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Analysis of Virtual Shorelines in Relation to Archaeological Sites in the Colorado River Ecosystem

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U.S. Department of the Interior
U.S. Geological Survey

Background: AMWG Motion

To review the flow levels (as indicated by the currently available shorelines of the HEC-RAS model) associated with each of the 158 archaeological sites that have been identified for monitoring and/or mitigation of impacts, and to report this information and any recommendations with regard to how these data would fit into the process of making choices of sites to be monitored and/or impacts mitigated to the AMWG at its next meeting, with the provision that any recommendation will not alter the choice of sites selected for impacts mitigation in FY09.

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TWG Motion

The CRAHG will review the revised virtual shoreline analysis, in relation to archaeological sites, and bring recommendations to the TWG at its next meeting focusing its review on the first part of the AMWG motion assessing the utility of flow lines as simulated (with uncertainty) by the HECRAS model and other error sources.

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Water Surface Model (Magirl and others, 2008)
USGS Scientific Investigation Report 2008–5075

- 1D model built in HEC-RAS (Hydrologic Engineering Center's River Analysis System) -- a "standard step" model
- Uses 1D equations of energy and continuity to predict stage (water-surface elevation) for known discharges at specific cross-sections
- 2,680 cross-sections generated between Lees Ferry & Diamond Creek
- Uses high-resolution topography for stage above 227 m^3/s (8,000 cfs) and synthetic bathymetry below
- Model for prediction of stage ONLY—other parameters (e.g., bed roughness, velocity) adjusted for each cross-section to predict stage
- Stage predicted to within:
  - ± 0.4 m (1.31 ft) for discharge less than 1,300 m^3/s (<46,000 cfs)
  - ± 1.0 m (3.28 ft) for discharge ranging 1,300−2,500 m^3/s (46,000-88,000 cfs)
  - ± 1.5 m (4.92 ft) for discharge ranging 2,500−5,900 m^3/s (88,000-210,000 cfs)

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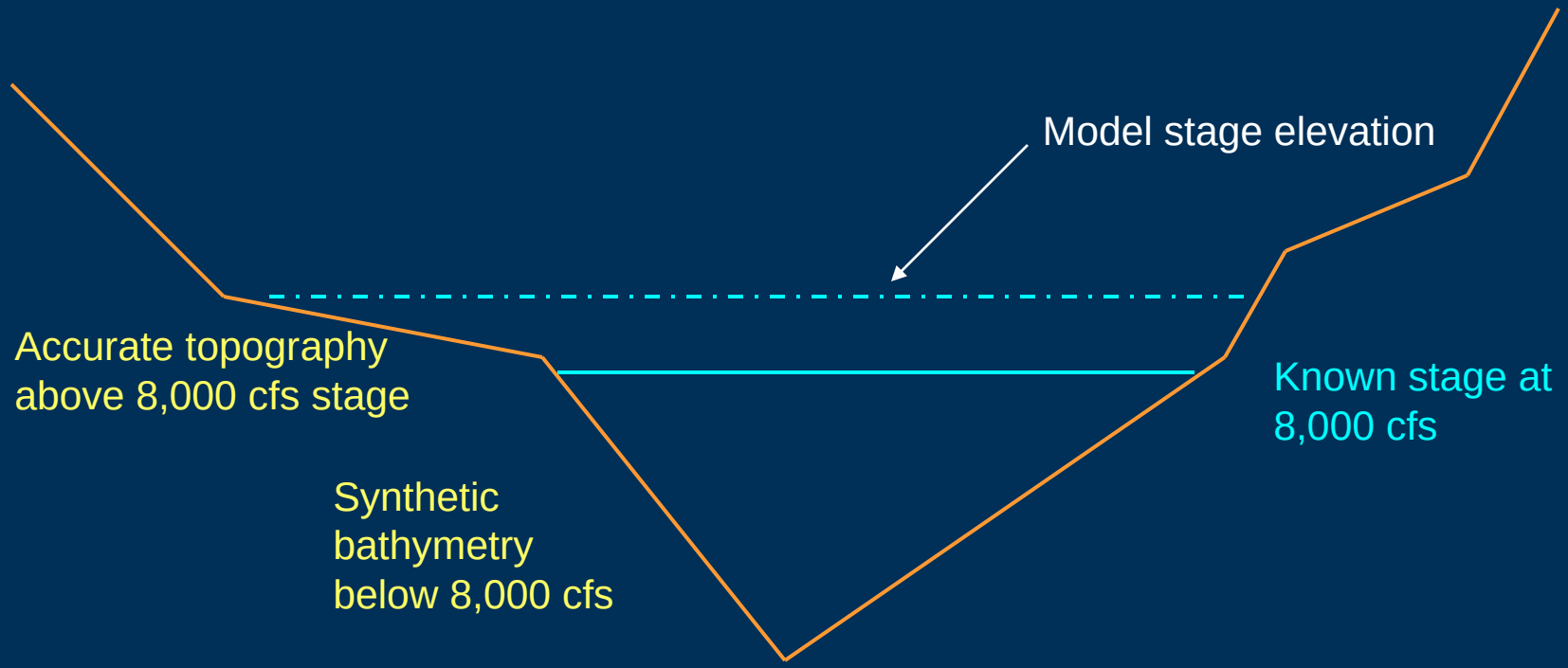
Basic Diagram of Model Components



