Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

GEOLOGIC MEMORANDUM
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Date: **April 7, 2025** **Project No. 223-430**
To: **Aaron Swafford, PE, Apurva Sawant, PE - Jacobs**
From: **Luke Salemme, EIT, Tom Whitman, PG, CEG (CA), Judd King, PE, GE (CA) - Yeh**
Reviewed by: **Brett Arpin, PE (UT) – Yeh**

PROFESSIONAL ENGINEER
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4/7/2025
STATE OF UTAH

Subject: **Glen Canyon National Recreation Area - Hite Boat Launch Ramp, Hite, Utah**

Yeh and Associates (Yeh) is providing site reconnaissance and geologic services for the Glen Canyon National Recreation Area (GLCA) Launch Ramp project in Hite, Utah. Our services are being provided per our Task Order No. 148054979 with Jacobs effective April 29, 2024, in association with Jacob's agreement for professional services with the National Parks Service (NPS).

NPS predicts that in the near future Lake Powell will have a limited number of operable boat launch ramps due to historically low water levels. The existing boat launch ramp at Hite is currently closed and no longer provides boat access to the Colorado River. NPS proposes to advertise a design-build contract to construct a new boat ramp at the Hite location to accommodate future access needs for Lake Powel. The location of the proposed boat launch ramp and the project limits are shown in Figure 1.

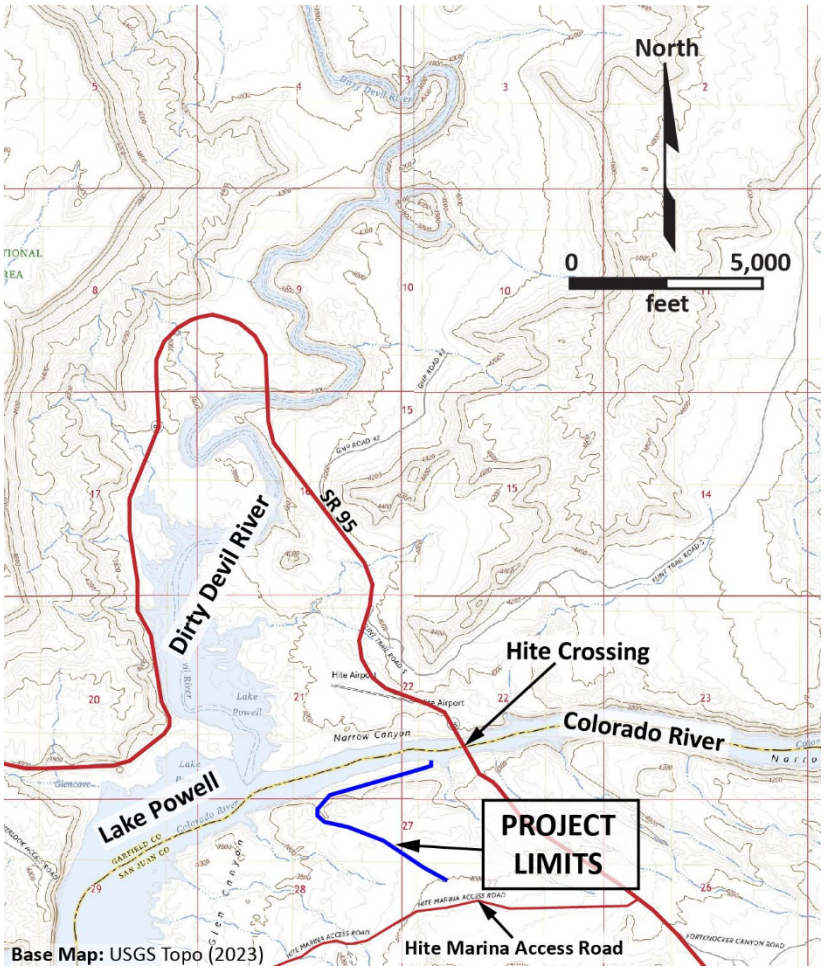

Figure 1: Vicinity Map

Yeh staff visited the proposed Hite boat launch ramp on May 15 and 16, 2024. During the site reconnaissance, staff walked the proposed alignment, performed surface geologic mapping, noted site-specific hazards along the proposed alignment, and obtained rock mass structural geologic data that could impact the proposed alignment. Yeh collected photographs and videos from the ground level and from the air utilizing a drone to supplement the

observations. This memorandum summarizes the existing conditions at the site, the results of the site reconnaissance and geologic mapping, as well as preliminary geologic recommendations for the construction of the Hite boat launch ramp.

