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Overview and Status of the Cultural Monitoring R&D Project

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Presentation to the Glen Canyon Dam Adaptive Management Program Technical Work Group
Phoenix, Arizona October 2, 2007

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

CR Monitoring Program: 1995-2005

- Conducted under the auspices of the PA (guided by the Interim Monitoring and Remedial Action Plan)
- Specifically focused on identifying types of impacts affecting sites and needs for future treatment
- Relied on a presence/absence, active/inactive format to document impacts (impacts not ranked or quantified; condition assessments arrived at independently of impact observations)
- Main question driving the program: "*Which sites are being impacted by what kinds of impacts, and which site attributes are being affected by these impacts?*"

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Summary of 2000 PEP Recommendations re: Future Monitoring Program Directions

"the monitoring program should serve as the basis for periodic quantitative evaluations of effect of dam operations, effectiveness of erosion control measures, and development of treatment plans."

Redesign the cultural resource monitoring program to:

1. assess need for and effectiveness of treatment strategies (e.g. check dams, trail obliteration, excavation, etc.)
2. evaluate effects of different flow regimes on archaeological sites and other resources directly affected by changing water levels and gain and loss of sediment, and
3. address both GCPA and NHPA monitoring information needs through a single unified monitoring program

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What questions are driving the monitoring program today?

- AMP priority concerns
- Strategic science questions
- Core Monitoring Info Needs
- Others (each stakeholder has their own . . .)

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AMP Priority Questions

- **AMWG Priority 2: Which cultural resources, including Traditional Cultural Properties, are within the Area of Potential Effect, which should we treat, and how do we best protect them? What are the status and trends of cultural resources and what are the agents of deterioration?**

- **AMWG Priority 3: What is the best flow regime?**

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Strategic Science Questions (MRP)

- Do dam controlled flows affect rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?
- If dam controlled flows are contributing to archaeological site and TCP erosion, what are optimal flows for minimizing future impacts to these resources?
- How effective are various treatments (e.g. check dams, vegetation management, etc.) in slowing erosion rates at archaeological sites long term?

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CORE MONITORING INFO NEEDS FOR CULTURAL SITES

CMIN 11.1.1 Determine the condition and integrity of prehistoric and historic sites in the Colorado River ecosystem through tracking rates of erosion, visitor impacts, and other relevant variables. *

CMIN 11.2.1 Determine the condition and integrity of TCPs in the Colorado River Ecosystem.*

EMIN 11.1.2 Determine the efficacy of treatments for mitigation of adverse effects to historic properties.

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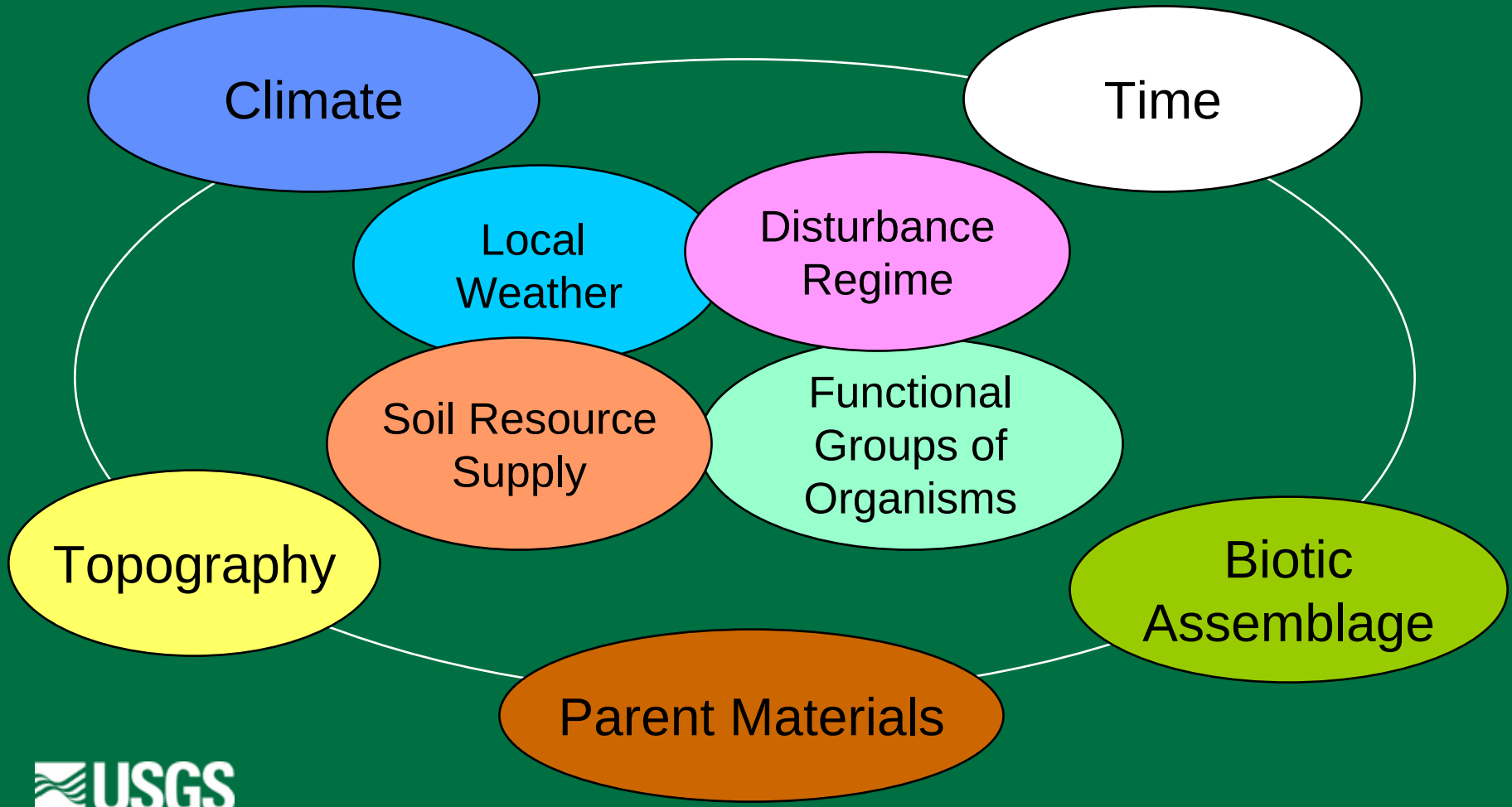
*Revised by CRAHG, adopted by SPG, Oct 2005

