Improving SCDOT Project Delivery Through Identifying Potentially Suitable Locations for Mitigation and Standardizing Section 401/404 Permit Application Process

FINAL REPORT

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16. Abstract

The South Carolina Department of Transportation (SCDOT) identified three areas that have significant effect on its ability to deliver projects on time and on budget: 1) inconsistent permit application submittals among consultants that led to delay in approval by the U.S. Army Corp of Engineers (USACE), 2) inability to consistently identify "red flags" early in the project development process, and 3) lack of mitigation credit coverage. The objective of this project is to decrease the risks in these three areas. A review of the literature and other state highway agencies' practices indicated that some agencies have used Geographic Information Systems (GIS) to develop in-house mitigation and project screening tools and some agencies have transitioned from paper-based permit applications to web-based permit applications. None of the off-the-shelf products or other agencies' in-house applications can be easily tailored to the SCDOT's practice. For this reason, this project focused on development and technology transfer of applications to enable the SCDOT's Environmental Services Office (ESO) to accelerate project delivery by improving the consistency of ESO's deliverables, avoiding and minimizing impact of projects through proper screening, and increasing available mitigation credits through transparency with the banking community. Five applications were developed which involved input from the Project Steering and Implementation Committee throughout the design and implementation process: 1) Project Screening Tool ArcGIS webapp, 2) Mitigation Forecasting Tool ArcGIS webapp, 3) Jurisdictional Determination (JD) ArcGIS webapp, 4) JD web-based smart form, and 5) General Permit web-based smart form. After several rounds of beta testing involving SCDOT staff, consultants, and USACE, these five apps have been adopted by the SCDOT and have been incorporated into the agency's existing workflows.

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- Sean Connolly (Chair)
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- Chad Long
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EXECUTIVE SUMMARY

The objectives of this research project were to: 1) review existing mitigation and conservation assessment models/tools used in the U.S. and use the gathered information to develop GIS-based applications that are implementable by the Environmental Services Office (ESO) to provide a sustainable statewide mitigation program, and 2) review existing Section 404 permit application processes and tools used in the U.S. and use the gathered information to develop web-based, interactive applications that are implementable by ESO staff and consultants to streamline the submittal process for Section 404 permit applications submitted to the U.S. Army Corps of Engineers (USACE).

A review of the literature and other state highway agencies' practices indicated that some agencies have used Geographic Information Systems (GIS) to develop in-house mitigation and project screening tools and some agencies have transitioned from paper-based permit applications to web-based permit applications. None of the off-the-shelf products and other agencies' in-house applications can be easily tailored to the SCDOT's practice. For this reason, this project focused on the development and technology transfer of applications to address the SCDOT's specific issues: 1) inconsistent permit application submittals among consultants that led to delay in approval by the USACE, 2) lack of user-friendly project screening tool to identify "red flags" early in the project development process, and 3) lack of mitigation credit coverage. Altogether, three web applications (webapps) and two web-based smart forms were developed, as described below.

The Mitigation Forecasting Tool (MFT) aims to reduce the number of projects at risk due to the lack of wetland and stream mitigation bank credit coverage and the number of projects at risk due to low wetland and stream credit availability. The external version of this webapp helps the SCDOT to be transparent with the banking community about the projected stream and wetland impacts statewide and per 8-digit Hydrologic Accounting Unit (HUC) watershed in South Carolina. As such, it will help guide the development of new mitigation banks, and in turn, improve project delivery outcomes for the SCDOT by having appropriate mitigation already in place when needed. This level of transparency removes several identified risk factors for the banking community. The bankers will now know which watersheds are critical, based on forecasted impacts, and can place their banks accordingly. Additionally, the bankers will gain an understanding of demand for credits in a given watershed, and thereby size their mitigation banks appropriately to deliver the required credits and not over build within a watershed. The internal version of the MFT webapp shows the available and pending mitigation bank(s) and will show credits available to SCDOT statewide and per watershed. As such, it will help the SCDOT reduce project delivery risk associated with mitigation. The Permit Manager will now be able to assist the Program Manager to appropriately develop a schedule based on whether mitigation risk will or will not be part of their project timeline. Learning early in the process if mitigation credits are available within a watershed allows an appropriate amount of time for SCDOT to develop a strategy that ensures project delivery and streamlines its USACE permit acquisition due to improved mitigation outcomes.

The Project Screening Tool (PST 2.0) aims to ensure that SCDOT projects are developed in a way that avoids, minimizes, and mitigates impacts to South Carolina's natural and human environment. This webapp provides ESO with a one-stop shop for previewing *all* critical environmental data such as endangered species, cemeteries, and protected waters, thereby allowing ESO staff to identify "red flags" early in the project development process to allow SCDOT engineers and contractors to design around them. The advantages of the PST 2.0 webapp over the

previous version of PST are that it is easier for the user to query the data and it generates a screening report with tables and maps in the same format for all use cases. The PST 2.0 webapp also allows ESO staff to identify the number of parcels along a project area for the Right of Way division and assist the Planning Office in developing Feasibility Reports for certain long-range projects.

The Jurisdictional Determination (JD) webapp aims to facilitate the creation of maps for the JD application. The use of this webapp by ESO staff and consultants ensure that maps included in the JD application provide the necessary information to the USACE for their review and approval. The JD webapp was designed to overcome common problems such as upland data points not being shown or shown in the wrong location on the map, acreage of streams not shown on the map, and acreage of project site not shown on the map. The other benefit of the JD webapp is that the maps it generates present information in a consistent format, regardless of who prepared the JD application, thereby expediting the USACE approval process.

The JD smart form works in conjunction with the JD webapp to produce the JD application package. Specifically, it converts a current paper-based form to a web-based smart form. There are several advantages to using the web-based smart-form. First, the submitted data, including maps, shape files, wetland determination data forms, and photo log, are stored in a database on ESRI servers which ensures SCDOT staff have access to all pertinent information. Second, certain fields can be auto populated with values and/or shown or hidden based on entered information. Third, it automatically generates a cover letter with all the pertinent and required information filled out. Lastly, the smart form automatically collates the cover letter, application form, maps, wetland determination data forms, and photo log into a single PDF containing all of the JD application documents and emails the PDF to the user. The inclusion of all the necessary information, having a consistent report layout, and having maps presented and formatted with consistent notations and symbology from one JD submittal to another will expedite the USACE approval process.

The General Permit smart form (e-permit) aims to standardize permit submittals in terms of what information to include, how the documents should be presented, where in the package each document should be placed, and how permit drawings should be presented. The benefits of using a smart form for the e-permit are similar to those explained for the JD smart form. The additional smart form features used in the e-permit include preventing the user from submitting the application with incorrect data, displaying warning messages, showing emojis to call out certain fields, performing back-end calculations, allowing the user to jump to a specific section of the application, and providing links to websites with guidelines or information the user may need to complete the application. As is the case with the JD smart form, the e-permit was also designed to provide ESO with consistent submittals. The USACE has reviewed and approved the new report format. It is expected that USACE will require less time to review each general permit application in the future.

The development and technology transfer of applications in this project has led to several tangible benefits for the SCDOT: 1) the external MFT webapp has strengthened the relationship between the SCDOT and the mitigation banking community, and as a result, the mitigation risk in South Carolina has been significantly reduced, 2) the use of the PST 2.0 webapp is expected to save ESO staff 20 to 25 hours per month based on a monthly average of one feasibility report and four to five project screenings, 3) the use of the e-permit smart form is expected to save consultants on contract 30 to 40 hours per month based on a monthly average of two general permits, and 4) it is anticipated that with the use of the developed e-permit smart form, the majority of GPs will be approved by USACE within 2 months.

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LIST OF ACRONYMS

CWA	Clean Water Act
e-Permit	Electronic Permitting
ESO	Environmental Services Office
GP	General Permit
JD	Jurisdictional Determination
MFT	Mitigation Forecasting Tool
NEPA	National Environmental Policy Act
PRM	Permittee-Responsible Mitigation
PSIC	Project Steering and Implementation Committee
PST	Project Screening Tool
SCDOT	South Carolina Department of Transportation
USACE	US Army Corps of Engineers
Webapp	Web Application
WOUS	Waters of the US

CHAPTER 1: INTRODUCTION

The South Carolina Department of Transportation (SCDOT) infrastructure projects often include unavoidable impacts to wetlands, rivers, and other aquatic resources. The State and Federal laws such as the United States (US) National Environmental Policy Act (NEPA) of 1969 and the Clean Water Act (CWA) under Section 404 (33 USC 1344) require such projects to include compensatory mitigation plans for offsetting those impacts on water resources. The goal of compensatory mitigation plans is to replace/enhance water resources and wetland functions to provide public benefits such as flood storage, water quality protection, fish and wildlife habitat, and groundwater recharge. Compensatory mitigation plans must meet the standards and criteria established by the US Army Corps of Engineers (USACE) and the US Environmental Protection Agency (EPA) under published regulations 33 CFR Parts 325 and 332 (EPA, 1995; US ACOE, 1995). Section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act have identified five alternative hierarchy for Mitigation Rules concerning the forms and location of compensatory mitigation including: (1) Mitigation Bank credits, (2) In-Lieu Fee (ILF) program credits, (3) Permittee-Responsible Mitigation (PRM) under a watershed approach, (4) PRM through on-site and in-kind mitigation, and (5) PRM through off-site and/or out-of-kind mitigation.

Compensatory mitigation generally includes careful evaluation of available options and strategies to reduce impacts where transportation and sensitive lands/waters intersect. These strategies include the use of off-site mitigation banks to comply with permitting requirements while others may develop mitigation sites at the project site or create or restore wetlands within the same watershed as the project. A mitigation bank is a wetland, stream, or other aquatic resource area that has been restored, established, enhanced, or in certain circumstances, preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under Section 404 of the Clean Water Act (33 U.S.C. § 1344). Site selection for mitigation projects is frequently determined by economic factors such as cost and land availability as well as ecologically factors (Brooks et al., 2017). These factors approximate mitigation areas that often fail to comply with permit criteria (Ambrose et al., 2006). It is not always practical and cost effective to locate suitable mitigation sites by field work, especially where larger areas of land are under consideration.

The SCDOT has had a number of projects delayed due to inadequate compensatory wetland mitigation. For example, in 2017, the number of projects in its 10-year plan that were at risk due to the lack of wetland credit coverage include 150 bridge projects, 120 miles of rural safety projects, and 10 miles of interstate widening projects, and the number of projects that were at risk due to the lack of stream credit coverage include 115 bridge projects, 400 miles of rural safety projects, and 45 miles of interstate widening projects. To improve project delivery, it is necessary to have the appropriate mitigation already in place when needed. Also, from an environmental perspective, it is best that the mitigation is performed holistically considering the compensatory mitigation needs of various projects in a region instead of considering the need of one project at a time.

The SCDOT's Environmental Services Office (ESO) had previously developed a Project Screening Tool (PST) to enable its staff to: 1) review environmental impacts associated with programmed projects, 2) identify studies required for NEPA/404 compliance as well as the type

of document/permit and need for public involvement, 3) document alternatives, 4) communicate with program managers, and 5) coordinate with resource agency personnel. The use of PST to identify potential conflicts was a complicated multi-step process where ESO staff had to check various in-house sources and various websites for potential conflicts. The complicated workflow sometimes resulted in oversight of critical path items which led to project delays and cost overruns. The PST needed to be enhanced to provide ESO staff with a one-stop shop for previewing *all* critical environmental project data in a way that is both easy to use and yields consistent results among users.

