Appendix B: GIS Program Workflow Examples

This appendix contains detailed examples of projects the GIS program has facilitated, oversees on an ongoing basis, or completed in the past five years. Projects have been selected because they highlight a representative workflow or represent the accomplishment of an important goal. Most examples are system-wide applications, but there are several that are unique to a specific watershed. There are also many operational sections which are independently completing excellent GIS work; their work is not included here unless otherwise noted.

Interactive Access Map
A collaborative effort with Interpretive Services and Management developed an interactive public access map for the Quabbin Watershed. The primary goal was to clearly define allowed areas of public access and what activities can occur in those locations. The map highlights access gates and clearly spells out access rules/regulations, displays DWSP roads and

Software used - Basic Viewer, ArcGIS Pro, Field Maps, Web AppBuilder.

trails where public access is allowed, defines allowed uses (e.g., bicycle, hiking, cross country skiing, etc.), display fishing areas (including Boat Launch Areas and shoreline fishing access), and clearly defined prohibited areas and activities. Points of interest around the watershed are highlighted to demonstrate locations interest, such as landmarks, parking areas, the QVC, and cemetery. Input from other sections was critical in ensuring that displayed information was correct; Watershed Rangers manage the Gate Inventory layer, while Interpretive Services, Forestry and Engineering staff were key players in ensuring the trail and road inventory was accurate.

This interactive map became an important way to communicate access information to the public with the onset of COVID in March 2020. A splash screen appears each time the map is visited, allowing DWSP to provide the public with up-to-date information about important closures, notices, etc. Over 35,000 users have visited this app to find information about trails use in the Quabbin (Figure A-1). A unified public access app for all four watersheds is planned to replace the Quabbin specific version.

As part of this project, it was necessary to create a system-wide Trail & Road Inventory for use in internal and external online applications. See *Trail Inventory and Unauthorized Trail Monitoring* for additional details on this portion of the project.
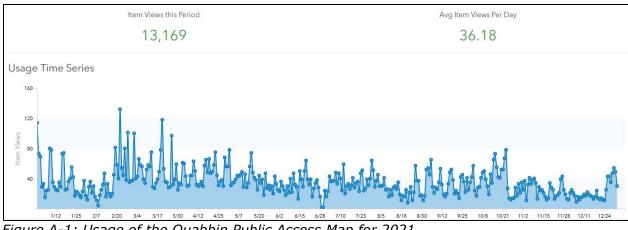
Figure A-1: Usage of the Quabbin Public Access Map for 2021.

Trail Inventory and Unauthorized Trail Monitoring

The Quabbin Public Access Viewer was the inspiration to create an improved Trail & Road Inventory for use in internal and external online applications. An upgraded, more detailed data schema was developed to apply to DWSP data through a collaboration with DCRS; this set-up leaves open the opportunity for future intra-agency collaboration on a statewide trail application. Creating a series of layers in ArcGIS Online allowed staff to edit the data easily in a variety of ways, including ArcGIS Pro and Field Maps. Edits appear in real-time in the public version of this layer. Custom coding created a detailed and informative pop-up window that clearly defines what is and is not allowed on any trail or road on DWSP property. This detailed data is now available for all DWSP watersheds.
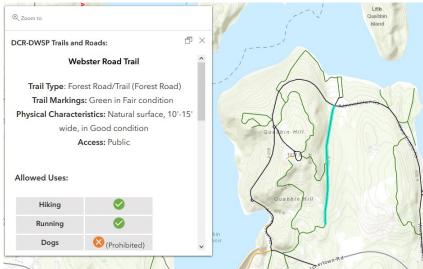
Software used - ArcGIS Pro, Field Maps and Web AppBuilder.

Figure A-2: Example of pop-up for Webster Road Trail in Quabbin Park. Allowed uses are clearly defined using icons.
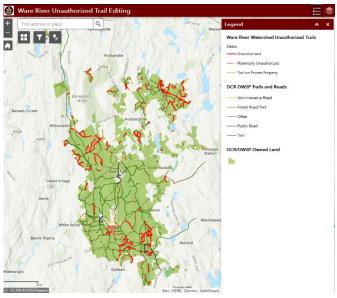
Figure A-3: Locations of unauthorized trails within the Ware River Watershed. Ranger staff can use iPads and Field Maps to collect and update information while in the field. All information can be viewed in the office via a web application.

It was important within the Ware River to facilitate the monitoring of unauthorized uses of both legal and illegal trails throughout the watershed. Watershed Ranger and Forestry staff track these uses through a series of attribute fields which are specifically designed to deal with unauthorized trails. In addition, it is possible to keep track of "re-visits" to unauthorized trails to keep a log of status changes over time. Collecting this data assures MassDEP that DWSP is meeting its obligations to monitor and manage public access and unauthorized used within the Ware River watershed. This information is only visible to internal staff and is not available to the public.

Hunting Access and Controlled Hunts

The Natural Resources section wanted to communicate clear and concise hunt information while also allowing hunters to see and explore where they can hunt. This goal was accomplished through the use of online viewers, providing the public with a system-wide hunting application, and two controlled hunt applications for Quabbin and Wachusett. These apps can be used in a web browser

Software used - Basic Viewer, ArcGIS Pro and Field Maps.

on any computer or mobile device; instructions are provided to hunters which also allows them to take advantage of Field Maps to see where they are on a map while scouting potential hunting locations. These initial programs are expected to migrate into a more modern-looking, unified "*Sportsman experience*," which will combine the various applications together into one place and also include fishing opportunities.

