Ohio's Research Initiative for Locals (ORIL) Research On-Call 2021-ORIL6 (Task 3) – Asset Management Practices by Ohio Local Public Agencies

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16. Abstract

This Research-on-Call (ROC) task was initiated by the Ohio's Research Initiative for Locals (ORIL) program to obtain information on the current state-of-practice for transportation asset management by local public agencies (LPAs) in Ohio. An online survey was conducted in this task to collect information from Ohio LPAs regarding their asset management practices as they relate to the tools and processes currently used to manage transportation assets; the types of asset data recorded in their asset management inventories; methods used for collecting, storing, and analyzing the transportation asset data; whether or not the LPAs use outside contractors to collect and/or process the asset data as well as the costs associated for doing so; and how LPAs use the asset management inventory data and analysis results. The research team received 69 responses to the survey. Widely varying practices were reported by LPAs for managing their transportation assets. Some LPAs reported using specialized software and ArcGIS-enabled systems to aid them in storing and analyzing their asset data. Other LPAs collect and store their asset data in Microsoft Excel spreadsheets or Microsoft Access databases and use basic functions to analyze the data. Some LPAs have no formal processes or systems in place for storing or managing their data. The majority of respondents reported that their agencies use asset inventory data and analysis results for performance evaluation and monitoring, fiscal planning, and project prioritization. About half or fewer respondents indicated that their agency uses the data and results for resource allocation; auditing, reporting, and communication; or for policy formulation. Follow-up emails were sent to selected respondents to solicit details about the systems or software used by their agencies. The features of these systems and other commercially available software were documented for the benefit of LPAs that are considering the adoption of such a system.

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None.

1. Problem Statement

Local Public Agencies (LPAs) in Ohio are responsible for maintaining a wide array of transportation assets, including pavements, bridges, culverts, etc. One of the most important functions of an LPA is to develop an annual capital improvement plan that identifies the capital needs of the agency and lays out a funding strategy to maintain these assets. This function involves collecting and analyzing detailed information about the assets; assessing the physical condition of these assets to evaluate their performance and estimate their remaining service life; assessing the cost to repair or replace the assets; prioritizing all options; and establishing a schedule for the appropriate activities.

The processes and systems used by LPAs in Ohio to manage the transportation asset information needed for the development of their annual capital improvement plans are not standardized, and the actual practices used by these agencies can vary widely. Some LPAs use robust, established systems to aid them in storing and analyzing their transportation data, and these systems may include built-in features that allow the data to be analyzed. Other LPAs collect and store their data in spreadsheets (such as Microsoft Excel) and use basic spreadsheet functions to analyze the data. Some LPAs have no formal processes or systems in place for storing or managing their data, and they simply rely on the knowledge of current staff when making decisions regarding future capital improvement plans.

Ohio's Research Initiative for Locals (ORIL) initiated this Research-on-Call (ROC) task to obtain information on the current state-of-practice in Ohio as it relates to the tools and processes that LPAs are currently using to collect, organize, store, and analyze data on their assets as well as to look at how LPAs are using these tools and processes to support their decisions on annual capital improvement plans. The recommendations made in this project can be used by LPAs to facilitate more informed decisions with regard to transportation planning, operations, maintenance, capital improvements and project prioritization. In addition, having better information on their transportation assets may also assist LPAs in supporting their requests for funding. Moreover, having the data and information on their transportation assets easily at hand may also help LPAs to coordinate more effectively with other public agencies on infrastructure projects that are not related to transportation (such as improvements to water lines, wastewater collection systems, and other public utilities) to prevent these projects from causing damage to any transportation infrastructure assets, especially those that have been recently updated or repaired.

2. Objectives of the Study

The primary goal of this task is to document the current state-of-the-practice by Ohio LPAs with regard to transportation asset management. The specific objectives of this task include:

- Identify the transportation asset data collected by LPAs in their jurisdictions.
- Document the current methods used by LPAs in Ohio to collect, store, analyze, and use the different types of data for transportation as well as the associated costs.
- Identify any gaps in current processes used by LPAs.
- Identify potential overlaps or opportunities for collaboration amongst LPAs related to transportation data.

3. Research Background

The Ohio Department of Transportation (ODOT) defines asset management as a "systematic and strategic investment decision process for operating, maintaining, upgrading and expanding physical assets effectively over their life cycle that is based on quality data and well-defined objectives" (ODOT, 2021a). These physical assets include roads, bridges, culverts, guard rails, pavement markings, signs, and other structures alongside the roads. Because of the number of different asset types and their variation in terms of service life, management of transportation assets is a highly complex process.

As computer systems became widely available, some transportation agencies have used spreadsheet software and database systems (such as Microsoft *Excel* and Microsoft *Access*) to track maintenance and performance of assets and infrastructure, particularly if they have only a small number of assets in a given asset class and if very few people have access to the spreadsheet. However, spreadsheets were not specifically designed for asset maintenance and can make the management of transportation assets more complex and difficult. Because employees need to make updates on a local computer, they may have multiple versions of a files on their workstations (and might not use the latest version), or they may lock out others if they do not close a file before leaving. In addition, other users of a shared file might modify, delete, or corrupt the files, and it may not be possible to restore the files to a previous version. Moreover, errors in formulas can be introduced if users make syntax errors or data entry errors. Finally, spreadsheets can generate only basic reports, graphs, or charts, and additional formatting of the reports is generally required (FasTrak SoftWorks, Inc. 2018).

Numerous software companies have also developed a type of system (or software) referred to as a computerized maintenance management system (CMMS; also known as *enterprise asset management software*) for asset management (MicroMain 2021), and some of these systems are

specifically designed for managing transportation assets. As shown in the schematic diagram in Figure 1, CMMS software functions by providing a central database for storing asset and maintenance information. This database can be accessed and modified by multiple users, from inspectors and field evaluators who enter the latest inspection or performance data to agency staff at the office who use this data to schedule maintenance and make budgetary forecasts. CMMS software has the capability to expedite certain processes, and it automates tasks such as performing calculations and checking for input errors.

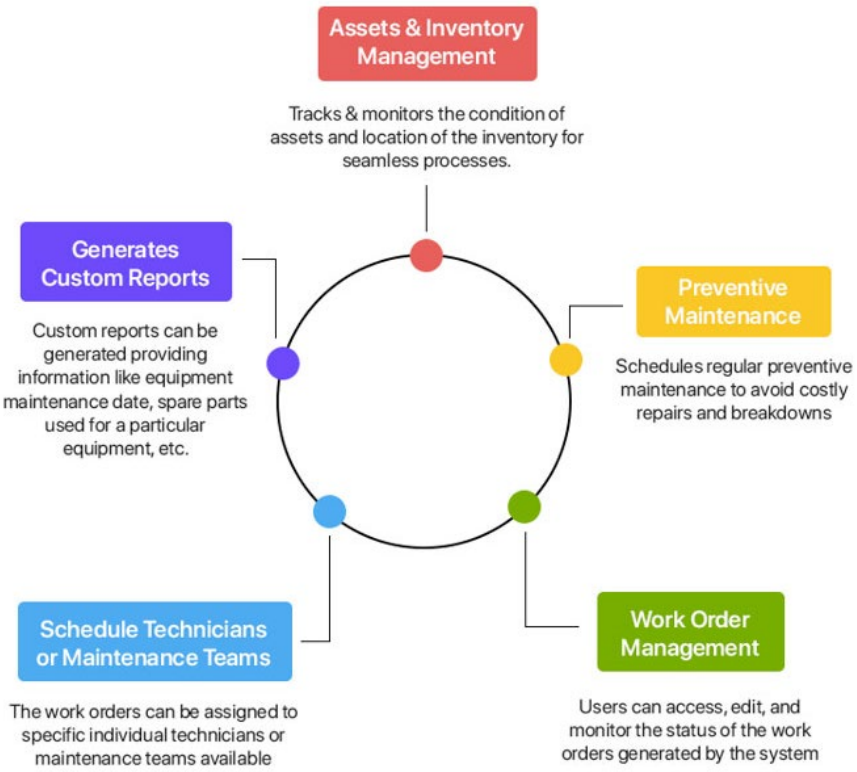

Figure 1. Functionality of a CMMS (Goodfirms 2021).

CMMS software has a number of features and functions than a standard spreadsheet. CMMS software can provide automatic notifications, trigger work orders, and make it easy to schedule preventive maintenance. CMMS software can also allow other types of information (such as schematic diagrams, manuals, photos, or videos) to be attached to a work order. In addition, web-based CMMS software enables employees to locally or remotely access the system from internet-enabled devices (computers, laptops, tablets, or smart phones), allows multiple people to have access to the system at the same time, and updates the database instantly, which ensures that all users will have the most up-to-date information. In CMMS software, all calculations are performed automatically (which makes it

less likely for errors to be introduced), and some will allow system administrators to set access privileges for various users to prevent information from being lost, overwritten, or deleted. However, if something should go awry, the most recent version of the central database can be recovered. CMMS software can also enable managers to view new maintenance requests and allow them to execute the request, document the work performed, and provide automatic updates to others regarding the status of the requested work throughout the entire process. Reports in CMMS systems are preformatted and are quick and easy to generate (often with only a few mouse clicks). These systems can also make it easier to compile information for audits and compliance purposes and produce detailed reports about completed work, as the system will record the time and date of any changes made to the database and will indicate which user made the change (FasTrak SoftWorks, Inc. 2018).

4. Research Approach

A detailed discussion of the research approach followed in this study is provided below.

4.1 Current State-of-the-Practice for Asset Management by LPAs in Ohio

An online survey was conducted in this study to document the current state-of-the-practice regarding transportation asset management systems used by LPAs in Ohio. A draft survey questionnaire was prepared by the research team that included multiple-choice questions and questions with short answers and was estimated to take 15 minutes or less to complete. The draft survey was sent to the Technical Advisory Committee (TAC) for this project in April 2021. Modifications were made and some questions were deleted or added based on comments received from the advisory committee, and the revised survey was implemented by the research team in Qualtrics. Survey invitations were sent to LPAs in Ohio by ODOT Research Section on May 26, 2021, and the due date for completing the survey was June 15, 2021. The due date was later extended to June 22, 2021, to give the invitees more time to respond.

The online survey was designed to collect the following information from LPAs: whether or not the LPAs use a transportation asset management system, the main assets included in the transportation asset management system, the data that is collected for each asset, the methods or software used to store and analyze the data (and whether they were developed in-house or are off-the-shelf products), whether the data is collected by the LPA itself or by external consultants or contractors, the costs associated with the data collection and analysis activities, and the main uses of the transportation asset management data and analysis results. The survey questionnaire is presented in Appendix A.

The research team received a total of 69 complete responses to the survey, and detailed summaries of the responses to the survey questionnaire were prepared. The results were presented to the TAC on July 12, 2021, and August 9, 2021. The survey findings are briefly discussed in Section 5 (Research Findings and Conclusions) below, and the complete survey results and a discussion of the findings are provided in Appendix B.

4.2 Asset Management Systems and Software

The research team contacted selected LPAs to obtain additional information regarding their responses to the survey questionnaire. All agencies who had reported using commercial software for transportation asset management and who had given their permission to be contacted in their survey responses were contacted by email. The respondents were asked to identify the software used by their agency and to elaborate on their use of the software. A total of 15 agencies (four city governments and 11 county engineers' offices) responded to the follow-up email message. The research team collected information about the CMMS platforms and software for transportation asset management that were mentioned by the respondents, as well as a few other software products that were identified during the course of this project. The email responses and software platforms are summarized in Section 5 (Research Findings and Conclusions). The email responses are summarized in Appendix C, and a summary of the CMMS platforms and software is provided in Appendix D.

5. Research Findings and Conclusions

As mentioned earlier, the research team received a total of 69 responses to the asset management survey. Responses were received from 67 local agency representatives in Ohio (34 counties, 13 cities, 13 townships, and 7 villages) as well as the Columbus Regional Airport Authority and the Ohio Turnpike Commission. The main findings were as follows:

- *Categories/Classes of Assets Overseen and Inventories Maintained for Transportation Assets*

The survey questionnaire asked general questions about what category/class of assets are overseen and what asset inventories are maintained. A total of 91% of agency representatives indicated that they oversee pavements, and 76% of respondents reported that their agency maintains a pavement inventory. A total of 64% of agency representatives indicated that they oversee bridges; of these respondents, 89% indicated that their agencies maintain bridge inventories. A total of 86% of agency representatives reported that they oversee hydraulic structures and systems; these respondents

indicated that their agencies maintain asset inventories for culverts (75%), stormwater management systems (42%), and roadside and non-roadside ditches (37%). A total of 80% of agency representatives indicated that they oversee traffic control and safety devices; these respondents indicated that their agencies maintain asset inventories for traffic signs (82%), pavement markings (60%), traffic signals (36%), street lighting (31%), and curb ramps (15%). Only 30% of agency representatives reported that they oversee utility assets; these respondents indicated that their agencies maintain asset inventories for water supply systems (75%), sanitary collection systems (76%), and electric power services (10%).

- *Types of Data Included in Asset Inventories*

Across all asset types, agency representatives indicated that asset location was the most frequently recorded data included in the asset inventory, with 100% of the locations for bridges, signals, curb ramps, water supply systems, sanitary collection systems, and electric power services included in the inventory, and between 88% and 98% for all other assets. The second most common asset data in asset inventories are attributes/characteristics, which were reported by respondents to be included in approximately 61–100% of asset inventories (with a much lower percentage of 29% for street lighting). Initial construction/installation data, performance/condition data, and data on maintenance and rehabilitation were far more frequently included in the asset inventories for bridges, pavements, and utility assets than in other asset categories. Relatively few agency representatives indicated that user feedback and/or complaints were included in asset inventories, regardless of the asset type.

- *Methods used by LPAs to Store and Process Asset Inventory Data*

When asked what method was used by their agencies to store and process their asset inventory data, the most frequent response from agency representatives was "commercial asset management software", but the percentage of adoption of this method varied by asset type. The lowest reported use of commercial software was for storing/processing pavement data (38% or agency responses), and the assets with the largest percentages were for curb ramps (75%), bridges (77%) and electric power services (100%). The next most frequent storage method reported by agency representatives was Microsoft Excel, which was consistent across most asset classes (in the range of 44 to 52%), with the exception of stormwater management systems (28%), ditches (32%), and traffic signs (36%). The use of custom in-house software for storing/processing asset data was reported by 8–19% of agency respondents for all asset classes except for electric power services (0%). The use of Microsoft Access

for the storage of asset data was reported by 5–13% of agency respondents for most asset classes; however, no agency respondents reported using Access for storing any utility asset data or data on traffic signals, street lighting, or curb ramps. The remaining agency representatives reported that their agencies are using other (unspecified) methods to store asset data.

- *Use of External Consultants or Contractors to Process or Analyze Asset Data*

The use of consultants or contractors for processing or analyzing of asset data varied by asset type. A total of 46% of agency respondents indicated that consultants or contractors were retained to process bridge data. Somewhat lower percentages of respondents reported that their agencies use consultants or contractors to process or analyze data for traffic signs (36%), traffic signals (35%), pavements (31%), and pavement markings (30%). Fewer respondents indicated that their agencies use consultants or contractors to process or analyze data on hydraulic structures or utilities.

The annual costs reported by agencies for processing or analyzing asset data by external consultants or contractors also varied by asset type:

- For pavements, agency respondents indicated that annual costs for external processing or analysis of asset ranged from less than $10,000 to around $75,000.
- For bridges, agency respondents indicated that annual costs for external processing or analysis of asset data ranged from less than $10,000 to around $50,000.
- Costs for external processing and analysis of data hydraulic structures were relatively low. The majority of agency respondents indicated that their agency's annual costs raged from less than $10,000 to about $25,000.
- For traffic control and safety devices, the vast majority of agency representatives reported that their agency's annual costs for the processing and analysis of asset data by external consultants/ contractors were under $10,000; this was the case for all respondents regarding pavement markings and curb ramps as well as the majority of respondents regarding traffic signs, traffic signals, and street lighting. The remaining respondents for traffic signs and street lighting reported annual costs of about $25,000, and the remaining respondent for traffic signals reported costs of about $75,000.
- Costs for external processing and analysis of utility asset data were relatively low. Agency respondents reported annual costs ranging from less than $10,000 approximately $25,000 for water supply systems and sanitary collection systems. Only one agency representative indicated that external contractors or consultants were used for processing and analysis of electric power services data, and this respondent reported that the annual costs were approximately $25,000.

- *Agency Use of Asset Inventory Data and Analysis Results*

The survey questionnaire also included a question about how LPAs use the asset inventory data and analysis results. In general, the majority of agency representatives report that their agencies use asset inventory data and analysis results for performance evaluation and monitoring, fiscal planning, and project prioritization. Around half or less of respondents reported that their agency uses the data and results for resource allocation; auditing, reporting, and communication; or for policy formulation.

- *Final Comments and Thoughts*

The last question on the survey questionnaire asked respondents to provide additional comments regarding asset management at their agency. The software used by LPAs for asset inventories included spreadsheets and databases (Microsoft Excel and Microsoft Access), ArcGIS-enabled systems, specialized software for particular assets (such as bridges or pavements), and dedicated CMMS systems as indicated in Table B.1 and the responses to follow-up emails (Appendix C). Respondents from several LPAs reported that their agencies are currently utilizing or are in the process of transiting an ArcGIS-enabled system. Several other agencies reported contracting with a company based in Ohio to record the location of their assets and to store/analyze asset data using the company's CMMS software, and some of these agencies also contract with the company to help them with asset data collection.