The SCDOT's ESO Permitting Division must coordinate with the U.S. Army Corps of Engineers (USACE) to acquire permit approval for any project that has impacts on wetlands and/or streams. Permit submittals are necessary to comply with the Sections 401 and 404 of the Clean Water Act (33 U.S.C. § 1341, 1344) when projects have unavoidable impacts to wetlands and streams. The vast majority (approximately 80-90%) of SCDOT projects with impacts to waters of the US (WOUS) can be permitted under the SCDOT General Permit (GP). In federal fiscal year 2020, 21 GPs and five individual permits (IP) were approved by USACE. The SCDOT's GP was established to streamline the permitting process for projects with minimal impact to WOUS. However, most GPs still require the consultant on contract approximately 100-150 hours to prepare the permit package. The current process is not only time consuming but also leads to inconsistent submittals due to each consulting firm having their own standard operating procedure. The inconsistent submittals have led to delay in approval of the GP applications and such delay adds unnecessary risk to a project's overall schedule. Moreover, the permit packages require review by ESO staff to ensure completeness before they can be sent to the USACE. Inconsistencies in these packages require ESO staff to spend more time reviewing them and to coordinate with the consultant to resolve deficiencies.

To decrease risks associated with GP submittals and mitigation, the objectives of this research project are to: 1) develop GIS-based applications that are implementable by the Environmental Services Office (ESO) to provide a sustainable statewide mitigation program, 2) enhance the project screening tool to provide a one-stop shop for project screening, and 3) develop web-based, interactive applications that are implementable by ESO staff and consultants to streamline the submittal process for Section 404 permit applications submitted to the U.S. Army Corps of Engineers (USACE). Altogether, three web applications (webapps) and two web-based smart forms were developed and delivered to the SCDOT for implementation in their day-to-day operations. These include Mitigation Forecasting Tool (MFT) webapp, Project Screening Tool (PST 2.0) webapp, Jurisdictional Determination (JD) webapp, JD web-based smart form, and General Permit web-based smart form (e-permit).

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Recent studies from the National Cooperative Highway Research Program (NCHRP), Washington State DOT, and Florida Department of Environmental Protection indicate that many wetland mitigation sites fail to comply with permit criteria or to provide wetland ecological functions due to insufficient hydrological and ecological attributes as a result of poor site selection (Brooks et al., 2017). Selecting a mitigation site is a complex process because it should have a good chance of being sustainable and compensates for the functions and services (also called "values") lost at the impact site (Hruby et al., 2009). In many infrastructure projects, site selection is frequently determined by economic factors such as cost and land availability that require wetlands to be restored or created within the same watershed to compensate for nearby wetland losses. In practice, infrastructure projects often locate mitigation sites at the transportation project site; this approach is time-consuming and requires extensive field work to locate suitable sites. The USACE and Environmental Protection Agency (EPA) recommended that the selection of the mitigation site must be based on a watershed scale that includes three phases. First, the functions and services lost at the impact site must be identified. Second, the selected site must be a location where those functions and services can be compensated. Lastly, it must be determined whether the mitigation will be feasible and sustainable. GIS approaches have been successfully used to identify suitable locations for mitigation projects. Some example mitigation applications are provided in Section 2.2.

State highway agencies have developed and used GIS-based project screening tool (PST) or environmental screening tool (EST). These tools are used to raise "red flags" early in the project development process so that designs could be altered to avoid the need for mitigation altogether, or if unavoidable, redesigned in a way that minimize and mitigate impacts to the natural and human environment. Additionally, these tools aid agencies in understanding the cost-benefit of a project, accessing the visual impact to the landscape after project development, and determining the effectiveness of mitigation measures (FHWA, 2022). Some example PST/EST applications are provided in Section 2.3.

Currently, all state DOTs and prime contractors still use the paper-based application developed by the USACE when applying for a Section 404 general permit. However, an emerging best-practice in permit applications is the development of E-Permit portals. These are web-based applications that provide a one-stop shop for environmental permits. They facilitate online submission and payment, allow applicants to track their applications and give applicants the ability to modify any of their existing applications. Some example applications of E-Permit portals are provided in Section 2.3.

2.2 GIS-based Mitigation Applications

The Maryland Environmental Service (MES) developed a Watershed Resources Registry (WRR) tool in collaboration with the EPA region 3, Maryland State Highway Administration, Maryland Department of Transportation, US Army Corps of Engineers (Baltimore District), Federal Highway Administration, Maryland Environmental Service, and Maryland Department of Natural Resources. WRR is a GIS-based targeting tool that analyzes watersheds to identify the best opportunities for the protection of high-quality resources, restoration of impaired resources,

resource conservation and environmental resource planning, and improvement of stormwater management (Figure 2-1).

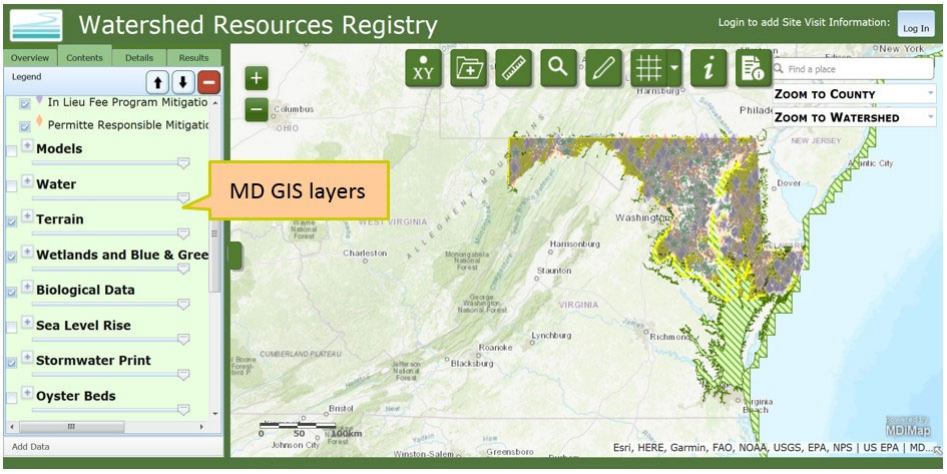

Figure 2-1. Watershed Resources Registry GIS tool developed by MES

West Virginia DOT developed a GIS based three-level framework to select, prioritize, and evaluate potential wetland and stream mitigation banking sites. This model includes GIS based analysis of watersheds and appropriate spatial data (level 1) with a field reconnaissance survey of sites using evaluation criteria weighted with the pairwise comparison Analytical Hierarchy Process (level 2) and an on-site evaluation of the highly ranked sites for model verification (level 3; Strager et al., 2010; see Figure 2-2). The developed tool showed successful selection of suitable sites, particularly for combined wetland and stream mitigation.

Texas Department of Transportation (TxDOT) and EPA jointly developed a mitigation site selection tool named GIS Screening Tool (GISST) as shown in Figure 2-3. This approach was later enhanced by the Maryland State Highway Administration. GISST is a GIS-based tool that uses a scoring structure on GIS coverages to inform decision making and prioritize the locations for environmental protection. By scoring and screening single and cumulative impacts into project planning and using innovative spatial analysis for state-wide planning (Osowski et al., 2005), it became possible to move environmental assessments earlier into the project planning process. This change also allowed for more strategic decision making to identify mitigation needs earlier in the infrastructure project. By explicitly establishing a clear rating system for environmental impacts and planning, GISST made the permitting process more objective and straightforward.

The Michigan DOT (MDOT) has developed a Wetlands Mitigation Site Suitability Tool (WMSST) shown in Figure 2-4 that considers hydrological and ecological criterion to select certain parcels that meet MDOT requirements such as size, adjacency to roads, and environmental factors (Brooks and Shuchman, 2017). WMSST is also able to change the weights and suitability rankings of the various variables used for site selection such as integrating specific soil types for weighting in the analysis as to get a better sense of those areas that are favorable for groundwater and surface water wetland types.

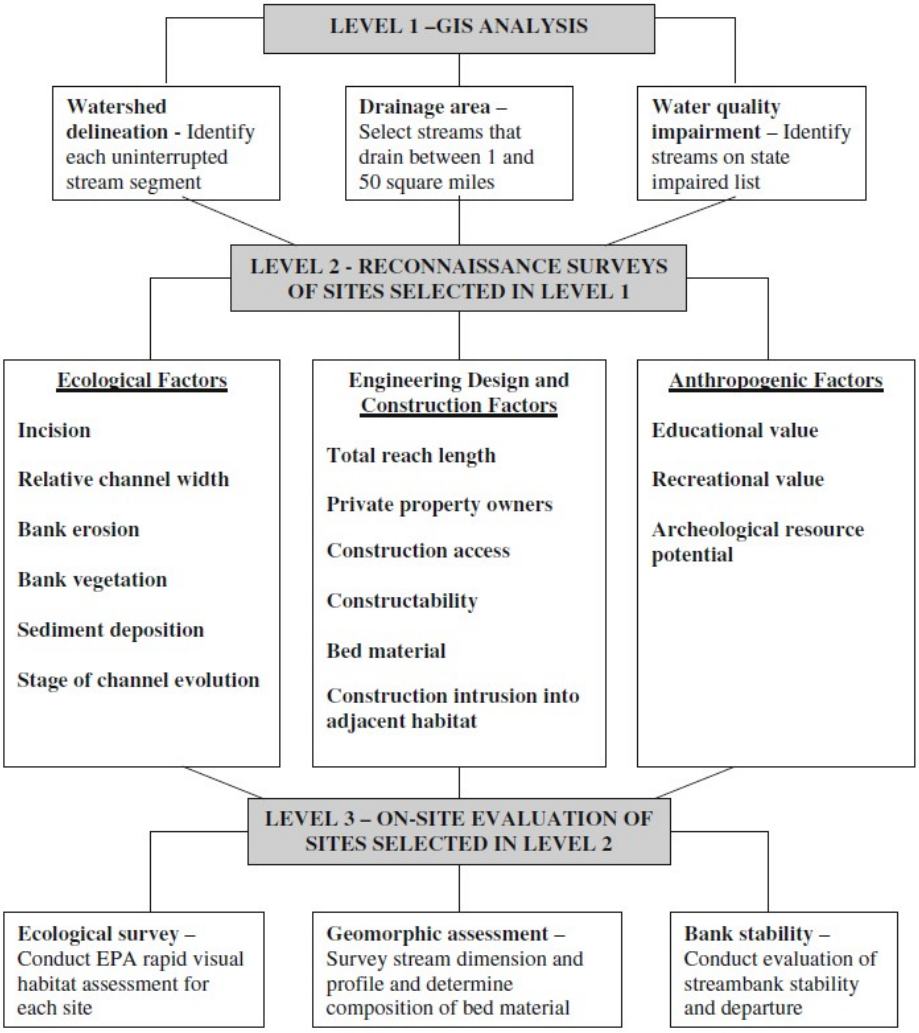

Figure 2-2. WVDOT three-level framework stream mitigation banking site ranking and selection (source: Strager et al., 2010)