Complex interactive factors contribute to archaeological site condition

(Adaptation of Jenny-Chapin model, after Chapin et al. 1996)



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Changes in site condition are linked to multiple interacting factors in this dynamic ecosystem. . . .

- Continuing reduction in sediment supply and surface sand storage under ROD operations

  (Potential Indicators: gully widening/deepening, surface deflation– tracked in relation to ROD flows & experimental flows)
- Change in natural disturbance regime/Insufficient high elevation sediment-replenishment

  (Potential Indicators: sediment gained/lost above 25,000 cfs during experiment flows; amount of aeolian transport; vegetation encroachment & elevation shifts)
- Ongoing weather-induced erosion

  (Potential Indicators: gully widening/ deepening, nick point migration, surface soil loss/deflation –tracked in relation to weather events and local climate)
- Increasing/cumulative human disturbance

  (Potential Indicators: social trails, artifact movement & removal, vegetation damage, degree of soil compaction, trampling of cryptobiotic crusts, graffiti)

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Indicators of site condition change that can be directly measured or counted

- Erosion
  - Rates of gully incision/widening
  - Rates of nick point migration
  - Topographic/volumetric change

- Human impacts
  - Length/depth/number of social trails
  - Area/amount of soil compaction due to trampling
  - Area of crypto biotic crust damage
  - Vegetation pedestals/loss/damage
  - Incidents of vandalism/graffiti
  - Artifact piles

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Condition indicator selection criteria

- Need indicators that reflect the agents of change
- Objective, replicable, verifiable measurements and observations – not just “professional opinion”
- Numeric measurements to quantify amount & rate of change (presence/absence data is not well suited for trend analysis)
- Monitoring methods must be relatively easy and cost-efficient to replicate and “light on the land”
- Multiple management objectives require monitoring data collected at different scales: landscape level (remotely sensed data; sample of sites) and site-specific level (individual sites)

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Diverse Sites Types in the CRE

(condition varies with exposure, materials, age, etc.)

- Late Archaic (2500-1000 BC): campsites, petroglyphs, split twig figurine caches in caves
- Pre-ceramic Ancestral Puebloan (BM II, ~ 1000 BC to AD 500): campsites, agricultural fields?
- Ancestral Puebloan (AD 900-1250): habitation structures, granaries, irrigation features, vessel caches, petroglyphs
- Ancestral Pai and Paiute: (~AD 1250-1850+):campsites, tool caches, roasting pits, pictographs
- Historic Anglo (~AD 1850-1950): structures, objects, inscriptions

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Problems/Questions

- Can we arrive at an objective and accurate assessment of site condition by combining a series of objectively measured indicators?
- Given variability in site types and settings, is it appropriate to use one set of indicators for all sites?
- There are ~ 269 sites in the original GRCA APE – given total population size, site diversity, and multiple program objectives, is a sampling approach necessary and/or appropriate? (How do we acquire the site specific information required for assessing future treatment needs with a random sample?)
- Given variability in sites and geomorphic settings, what sample type and sample size would be most appropriate to use (if a sample is appropriate)?

