Developing a Collaborative Environment for Sharing Geographic Information Systems (GIS) Data Between Reclamation and Irrigation Districts

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Paul D. Martin / Natural Resource Specialist

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14. ABSTRACT
The objective of this research project is to design, develop, and test a pilot collaborative environment between two Irrigation Districts and Reclamation within the Missouri Basin (MB Region). The collaborative environment will utilize ArcGIS Online, ArcGIS Pro, and Field Maps. Through robust testing, the design process, procedural standards, and lessons learned in the implementing stages will be documented and shared with all Regions.

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Peer Review

Bureau of Reclamation
Research and Development Office
Science and Technology Program

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PAUL MARTIN

Digitally signed by PAUL MARTIN
Date: 2023.10.02 14:00:30 -06'00'

Prepared by: Paul D. Martin
Natural Resource Specialist, Bureau of Reclamation

JOSEPH FELGENHAUER

Digitally signed by JOSEPH FELGENHAUER
Date: 2023.10.02 13:52:27 -06'00'

Discretionary Peer Review by: Joseph Felgenhauer
MB/ART Regional Recreation Coordinator, Bureau of Reclamation

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Overview

The question this project attempts to answer is whether a collaborative GIS environment between Irrigation Districts and the U.S. Bureau of Reclamation (Reclamation) Missouri Basin (MB) Regional Office can be developed, transferable data processes be documented, and results utilized to streamline efforts for developing other collaborative environments. These collaborative environments facilitate GIS data sharing. GIS data sharing can help inform decision making, resource management, and planning efforts.

John Nelson, a MB Regional Office employee who is now retired, was this projects' original principal investigator. The Reclamation Columbia Pacific Northwest (CPN) Region and the California Great Basin (CGB) Region inspired Nelson. Both Regions had utilized cloud enabled Environmental Systems Research Institute, Inc (ESRI) GIS products to create collaborative environments with their irrigation district partners. Nelson wanted to apply the use of this technology in the MB Region so he began researching the collaboration capabilities of current ESRI GIS software and web products. Nelson started by conducting preliminary scoping and limited testing with Greenfields Irrigation District (GID) in Montana, and Frenchman Cambridge Irrigation District (FCID) in Nebraska. Based on the positive results of the scoping and testing Nelson was confident that a collaborative GIS data sharing environment could be established between the MB Region and an irrigation district using cloud enabled ESRI GIS products. FCID was awarded a grant to accomplish the establishment of a cloud enabled GIS data sharing environment with Reclamation.

FCID is a political subdivision of the State of Nebraska organized under irrigation district laws of Nebraska on April 18, 1946 (Statutes 46-101 to 46-128). FCID was created to enable the people of southwest Nebraska to develop the State's irrigation potential. FCID delivers natural flow irrigation water to more than 45,600 acres in southwest Nebraska using four different canal systems; we hold 41 direct flow permits with priority dates ranging from December 22, 1890 to November 13, 1987, and can legally divert 531.5 cubic feet per second of natural flow. It is the 8th largest Irrigation District in Nebraska based on acres served.

One hundred fifty-six (156) miles of main canal and many more miles of laterals provide recharge that help stabilize groundwater supplies for municipal, industrial and irrigation uses. Irrigation return flows help maintain Harlan County Reservoir levels. U.S. Department of the Interior, Bureau of Reclamation holds the storage use permits for the same 45,600 acres and has contracts with FCID to deliver supplemental water when the natural flow is inadequate to irrigate the lands. Reclamation Reservoirs also provide flood control and recreation for southwest Nebraska. FCID is also responsible for a percent of the maintenance cost associated with the Reclamation Dams.