Creation of these applications was led by Natural Resources staff, but also required the assistance of various sections to ensure that data was correctly presented. Ranger staff curate and maintain the Parking and Access layers, while GIS staff maintains the Huntable Land and Setbacks layers. Reference data, such as stonewalls, is provided by Foresters, while public authoritative data from MassGIS is also leveraged when possible. Natural Resources staff provide oversight to ensure that the correct information is included and shared with the public.

Beaver Activity Monitoring

The Beaver Activity Monitoring workflow is representative of field data collection processes established by DWSP. Natural Resources staff can now use field data collection apps to monitor beaver activity, record trapping and removal locations, and record trapped/removed beaver biological information throughout the watershed system.

Software used - Field Maps, Survey123 and Dashboards.

Integrating Field Maps and Survey123 provides both a map-centric view (Field Maps) and form-centric data entry of (Survey123). This set-up enables information to be passed from the Trapping & Removal Sites layer in Field Maps to the Beaver Biological Data form, ensuring that data records are properly and effortlessly connected.

A Dashboard provides a map and summaries – as tables, indicators, and charts – which can be used within annual reports. The Dashboard is configured to display all collected information but can be filtered by date ranges, providing the flexibility to generate custom summaries going back to fall 2017. Staff can also quickly and easily export data summarized within tables and charts to CSV files for further analysis or reporting.

Information gathered using these field data collection tools can also easily be accessed in desktop GIS for editing or additional analysis. For example, beaver data can be used to visualize trends in active beaver sites over time, which could help identify "hot spots" that would be candidates for mitigation efforts.
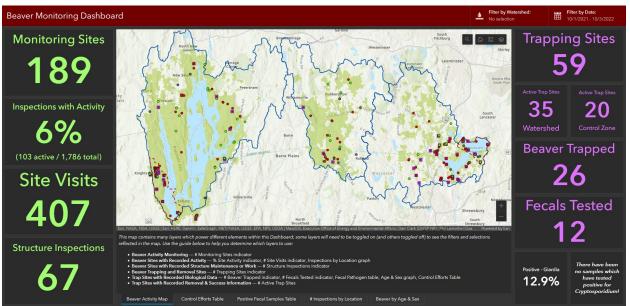

Figure A-4: This Dashboard provides NR staff with a quick operational picture of beaver activity throughout the watersheds. Using this, NR staff can easily generate reports, and to summarized statistics from their collected data.

Watershed Protection Act Database Migration

The goal of this project was to provide Environmental Planning staff with a unified Watershed Protection Act (WsPA) database that can be easily managed using tools available through ArcGIS Online. The key objective was to migrate regional non-spatial WsPA databases into a unified, functional, spatial database that provides Planning staff with new tools for data management, data exploration, and reporting.

Software used - ArcGIS Pro, Field Maps, Survey123, Dashboards, StoryMap Collections, Experience Builder, SharePoint and Power Automate.

Data quality controls – utilizing domains, constraints, calculations, and custom code – ensure that no duplicate file numbers can be entered, that all address questions have a reverse geocode "search" capability, and related projects within a 0.5 mi radius can be easily located. A data entry form integrated with Experience Builder facilitates the capture of the filing parcel boundary and attribute information from authoritative MassGIS parcel data ensuring that the original filing boundary is maintained in DWSP records. Power Automate is used to automatically create a new folder in SharePoint for storage of project files when a new WsPA file is entered, as well as to send a series of automatic email reminders as a filing nears decision deadlines.

This workflow combines Survey123 with a Dashboard to provide staff an efficient interface for managing the database. The "Data Update" Dashboard offers various filters for searching the database and the ability to easily determine what information is missing from an incomplete file. This internal workflow also has a "read only" version to share with associated staff that do not regularly handle WsPA applications. The "Data Exploration" Dashboard provides all staff the ability to query the database for reporting purposes. Using Survey123 as the "front end" of this new database has DWSP well-prepared for the eventual change to electronic submittal of WsPA applications.
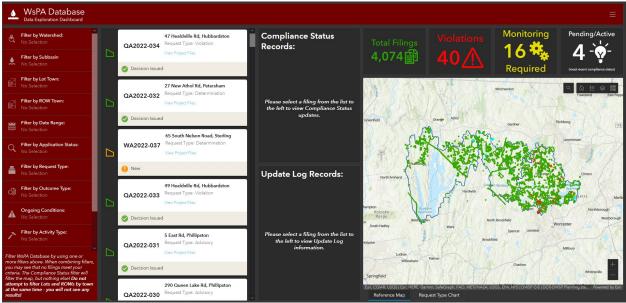

Figure A-5:WsPA Data Exploration Dashboard allows staff to use filters along left to answer questions about WsPA data for various purposes, including for EQA, quarterly and annual reports.

