TSEGI WASH - 50% DESIGN REPORT

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Table of Contents

Acknowledgements

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1.0 Project Description

1.1 Purpose

The purpose of this project is to determine the feasibility of a stabilization method to minimize soil erosion and stream scour of a channel headcut. A headcut is an abrupt vertical drop in the channel, resembling a waterfall. The following image is a visual representation of what's occurring at the site.

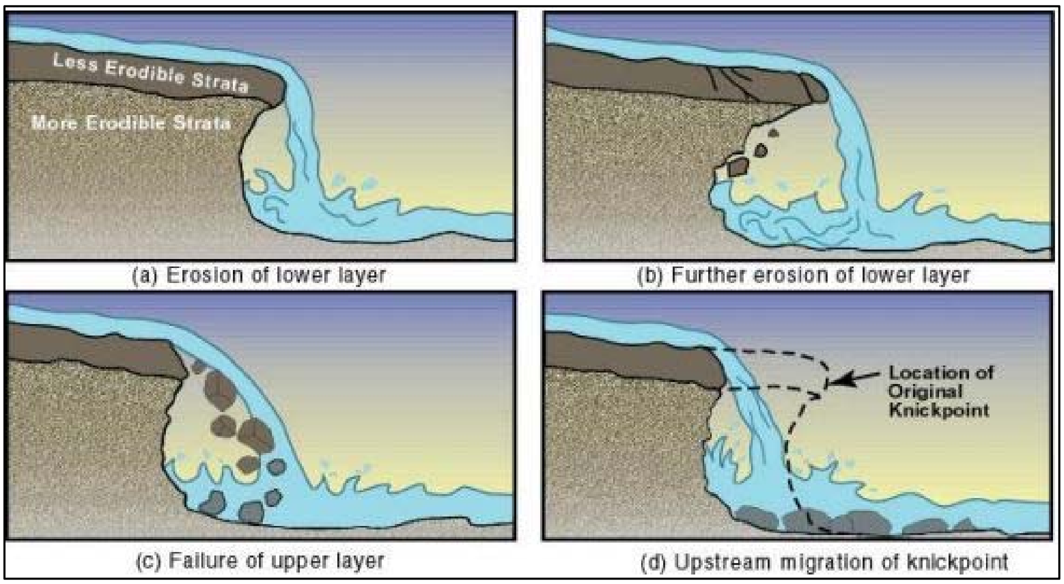

Figure 1. Erosion of a Headcut (Iowa DOT)

As seen in the figure above, during the rainy season when water is a plunge pool is formed at the bottom of the headcut, eroding the bottom layer causing the top layer to fail. As a result, the headcut continues to migrate upstream.

The existing site consists of a 23-foot high by 40 foot wide headcut, composed of sandstone. The site location is 36°40'04.4"N 110°48'52.2"W. The stabilization alternative chosen will act as a conceptual design and will not result in construction plans.

1.2 Project Understanding

Tsegi Wash is located in Nitsin Canyon, west of the Navajo National Monument. Navajo National Monument is divided into three units, the designated unit for this project will be the Inscription House unit, which is comprised of 40 acres. Inscription House has been closed to the public since 1968 to preserve the site. About 50 years ago the canyon consisted of farmland and housing structures, but around 40 years ago the headcut began spreading along the canyon reducing the available farmland. The current land user inside the canyon owns the cattle contributing to the soil erosion problem due to their grazing. As the cattle graze they uproot the grass, removing one of the sources of stabilization for the canyon.

The lack of soil stability near the site may be due to the cattle grazing and lowering of the water table. The vegetation at the site includes cottonwood trees, willows, and shrubbery. The bed material at the headcut is composed of a sandy soil. Currently, the only source of stabilization at the headcut comes from the roots of the nearby cottonwood tree. The headcut is located a quarter mile upstream from the point water source at the canyon. The canyon drains 30 miles downstream into Lake Powell. Below is an aerial view of the canyon where the site is located and a closer overhead view of the headcut.