This project promotes the use of cloud enabled hardware and software for GIS data access and collection using a smartphone, a Bluetooth GPS receiver, and a desktop computer. Through the effective utilization of this technology the project provides the basic framework necessary to establish a geospatial collaborative environment between Irrigation Districts like FCID, Reclamation, and other organizations. This project also demonstrates the requirements for an organization to transition from using ArcMap to ArcGIS Pro. The GIS collaborative environment developed in this project allows individuals within other organizations to work with Reclamation in a centralized environment, share data, and modify data from a variety of devices. Reclamation and irrigation districts using this technology will be able to share GIS data in near real time, in a standardized format, as the data is collected or updated. The project results could be applied within

the MB Region to most projects that have a geospatial component, inform plans to implement future collaborative environments between Reclamation and Irrigation Districts, and provide insights improving how Reclamation collaborates with its partners.

Objective

Cloud technology, servers accessible over the internet and software and databases that run on those servers, recently became available for use by government agencies. ESRI technology and software in this project utilize the cloud through applications like ArcGIS Pro, ArcGIS Online (AGOL), and the Field Maps application providing an ideal environment for collaboration. The main goal for this project is to use this technology to build a collaborative environment where an Irrigation District and Reclamation can collect and share geospatial data. To achieve this goal FCID will need to learn how to use the technology and then implement it into their business workflows. After creating and testing the collaborative GIS data sharing environment, the processes, and standards FCID implements in the project will be documented. Other goals of this project are for FCID to develop standardized schemata for two of their assets, for FCID to develop a standardized workflow to collect field data in the schemata describing those assets, for FCID to use ArcGIS Pro to conduct quality assurance and quality control of the data, to transfer and share the data to a collaborative AGOL group between Reclamation and FCID, and to develop an ESRI web map application for visualization and analysis of FCID data.

Scope of Work

Throughout the project the principal investigator will meet with FCID periodically to discuss progress. The first step will be for FCID to obtain and install the ArcGIS Pro software and set up their AGOL organizational account. The next step will be to establish a collaborative environment between FCID and Reclamation using a collaborative AGOL group. The following steps need to be taken to accomplish creating a collaborative group: log into AGOL, create a group, and in the settings of that group enable outside organizations to join. This may require elevated AGOL privileges. A Reclamation GIS Data Manager has administrative rights to configure these AGOL settings. FCID will then develop two schemata.

Two new Hosted Feature Layers (HFL) will be created using the FCID schemata and shared with the collaborative AGOL group. HFL's are web enabled and easily shareable GIS data layers that are stored in the cloud (AGOL). The next steps are to migrate any existing FCID GIS data to the new schemata, upload and share the data to AGOL, enable the two new HFL's for use on mobile devices for field data collection, train on the use of GIS software and applications, connect to an external Bluetooth enabled Global Positioning System (GPS) using a mobile device, and use Field Maps to conduct field data collection using the two new HFL's. Once the data is collected it will be displayed in AGOL for Reclamation and FCID to use. The data will also be used by FCID to develop a web application in which the data can be viewed by FCID and its partners.

The last step will be to create the final report containing a collaboration options matrix with cost estimate description, documentation of the steps taken, various costs of the project, and share it with other irrigation districts. This will include pricing for software, identifying collaboration capabilities with associated benefits, minimum hardware and software requirements, costs of varying ESRI license levels, and the HFL schemata.

Security and Access Considerations

Data shared in AGOL between Reclamation and external collaborators will have different security and access restrictions depending on the sensitivity of the data. Recently, AGOL was rated Federal Information Security Act (FISMA) moderate, meaning AGOL can now store Controlled Unclassified Information (CUI), which includes Personally Identifiable Information (PII). According to Reclamation Manual Directive and Standards SLE 02-01 CUI can only be shared with those who have a need-to-know purpose, a determination made by the authorized holder of the CUI. The authorized holder of the CUI data should determine and specify the correct handling and access required for that data. A non-disclosure agreement may be necessary in certain circumstances. No FCID CUI data was generated or used in this project. No Reclamation CUI data was used or created in the project.