6. Recommendations for Implementation

Utilizing an asset management system can provide several benefits to an LPA. In addition to providing a central database for storing asset and maintenance information, CMMS systems are accessible to multiple users (both from workstations in the office and from smartphones or tablets used by inspectors or evaluators in the field). CMMS systems store all maintenance, repair, and replacement information, and asset managers can query the system to provide information on a particular asset or a general class of assets. The CMMS systems can perform automated calculations and check for input errors, and users can use analysis results to help them schedule maintenance and produce reports to help their agencies make budgetary forecasts. CMMS software has the capability to expedite certain processes: for example, some CMMS systems enable residents to report issues via their smartphones and send these reports straight to an asset manager, who can then use the system to create a work order and assign staff to conduct maintenance, repairs, or replacement. Some CMMS systems include

modules for different assets, enabling LPAs to add asset classes one at a time to build a more comprehensive system or to only choose modules for asset classes overseen by their agencies.

Recent advancements in asset management systems and data collection technology have made it more affordable for LPAs to implement an asset management system. As part of this study, the research team prepared a detailed summary of available asset management systems used by LPAs in Ohio and outside Ohio (Appendix D). The findings of this project can be used by Ohio LPAs that may have an interest in adopting a new asset management system or switching to a different system to assist them in making an informed decision regarding the available software and features.

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Appendix A
Survey Questionnaire

A.1 Introduction

A survey was conducted in this study to document the current state-of-the-practice regarding transportation asset management systems used by local public agencies (LPAs) in Ohio. A draft survey questionnaire was prepared by the research team and sent to the Technical Advisory Committee (TAC) for this project in April 2021. Modifications were made and some questions were deleted or added based on comments received from the advisory committee, and the revised survey was implemented by the research team in Qualtrics. Survey invitations were sent to LPAs in Ohio by ODOT Research Section on May 26, 2021, and the due date for completing the survey was June 15, 2021. The due date was later extended to June 22, 2021, to give the invitees more time to respond.

A.2 Survey Organization

A copy of the survey questionnaire is provided below. The questionnaire included a total of 38 questions organized into seven sections. In the first section, respondents were asked to provide their contact information to be used for follow-up purposes (if needed) and indicate the type of LPA that they work for. In the second section of the questionnaire, respondents were asked to indicate what general category/class of transportation assets (pavements, bridges, hydraulic structures, etc.) fall within their responsibility. For respondents who did not select any transportation assets, that was the end of the survey and the respondent was not required to answer the remaining questions. Respondents who indicated they oversee pavements and/or bridges were asked if their agency maintains an asset management inventory for pavements and/or for bridges. Agencies that indicated that they oversee hydraulic structures and systems, traffic control and safety devices, and utility assets were asked if their agencies maintained an asset management inventory for specific types of assets in each category. In the third section of the questionnaire, respondents were asked about the types of data they collect for each type of asset they oversee, including the location, attributes/characteristics, installation data, performance or condition data, information on maintenance/rehabilitation, and user feedback and/or complaints. The survey proceeded to the next section, which solicited information about the method(s) the agencies use to

store and analyze asset management inventory data for each specific type of asset they oversee. Available options included commercial software, custom software developed in-house, Excel spreadsheets, Access spreadsheets, or "other." In the fifth section, agencies were asked if they use external consultants or contractors to collect or analyze asset management data for each asset class and the associated costs. The sixth section asked about the main uses of the asset management data in each category and included options such as performance evaluation and monitoring, fiscal planning, project utilization, resource allocation, auditing/reporting/communication, and formulating policy. The seventh section asked for any additional thoughts or comments regarding asset management systems. The last screen of the survey thanked the respondents for their time and effort and included contact information for the principal investigator for the project, should the respondents have any questions regarding the survey.

Asset Management Practices by Local Public Agencies in Ohio

This survey is conducted for the Ohio's Research Initiative for Locals (ORIL) program to document the current state-of-the-practice by Ohio local public agencies (LPAs) with regard to transportation asset management.

The survey should take less than 15 minutes to complete.

Please complete the survey by June 22, 2021.

To view the survey questionnaire, please click: Asset management practices by local public agencies in Ohio.

For questions about this survey, please contact:
Dr. Ala R. Abbas
Department of Civil Engineering
The University of Akron
Email: abbas@uakron.edu

Collaborating researchers:
Dr. Eric Steinberg of Ohio University
Dr. Munir Nazzal of the University of Cincinnati
Dr. Douglas Nims and Dr. Serhan Guner of the University of Toledo

→

The University of Akron

Contact Information:

Name:

Position:

Agency:

Email address:

Phone number:

Type of local public agency that you work for:

- ○ City
- ○ County
- ○ Township
- ○ Village
- ○ Other. Please specify:

→

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Which of the following assets are you responsible for (please select all that apply)?

- [ ] Pavements
- [ ] Bridges
- [ ] Hydraulic structures and systems (culverts, storm water management system, or roadside and non-roadside ditches)
- [ ] Traffic control and safety devices (traffic signals, traffic signs, pavement markings, street lighting, or curb ramps)
- [ ] Utility assets (water supply system, sanitary collection system, or electric power services)
- [ ] None of the above

→

Does your agency have an asset management inventory for **pavements**?

- ○ Yes
- ○ No

Does your agency have an asset management inventory for **bridges**?

- ○ Yes
- ○ No

Does your agency have an asset management inventory for any of the following **hydraulic structures and systems**?

	Yes	No
Culverts	○	○
Storm water management system	○	○
Roadside and non-roadside ditches	○	○

Does your agency have an asset management inventory for any of the following **traffic control and safety devices**?

	Yes	No
Traffic signals	○	○
Traffic signs	○	○
Pavement markings	○	○
Street lighting	○	○
Curb ramps	○	○

Does your agency have an asset management inventory for any of the following **utility assets**?

	Yes	No
Water supply system	○	○
Sanitary collection system	○	○
Electric power services	○	○

→

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Which of the following data is included in the asset management inventory for **pavements** (please select all that apply)?

	Asset location	Attributes / characteristics	Initial construction / installation data	Performance / condition data	Maintenance and rehabilitation data	User feedback and/or complaints
Pavements	☐	☐	☐	☐	☐	☐

Which of the following data is included in the asset management inventory for **bridges** (please select all that apply)?

	Asset location	Attributes / characteristics	Initial construction / installation data	Performance / condition data	Maintenance and rehabilitation data	User feedback and/or complaints
Bridges	☐	☐	☐	☐	☐	☐

Which of the following data is included in the asset management inventory (or inventories) for **hydraulic structures and systems** (please select all that apply)?

	Asset location	Attributes / characteristics	Initial construction / installation data	Performance / condition data	Maintenance and rehabilitation data	User feedback and/or complaints
Culverts	☐	☐	☐	☐	☐	☐
Storm water management system	☐	☐	☐	☐	☐	☐
Roadside and non-roadside ditches	☐	☐	☐	☐	☐	☐

Which of the following data is included in the asset management inventory (or inventories) for **traffic control and safety devices** (please select all that apply)?

	Asset location	Attributes / characteristics	Initial construction / installation data	Performance / condition data	Maintenance and rehabilitation data	User feedback and/or complaints
Traffic signals	☐	☐	☐	☐	☐	☐
Traffic signs	☐	☐	☐	☐	☐	☐
Pavement markings	☐	☐	☐	☐	☐	☐
Street lighting	☐	☐	☐	☐	☐	☐
Curb ramps	☐	☐	☐	☐	☐	☐

Which of the following data is included in the asset management inventory (or inventories) for **utility assets** (please select all that apply)?

	Asset location	Attributes / characteristics	Initial construction / installation data	Performance / condition data	Maintenance and rehabilitation data	User feedback and/or complaints
Water supply system	☐	☐	☐	☐	☐	☐
Sanitary collection system	☐	☐	☐	☐	☐	☐
Electric power services	☐	☐	☐	☐	☐	☐

→

What method is used for storing the asset management inventory data for **pavements** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Pavements	☐	☐	☐	☐	☐

What method is used for storing the asset management inventory data for **bridges** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Bridges	☐	☐	☐	☐	☐

What method is used for storing the asset management inventory data for **hydraulic structures and systems** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Culverts	☐	☐	☐	☐	☐
Storm water management system	☐	☐	☐	☐	☐
Roadside and non-roadside ditches	☐	☐	☐	☐	☐

What method is used for storing the asset management inventory data for **traffic control and safety devices** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Traffic signals	☐	☐	☐	☐	☐
Traffic signs	☐	☐	☐	☐	☐
Pavement markings	☐	☐	☐	☐	☐
Street lighting	☐	☐	☐	☐	☐
Curb ramps	☐	☐	☐	☐	☐

What method is used for storing the asset management inventory data for **utility assets** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Water supply system	☐	☐	☐	☐	☐
Sanitary collection system	☐	☐	☐	☐	☐
Electric power services	☐	☐	☐	☐	☐

→

What method is used for processing and/or analyzing the asset management inventory data for **pavements** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Pavements	☐	☐	☐	☐	☐

What method is used for processing and/or analyzing the asset management inventory data for **bridges** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Bridges	☐	☐	☐	☐	☐

What method is used for processing and/or analyzing the asset management inventory data for **hydraulic structures and systems** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Culverts	☐	☐	☐	☐	☐
Storm water management system	☐	☐	☐	☐	☐
Roadside and non-roadside ditches	☐	☐	☐	☐	☐

What method is used for processing and/or analyzing the asset management inventory data for **traffic control and safety devices** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Traffic signals	☐	☐	☐	☐	☐
Traffic signs	☐	☐	☐	☐	☐
Pavement markings	☐	☐	☐	☐	☐
Street lighting	☐	☐	☐	☐	☐
Curb ramps	☐	☐	☐	☐	☐

What method is used for processing and/or analyzing the asset management inventory data for **utility assets** (please select all that apply)?

	Commercial asset management software	Custom software developed in-house	Microsoft Excel	Microsoft Access	Other
Water supply system	☐	☐	☐	☐	☐
Sanitary collection system	☐	☐	☐	☐	☐
Electric power services	☐	☐	☐	☐	☐

→

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Does your agency rely on external consultants or contractors for collecting and/or analyzing the asset management data for **pavements**?

	Yes	No
Pavements	○	○

→

What is the approximate cost per year paid to external consultants or contractors for collecting and/or analyzing the asset management data for **pavements**?

	< $10,000 per year	~$25,000 per year	~ $50,000 per year	~ $75,000 per year	> $100,000 per year
Pavements	○	○	○	○	○

→

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Does your agency rely on external consultants or contractors for collecting and/or analyzing the asset management data for **bridges**?

	Yes	No
Bridges	○	○

→

What is the approximate cost per year paid to external consultants or contractors for collecting and/or analyzing the asset management data for **bridges**?

	< $10,000 per year	~$25,000 per year	~ $50,000 per year	~ $75,000 per year	> $100,000 per year
Bridges	○	○	○	○	○

→

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Does your agency rely on external consultants or contractors for collecting and/or analyzing the asset management data for **hydraulic structures and systems**?

	Yes	No
Culverts	○	○
Storm water management system	○	○
Roadside and non-roadside ditches	○	○

→

What is the approximate cost per year paid to external consultants or contractors for collecting and/or analyzing the asset management data for **hydraulic structures and systems**?

	< $10,000 per year	~$25,000 per year	~ $50,000 per year	~ $75,000 per year	> $100,000 per year
Culverts	○	○	○	○	○
Storm water management system	○	○	○	○	○
Roadside and non-roadside ditches	○	○	○	○	○

→

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Does your agency rely on external consultants or contractors for collecting and/or analyzing the asset management data for **traffic control and safety devices**?

	Yes	No
Traffic signals	○	○
Traffic signs	○	○
Pavement markings	○	○
Street lighting	○	○
Curb ramps	○	○

→

What is the approximate cost per year paid to external consultants or contractors for collecting and/or analyzing the asset management data for **traffic control and safety devices**?

	< $10,000 per year	~$25,000 per year	~ $50,000 per year	~ $75,000 per year	> $100,000 per year
Traffic signals	○	○	○	○	○
Traffic signs	○	○	○	○	○
Pavement markings	○	○	○	○	○
Street lighting	○	○	○	○	○
Curb ramps	○	○	○	○	○

→

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Does your agency rely on external consultants or contractors for collecting and/or analyzing the asset management data for **utility assets**?

	Yes	No
Water supply system	○	○
Sanitary collection system	○	○
Electric power services	○	○

→

What is the approximate cost per year paid to external consultants or contractors for collecting and/or analyzing the asset management data for **utility assets**?

	< $10,000 per year	~$25,000 per year	~ $50,000 per year	~ $75,000 per year	> $100,000 per year
Water supply system	○	○	○	○	○
Sanitary collection system	○	○	○	○	○
Electric power services	○	○	○	○	○

→

How are the asset management data and analysis results used for **pavements** (please select all that apply)?

	Performance Evaluation and Monitoring	Fiscal Planning	Project Prioritization	Resource Allocation	Audit, Reporting, and Communication	Policy Formulation
Pavements	☐	☐	☐	☐	☐	☐

How are the asset management data and analysis results used for **bridges** (please select all that apply)?

	Performance Evaluation and Monitoring	Fiscal Planning	Project Prioritization	Resource Allocation	Audit, Reporting, and Communication	Policy Formulation
Bridges	☐	☐	☐	☐	☐	☐

How are the asset management data and analysis results used for **hydraulic structures and systems** (please select all that apply)?

	Performance Evaluation and Monitoring	Fiscal Planning	Project Prioritization	Resource Allocation	Audit, Reporting, and Communication	Policy Formulation
Culverts	☐	☐	☐	☐	☐	☐
Storm water management system	☐	☐	☐	☐	☐	☐
Roadside and non-roadside ditches	☐	☐	☐	☐	☐	☐

How are the asset management data and analysis results used for **traffic control and safety devices** (please select all that apply)?

	Performance Evaluation and Monitoring	Fiscal Planning	Project Prioritization	Resource Allocation	Audit, Reporting, and Communication	Policy Formulation
Traffic signals	☐	☐	☐	☐	☐	☐
Traffic signs	☐	☐	☐	☐	☐	☐
Pavement markings	☐	☐	☐	☐	☐	☐
Street lighting	☐	☐	☐	☐	☐	☐
Curb ramps	☐	☐	☐	☐	☐	☐

How are the asset management data and analysis results used for **utility assets** (check all that apply)?

	Performance Evaluation and Monitoring	Fiscal Planning	Project Prioritization	Resource Allocation	Audit, Reporting, and Communication	Policy Formulation
Water supply system	☐	☐	☐	☐	☐	☐
Sanitary collection system	☐	☐	☐	☐	☐	☐
Electric power services	☐	☐	☐	☐	☐	☐

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Any final thoughts or comments that you would like to provide that may benefit this research project?

→

Do we have your permission to contact you for more information regarding your responses in the future (if needed)?

- ○ Yes
- ○ No

→

We thank you for your time spent taking this survey.
Your response has been recorded.

Appendix B
Survey Results

B.1 Introduction

The research team received a total of 69 responses to the survey on asset management. Responses were received from 67 local agency representatives in Ohio (34 counties, 13 cities, 13 townships, and 7 villages) as well as the Columbus Regional Airport Authority and the Ohio Turnpike Commission. The following sections present a summary of the responses to the survey questionnaire.

B.2 General Categories of Classes of Assets

- Category or Class of Assets Overseen by Respondent: The percentage of respondents who oversee each category or class of asset is shown in Figure B.1. In this figure, the y-axis indicates general categories or classes of assets, while the x-axis indicates the percentage of respondents who chose the specific response. Labels on each bar indicate the percentage of respondents choosing a specific response over the total number of responses received for that question. As can be noticed from this figure, 91% of agency representatives indicated that they oversee pavements, 86% reported that they oversee hydraulic structures and systems, 80% indicated that they oversee traffic control and safety devices, 64% indicated that they oversee bridges, and only 30% reported that they oversee utility assets. For respondents who do not oversee any of these types of assets, this was the last question on the survey, and the respondents were thanked for their time.

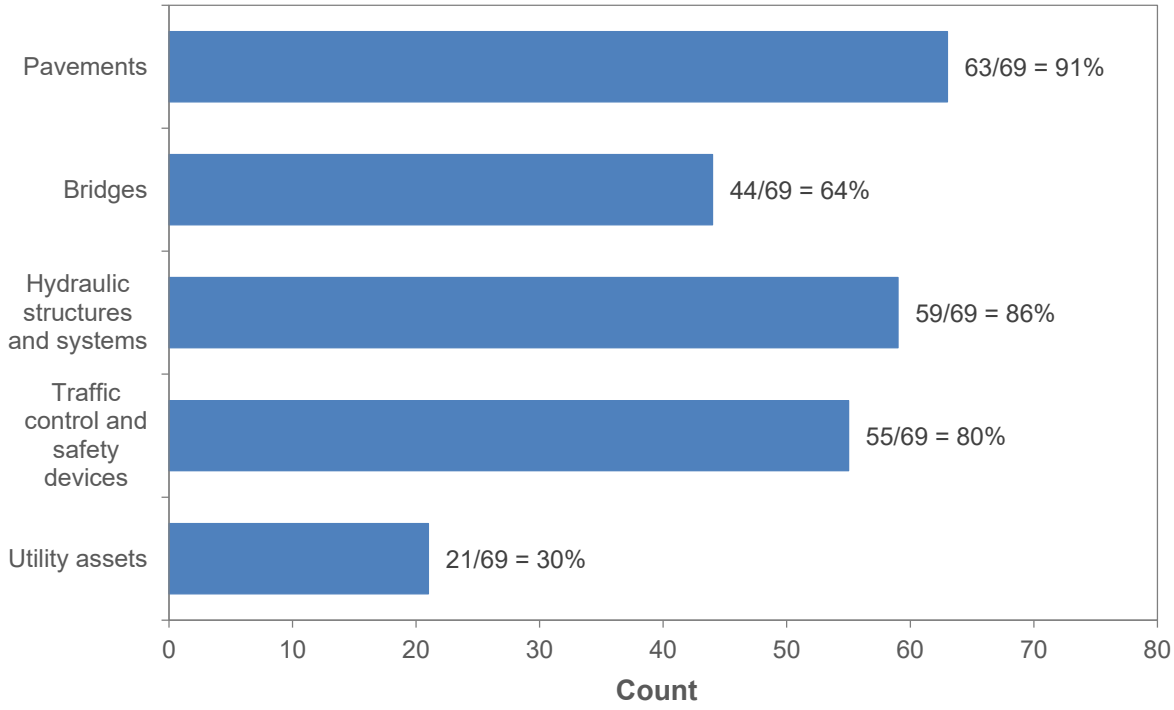


Figure B.1: Percentage of Respondents who Oversee Each Asset Category.