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Phase I R&D (FY06-FY07): Primary Tasks

1. **Assess archaeological attributes (in relation to aspects of integrity) & geomorphic site attributes**
   1. **for clustering/grouping similar sites**
   2. **for stratifying population for future sampling**
2. **Evaluate utility of existing data (legacy data review, remotely sensed data sets)**
3. **Complete site boundary mapping of sites for GIS**
4. **Develop/evaluate/test pilot monitoring protocols**
   - Compare efficiency/accuracy/impacts of different survey techniques for measuring changes
   - Design and test check dam effectiveness monitoring protocols
   - Implement pilot weather monitoring project
   - Select and test human impact monitoring protocols

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FY06-07 Accomplishments

- Conducted initial evaluation of existing site data and identified critical data gaps (e.g., many sites not in GIS; only limited geomorphic data available; inconsistencies in site categorization.)
- Completed archaeological and geomorphic assessments of 234 sites * (151 in conjunction with FY06 treatment planning; 83 additional sites assessed in FY07)
- Installed 9 weather stations at 7 locations
- Completed 4 repeat gully surveys for check dam effectiveness at six locations (eight archaeological sites – same ones studied by Pederson et al. in 2001-2002)
- Conducted systematic comparison of total station vs. LiDAR survey techniques for tracking topographic change – report in preparation
- Convened expert panel to conduct independent review of legacy monitoring data and provide recommendations to GCMRC – report in preparation
- Initiated an analysis of legacy monitoring data in relation to flow data (analysis in progress but not yet completed)

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*USGS, NPS, USU

FY06-07 Site Assessments

- Identified important site attributes essential to monitor (key attributes linked to site significance and integrity)
- Systematically characterized geomorphic setting of each site and identified potential for future erosion (or other geomorphic processes) to affect site integrity
- Identified geomorphic attributes important to track/monitor in the future (e.g., incipient gullies, cryptobiotic crusts, deflation hollows)
- Identified immediate/potential treatments

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Evaluate Potential Monitoring Tools for tracking/measuring physical changes

- Remotely sensed, orthorectified imagery
- Airborne LiDAR
- Ground based LiDAR
- Total station measurements of gully erosion
- Analog or digital photographs
- Visual observations/verbal documentation of change
- Stage-elevation predictive flow model

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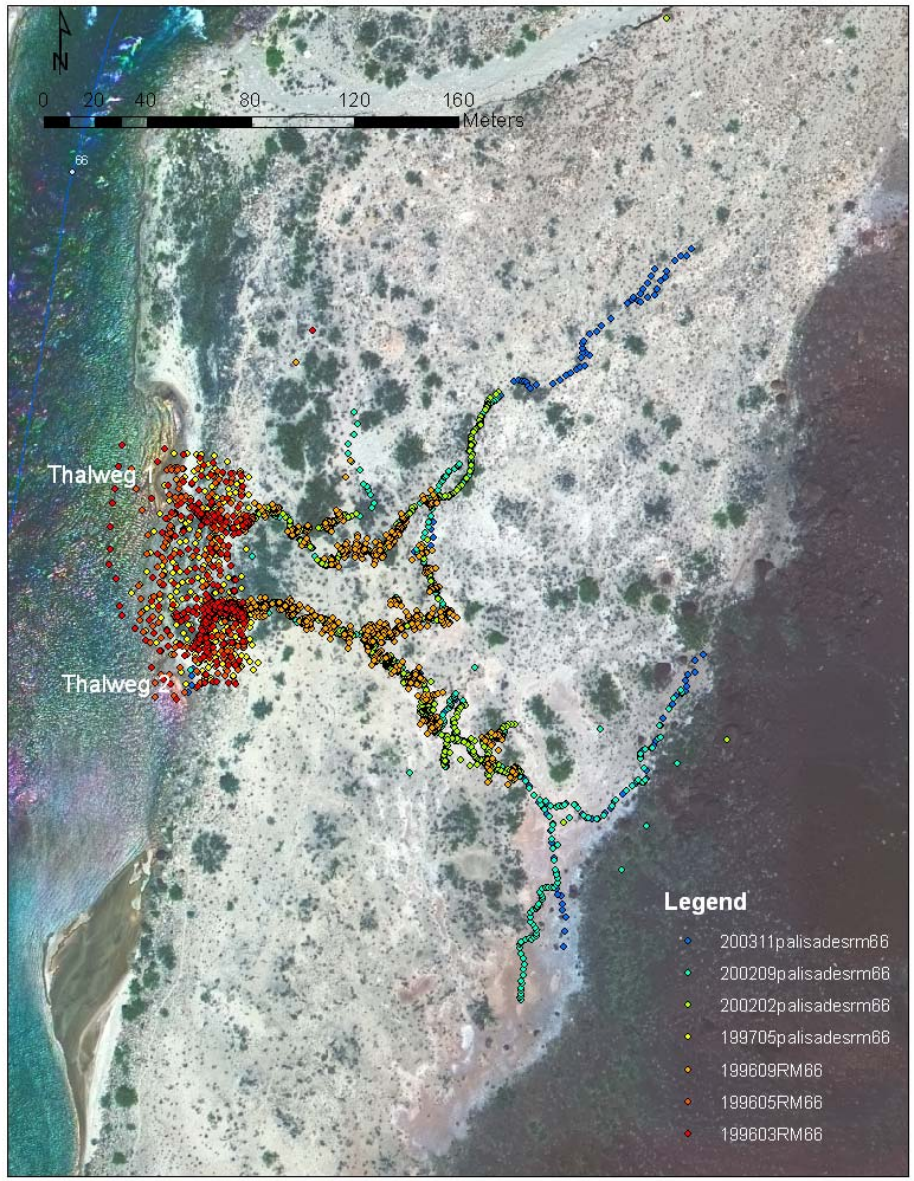
Total Station surveys of gully thalwegs in the Palisades area