External collaborators do not have direct access to Reclamations' GIS data stored in AGOL, unless Reclamation shares that data with them. Creating an AGOL account for sharing data between partners and Reclamation can be done either by the Region or Area Office GIS Data Manager. The Bureau of Reclamation GIS (BORGIS) system administrators can also assist with this task. An AGOL Collaborator Data Use Agreement form will need to be filled out by all parties in the collaboration. This agreement needs to be submitted to the BORGIS system architect and approved before an AGOL collaboration is established between Reclamation and an outside organization.

Requirements

Schemata

Table 1 - Observation Well Project

#	Field Name	Field Description	Data Type
1	Canal Name	• Meeker-Driftwood Canal • Red Willow Canal • Bartley Canal • Cambridge Canal	Text 255, Domain
2	Condition of Pip/Well	• Good • Fair • Poor • Broken • Missing	Text 255, Domain
3	Code	Extra field for condition code.	Text, 255
4	Inspector	Name of the person collecting the data.	Text, 255
5	Tapedown	Height measurement when measuring tape is in the well.	Text, 255
6	Remarks	Comments the inspector may have.	Text, 255
7	Date and Time	The date and time the data was collected.	Date
8	Cut	Water level on the tape as evidenced by the wet chalk mark.	Text, 255
9	Water Level	The Tapedown height minus the Cut from the top of pipe.	Text, 255
10	Photos and Files	For collecting a photo of the feature or uploading a file.	Attachment

Table 2 - Old Cambridge Canal Wells

#	Field Name	Field Description	Data Type
1	ID	Well identification number.	Number, 2 Decimals
2	Location	Description of where the well is located.	Text 255

Table 3 – Canal Layers

#	Field Name	Field Description	Data Type
1	DNRUSE	For Department of Natural Resources use.	Text 255
2	FOOTN	Length in Feet.	Text 255
3	PLAN	Internal plan reference field.	Text 255
4	LEGAL	Legal description.	Text 255
5	SUB	Sub description.	Text 255
6	SECTION	Public land survey section number.	Number, 2 Decimals
7	TWN	Public land survey township number.	Number, 2 Decimals
8	RNG	Public land survey range number.	Number, 2 Decimals
9	RDIR	Public land survey range direction number.	Number, 2 Decimals
10	CANAL	Canal Name.	Text 255

Recommended Hardware and Software

Table 4 - Software Pricing*

ESRI License Level/Software	Hardware (Same for all license levels)	Cost/Benefits	Collaboration Capabilities
Basic: ArcGIS Pro Basic ArcGIS Online subscription Essential Apps: -ArcGIS Instant Apps -ArcGIS StoryMaps -Map Viewer -ArcGIS Dashboards -Scene Viewer -ArcGIS Web AppBuilder -ArcGIS Hub Basic -ArcGIS for Power BI -ArcGIS AppStudio -ArcGIS Experience Builder -ArcGIS Maps for Adobe Creative Cloud -ArcGIS Earth Field Apps: -ArcGIS Collector -ArcGIS Field Maps -ArcGIS QuickCapture -ArcGIS Survey123 -ArcGIS Workforce Office Apps: -ArcGIS for Excel -ArcGIS for SharePoint Compatibility with add-on apps like the following: -ArcGIS Navigator, ArcGIS Business Analyst, ArcGIS Insights, ArcGIS Drone2Map -500 Credits	**CPU:** -Minimum: 2 cores, simultaneous multithreading -Recommended: 4 cores -Optimal: 10 cores Platform: x64 Storage: -Minimum: 32 GB of free space -Recommended: 32 GB or more of free space on a solid-state drive (SSD) Memory/RAM: -Minimum: 8 GB -Recommended: 32 GB -Optimal: 64 GB or more Dedicated (not shared) graphics memory: -Recommended 4 GB or more -If you're using a notebook computer with an integrated GPU, consider increasing the system RAM to compensate for the use of shared memory. Visualization cache: -The temporary visualization cache for ArcGIS Pro can	**Cost:** $765.00/year **Benefits:** -Map, visualize, analyze, and manage data with ArcGIS Pro -Combine 3D, CAD, imagery, and other types of data on a single map -Connect people and data with ArcGIS Online and ArcGIS Living Atlas of the World	-Will be able to create an ArcGIS Online group and join another organizations AGOL group to set up a collaboration to share data. - The most affordable option. Will allow one mobile worker, at a time to collect field data using a mobile device (more mobile workers can be added on at additional cost per field worker). One person at a time will be able to use ArcGIS Pro. Limited data analysis tools available. -May need to purchase more service credits as content uploaded to AGOL increases.