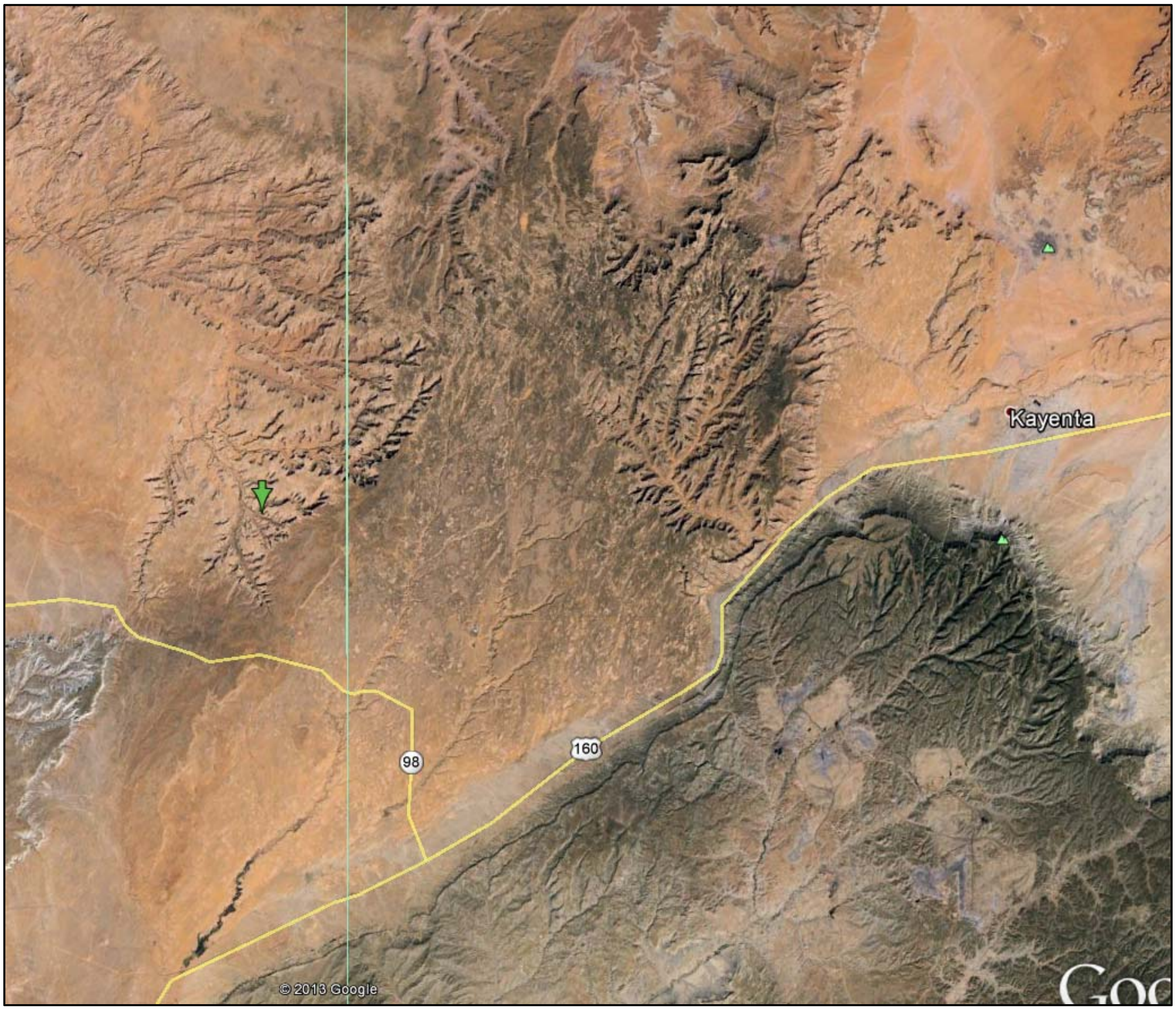

Figure 2. Aerial View of Nitsin Canyon (Google Earth)

As seen in Figure 2, the site location in indicated by the arrow, west of Kayenta.