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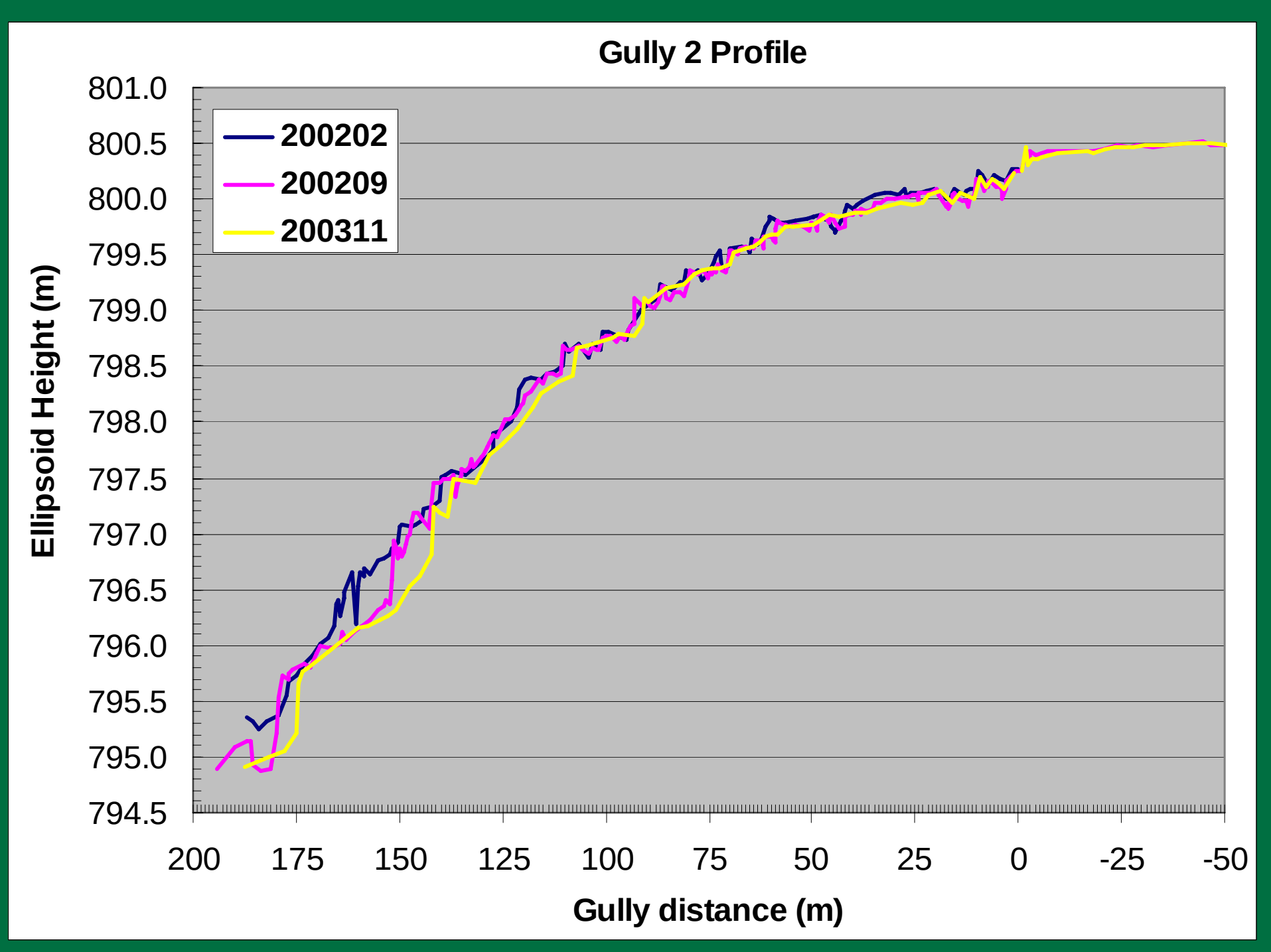