B.3 Pavement Inventory Data

- Use of a Pavement Inventory: Information was solicited to find if the agency maintained an asset management inventory for pavements. The survey results, shown in Figure B.2, reveal that 76% of agencies do maintain a pavement inventory, while 24% do not.

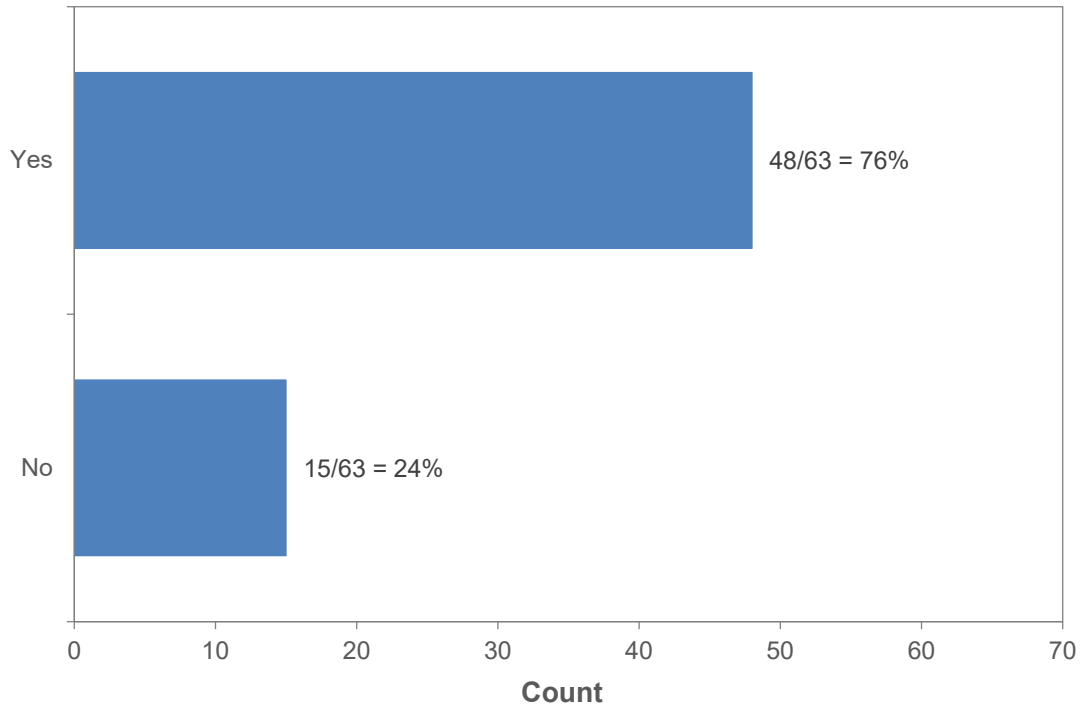


Figure B.2: Agency Use of an Asset Management Inventory for Pavements.

- Data in the Pavement Inventory: The survey results shown in Figure B.3 indicate that the vast majority of agencies (92%) include location data for pavements. Most agencies include pavement attributes/characteristics (79%), maintenance and rehabilitation data (75%), and performance or condition data (67%). Roughly half of the agencies (56%) include data on initial construction or installation. Only 13% of agencies reported that they include user feedback or complaints.

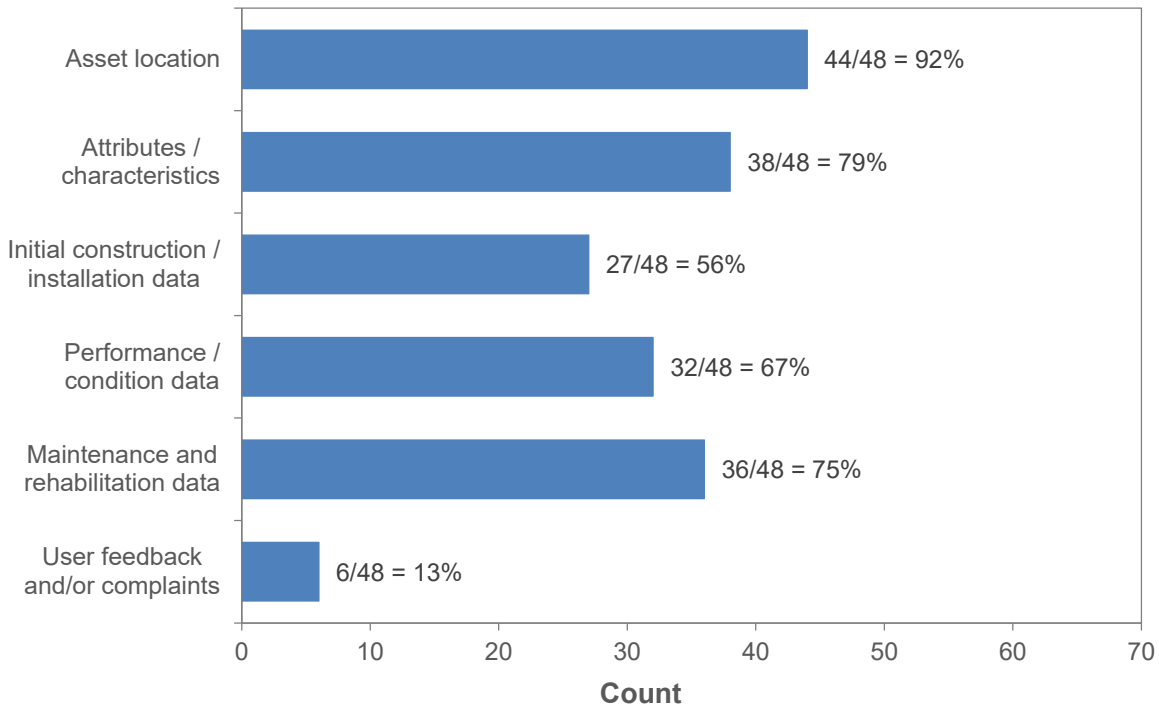


Figure B.3: Types of Data Included in the Pavement Inventory.

- Method Used for Storing Pavement Inventory Data: When asked what methods they use to store their pavement inventory data, 44% of respondents indicated that they use commercial software, while 13% indicated that they use custom software that was developed in-house (Figure B.4). Respondents also reported that they use Microsoft Excel (63%) or Microsoft Access (19%). A total of 23% of respondents indicated that they use other methods to store the pavement inventory data.

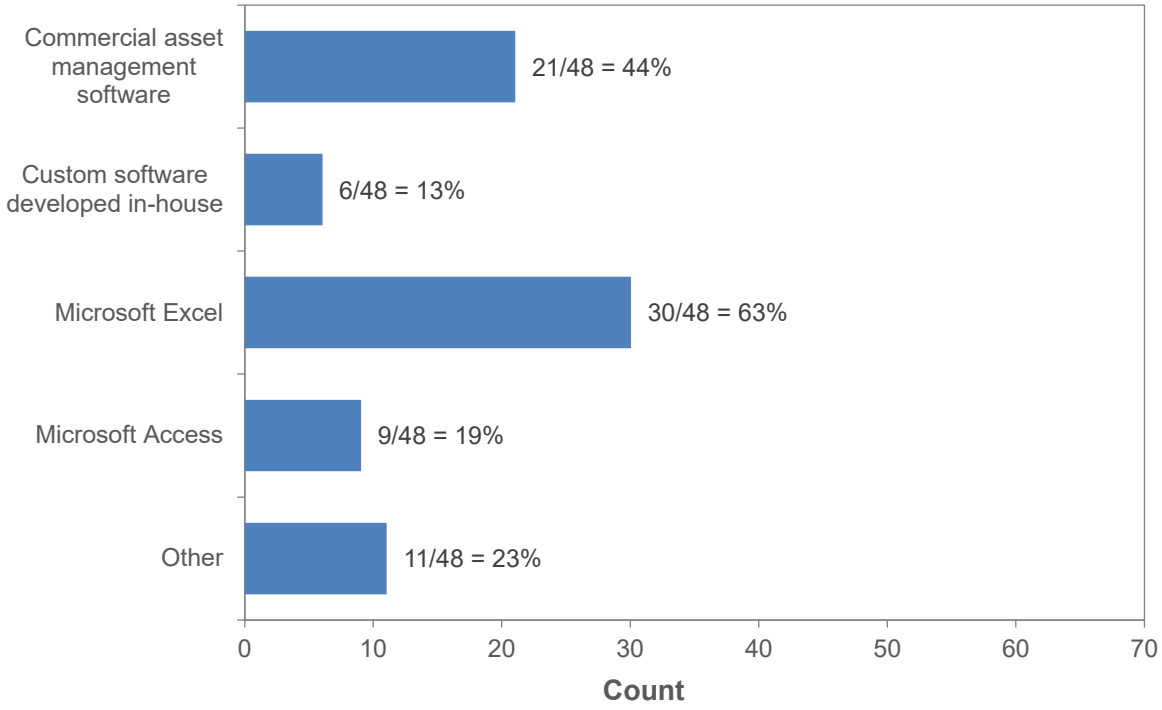


Figure B.4: Method Used for Storing Pavement Inventory Data.

- Method Used to Process or Analyze Pavement Inventory Data: This question asked respondents to indicate what method they used for processing and/or analyzing asset management inventory data for pavements. As can be noticed from Figure B.5, 38% of agencies reported using commercial asset management software, and 8% indicated using custom software. Some agencies reported that they use Microsoft Excel (52%) or Microsoft Access (13%), while 27% of respondents indicated that they use some other method.

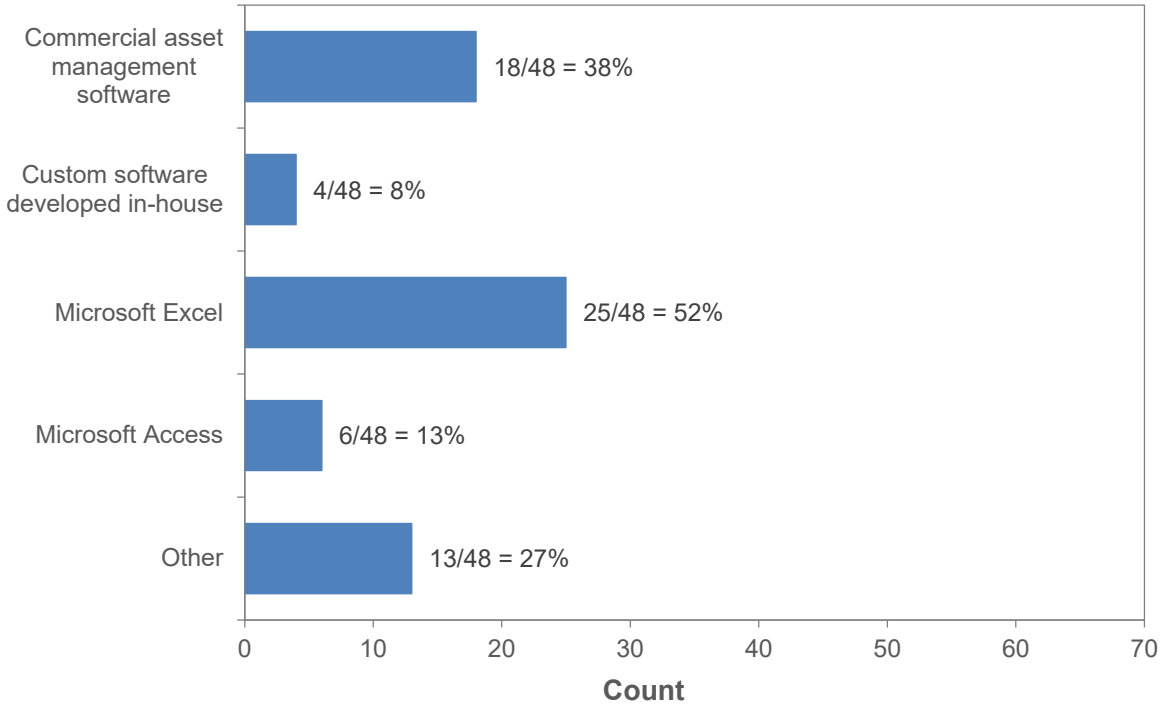


Figure B.5: Method Used for Processing or Analyzing Pavement Inventory Data.

- Use of Consultants or Contractors to Collect/Analyze Pavement Data: When asked if their agency relies on external consultants or contractors to collect and analyze pavement data, 31% indicated that they do, while the remaining 69% collect the data themselves (Figure B.6).

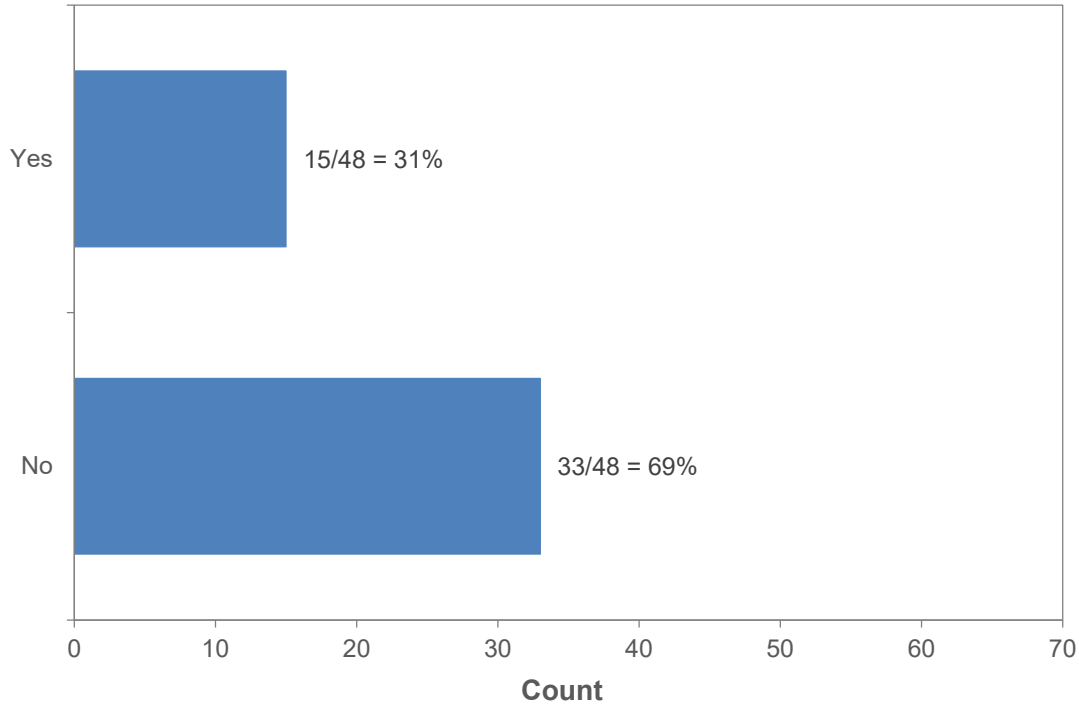


Figure B.6: Use of Consultants or Contractors to Collect/Analyze Pavement Data.

- Annual Cost for External Consultants or Contractors to Collect/Analyze Pavement Data: This question asked respondents to indicate how much they paid to external consultants or contractors for processing and/or analyzing asset management inventory data for pavements. As can be noticed from Figure B.7, 47% of agencies had annual costs of under $10,000/year, 13% of agencies reported annual costs of around $25,000, 27% of agencies reported annual costs of around $50,000, and 13% of agencies reported annual costs of approximately $75,000/year. No agencies reported spending more than $100,000 annually.

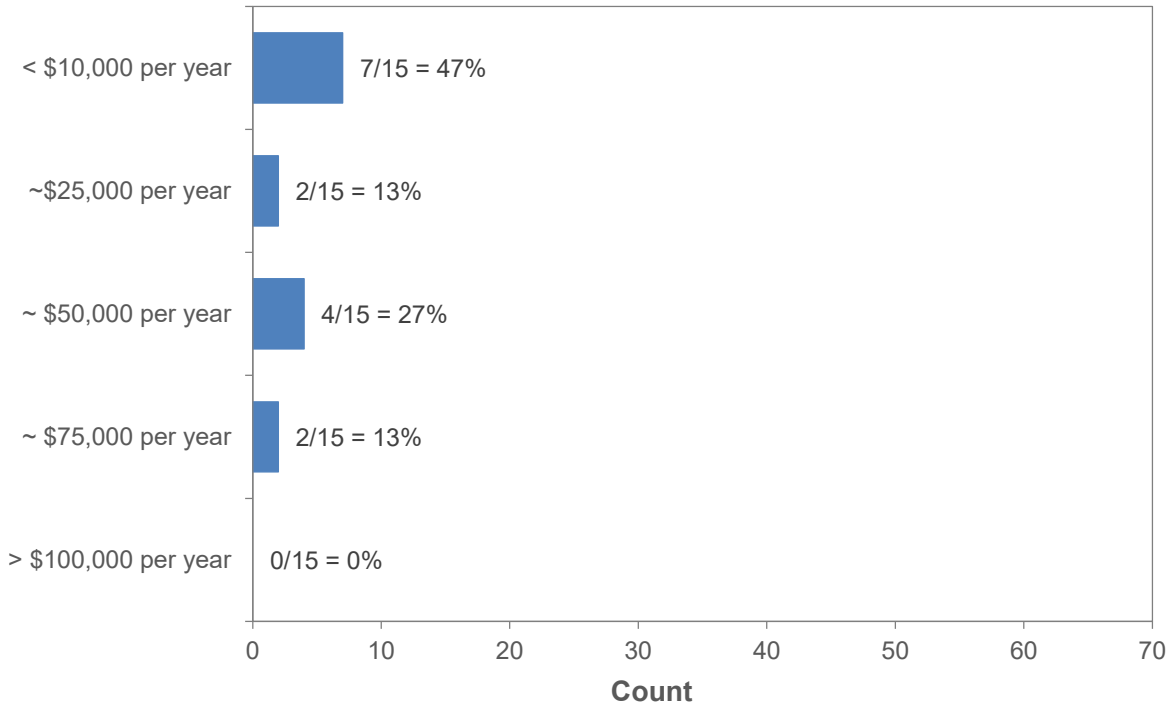


Figure B.7: Costs for External Consultants/Contractors to Collect/Analyze Pavement Data.

