Erosion Control Project at Palisades Delta along the Colorado River Corridor Grand Canyon National Park

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Introduction

Cultural materials located on the Colorado River Corridor deltas below Glen Canyon Dam have existed for thousands of years. Prior to the dam, natural flooding either buried these materials, or washed them downstream. Now, due to the existence of the dam, large sediment-laden floods no longer occur, and the natural process of sediment deposition is disrupted. The rate of erosion has increased, and as a result, these archaeologically rich deltas are being methodically stripped of cultural deposits.

As part of the Long-Term Monitoring and Remedial Action Plan, signatories to the Programmatic Agreement (PA) planned a work trip for September 1995, solely dedicated to implementing remedial actions that would slow down erosional processes at unstable sites. When sites were prioritized based on the severity of deterioration, the most extensive erosion was observed at Palisades delta. The signatories were involved in three years of discussions, a four day stabilization workshop at Lee's Ferry, and several visits to Palisades, in order to develop a team approach that would decrease site impact.

The objective of the September trip (95-6) was to implement erosion control techniques at Palisades that would slow down erosion. These methods would include employing traditional Zuni erosion control practices, using the natural resources from the area, and accomplishing our objectives without inundating any surface or subsurface cultural features.

Geomorphic Background of Palisades

Understanding the geomorphic processes which shape the surface of Grand Canyon is integral to understanding the archaeological record. The forces of wind and water, in combination with gravity and time, have sculpted a landscape which is constantly changing. This change is generally imperceptibly slow but occasionally cataclysmic in the case of debris flows and flash floods.

Interspersed within the uppermost levels of the geomorphic record are the fragile and easily eroded remains of the human history in Grand Canyon. At Palisades the cultural materials are at risk of being completely lost. In order to better determine the proper methods for managing this heritage, a basic picture of the local geomorphology must be addressed.

Structurally, the main drainage (Palisades Creek) is determined by the Palisades Fault. This system is Precambrian in age with a second period of activity during the Laramide orogeny. Over 2,400 feet of displacement can be measured along this section of the fault. It is down this large, structurally-determined side canyon that the debris flows of varying intensity surge to produce the landscape seen in the project area. Throughout the river corridor it is these side canyon debris flows that determine the location and to some degree the intensity of the rapids. It is also the debris flows which create the large, fan-shaped deltas wherever a large secondary canyon intersects with the Colorado River.

Richard Hereford of the USGS, along with other researchers (Hereford et al. 1993), has studied this phenomenon in detail determining frequency and magnitude for several debris flow events including Palisades. Included in this study is a detailed look at the alluvial sequence of terrace and dune forming events which determine even further the configuration of the modern landscape along the river corridor. At Palisades the bulk of this story has been removed and the cultural materials are essentially left exposed without benefit of a protective covering of river-deposited sediment. The isolated remnants of alluvium which remain in the immediate area are being continuously incised and removed by locally intense erosion.

The drainages present are defined as either river- or terrace-based. River-based drainages deposit their load directly into the Colorado River, whereas terrace-based channels die out in dunes or areas of dense vegetation before reaching the river. Due to the increased lowering of base levels in the main river and the lack of natural replacement of sand on a yearly basis, drainages currently reaching the river must steepen their grade thus increasing their erosive potential. Oftentimes this has repercussions to archaeological sites which tend to be located in or on top of alluvial deposits. As the drainages cut their way to the river the cultural history of the Grand Canyon is often carried along.

There are three river-based streams of concern at Palisades. These streams, referred to as RB1, RB2 and RB3, intersect two sites, C:13:099 and C:13:100. RB1 has seven known features that are either adjacent to or in the drainage. RB2 has two known features in the drainage, and RB3, which connects to RB2, contains three features. These drainages were the focal areas of erosion control, while several active tributaries to these streams were also used for opportune sediment catchment locations. See Figure 1 for site locations and the drainage systems where remedial action occurred.

Personnel

Key players included a Zuni conservation team, the National Park Service (NPS) and the Bureau of Reclamation (BOR). Programmatic Agreement representatives came from the State Historic Preservation Office (SHPO), Hopi Tribe, Hualapai Tribe, and Navajo Nation. Other participants were from the United States Geological Survey (USGS), Northern Arizona University (NAU) and the National Forest Service (NFS). In total, 28 people were directly involved with the "hands on" erosion control project. Representatives from these