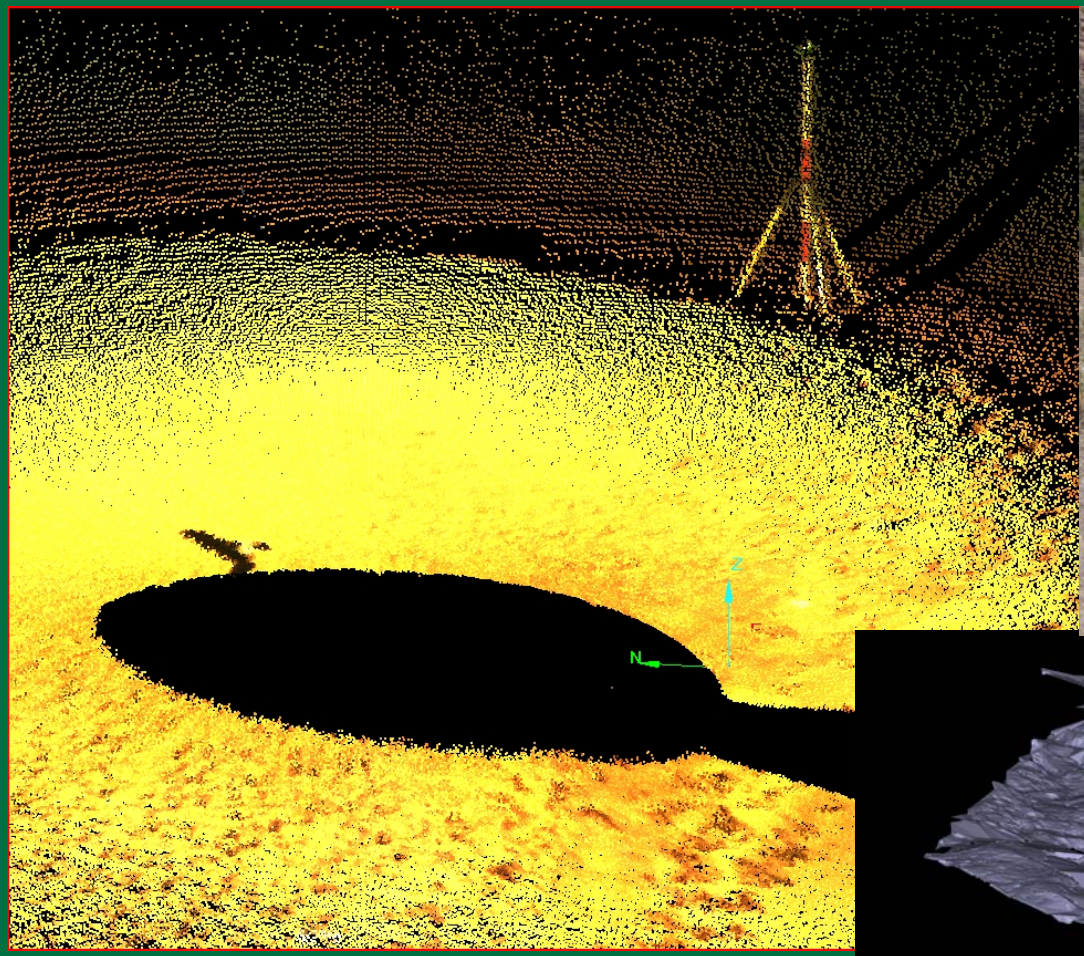
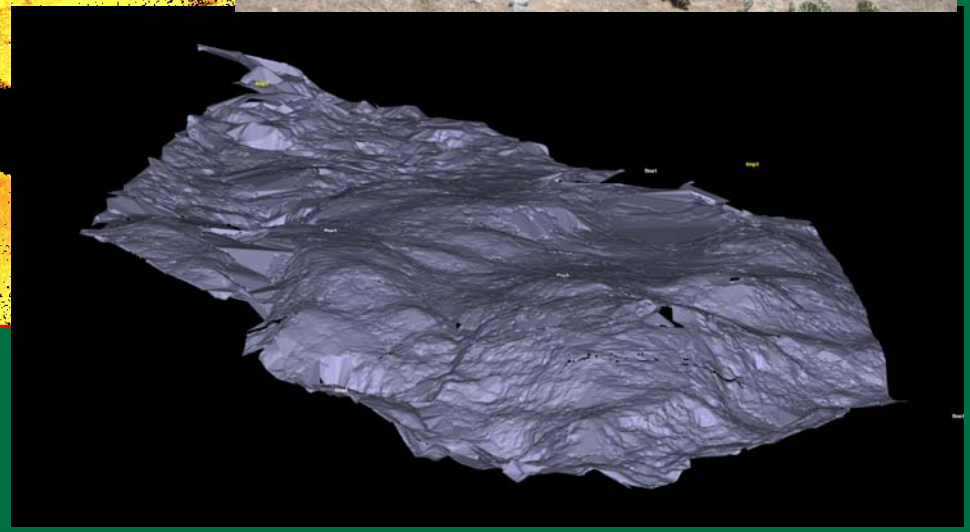