A Return on Investment (ROI) was written at the completion of this project; this highlights the significant savings in staff time from the Access data base and paper-based workflow (at 675 hours annually) to the ArcGIS Online-based workflow (at 150 hours annually). This savings in staff time is an additional bonus to the many other tangible benefits of this workflow migration mentioned above.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)				
			Current workflow	
Hours to complete current workflow	9.0	*Time to complete the current workflow once.*	cost	$315.00
Hourly wage rate*	35.00		Current annual cost	$23,625
Annual occurrence of workflow	75			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhanced Workflow Costs				
			Enhanced workflow	
Hours to complete workflow after enhancement	2.0	*Time to complete the enhanced workflow once.*	cost	$70.00
Hourly wage rate*	35.00		Enhanced annual cost	$5,250
Annual occurrence of workflow	75			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhancement Production Costs and Savings				
Hours to complete enhancement	108.0		Enhancement cost	$3,780.00
Hourly wage rate*	35.00		Initial Annual Savings	$14,595
Annual maintenance costs of enhancement, if any	$0.00		Future Annual Savings	$18,375
Projected ROI				
			Initial Year ROI	120%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost			**Future Annual ROI**	203%

Figure A-6: A completed Return on Investment (ROI) study for this workflow migration clearly shows savings in staff time that were introduced once the new workflow was adopted.

Land Acquisition Panel StoryMap

The Land Acquisition Panel (LAP, Section 4.1) keeps up with the fast-paced real estate market, confidentially assessing potential acquisitions on an ongoing schedule. Historically LAP met in person and reviewed cases presented on printed maps. It was decided in mid-2020, as the COVID-19 pandemic forced staff to work remotely, to pivot the review of potential projects to a digital format. LAP now uses ArcGIS Online StoryMaps to review projects prior to every meeting.

Software used - StoryMaps (ArcGIS Online).

Collaboration between the Land Acquisition Program Coordinator and the Wachusett Regional GIS Specialist results in an immersive experience where LAP members can review narrative, facts/figures, interactive maps, and images of proposed acquisitions. Each prospective property receives its own chapter within the StoryMap, which includes a parcel overview, WsPA information, relationship to other DWSP holdings, information on the parcel ranking on the Land Acquisition Model, and details on natural resources on or adjacent to the property.

The LAP StoryMap also allows for archival of projects, including those which are complete, projects which were not selected for potential acquisition by the panel, or projects that never came to fruition. This is useful as a record of parcels which have come in front of the panel and if a project becomes active once more.
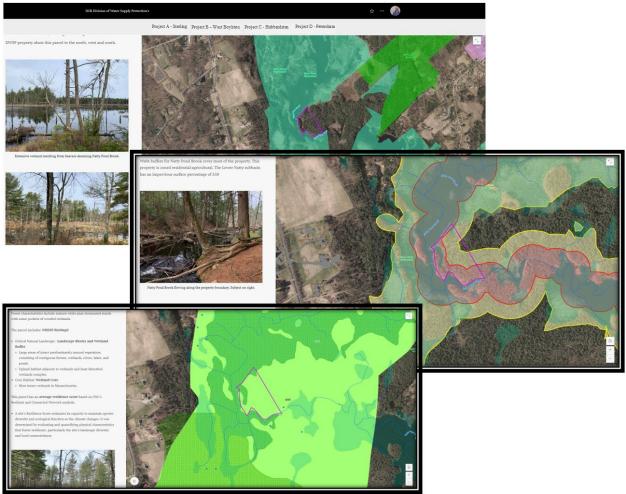
Figure A-7: Mock-up of the Land Acquisition Panel StoryMap.

Watershed Preservation Restriction (WPR) Monitoring

WPR monitoring (Section 4.2) occurs primarily on a bi-yearly basis, except for the annual requirement for parcels acquired through the federal Forest Legacy program. Limited staff availability and a complicated, time-consuming monitoring process had made DWSP behind on monitoring goals. While recruiting additional staff to assist with monitoring efforts, a new workflow was developed that combines field data collection tools (Field Maps and Survey123) and online tools (Web AppBuilder and Survey123 Reports) to streamline the monitoring and report-writing process. The Survey123 form guides staff through the monitoring process and ensure that data is collected consistently and efficiently.

Software used - ArcGIS Pro, Field Maps, Survey123, Web AppBuilder, Tracker and Python.
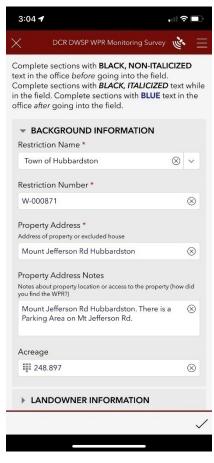
Figure A-8: By entering the restriction name at the top of the form, information about the WPR (blue text) is pulled into the form for monitors to review and update.

The survey form can be completed over time, allowing staff flexibility to enter information before, during, and after a monitoring visit. The monitoring process has been further streamlined by pulling information from past visits into the current form, allowing review and update as needed. This reduces the amount of time staff need to spend on data entry prior to the monitoring visit. Field Maps automatically tracks the monitor's location on the property; this is used within the report's monitoring map that shows the path traveled during a visit. The collected track also provides a historic record to refer to in subsequent years, ensuring that monitors visit different parts of the property on other visits.

A standardized monitoring report can be generated with the click of a button, and monitoring maps are developed using an online application, ensuring consistency regardless of the monitor. Collaboration with colleagues in DCRS ensured the same workflow and monitoring report template were adopted by the Conservation Restriction Monitoring program. All DCR monitoring efforts now result in the same type of report, showcasing agency unity.