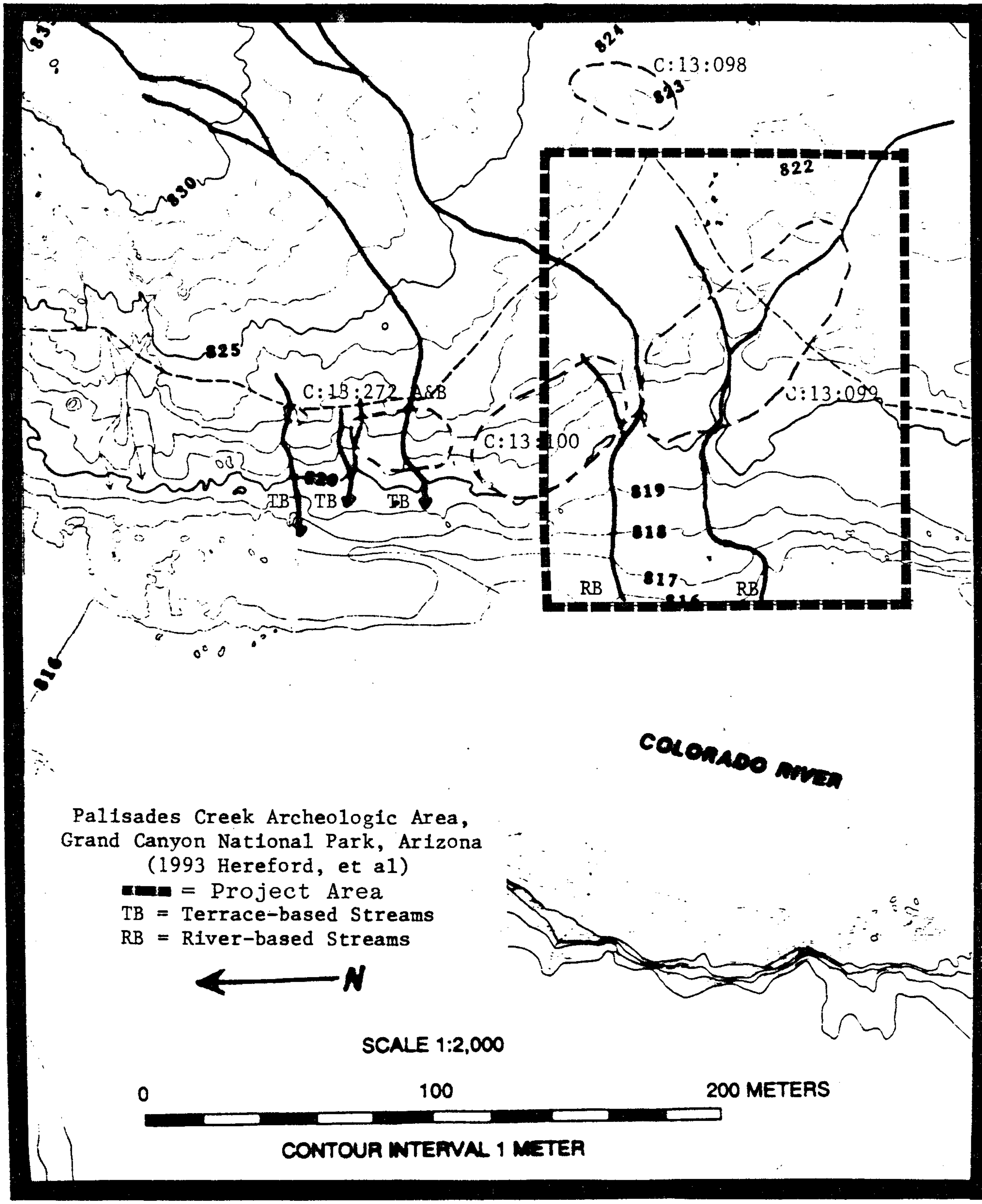


Figure 1. Locational map of C:13:099 and C:13:100 and the river-based streams where erosion control was implemented.

agencies were included because this project set the precedent for the type of site preservation methods that may be proposed for other areas. See Appendix A for the personnel list.

Methods and Results

The basic goal of the project was to capture sediment from the runoff that came from the river-based drainages. The idea was not to stop erosion but to decrease water velocity, increase sediment deposition, thus slowing the erosive process down. A sediment catchment system would theoretically lessen the erosion of exposed features and preserve the features and materials still in the subsurface.

Construction of various catchment systems was led by a Zuni soil conservation team. Initially, the Zuni and NPS specialists and archaeologists would walk through a river-based stream and discuss where and what type of catchment system should be built. After each discussion the location was flagged and numbered, and a photograph was taken. Descriptions of what style to construct and the materials needed were also written on the flagging tape and in a notebook.

During check assessments, newly exposed items were observed. At site C:13:099 two projectile points were found and a new charcoal lens was exposed. All features were sketched and described. Site C:13:100 had a ninth feature exposed. The new feature is a rock alignment constructed of Dox sandstone located in RB3. This feature was also properly documented.

Materials gathered for construction included: wet and dry camel thorn (<u>Alhagi camelorum</u>), wet and dry arrowweed (<u>Tessaria sericea</u>), low brush, and driftwood logs and branches. The several tons of rock manuported included: river cobbles and boulders, debris-flow limestone and sandstone cobbles and boulders, and Cardenas lava cobbles. All rocks were carried by buckets or rock litters. Care was taken not to denude an entire area of its protective rock cover.

<u>Checkdam Styles</u>

The standard sediment catchment construction utilized was surface checks. Simply stated this means checks built on the surface. Five types were built. The majority were rock and log checks. At times, a long driftwood log and rock were used to act as a retaining wall to avoid further undercutting of a bank. The height, length and width varied slightly, depending on the attributes of the arroyo.

The procedures to build a log or rock check begins with laying an initial thick bed of brush on the arroyo floor followed by placing two rows of large boulders (or a log) in the center of the brush, perpendicular to the walls. Thirdly, medium to small cobbles were placed on either side of the center of the check, inserting each rock to fit like a puzzle. This is called "rock rubbling". Finally, a steep grade of ramped rock is built on the upstream side and a gradual grade is built on the downstream side. As a standard procedure, larger rocks are placed on the bottom and smaller rocks on top. (When checks were constructed off the sites and logs were used, a shovel full of the arroyo's side wall was taken out to place the ends of the log in the walls for more support.) See Figures 2 and 3 for a photograph and cross-section of a rock and log check.

A third check construction (rock fill) involved lining the arroyo floor with several large boulders, cobbles, brush and logs. This structure was built in the arroyo section nearest to the river. See Figure 4 for a photograph of a rock lining in RB1, site C:13:099, that was approximately 10 m long.

A fourth style of dam was constructed similar to a log or rock check, yet, the only difference was that the planview is in the shape of a horseshoe. This "horseshoe" check was fabricated in sections where the arroyos were wide and shallow. See Figure 5 for the planview and photograph of a "horseshoe" check.