1. Existing Site Conditions

The project site is located along the south side of the Colorado River, just west of the Hite Crossing Bridge on State Route 95 and east of the confluence of the Colorado and Dirty Devil rivers in Hite, Utah. The location of the project site is shown in Figure 1 and the approximate ramp alignment from the site map is shown in Figure 2. The site consists of the main canyon incised by the Colorado River defined by a series of terraces with local descending ravines acting as drainage throughout the valley floor area. The proposed boat launch ramp alignment begins on the valley floor along an existing unpaved access road approximately 2,500 feet northwest from its intersection with Hite Marina

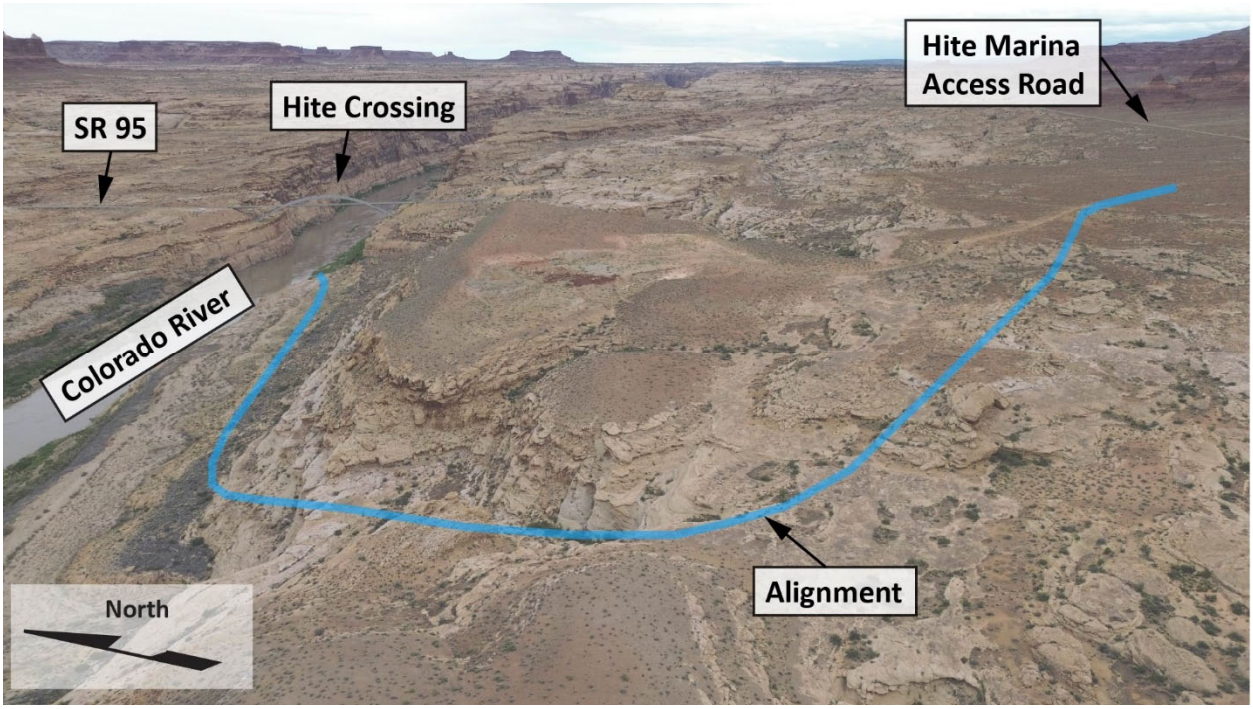

Figure 2: Proposed Ramp Alignment (Looking East)

Access Road at an approximate elevation of 3,990 feet[1]. From Station 13+00 to 51+50[2], the alignment continues northwest along the valley floor until reaching a steep ravine. The alignment turns to the northeast and descends the ravine between Station 51+50 and Station 61+25 until it reaches a terrace at an approximate elevation of 3,800 feet. The alignment continues to the northeast and

