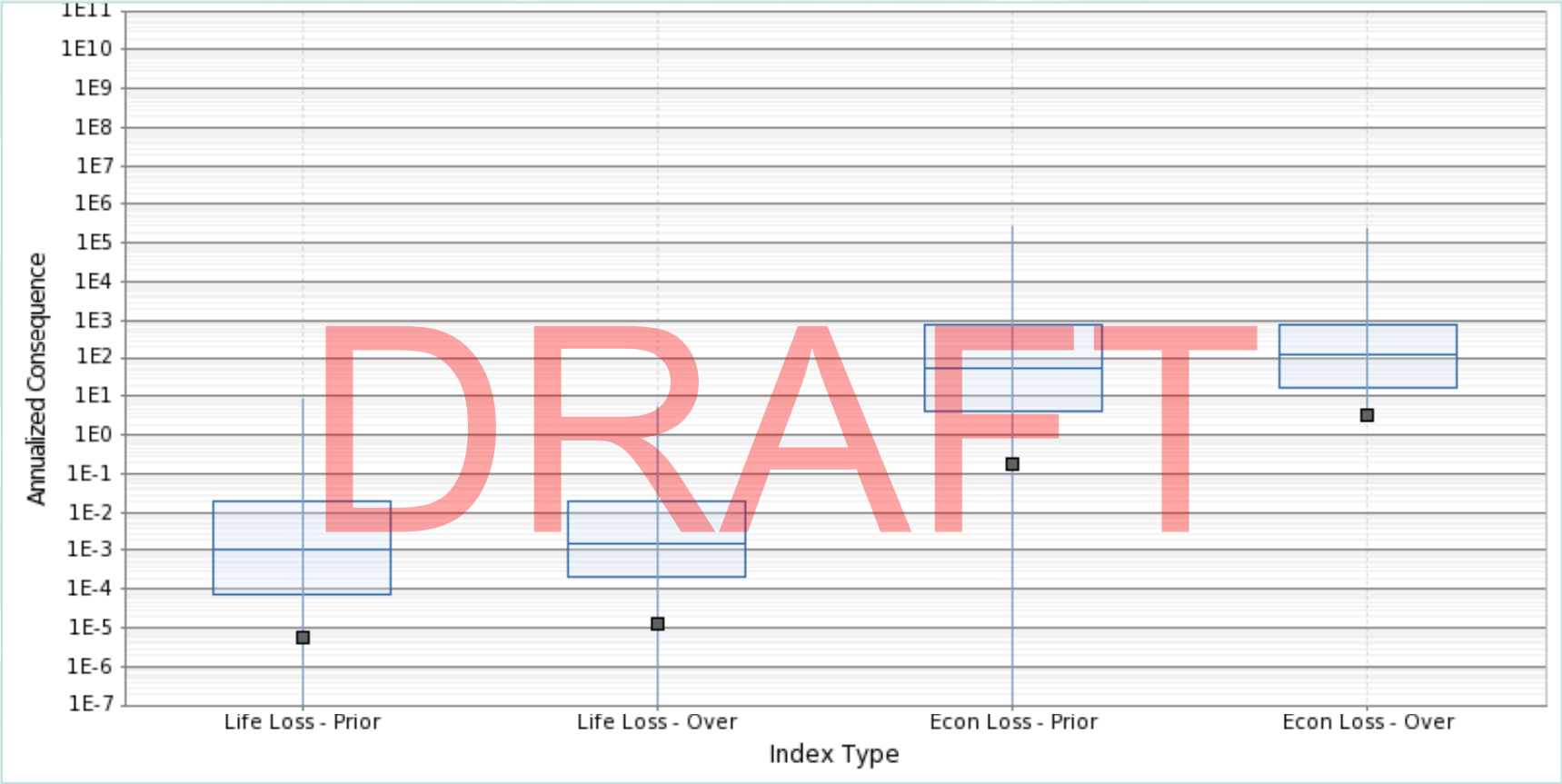
Major Contributors to Risk Prior to Capacity Exceedance