ESRI License Level/Software	Hardware (Same for All)	Cost/Benefit	Collaboration Capabilities
Standard: ArcGIS Pro Standard ArcGIS Online subscription Essential Apps: -ArcGIS Experience Builder -ArcGIS Instant Apps -ArcGIS StoryMaps -Map Viewer -ArcGIS Dashboards -Scene Viewer -ArcGIS Web AppBuilder -ArcGIS Hub Basic -ArcGIS for Power BI -ArcGIS AppStudio -ArcGIS GeoBIM -ArcGIS Maps for Adobe Creative Cloud -ArcGIS Earth Field Apps: -ArcGIS Collector -ArcGIS Field Maps -ArcGIS QuickCapture -ArcGIS Survey123 -ArcGIS Workforce Office Apps: -ArcGIS for Excel -ArcGIS for SharePoint -500 Credits	consume up to 32 GB of space, if available, in the user-selected location. By default, the visualization cache is written to the user profile's \Local subfolder, so it does not roam with the user profile if roaming profiles are enabled by your system administrator. DirectX*: -Minimum DirectX 11, feature level 11.0, Shader Model 5.0 OpenGL*: -Minimum OpenGL 4.3 with the ARB_clip_control and EXT_texture_compression_s3tc extensions -Recommended: OpenGL 4.5 with the ARB_shader_draw_parameters, EXT_swap_control, EXT_texture_compression_s3tc, and EXT_texture_filter_anisotropic extensions Screen resolution: -Minimum: 1024x768 -Recommended: 1080p or higher View ESRI website for latest updates on hardware: https://pro.arcgis.com/en/pro-app/latest/get-started/arcgis-pro-system-requirements.htm	**Cost:** $3,025/year **Benefits:** -Everything that is included with GIS Professional Basic user type -Data editing capability and ability to edit multiuser geodatabases -Ability to automate quality control such as managing workflows	-Will be able to create an ArcGIS Online group and join another organizations AGOL group to set up a collaboration to share data. -Can have multiple users editing the data. -May need to purchase more service credits as content uploaded to AGOL increases.
Advanced: ArcGIS Pro Advanced ArcGIS Online subscription Essential Apps: -ArcGIS Instant Apps -ArcGIS StoryMaps -Map Viewer -ArcGIS Dashboards Scene Viewer: -ArcGIS Web AppBuilder -ArcGIS Hub Basic -ArcGIS for Power BI -ArcGIS AppStudio -ArcGIS Experience Builder -ArcGIS GeoBIM -ArcGIS Maps for Adobe Creative Cloud -ArcGIS Earth Field Apps: -ArcGIS Collector -ArcGIS Field Maps -ArcGIS QuickCapture -ArcGIS Survey123 -ArcGIS Workforce Office Apps: -ArcGIS for Excel -ArcGIS for SharePoint -500 Credits		**Cost:** $4,150/year **Benefits:** -Everything included with GIS Professional user type standard -Advanced GIS data analysis, modeling, and high-end cartography -Extensive data and database management capabilities	-Will be able to create an ArcGIS Online group and join another organizations AGOL group to set up a collaboration to share data. -May need to purchase more service credits as content uploaded to AGOL increases.
Esri Mobile Worker Subscription (for collecting field data): Location Sharing User Type Extension Field Apps: -ArcGIS Collector -ArcGIS Field Maps		**Cost:** $385/1 worker/year **Benefits:** --Edit existing data and add new data	-The Mobile Worker user type is for those within the subscription who collect data, manage field assignments,