[1] CalTopo (2024), Online Topography tool, accessed May 22, 2024, https://caltopo.com/map.html#ll=37.88466,-110.37995&z=16&b=mbt&a=sf
[2] Schematic Design - Low Water Ramps – Hite Launch Ramp, Glen Canyon National Recreation Area, National Park Service, by Jacobs, dated March 28, 2025

traverses through a series of relatively small, benched terraces just south of the Colorado River between Station 61+25 and 76+82 reaching a lower terrace at an approximate elevation of 3,670 feet. From Station 76+82 to 88+00 the alignment descends through existing steep and incised cut section, turns north, and enters the Colorado River. The elevation of the river at the time of our site reconnaissance was approximately 3,574 feet.

The vegetation throughout the project area consists of sparsely scattered shrubs and grasses. More dense shrubs and grasses are prominent along the floodplain along the southern riverbanks of the Colorado River.

2. Geologic Setting and Mapping

2.1 Regional Geology

The project is located within the Colorado Plateau geomorphic province, which is centered on the four corners area of the Southwest including portions of Arizona, New Mexico, Colorado, and Utah. The Colorado Plateau contains a series of plateaus separated by north-south trending faults or

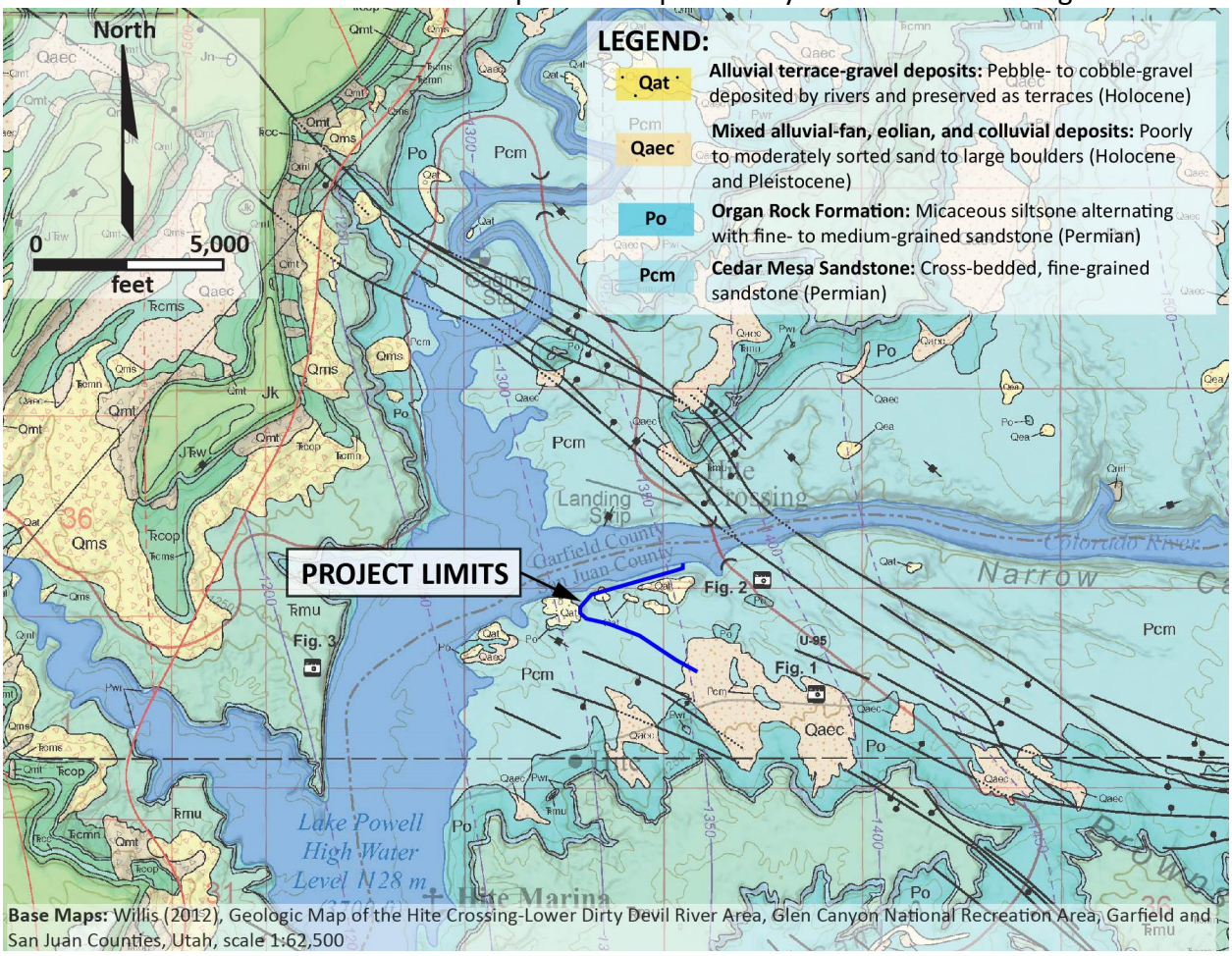

Figure 3: Geologic Map (Adapted from Willis 2012)

monoclines with mesas located in a vast basin surrounded by highlands with widely spaced streams dissecting the region[3,4]. The province is characterized by wide areas of nearly flat lying sedimentary rock sequences separated by bends of strata along monoclinal folds.

Figure 3 shows the regional geology mapped by Willis (2012)[5]. Willis (2012) mapped bedrock in the site vicinity as Cedar Mesa Sandstone (Pcm) that is described as "light-grayish-orange, cross-bedded, fine-grained sandstone interbedded with lenses of reddish-brown to grayish-green sandy siltstone." The Cedar Mesa Sandstone weathers to massive cliffs with scattered ledges at siltstone beds and is topped by a broad bench from the erosion of the overlying Organ Rock Formation. Alluvial terrace-gravel deposits (Qat) described as "pebble- to cobble-gravel with less common boulders, sand, and silt deposited by rivers" overlie Cedar Mesa Sandstone in local areas. Multiple high-angle normal faults are mapped north, east, and south of the project limits.