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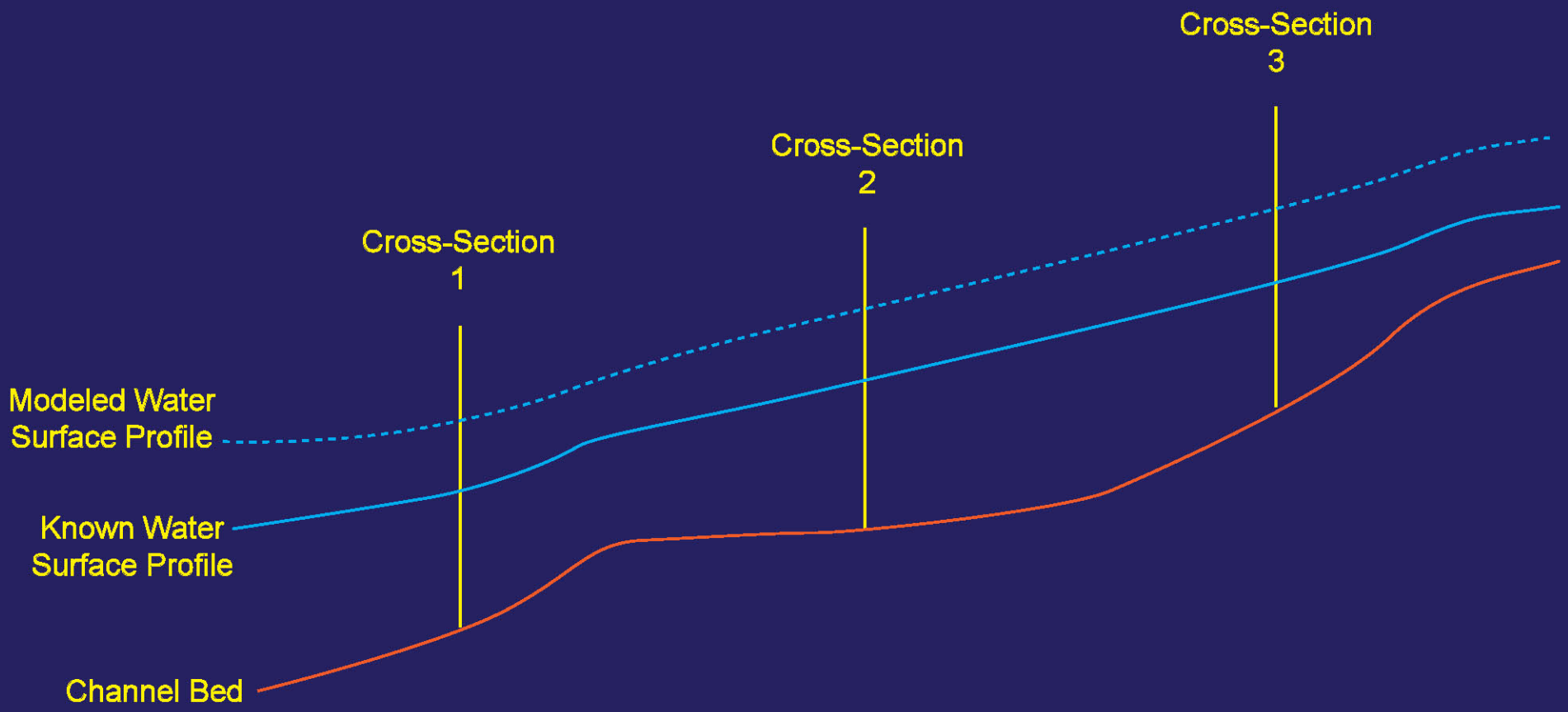
Example Longitudinal Profile



Modeling Virtual Shorelines

- Uses topography generated from 2002 remotely sensed aerial imagery (photogrammetry)
- Assigns elevation values from 1D model at the 2,680 cross-sections, then interpolates between cross-sections to generated a 3D surface
- Generates “areas of inundation” by comparing the elevation of the water surface layer with the topographic layer