Gully 2 Profile
200202
200209
200311
Ellipsoid Height (m)
801.0
800.5
800.0
799.5
799.0
798.5
798.0
797.5
797.0
796.5
796.0
795.5
795.0
794.5
200
175
150
125
100
75
50
25
0
-25
-50
Gully distance (m)

LIDAR SURVEY





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Comparison of Total Station vs. Ground Based LiDAR for measuring changes

- Time/personnel to collect data
- Time/personnel to process data
- Amount of data that can be collected in a given amount of time
- Accuracy of the data
- Total costs
- Impacts to sites (and to wilderness experience?)

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Human Impact Protocol Evaluation (FY07 Work in Progress)

- Coordinated with goals/objectives of the NPS Colorado River Management Plan (NPS currently defining CRMP monitoring needs)
- NPS to focus primarily on documenting effects of visitation on site aspects of integrity (for NHPA 106 and 110 compliance)
- AMP monitoring protocols will complement NPS approach by focusing on measuring & quantifying effects of geomorphic processes on site condition

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Site Assessment and Data Review Tasks (Additional FY07 work in progress)

- NPS is completing GIS polygon mapping of site boundaries so additional GIS analysis can be completed in winter, 2007-2008
- September 6-7, 2007: GCMRC convened a small panel of independent experts to review and make recommendations re: applicability and utility of legacy monitoring data. Panel report is under development
- GCMRC is analyzing legacy monitoring data in relation to flow data to determine whether any meaningful correlations between these data sets can be detected
- GCMRC cooperators are completing stage-discharge "flow line" modeling to facilitate future GIS-based evaluations of flow impacts

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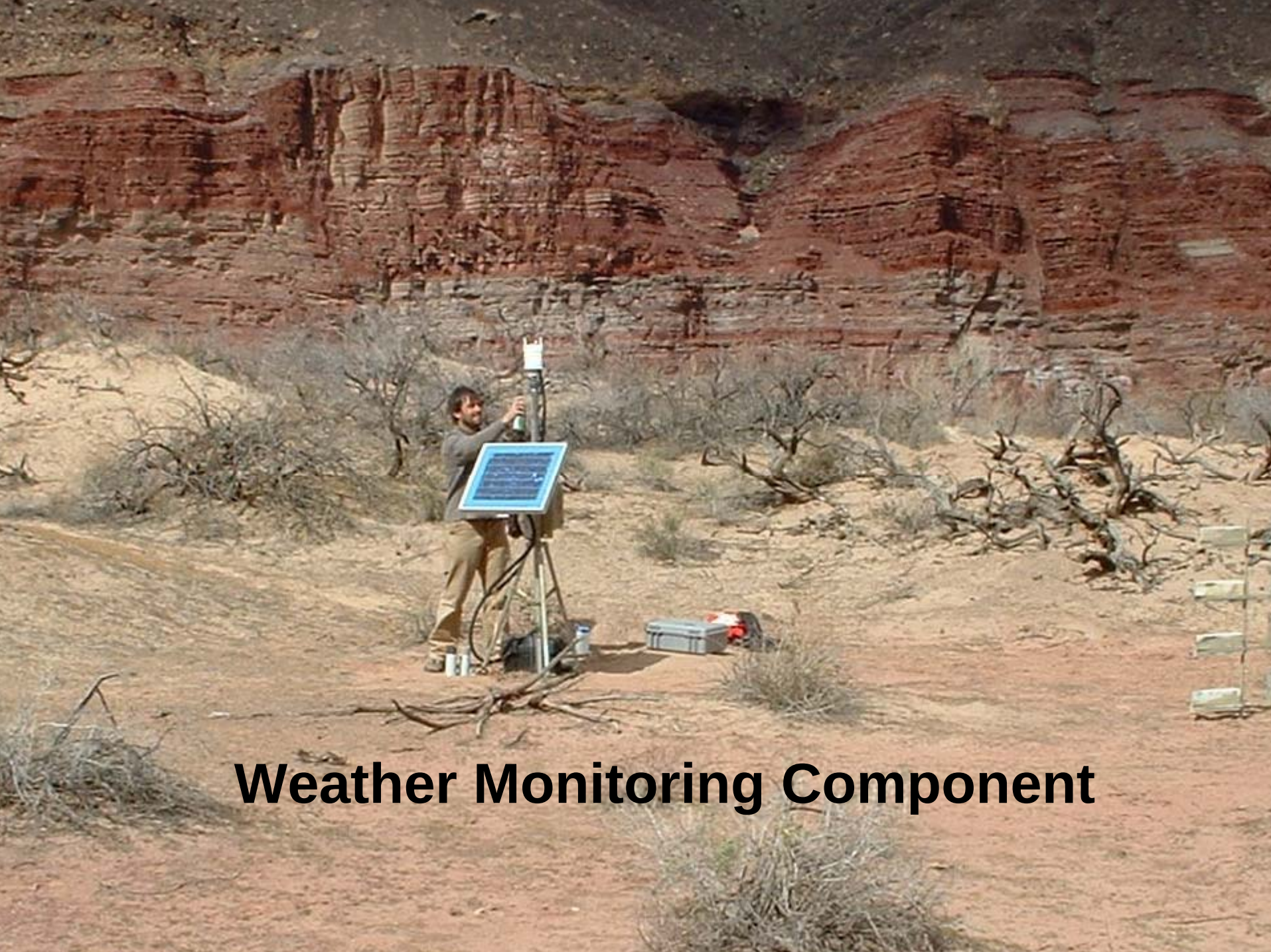