-ArcGIS QuickCapture -ArcGIS Survey123 -ArcGIS Workforce -ArcGIS Online: view content and edit layers -ArcGIS Living Atlas of the World Essential Apps (view content and edit layers) -ArcGIS Instant Apps -ArcGIS StoryMaps -Map Viewer -ArcGIS Dashboards -Scene Viewer -ArcGIS Web AppBuilder -ArcGIS Hub Basic -ArcGIS Experience Builder -ArcGIS Maps for Adobe Creative Cloud -ArcGIS Earth Office Apps -ArcGIS for Excel -ArcGIS for SharePoint -250 credits		-View your team's private maps and apps -Use field apps for real-time data collection, tasking, and operations	inspect assets, survey, and share their location. Mobile Workers connect the field to the office using apps such as ArcGIS Collector, ArcGIS Field Maps, ArcGIS Survey123, and ArcGIS Workforce for real-time data collection, tasking, and operations. Typical job titles of those with a Mobile Worker user type include maintenance foreman, field technician, and volunteer.

*All information in the table obtained from the ESRI website. 2023 prices shown. Pricing changes over time.

Table 5 – Hardware Pricing*

Item	**Price**
Trimble Catalyst DA2 Receiver	$415.00
Trimble Catalyst GNSS Antenna Handle	$170.00
Trimble External USB Power Pack, Li-Ion, 5000mAh, 1ft USB cable	$36.00
Trimble Catalyst Pouch	$30.00
Trimble Annual GNSS Subscription	$445.00
Seiler (non-Trimble company) MGIS Tier 2 Tech Support	$295.00
Computer - Dell Precision 3431 Small Form Factor	$1654.84
Two (2) Dell Monitors (24 inch)	$324.98
Four (4) Adapter Cables	$41.24
Total Cost	**$3,412.06**

*Prices of Trimble products are from Trimble, Inc. Trimble product prices vary by purchase location and year.

Table 6 – Trimble Subscription Plans*

Plan	**Accuracy**	**Price**
Catalyst 1	1 CM	$430/Month
Catalyst 10	10 CM	$250/Month
Catalyst 30	30 CM	$150/Month
Catalyst 60	60 CM	$50/Month

*Prices of Trimble products are from Trimble, Inc. Trimble product prices vary by purchase location and year.

There are many Bluetooth GPS receivers available on the market. Some are cheaper or more expensive than the option used in this project. An organization considering buying one of these receivers should determine what product works best based on their business and technical needs. The Trimble Catalyst DA2 receiver was the receiver used for this project. There is an optional (for purchase) carbon fiber extension pole on top of which the receiver can be installed for improved accuracy. The Catalyst DA2 receiver is a compact, lightweight GNSS receiver that provides professional-grade positioning information to any connected mobile device using Bluetooth

connectivity. The receiver is capable of centimeter to sub meter accuracy. GNSS subscription options are flexible allowing a user to purchase increased accuracy capability for their receiver (see Table 6). The subscription plan used in this project was Catalyst 60, a GPS locational accuracy of 60cm. ESRI Field maps is an application that allows users in the field to access and edit existing GIS data or collect new data. The application has an intuitive interface allowing users to easily navigate and edit fields of information within their data. The application will also help users to navigate to features by giving driving directions. Use of Field Maps is available after purchase of an ESRI subscription (see Table 4).