- Use of Pavement Inventory Data and Analysis Results: When asked how their agency uses the pavement asset management data and analysis results, 60% of agencies reported that they are used for performance evaluation and monitoring, 81% indicated that they are used for fiscal planning purposes, 90% indicated that they are used for prioritize projects, and 44% indicated that they are used for resource allocation (Figure B.8). Only 25% of agencies reported that they use the data and results for audits, reporting, and communication, and only 25% indicate using the data and results for policy formulation.

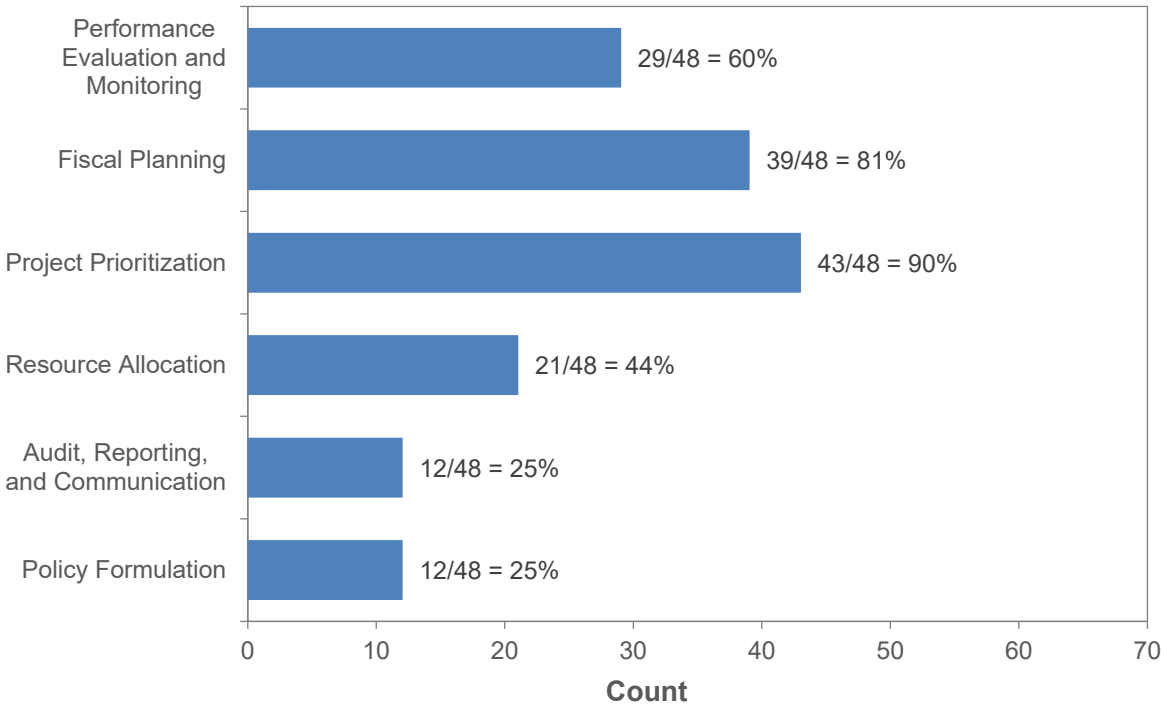


Figure B.8: Use of Pavement Inventory Data.

B.4 Bridge Inventory Data

- Use of a Bridge Inventory: Information was solicited to find if the agency maintained an asset management inventory for bridges. The survey results, shown in Figure B.9, reveal that 89% of the agencies do maintain a bridge inventory, while 11% do not.

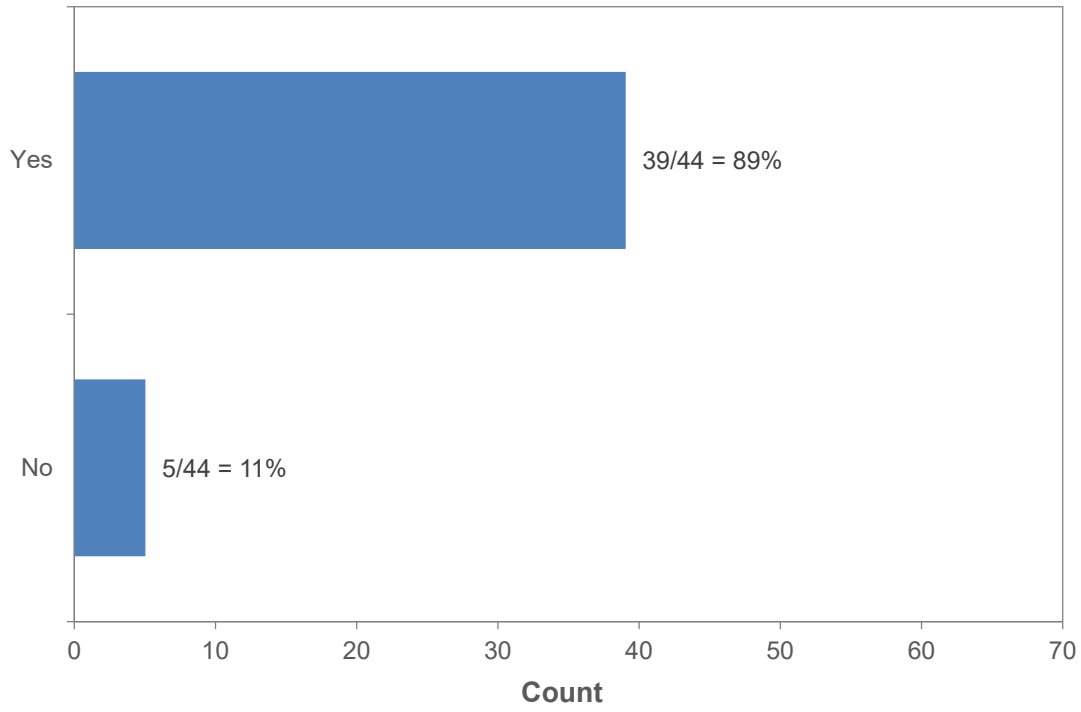


Figure B.9: Agency Use of an Asset Management Inventory for Bridges.

- Data in the Bridge Inventory: The survey results shown in Figure B.10 indicate that all agencies (100%) include location data for bridges. The vast majority of agencies include bridge attributes/characteristics (97%), performance or condition data (92%), data on initial construction or installation (87%), and maintenance and rehabilitation data (85%). Only 10% of agencies reported that they include user feedback or complaints.

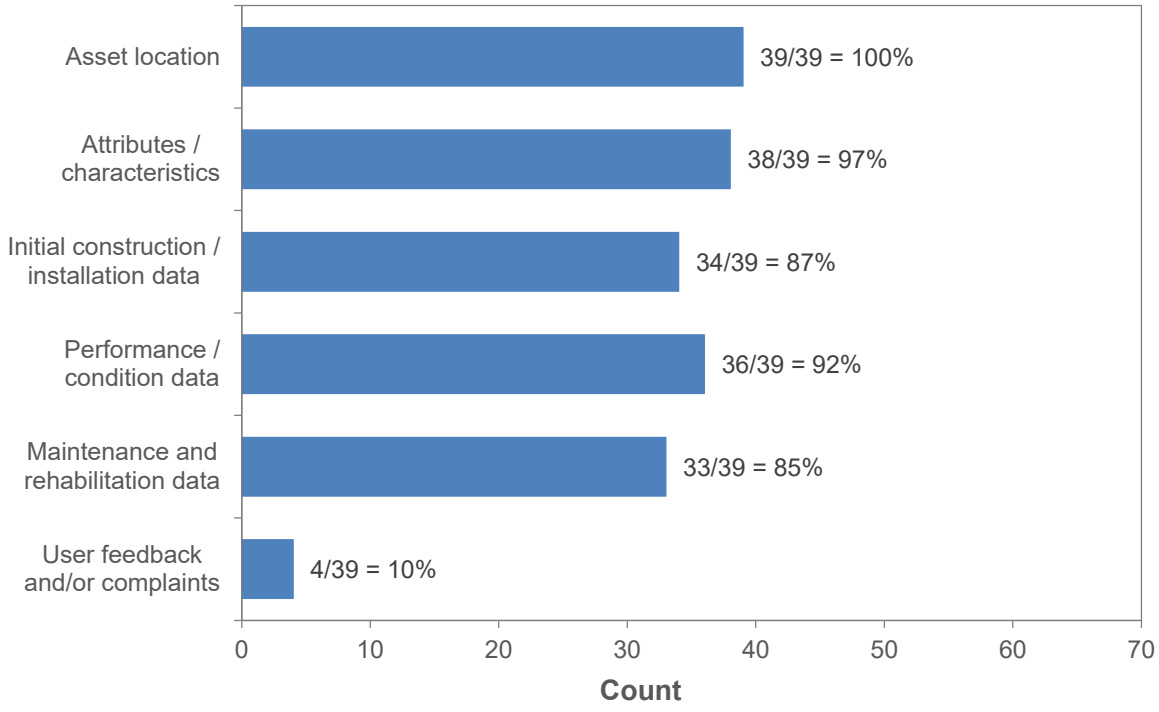


Figure B.10: Types of Data Included in the Bridge Inventory.

- Method Used for Storing Bridge Inventory Data: When asked what methods they use to store their bridge inventory data, 77% of respondents indicated that they use commercial software, while 13% use custom software that was developed in-house (Figure B.11). Respondents also reported that they use Microsoft Excel (41%) or Microsoft Access (5%). A total of 18% of respondents indicated that they use other methods to store the bridge inventory data.

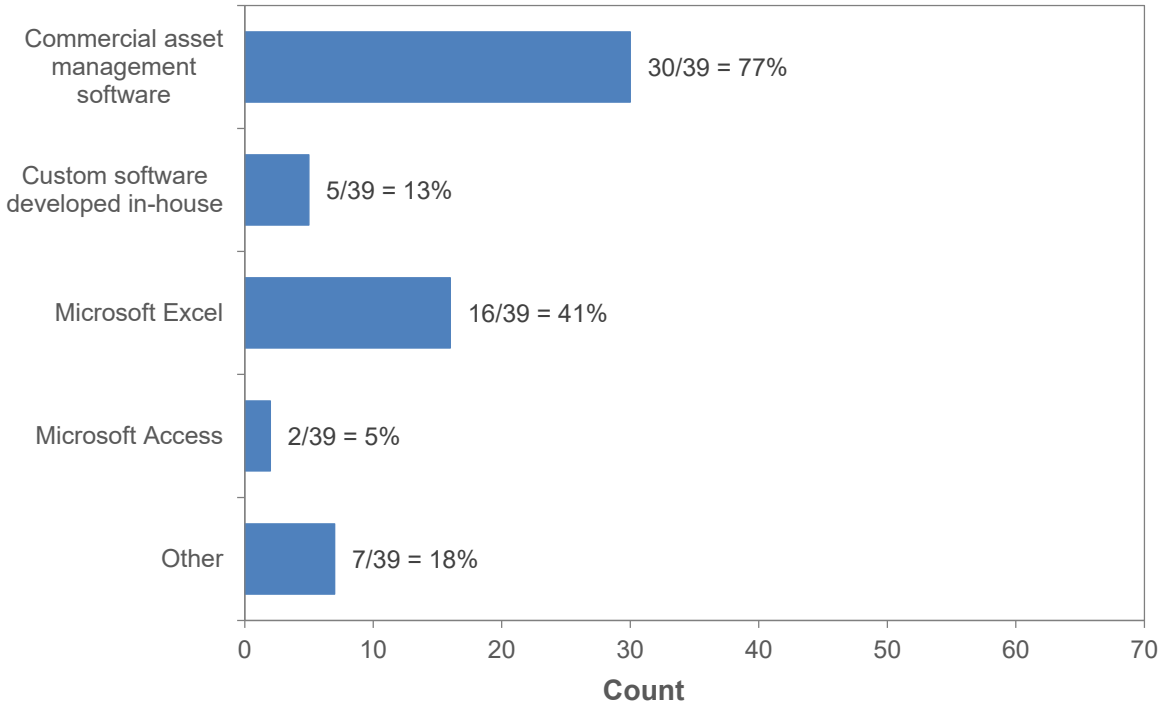


Figure B.11: Method Used for Storing Bridge Inventory Data.

- Method Used to Process or Analyze Bridge Inventory Data: This question asked respondents to indicate what method they used for processing and/or analyzing asset management inventory data for pavements. As can be noticed from Figure B.12, 67% of agencies reported using commercial asset management software, and 8% indicated they use custom software. Some agencies reported that they use Microsoft Excel (36%) or Microsoft Access (5%) for this purpose, while 28% of respondents indicated that they use some other method.

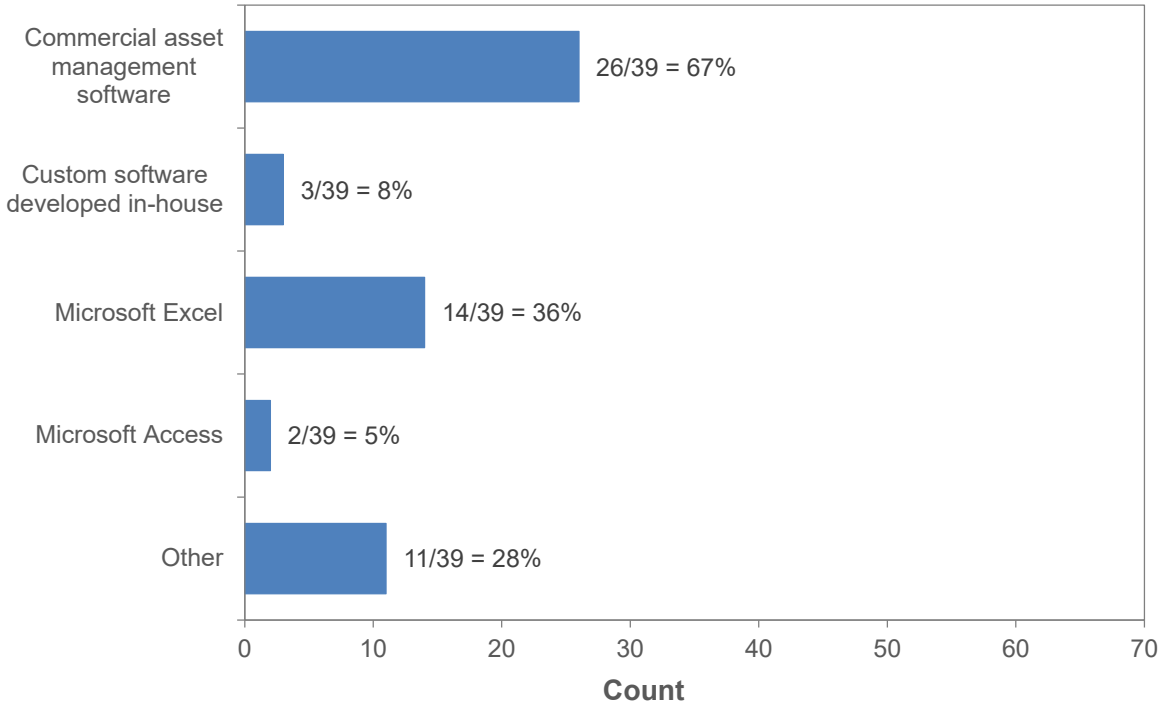


Figure B.12: Method Used for Processing or Analyzing Bridge Inventory Data.

- Use of Consultants or Contractors to Collect/Analyze Bridge Data: When asked if their agency relies on external consultants or contractors to collect and analyze data for bridges, 46% indicated that they do, while the remaining 54% indicated that they collect the data themselves (Figure B.13).

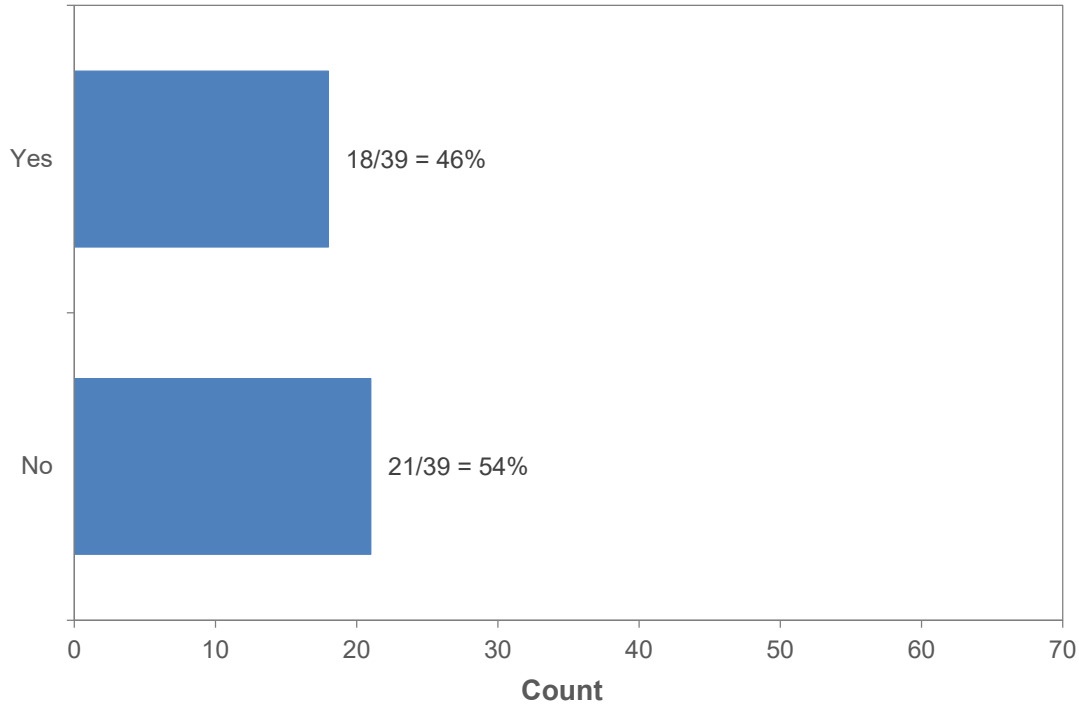


Figure B.13: Use of Consultants or Contractors to Collect/Analyze Bridge Data.