Weather Monitoring Component

Check dam effectiveness monitoring (R&D) is testing the use of high resolution weather and erosion/deposition data to track/compare efficacy of treatments

- Track and evaluate role of weather-events in driving erosion at arch sites
- Compare differences in response between “treated” and “untreated” sites under similar weather parameters

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Monitor Role of Aeolian Processes in Site Preservation

- Continue to monitor sediment transport rates at a sample of sites to refine understanding of how aeolian sediment may help to preserve archaeological sites (e.g., quantify rates of gully backfilling)
- Evaluate effects of future experimental flows re: improving sediment supply (dry, upwind sand bars) and rates of subsequent transport to archaeological sites

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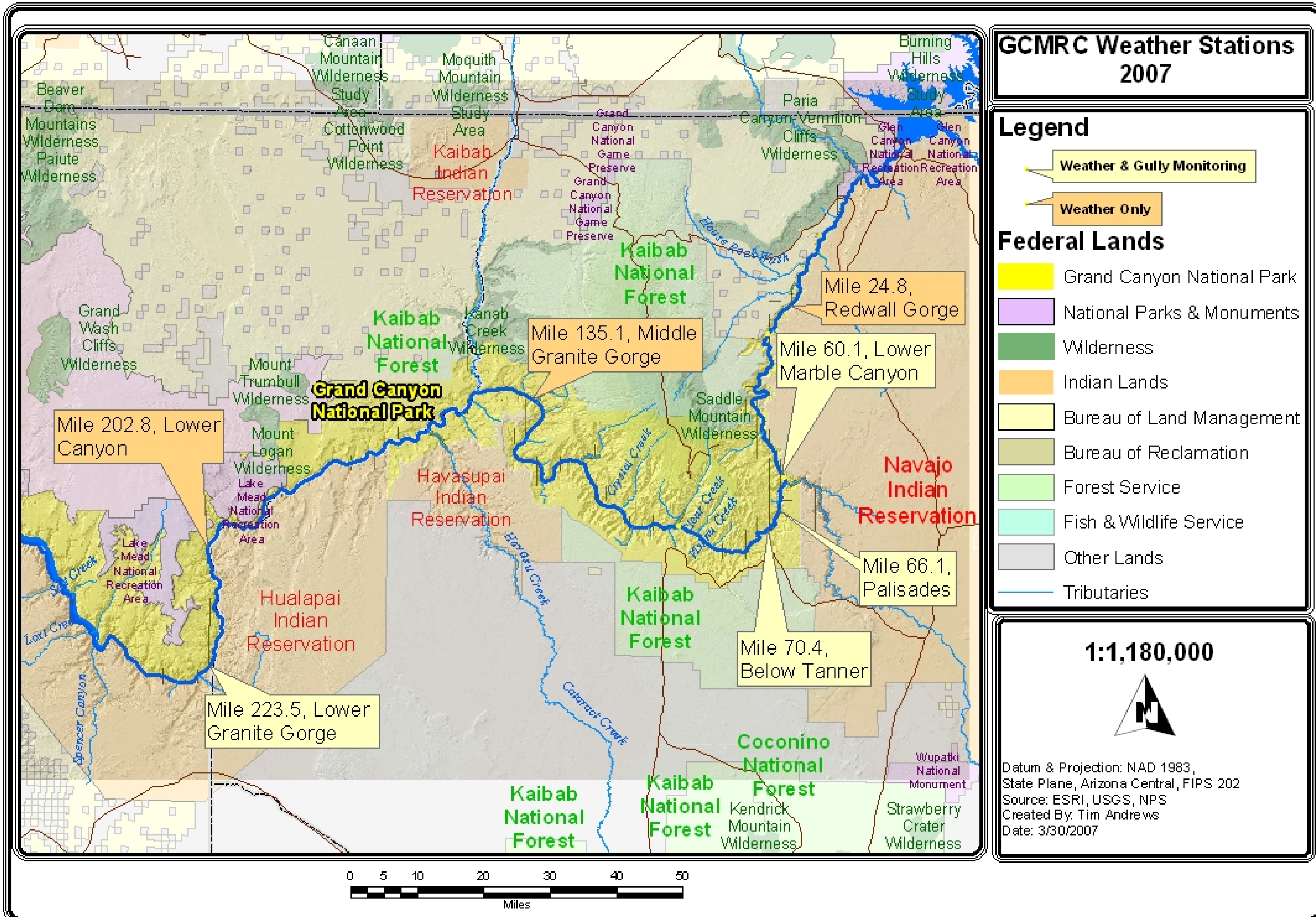