The fifth checkdam style is called a "basket weave" check. This is a very different structure, and was built in deep, narrow sections of the arroyo. The "basket" check was constructed of driftwood branches, brush, arrowweed and rock. The driftwood branches were cut and shaped to about 1 m in height and were placed upright in the arroyo, approximately .30 m apart, to form the outline of a rectangle. An abundance of brush was placed on the arroyo's floor between the posts. Arrowweed was then forced into the arroyo side wall and woven in basket like fashion through the driftwood posts. This process was repeated until a rectangular-shaped box of driftwood posts and arrowweed was created. Small to large rocks were selectively placed inside the "basket" for additional support. A steep grade of large to small cobbles were placed on the outside and upstream side of the dam, and a more gradual rock grade was built on the outside and downstream side of the dam. See Figure 6. for a front view of the weave, and a sketch and photograph of the final product.

Rock Check Cross-section

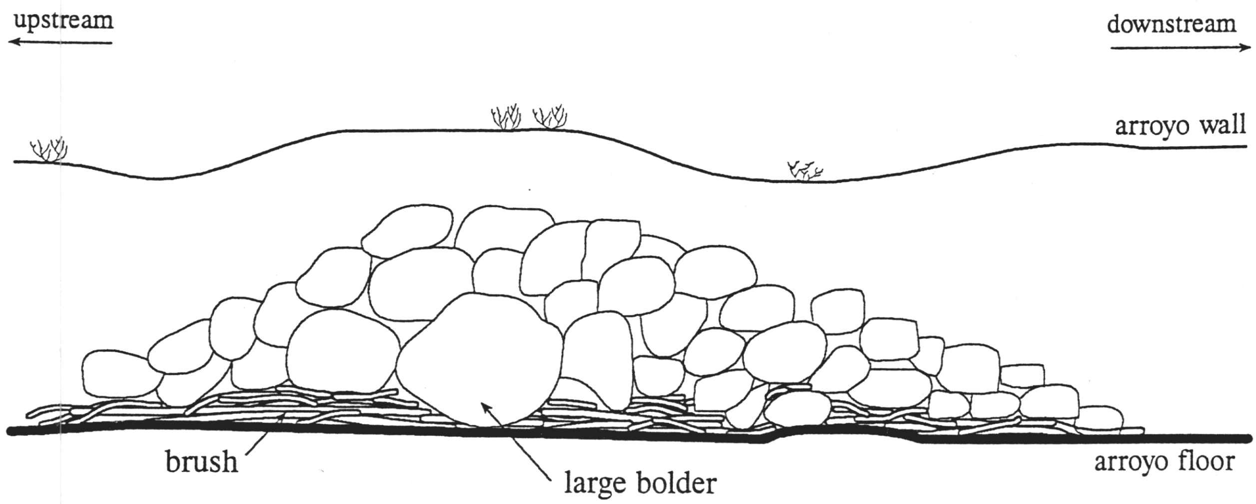
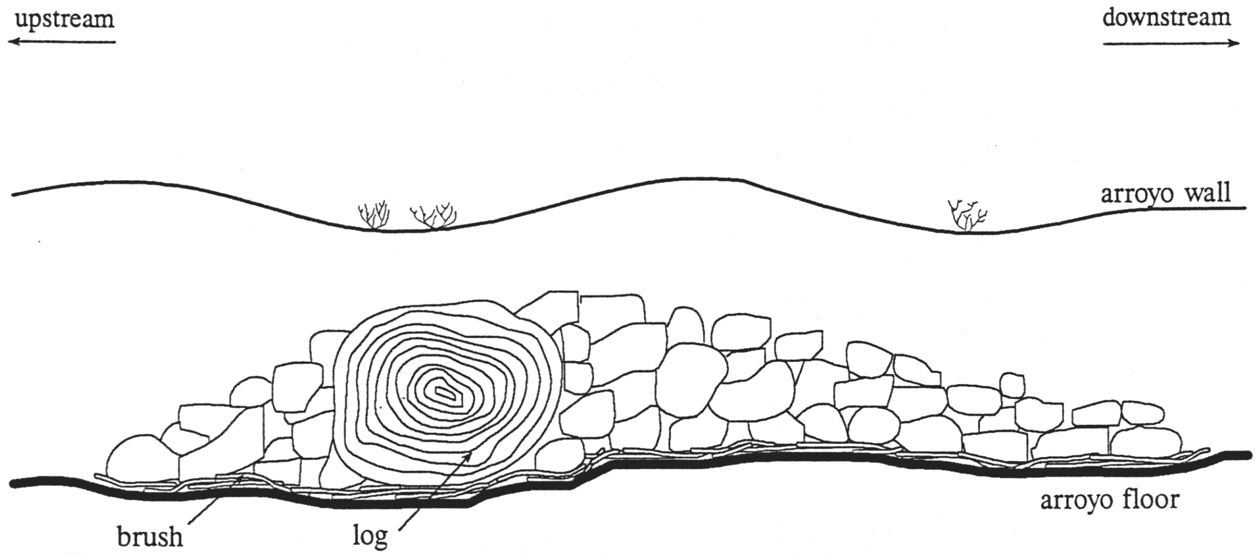


Figure 2. Cross-section and photograph of a rock check.