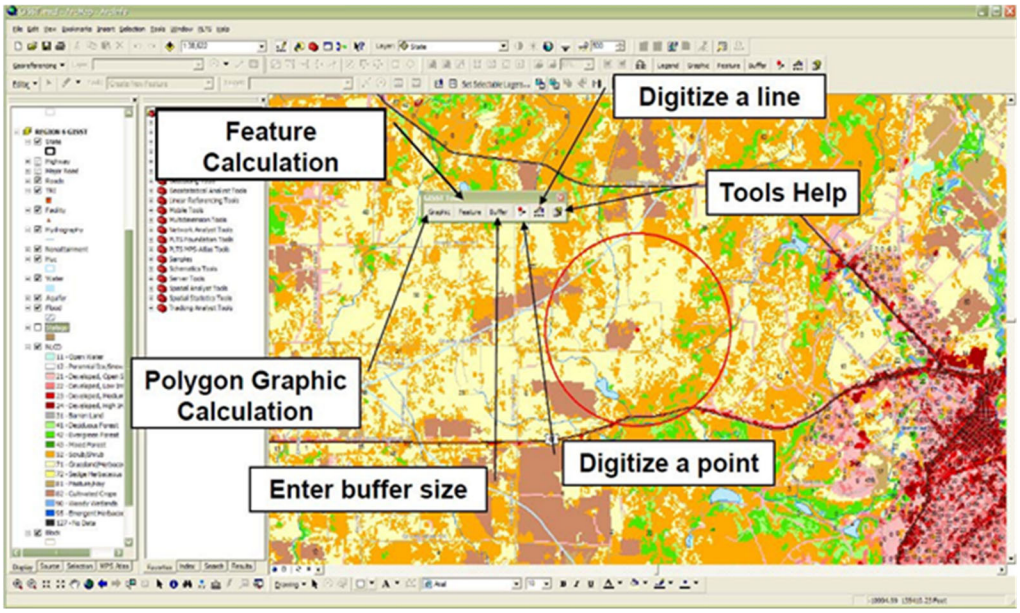

Figure 2-3. GIS screening tool developed by TxDOT and enhanced by Maryland State Highway Administration (source: Osowski et al., 2005)

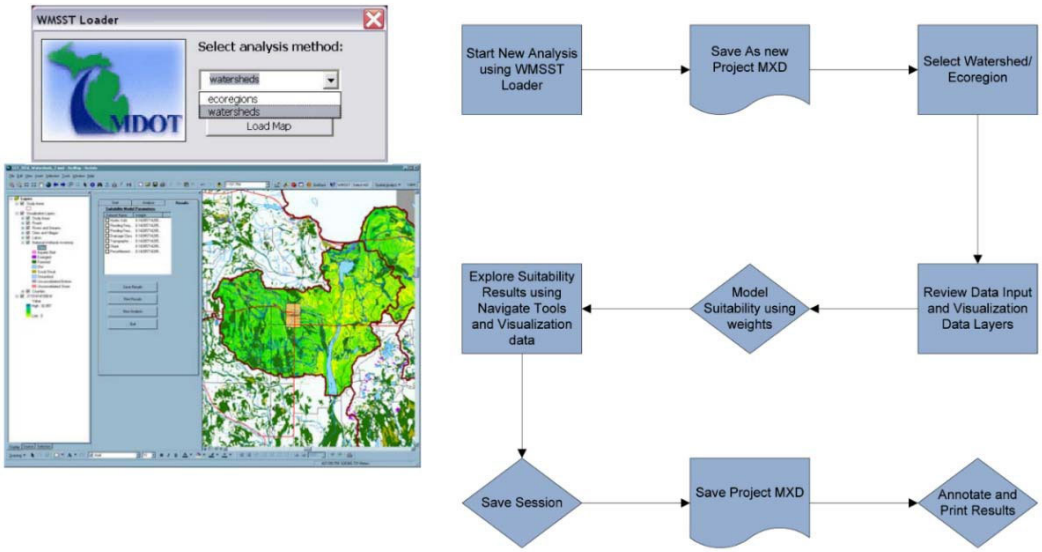

Figure 2-4. MDOT WMSST environment (left) and workflow for suitability modeling projects (right) (source: Brooks et al., 2017).

The SCDOT has developed a wetland likelihood model (layer) for mitigation forecasting (Hodgson and Kupfer, 2017). This model forecasts the likelihood of wetlands (i.e., a wetlands likelihood layer). The (overlaid) layer is a mapped wetland that is a combination of National Wetland Inventory (NWI), SSURGO soils, and land use/cover wetlands data. This layer was later integrated with infrastructure project (e.g., lane widening) and presented as a web-based tool to identify the areal and lineal impact of wetlands as shown in Figure 2-5.

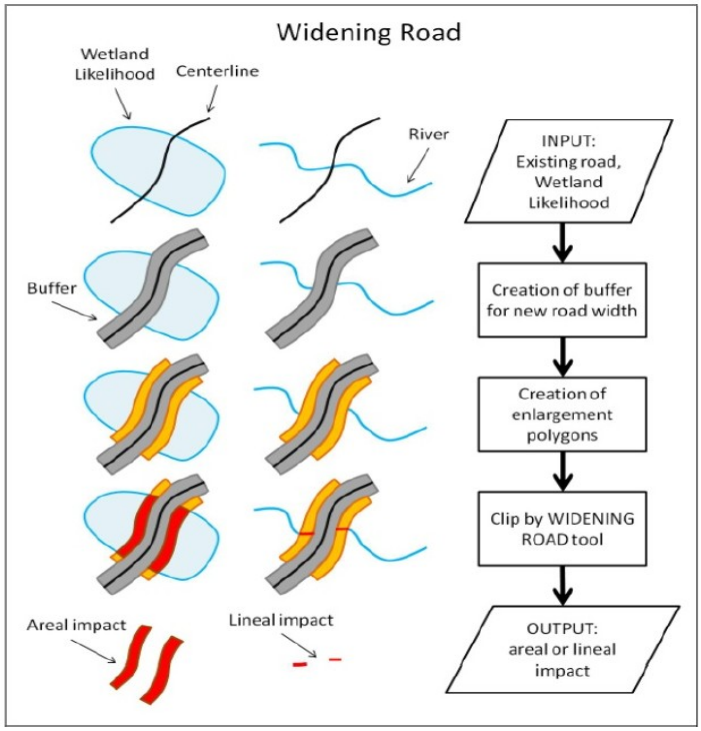

Figure 2-5. SCDOT wetland likelihood layer (source: Hodgson and Kupfer, 2017)

2.3 GIS-based Project Screening Tools

The Florida DOT (FDOT) has developed a GIS-based Environmental Screening Tool (EST) that provides information on potential impacts, permitting issues, and means to minimize impacts for proposed transportation projects (FDOT, 2022). EST was designed as part of the Efficient Transportation Decision Making program that consists of planning screen, programming screen, and project development and environment phase (see Figure 2-6). This tool integrates data from multiple sources to allow users to analyze the effects of proposed projects on the human and natural environment in an easy-to-use interface. It includes capabilities such as uploading data, storing environmental review results, and disseminating information to the public.

The Massachusetts DOT (massDOT) developed a web-based project screening tool named MaPIT (Massachusetts Project Intake Tool) designed to help both state and municipal proponents map, create, and initiate roadway projects, while screening against all relevant in-house GIS resources. The goal of MaPIT is to help the agency identify issues and vulnerabilities early in project development, improve efficiency in generating a scope of work, environmental permitting, safety audits, scoring, and project delivery, and increase MassDOT's transparency in project

development and scoring process. A unique feature of MassDOT MaPIT is the inclusion of data entry form within the ArcGIS environment as shown in Figure 2-7.

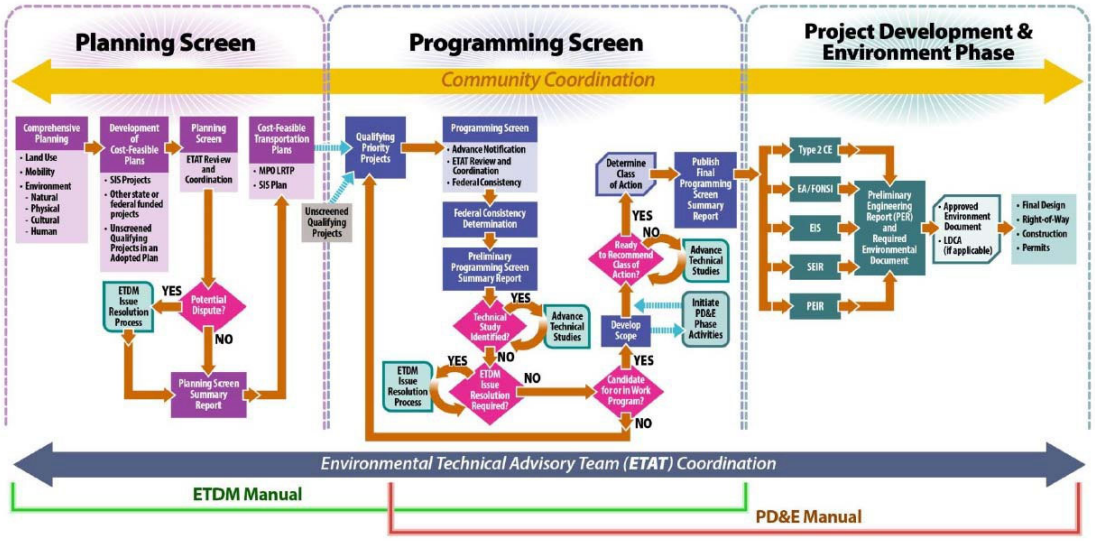

Figure 2-6. FDOT Environmental screening tool (source: FDOT, 2022)

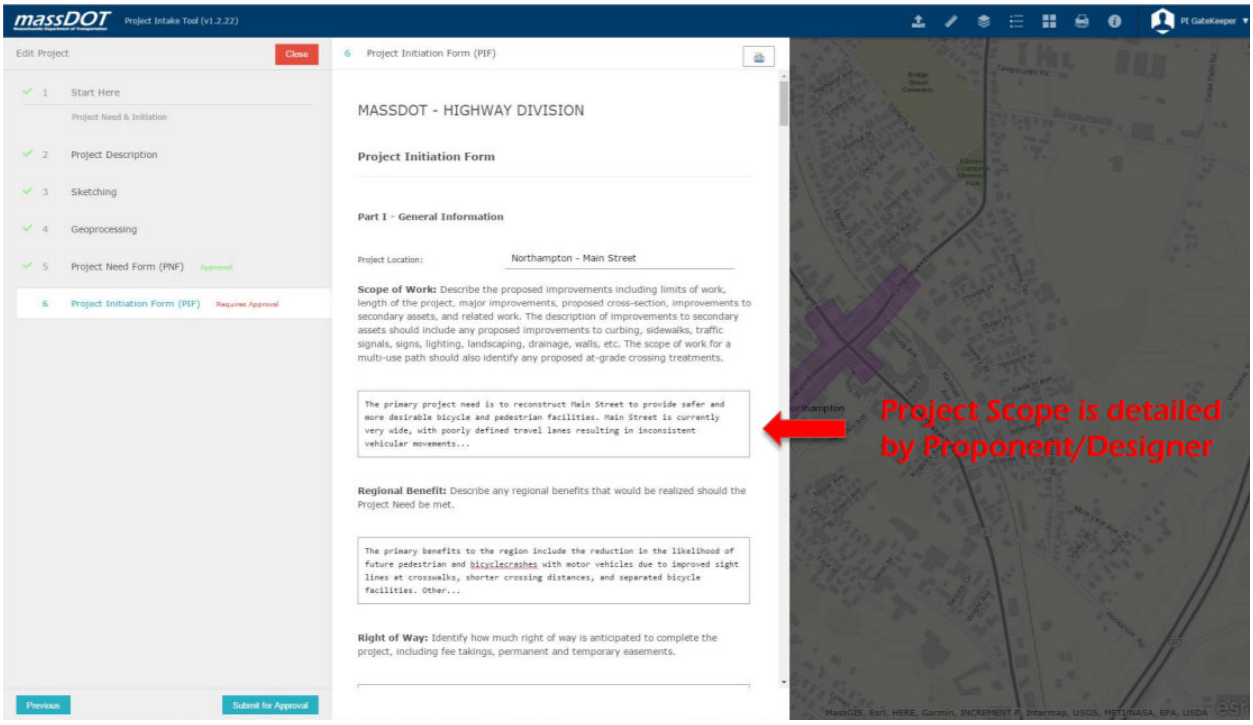

Figure 2-7. MassDOT project need form (source: Bolduc, 2022)

2.4 Electronic Permit Application Submittals

The Florida Department of Environmental Protection developed an e-Permitting system that allows the user to: 1) request verification whether an activity qualifies for an exemption from the Environmental Resource Permit (ERP) requirements, 2) submit a General Permit, 3) submit an Individual Permit, and 4) continue an incomplete application. Their E-Permitting system also allows the users to upload supporting documents and pay processing fees online (https://tinyurl.com/yhe7w3ax).