2.2 Geologic Mapping

Geologic mapping was performed to identify the geologic conditions that may impact the construction of the proposed Hite boat launch ramp. Our field work found that the majority of the project site is contained within the Cedar Mesa Sandstone (Pcm). In addition, localized river terrace deposits were visually identified in the lower portions of the project on the terrace above the river. The proposed alignment traverses four distinct areas of geomorphic significance that will be further subdivided to address each area. These areas are named according to their unique construction or geology attribute with their approximate stationing labeled. Traveling from the beginning to end of the proposed alignment, these areas are named Valley Floor, Ravine, Terrace, and Final Cut. Notes and areas identified in our geologic mapping are shown on Plates 1 and 2.

2.2.1 Valley Floor Alignment Section (Sta 13+00 to 51+50)

This portion of the proposed alignment traverses the valley floor consisting of the Cedar Mesa Sandstone regionally striking N80°W/5°NE (strike/dip). The topography along the valley floor is generally flat to slightly sloping to the north. Ephemeral drainages are present throughout the area; no bodies of water or flowing drainages were observed at the time of the site reconnaissance. This segment of the project can be seen in Figure 4. Continuous regional joints within the Cedar Mesa Sandstone spaced 10 to 15 feet were measured striking N70°W and dipping near vertical. The

[3] Foos (1999), *Geology of the Colorado Plateau,* Geology Department, University of Akron, http://www.riversimulator.org/Resources/NPS/FoosPlateauGeology.pdf
[4] National Park Service (2019), The Colorado Plateau, https://www.nps.gov/articles/the-colorado-plateau.htm#:~:text=The%20Colorado%20Plateau%20is%20centered,%2C%20Colorado%2C%20and%20New%20Mexico.&text=Originally%20named%20by%20John%20Wesley,immense%20basin%20surrounded%20by%20highlands
[5] Willis (2012), Geologic Map of the Hite Crossing-Lower Dirty Devil River Area, Glen Canyon National Recreation Area, Garfield and San Juan Counties, scale 1:62,500

alignment passes through two relatively small sandstone ledges up to 10 feet tall. This portion of the ramp will be constructed on an embankment with fills ranging from 5 to 28 feet.