Log Check Cross-section



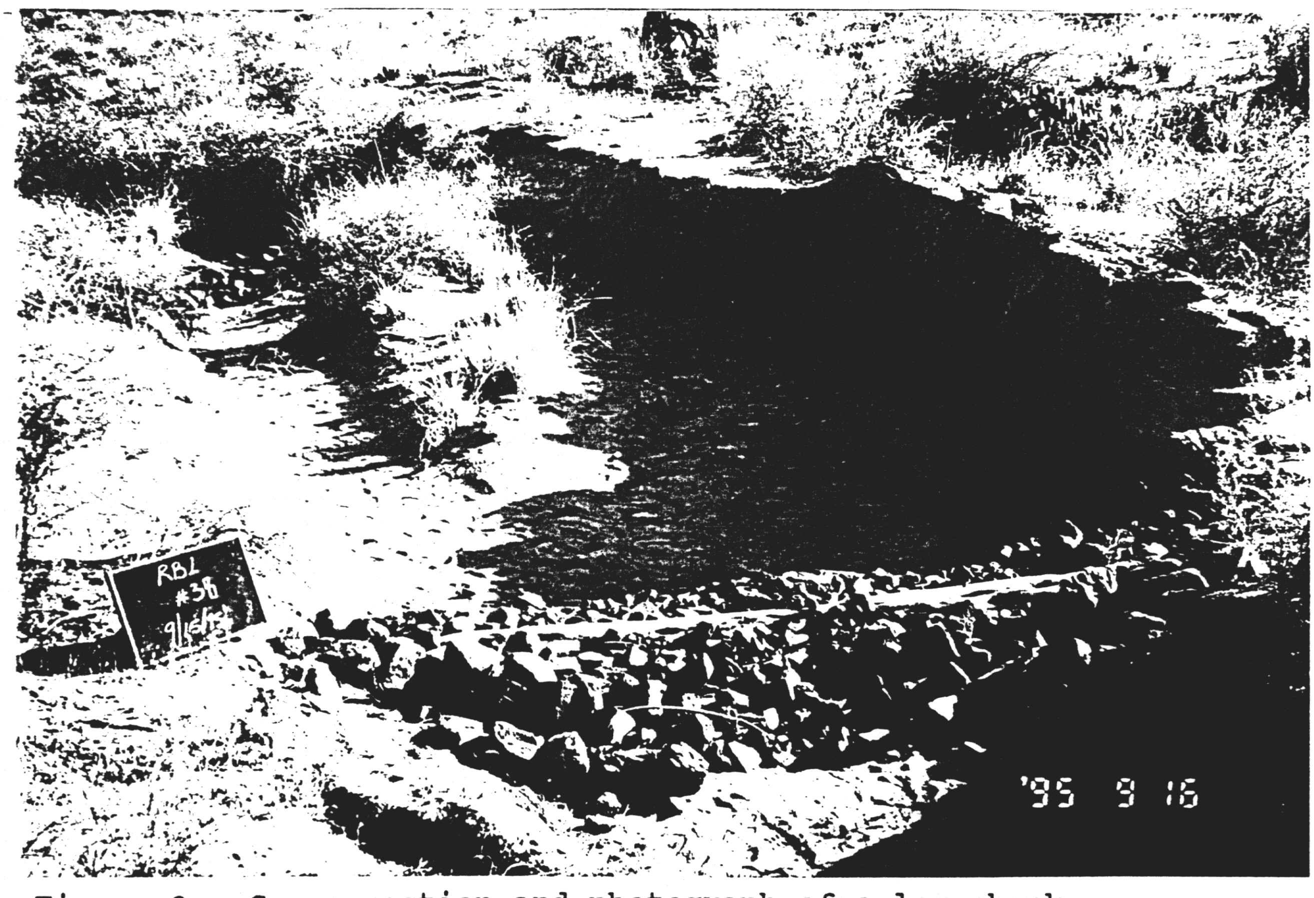
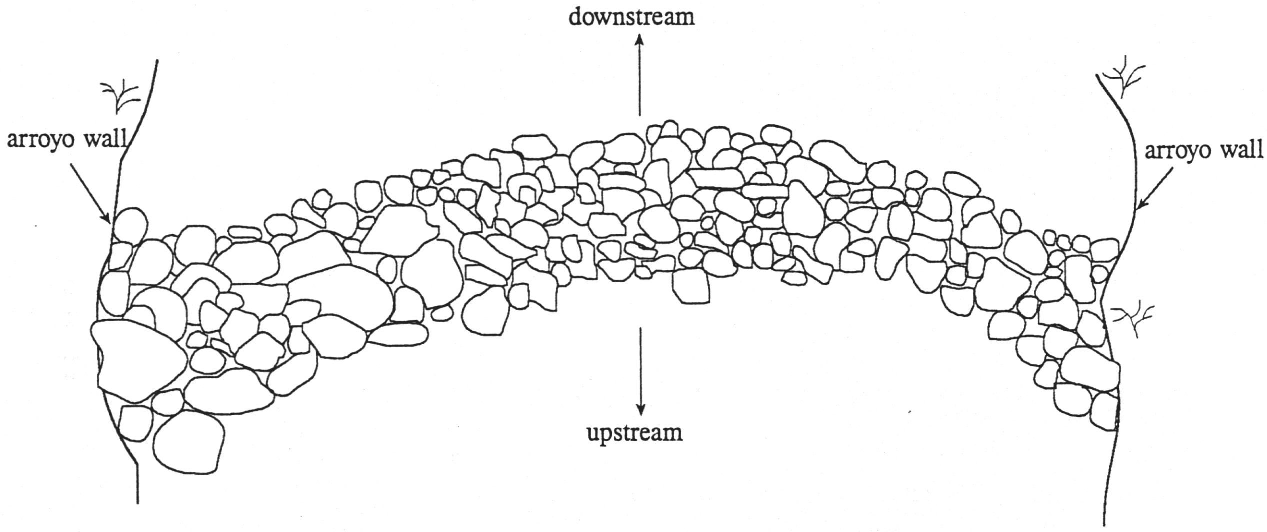


Figure 3. Cross-section and photograph of a log check.

Figure 4. Photograph of lining an arroyo with cobbles, boulders and brush (rock fill).

"Horseshoe" Check Plan View



The cross-section is the same as a rock check.
Brush was always placed on the arroyo floor.

Figure 5. Planview and photograph of a "horseshoe" check.