This streamlined monitoring workflow is administered through a collaboration between the GIS and WPR programs. This workflow has helped DWSP meet its obligations to bi-annually monitor WPRs. These tools provide the WPR program the ability to quickly address any potential issues or violations of the WPR agreement which could negatively impact water quality.

Watershed Security – Gate Inventory

This project developed a comprehensive gate inventory of all DWSP owned/managed gates throughout the watershed system. The gate inventory is managed and updated on a regular basis by Ranger and Maintenance staff. The workflow was designed allow staff to easily find comprehensive information on gate type, lock details, signage present, and gate/lock conditions. Attribute fields track gate inspections and identify where work is needed to replace signage, locks, and repair gates. Two connected versions of the data are available through ArcGIS Online – an internal version which DWSP staff can edit and a non-editable public version for use in DWSP public access web applications.

Software used - Field Maps, Survey123, Web AppBuilder and Attachment Viewer.

Maintaining a gate inventory in this way ensures that public-facing applications contain up-to-date information on access gates. As soon as updates are made by staff to the inventory, the information becomes available to the public. Providing gate numbers and pictures of the gate

helps visitors know their location while on DWSP properties. This layer is used within all public access applications, including the Quabbin Public Viewer and the various deer hunt maps.

Watershed Ranger Daily e-Log Program
The GIS Program worked with the Wachusett-Sudbury Rangers to transform their tedious and inefficient paper-based daily patrol log into a digital e-log. This process also created a series of useful reporting and management tools to further improve their understanding of where additional ranger presence was required in the watersheds. This workflow migration eliminated the

Software used - Survey123, Dashboards, Python and Amazon WorkSpace.

requirement that hundreds of paper logs be manually entered into Excel to complete weekly and quarterly reports. This not only saves valuable staff time, but it also reduces data entry errors and/or the likelihood that a paper log may be accidentally lost. Using Survey123, Rangers now start one log at the beginning of a shift and add log entries throughout the day. A single log entry can contain one incident and up to three CMR violations (including the number of violations recorded); locations are collected for all incidents and CMR violations. This information is used to quickly generate quarterly reports; individual daily e-logs can also be exported to detailed reports for use in legal proceedings.
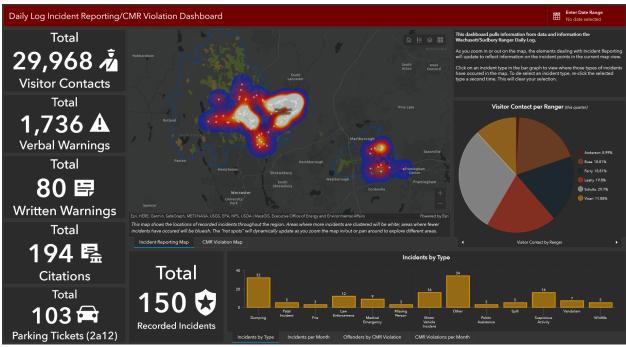

Figure A-9: This Dashboard summarizes all information collected via the e-log. All elements can be filtered by date (upper right corner) to provide users with statistics/details on what occurred within the selected date range.

An "Accountability" Dashboard allows Ranger management to review submitted logs over two weeks to ensure staff are properly completing their logs. An "Incident and CMR Reporting" Dashboard provides all Rangers and regional management with an operational picture of what and where is happening in the region. This presentation includes heat maps of both incident and

CMR violation locations, charts, graphs, and indicators; all content can be filtered by user-specified date ranges. This Dashboard is useful for quickly completing weekly reports as well as allocating limited ranger resources. The goal of increasing Ranger efficiency is less violations and a subsequent increase in groundwater/tributary/reservoir water quality, benefiting DWSP and MWRA management, MWRA ratepayers, and the flora/fauna within each watershed.

A Return-on-Investment (ROI) study for this workflow migrations shows that the initial year savings was 97%, while future annual ROI will be 263% savings, demonstrating that these workflow modernization projects hugely beneficial to the agency. Comparing the paper-based workflow costs (under Current Workflow Costs) with the e-log workflow costs (under Enhanced Workflow Costs), shows significant savings in the amount of staff time required to complete both weekly and quarterly reporting requirements. Ranger staff can now better utilize their time to complete more important tasks. After the success of this project for the Wachusett-Sudbury Region, this same workflow transformation was implemented for the Quabbin-Ware River Region Rangers.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)			
Hours to complete current workflow - *quarterly reporting*	6.0	*Current workflow cost*	$198.00
Hourly wage rate*	33.00	*Current annual cost*	$792.00
Annual occurrence of workflow	4		
Hours to complete current workflow - *weekly reporting*	8.0 *tally of time spent by Ranger captain & 2x lieutenants on weekly reporting*	*Current workflow cost*	$264.00
Hourly wage rate*	33.0	*Current annual cost*	$13,728.00
Annual occurrence of workflow	52	*Current TOTAL annual*	$14,520
Enhanced Workflow Costs			
Hours to complete workflow after enhancement - *quarterly reporting*	0.25	*Enhanced workflow cost*	$8.25
Hourly wage rate*	33.00	*Enhanced annual cost*	$33.00
Annual occurrence of workflow	4		
Hours to complete workflow after enhancement - *weekly reporting*	0.50	*Enhanced workflow cost*	$16.50
Hourly wage rate*	33.00	*Enhanced annual cost*	$858.00
Annual occurrence of workflow	52	*Enhanced TOTAL annual cost*	$891
Enhancement Production Costs and Savings			
Hours to complete enhancement	130.0	**Enhancement cost**	$4,290.00
Hourly wage rate*	33.00	**Initial Annual Savings**	$9,339
Annual maintenance costs of enhancement, if any	$0.00	**Future Annual Savings**	$13,629
Projected ROI			
		Initial Year ROI	97%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost		**Future Annual ROI**	263%