The Pennsylvania Department of Transportation developed the "Keystone Environmental *e*Permitting System (KEES)" in collaboration with the Department of Environmental Protection (DEP) to increase the efficiency of the e-permitting process through the delivery of a new interface that supports the submission and review of DEP permit applications and the authorization of DEP permits. It is used by PennDOT to develop and submit Chapter 105 permit applications, and it is used by DEP to review, process and take action on Chapter 105 permits. KEES communicates with DEP's database - Environment Facility Application Compliance Tracking System (eFACTS), which helps streamline DEP's reviews and avoids the need to enter duplicate information. PennDOT anticipates the use of KEES to develop and submit Chapter 102 permit applications as well (https://tinyurl.com/mrxd5577).

The South Carolina Department of Health and Environmental Control (DHEC) developed an online, ePermitting system for environmental permitting, licensing, registration, reporting, monitoring, complaints, compliance and enforcement. It is designed to support the full regulatory lifecycle. A number of programs have already been phased into ePermitting and DHEC is currently working to implement and add others such as Air Quality and Environmental Response (https://tinyurl.com/2pn8rb26).

CHAPTER 3: APPLICATION DEVELOPMENT PLATFORMS

3.1 Introduction

The findings from the literature review indicated that no other state DOT has developed an electronic permitting application for Section 401/404 General Permits and a few agencies have developed mitigation tools and project screening tools (PST). The MaPIT tool developed by MassDOT was the most advanced and had the features the SCDOT wanted for their PST. The SCDOT Project Steering and Implementation Committee (PSIC) discussed with MassDOT about the possibility of adapting their tool. Although MassDOT agreed to assist and share information with the SCDOT, the PSIC ultimately decided against adapting MaPIT for SCDOT needs for the following reasons: 1) MaPIT was developed to meet MassDOT specific needs, not all of which are applicable to SCDOT practice, 2) adapting MaPIT would require an enormous amount of time from MassDOT staff and such commitment cannot be expected, and 3) MaPIT required ESRI Services to develop customized components (called "widgets") and paying for such services were beyond the budget of this project. As a result, the PSIC directed the project team to develop applications that address SCDOT specific needs. Extensive research was conducted by the project team to determine the most suitable platforms and development tools to use to develop the webapps. The following describes the methods employed by the team in this project.

3.2 Django Web Framework

The initial plan was to develop a stand-alone e-permit web application that would handle the submission, review, and comment workflow for the SCDOT. A user-centered design and agile development process was utilized in which the project team presented the PSIC with a new version of the software each week for their review. The provided feedback was then incorporated in the next release. The initial versions of the webapp, named "SCDOTEnvTools" included a permit form page that lists the various permit applications created by users, as well as a basic approval workflow with roles for the permit manager, project manager, and consultants. This webapp was deployed on scdotenvtools.cse.sc.edu and implemented using Django with a PostgreSQL backend.

Many features were added to the e-permit webapp based on PSIC's feedback, such as implementation of a comment system for certain fields in the application (so that reviewers could provide specific feedback to the submitters), generation of a custom-designed report that includes all of the user's input, allowing the project manager to add new users to the system, implementing the Avoidance and Minimization checklist, implementing dynamic forms that show/hide fields under certain conditions, breaking the application into several parts and showing the user their progress, adding review functionality, and many others. The final project had a total of 687 commits and resolved about 200 issues.

While the e-permit webapp worked well as implemented, issues were encountered during the technology transfer to the SCDOT. The SCDOT's standards for development and deployment did not allow the use of the Django web framework. Different deployment strategies were explored with the SCDOT IT staff, but ultimately, the only viable option would be to re-write the e-permit webapp using Microsoft Asp.NET technology, a platform and programming language the project team did not have expertise in. Several alternatives to Microsoft Asp.NET were investigated and the most suitable one was ESRI's ArcGIS Survey123. The PSIC was presented with two choices: 1) use Microsoft Asp.NET which has extensive capability but slow development time, a year or

longer to re-create the functionalities of the Django webapp, or 2) Survey123 which has limited capability but much faster development time. The PSIC selected the latter option.

3.3 ArcGIS Survey123

ArcGIS Survey123 is a form-centric data-gathering solution which allows the project team, as survey creators, to create online smart forms that can then be completed by the users using their computers, smartphones, or tablets via an app provided by ESRI. All the submitted data is stored on ESRI servers.

The Survey123 platform was selected for several reasons:

1. **No deployment server.** Since all the data (surveys and their responses) is stored on ESRI servers, the SCDOT will not need to purchase, configure, and deploy the server.
2. **Ease of development and maintenance.** Survey123 allows the survey creators to create surveys using spreadsheets that follow the XLSForms schema; that is, texts, style, and format must be specified according to a set of rules. While there is a learning curve associated with XLSForms and the spreadsheets can get complicated, the entire survey can be developed with minimal knowledge of computer programming. Thus, the surveys are also easy to maintain and can be performed by anyone who has been trained to edit these spreadsheets.
3. **Multiple devices.** Survey123 smart forms can be filled out using ESRI's free-to-use apps, which are available for desktops (Windows, Mac, or Linux), smartphones (iOS or Android), and tablets (iOS or Android). These apps can be downloaded from Apple App Store, Google Play, Amazon Appstore, or Microsoft Store. The ability to complete the survey in the field was identified as a need by the SCDOT for a future app – compliance.
4. **Familiarity with ArcGIS**. The SCDOT had staff in the IT department, Road Data Services office, and Environmental Services office who were familiar with ArcGIS. These staff members maintain several sources of data made publicly available by the SCDOT, such as Project Viewer and Traffic Counts, all of which used ArcGIS. Thus, the SCDOT IT knows how to manage the ArcGIS licenses, server deployment, and its users.

3.3.1 Survey123 Development

The Survey123 spreadsheet, using XLSForms schemas, proved to be very flexible. It allows the project team to specify in the spreadsheet different data types (strings, numbers, and locations), customize the look of the survey by adding bits of HTML, use many different types of questions (text, checkbox, etc.), implement complex calculations to autofill fields, allow the user to upload files in various formats (e.g., doc, .pdf, and .zip) as part of their answer, and more.

Survey123 also provides custom report functionality. This feature allowed the team to create templates which are then used to generate custom reports for the JD and GP applications. Since the templates are created in Word, they can be edited by anyone trained to use Survey123's report template syntax. Making changes to the reports require minimal understanding of computer programming.

To implement the multi-stage workflow, Survey123's Feature Service (FS) and Inbox functionality were used. A "Master" form was created, and it was subsequently used a FS for three

separate forms: JD form, GP form, and GP-Review form. The FS allows the data to be passed from the JD form to the GP form, and from the GP form to the GP-review form because they all belong to the same FS. The Inbox feature allows a user to receive, view and edit an application completed by another user.

3.3.2 Survey123 Limitations

Survey123 allowed the project team to reproduce most of the functionality of the original stand-alone web application very quickly. However, due to it not being a full-fledge computer programming language, it has several limitations:

1. **Reports cannot include attachments.** While the report templates allowed for custom reports to be generated in PDF or Word format, the report can only contain the information the user submitted and not the PDF or Word files the user attached/uploaded. That is, Survey123 cannot merge the report and attached files into a single document.
2. **Lack of email functionality**. Survey123 cannot be programmed to send emails as part of the workflow. For example, upon the user submitting the form, the report cannot be emailed to that user.
3. **Lack of workflow automation.** Survey123 does not support workflow automation. For example, the survey creators cannot program Survey123 to retrieve the report the user has submitted.

Fortunately, Survey123 provides a REST API so that it can be integrated into third-party workflow automation apps. Integromat was used to overcome the above limitations. Its setup is explained in the next section.

3.3.3 Integromat Workflow Automation

Integromat was used to create an automated workflow to accomplish the following:

1. Workflow is activated when someone submits a survey response.
2. Calls Survey123 back to request that it generates a report as a PDF file.
3. Fetches the report from Survey123.
4. Fetches all the documents the user submitted with the survey.
5. Sends a request to CloudConvert to merge all the above files: the report and all the attachments
6. Fetches the resulting merged document from CloudConvert.
7. Sends an email to the consultant and/or SCDOT staff member depending on selection. That is, if the JD or general permit application is not ready for SCDOT review, then only the consultant will receive the email with the report. If it is ready, then both the consultant and specified SCDOT requestor will receive the email and report.

Figure 3-1 shows the workflow created in Integromat. The sequence of nodes performs the following processes.

- First Survey123 node: gets the data submitted.
- Second Survey123 node: asks Survey123 to generate the PDF Report.

- The JSON, Iterator, and Array aggregator nodes are needed to transform the data from the format returned by Survey123 into the format that CloudConvert expects as input.
- The CloudConvert node calls CloudConvert to merge all the PDFs, including the title pages for the appendices, into one PDF.
- The HTTP node fetches the PDF Report from Survey123.
- The Microsoft email nodes send the emails.

Figure 3-1. Workflow automation configuration using Integromat

3.4 ArcGIS Web Applications

Several GIS platforms were considered at the start of the project. These include ArcGIS Online, ArcGIS Pro, and QGIS. The PSIC wanted the tools to be available agency wide and to its contractors. Since both ArcGIS Pro and QGIS are desktop-oriented applications, ArcGIS Online was best suited for this purpose. The development of the webapps utilized ArcGIS Web AppBuilder which works in conjunction with ArcGIS Online. The following describes the benefits and limitations of the chosen platform.

3.4.1 PST 2.0 Webapp

The PST 2.0 webapp was also developed using ArcGIS Web AppBuilder, which provided the following benefits:

- Comes with many ready-to-use widgets such as report and printing.
- Allows for use of JavaScript to provide additional functionality.
- Able to process a large number of layers/datasets quickly for report creation.
- Has plenty of documentation and a large user base/community.

Some of the features requested by the SCDOT were beyond the capabilities of the ready-to-use widgets. In such instances, the project team developed codes to achieve the desired functionality. For example, the built-in screening widget analyzes a fixed set of layers. To screen all available layers, the Query widget was combined with the Screening widget so that the results obtained from the Query widget are passed onto the Screening widget for analysis. A unique feature requested by the SCDOT was to be able to screen a project by specifying the beginning and ending mile point of a road. This feature is not supported by ESRI, thereby requiring custom code. Another feature requested by the SCDOT that is not supported by ESRI is the ability to group the different

data layers and perform screening at the group level (not at the data layer level to expedite the process). This functionality was also accomplished using custom code.

3.4.2 Mitigation Forecasting Tool

The MFT webapps were developed using ArcGIS Dashboard, which provided the following benefits.

- It is easy for the project team to configure the dashboard widgets and elements.
- Graphs and maps are updated quickly upon user input.
- Has plenty of documentation and many layout examples.

While not a limitation *per se*, the PSIC did not want the banking community to be able to zoom in on maps and drill down for additional information. These capabilities were removed from the MFT app by modifying the Javascript code associated with the Dashboard infographic widget.

3.4.3 Jurisdictional Determination Webapp

Like the PST 2.0 webapp, the JD webapp was also developed using ArcGIS Web AppBuilder. Its benefits have been mentioned previously. A key limitation encountered with the JD webapp development in the creation of an index map and associated supporting maps for large projects that cannot be shown all on one page. Such functionality is not supported by any existing widgets. Custom code will need to be developed to automate some of the steps in this complicated workflow.