Results

The final outcome of this labor intensive work produced 70 checkdams: 44 in RB1, 24 in RB2 and two in RB3. The estimated total weight for the 70 checks was 102.4 tons. This estimate was derived by using a simple equation and the specific density of sandstone (2.3 UNIT) and basalt (3.0 UNIT) and up. Although basaltic rock was used in construction, it was not used to determine weight as to avoid a false high. Units were converted to the English system in order to arrive at a total figure in tons. The volume of each check was determined in cubic feet and multiplied by 145 (the weight in pounds of a cubic foot of sandstone). The individual weights were tallied and a sum figure was established. Twenty percent (20%) of the total was subtracted to account for interstitial space and volume displaced by logs and brush. In doing so we feel confident that the total estimated weight is not an inflated figure. See Appendix B for the individual descriptions and locations of the 70 checks.

Documentation

Photography

Photographic documentation for the project was accomplished through the use of an 8 mm video camera, Pentax 105R 35 mm cameras and a 6 x 7 cm Pentax medium format camera. The original video taken was an hour and a half in length, from which two shorter edited versions will be used for future presentations. The video recorded several aspects of the project including the construction of the dams and the discussions held prior to check placement.

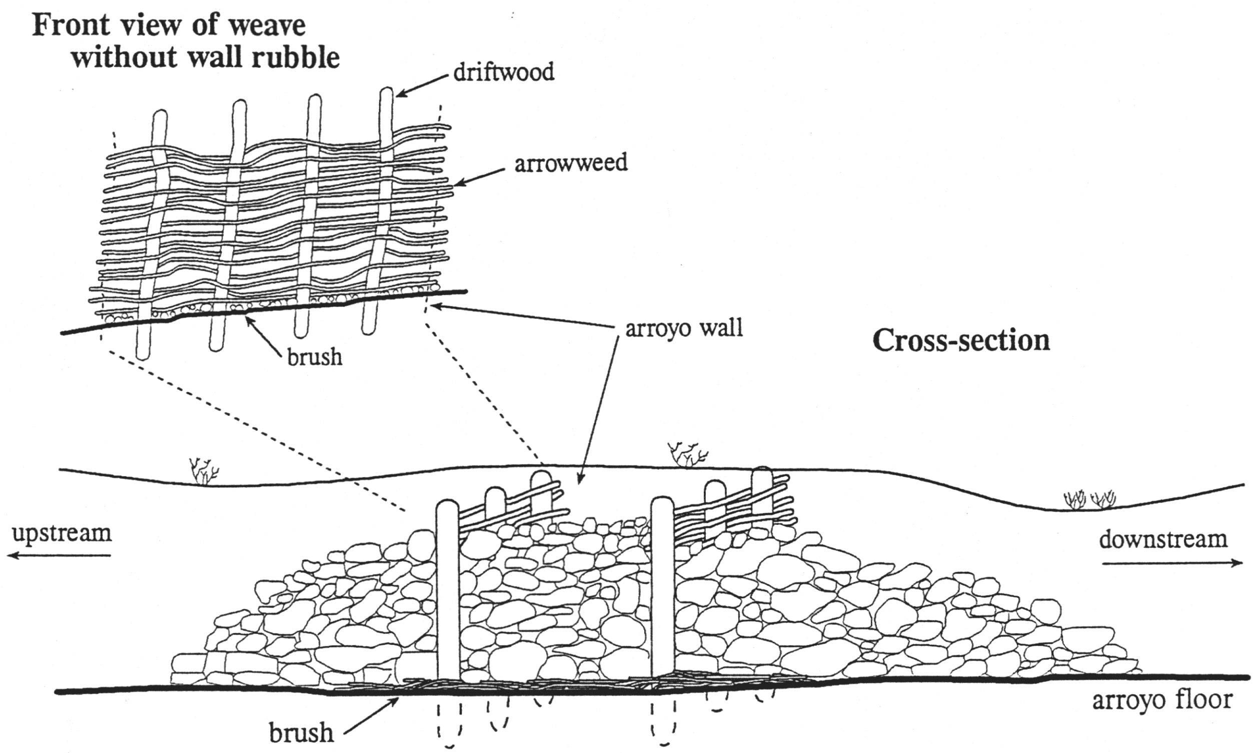
The 35 mm cameras used Kodak Plus-X Pan 125-36 exp black and white prints, and Kodachrome 64-36 exp and 200-36 exp color slide film. Kodak 5-txp 120 black and white film was used in the 6 x 7 cm Pentax. Other documentation materials included photo boards, a tripod, and compass. One hundred and fifty black and white images, approximately 200 color slides, and 110 medium format black and white prints were produced. The photographs reflect checkdam locations, before and after, and other detailed and general events that occurred.

Mapping Checkdam Locations

Each checkdam was plotted on a 1:2,000 scale topographic map generated by USGS geomorphologist, Richard Hereford. The plots were digitized in the office for archival and field use.

The GeoExplorer locational unit was also used to point provenience all checkdams. It took approximately 2-3 minutes to receive 20