Figure A-10: Return on Investment (ROI) study for Watershed Ranger workflow transformation. This ROI study was only completed at the conclusion of the Wachusett-Sudbury Region workflow migration and does not include savings realized by implementing this same workflow within the Quabbin-Ware River Region.

Boat Seal Program

This project modernized the Quabbin Boat Seal Program, moving it away from a paper-based methodology into a streamlined and time efficient mobile data collection system. There are two main components to this project: first there is the *Boat Seal Tag In/Out Survey and Dashboard* and second there is the *Boat Appointment and Decontamination Survey*.

Software used: Survey123, Dashboards, Python, Amazon Workspace, Power Automate, and SharePoint.

This new system utilizes Survey123 and Dashboards in conjunction with custom Python scripting to power the Boat Seal database to monitor compliance with the Boat Seal Program (maintained by Environmental Quality staff), and a real-time dashboard that can be utilized by Management, Boat Launch Area staff and Watershed Rangers to monitor reservoir usage and the number/names of boaters on the water at each Boat Launch Area (BLA).

A Survey123 form allows attendants at each BLA to enter a new survey response each time a boater enters or exits a BLA. Critical information such as Boater Name, Boat Registration Number, and Boat Seal Number are recorded. Methodology for reducing data entry errors were introduced, the most important being the implementation of a "Boater ID Card" system; this allows BLA attendants to simply scan a boater's card to automatically pull in the correct Name and Registration Number into the form. Each time a survey is submitted, data is sent to a cloud database within ArcGIS Online.

A series of Python scripts were created to download and process data collected by BLA attendants every 15 minutes. These scripts result in data that can be used in a real-time Dashboard. The Quabbin Reservoir Boat Launch Area Dashboard, used only by DWSP staff, is updated every 15 minutes during the April to October fishing season. This dashboard presents the total number of boats (private and rental) on the reservoir with breakdowns by area and includes boater names and registration numbers, providing enhanced public safety and emergency response capabilities. BLA supervisors use the data to determine priority for visiting BLAs throughout the day, while Ranger staff can determine allocation of resources. Two derivative products are also available: a public dashboard for rental boat availability, and an internal Emergency Contact Dashboard which Rangers can use in case of emergencies.

A *Reporting Tools Dashboard* was developed to provide statistics on boating throughout the season. This Dashboard can be filtered by BLA or can be used to show summaries of all collected information; it also is useful for quick information on reservoir usage (Figure x-x).
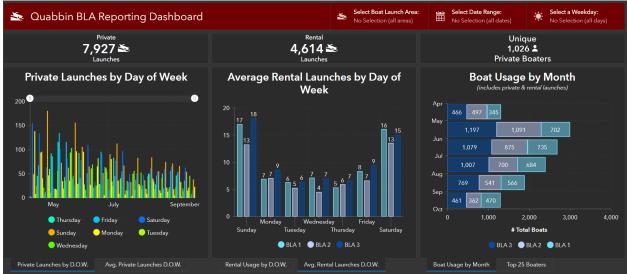

Figure A-11: Screen Capture of the Quabbin BLA Reporting Dashboard.

The *Boat Appointment and Decontamination Survey* allows DWSP staff to conduct boat decontamination inspections. This ensures the Boater Database is up to date with accurate boater information and ensures all required information from a decontamination appointment is efficiently and accurately captured. This workflow is an excellent example of collaboration between sections – Interpretive Services, Environmental Quality and Watershed Ranger staff all work together to collect information and conduct decontaminations.