CHAPTER 4: WEB APPLICATIONS AND SMART FORMS

4.1 Introduction

The following provides the key features and functionalities of the developed webapps and smart forms. Video tutorials for how to these apps have been prepared by ESO staff and are available on ProjectWise (in the *Deliverables* folder that resides within the *SPR 741* and *Exchange* directories).

4.2 Mitigation Forecasting Tool

The external MFT webapp is an ArcGIS Dashboard application which shows the banking community the projected wetlands and streams impact at the state level as well as per watershed in South Carolina. Figure 4-1 shows a screenshot of the dashboard. As shown, there are two text widgets (title and disclaimer), four infographic widgets, a listing widget (of transportation projects), and a selection widget which allows the user to select a watershed.

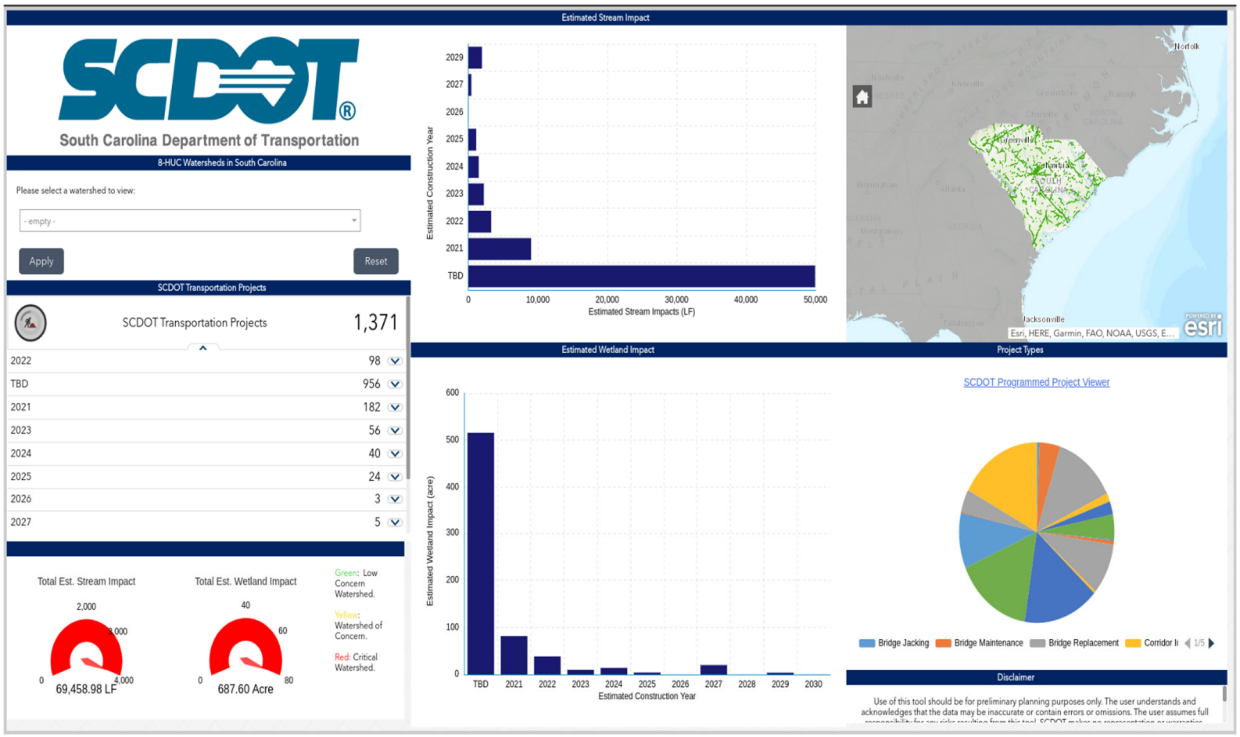

Figure 4-1. External MFT dashboard

By default, the impacts for the entire state are shown. The user can view the impact per watershed by using the selection widget and selecting the desired watershed as shown in Figure 4-2. Upon selecting a watershed, the information in the four infographic widgets will automatically be updated. The user can hover the mouse over the graph/chart in the infographic widget to obtain additional information.

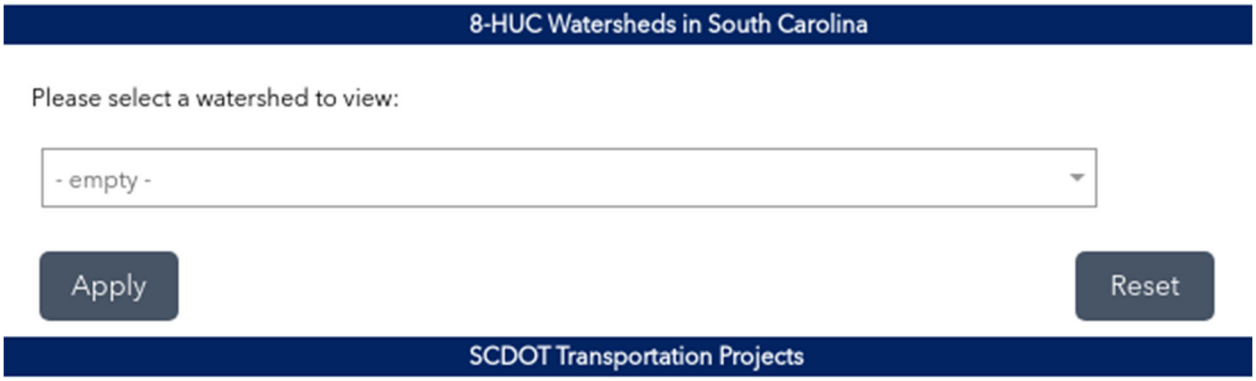

Figure 4-2. Selection widget to filter results by watershed

4.3 Project Screening Tool (PST 2.0)

Figure 4-3 shows the default view of PST 2.0, available only to SCDOT staff (ESO personnel and certain individuals outside of ESO). This view is shown after the user has provided a valid ArcGIS Portal/Online login credential and accepted the disclaimer. Except for the external MFT webapp, all webapps and smart forms require ESRI license.

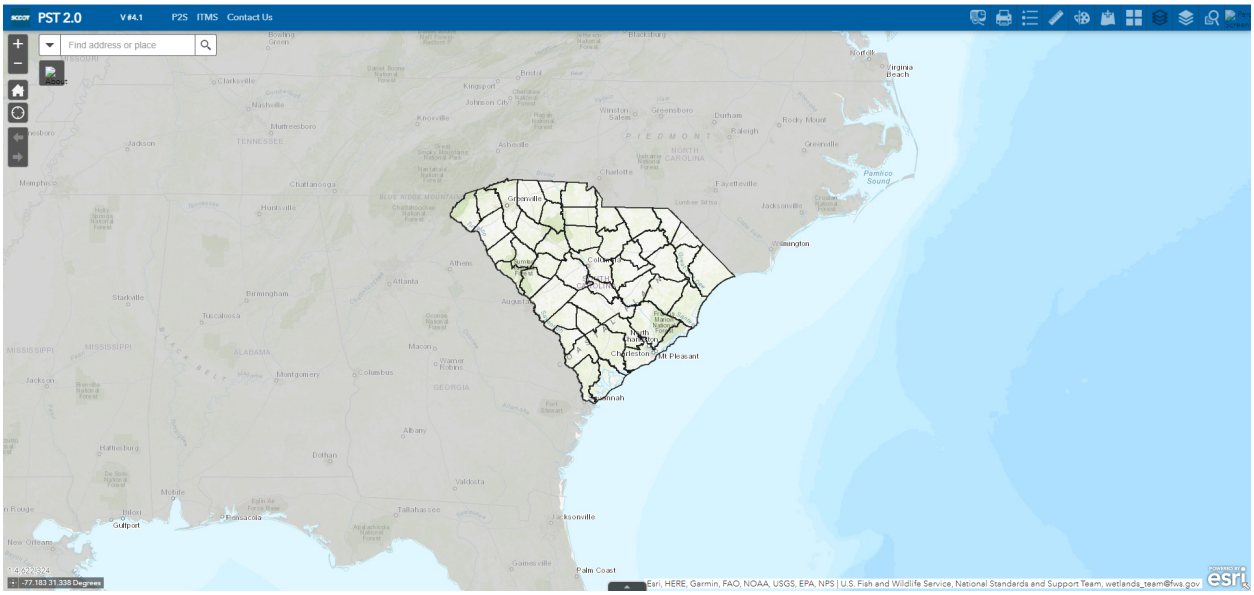

Figure 4-3. PST 2.0 default view

The user can screen a project using a number of options: 1) enter the project ID or project name in the "Find address or place" within the "Screening by Groups" widget, 2) draw the project's centerline and indicate a buffer or draw the project's boundary, 3) upload the shapefile of the project, or 4) using the Query widget and specify the route type, route number, beginning mile point, ending mile point, and county. Once the desired project/area is spedified, the screening results can be obtained by clicking on the "Report" button.

The screening analysis uses the following data layers: 1) Water (WOUS), 2) water quality, 3) biological resources, 4) land and waste, 5) coastal resources, 6) protected lands, 7) boundaries, 8)

cultural resources, and 9) roads and bridges. By default, all these data layers are selected. However, users may unselect some of these if they are not needed for the screening report.

Once the screening analysis is finished, users will be able to view environmental impacts of the project as shown in Figure 4-4. Expanding the found impacted data layers (if the analysis returns a non-zero value) will show additional information.

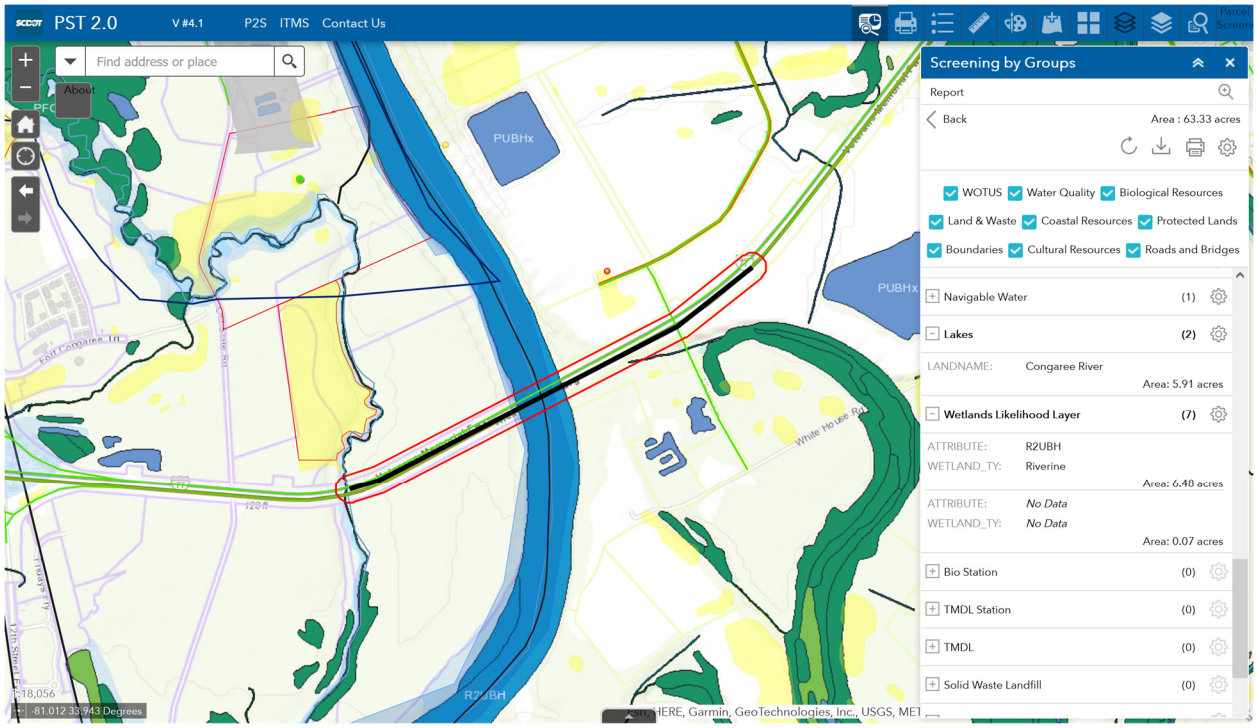

Figure 4-4. PST 2.0 screening analysis results showing data layers being impacted

The screening report can be obtained by clicking on the "Print" button. Page one of the report shows a map of the project area (see Figure 4-5). This is followed by a summary of the impacts and detailed information about each impact as illustrated in Figure 4-6.