Figure 3. Site Location (Google Maps)
The image in Figure 3 presents a close up view of the headcut located beneath the tree denoted by the arrow.

2.0 Design Alternatives

The following section details the three types of design alternatives best suited for the project.

2.1 Live Vegetation

Live vegetation is the process of planting suitable vegetation along the shorelines of a channel to prevent erosion. The plant roots provide a base of stabilization for the soil. Plants that haven't established deep roots can be washed away during high velocity flows. Possible native plants of consideration for the project are: russian olives, cottonwood, and/or willow trees.

2.2 Bioengineering

Bioengineering is the combined use of live vegetation with structural materials to provide stream bank stabilization and erosion control. The practice applies engineering techniques while maintaining the natural environment around the project site. An example of bioengineering would be a geotextile system that combines layers of encased vegetation to create successive layers to reduce flow.

2.3 Hard Armoring

Hard armoring is the technical placement of various sized rocks along a channel slope or streamline, reducing the flow energy of the stream and stabilizing the headcut. An example of hard armoring is a rock chute spillway that prevents erosion at the lower layer of the headcut, as can be seen in the image below.

Figure 4. Rock Chute Spillway (Agriculture Canada)

3.0 Testing/Analysis

3.1 Manning's Coefficient

After assessing the bed material of the channel during the site visit a Manning's Coefficient of 0.0235 was selected using the table below.

Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035

Table 1. Manning's Coefficient (Engineering Toolbox)

The final factor was determined by averaging coefficients for “Earth channel – clean” and “Earth channel – gravelly” as the reach mainly consists of sandy soil with intermittent rocks spaced throughout. The image on the following page shows the composition of the channel bed material at the time of the site visit.

Figure 5. Bed Material (Tsegi Wash Group)

As seen in the figure above, the channel composition is mostly soil with tree litter and relatively little shrubbery is present.

3.2 Watershed Delineation

A watershed delineation of the site was performed using United States Geological Survey (USGS) StreamStats program. USGS StreamStats for Arizona was developed by the U.S. Dept. of the Interior, Bureau of Reclamation, Navajo County, U.S. Forest Service and various other reputable government entities, it is widely used by engineers to map floodplains and aid in the design of bridges and culverts. The basic concept of watershed delineation is to start at a point source, which for this project was the location of the headcut. Then from each side of the stream a line is formed working its way to the highest point in the area by crossing contour lines perpendicularly until both lines connect forming the area. Figure 6 on the following page displays the final delineation.