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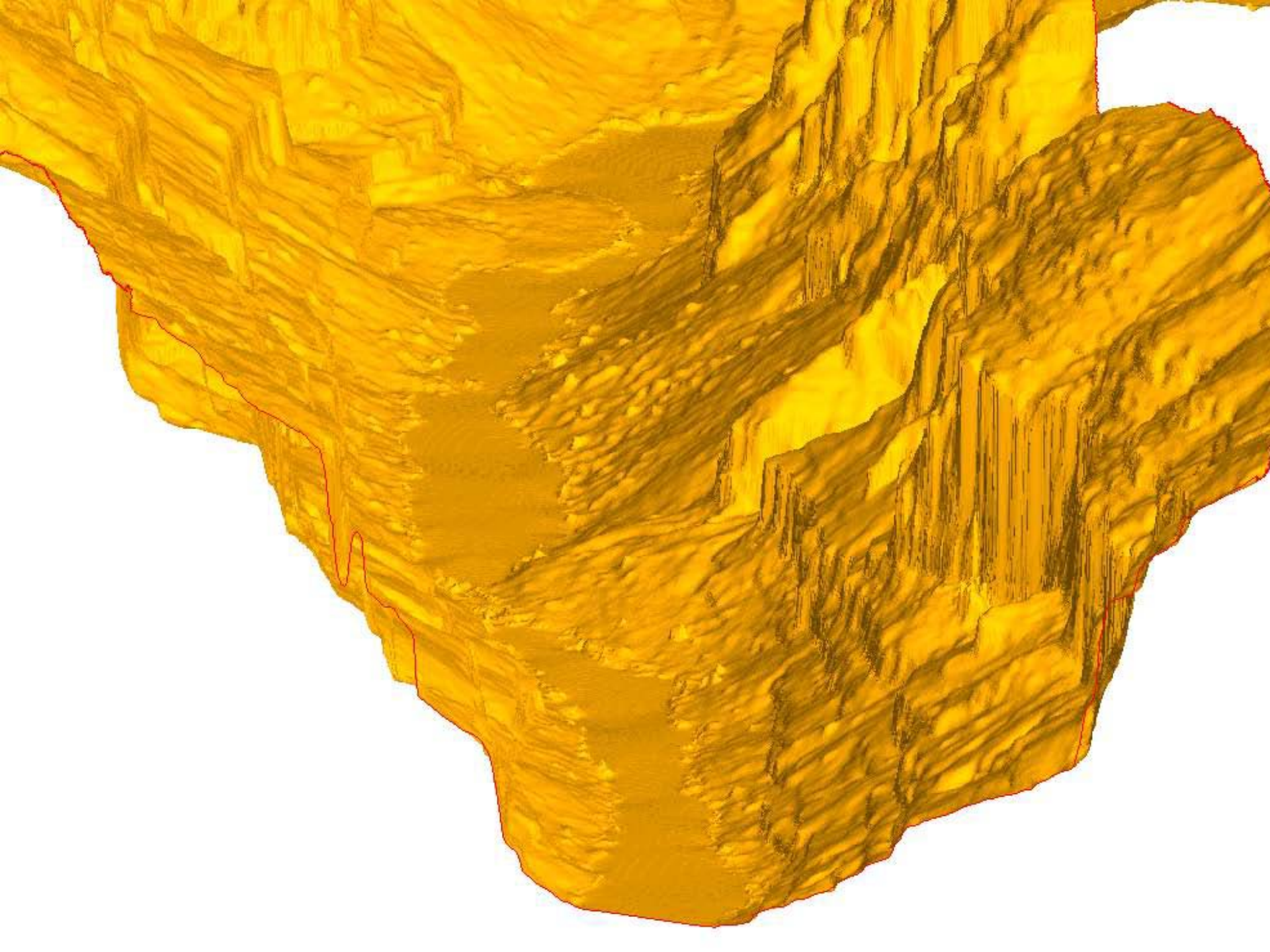