- Annual Cost for External Consultants or Contractors to Collect/Analyze Bridge Data: This question asked respondents to indicate how much they paid to external consultants or contractors for processing and/or analyzing asset management inventory data for bridges. As can be noticed from Figure B.14, 33% of agencies had annual costs of under $10,000/year, 44% of agencies reported annual costs of around $25,000, and 22% of agencies reported annual costs of around $50,000. No agencies reported spending more than $75,000 annually.

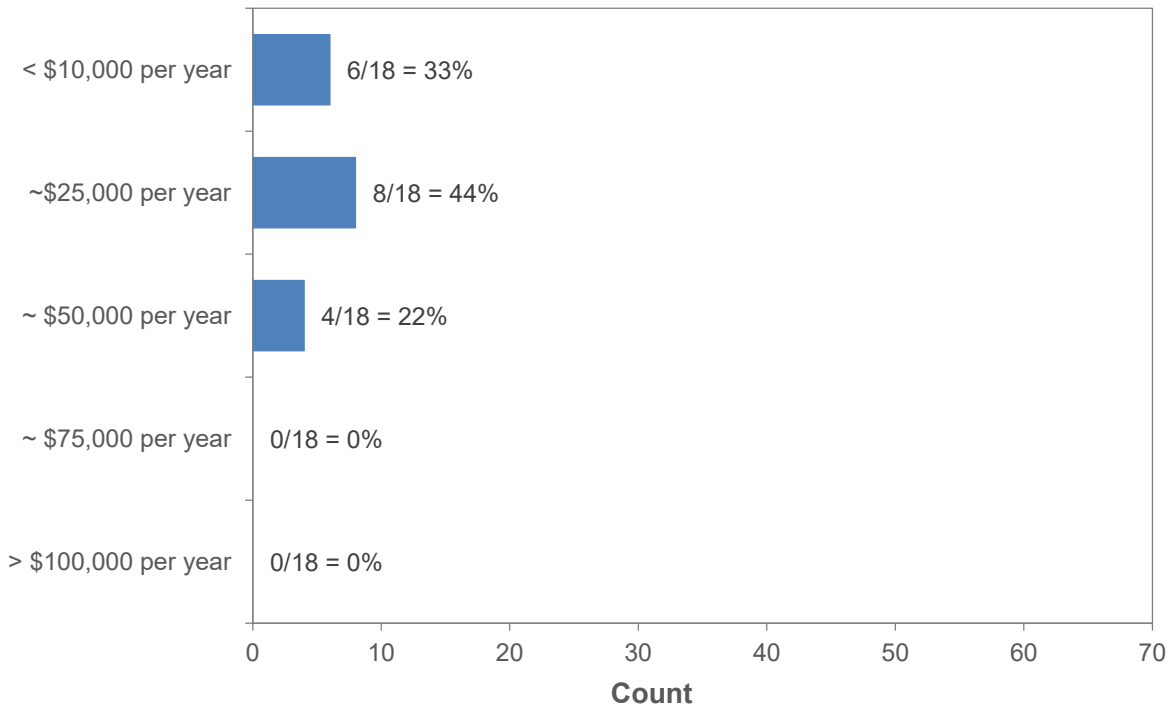


Figure B.14: Costs for External Consultants/Contractors to Collect/Analyze Bridge Data.

- Use of Bridge Inventory Data and Analysis Results: When asked how their agency uses the bridge asset management data and analysis results, 79% of agencies reported that they are used for performance evaluation and monitoring, 87% indicated that they are used for fiscal planning purposes, and 95% indicated that they are used for prioritize projects (Figure B.15). About half of the agencies indicated that they are used for resource allocation (54%) or for audits, reporting, and communication (51%). Only 26% of the agencies indicated using the data and results for policy formulation.

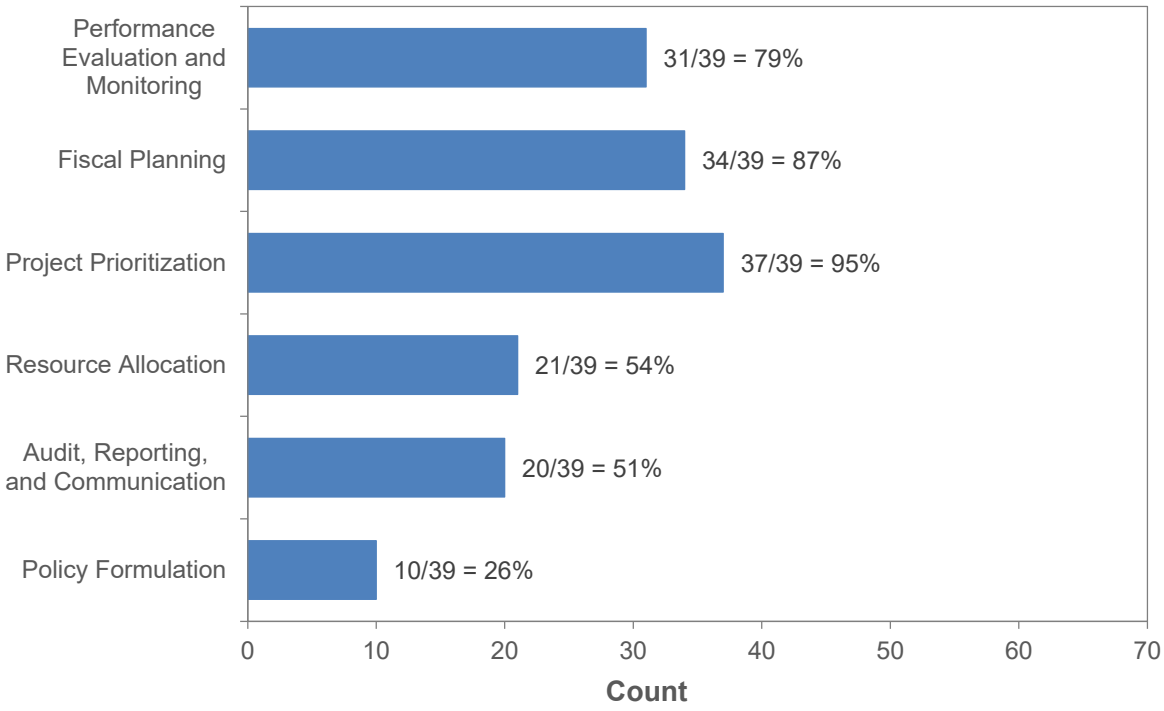


Figure B.15: Use of Bridge Inventory Data.

B.5 Hydraulic Structure Inventory Data

- Use of an Inventory for Hydraulic Structures: Information was solicited to find if the agency maintained an asset management inventory for hydraulic structures. In the survey results shown in Figure B.16, 75% of respondents reported that they maintain an inventory of culverts, 42% reported that they maintain an inventory of stormwater management systems, and 37% indicated that they maintain an inventory of roadside and non-roadside ditches.

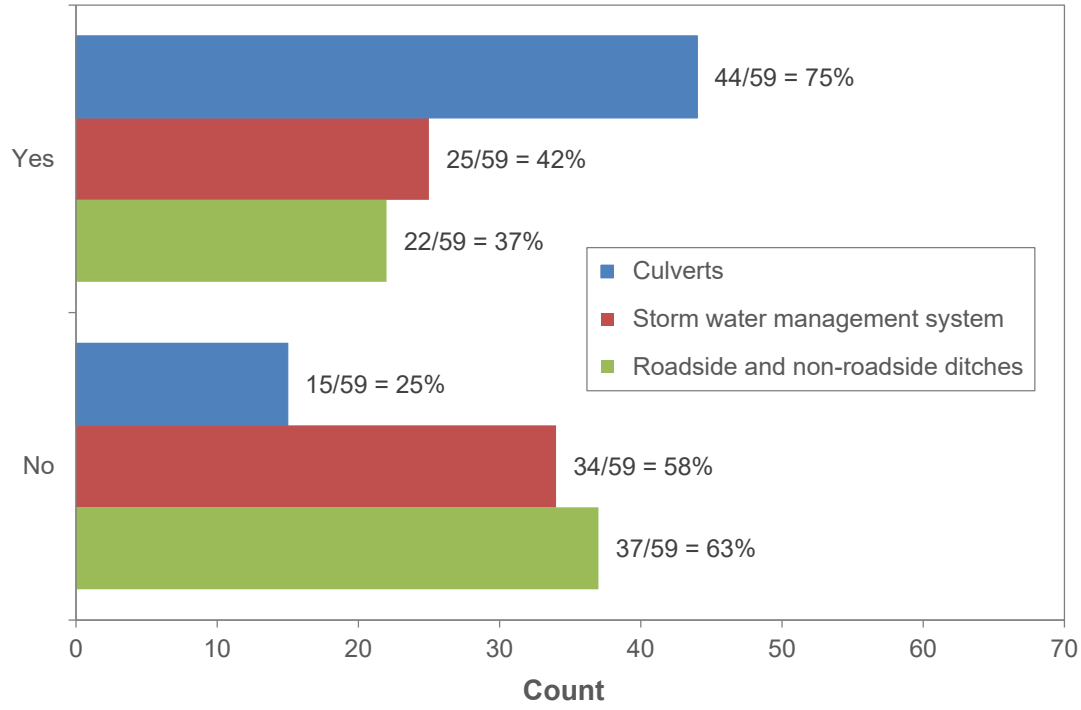


Figure B.16: Agency Use of an Asset Management Inventory for Hydraulic Structures.

- Data in the Hydraulic Structures Inventory: The survey results regarding the data collected for hydraulic structures are shown in Figure B.17. A total of 98% agencies reported that they include location data for culverts, 96% for stormwater management systems, and 91% for roadside and non-roadside ditches. A total of 86% of agencies include attributes/characteristics for culverts, 80% for stormwater management systems, and 64% for ditches. Agencies reported that they include data on initial construction or installation for culverts (59%), stormwater management systems (44%), and ditches (41%). Agencies indicated that they include performance or condition data for culverts (57%), storm water management systems (44%), and ditches (41%). Agencies also reported that they include maintenance and rehabilitation data for culverts (52%), stormwater management systems (44%), and ditches (45%). Only 11% of agencies reported that they include user feedback or complaints regarding culverts, while 12% indicated that they include this information for stormwater management systems, and 27% reported that they include this information for ditches.

	Culverts	Storm water management system	Roadside and non-roadside ditches
Asset location	43/44 = 98%	24/25 = 96%	20/22 = 91%
Attributes / characteristics	38/44 = 86%	20/25 = 80%	14/22 = 64%
Initial construction / installation data	26/44 = 59%	11/25 = 44%	9/22 = 41%
Performance / condition data	25/44 = 57%	6/25 = 24%	7/22 = 32%
Maintenance and rehabilitation data	23/44 = 52%	11/25 = 44%	10/22 = 45%
User feedback and/or complaints	5/44 = 11%	3/25 = 12%	6/22 = 27%

Figure B.17: Types of Data Included in the Inventory for Hydraulic Systems.

- Method Used for Storing Hydraulic Structure Inventory Data: When asked what methods they use to store their hydraulic structure inventory data, commercial software was reported to be used for storing information on culverts (43%), stormwater management systems (44%), and roadside and non-roadside ditches (45%), as shown in (Figure B.18). Custom software that was developed in-house is used by agencies for storing data on culverts (16%), stormwater management systems (20%), and ditches (18%). Respondents also reported that they use Microsoft Excel (50% for culverts, 28% for stormwater management systems, and 32% for ditches) or Microsoft Access (11% for culverts, 8% for stormwater management systems, and 9% for ditches). A total of 14% of respondents indicated that they use other methods to store the inventory data for culverts, while 32% use other methods for data on stormwater management systems, and 41% use other methods for storing data on ditches.

	Culverts	Storm water management system	Roadside and non-roadside ditches
Commercial asset management software	19/44 = 43%	11/25 = 44%	10/22 = 45%
Custom software developed in-house	7/44 = 16%	5/25 = 20%	4/22 = 18%
Microsoft Excel	22/44 = 50%	7/25 = 28%	7/22 = 32%
Microsoft Access	5/44 = 11%	2/25 = 8%	2/22 = 9%
Other	6/44 = 14%	8/25 = 32%	9/22 = 41%

Figure B.18: Method Used for Storing Hydraulic Structure Inventory Data.

- Method Used to Process or Analyze Hydraulic Structure Inventory Data: This question asked respondents to indicate what method they use for processing and/or analyzing asset management inventory data for hydraulic structures. As can be noticed from Figure B.19, most agencies reported using commercial asset management software, Microsoft Excel, or other methods to process or analyze the data, while lower number of agencies indicated that they use custom software. Very few agencies report using Microsoft Access for this purpose.

	Culverts	Storm water management system	Roadside and non-roadside ditches
Commercial asset management software	17/44 = 39%	9/25 = 36%	9/22 = 41%
Custom software developed in-house	8/44 = 18%	6/25 = 24%	4/22 = 18%
Microsoft Excel	17/44 = 39%	6/25 = 24%	8/22 = 36%
Microsoft Access	3/44 = 7%	1/25 = 4%	1/22 = 5%
Other	13/44 = 30%	9/25 = 36%	9/22 = 41%

Figure B.19: Method Used for Processing or Analyzing Hydraulic Structure Inventory Data.

- Use of Consultants or Contractors to Collect/Analyze Hydraulic Structure Data: When asked if their agency relies on external consultants or contractors to collect and analyze data for hydraulic structures, very few indicated that they do (Figure B.20). The vast majority of agencies indicated that they collect the data themselves.

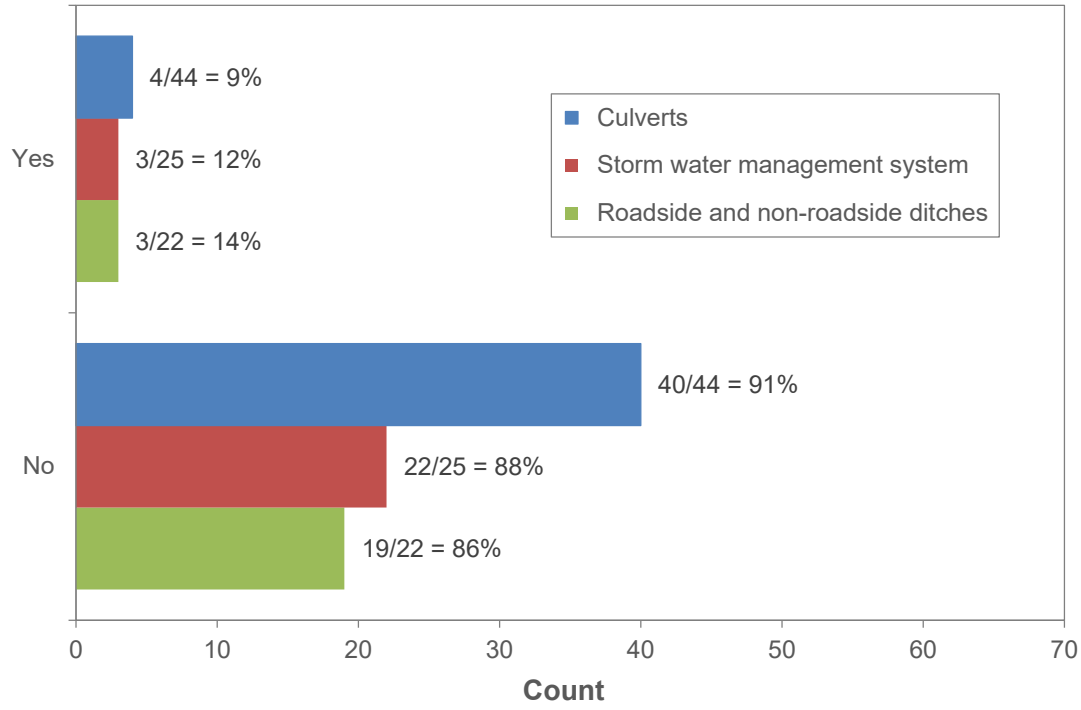


Figure B.20: Use of Consultants or Contractors to Collect/Analyze Data on Hydraulic Structures.

- Annual Cost for External Consultants or Contractors to Collect/Analyze Data on Hydraulic Structures: This question asked respondents to indicate how much they paid to external consultants or contractors for processing and/or analyzing asset management inventory data for hydraulic structures, and the results are shown in Figure B.21. As can be noticed from this figure, the majority of agencies (75%) reported that they had annual costs of under $10,000/year for culverts, while 25% reported annual costs of about $25,000. The majority of agencies (67%) reported annual costs of under $10,000 for stormwater management systems, while 33% reported annual costs of around $25,000. All respondents indicated that annual costs for roadside and non-roadside ditches were less than $10,000.

	Culverts	Storm water management system	Roadside and non-roadside ditches
< $10,000 per year	3/4 = 75%	2/3 = 67%	3/3 = 100%
~$25,000 per year	1/4 = 25%	1/3 = 33%	0/3 = 0%
~ $50,000 per year	0/4 = 0%	0/3 = 0%	0/3 = 0%
~ $75,000 per year	0/4 = 0%	0/3 = 0%	0/3 = 0%
> $100,000 per year	0/4 = 0%	0/3 = 0%	0/3 = 0%

Figure B.21: Costs for External Consultants/Contractors to Collect/Analyze Data on Hydraulic Structures.