2.2.2 RAVINE ALIGNMENT SECTION (STA 51+50 TO 61+25)

This portion of the proposed project alignment descends a ravine and connects the valley floor to the southern terraces carved by the Colorado River. The ravine is characterized by near vertical

Figure 4: Ravine Alignment

Left: Ledges to road segment below; Right: Weathered and Fractured Area with Rockfall Potential

weathered ledges that vary from 10 to 30 feet tall connected by gently sloped areas incising into the Cedar Mesa Sandstone. Cross bedding is evident along the sandstone exposures with local bedding striking N58°E/6°SW. Continuous joints spaced approximately 10 to 20 feet apart in the bedrock were observed striking N56°W/62°NE, N64°W/80°NE, N68°W/90°, and N62°W/90°. Natural slopes of the Cedar Mesa Sandstone plunge as steep as 80 degrees as can be seen in Figure 5. Between Station 55+00 and 55+70 is a highly weathered and fractured portion of the Cedar Mesa Sandstone where displaced blocks are evident downslope (see photo on right in Figure 5). Between Stations 59+00 and 61+25 the proposed alignment crosses beneath a steep cliff where previous rockfall has occurred (see photo on left in Figure 5). Based on field observations and profile sheets this portion of the proposed alignment descends through areas where fills will vary from 0 to 30 feet in height.

2.2.3 TERRACE ALIGNMENT SECTION (STA 61+25 TO 76+82)

This portion of the proposed alignment traverses a series of relatively small, benched terraces adjacent to the Colorado River. The terraces consist of terrace deposits overlying the Cedar Mesa Sandstone. Vehicle pull-outs for staging and traffic will be constructed between Stations 63+00 and 66+00 and at Station 71+00. Cut and fills will vary up to 20 feet until about Station 66+25 when the ramp starts to descend towards the river at a 16 percent grade. Cuts through the terrace alignment section will reach depths of 150 feet along the centerline of the ramp.

Figure 5: Wood Debris (~el. 3,700 feet)

A predominant layer of wood debris likely deposited during the 1983 floods along the Colorado River was present along the uphill side of this section. The approximate elevation of this debris was 3,700 feet which coincides with the water level in Lake Powell downstream at 100 percent capacity. The approximate location of this layer of wood debris is shown on Plate 1.

The terrace deposits along the upper portion of this segment primarily consist of rounded cobbles and the downslope sections primarily consist of silty clay with isolated lenses of rounded cobbles. A continuous joint in Ceder Mesa Sandstone was measured striking N85°E/90°. Natural slopes of the Cedar Mesa Sandstone plunge as steep as 50 degrees.

2.2.4 FINAL CUT ALIGNMENT SEGMENT (STA 76+82 TO 79+66)

The Final Cut section of the alignment descends from the terrace deposits alignment section and exits into the Colorado River. The Final Cut section is characterized by the adjoining cliff to the Colorado

River exposing Cedar Mesa Sandstone. Conjugate jointing was observed and measured in this section, with one set of bedrock joints striking N80°E/82°SE, N85°E/90°, and N85°E/90°. The second set strikes N18°E/64°S, N23°E/64°S, and N5°E/58°S.

Conjugate jointing can result in wedge failures and displaced blocks where cuts are planned if the cuts coincide with the pairs of joints. Evidence of wedge and block failures that likely resulted from conjugate jointing within the Cedar Mesa Sandstone were observed in the area and are shown in Figure 7. This portion of the proposed alignment will involve cuts up to 160 feet in height as the final segment of the new launch ramp descends to the Colorado River.

Figure 6: Conjugate Jointing – Final Cut Alignment

3. Preliminary Geotechnical Considerations and Recommendations

A summary of preliminary geotechnical considerations for the project is provided below. The selected design-build contractor will be the engineer of record and will evaluate the findings and recommendations included in this report and perform their own geotechnical exploration and evaluation of the proposed project. The considerations and recommendations provided in this memorandum are intended to provide preliminary information to the design-build entity.

3.1 Cut Slopes

Cuts in soil overlying the Cedar Mesa Sandstone should be planned at 2h:1v (horizontal to vertical) or flatter to reduce the potential for erosion and slope instability. Cuts in the Cedar Mesa Sandstone could likely be planned steeper than 2h:1v. Near vertical cuts along roadways in the region in the same geologic unit were observed (see Figure 8). Rock cuts will expose bedrock that dips at approximately 5 degrees north-northeast. We did not observe conditions susceptible to failures along the predominant bedding. There is a potential for wedge failures near the end of the ramp in the

Final Cut alignment section (Sta 76+82 to 79+66). Differential erosion rates of rocks are predominant in the region. This can lead to undermining slopes which leads to increased rock fall potential. Cut slope underdrains may be needed that conform to Eastern Federal Lands (EFL) Standard Detail 605-03.