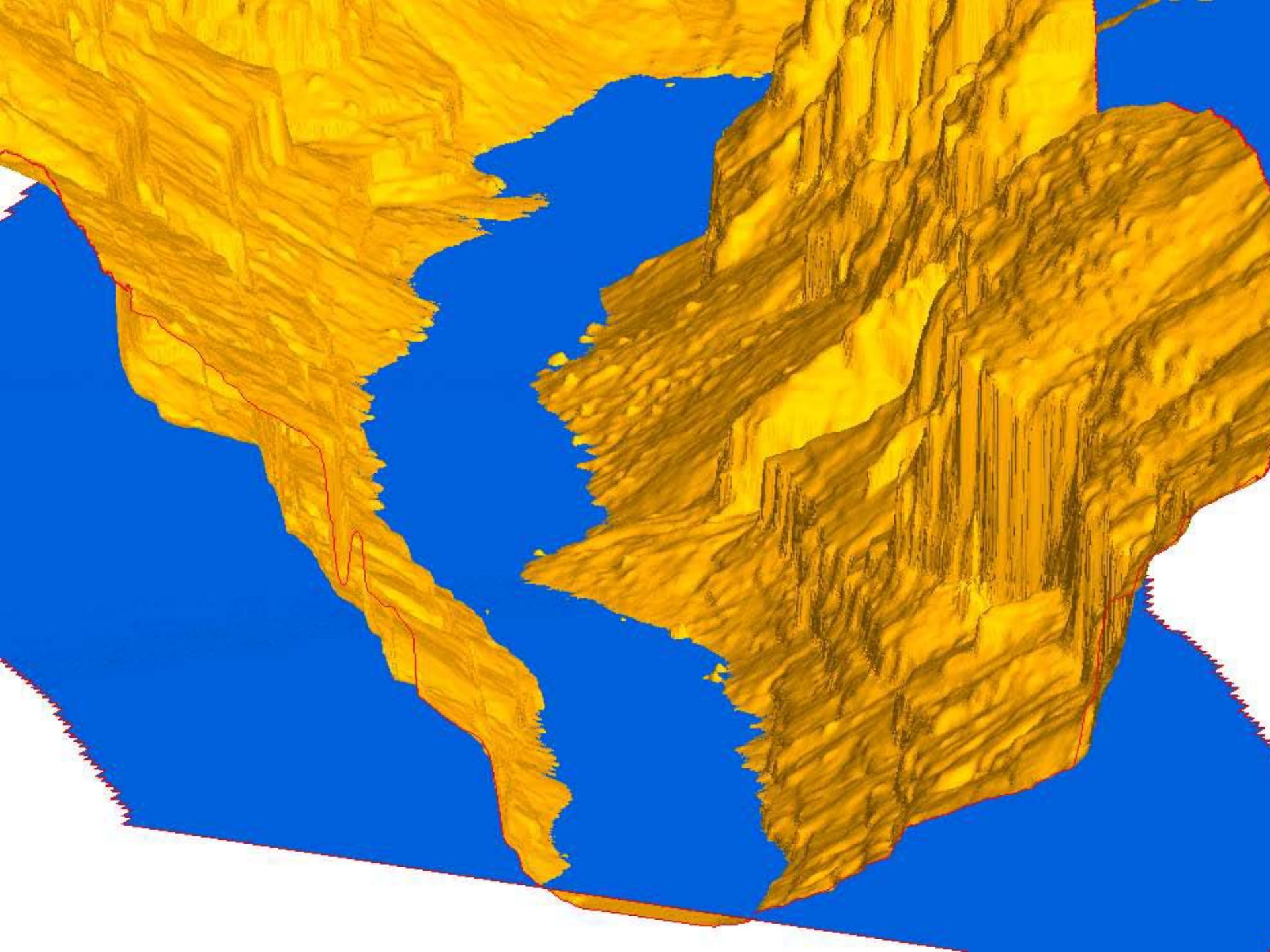
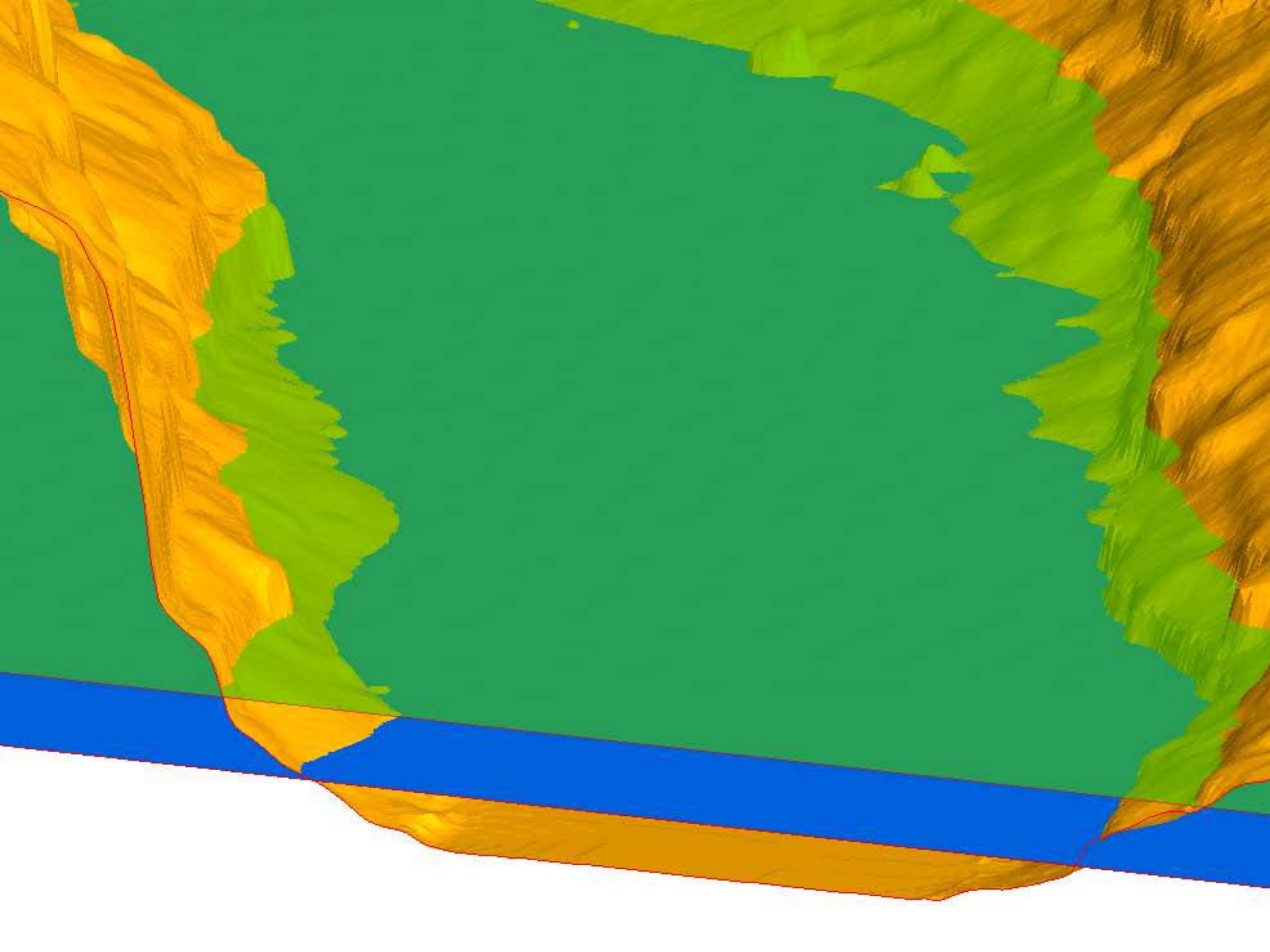
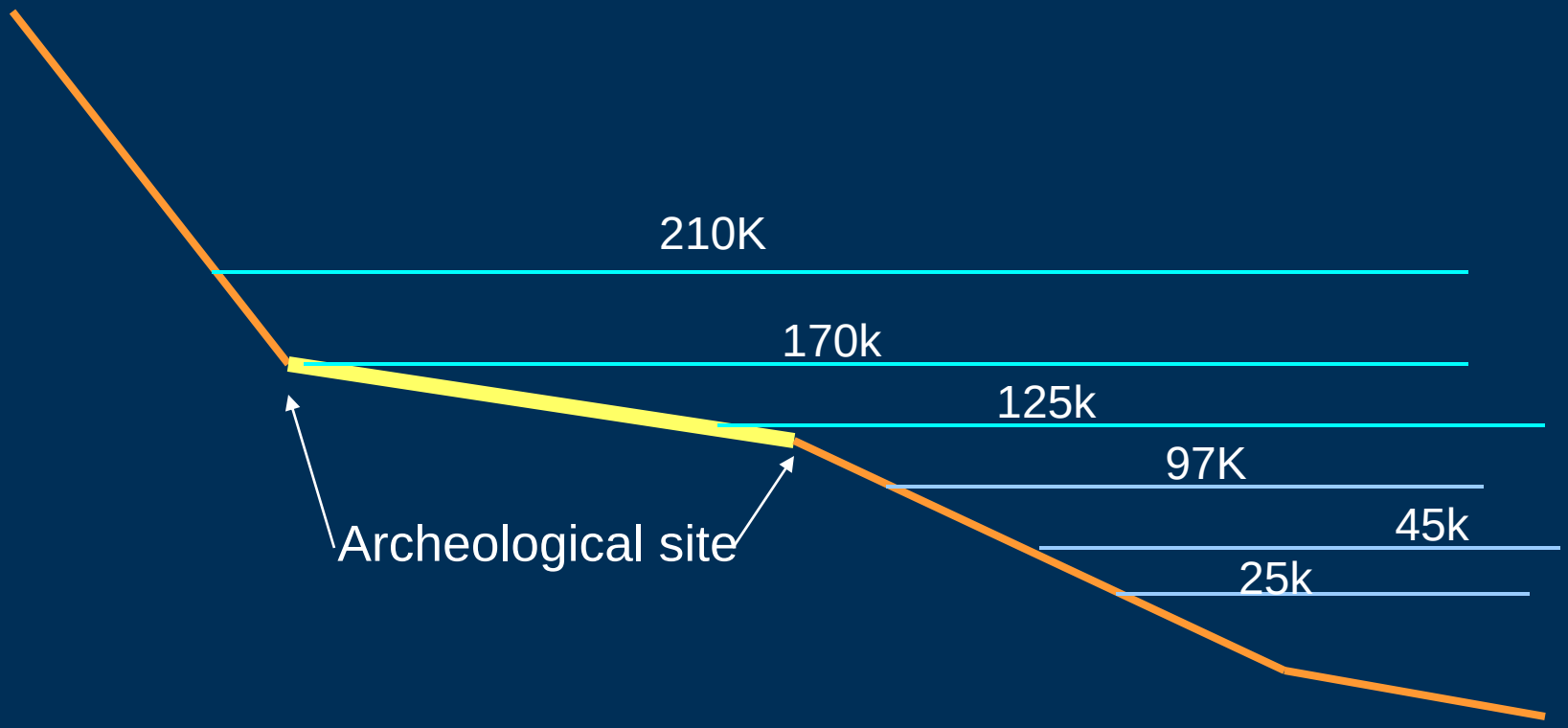