Both components result in a standardized boater database which is updates three to four times per week, using semi-automated methods to check for data consistency and flag potential program violations. Boat seal and decontamination information were previously captured on paper forms and not entered until after the boating season was over. This not only cost us massive amounts of staff time (approx. 768 hours), but it also prevented the potential enforcement of violations in a timely manner.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)				
These current workflow costs have been estimated for one season of the boater program using data from 2018.				
Hours to complete current workflow *(appointments)*	11.3	This value represents the actual number of times the workflow is completed multiplied by the time taken to complete the workflow once according to IS staff.	Current workflow cost	$294.23
Hourly wage rate*	26.00			
Hours to complete current workflow *(decontamination)*	25.9	This value represents the actual number of times the workflow is completed multiplied by the time taken to complete the workflow once according to EQ/Ranger staff.	Current workflow cost	$517.33
Hourly wage rate*	20.00			
Hours to complete current workflow *(BLA)*	116.7	This value represents an estimated number of times the workflow was completed in 2018 multiplied by the time taken to complete the workflow once according to BLA attendants.	Current workflow cost	$2,450.00
Hourly wage rate*	21.00			
Hours to complete current workflow *(data entry)*	768.8	This value based on reports of time spent on task by staff.	Current workflow cost	$25,368.75
Hourly wage rate*	33.00		Current annual cost	$28,630
Annual occurrence of workflow	1			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhanced Workflow Costs				
These enhanced workflow costs have been estimated for one season of the boater program.				
Hours to complete workflow after enhancement *(appointments)*	11.3	This value represents the estimated number of times the workflow is completed multiplied by the time taken to complete the workflow once according to IS staff.	Enhanced workflow cost	$294.23
Hourly wage rate*	26.00			
Hours to complete workflow after enhancement *(decontamination)*	16.2	This value represents the estimated number of times the workflow is completed multiplied by the time taken to complete the workflow once according to EQ/Ranger staff.	Enhanced workflow cost	$323.33
Hourly wage rate*	20.00			
Hours to complete workflow after enhancement *(BLA)*	141	This value represents the number of times the workflow was completed in 2019 multiplied by the time taken to complete the workflow once.	Enhanced workflow cost	$2,965.90
Hourly wage rate*	21.00		One time equipment	$2,587
Annual occurrence of workflow	1		**Enhanced annual cost**	$6,170.47
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhancement Production Costs and Savings				
Hours to complete enhancement	200.0	This value represents the estimated number of hours spent on development; this adds up hours for GIS, EQ and EEA-IT time.	**Enhancement cost**	$6,600.00
Hourly wage rate*	33.00		**Initial Annual Savings**	$15,860
Annual maintenance costs of enhancement***	$1,560.00	The actual cost for three iPad data plans per year.	**Future Annual Savings**	$20,900
Projected ROI				
			Initial Year ROI	73%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost			**Future Annual ROI**	164%

Figure A-12: ROI study for the Quabbin Boat Seal Program.

Due to the importance of the BLA program and the extensive nature of this workflow update, a Return-on-Investment (ROI) analysis was performed to determine the savings that could be expected due to this workflow modernization (Figure A-11). The ROI showed that significant staff time was saved by eliminating manual data entry – time that can now be used to complete other, more important tasks. The ROI report also demonstrates how DWSP is seeing value from the investment EEA has made in all secretariat GIS programs.

Bird Harassment Program
This project modernized the Quabbin Bird Harassment Program (BHP), moving it away from a paper-based system and into a more streamlined and time efficient mobile data collection system. This updated workflow also enables real-time analysis, Dashboarding, and results in a Hub site that can serve as a centralized repository and access point for program information.

Software used - Survey123, Dashboards and Hub Sites.

Central to the development of this new workflow was the ability to create a standardized way to capture the nightly program's observation information and produce a daily report. The new workflow ensured a standard product and helped save staff time after completing their efforts to move birds away from critical areas on the reservoirs. A report template was developed in collaboration with EQ and CE staff that automatically generates a report at the end of each shift.

All the data is integrated in a Hub site which is available to DWSP or partner agencies, such as MWRA; various sections of the site are only visible if staff are logged into their AGOL account, while others are password protected for additional security and control of content. The Hub Site brings together disparate pieces of the BHP program into one place, making it easier for management and program participants to access important information and forms from one place. It is possible for users with proper credentials to access all BHP-related Survey123 forms, such as the BHP survey, the Quabbin Roost Count survey and the Reservoir Temperature/Bacteria Count surveys. The Hub site also includes a Dashboard of regional gull activity from the Natural Resources department, which helps provide a better overall picture of gull activity in Central Massachusetts. Staff are better able to make informed decisions with all this information together in one place.

An ROI study on the Bird Harassment Program's workflow showed future annual savings of over three-quarters of the current cost for data collection and distribution. (Figure A-12)

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)			
Hours to complete current workflow	1.2	Current workflow	$39.60
Hourly wage rate*	33.00	Current annual cost	$3,168
Annual occurrence of workflow	80		
Other workflow costs (consumables/travel exp., etc.)			
Enhanced Workflow Costs			
Hours to complete workflow after enhancement	0.5	Enhanced workflow	$16.50
Hourly wage rate*	33.00	Enhanced annual cost	$1,320
Annual occurrence of workflow	80		
Other workflow costs (consumables/travel exp., etc.)			
Enhancement Production Costs and Savings			
Hours to complete enhancement	30.0	Enhancement cost	$990.00
Hourly wage rate*	33.00	Initial Annual Savings	$858
Annual maintenance costs of enhancement, if any	$0.00	Future Annual Savings	$1,848
Projected ROI			
		Initial Year ROI	-6%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost		**Future Annual ROI**	80%

Figure A-13: ROI study for the Quabbin Bird Harassment Program.

Quabbin Park Cemetery

The Quabbin Park Cemetery, established between 1931 and 1932, was created as the final resting place for the remains from local cemeteries within the area of the proposed Quabbin Reservoir; ultimately there were 34 cemeteries with 7,613 graves removed. The majority of these graves, 6,601, were reinterred in Quabbin Park Cemetery, while the remainder were reinterred in surrounding town cemeteries by their respective families. DWSP manages the Quabbin Park Cemetery and maintains all associated historical records.