The majority of the data layers in PST 2.0 are dynamically linked through Representational State Transfer (REST) services provided by other organizations. The advantage of using this approach is that when the data are updated by other agencies, they are automatically updated in PST 2.0. Table 4-1 provides the source of each data layer. The layers associated with cultural resources were downloaded from ArchSite (http://www.scarchsite.org/). The SCDOT ESO will be responsible for monitoring changes to the data layers and will coordinate with IT/GIS staff to have the necessary layers updated.

P026822 Screening....

Area of Interest (AOI) Information

Area : 3.21 acres

Buffer: 15 Feet

Feb 8 2022 10:33:00 Eastern Standard Time

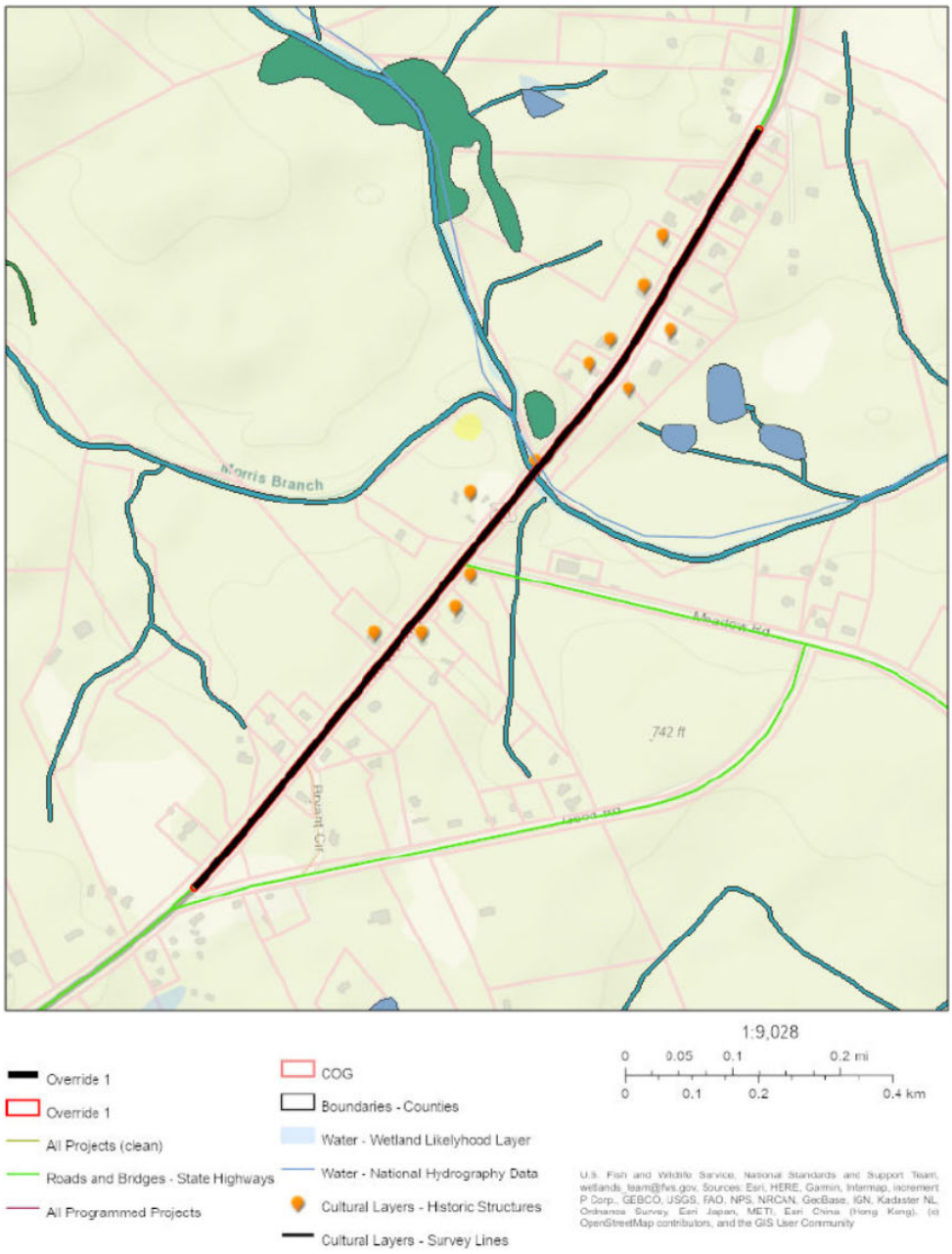

Figure 4-5. Page 1 of PST 2.0 report showing project area

Summary

Name	Count	Area(acres)	Length(ft)
Other Roads	1	N/A	12.90
Watershed	1	3.21	N/A
Ecoregion	1	3.21	N/A
Historic Structures	1	N/A	N/A
Survey Lines	1	N/A	1,913.41
Navigable Water	1	N/A	31.90
USGS Streams	1	N/A	31.90

Other Roads

#	STREET_NAM	ROUTE_TYPE	ROUTE_NUMB	Length(ft)
1	BRYANT CIR	L-	3,731	12.90

Watershed

#	Basin	HUC 8	Area(acres)
1	Catawba	03050101	3.21

Ecoregion

#	L4_KEY	L3_KEY	Area(acres)
1	45b Southern Outer Piedmont	45 Piedmont	3.21

Historic Structures

#	Site_Numbe	Report_Tit	NR_Eligibi	Address	Count
1	3844	Phase I Cultural Resources Survey of the US 321 Bridge over Allison Creek	Not Eligible	US 321/ Filbert Highway at Allison Creek	1

Survey Lines

#	Survey_nam	Survey_Dat	Length(ft)
1	Phase I Cultural Resources Survey of the US 321 Bridge over Allison Creek	2017	1,913.41

Navigable Water

#	NAME	GNIS_Name	Length(ft)
1	Allison Creek	*No Data*	31.90

USGS Streams

#	NAME	Length(ft)
1	Allison Creek	31.90

Figure 4-6. PST 2.0 report showing summary and detailed impact information

Table 4-1. List of data layers in PST 2.0 and their sources

Group	Layer	Attribute Naming	Source
Boundary	Counties	County ID; County Name; Engineering District	SCDOT Server
	Cities	Name	SCDOT Server
	COG	Name	SCDOT Server
	Watershed	Name; 8 Hydrologic Unit Code	USGS - Rest Service
	Ecoregion	Level 3 Ecoregion	SCDOT Server
Roads & Bridges	Statewide Bridges	Route Type; Route Number; Structure ID; Mile Point	SCDOT Server
	Other Roads	Street Name; Route Type; Route Number	SCDOT Server
	State Highways	Route Number; Route Type; Street Name	SCDOT Server
Biological Resources	T & E Species	Scientific Name; Common Name; National Ranking; Occurrence Location	U.S. Fish & Wildlife Service - Rest Service
	Statewide Element Occurrence's	Scientific Name; Common Name; Category; Federal Protection; Date Last Observed	U.S. Fish & Wildlife Service - Rest Service
	T & E Critical Habitat	Common Name; Scientific Name; Listing Status	U.S. Fish & Wildlife Service - Rest Service
	Oyster Habitat Corridor		U.S. Fish & Wildlife Service - Rest Service
	Bald Eagle Nests		U.S. Fish & Wildlife Service - Rest Service
Cultural Resources	Archaeological Point	Site Number; National Register of Historic Places Status	USC - Rest Service
	Civil War Earthworks	Resource Number; Report Title	USC - Rest Service
	Historic Structures	Site Number; Report Title; National Register Eligibility; Address	USC - Rest Service
	National Register Points	Resource Number; Certification; Address	USC - Rest Service
	Restricted National Register Points	Resource Number; Certification;	USC - Rest Service

Group	Layer	Attribute Naming	Source
	Survey Lines	Survey Name; Survey Date	USC - Rest Service
	Archaeological Site	Project; Site Number	USC - Rest Service
	Survey Areas	Survey Name; Survey Date	USC - Rest Service
	Historic Areas	Site Number; Resource Number; National Register Eligibility; Report Title	USC - Rest Service
	National Register Polygon	Resource Number; Address; Certification	USC - Rest Service
	Restricted National Register Polygon	Resource Number	USC - Rest Service
Coastal Resources	Shellfish Monitoring Station		SCDNR - Rest Service
	Critical Area Boundary		SCDNR - Rest Service
	Shellfish Classification		SCDNR - Rest Service
	SCDNR Oyster Habitat		SCDNR - Rest Service
	SCDNR Oyster Beds		SCDNR - Rest Service
Protected Lands	NWF Wildlife Refuges Area	Name	NWF- Rest Service
	NRCS Easements	Easement Name	NRCS - Rest Service
	Heritage Preserves	Name	USFS - Rest Service
	Parks	Name	USFS - Rest Service
	US Forest	Name	USFS - Rest Service
	Wildlife Management Areas	Name	NWF- Rest Service
WOTUS	Navigable Water	Name; GNIS Name	USGS - Rest Service
	Lakes	Lake Name	SCDNR - Rest Service
	NWI		NWI - Rest Service
	Wetlands Likelihood Layer		USC - Rest Service

Group	Layer	Attribute Naming	Source
Water Quality	DHEC 303 D Listed Stream	Station; Description; Waterbody Use; Status; Impairment	SCDHEC - Rest Service
	Bio Station	Station	SCDHEC - Rest Service
	Station	Station	SCDHEC - Rest Service
	TMDL	Technical Report & TMDL; Waterbody	SCDHEC - Rest Service
Land and Waste	Solid Waste Landfill		SCDHEC - Rest Service
	Underground Storage Tank		SCDHEC - Rest Service
	Above Ground Storage Tank	Main Point; Name; Site	SCDHEC - Rest Service
	CERCLA	EPA ID Number; Site Name; Site Type	SCDHEC - Rest Service
	Compliance and Enforcement	File Name; EPA ID Number; Address	SCDHEC - Rest Service
	Dry Cleaners	Facility; Address; Project Number	SCDHEC - Rest Service
	Leaking Underground Storage Tank	Site Number; Local Address	SCDHEC - Rest Service
Others	minority	Name	SCDHEC - Rest Service
	Soil Classification	Soil Name; Soil Symbol; Soil Key	USGS - Rest Service

4.4 Jurisdictional Determination Webapp

Figure 4-7 shows the default view of the JD webapp. This view is shown after the user has provided a valid ArcGIS Portal/Online login credential and accepted the disclaimer.