- Use of Inventory Data and Analysis Results for Hydraulic Structures: When asked how their agency uses their hydraulic structure inventory data and analysis results, the majority of responding agencies reported that they are used for performance evaluation and monitoring, fiscal planning purposes, and for prioritizing projects (Figure B.22). About half of the agencies indicated that the data and analysis results are used for resource allocation. Fewer than half of agencies reported using their data and analysis results or for audits, reporting, and communication. And fewer than 25% of agencies reported that they used the data and results for policy formulation.

	Culverts	Storm water management system	Roadside and non-roadside ditches
Performance Evaluation and Monitoring	26/44 = 59%	16/25 = 64%	13/22 = 59%
Fiscal Planning	26/44 = 59%	15/25 = 60%	10/22 = 45%
Project Prioritization	35/44 = 80%	16/25 = 64%	13/22 = 59%
Resource Allocation	18/44 = 41%	13/25 = 52%	11/22 = 50%
Audit, Reporting, and Communication	16/44 = 36%	11/25 = 44%	9/22 = 41%
Policy Formulation	5/44 = 11%	6/25 = 24%	4/22 = 18%

Figure B.22: Use of Inventory Data for Hydraulic Systems.

B.6 Traffic Control and Safety Device Information

- Use of an Inventory for Traffic Control and Safety Devices: Information was solicited to find if the agency maintained an asset management inventory for traffic control and safety devices. In the survey results shown in Figure B.23, 82% of respondents reported that they maintain an inventory of traffic signs, 60% maintain an inventory of pavement markings, 36% maintain an inventory of traffic signals, 31% maintain an inventory of street lighting, and 15% indicated that they maintain an inventory of curb ramps.

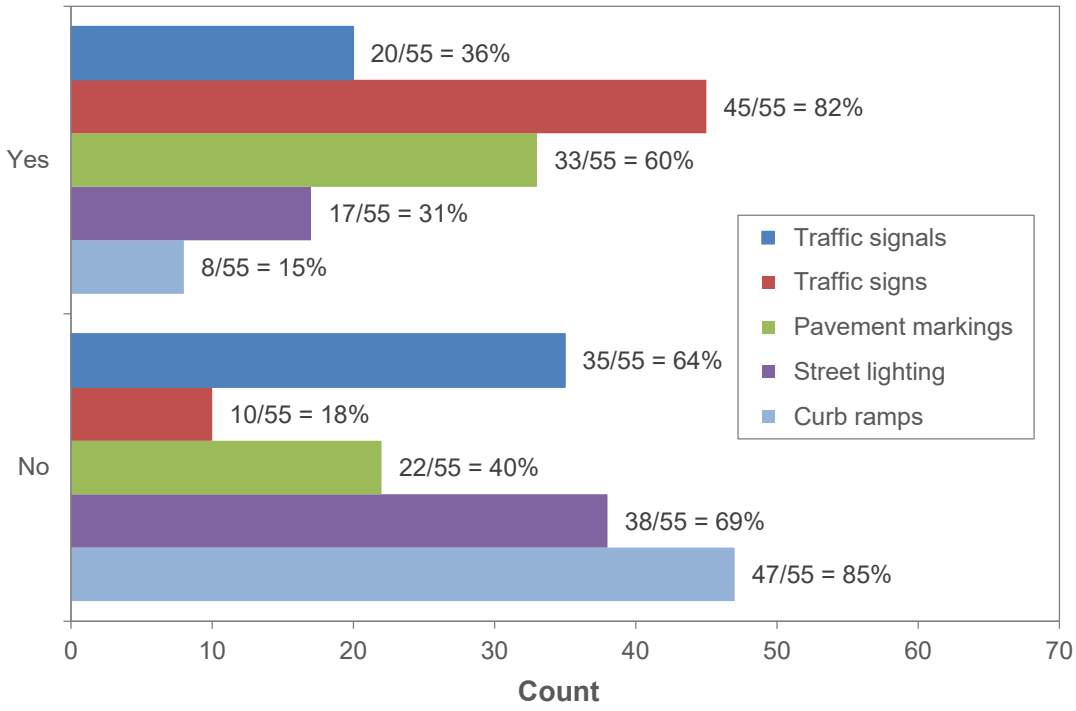


Figure B.23: Agency Use of an Asset Management Inventory for Traffic Control and Safety Devices.

- Data in the Traffic Control and Safety Devices Inventory: The survey results regarding the data collected for traffic signals, traffic signs, pavement markings, street lighting, and curb ramps are shown in Figure B.24. The vast majority of agencies (~90% to 100%) include location data for these assets. Approximately 60% to 75% of agencies include attributes/characteristics for traffic signals, traffic signs pavement markings, and curb ramps, while only 29% reported that they included attributes/characteristics for street lighting. Roughly half of agencies reported that they include data on initial construction or installation for traffic signals, traffic signs, pavement markings, and curb ramps, while only 18% reported that they included this information for street lighting. A total of 25% to 44% of agencies indicated that they include performance or condition data for traffic signals, traffic signs pavement markings, and curb ramps, while only 12% reported that they included this information for street lighting. Roughly 60% of agencies reported that they include maintenance and rehabilitation data for traffic signals, traffic signs, and curb ramps, while roughly 30% of agencies reported including this information for pavement markings and street lighting. A total of 29% of agencies reported that they include user feedback or complaints regarding street lighting, while fewer agencies reported including this information for traffic signals (15%), traffic signs (16%), pavement markings (6%), or curb ramps (13%).

	Traffic signals	Traffic signs	Pavement markings	Street lighting	Curb ramps
Asset location	20/20 = 100%	43/45 = 96%	30/33 = 91%	15/17 = 88%	8/8 = 100%
Attributes / characteristics	14/20 = 70%	32/45 = 71%	20/33 = 61%	5/17 = 29%	6/8 = 75%
Initial construction / installation data	9/20 = 45%	24/45 = 53%	19/33 = 58%	3/17 = 18%	4/8 = 50%
Performance / condition data	7/20 = 35%	20/45 = 44%	10/33 = 30%	2/17 = 12%	2/8 = 25%
Maintenance and rehabilitation data	12/20 = 60%	28/45 = 62%	12/33 = 36%	5/17 = 29%	5/8 = 63%
User feedback and/or complaints	3/20 = 15%	7/45 = 16%	2/33 = 6%	5/17 = 29%	1/8 = 13%

Figure B.24: Types of Data Included in the Inventory for Traffic Control and Safety Devices.

- Method Used for Storing Traffic Control and Safety Device Inventory Data: When asked what methods they use to store their traffic control and safety device inventory data, 75% of agencies reported using commercial software for curb ramps but roughly 50% for traffic signals, traffic signs, pavement markings, and street lighting, as shown in Figure B.25. Custom software that was developed in-house is used by fewer than 15% of agencies for traffic control and safety devices. Fewer than half of the respondents reported that they use Microsoft Excel. Microsoft Access was also reported to be used by 9% of agencies for traffic signs and by 6% of agencies for pavement markings, but it was not reported to be used by any agencies for traffic signals, street lighting, or curb ramps. Fewer than 30% of respondents indicated that they use other methods to store the inventory data for their traffic control and safety devices.

	Traffic signals	Traffic signs	Pavement markings	Street lighting	Curb ramps
Commercial asset management software	8/20 = 40%	24/45 = 53%	17/33 = 52%	8/17 = 47%	6/8 = 75%
Custom software developed in-house	3/20 = 15%	6/45 = 13%	3/33 = 9%	2/17 = 12%	1/8 = 13%
Microsoft Excel	8/20 = 40%	16/45 = 36%	14/33 = 42%	7/17 = 41%	4/8 = 50%
Microsoft Access	0/20 = 0%	4/45 = 9%	2/33 = 6%	0/17 = 0%	0/8 = 0%
Other	6/20 = 30%	10/45 = 22%	5/33 = 15%	5/17 = 29%	2/8 = 25%

Figure B.25: Method Used for Storing Traffic Control and Safety Device Inventory Data.

- Method Used to Process or Analyze Traffic Control and Safety Device Inventory Data: This question asked respondents to indicate what method they used for processing and/or analyzing asset management inventory data for traffic control and safety devices. As can be noticed from Figure B.26, The majority of agencies reported using commercial asset management software for curb ramps, but less than half used such software for processing or analyzing data for other assets. Between 25% and 40% of respondents reported that their agencies use Microsoft Excel, while ~25% to 50% of agencies reported that they use other methods to process or analyze the data. Roughly 10% to 15% of agencies reported using custom software. Very few agencies indicated that they use custom use Microsoft Access for traffic signs (7%) and pavement markings (6%), and no agencies reported using Access for traffic signals, street lighting, or curb ramps.

	Traffic signals	Traffic signs	Pavement markings	Street lighting	Curb ramps
Commercial asset management software	7/20 = 35%	21/45 = 47%	16/33 = 48%	7/17 = 41%	5/8 = 63%
Custom software developed in-house	3/20 = 15%	6/45 = 13%	3/33 = 9%	2/17 = 12%	1/8 = 13%
Microsoft Excel	6/20 = 30%	15/45 = 33%	13/33 = 39%	4/17 = 24%	2/8 = 25%
Microsoft Access	0/20 = 0%	3/45 = 7%	2/33 = 6%	0/17 = 0%	0/8 = 0%
Other	7/20 = 35%	11/45 = 24%	9/33 = 27%	6/17 = 35%	4/8 = 50%

Figure B.26: Method Used for Processing or Analyzing Traffic Control and Safety Device Inventory Data.

- Use of Consultants or Contractors to Collect/Analyze Traffic Control and Safety Device Data: This question asked respondents if their agency relies on external consultants or contractors to collect and analyze data for traffic control and safety devices, and the results are shown in Figure B.27. The majority of agencies indicated that they collect this data themselves.

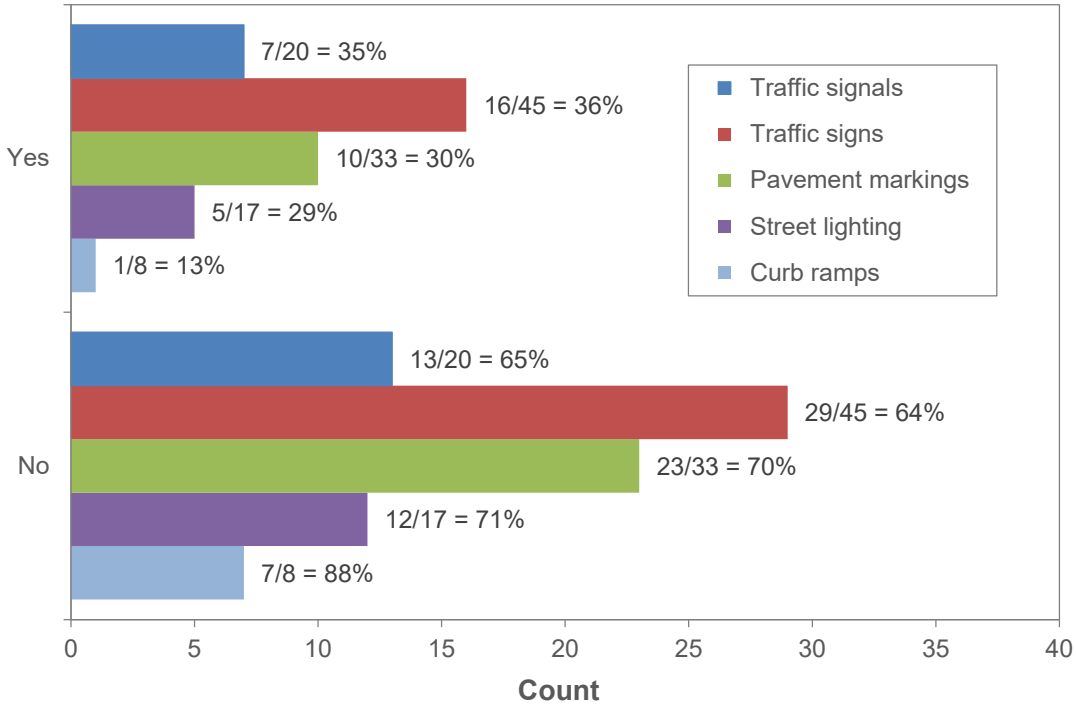


Figure B.27: Use of Consultants or Contractors to Collect/Analyze Data on Traffic Control and Safety Devices.

- Annual Cost for External Consultants or Contractors to Collect/Analyze Data on Traffic Control and Safety Devices: This question asked respondents to indicate how much they paid to external consultants or contractors for processing and/or analyzing asset management inventory data for traffic control and safety devices, and the results are shown in Figure B.28. As can be noticed from this figure, all respondents indicated that annual costs for pavement markings and curb ramps were less than $10,000. The vast majority of agencies (94%) reported that they had annual costs of under $10,000/year for traffic signs, while 6% reported annual costs of about $25,000. The majority of agencies (80%) reported annual costs of under $10,000 for street lighting, while 20% reported annual costs of around $25,000. Finally, the majority of agencies (86%) reported annual costs of under $10,000 for traffic signals, while one agency reported annual costs of around $75,000.

	Traffic signals	Traffic signs	Pavement markings	Street lighting	Curb ramps
< $10,000 per year	6/7 = 86%	15/16 = 94%	10/10 = 100%	4/5 = 80%	1/1 = 100%
~$25,000 per year	0/7 = 0%	1/16 = 6%	0/10 = 0%	1/5 = 20%	0/1 = 0%
~ $50,000 per year	0/7 = 0%	0/16 = 0%	0/10 = 0%	0/5 = 0%	0/1 = 0%
~ $75,000 per year	1/7 = 14%	0/16 = 0%	0/10 = 0%	0/5 = 0%	0/1 = 0%
> $100,000 per year	0/7 = 0%	0/16 = 0%	0/10 = 0%	0/5 = 0%	0/1 = 0%

Figure B.28: Costs for External Consultants/Contractors
to Collect/Analyze Data on Traffic Control and Safety Devices.

- Use of Inventory Data and Analysis Results for Traffic Control and Safety Devices: When asked how their agency uses their traffic control and safety device inventory data and analysis results, more than half of responding agencies reported that they are using the data and results for performance evaluation and monitoring, fiscal planning purposes, and for prioritizing projects (Figure B.29). The majority are using the data and results for traffic signals, street lighting, and curb ramps, but less than half of agencies indicated that the data and analysis results are used for resource allocation for traffic signs and pavement markings. A total of 63% of agencies reported using their data and analysis results for curb ramps for audits, reporting, and communication purposes, but approximately 25% of agencies use their data and results for traffic signals, traffic signs, pavement markings, and street lighting for this purpose. A total of 38% of agencies reported using data and results for curb ramps for policy formulation, but fewer than 20% of agencies reported that they used the data and results for traffic signals, traffic signs, pavement markings, and street lighting for this purpose.

	Traffic signals	Traffic signs	Pavement markings	Street lighting	Curb ramps
Performance Evaluation and Monitoring	14/20 = 70%	32/45 = 71%	19/33 = 58%	9/17 = 53%	5/8 = 63%
Fiscal Planning	11/20 = 55%	24/45 = 53%	20/33 = 61%	10/17 = 59%	5/8 = 63%
Project Prioritization	12/20 = 60%	23/45 = 51%	18/33 = 55%	10/17 = 59%	6/8 = 75%
Resource Allocation	12/20 = 60%	18/45 = 40%	16/33 = 48%	9/17 = 53%	6/8 = 75%
Audit, Reporting, and Communication	5/20 = 25%	11/45 = 24%	7/33 = 21%	4/17 = 24%	5/8 = 63%
Policy Formulation	4/20 = 20%	7/45 = 16%	4/33 = 12%	2/17 = 12%	3/8 = 38%

Figure B.29: Use of Inventory Data for Traffic Control and Safety Devices.

B.7 Utility Asset Information

- Use of an Inventory for Utility Assets: Information was solicited to find if the agency maintained an asset management inventory for utility assets. In the survey results shown in Figure B.30, 76% of respondents reported that they maintain an inventory of water supply systems, 76% maintain an inventory of sanitary collection systems, and 10% maintain an inventory of electric power services.

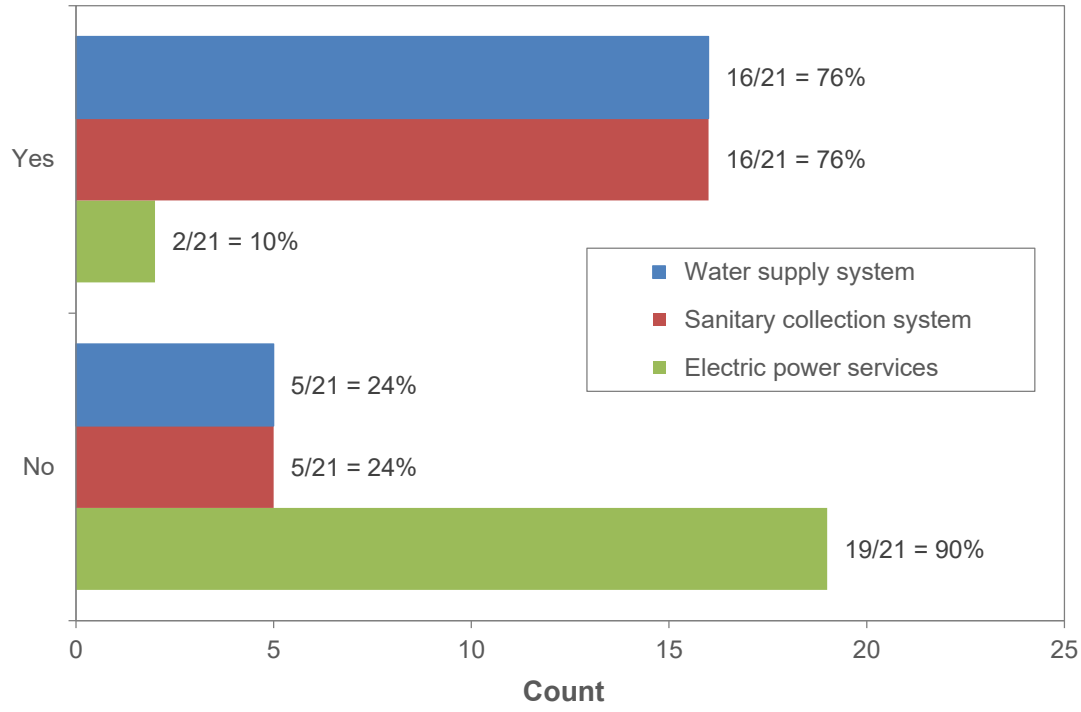


Figure B.30: Agency Use of an Asset Management Inventory for Utility Assets.