Software used - StoryMaps, Survey123, Dashboards, ArcGIS Pro, Experience Builder, Web AppBuilder, Field Maps, and Power Automate.

DWSP contracted GraVoc in early 2000 to develop a cemetery management system, which included digitizing over 12,200 index cards of burial and owner lot records. While this program was very helpful in updating new burials and owner lots, it was seldom used due to infrequent burials, there was no spatial component linking records to actual grave locations, no ability to view or enter information while in the cemetery, and there were annual software maintenance fees.

EEA has an Enterprise License Agreement with Esri to provide a suite of software services familiar to staff which includes the capability of linking tabular records to spatial features. DWSP decided to use this suite of software available through ArcGIS Online to rebuild the cemetery database. This update allows DWSP to utilize field data collection tools to manage records on interments, lot ownership and deeded lots. In addition, an online Cemetery database provides access to the public via online applications, allowing interested groups to query the database records to locate someone buried in the cemetery (a request made often by public advocates, such as the Friends of Quabbin and the Quabbin Watershed Advisory Council).

A suite of Survey123 forms, Dashboards and Power Automate notifications now allow Engineering, Maintenance and GIS staff to manage new and existing interments in the Cemetery database. A detailed workflow, data consistency checks within the Survey123 forms, and email notifications ensure that new interments are entered properly and are included within the

authoritative Cemetery database. These tools also allow non-GIS users to enter, manage and interact with the Cemetery database through a web browser.
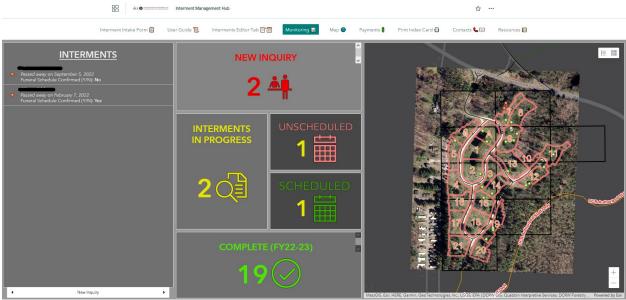

Figure A-14: The Monitoring dashboard from the internal Cemetery Interment Management Hub, which allows staff to review interments moving through the process from "new interment" to "completed interment."

A series of public-facing applications are also available which facilitate interaction and querying of the Cemetery database. Both map-centric (Web AppBuilder) and form-centric (Experience Builder) applications were configured to facilitate data searches. A new webpage was created to bring all these tools together into one location. Interpretive Services staff also collaborated with the GIS program to develop a Quabbin Park Cemetery Tour StoryMap. This immersive page provides a detailed tour of the cemetery that includes narrative, historic images, and an interactive map.

This project highlights how the GIS program can provide solutions to problems that are not necessarily GIS-specific. None of these cemetery related apps would have been possible without the work done to migrate the database into ArcGIS Online. Thinking creatively about how to utilize a range of software improved workflows, while also expanding access to information by stakeholders, partners, and the public.

Wachusett-Sudbury Employee Portal and Resources
The ArcGIS Online platform provides access to many tools that might not obviously fall under the GIS program's purview; however it is easy to create a website (using ArcGIS Hub) for a specific program, project, or purpose. Wachusett-Sudbury regional management collaborated with the GIS Program in late 2019 to develop an Employee Portal to replace the internal "DCR Intranet" that was used for sharing a variety of employee information. The timing was fortuitous, as the COVID-19

Software used - Hub Site, Survey123, Dashboards, SharePoint, Power Automate and Power Apps.

pandemic would make the Intranet largely inaccessible because it required a network connection (not available to most staff). The Employee Portal went live in January 2020 and provides all DWSP staff access to important tools, forms, and information through an internet connection. Credentials to either ArcGIS Online and/or a mass.gov account are required to access most of the information available on the Portal, ensuring that access is controlled and limited to only DWSP staff.

The Employee Portal integrates with other ArcGIS Online tools, including Survey123 Work Order Request, Time Off Request, and Boat Reservation forms; Work Order Status Dashboard; and various public-facing applications which are useful to staff. A series of password protected pages also provide staff with easy access to all their ArcGIS Online-based tools. Defining access to these pages through ArcGIS Online groups guarantees that the pages only become visible to logged-in users. The Employee Portal brings all these disparate elements together in one place, providing Wachusett-Sudbury staff with a useful home page.
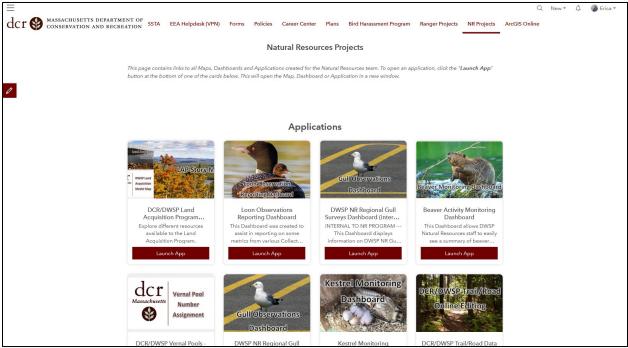

Figure A-15: Example of Natural Resources section project page; this and the 'Ranger Projects' pages are only accessible to subsets of users when they log in with their ArcGIS Online credentials.