Profile view showing intersection of modeled water surfaces with arch. site



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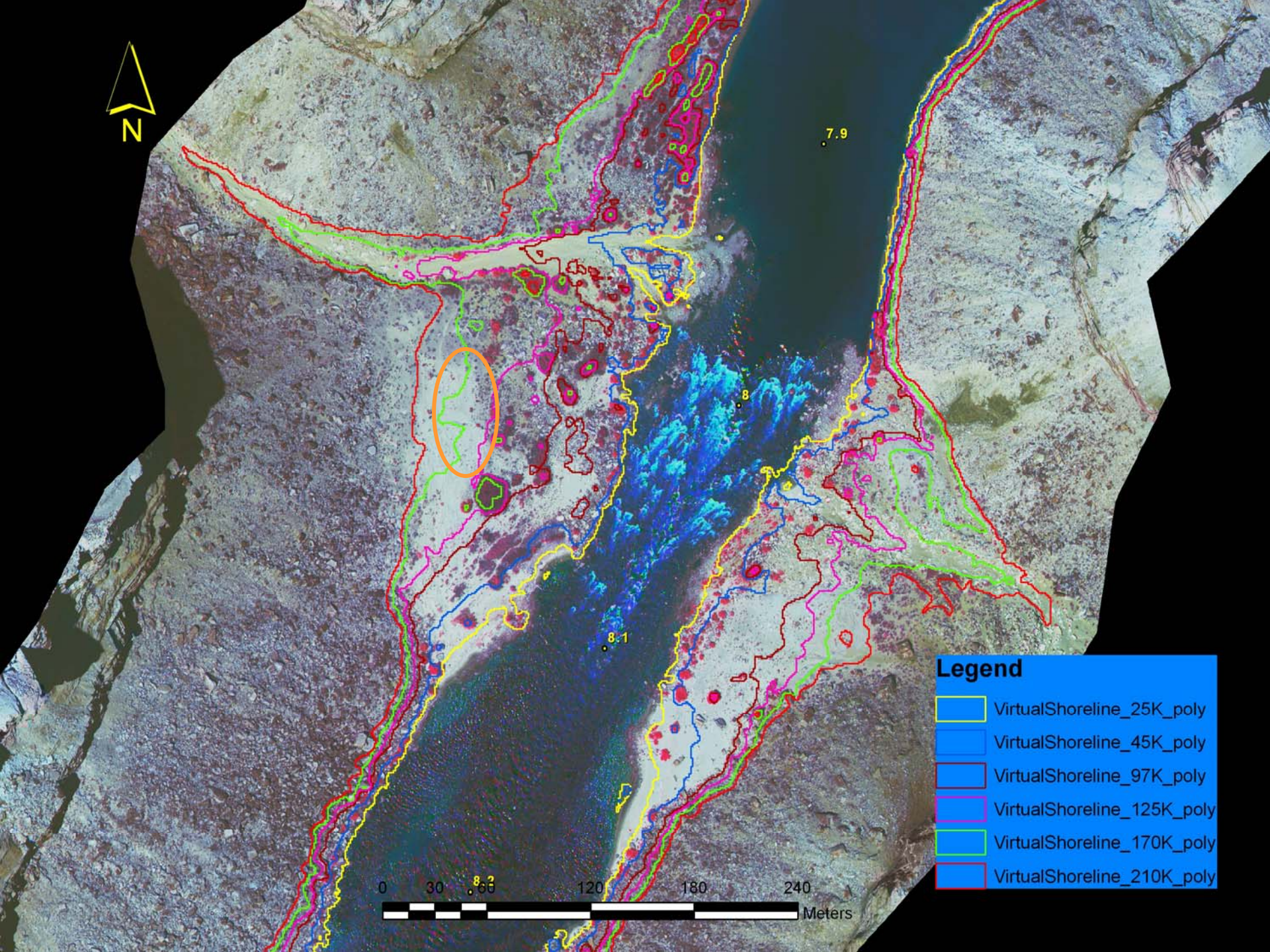
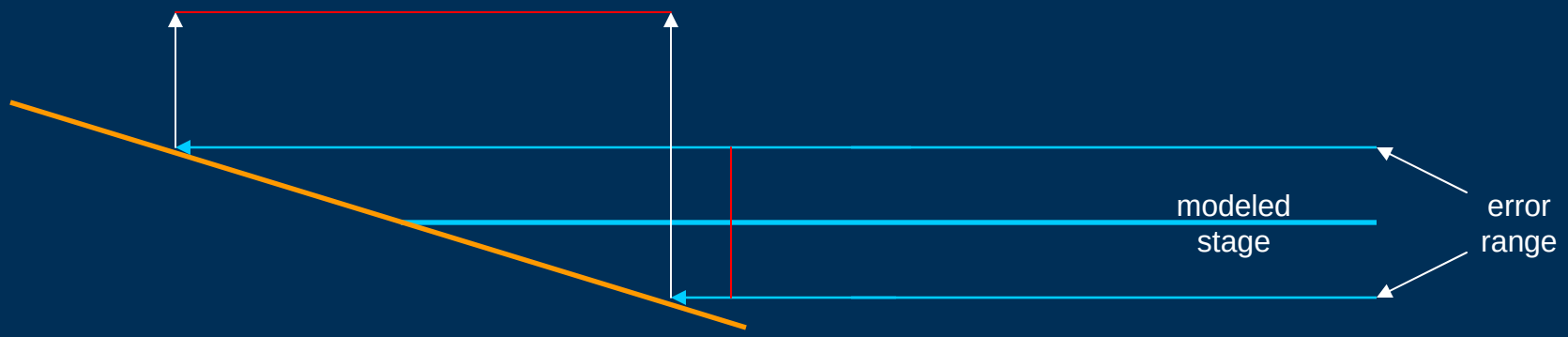

N
7.9
8
8.1
8.2
Legend
VirtualShoreline_25K_poly
VirtualShoreline_45K_poly
VirtualShoreline_97K_poly
VirtualShoreline_125K_poly
VirtualShoreline_170K_poly
VirtualShoreline_210K_poly
0
30
60
120
180
240
Meters