Results

Greenfields Irrigation District was originally intended to be a participant in this project, but due to limited staffing and time they were not able to participate. FCID was the only irrigation district involved in this project. Before this project FCID was using ArcGIS Desktop with an ArcView license level, and a handheld Garmin GPS to collect geospatial data in the field. ArcView is the basic license level of ArcGIS Desktop, an older GIS software program. In April 2023 ESRI announced ArcGIS Desktop will no longer be supported by ESRI after March 1, 2026. ESRI is recommending their customers transition to ArcGIS Pro, which is the newer version of ArcGIS Desktop. Reclamation is currently transitioning from ArcGIS Desktop to ArcGIS Pro. The Garmin GPS that FCID was using was a simple handheld GPS unit that could record GPS information in the field and output the data in an ESRI shapefile format. The Garmin was an older GPS unit with a cumbersome user interface, and was not able to connect to internet applications, which for the purposes of this project would not suffice.

First an AGOL group was created in the Reclamation organization. The settings of that group were configured to allow outside organization members to be added to the group, by invitation only. Reclamation then invited FCID to that group by searching for FCID's organization account. The collaborative group was then ready for use by Reclamation and FCID. FCID started by purchasing the necessary computer hardware (see Table 5) to run the ArcGIS Pro software on it. Next FCID reached out to ESRI and obtained a quote and purchased an ESRI annual basic license level subscription with a mobile worker subscription (see Table 4). FCID then took introductory virtual GIS training (free through ESRI license subscription purchase and free YouTube tutorials) on how to use ArcGIS Pro, AGOL, and the Field Maps application. FCID proceeded with the purchase of a Trimble Catalyst DA2 GPS receiver and accessories. FCID identified two main categories assets (represented in three tables, two of which represent the same asset type) for the development of data models or schemata (see Tables 1-3). These two categories were canals and water wells.

To create the schemata for canals and water wells FCID used ArcGIS Pro to create layers in a geodatabase and then used the table edit functionality to create the schemata (data fields) for those layers. FCID then shared (published) the two layers to their organization AGOL account. The two HFL's created were called "Old Cambridge Canal Wells" (point geometry type) and "Observation Well Project" (point and line geometry type). The Observation Well Project HFL contained canals, roads, and water wells. The Observation Wells Project layer was created to capture new well data and had no historical data in it. The Old Cambridge Canal Wells layer consisted of points indicating where water wells are located along the Old Cambridge Canal. This layer consisted of historical FCID GIS data developed using ArcGIS Desktop. FCID shared these two (HFL) layers to the collaborative AGOL group. In the last step before collecting field data FCID conducted some tests outside their office making sure they could access their data in AGOL from within the Field Maps application and the GPS receiver was working properly with their mobile device.

The irrigation district used a Trimble Catalyst DA2 GPS receiver that connected using Bluetooth to a smartphone. The FCID mobile device (an Android smartphone) had the ESRI Field Maps application installed on it. This application used the Trimble GPS receiver as an external antenna to increase the accuracy of the coordinate data collected. The coordinate data was collected using the Field Maps application, not solely using the Trimble GPS receiver, as the receiver has no user interface. The Trimble GPS receiver increases the locational accuracy of the coordinate information obtained while interfacing with the mobile device. The data was collected and stored in two HFL's saved in the web map, which was accessible through the Field Maps application. For the Old Cambridge Canal Wells HFL layer that already had spatial locations, FCID inputted and updated the data where necessary while in the field. FCID collected new features in the Observation Wells HFL. Both the hosted feature layer and web map were created by FCID. If there was internet connection while collecting data in the field, the data was either uploaded immediately to the hosted feature layer or stored on the mobile device for upload later when there was internet connection. The data was collected by walking to the assets in the field and either standing near the feature with the Trimble GPS receiver or putting the receiver directly over, or on top of the feature. When the Trimble GPs receiver was in position the user interacted with the Field Maps application by tapping their finger on the mobile device screen to select the feature collect button, which then initiated the collection of point, or line feature data.