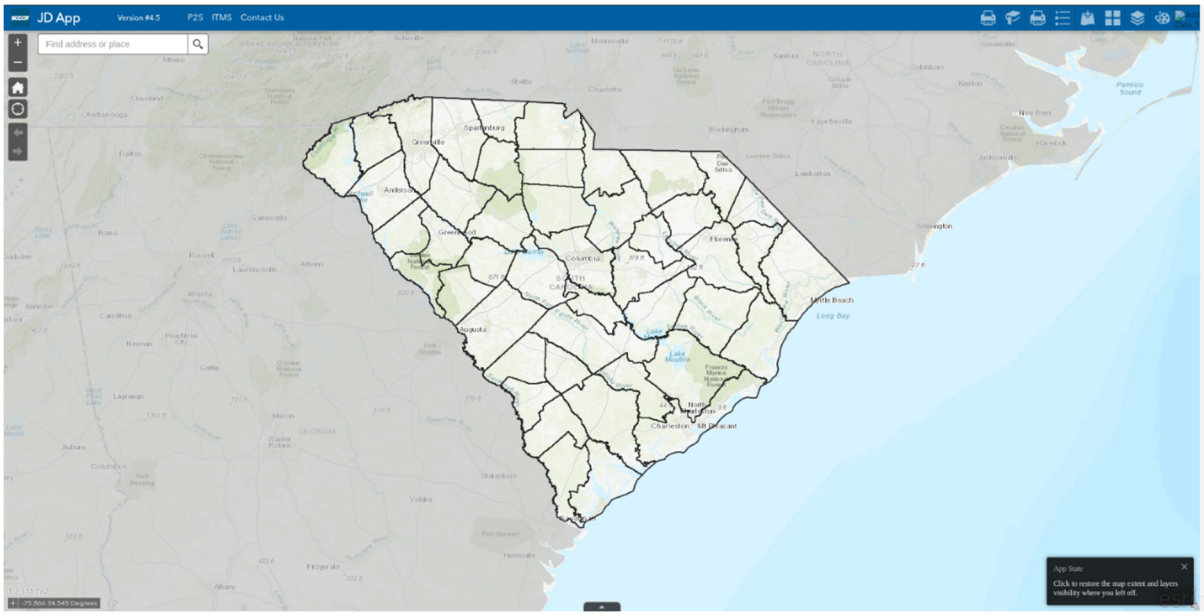

Figure 4-7. JD webapp default view

To create the standard seven maps that are needed for every JD application, the user will first need to upload four different shapefiles: 1) wetland boundary shapefile (polygon), 2) non-wetland water shapefile (can be line or polygon), 3) project data points shapefile (multipoint), and 4) project boundary shapefile (polygon). The uploaded files must follow a specific naming convention as indicated in the app. Once the shapefiles are uploaded, the maps' header information, such as author, project name, project ID, and acreage, can be specified by selecting the JD Print widget. Clicking on the "Print ePermit Maps" button will generate seven maps in PDF format: 1) location map, 2) project location map, 3) aerial photo map, 4) topographic map, 5) soil survey map, 6) NWI map, and 7) jurisdictional feature map. These maps will need to be downloaded onto the local drive and uploaded when completing the JD application using the JD smart form.

4.5 Jurisdictional Determination Smart Form

Figure 4-8 shows a condense view of the JD smart form after the user has provided a valid ArcGIS Portal/Online login credential. As shown, the first three sections of the smart form are identical to those of the paper form. The questions within each section are also identical to those found in the paper form. Only the method of completing the form is different. The use of the smart form facilitates data entry. For example, by using the provided map to indicate the project site, the city, county, latitude, and longitude will be auto populated. Also, by selecting the name of the SCDOT requestor, the phone and email address of the selected person will be auto populated, as well as the address of the SCDOT.

The last two sections of the JD smart form are added functionalities. The section titled "Supporting Documentation" requests the user to upload: 1) maps for the project (these are the seven maps generated by the JD webapp), 2) source files / shapefiles used to create the maps, 3) summary feature table, 4) wetland determination data form, and 5) photo log. In the section titled "Review Status," if the user indicates the application is ready for SCDOT review, then the SCDOT requestor will also receive a copy of the email and JD report. Otherwise, only the user will receive the email and copy of the JD report.

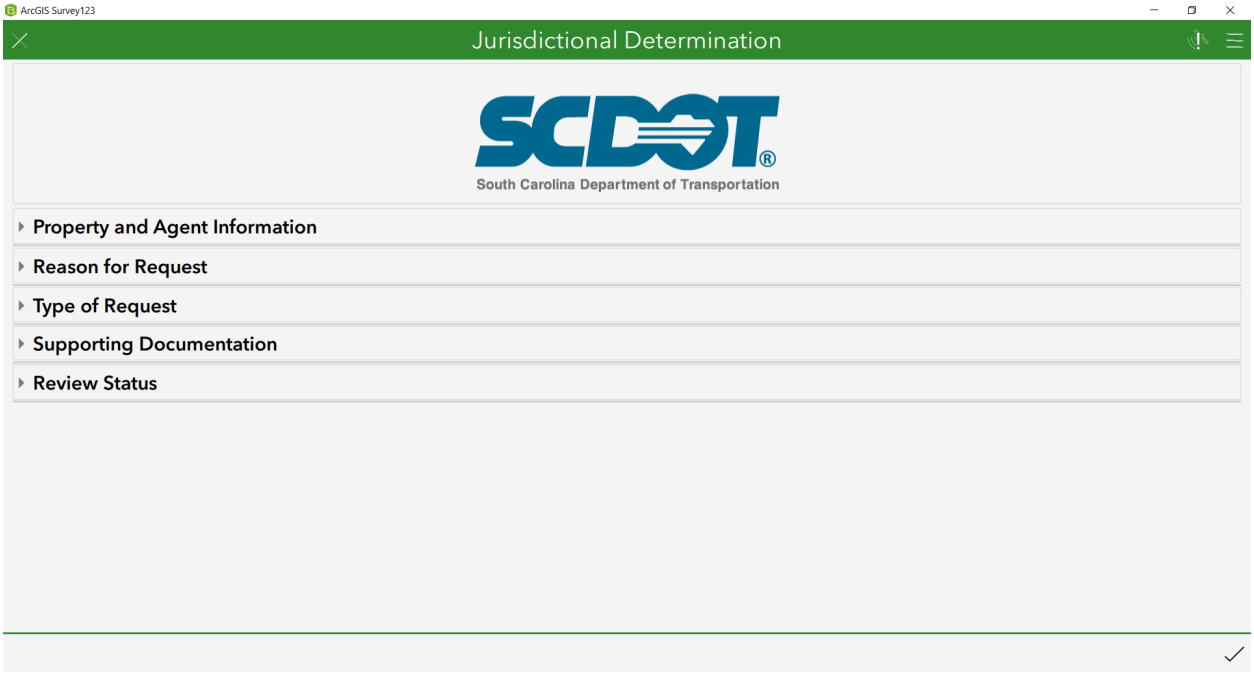

Figure 4-8. JD smart form condensed view

4.6 General Permit Smart Form

Figure 4-9 shows the first page of the GP smart form after the user has provided a valid ArcGIS Portal/Online login credential. Unlike the JD smart form, the sections and questions of the GP smart form are very different from those of the paper form. However, the final product, the report itself is similar to the paper form.

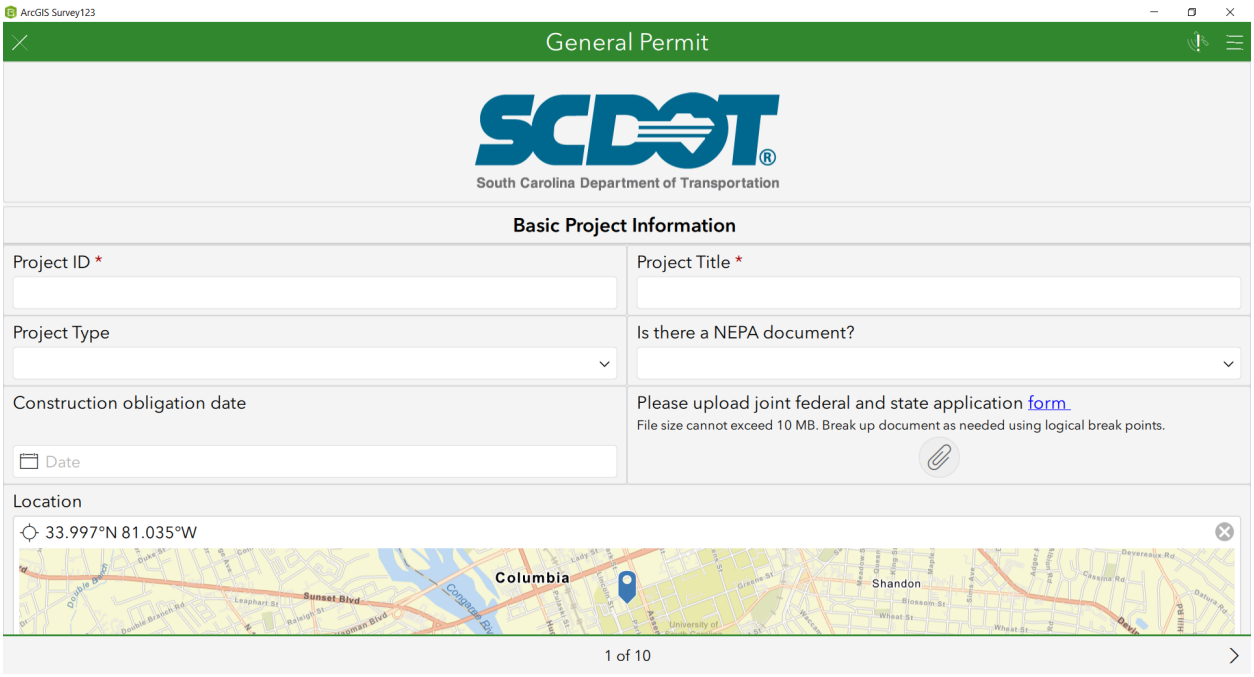

Figure 4-9. Page 1 of GP smart form

As shown in Figure 4-9, page 1 of the GP smart form requests the user to provide basic project information. Page 2 requests detailed project information. Pages 3, 4, and 5 request project impacts information for freshwater wetlands, tidal wetlands, and streams. These pages implement the mitigation credit table and worksheet. Page 6 shows the overall project impacts based on entry on pages 3, 4, and 5. Page 7 requests the user to indicate the avoidance and minimization measures taken for the project. This page was designed to allow the SCDOT to take credit for the avoidance and measures taken without complicating the data entry process. Pages 8, 9, and 10 request for information regarding mitigation for freshwater wetlands, tidal wetlands, and streams, respectively. These pages appear only if the user had indicated an impact on pages 3, 4, or 5. Page 11 requests the user to provide supplemental information, including: 1) endangered species act, 2) essential fish habitat, 3) section 106 properties, 4) floodplains, 5) critical area delineation, and 6) permit drawings. The last page asks for names and email addresses of the consultant and SCDOT requestor. As is the case with the JD smart form, if the user indicates the application is ready for SCDOT review, then the SCDOT requestor will also receive a copy of the email and GP report. Otherwise, only the consultant will receive the email and copy of the GP report.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This project investigated methods to decrease three known risk areas that have led to project delays and cost overruns for the SCDOT: 1) inconsistent general permit application submittals, 2) inability to consistently identify "red flags" early in the project development process, and 3) lack of mitigation credit coverage. The findings from the literature review indicated that no other state DOT has developed an electronic permitting application for Section 404 general permits and a few agencies have developed GIS-based mitigation tools and project screening tools (PST). However, none of the other agencies' in-house mitigation and project screening tools can be easily tailored to the SCDOT's practice. As a result, the PSIC directed the project team to develop applications that address SCDOT specific needs. Altogether, three web applications (webapps) and two web-based smart forms were developed with weekly input and feedback from the PSIC. These include Mitigation Forecasting Tool (MFT) webapp, Project Screening Tool (PST 2.0) webapp, Jurisdictional Determination (JD) webapp, JD web-based smart form, and General Permit web-based smart form (e-permit). These five applications have been delivered to the SCDOT for implementation.