"Basket Weave" Check



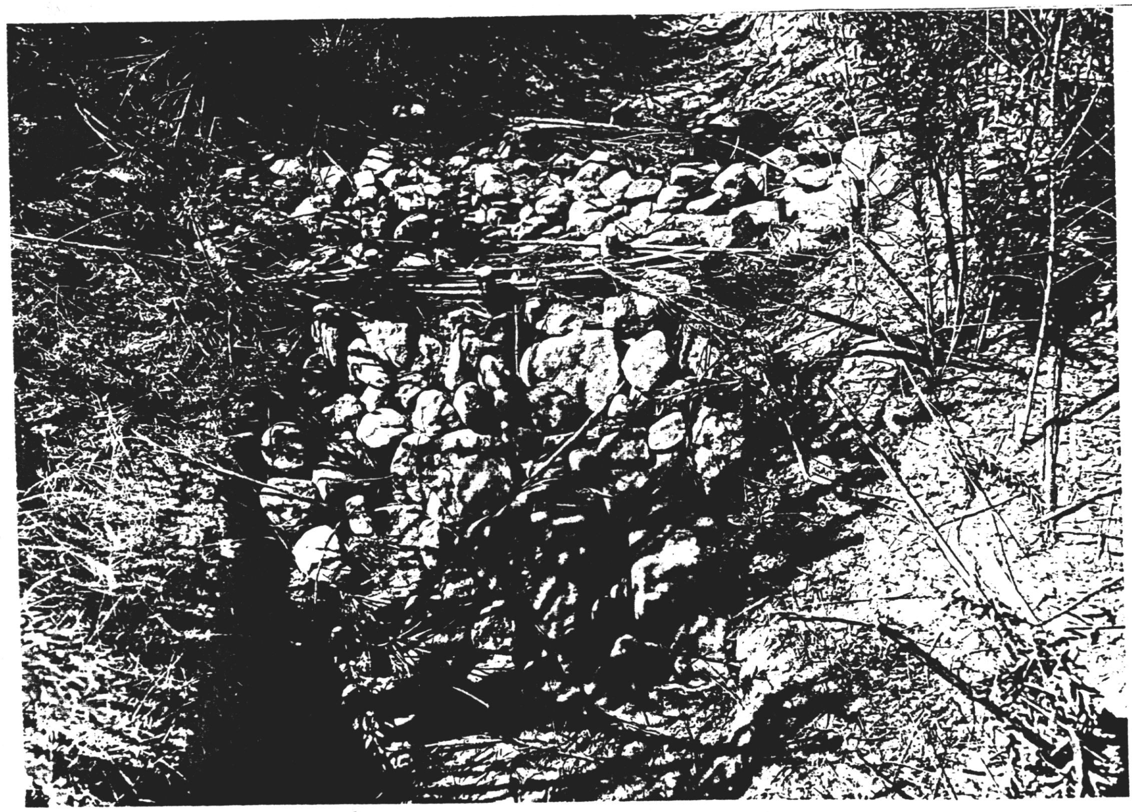


Figure 6. Front view sketch of "basket weave" and photograph of a "basket weave" check.

positions per checkdam. In the lab the GPS positions were downloaded and differential correction was applied to create an accuracy within 3-5 m.

After several hours of computerization, the map showed clusters of scattered points falling only within the vicinity of their exact locations. Although these points do not furnish the expected accuracy, they do supply us with a general outline of the project area on a larger scale.

The two problems encountered operating the GPS unit was using 2D instead of 3D (due to the location and the availability of only 2 satellites), and having a GPS margin of error greater than the actual distance between each checkdam.

Monitoring at Palisades

Monitoring archaeological features at sites C:13:099 and C:13:100 will continue on the designated semiannual schedule. Yet, alternative schedules may be recommended depending on the short term repercussions to the checkdams.

Due to the magnitude of work completed at Palisades this September, monitoring the checks will be a project in and of itself. The proposed schedule is to monitor the checks annually, beginning on the May, 1996 monitoring river trip.

Minor, routine maintenance will occur if deemed necessary. A major topic of discussion by the group was what if it does not work? What if the dams do not hold? In response, the Zuni and Hopi both agreed that if the dams are blown out, then it was not meant to be and further tactics would be discussed.

Conclusion

For at least the last 13 years and probably much longer, sites that have been monitored exhibit extreme erosional deterioration. So severe that cultural features are lost forever due to permanent loss of sediment compounded by the unabated downcutting of arroyos caused by the very existence of the dam. Palisades is a perfect example of this process.

At first, some PA representatives were skeptical of the Palisades project. Yet, as days past, attendees saw and understood the need for such a task. This was not a typical archaeological stabilization project where walls are repointed and roaster features are altered. The only alterations made were on the landscape around or near the cultural features. Several archaeologists were present to insure that no features were disturbed.

Several PA representatives questioned the order of procedure. This project did not follow the normal sequence of events: proposal, work plan, comments or response to the work plan, complete the work, write the report. The order of procedure began with notifying the PA agencies of the problems, visiting the area, discussing different techniques used on sites, and then actually doing the work, prior to any specific work plan. However, due to time, money, availability of people and the location of the project area, it would have been very inefficient to conduct two river trips -- one trip to discuss where and what types of dams to be built, and another trip to do the work. Remedial actions should be implemented on a site-by-site basis. No generic model can be formulated to accommodate all sites. It is important to remember that all signatories to the PA were represented during the construction phase and could have stopped any action that they deemed inappropriate.

This crucial first step in a long term commitment to preserve our cultural resources is a move in a positive direction and changes the role of the monitoring project from a passive to an active phase. It is hopefully only the beginning of a program to preserve for the future all of the sites put at risk along the Colorado River Corridor below Glen Canyon Dam.

References Cited

Hereford, Richard, Helen C. Fairley, Kathryn S. Thompson, Janet Balsom
1993 Surficial Geology, Geomorphology, and Erosion of Archeologic Sites Along the Colorado River, Eastern Grand Canyon, Grand Canyon National Park, Arizona. U.S. Geological Survey Open-File Report 93-517, prepared in cooperation with the U.S. Bureau of Reclamation, Glen Canyon Environmental Studies, Flagstaff.

Appendix A

Trip Personnel

NPS
Jan Balsom, archaeologist
Kim Crumbo, resource specialist
Don Sharlow, trails specialist
Chris Coder, archaeologist
Mary Lois McCaslin, volunteer cook
Clare Mortley, volunteer cook
Mike Quinn, photographer
Nancy Brian, botanist, boatman
Lisa Leap, archaeologist
Linda Jalbert, resource specialist
Brooks Jacobson, volunteer boatman

NFS
Jennifer Burns, volunteer boatman

ZUNI TRIBE
Daniel Seoutewa
Albert Chopito
Gabriel Yuselew

NAU
Chris Downum
Duane Hubbard

HUALAPAI TRIBE
Loretta Jackson
Wilfred Imus

NAVAJO NATION
Timothy Begay
Rolf Nabahe
Roger Henderson

SHPO
Jim Garrison
Cathy Johnson

HOPI TRIBE
Rex Talayumptewa
Mike Yeatts

USGS
Kate Thompson
Kelly Burke

APPENDIX B

Checkdam Descriptions and Locations

Checkdam Description for River-Based Stream 1 at C:13:099.