Subsurface exploration and geologic evaluation of the potential for wedge and block failures should be evaluated. The final inclination for cut slopes should be recommended in the design-level geotechnical report based on subsurface exploration, analyses and an evaluation of the specific slope conditions associated with the proposed project.

Figure 7: SR 95 Road Cut at Hite Crossing

3.2 Fill Slopes

Fill slopes should typically be graded to an inclination 2h:1v or flatter. Proper hillside grading procedures that include keyways and benches should be provided where fill slopes will be constructed on existing slopes steeper than 20 percent (5h:1v) similar to EFL Standard Detail E204-02[6]. Underdrains conforming to EFL Standard Detail 605-02 for keyways and benches should also be incorporated into grading design where fill is to be placed over existing drainages or in areas of seeps or groundwater. Fill slopes can be steepened by using internal geosynthetic reinforcements or retaining walls, if needed. The final inclination for graded slopes and use of keyways, benches, and need for subdrains should be recommended in the design-level geotechnical report based on an evaluation of the specific slope conditions associated with the site grading.

3.3 Erosion

Erosion due to wind and water has formed many of the incised gullies and canyons in the project region. Erosion on cut and fill slopes should be anticipated. Existing drainages and drainage patterns should be reviewed, and runoff collection systems designed to limit erosion of cut and fill slopes. Seasonal monsoons can impact cut and fill slopes. Rock slope protection, culverts and debris fencing should be considered to reduce the impact of flash flooding from monsoons on the proposed project.

[6] https://flh.fhwa.dot.gov/resources/standard/efl/ord.htm

Erosion of cut slopes will also result in deposition of material along the base of cuts. Catchment areas should be planned to collect eroded material for storage until removal can be arranged as part of a maintenance program.

Erosion of cut and fill slopes within the active water region of the Colorado River should be anticipated. As water levels rise and lower, the surface of the Cedar Mesa Sandstone and overburden soil become saturated and fail. Catchment areas and sufficient shoulders should be planned to accommodate intermittent erosion.

We did not observe spring activity during the site reconnaissance, but there is a potential for springs to be encountered during grading of the project as they can be common in rock joints. Springs and the need for drainage should be evaluated if they are encountered. Surface drainage, underdrains (EFL Standard Detail 605-03) or possibly horizontal drains may be needed to reduce hydrostatic pressure within the rock.

3.4 ROCKFALL

Evidence of rockfall from existing slopes was observed along the Ravine and portions of the Terrace Alignment of the project. The approximate location and evidence of rockfall are shown in plates 1 and 2. Mitigation of rockfall often involves the use of bolting, netting or some type of structure to restrain or capture rocks. It would be more advantageous to review the proposed alignment and possibly shift or widen the roadway to accommodate intermittent rockfall. This approach combined with scaling of hazardous blocks could be performed and would not result in visual impacts to the region like rock netting or shotcrete would. The design-build entity should further evaluate the potential for rockfall along the alignment and consider scaling and providing catchment and possibly a rockfall fence or a barrier along the toe of the slope adjacent to the road. Potential rockfall catchment areas may require maintenance in clearing of material.

3.5 EXCAVATION CHARACTERISTICS

The soil above the underlying bedrock is expected to be readily excavatable using conventional earthmoving equipment. Sand, clay and cobbles were observed along portions of the project alignment. The soil mantle thickness including the Terrace Deposits is estimated to range from 0 to 10 feet. For preliminary planning purposes 90 percent of excavations can be anticipated to be within Cedar Mesa Sandstone and 10 percent within soil. Rounded and subrounded cobbles ranging in size up to 1 foot in dimension are estimated to comprise 10 percent of the soil portion of the excavation. Excavating the underlying Cedar Mesa Sandstone will likely be challenging along most of the project alignment where encountered. Rock cuts along roadways in the region revealed evidence of drilling and blasting (portions of drill holes were visible on cuts along State Route 95 near the site). Visible exposures of the sandstone were moderately weathered and friable. Exposed surfaces indicate the material is moderately hard when impacted with a rock hammer.