Analysis incorporates error range



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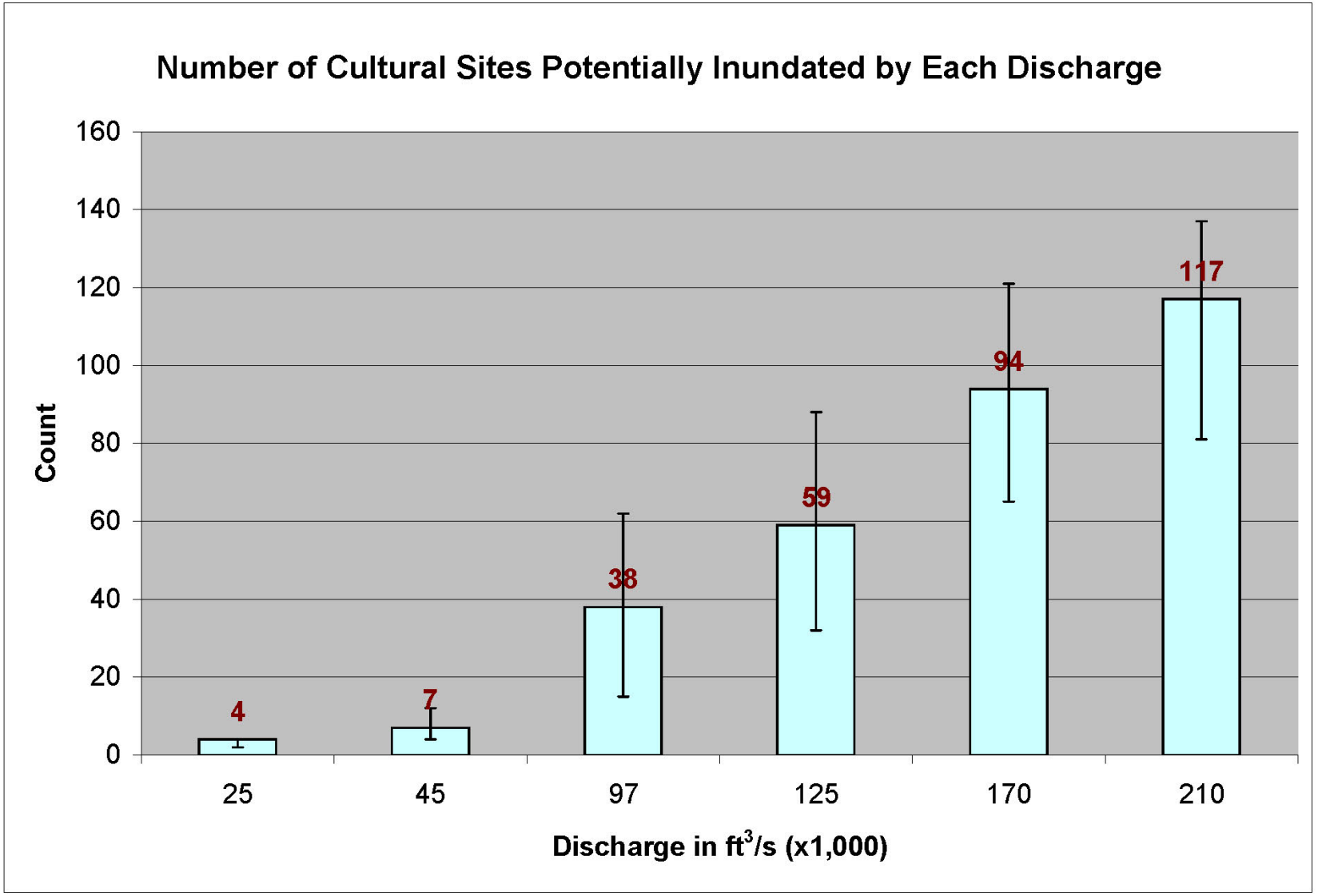
Number of Cultural Sites Potentially Inundated by Each Discharge
Count
160
140
120
100
80
60
40
20
0
4
7
38
59
94
117
25
45
97
125
170
210
Discharge in ft3/s (x1,000)

Limitations of Analysis

- Only ground surface at archaeological sites was considered—how each flow level could affect 3D sites was not analyzed
- Analysis depends on accurate outline of archaeological site area – small boundary changes may produce different results
- Error range may exceed preceding or subsequent stage (e.g., upper error range of 170K exceeds lower & mid range of 210K)
- Modeled water-surface elevations are based on current topography—changes in local topography (e.g., debris flow from side canyon) may change local stage-discharge relationships
- Synthetic bathymetry suboptimal— future measured bathymetry from channel mapping project may be used to update model

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Virtual shorelines at excavated sites

SITE	Project	Lowest stage of partial Inundation
C:13:291	MNA-GRCA	25k
C:13:010	MNA-GRCA	45K
C:13:371	MNA-GRCA	45K
C:02:096	MNA-GRCA	97K
C:13:099	MNA-GRCA	97K
C:13:070	MNA-GRCA	97K
C:13:347	MNA-GRCA	97K
B:15:138	MNA-GRCA	97K+
G:03:020	MNA-GRCA	125K

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Virtual shorelines at excavated sites

SITE	Project	Lowest stage of partial inundation
C:02:032	BOR TP 2008	N/A (Glen Canyon)
A:15:039	BOR TP 2008	125K+
C:13:323	BOR TP 2008	>210K
C:13:327	BOR TP 2008	>210K
C:02:098	BOR TP 2009	45K+
C:13:069	BOR TP 2009	97k+
C:13:385	BOR TP 2009	>210K
C:13:387	BOR TP 2009	170K+
G:03:064	BOR TP 2009	97K+

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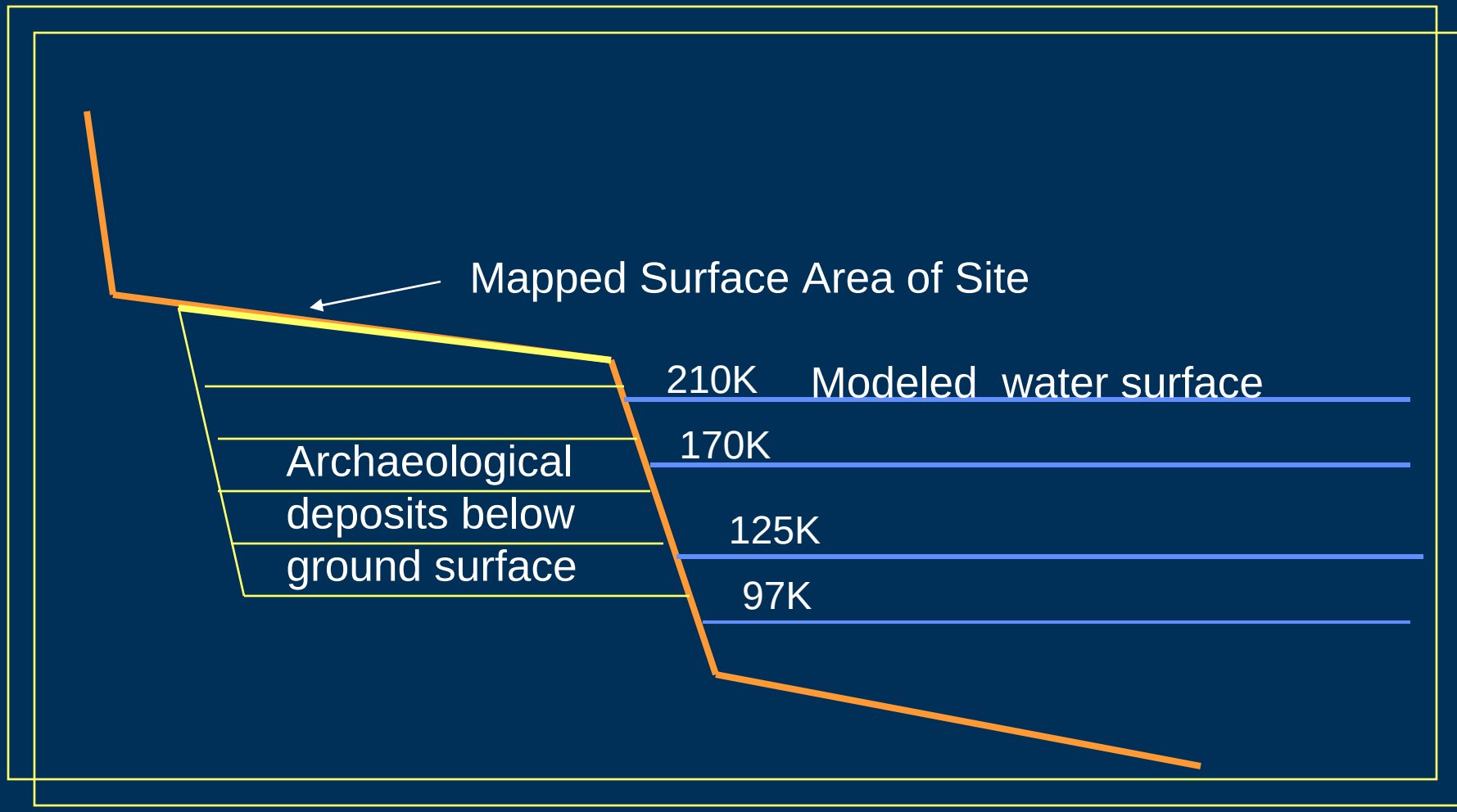
False negative: Archaeological site is affected but GIS analysis says otherwise