GCMRC Weather Stations 2007
Legend
Weather & Gully Monitoring
Weather Only
Federal Lands
Grand Canyon National Park
National Parks & Monuments
Wilderness
Indian Lands
Bureau of Land Management
Bureau of Reclamation
Forest Service
Fish & Wildlife Service
Other Lands
Tributaries
1:1,180,000
Datum & Projection: NAD 1983,
State Plane, Arizona Central, FIPS 202
Source: ESRI, USGS, NPS
Created By: Tim Andrews
Date: 3/30/2007
Mile 24.8, Redwall Gorge
Mile 60.1, Lower Marble Canyon
Mile 66.1, Palisades
Mile 70.4, Below Tanner
Mile 135.1, Middle Granite Gorge
Mile 202.8, Lower Canyon
Mile 223.5, Lower Granite Gorge
Grand Canyon National Park
Kaibab National Forest
Coconino National Forest
Navajo Indian Reservation
Hualapai Indian Reservation
Havasupai Indian Reservation
Kaibab Indian Reservation
Beaver Dam Mountains Wilderness
Paiute Wilderness
Grand Wash Cliffs Wilderness
Mount Trumbull Wilderness
Mount Logan Wilderness
Kanab Creek Wilderness
Saddle Mountain Wilderness
Cottonwood Point Wilderness
Canaan Mountain Wilderness Study Area
Moquith Mountain Wilderness Study Area
Burning Hills Wilderness Study Area
Paria Canyon-Vermilion Cliffs Wilderness
Glen Canyon National Recreation Area
Grand Canyon National Game Preserve
Lake Mead National Recreation Area
Wupatki National Monument
Kendrick Mountain Wilderness
Strawberry Crater Wilderness
Havasu Creek
Cataract Creek
House Rock Wash
Crystal Creek
Spencer Canyon
0 5 10 20 30 40 50
Miles

Location	Nearest Archaeological sites ID	Number of weather stations +	Number of sand traps
RM 24.5	AZ C: 5:031	2	2
RM 60*	AZ C:13:006	1	1
RM 66	AZ C:13:336	1	1
RM 70	AZ C:13:346, 352	2	2
RM 135	AZ B:11:277	1	1
RM 203	AZ A:15:33	1	1
RM 207**	AZ G:3:041	0	0
RM 208	AZ G:3:002, 025	0	0
RM 223*	AZ G:3:072	1	2

Site numbers in yellow identify gully survey sites

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Other potential applications for the weather monitoring data

- Characterize local weather variability in the CRE
- Support development of geomorphic model of site erosion potential
- Support other modeling/monitoring initiatives, e,g., temperature model for the mainstem river, terrestrial ecosystem monitoring program

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Cultural Monitoring R&D Project: Next Steps

- Complete Phase I data analysis (winter 2007-2008); draft reports from USU and Western Coastal Marine Team due end of February 2008; final products May & June 2008
- Design and select monitoring sample; define and initiate pilot project (winter-spring 2008)
- Conduct 3-yr cycle of monitoring (FY08-FY10) - includes FY08 test of new ground based LiDAR system and FY09 GCMRC over-flight with airborne LiDAR
- FY11: review monitoring results with PEP, refine protocols, implement long-term monitoring plan

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The End

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