Subsurface exploration and a rippability study should be performed to better understand the excavation characteristics and the need for blasting and/or equipment selection. Removal of hazardous rocks by scaling should also be anticipated in the project.

3.6 Trenching and Shoring

Excavations where soil is exposed over bedrock should be sloped or shored accordingly. Bedrock will likely be encountered in the upper 1 to 10 feet in excavations. It is anticipated that conventional sloping of trenches would be performed to accommodate excavations for utilities and storm drains. Shoring systems such as trench shields or slide rail shoring systems that provide positive support for excavated slopes are considered suitable to supporting excavations during construction. Competent personnel at the time of construction should review the excavations and augment sloping and shoring as needed.

3.7 Reuse of Site Soil and Rock

Excavated on-site soil and bedrock is not considered suitable for use as aggregate base, crushed aggregate, or aggregate for use in hot-mix asphalt or concrete. The material can likely be processed and used as a backfill material, select granular backfill, select borrow, or unclassified borrow. Processing, crushing and removal of oversize blocks should be anticipated to reuse the material for these purposes.

4. Recommended Additional Work, Field Exploration, Testing, and Analyses

Additional geotechnical evaluation and exploration is recommended. The design-build entity should consider the following to refine and better understand the subsurface conditions along the proposed project alignment:

- Excavation of test pits to better understand the variable thickness of soil overlying the bedrock and the excavation characteristics of the different materials.

- At a minimum, exploratory drilling should be performed where rock cuts are planned. Sampling and testing of collected cores to evaluate rock mass characteristics, weathering, strength and hardness. Oriented coring could also be used to evaluate jointing and bedding. Consider installing one or two groundwater monitoring wells where excavations will be near the river to characterize groundwater in the proposed cut at the river's edge.

- Kinematic and slope stability analyses of slopes that will be cut steeper than 1v:2h. Seepage analyses should be performed where cut and fill slopes will be inundated from flooding in the river.

- Geophysical survey to evaluate the subsurface stratigraphy and rippability of the underlying material.

- Material source evaluation for aggregate, hot-mix asphalt, concrete and other construction materials needed for the project.

5. LIMITATIONS

This study has been conducted in general accordance with currently accepted geotechnical practices in this area for use by the client for preliminary design and conceptual planning purposes. The conclusions and recommendations submitted in this memorandum are based upon the data obtained from field reconnaissance and our understanding of the proposed project and type of construction. If there are any changes in the project or site conditions, Yeh should review those changes and provide additional recommendations, if needed. Any modifications to the recommendations of this report or approval of changes made to the project should not be considered valid unless they are made in writing. The report and drawings contained in this report are intended for conceptual design purposes; and are not intended to act as construction drawings or specifications.

We trust this memorandum meets your needs at this time. Please contact Judd King at 805-801-6416 or jking@yeh-eng.com if you have questions or require additional information.

COLORADO RIVER

DESIGN WATER LEVEL +3596 FT

HITE CROSSING

POTENTIAL AREA OF WEDGE FAILURES

AREA OF WEDGE FAILURES

79+66

75+00

70+00

65+00

61+25

60+00

59+00

55+70

55+00

51+50

50+00

45+00

40+00

SURFACE TERRACE DEPOSITS - SILTY CLAY WITH ISOLATED LENSES OF ROUNDED COBBLES

SURFACE TERRACE DEPOSITS - ROUNDED COBBLES

WOOD DEBRIS FROM 1983 FLOOD

UNNAMED DRAINAGE

Af

SR 95

POTENTIAL ROCKFALL HAZARD

WEATHERED/FRACTURED ROCK

RAMP ROAD CONTINUES TO HITE MARINA ACCESS ROAD

Pcm

Pcm

6 58 82 64 64

50

62 80

6 60 47

5

North

0 250 feet

LEGEND:

- Strike and dip of joint
- Vertically dipped joint
- Strike and dip of Bedding Plane
- Direction of Natural Slopes Plunging X Degrees
- Valley Floor Alignment
- Ravine Alignment
- Terrace Alignment
- Final Cut Alignment
- Area of Potential Geologic Hazard
- Surface Terrace Deposits - Silty Clay with Isolated Lenses of Rounded Cobbles
- Surface Terrace Deposits - Rounded Cobbles
- Af - Artificial Fill
- Pcm - Cedar Mesa Sandstone