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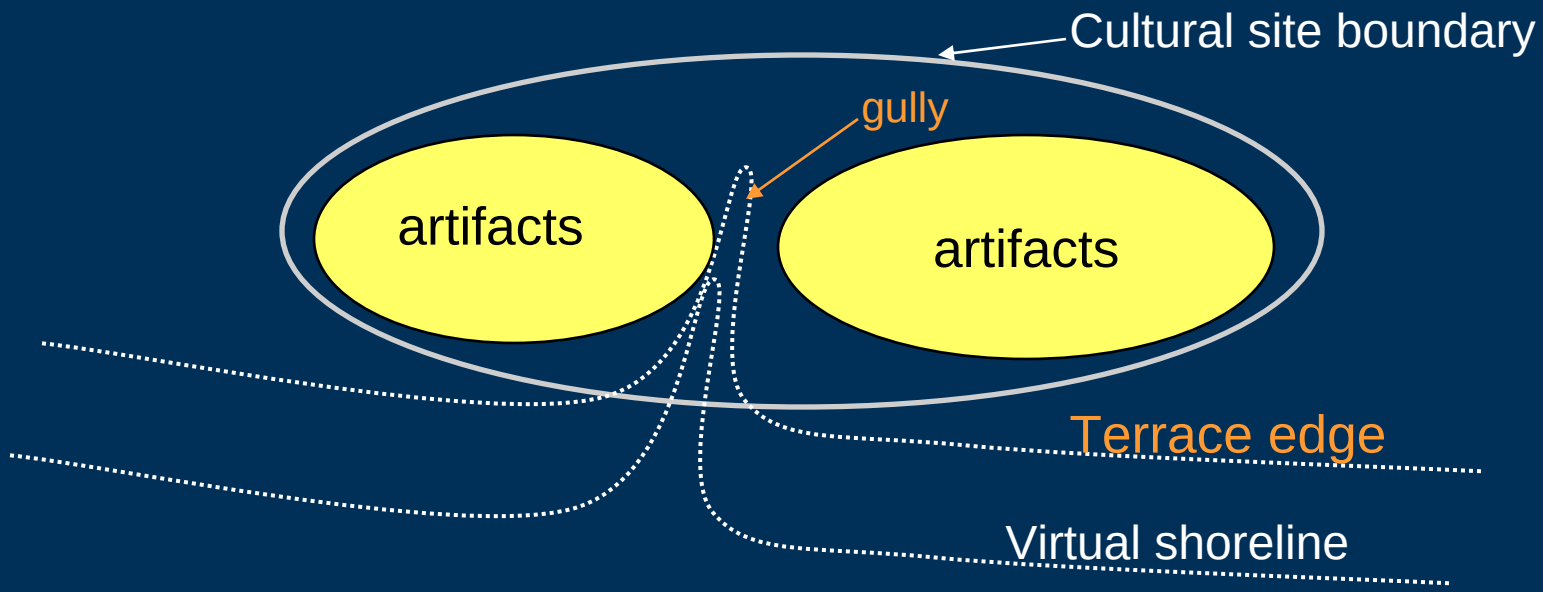
False positive: GIS analysis indicates site is inundated when it is not

Cultural site on top of a terrace with surface artifacts and a deep gully cutting through the middle. GIS analysis would indicate that a portion of this site was inundated, when in fact, no archaeological materials are affected.