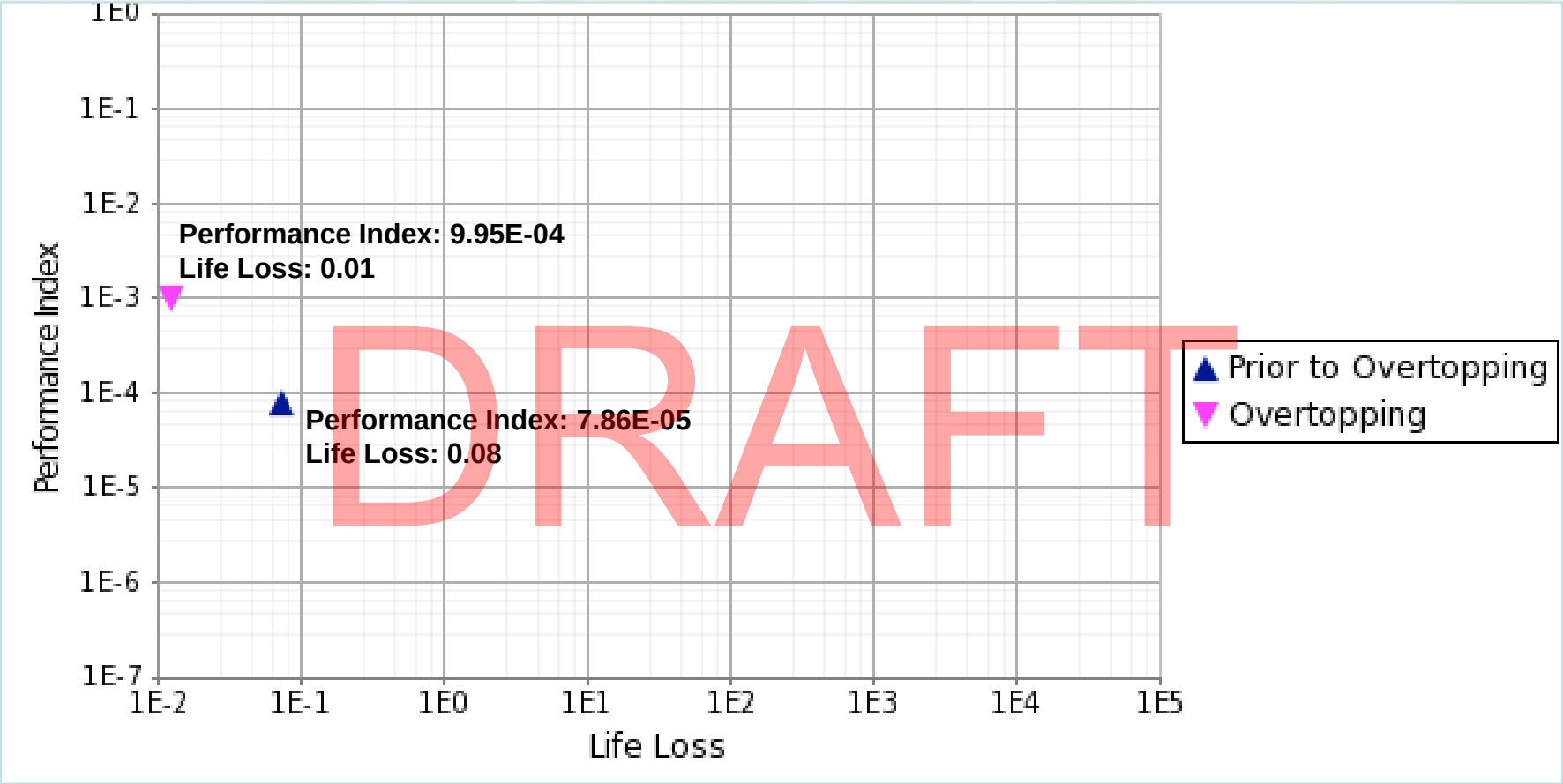
Conditional Performance Index Whisker



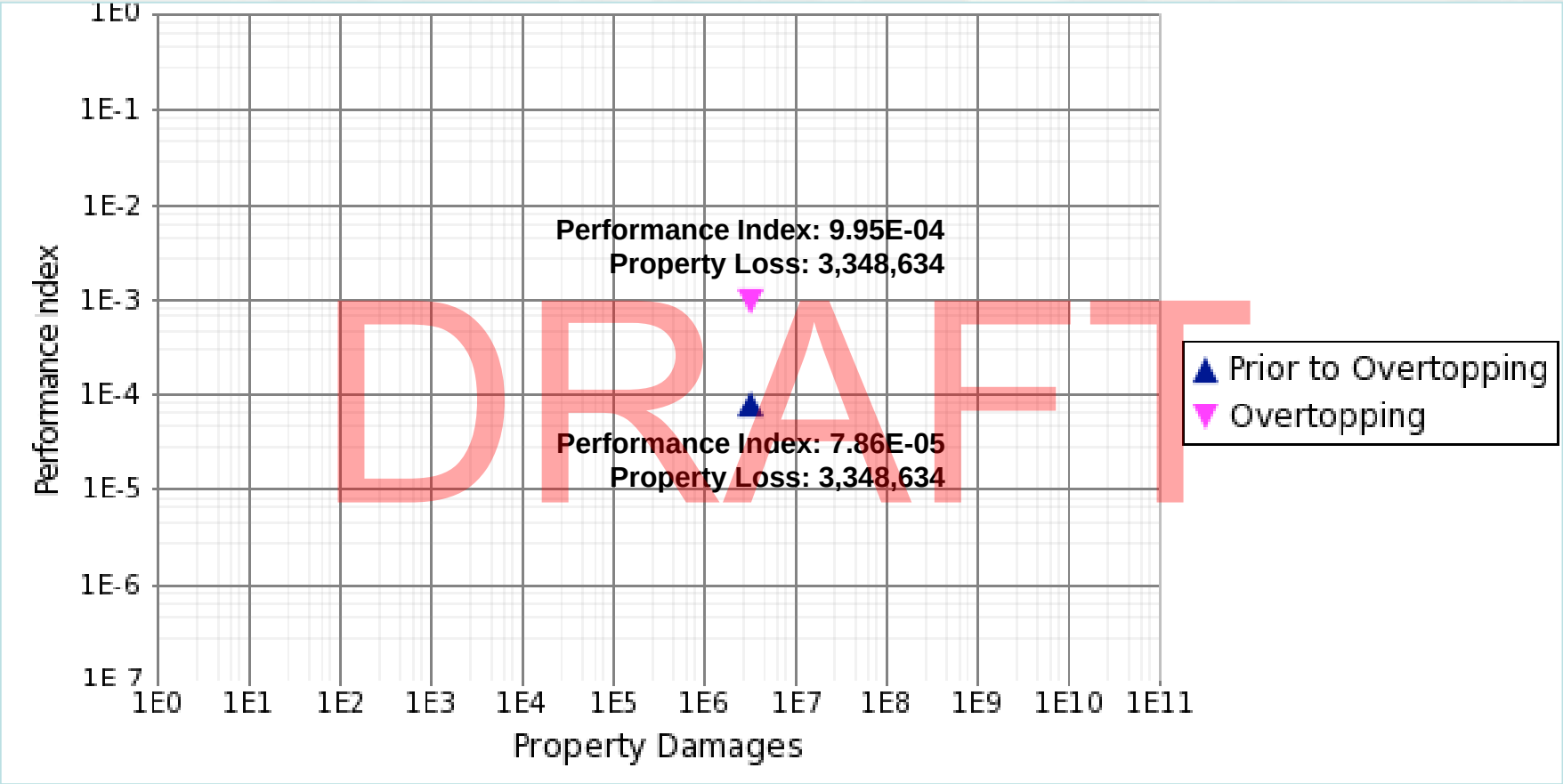
Annualized Risk Whisker



Performance Index vs. Life Loss



Performance Index vs. Property Damage



Recommendations

- Sponsor should continue to focus on operations and maintenance activities including:
  - Performing another video inspection with the invert of the 36” CMP visible. Sponsor should replace or slip-line any culvert assessed as unacceptable.
  - Repairing the area or erosion on levee crown/RS slope near Station 41+00.

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