Reservoir Surveys for Aquatic Invasive Species Monitoring
This project enables aquatic biologists to efficiently collect point locations or polygon areas, attributes and photos while conducting Aquatic Invasive Species reservoir surveys in a moving boat. QuickCapture was selected for this workflow, as this "big button" app is ideal for "at speed" data collection and requires few on-screen clicks for collecting basic attribute data and a photo. In

Software used - Field Maps and QuickCapture.

addition, this same app can be used to simultaneously collect locations and information about native species encountered during the surveys. Field Maps can be used to enter additional notes or information if required and for reference of previously collected data.

This project was the result of the GIS program helping Wachusett aquatic biology staff to realize their goal of quick and efficient data collection while conducting surveys in a moving boat. Due to the success of this data collection program, the Quabbin aquatic program also adopted this same workflow for conducting their reservoir surveys.

Figure A-16: The data collection screen of QuickCapture. Biologists adjust the density (top grey bar, currently set to 'Sparse') and then select a category and click a button to capture a point location or to start tracing a polygon area.

Lake Trout Modeling

DWSP aquatic biologists complete lake trout surveys in the Wachusett Reservoir each October and November. Staff have a good idea of where to set nets during sampling based on their knowledge of the reservoir and lake trout spawning habits, but they realized it was possible there were additional desirable sampling locations that were being overlooked. A lake trout habitat suitability model was completed prior to 2017's sampling, using methodology developed by Bigelow & Hubert (2008), to better predict where spawning would likely occur. Suitability was modeled via an overlay analysis using five inputs in a Weighted Sum overlay.

Software used - ArcGIS Pro and Field Maps.

Parameter	Weight
Fetch (*based on avg. direction past 5 season's wind directions*)	0.44
Slope (*between 3 and 25%*)	0.14
Depth (*areas ≤ 6.5m*)	0.28
Erosive Zone (*areas ≤ mud DBD 13.6297*)	0.07
Transition Zone (*1m buffer around erosive zone*)	0.07

Figure A-17: Model parameters and weights used to determine lake trout habitat suitability index. The result of this model was used to improve location selection for net sets.

The output of this model was a continuous raster layer for the entire reservoir and three polygon layers showing three classes of areas lake trout should find suitable for spawning. Biologists were better able to select locations for net sets during sampling with this analysis.
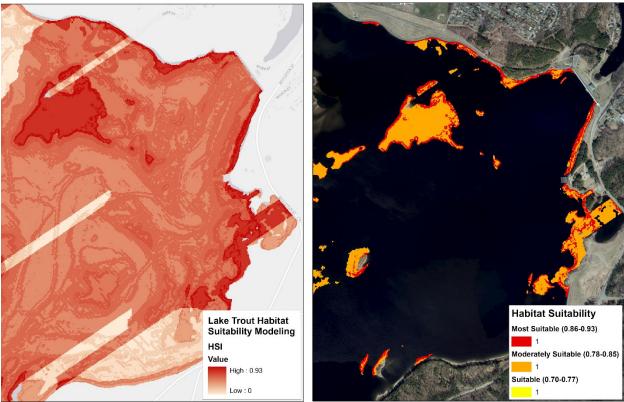

Figure A-18: Habitat suitability model (left) shows moderately and most suitable areas in darker red. By extracting values from habitat suitability model, areas of moderate suitability and most suitable areas are isolated (right).

The next step to streamline the data collection workflow occurred in 2019 by transitioning data collection from a combination of onboard sonar and paper forms to leverage Field Maps. This further enhanced the ability to plan net sets by providing the ability to view past net set locations while on the water. By collecting locations and catch data for each net, it was possible to standardize data collection efforts and to eliminate the need to transcribe data from paper forms. Field Maps also made it possible for all historic net set and catch data to be included in the new online database to ensure that all information was available during surveys.

A Return-on-Investment study was performed after the completion of this simple workflow migration. The ROI highlights how GIS can provide significant savings – almost 200% on an annual basis – on a relatively uncomplicated project. Small-scale projects such as this Lake Trout modeling make up the majority of projects undertaken by the GIS program; adding these efforts together demonstrates the positive financial impact of these new GIS based workflows.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)				
Hours to complete current workflow	2.0	*This value represents the time taken to complete the original workflow one time.*	Current workflow cost	$66.00
Hourly wage rate*	33.00		Current annual cost	$462
Annual occurrence of workflow	7	*The number of times (nights) the LT survey is completed each year.*		
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhanced Workflow Costs				
Hours to complete workflow after enhancement	0.5	*This value represents the time taken to complete the workflow after the enhancement.*	Enhanced workflow cost	$16.50
Hourly wage rate*	33.00		Enhanced annual cost	$116
Annual occurrence of workflow	7			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhancement Production Costs and Savings				
Hours to complete enhancement	2.3	*Time taken to set up Collector map, including initial meeting (.5), schema development (.5), deployment (.75) and revision time (.5).*	Enhancement cost	$75.90
Hourly wage rate*	33.00		Initial Annual Savings	$271
Annual maintenance costs of enhancement, if any	$0.00		Future Annual Savings	$347
Projected ROI				
			Initial Year ROI	102%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost			**Future Annual ROI**	181%

Figure A-19: ROI study for the Lake Trout workflow migration from a paper-based data collection workflow to leverage Field Maps.