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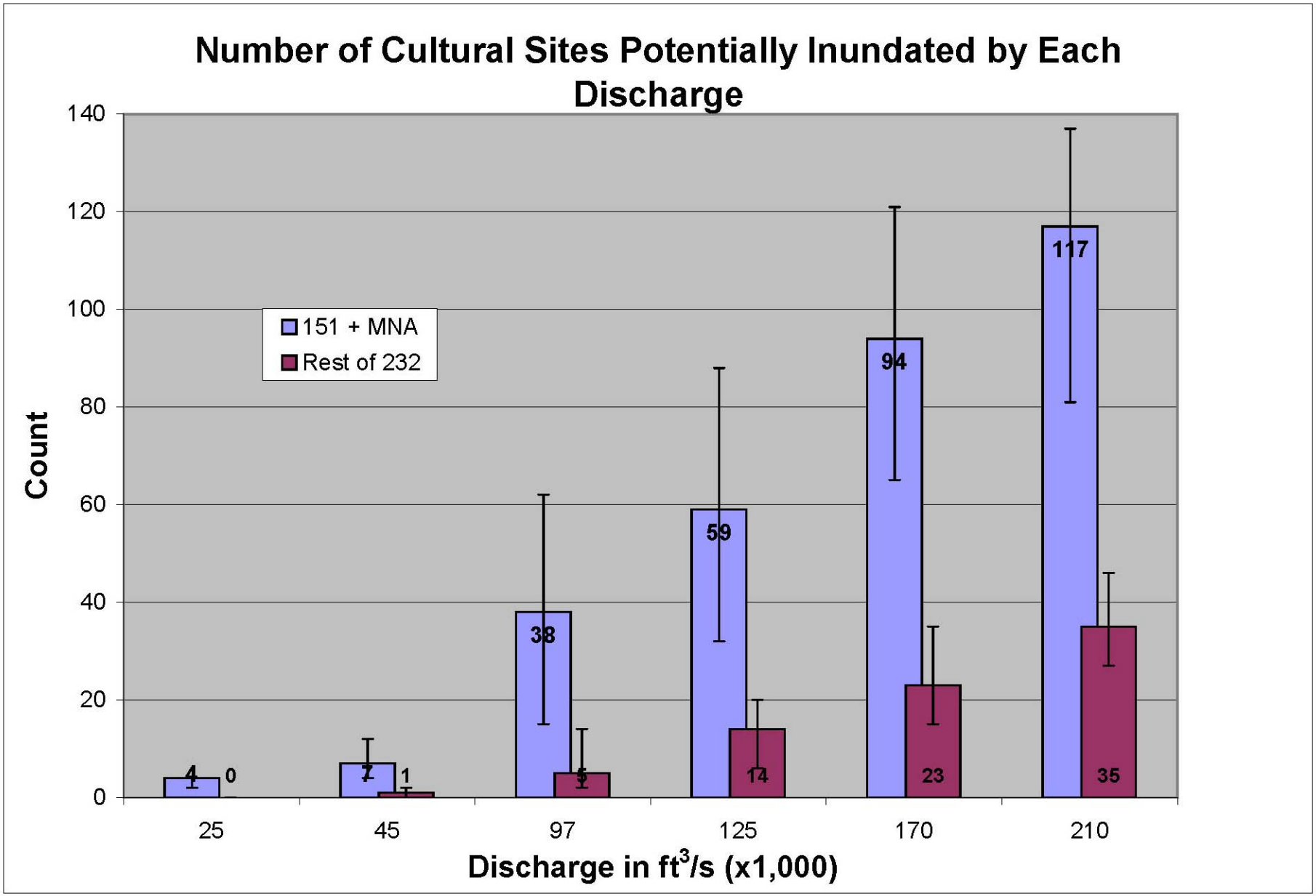
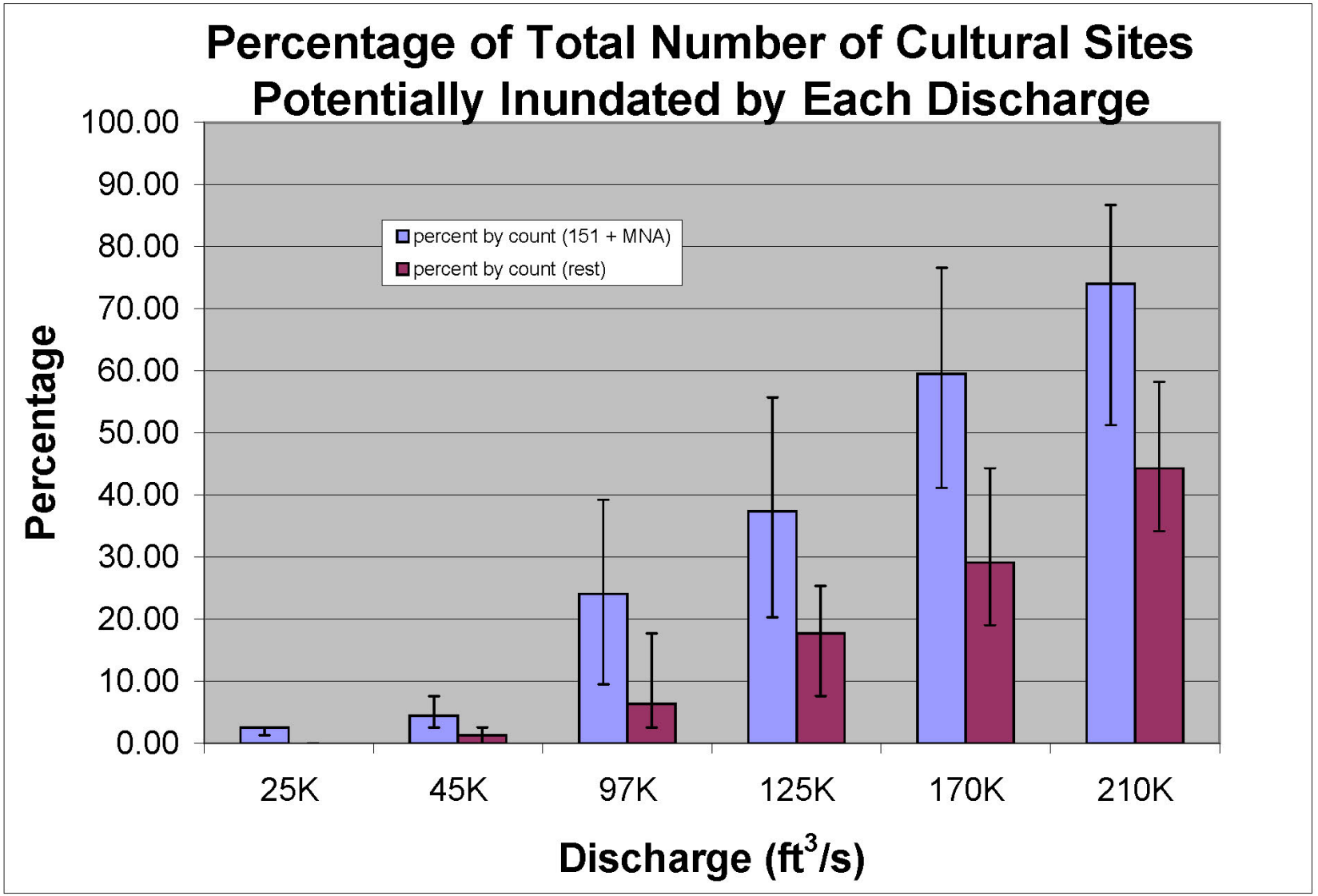

Number of Cultural Sites Potentially Inundated by Each Discharge
Count
140
120
100
80
60
40
20
0
151 + MNA
Rest of 232
4
0
7
1
38
5
59
14
94
23
117
35
25
45
97
125
170
210
Discharge in ft3/s (x1,000)


Percentage of Total Number of Cultural Sites Potentially Inundated by Each Discharge
Percentage
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
percent by count (151 + MNA)
percent by count (rest)
25K
45K
97K
125K
170K
210K
Discharge (ft3/s)


QUESTIONS?