- Data in the Utility Assets Inventory: The survey results regarding the data collected for water supply systems, sanitary collection systems, and electric power services are shown in Figure B.31. All respondents indicated that their agencies include location data for these assets, and the vast majority of respondents indicated that their agencies include the attributes/characteristics of these assets. All respondents indicated that their agencies include data on initial construction or installation for electric power services, while 81% reported that they included this information for their water supply systems, and 63% reported that they include this information for their sanitary collection systems. All respondents indicated that their agencies include performance or condition data for electric power services, while 50% reported that their agency includes this information for their water supply system, and only 38% reported that their agency includes this information for their sanitary collection system. All respondents indicated that their agencies include maintenance and rehabilitation data for electric power services, while 88% of agencies reported including this information for their water supply system, and only half include this information for their sanitary collection system. No respondents indicated that their agencies include user feedback or complaints regarding electric power services, and only 19% of agencies reported including this information for their water supply system or sanitary collection system.

	Water supply system	Sanitary collection system	Electric power services
Asset location	16/16 = 100%	16/16 = 100%	2/2 = 100%
Attributes / characteristics	14/16 = 88%	13/16 = 81%	2/2 = 100%
Initial construction / installation data	13/16 = 81%	10/16 = 63%	2/2 = 100%
Performance / condition data	8/16 = 50%	6/16 = 38%	2/2 = 100%
Maintenance and rehabilitation data	14/16 = 88%	8/16 = 50%	2/2 = 100%
User feedback and/or complaints	3/16 = 19%	3/16 = 19%	0/2 = 0%

Figure B.31: Types of Data Included in the Inventory for Utility Assets.

- Method Used for Storing Utility Asset Data: When asked what methods they use to store their utility asset data, 100% of agencies reported using commercial software for electric power services but only 63% for their water supply systems and 56% for their sanitary collection systems, as shown in Figure B.32. Custom software that was developed in-house is used by only 19% of agencies for their water supply systems and sanitary collection systems. Rougly half of the respondents reported that they use Microsoft Excel for utility asset data, and no respondents indicated using Microsoft Access. Half of respondents indicated that their agencies use other methods to store the inventory data for their utility assets, and fewer than 40% of respondents indicated that they use other methods for this purpose.

	Water supply system	Sanitary collection system	Electric power services
Commercial asset management software	10/16 = 63%	9/16 = 56%	2/2 = 100%
Custom software developed in-house	3/16 = 19%	3/16 = 19%	0/2 = 0%
Microsoft Excel	7/16 = 44%	7/16 = 44%	1/2 = 50%
Microsoft Access	0/16 = 0%	0/16 = 0%	0/2 = 0%
Other	5/16 = 31%	6/16 = 38%	1/2 = 50%

Figure B.32: Method Used for Storing Utility Asset Inventory Data.

- Method Used to Process or Analyze Utility Asset Inventory Data: This question asked respondents to indicate what method they used for processing and/or analyzing asset management inventory data for utility assets. As can be noticed from Figure B.33, all respondents indicated that their agencies use commercial asset management software for electric power services, and half also use other methods for this purpose. Custom software was reported by 13% of respondents to be used at their agencies for processing and analyzing water supply system and sanitary collection system data, while 31% of respondents reported that their agencies use Microsoft Excel for this purpose. Less than 40% of agencies reported using other methods to store and analyze water supply system and sanitary collection system data. No agencies reported using Microsoft Access to process or analyze utility assets.

	Water supply system	Sanitary collection system	Electric power services
Commercial asset management software	10/16 = 63%	9/16 = 56%	2/2 = 100%
Custom software developed in-house	2/16 = 13%	2/16 = 13%	0/2 = 0%
Microsoft Excel	5/16 = 31%	5/16 = 31%	0/2 = 0%
Microsoft Access	0/16 = 0%	0/16 = 0%	0/2 = 0%
Other	5/16 = 31%	6/16 = 38%	1/2 = 50%

Figure B.33: Method Used for Processing or Analyzing Utility Asset Inventory Data.

- Use of Consultants or Contractors to Collect/Analyze Utility Asset Data: This question asked respondents if their agency relies on external consultants or contractors to collect and analyze data for utility assets, and the results are shown in Figure B.34. The majority of agencies indicated that they collect this data themselves.

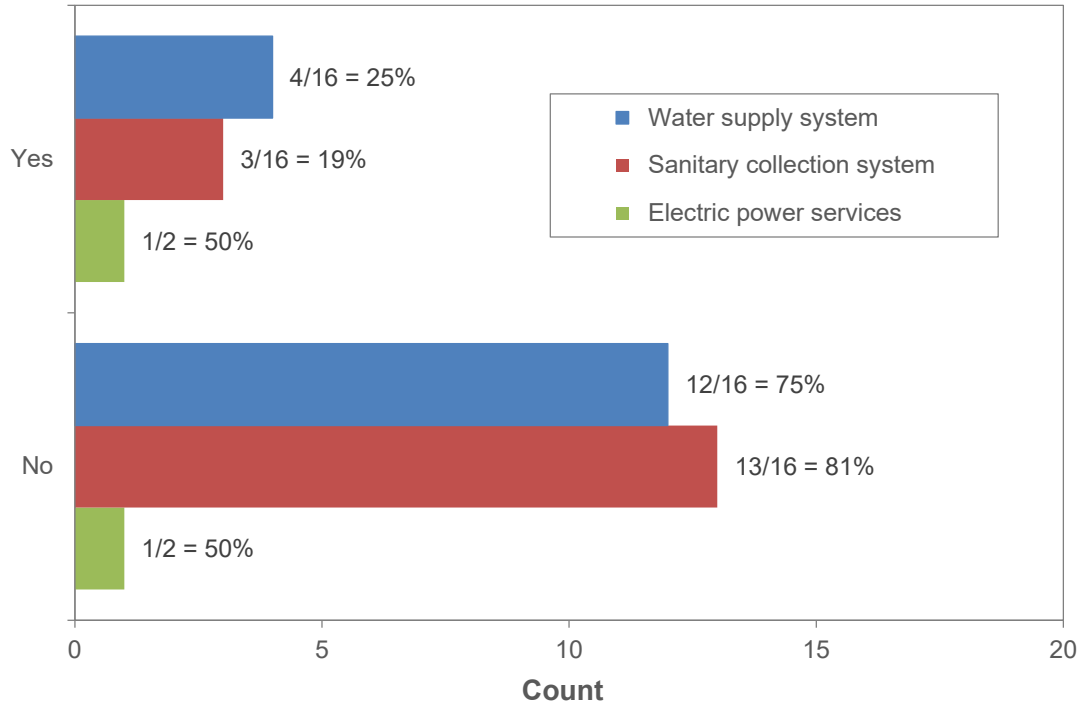


Figure B.34: Use of Consultants or Contractors to Collect/Analyze Data on Utility Assets.

- Annual Cost for External Consultants or Contractors to Collect/Analyze Data on Utility Assets: This question asked respondents to indicate how much they paid to external consultants or contractors for processing and/or analyzing asset management inventory data for utility assets, and the results are shown in Figure B.35. As can be noticed from this figure, the one respondent indicated that annual costs for electric power services were approximately $25,000. Two agencies reported that they had annual costs of under $10,000/year for sanitary collection systems, while one agency reported annual costs of about $25,000. Two respondents indicated their agencies had annual costs of under $10,000 for water supply assets, while two other respondents reported annual costs of around $25,000.

	Water supply system	Sanitary collection system	Electric power services
< $10,000 per year	2/4 = 50%	2/3 = 67%	0/1 = 0%
~$25,000 per year	2/4 = 50%	1/3 = 33%	1/1 = 100%
~ $50,000 per year	0/4 = 0%	0/3 = 0%	0/1 = 0%
~ $75,000 per year	0/4 = 0%	0/3 = 0%	0/1 = 0%
> $100,000 per year	0/4 = 0%	0/3 = 0%	0/1 = 0%

Figure B.35: Costs for External Consultants/Contractors to Collect/Analyze Data on Utility Assets.

- Use of Inventory Data and Analysis Results for Traffic Control and Safety Devices: When asked how their agency uses their utility asset inventory data and analysis results, the majority of responding agencies reported that they are using the data and results for their utility assets for performance evaluation and monitoring, fiscal planning purposes, and for prioritizing projects (Figure B.36). Half of the respondents reported that their agencies are using the data and results for utility assets for resource allocation. Half of agencies reported using their data and analysis results for electric power services for audits, reporting, and communication purposes, while 31% of agencies use their data and results for their water supply systems and sanitary collection systems for this purpose.

	Water supply system	Sanitary collection system	Electric power services
Performance Evaluation and Monitoring	11/16 = 69%	11/16 = 69%	2/2 = 100%
Fiscal Planning	14/16 = 88%	13/16 = 81%	2/2 = 100%
Project Prioritization	14/16 = 88%	14/16 = 88%	2/2 = 100%
Resource Allocation	8/16 = 50%	8/16 = 50%	1/2 = 50%
Audit, Reporting, and Communication	5/16 = 31%	5/16 = 31%	1/2 = 50%
Policy Formulation	5/16 = 31%	5/16 = 31%	1/2 = 50%

Figure B.36: Use of Inventory Data for Utility Assets.

B.8 Final Comments

- Additional comments: Final comments provided by the respondents regarding the asset management in their agencies are provided in Table B.1.

Table B.1: Additional Comments Provided by Agency Respondents.

Comments
Circleville Township: For small townships (Circleville Township is 14 miles of road), the control of driving speeds, bridge maintenance and even roadways is often a multi-agency situation. CT has no jurisdiction over traffic lights or speed limit in areas of the township that include ODOT state highways. One of CT's roads is divided into three entities: Circleville Township, City of Circleville Yamrick Township, and Washington Township. Most of the township roads are in three small subdivisions.
The City of Dublin: The City of Dublin Asset Management team manages many of the infrastructure assets in the city (sidewalks, roads, bridges, bike paths, etc.) and determines what needs done and when in order to keep all of our assets in good condition. We do this through inventory, inspections, analysis, and establishing work plans utilizing Cityworks, GIS, and Tableau software applications.
Williams County: All our asset management is heavily tied to GIS, and there is still a lot more we could do with it if we had streamlined services. I'm an engineer, not a computer code writer. The code and automated processes are what slow me up.
Putnam County: Our Commercial software that we use is an ESRI SQL Geo Database managed with the ESRI Web application with in-house personnel.
Geauga County: In the near future the ability to utilize an updated GIS platform will be in place to make use of effective data management tools.
Mead Township: ODOT and some of its programs are valuable resources. Unfortunately many do not tap into the service.
Brown Township: We have 21 miles of township roads. We ride these with the county engineer two times per year to determine maintenance needs
Columbus Regional Airport Authority: As an airport authority we reference and act in accordance with several industry standards for asset management program development. We are more interested in what the inventory and condition data tells us and therefore relay heavily on spreadsheets which are easy to manage and update, rather than asset management software. Our asset management program is supported by our growing GIS program, using a cloud-hosted ArcGIS Online platform. Effective, easy to operate and cost effective for our organization.
Champaign County: We have no curb, sidewalks or traffic signals to inventory or monitor. No software. We do have a guardrail shape file and database that we also maintain. We only use spreadsheets for our equipment and trucks.
Ohio Turnpike Commission: While I indicated that we do not have an asset management system implemented, we have begun work to start introducing GIS to the Turnpike organization. We are in the initial phase of the program of starting with a

small paper-based process, converting it into a GIS form and using ESRI software and apps to manage the data. Once a program is fully implemented, outreach is planned to be developed to promote data management in general. Until then we are collecting data and building a database of asset datasets in preparation that Asset Management is next on the list to implement.
Defiance County: Our inventory is small enough that we can have the same person evaluate each road each year. We keep a database of history of treatments and dimensions. We find that this is more cost effective and accurate than trying to build an accurate computer model of deterioration. Our experience is that pavement age is as accurate a proxy for pavement condition as any to predict future condition.

Appendix C
Follow-up Questions to Selected LPAs

C.1 Introduction

The research team contacted by email the survey respondents from selected agencies who had reported using commercial software for transportation asset management and who had given their permission to be contacted in their survey responses. The respondents were asked to identify the software used by their agency and to elaborate on their use of the software. A total of 15 agencies (four city governments and 11 county engineers' offices) responded to the follow-up email communication.

The following sections provide a summary of the responses to the follow-up questions, organized by the general type of software. The first section describes the agencies' use of Microsoft Excel, the second section discusses mapping and geographic information (GIS) software, the third section mentions specialized asset management systems designed for particular classes of assets, and the fourth section lists dedicated computerized maintenance management system (CMMS) software that agencies use to manage their assets. Detailed descriptions of the CMMS software are included in Appendix D.

C.2 Microsoft *Excel*

Three county engineers' offices reported that they use Microsoft *Excel* spreadsheets to help them manage their assets. Tuscarawas County stores their culvert information on *Excel* spreadsheets. Champaign County manages their culverts using *Excel*, databases, and ArcMap. Wayne County uses a custom Excel spreadsheet to manage their traffic signals, as they manage only three signalized intersections; they also manage their roadside and non-roadside ditches using an internal Excel spreadsheet and *iWorQ* CMMS software.

C.3 *ArcGIS* and *ArcMap* (Esri Industries)

Respondents from three city agencies and three county agencies reported that they use *ArcGIS* geographic information (GIS) software and/or *ArcMap* mapping software by Esri Industries as part of their asset management programs. Some respondents use *ArcGIS* develop their inventory systems in GIS format: they map the locations of assets and collect, organize, and

analyze data for the assets, and they use *ArcGIS Collector* app on smartphones or tablet computers (such as Apple iPads) to update the information on the assets in the field when the assets are maintained or replaced. Some agencies use *ArcGIS* for nearly every category of assets listed in the survey questionnaire, while others use it only for specific categories of assets (Clark County Engineer's Office uses it for culverts, stormwater management systems, or traffic signs, while the Champaign County Engineer's Office uses it only for culverts). Two respondents mentioned that they use Esri software in conjunction with other software for managing their assets. The Champaign County Engineer's Office uses *ArcMap*, databases, and Microsoft *Excel* for culverts. The City of Beavercreek is using databases and maps in *ArcGIS Online* that they export to a dedicated CMMS system called *Asset Essentials* (by Dude Solutions).

C.3 Specialized Software for Specific Assets

Some local agencies use software that is designed for managing specific task or a particular type of asset. Several agencies reported that they use *AssetWise* Asset Reliability Inspections CONNECT Edition from Bentley Systems, as supplied by ODOT, to maintain their bridge inventory and inspection data. Two county agencies reported that they use *PAVER* software, developed by the U.S. Army Corps of Engineers and Colorado State University, to manage their pavement assets.

C.4 Dedicated CMMS Systems

Several city and county transportation agencies in Ohio reported that they use comprehensive CMMS systems to manage their assets. As mentioned earlier, the City of Beavercreek has adopted a web-based system called *Asset Essentials* (Dude Solutions), and it uses this system to monitor assets listed below and create work orders to inspect, maintain, repair, or replace their assets. The City of Dublin uses a CMMS system called *Cityworks AMS* (Citiworks) to record inspections and service requests and to create work orders. Franklin County uses *VUEWorks* (Data Transfer Solutions) to manage its assets. The Wayne County Engineer's Office uses *iWorQ* (iWorQ Systems, Inc.) to manage its pavement and culverts, and they use *iWorQ* and *Excel* spreadsheets to manage their roadside and non-roadside ditches. Two respondents from county agencies reported that their agencies use a CMMS system called *Softworks* (Softworks,

Inc.): Medina County uses it to track numerous asset inventories, and Tuscarawas County uses it to maintain information on its sign inventory.

One comprehensive CMMS system, *MasterSuite* (MasterMind Sytems LLC), was mentioned by respondents from several county agencies, and the agencies use it to handle a number of different assets. Several county agencies (including Logan County) are already using this system, and another (Medina County) is planning to adopt this system. Champaign County, Huron County, and Wayne County use this system to manage their traffic signs and pavement markings. Ross County maintain its inventory data for signs, guardrails, pavement markings, and centerline straight line mileage (SLM)/control points. MasterMind LLC also provides road data collection services, performs traffic safety surveys, and provides GIS services (such as video mapping), and some county agencies contract with the company for these service in addition to using the *MasterSuite* CMMS system. MasterMind drives over the roads in Williams County with a video capture vehicle to collect data on the county's sign, guardrail, and pavement marking assets, and the information is stored and accessed via *MasterSuite.* Tuscarawas County contracts with the company to record centerline data, which is provided to the county in digital form on a device similar to a thumb drive.

Appendix D
Asset Management Systems and Software

D.1 Introduction

This appendix provides brief descriptions of the features of the various CMMS platforms and software for transportation asset management that were identified in this project. Some of the software platforms are more complex and include advanced features (such as data analytics) that are more geared toward state transportation agencies but may have specific modules that may be useful for local public agencies (LPAs), while others have been specifically designed with LPAs in mind. Please note that not all software developers have provided screenshots and/or detailed descriptions or tutorials. However, most developers will offer demonstrations of the software if they are contacted directly by an LPA.

