Modernizing data telemetry efforts for important riparian resources in Grand Canyon

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Abstract

The Grand Canyon Monitoring and Research Center (GCMRC), as the science provider to the Glen Canyon Dam Adaptive Management Program (GCDAMP), monitors the status and trends of resources downstream of Glen Canyon Dam in support of ongoing adaptive management. Similar to its role in providing long-term monitoring for the Colorado River ecosystem, the GCMRC often responds to more immediate needs of GCDAMP stakeholders on the current status of important resources. The remote environment and extreme terrain of the Grand Canyon region presents many challenges for collecting information about Colorado River resources, both in traditional methods and in acquiring data through remote access.

GCMRC's Geospatial Science and Technology project has taken the lead in modernizing existing data telemetry efforts in order to address the growing need from stakeholders while aligning our efforts with emerging trends in information technology. To this end, project staff have explored new avenues now available for improving access to data in near real-time. In this presentation we introduce advances in data telemetry that have been achieved recently for the Science Center, highlight new tools for exploring data online, and address future possible directions that can be pursued.

Evolution of Telemetry in Grand Canyon

Prior to Telemetry (Historical)
- Data only accessible through field visits to Marble and Grand Canyons
- Involved travel in remote locations, extreme terrain

Early Telemetry (prior to 2003)
- One-way data uplink via satellite (GOES)
- Many sites still in operation – USGS gage stations

GCMRC Telemetry solutions (2003 – 2018)
- Two-way satellite telemetry (SageNet, Iridium)

Emergence of Internet of Things (IoT) (2018 – Present)
- Continued use of Two-way satellite telemetry
- Two-way cellular telemetry (Verizon, other carriers) – emergence of Internet of Things (IoT) technology for monitoring natural resources

Fiscal Year 2022

We have expanded the Center's use of the USGS' Cloud Hosting Solutions (CHS) Sensor Processing Framework and provided unparalleled opportunities for accessing important GCMRC data resources. In FY2022, Project K work focused on improving the stability of the existing IoT study sites. This work involved a considerable amount of re-engineering, system configuration, and programming code used to perform the data telemetry tasks at our established sites. Additionally, this work involved multiple site visits for performing maintenance of our IoT systems, however with the improvements added over the past year, it is expected that the number of site visits and the amount of system downtime will be greatly reduced.

Continued coordination led by Project K has allowed GCMRC to leverage USGS resources, including continued involvement with Cloud Hosting Solutions (CHS) and the CHS Sensor Cloud Processing Framework, the Center for Data Integration (CDI), and the Actionable and Strategic Integrated Science and Technology (ASIST) project. The ASIST project is the next generation of the previous Earth Monitoring, Analysis, and Prediction (EarthMAP) initiative, and the EarthMAP Colorado River Basin pilot project, that was instituted to improve data workflows, modeling, and prediction for the Colorado River Basin.

The base map shown here highlights the locations of the data telemetry sites including water quality monitoring at Glen Canyon Dam and the Lee's Ferry gauging station, suspended sediment monitoring at five locations along the Colorado River, and fish pit-tag antenna array from the Little Colorado River.

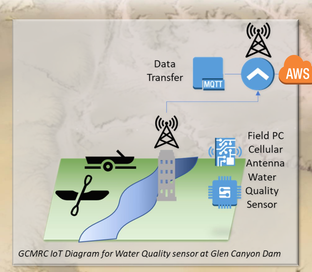
By leveraging the power of cloud computing, data can now be viewed almost instantaneously, improving on a process that would take days to weeks to do previously at certain locations. These data are viewable through a series of dashboard tools and web-based data visualizations that can be shared with other researchers and stakeholders.

Lees Ferry Gauge IoT Site

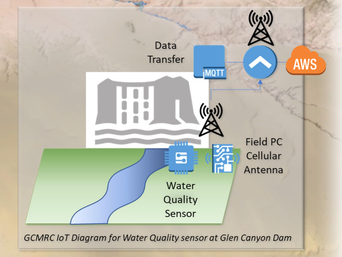
Glen Canyon Dam IoT Site

Water Quality IoT Sites: Sensor to Cloud Data Workflow

- A Microsoft Windows program was developed specifically to query water quality sensors for the most recent data value at a scheduled interval.
- Software and Python code, developed by GCMRC scientists, allows for direct communication between water quality sensors and field computers.
- Data values are then packaged into an MQTT encrypted message and published to an MQTT server (ThingLogix Foundry) hosted in AWS using a Python script and cellular connection.



GCMRC IoT Diagram for Water Quality sensor at Glen Canyon Dam



GCMRC IoT Diagram for Water Quality sensor at Glen Canyon Dam

Little Colorado River (LCR) IoT

LCR Fish IoT Site

- The fish pit-tag multiplex antenna connected via cellular data service.
- Serial-radio bridge allows for direct communication between the data logger and field computer at the rim.
- Radio transmission of ~ 2-mile distance & ~3,000 feet up to the rim
- Python script automatically queries the pit-tag data logger and publishes between 500-1200 individual pit-tag scans to the cloud per day
- Data available to researchers via direct downloads and as a visualization in Tableau.

Benefits of IoT Telemetry

- Leverage newer technologies for remote monitoring
- Improved researcher access to perform sensor checks and data downloads (direct login method)
- Data also being sent via encrypted MQTT messages to AWS (automated method)
- Allows for viewing important water quality data in near real-time
- Ability to inform subscribed clients through alerts
- External data download capabilities are now possible through online visualization site

Amazon Web Services (AWS) Cloud to Client Data Workflow

1. Data is sent to ThingLogix Foundry via MQTT encrypted messages and arranged in Foundry by MQTT Topic.
2. Data in Foundry is optionally stored in a PostgreSQL database instance.
3. Postgres database is used as a live link data source for Tableau Desktop data visualization.
4. Tableau visualization is published for external access and shared with stakeholders.

Recent Telemetry Modernization Efforts

2016: SBSC – GCMRC adopts use of cloud-based computing resources through the USGS' Cloud Hosting Solutions (CHS) team on Amazon Web Services (AWS)
2018: Pilot project for CHS on data telemetry using cellular transmission to a cloud-based data brokering client on AWS
2019: Lake Powell reservoir declining levels and related effects to water quality downstream led to redirecting efforts to connecting a water quality sensor located at outflow of Glen Canyon Dam.
2021: Water quality sensors at Lees Ferry and Glen Canyon Dam are connected online and available to USGS researchers / DOI partners
2023: Upcoming installation of first Starlink high-speed satellite terminal at Phantom Ranch Gaging Station

Future IoT Goals

- Increase reliability of field systems and reduce the complexity from original field designs
- Improve power consumption and system uptime, especially at LCR site
- Continue to document field systems and data workflows
- Release data visualizations to the public through USGS policies
- Look to possibly implement LoRa technology along the Colorado River, possibly in Glen Canyon Reach
- Continue to seek collaboration with USGS ASIST initiative for new opportunities

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