Check No.	Length x Width x Height in Meters	General Description
1	12.8 x 2.0 x --	river cobbles and boulders, scattered logs
2	4.0 x 2.0 x --	river cobbles and boulders, brush
2a	1.0 x 1.0 x .15	1 log, river cobbles and boulders, brush
3	2.5 x 1.5 x --	check 3 and 4 are one feature at channel junction constructed ofriver cobbles and boulders, brush
4	"	"
5	1.3 x .80 x --	filled headcut of river cobbles and boulders, brush
6	1.6 x .90 x .15	1 log, river cobbbles and boulders, brush
7	1.6 x .90 x .15	1 log, river cobbles and boulders, brush
8	1.8 x .90 x .15	1 log, river cobbles and boulders, brush; Beamer trail crosses just up channel
9	1.6 x 2.0 x .20	v-shaped logs, river cobbles and boulders, brush
10	2.0 x 1.0 x .60	woven dam of driftwood, willow, brush, river cobbles
11	1.0 x .80 x .15	1 log, river cobbles and boulders, brush
12	1.5 x 1.9 x .25	horseshoe shape, 2 logs, river cobbles and boulders, brush
13	1.5 x 2.5 x .30	horseshoe shape, one log, river cobbles and boulders, some Cardenas lava, brush
13a	2.4 x -- x --	retaining wall, right side of channel, 1 log, river cobbles
14	1.6 x 3.0 x .30	horseshoe shape, many logs, river cobbles and boulders, brush

15	1.6 x 1.9 x .45	woven dam of driftwood, willow, brush, river cobbles, Cardenas lava
16	.80 x 2.5 x .30	logs, Cardenas lava
17	1.7 x 2.0 x .40	debris flow sandstone (ss) boulders, log, Cardenas lava
18	1.1 x 1.6 x .20	1 log, Cardenas lava
19	2.4 x -- x --	retaining wall, right side of channel, Cardenas lava; check 16, 17 and 19 are one feature
20	7.2 x -- x --	retaining wall, right side of channel, Cardenas lava, debris flow ss boulders and cobbles; also fills in gully forming on right bank
21	.70 x .60 x --	debris flow ss and limestone (ls) boulders and cobbles, brush
22	.70 x .60 x --	debris flow ss and ls boulders and cobbles, brush
23	.70 x .60 x --	debris flow ss and ls boulders and cobbles, brush
24	1.0 x 1.0 x .15	debris flow ss and ls boulders and cobbles, brush
25	.70 x .60 x --	debris flow ss and ls boulders and cobbles, brush
26	.90 x 2.10 x .30	logs and debris flow ss and ls boulders and cobbles, brush
27	.80 x 1.0 x .20	debris flow ss and ls cobbles and boulders, brush
28	.50 x 1.10 x .20	debris flow ss and ls cobbles and boulders, Cardenas lava, brush
29	4.0 x -- x --	debris flow ss and ls cobbles and boulders, brush; rock fill in gully - left bank
30	.60 x 2.20 x .20	debris flow ss and ls cobbles and boulders, brush
31	.90 x 1.7 x .20	debris flow ss and ls cobbles and boulders, brush

32	.80 x 2.0 x .20	debris flow ss and ls cobbles and boulders, brush
33	4.0 x -- x --	debris flow ss and ls cobbles and boulders, brush; headcut fill at top of channel
34	1.6 x 2.4 x .20	1 log, Cardenas lava cobbles, brush
35	1.7 x 2.4 x .20	1 log, Cardenas lava cobbles, brush
36	1.7 x 2.4 x .20	1 log, Cardenas lava cobbles, brush
37	1.5 x 4.0 x .15	1 log, Cardenas lava cobbles, brush; L-shaped check stabilizing right bank
38	1.6 x 4.0 x .20	1 log, Cardenas lava cobbles, brush; left bank reinforced
39	1.6 x 4.0 x .20	1 log, Cardenas lava cobbles, brush
40	1.6 x 3.4 x .20	1 log, Cardenas lava cobbles, brush
41	1.0 x 4.0 x .15	1 log, Cardenas lava cobbles, brush; at drainage junction
42	.80 x 3.2 x .15	1 log, Cardenas lava cobbles; right bank reinforced
43	.70 x 2.4 x .25	1 log, Cardenas lava cobbles; right bank reinforced
44	.70 x 4.5 x .20	1 log, Cardenas lava cobbles; right bank reinforced

Checkdam Description for River-Based Stream 2 at C:13:100.

Check No.	Length x Width x Height in Meters	General Description
1	2.5 x 1.5 x .30	1 log, river boulders and cobbles
2	1.0 x 1.5 x .30	river cobbles and boulders
3	1.0 x 3.0 x .30	river cobbles and boulders; horseshoe check

4	1.5 x 2.5 x .20	1957 wooden beam, river cobbles and boulders
5	.30 x 1.0 x .20	driftwood debris
6	1.0 x 2.0 x .50	1 log, river cobbles and boulders
7	1.5 x 1.5 x .30	1 log, river cobbles and boulders, brush
8	1.5 x 2.5 x .50	river cobbles, 1 log, brush
9	1.0 x 1.0 x .30	logs, river cobbles, brush
10	1.0 x 1.5 x .50	2 logs, river cobbles, brush
11	1.0 x 1.0 x .50	river cobbles and boulders, brush
12	1.0 x .75 x .50	river cobbles and boulders, brush
13	1.5 x 2.5 x .50	brush, river cobbles and boulders; placed between 2 very large, pre-existing boulders
14	1.0 x 1.0 x .50	river cobbles, brush
15	3.0 x 1 x .20	brush, river cobbles; just below Feature 4
16	3.0 x 1.0 x .20	brush, Cardenas lava cobbles; between Features 4 and 8
17	1.0 x 1.0 x .30	debris flow ss boulders, Cardenas lava cobbles, brush
18	1.0 x .50 x .30	1 log, Cardenas lava, brush
19	1.0 x .50 x .30	brush, debris flow ls, Cardenas lava
20	1.0 x .50 x .50	debris flow ss and ls, Cardenas lava, brush
21	1.0 x .50 x .50	debris flow ss and ls, Cardenas lava, brush
22	1.0 x 1.5 x .30	debris flow ss and ls, Cardenas lava, brush
23	1.0 x .50 x .30	debris flow ss and ls, Cardenas lava, brush
24	1.0 x .50 x .30	debris flow ss and ls, Cardenas lava, brush