The data management workflows consisted of storing working copies of the standardized data sets within the irrigation district's AGOL organization account and sharing them with the collaborative group Reclamation created. This only needed to be done once. Although the shared data was stored in standardized HFL's to ensure data integrity with respect to security (FISMA Low) the GIS data shared with Reclamation was backed up by the irrigation district either on an external hard drive or some other safe save location to mitigate the potential risk of the data disappearing from AGOL. Likewise, any Reclamation data shared with the irrigation district was backed up outside of AGOL. After collecting the data FCID created a web application to display the data. FCID used several tools in their web application: measurement tool for measuring distances, a legend, and a full screen and minimize functionality. The web application can be shared with project partners by sharing a HTML web link.

No problems were encountered in during the technology set up phase of the project. FCID did encounter issues with staffing and was unable to collect much field data. FCID only had one person available to carry out all the project tasks, and that person was a manager with many other responsibilities to balance. FCID was planning on having a student intern help collect GIS data, but the student intern was not available to assist. Despite this set back FCID was still able to collect some field data and accomplish all of the project objectives. FCID was able to implement a very simple quality assurance and quality control (QA/QC) workflow to review the data they collected in the office where they reviewed the new feature attributes to make sure the information was correct. FCID was not able to populate basic metadata for the data collected due to a lack of time, understanding of what metadata is, and how to populate create it. This is something that FCID can and should address in the future. Another item that should be addressed is a data management schedule to ensure the data is actively managed and stays up to date.

A briefing was conducted with FCID after the project was completed. During this briefing the hosted feature layers, web application, web maps, project costs, and project feasibility were reviewed and discussed. FCID stated the project benefited them enabling the district to better communicate and share its data with other agencies and its customers through public data sharing, and a web application to showcase the data (see Appendix A). The results of this project could be applied across all of Reclamation to projects with irrigation districts that have a geospatial component. The

results of this project will be publicly available to irrigation districts in the Reclamation Information Sharing Environment (RISE). The two FCID HFL's can be used for analysis, visualization, or used to locate FCID assets in the field. The data collected can be viewed in near real time in the web map while in the office using AGOL to view the web map. This type of collaborative environment allows individuals within different organizations to work in a centralized environment, share data, and modify the data from a variety of devices.

Not only does this collaborative environment modernize the dated GIS technology FCID was using but also allows them to better communicate with project partners, customers, and meet state reporting requirements. FCID data can also be incorporated into a Reclamation Enterprise system such as RISE and BORGIS to be used by Reclamation and the public.

Implementation of a Collaborative Environment for GIS Data Sharing with Other Irrigation Districts

The impacts of this project could have a positive impact on the way Reclamation does business. It provides the basic framework necessary to establish a geospatial collaborative environment between Irrigation Districts, Reclamation, and other organizations. This can allow for faster sharing of higher quality GIS data between Reclamation and project partners that can be used to better inform high level agency decisions. The project promotes the use of new technology for field data collection and access to the data using tablets, phones, and desktop computers. Using the accompanying PDF document other irrigation districts can follow the guidance to set up a cloud enabled GIS for their office and work with Reclamation to create a collaborative data sharing environment. From the Reclamation side GIS specialists can find and complete the required form prior to following the directions for creating a collaborative AGOL group. If Reclamation chooses to pursue establishing AGOL collaborations with irrigation districts it would help meet Reclamation's mission statement by implementing innovative, sound business practices with timely and cost-effective, measurable results while working with Reclamation's customers and stakeholders to achieve mutual objectives.

Workload and Staffing Implications

To manage and maintain irrigation district data requires staff, funding, and time. The recommendation is that an irrigation district have at least one full time employee available to collect GPS data in the field during field season, QA/QC the data in the office, create web maps and applications to display the data collected, and ensure the data is shared with the appropriate partners (federal and state). This workload is expected to be a full-time duty during field season. There are more benefits if an irrigation district can employ two workers to collect field data: more data can be collected, they can take turns collecting the data offsetting the risk for burnout from too many field hours, one worker can use office days for managing the data (populating metadata and QA/QC checking for errors) while the other worker collects the data in the field. Outside field season the data will need to be managed and analyzed using ArcGIS Pro allowing the possibility for productive insights to come from authoritative information. These insights can help inform project planning and resource management.