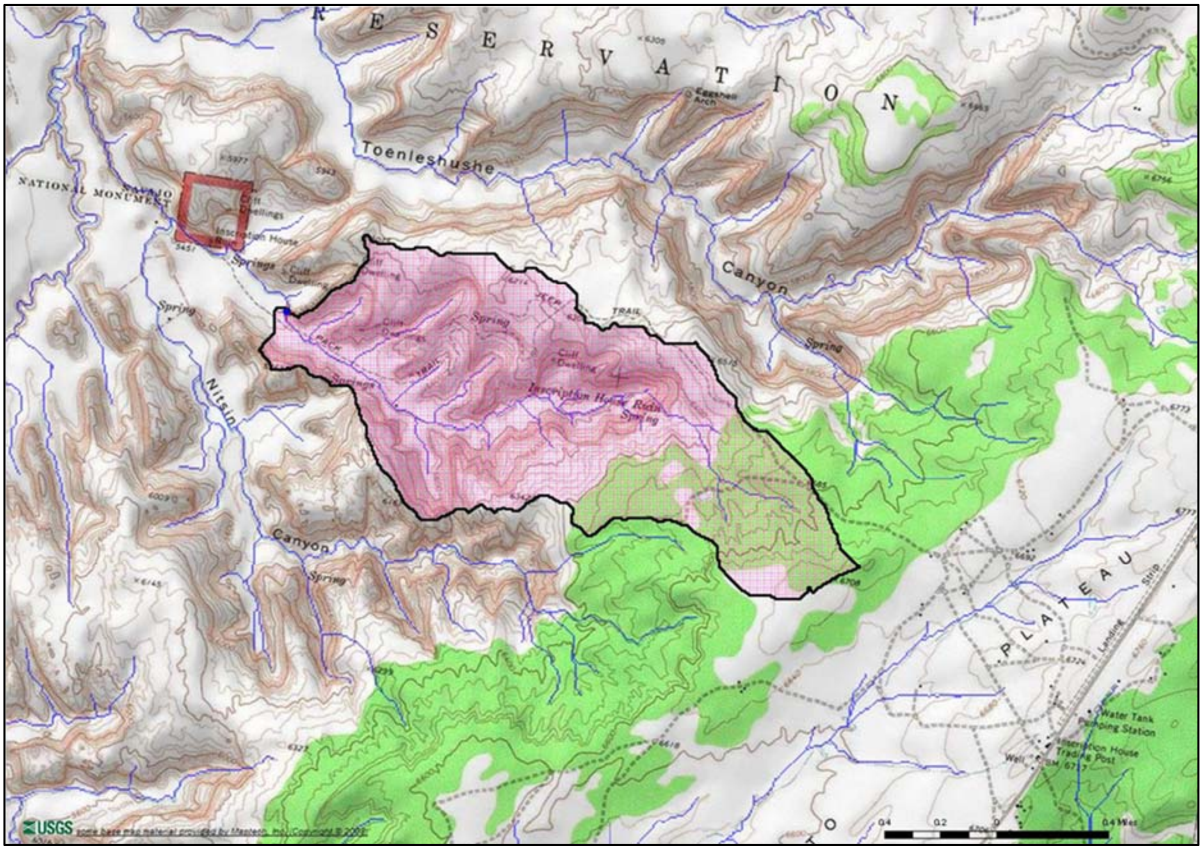

Figure 6. Watershed Delineation (USGS StreamStats)
The area outlined in black is the delineated watershed. The watershed was delineated from the point source located at the headcut, in the image above. The final watershed encompasses 1.32 square miles with an average basin elevation of 6080 ft.

3.3 Survey Data

The raw survey data was taken from the survey of the headcut during the second site visit. The headcut was surveyed using a total station in which 207 points were collected and uploaded as a Comma Separated Value(CSV) file into excel containing the point, northing, easting, and elevation data, which can be seen in Appendix B.

3.4 AutoCAD

Using the CSV file with all the survey data, the points were inserted into AutoCAD and a topographic map of the area was created, which can be seen in Appendix C. An alignment was drawn along the channel and cross sections were created. The cross sections can be viewed in Appendix C. A channel profile was also formed and is attached in Appendix D. An excel spreadsheet containing the station, elevation, and distance to the right and left bank for each cross section was created to be inputted into the HEC-RAS software, which can be seen in Appendix E .

3.5 Flow

The flow of the channel was obtained using National Streamflow Statistics (NSS). The region where the headcut is located was selected and the watershed area and average elevation were entered into the program. The headcut is located in Four Corners Region 8, which was determined from the hydrologic flood regions for Arizona map. The watershed area of 1.32 square miles and mean elevation of 6,080 feet were obtained from the basin characteristics determined in USGS StreamStats. Flow results can be seen in the image below.