5.2 Recommendations

It is recommended that the SCDOT consider adopting and utilizing the developed applications in its day-to-day operations. Results from actual use and beta testing of these applications indicate the following tangible benefits for the SCDOT:

1. The external MFT webapp has strengthened the relationship between the SCDOT and the mitigation banking community. As a result, the mitigation risk in South Carolina has been significantly reduced and will continue to be reduced with the increase in the number of approved banks across the state, with more on the horizon, pending approvals.

2. The use of the PST 2.0 webapp is expected to save ESO staff 20 to 25 hours per month based on a monthly average of one feasibility report and four to five project screenings.

3. The use of the e-permit smart form is expected to save SCDOT money by reducing consultants on contract by 30 to 40 hours per month based on a monthly average of two general permits.

4. The average USACE review and approval time over the past 2 years is 75 days with the longest duration being 243 days. It is anticipated that with the use of the developed e-permit smart form, the majority of GPs will be approved within 2 months.

The direct time and cost savings of this project has led to an ongoing Phase II to further streamline ESO processes. The work plan includes: 1) integrating webapps and smart forms with P2S to enable more information to be auto populated, 2) converting the current paper-based NEPA form to a web-based smart form like the e-permit, 3) improving upon an existing compliance app to provide additional capabilities such as copying an existing report and make adjustments to it and performing data analytics on the compliance data, and 4) incorporating wetland delineation data into the JD and PST 2.0 webapps.

5.3 Implementation Plan

The developed applications have been transferred to the SCDOT IT. Source codes have been put in the project's deliverables folder on ProjectWise. The instructions for installing and deploying Survey123 application have been shared with SCDOT IT and are included in Appendix A. The SCDOT IT has been successful in deploying the forms in their GIS Portal environment. Similarly, the instructions for deploying the ArcGIS webapps have been shared with SCDOT IT and are included in Appendix B. The SCDOT IT is in the process of deploying these apps on its own web server. The SCDOT ESO will be responsible for monitoring changes to the data layers in PST 2.0 and will coordinate with IT/GIS staff to have the necessary layers updated. The SCDOT ESO will also be responsible for updating the data used by the internal and external MFT webapps.

The use of webapps and Survey123 forms require SCDOT GIS Portal login credentials. The SCDOT IT acquired additional licenses for both applications for ESO staff in 2021. The workflow automation was originally implemented using Integromat and CloudConvert. In phase II of this project, they will be replaced by Microsoft Power Automate and Encodian. The SCDOT IT has purchased licenses for both these products.

Several initiatives have been implemented and several more are being planned to assist SCDOT staff, consultants, and partners in using the developed tools. Training was provided to SCDOT superusers throughout the project duration, and these superusers in turn have produced video tutorials for their colleagues and consultants. The SCDOT superusers have also shown the mitigation bankers how to use the external MFT webapp. Current initiatives to further assist with the implementation of the tools include working with the SCDOT video production office to produce shorter how-to video tutorials, a workshop for select consultants in March of 2022, a workshop for all consultants that do business with SCDOT ESO in May of 2022, and demonstration of the tools at the 2022 SC Highway Engineers Conference. Lastly, a promotional YouTube video is being put together to showcase the tools developed in this project for the benefit of SCDOT peers.

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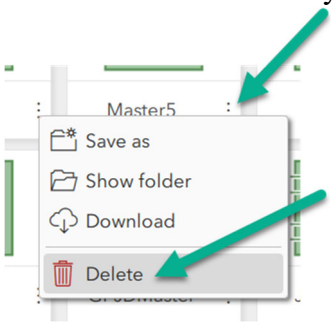
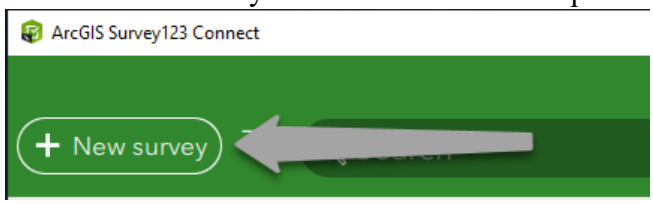
APPENDIX A

Instructions for Installing and deploying Survey123 smart forms

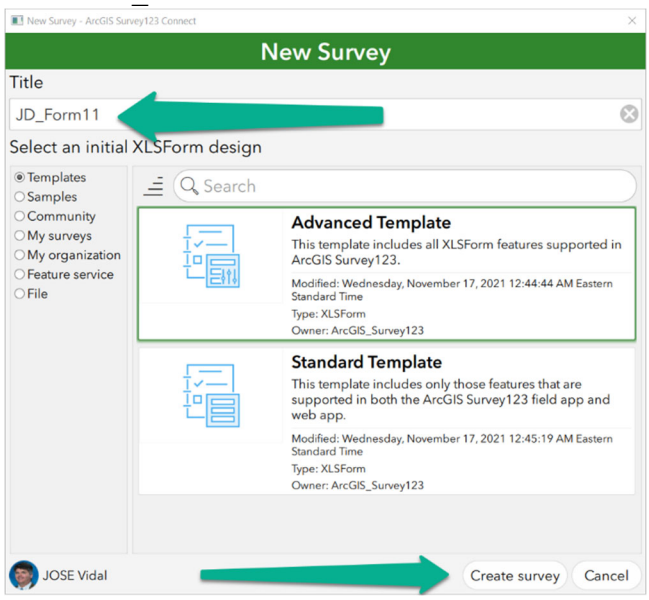
1. Download and install Survey123 Connect desktop app: https://www.esri.com/en-us/arcgis/products/arcgis-survey123/resources. Scroll to the bottom of the page.
2. Download and install ArcGIS Survey123 field app: https://www.esri.com/en-us/arcgis/products/arcgis-survey123/resources. Scroll to the bottom of the page.
3. Open the Survey123 Connect desktop App.
4. Delete the current JD form. To delete a survey from Survey123 Connect, click the menu button next to its name, and click Delete. To confirm your action, click Press and hold to delete to delete the survey and all files stored locally in the survey folder.



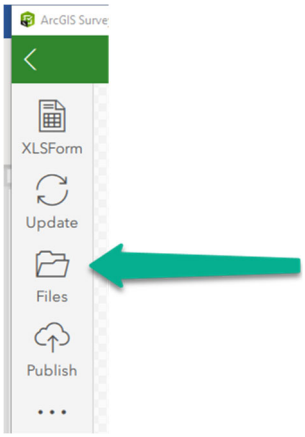
5. Delete the current General Permit form. Same procedure as above.
6. Create a new survey based on advanced template.



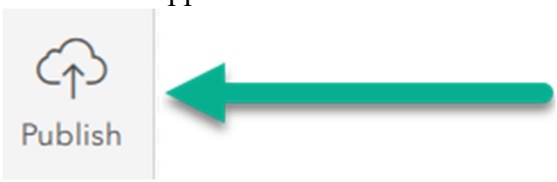
7. Enter "JD_Form11" for the Title and then select Create Survey



8. Click on the Files folder icon which will bring up a Files Explorer folder.



9. In the Files Explorer folder, delete the JD_Form11.xlsx file. Copy the provided JD_Form11.xlsx file into this folder.
10. In the Files Explorer folder, create a folder called "media" and place the provided "scdot_districts.csv", "scdot_requestors.csv", and "scdot_logo.png" files in this folder.
11. Publish the app.



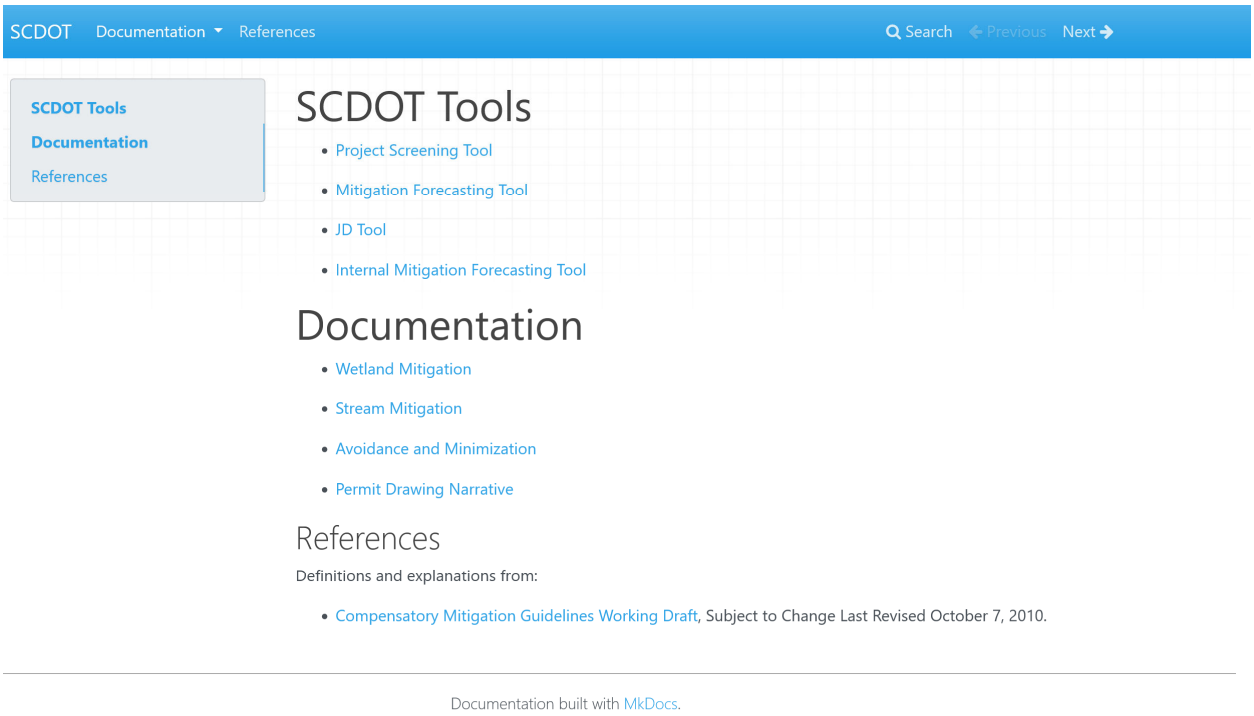
12. Create a new survey. Enter "GP_Form11" for Title and the select Create Survey.
13. Click on the Files folder icon which will bring up a Files Explorer folder.
14. In the Files Explorer folder, delete the GP_Form11.xlsx file. Copy the provided GP_Form11.xlsx file into this folder.
15. In the Files Explorer folder, create a folder called "media" and place the provided "scdot_districts.csv", "scdot_requestors.csv", and "scdot_logo.png" files in this folder.
16. Publish the app.
17. Close the Survey123 Connect App
18. Open the Survey123 Field App
19. Type "JD_Form11" in the search bar. The JD_Form11 app should appear in the list below. Click on the download icon to download the app.

20. Type "GP_Form11" in the search bar. The GP_Form11 app should appear in the list below. Click on the download icon to download the app.

APPENDIX B

Instructions for deploying ArcGIS webapps

1. Create a static webpage where users can run the webapps. The webapps are currently hosted at: https://scdot.cse.sc.edu/ as shown below.



2. Deploy (i.e., copy) the zipped files in ProjectWise to the respective folders on the SCDOT webserver (e.g., mft.zip should be copied into the MFT folder). Unzip the files. The figure below shows the directory structure of the cse.sc.edu webserver. Note that each app has its own folder.

3. Set the path/folder_name as the URL reference for each app. That is, Hypertext REFerence (HREF) each app on the static web page to the folder where the source code resides. For example, `<a href="/path-to-folder/MFT/index.html">Mitigation Forecasting Tool</a>.`