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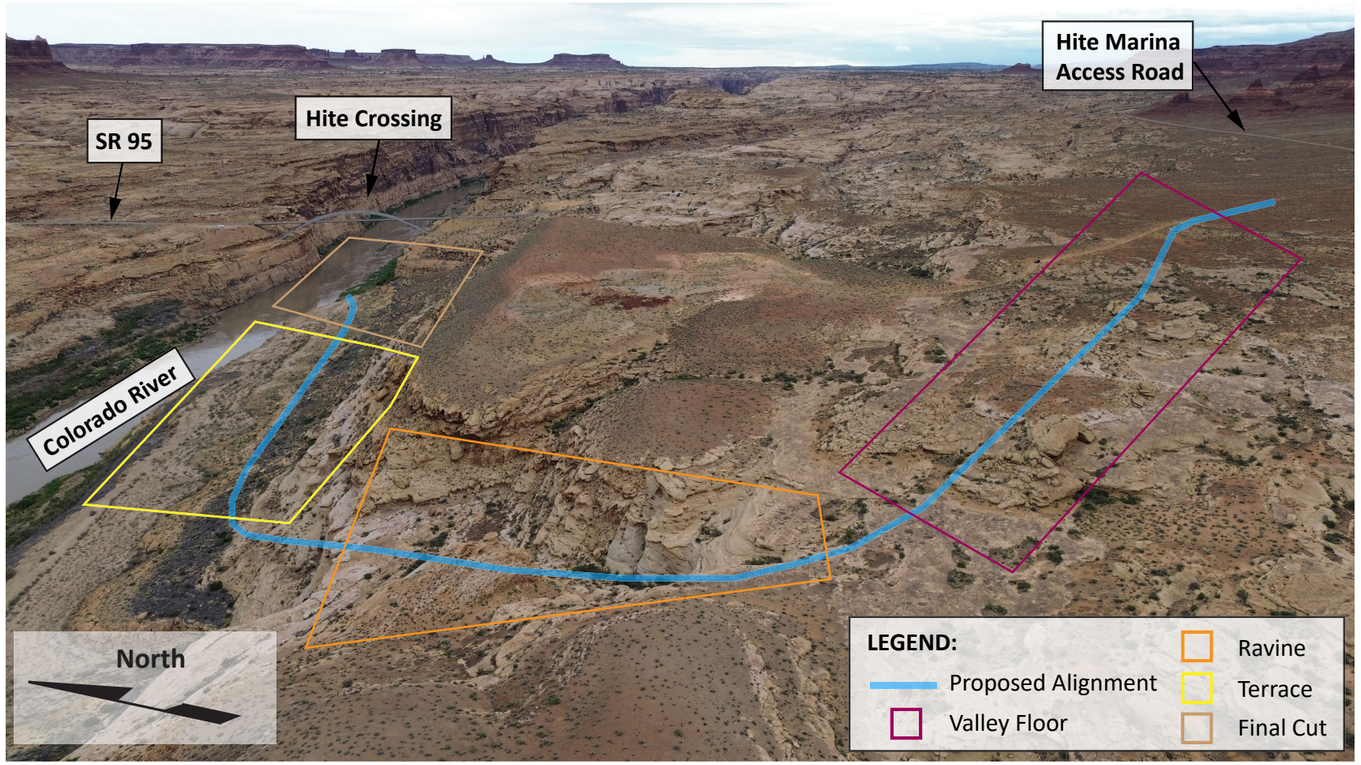
SITE GEOLOGIC MAP

PROJECT NAME:		PLATE
GLCA HITE BOAT RAMP Hite, Utah		1
PROJECT NUMBER: 223-430	REVISION DATE: 3/31/2025	

Proposed Ramp Alignment



Sandstone Ledge on Valley Floor

Note Circled Person for Scale.

Weathered and Fractured Rock

Adverse Jointing/Wedge Failures at Final Cut

Note Circled Person for Scale.

Terrace Conditions

Ledge Area off Ravine

Note: Outline color of pictures corresponds with outlined section in Proposed Ramp Alignment photo.

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SITE PHOTOS

PROJECT NAME:	PLATE
GLCA HITE BOAT RAMP Hite, Utah	2
PROJECT NUMBER: 223-430	**REVISION DATE:** 5/31/2024