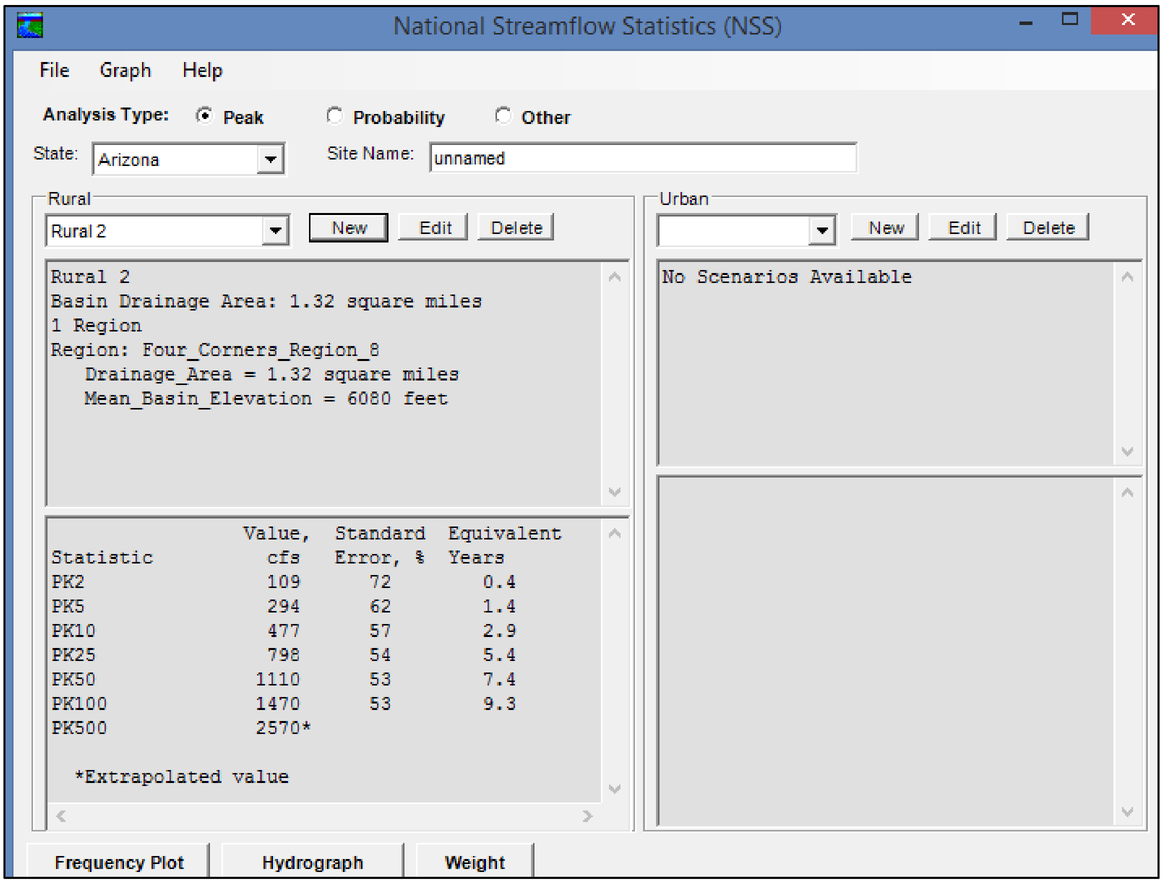

Figure 7. NSS Results (NSS)

As seen in figure 7, the results for 10, 25, and 100-year flood flow were 477 cubic feet per second (cfs), 798 cfs, and 1470 cfs. Flow results were verified using regression equations for Arizona created by the USGS, as seen on the next page.

Regression equation	Average standard error of prediction, in percent	Equivalent years of record
Region 8 -108 stations		
$Q_2 = 598AREA^{0.501}(ELEV/1{,}000)^{-1.02}$	72	0.37
$Q_5 = 2{,}620AREA^{0.449}(ELEV/1{,}000)^{-1.28}$	62	1.35
$Q_{10} = 5{,}310AREA^{0.425}(ELEV/1{,}000)^{-1.40}$	57	2.88
$Q_{25} = 10{,}500AREA^{0.403}(ELEV/1{,}000)^{-1.49}$	54	5.45
$Q_{50} = 16{,}000AREA^{0.390}(ELEV/1{,}000)^{-1.54}$	53	7.45
$Q_{100} = 23{,}300AREA^{0.377}(ELEV/1{,}000)^{-1.59}$	53	9.28

Figure 8. USGS Arizona Regression Equations (USGS Nation Flood Frequency Program)

The standard error for the 10, 25 and 100-year flood flows is 57, 54 and 53 percent, respectively.