Lessons Learned

Lessons learned from this research project include:

- Limited time, staff, and budget at some irrigation districts making it challenging to implement cloud enabled GIS data sharing infrastructure.
- Recruiting and retaining staff at some irrigation districts may be a challenge.
- Cloud enabled GIS requires a lot of training through learning new technology and techniques. It can be a steep learning curve - interested irrigation districts must be willing and able to undertake the effort.
- Obtaining funding for projects like this can be challenging when government contracting staff and time are limited.
- The future ability to access irrigation district water data in real time-or near real time.
- It is imperative that data management workflows are implemented on a Reclamation-wide scale to facilitate the future acquisition and storage of partner GIS data.
- In order increase the value of data GIS metadata standards need to be implemented within Reclamation and the same should be promoted, when necessary, with project partners while collaborating to share GIS data.
- Standard data schemas can be used by multiple irrigation districts and be incorporated seamlessly into Reclamation Enterprise Data.
- Irrigation district data created and managed using cloud enabled GIS technology can be beneficial to Reclamation and irrigation district operations.

Team Members, Partners, Contributors, and Reviewers

Table 4 - Project Members

Name	Role	Mail Code
John Nelson (Retired)	Original Principal Investigator: Developed the original project proposal.	MB-4200, (406) 247-7746
Paul Martin	Current Principal Investigator: Facilitated completion of the project.	MB-4200, (406) 247-7722
Brad Edgerton	Frenchman Cambridge Irrigation District: Project partner.	(308) 697-4535
Joseph Felgenhauer	Reclamation Peer Reviewer: Provided a discretionary review of the final report.	MB-4200, (307) 261-5697

Appendix A

Frenchman Cambridge Irrigation District

Dale Cramer,President
Todd Lichty, Vice Pres.
Duane Vorderstrasse, Sec. / Treas.
Brad Edgerton, Manager

"Water is Life"

www.fcidwater.com

September 12, 2023

Paul Martin
Regional GIS Data Manager
Natural Resource Specialist
U.S. Bureau of Reclamation

Dear Mr. Martin

I wanted to take a moment to share with you the incredible benefits I have gained from my recent training in ESRI's ArcGIS Pro and ArcGIS Online, and how these tools can revolutionize the way we manage and enhance the data and mapping of our irrigation district's infrastructure and Water right permits.

First and foremost, the training in ArcGIS Pro has significantly improved my ability to create detailed and accurate maps of our irrigation district's infrastructure. I can now easily visualize and analyze various aspects of our infrastructure, such as the location of pipelines, pumps, valves and observation wells. This enables us to make more informed decisions about maintenance and repairs, leading to cost savings and increased efficiency.

ArcGIS Online has been equally instrumental in transforming the way we manage our data and share information. With the cloud-based platform, we can now access our maps and data from anywhere, facilitating collaboration among team members.

GIS maps and dashboards can be used to engage with our stakeholders, including farmers and government agencies, and County Officials, providing them with transparent access to information about our operations and water distribution and State permitted acres.

Incorporating GIS into our daily operations will not only enhance our decision-making processes but also contribute to the long-term sustainability of our irrigation district. I am excited about the possibilities that lie ahead and look forward to discussing how we can implement these GIS technologies to benefit our organization further.

If you have any questions, I am more than willing to provide additional information.
Thank you for your time with this project and I can update you going forward on new ways that FCID can utilize GIS within our irrigation district and improve our infrastructure management.

Sincerely,

Brad Edgerton, Manager
Frenchman Cambridge Irrigation District

Frenchman Cambridge Irrigation District, 1310 West Highway 6 & 34, P.O. Box 116, Cambridge NE 69022
Phone (308)697-4535, Fax (308) 697-3218, Toll Free (800) 841-0419, Email: FCID@fcidwater.com