Checkdam Description for River-Based Stream 3 at C:13:100.

Check No.	Length x Width x Height in Meters	General Description
1 (25)	1.0 x 2.5 x .50	river cobbles, brush; horseshoe check
2 (26)	1.0 x 3.0 x .50	river cobbles, brush; horseshoe check

Grand Canyon National Park

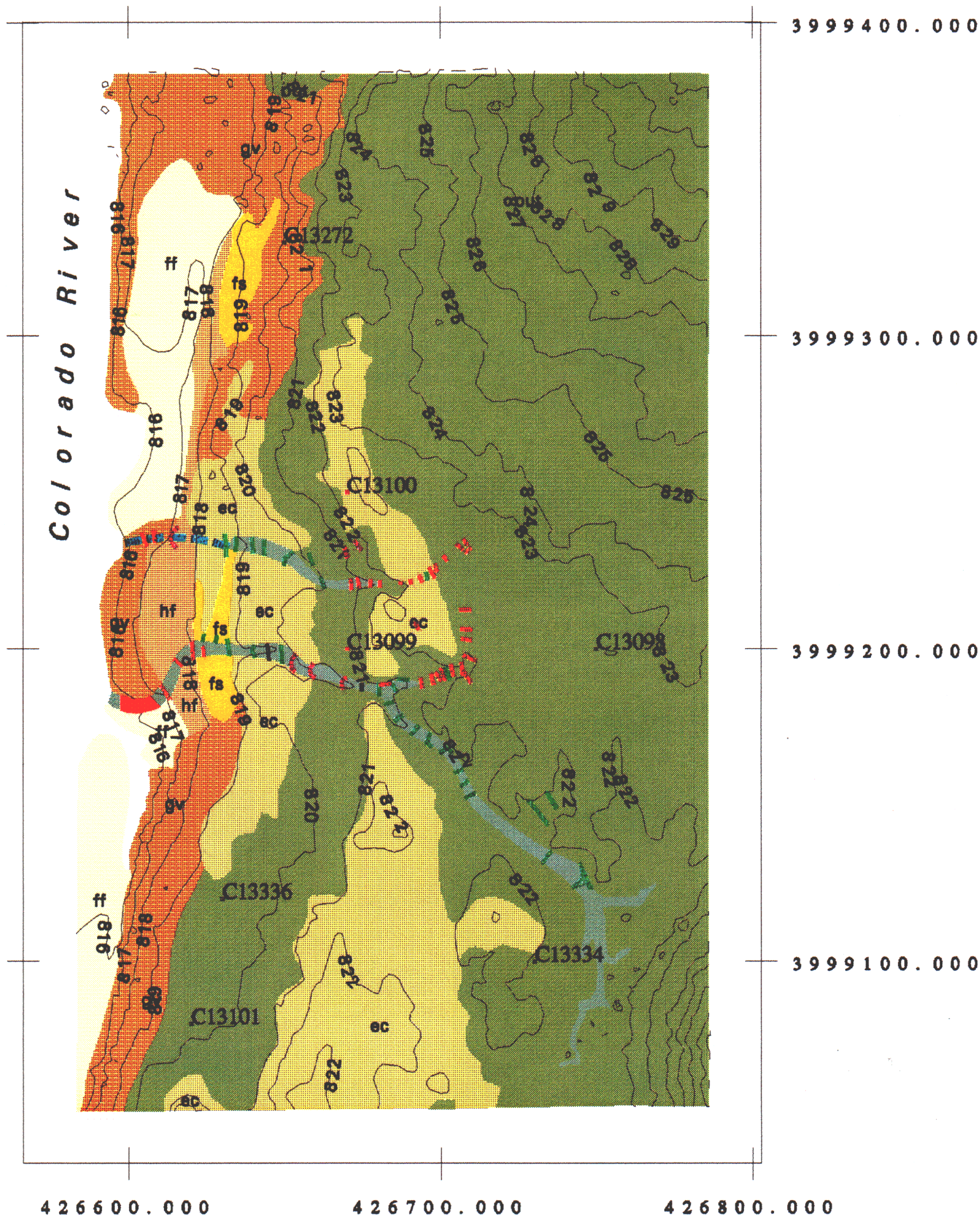
Palisades Creek Archeologic Area

Stabilization Checkdam Locations, September 1995

Surficial Geology and Geomorphology by Richard Hereford 1993

Legend

- Channel Alluvium in Arroyos
- Coppice Sand Dune
- Fluctuating-Flow Sand
- Flood Sand (summer 1983)
- Gravel Deposits
- High Flow Sand (1986-1984)
- Outside Study Area
- other sites
- 2 sites of interest
- Horseshoe Dam
- Log Dam
- Rock Dam
- Weave Dam
- Fill Dam



SCALE 1:2000

10 0 10 20 30 40 50 60 70 80 90 100

METERS

Contour Interval 1 Meters

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Prepared by:
Grand Canyon National Park
National Park Service
United States Department of the Interior

Coordinate System: UTM zone 12
1927 North American Datum