3.6 HEC-RAS

An analysis of the current conditions of the channel was run using the HEC-RAS program for a 10, 25, and 100- year flood flow. A reach was traced using the data from AutoCAD. The reach totaled in length 544 ft. 21 cross sections were created along the reach beginning upstream with intervals of 50ft. As the cross sections neared the headcut intervals decreased to 25, 15, 10, and 5 feet both above and below the headcut to obtain a comprehensive analysis of energy change at the headcut. Below is an image taken from HEC-RAS of the complete reach and cross sections.

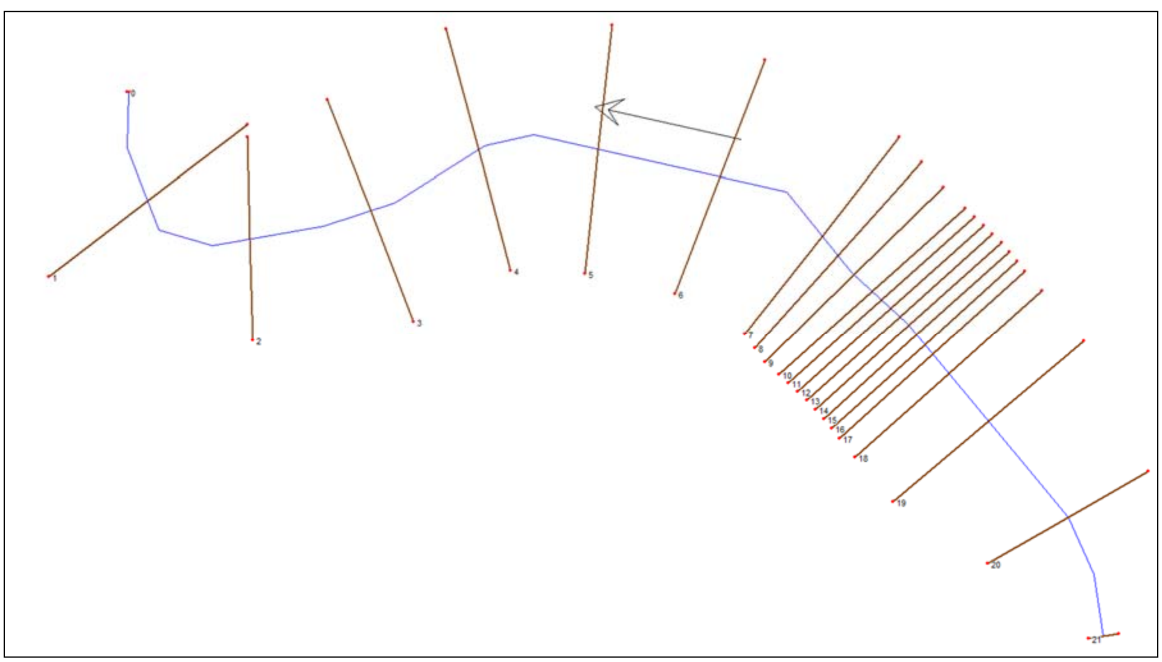

Figure 9. HEC-RAS Reach and Cross Sections (HEC-RAS)

As seen on Figure 9, all 21 cross sections have been created in HEC-RAS, using the dimensions created from the profile view in AutoCAD.

4.0 Identification of Selected Design

5.0 Final Design

6.0 Cost

7.0 Summary of Project Costs

Appendices

Appendix A - Gantt Chart
Appendix B - CSV Point File
Appendix C - AutoCAD Topographic map
Appendix D - AutoCAD Profile View
Appendix E - Cross Section Data