D.2 *ArcGIS*

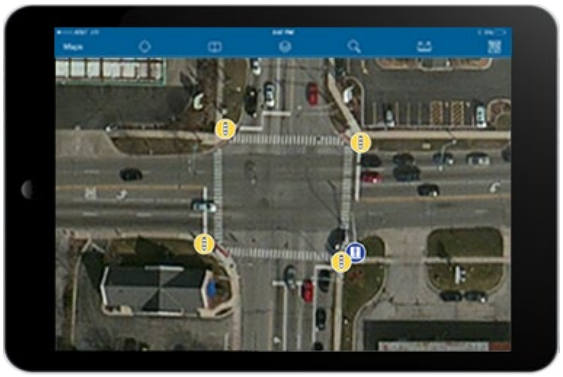
Esri (Redlands, California) is specialized in the development of geographic information system (GIS) software, web GIS, and geodatabase management applications (Esri 2021). They are best known for the *ArcGIS* family of software. *ArcGIS Pro* software allows users to visualize data, conduct advanced data analysis, and maintain data (in two, three, and four dimensions). Data can be shared with ArcGIS products (*ArcGIS Online, ArcGIS Enterprise*, etc.) through *Web GIS.* A mobile app called *ArcGIS Explorer* gives users access to digital maps when working in the field in areas without internet access. Users can search the map to find a particular asset, employ markup tools to record data and field notes, and make sketches on the map to define areas, and share the maps with others. The app is available for Android, iOS, and Windows devices.

Esri also develops software systems and modules that are specifically targeted towards transportation applications. The software *Right of Way (ROW) Asset Inventory* can be used to maintain an inventory of transportation assets. Esri provides various modules to allow users to identify and track different assets as well as to prepare the data collected for planning and evaluation tasks in *ROW Asset Inventory.*

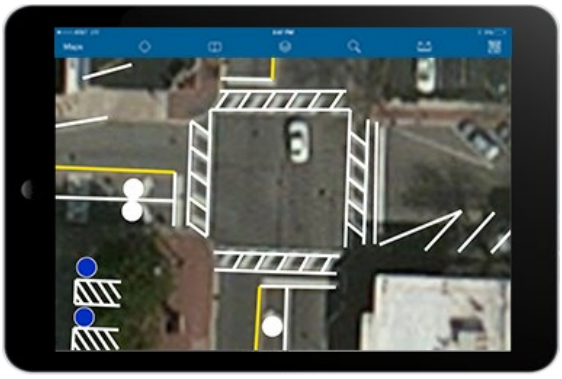
Modules are available for compiling and updating inventories for street intersections, signs, signals, pavement markings, bridges, and guardrails, as shown in Figure D.1. *Street Intersection Inventory* is a module for compiling and updating information on street intersections and approach characteristics (such as approach speed, pedestrian crossings, and signal timing). *Sign Inventory* can be used to inventory traffic signs erected beside or above roads. *Signal Inventory* can be used to inventory traffic signals and signal cabinets. *Bridge Inventory* is used to collect and store information to identify bridges (such as bridge type, design specifications, and dimensions). *Guardrail Inventory* allows the collection and storage of railings along roads.

Street Intersection Inventory

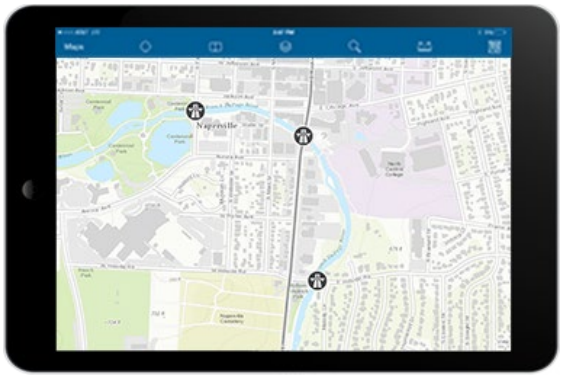
Sign Inventory



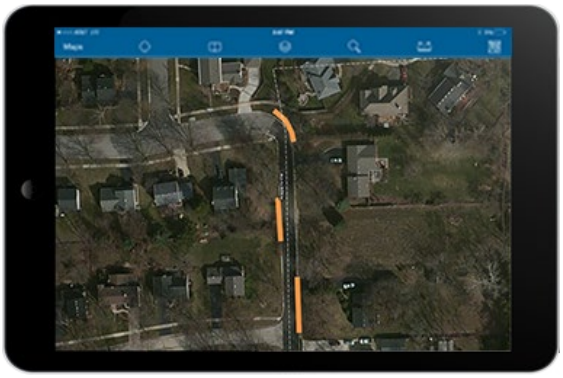
Signal Inventory



Pavement Markings Inventory



Bridge Inventory



Guardrail Inventory

Figure D.1. Modules for Intersections, Various Signals and Markings, Bridges, and Guard Rails. Images from Esri.

Other modules for miscellaneous street structures are available from Esri. *Streetlight Inventory* is used to create and update an inventory of streetlights and light poles adjacent to public roads or walkways. *Traffic Calming Inventory* is used to create and maintain an inventory of devices for reducing traffic flow and encouraging drivers to slow down and drive more

responsibly. *Sidewalk Inventory* enables users to inventory public sidewalks and curb ramps. *Street Furniture Inventory* is used to create and update inventory on street furniture (such as benches, barriers, bus stops, public sculptures, waste receptacles, and other items), and *Street Tree Inventory* is used to records the locations, species, and conditions of the trees alongside the road.

Streetlight Inventory *Traffic Calming Inventory*

Sidewalk Inventory *Street Furniture Inventory*

Street Tree Inventory

Figure D.2. Modules for Misc. Street Structures. Images from Esri.

Esri also produces modules for collecting information on railroad crossings and cycling amenities, as shown in Figure D.3, are also available. *Railroad Crossings Inventory* is used to record the locations and attributes of railroad crossings, and *Cycling Infrastructure Inventory* is used to track assets such as bike paths and lanes, shared paths and lanes, cycle tracks, traffic calming devices, and parking stations.

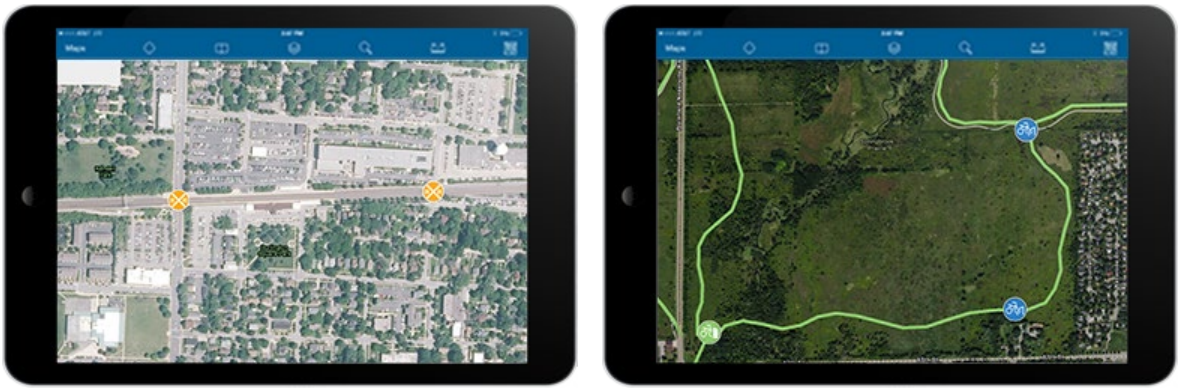


Figure D.3. *Railroad Crossings Inventory* (*left*) and *Cycling Infrastructure Inventory* (*right*). Images from Esri.

Esri has developed two mobile applications for using *ROW Asset Inventory* in the field. Esri's data collection app, *ArcGIS Collector*, allows people working in the field to capture accurate data on map-driven forms (and to attach photos, videos, audio recordings) from their mobile devices, edit the data in the field, and upload the data once a connection to the database is available. *ArcGIS Field Maps* is an all-in-one mobile app for fieldwork that requires minimal training and incorporates the features of *ArcGIS Collector* as well as some additional functions. *ArcGIS Field Maps* employs data-driven maps to aid in the collection and editing of data in the field, helps users to find asset locations and other information, and enables them to indicate their locations in real time. It gives users in the field (as well as others back at the office who are using the *ArcGIS* platform) access to current data at all times. *ArcGIS Field Maps* is available for download from app stores. Screen captures from *ArcGIS Collector* and *ArcGIS Field Maps* are presented in Figure D.4.

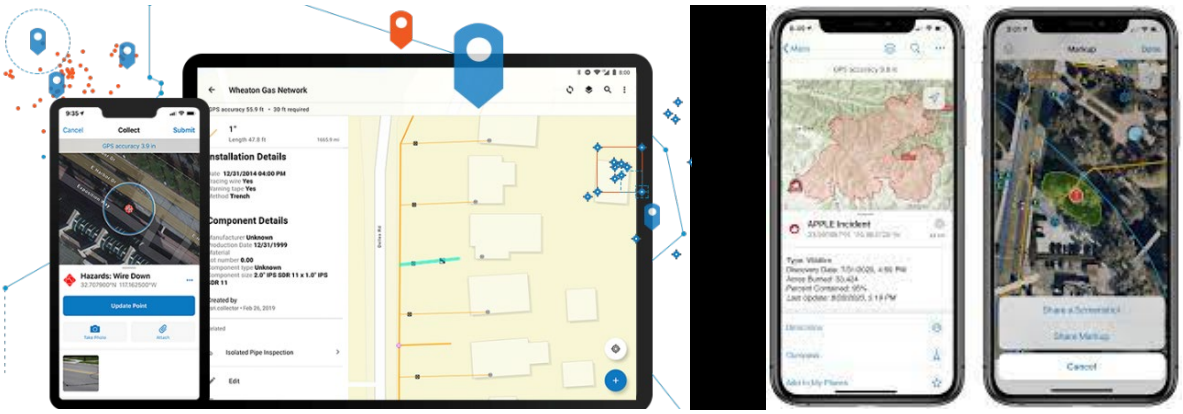


Figure D.4. Mobile data collection: *ArcGIS Collector* on a smartphone and tablet (*left*) and *ArcGIS Field Maps* on smartphones (*right*). Images from Esri.

D.3 *PAVER*™

PAVER™ was developed for the U.S. Department of Defense by Colorado State University in the 1970s to help the manage maintenance and rehabilitation for its pavements (Colorado State University 2021). This pavement maintenance management system uses inspection data and a pavement condition index (PCI; which became ASTM standard D6433 in 1999*)* that employs ratings from zero (failed) to 100 (excellent) to describe the pavement condition. The PCI as of the "today condition" is available for use in several reports in the program (such as *"*GIS" and "Summary Charts"). An Engineered Management System (EMS) query tool permits the user to choose pavement sections based on the today condition, and the program also makes it easy to split pavement sections, and a section history report can be generated. With *PAVER*™, the user has the option to use *Access*, SQL, or local databases, and multiple users can connect to a server and use the same *PAVER* database. Users can create or update the pavement inventory and work history using an *Excel* spreadsheet. In addition, inventory samples can be imported from GIS, and the samples can be displayed on a GIS map. *PAVER*™ can be used to conduct multiple levels of analysis to determine how to best allocate funds in an agency's maintenance and rehabilitation budget. Pavement system tables (such as cost tables, maintenance policies, etc.) can be kept private or shared with other users. The budget table includes a tool that allows users to enter data when creating a new budget.

PAVER FieldInspector™ is a companion software for handheld computer tablets that uses graphics and GIS technology and expedite pavement inspection. A user in the field can identify their location on a geo-referenced pavement network map displayed on their tablet computer and can enter the pavement distress data for that location. As pavement distress data is entered, the PCI calculations are performed and displayed in real time, and built-in data entry validation tools are used to flag errors before they are recorded in the system. When performing inspections of cement concrete pavements, the user can create graphics of individual concrete slabs and record the distresses on each slab. Screen captures from *PAVER*™ and *FieldInspector*™ are shown in Figure D.5.

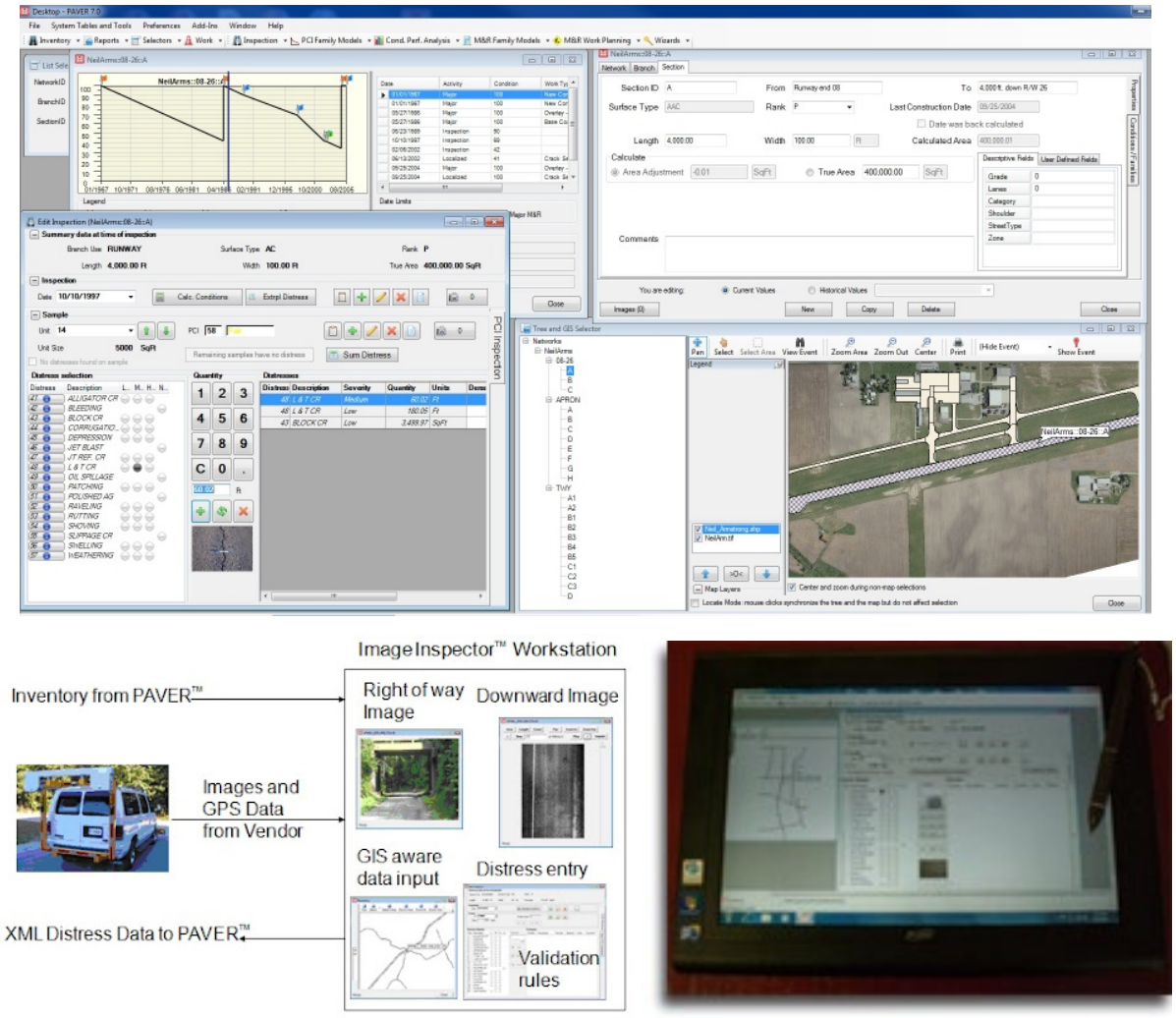


Figure D.5. Screenshots from *PAVER*™ (*top*) and *ImageInspector*™ (*bottom left*). *FieldInspector*™ running on a tablet computer (*bottom right*). Images from Colorado State University.

D.4 *AssetWise*

AssetWise is web-based application from ODOT that is hosted on servers at Bentley Systems, Inc. and is used to collect inventory and inspection data for bridges and tunnels in Ohio (ODOT 2021b). AssetWise can be accessed via the web or by using a data collection application, *InspectTech Collector*, that was made for use on Apple iPads.

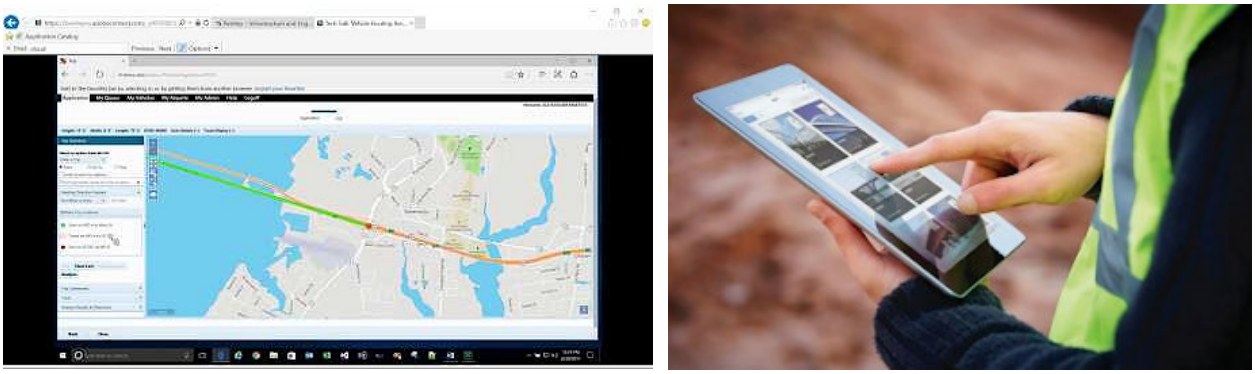


Figure D.6. *AssetWise* by Bentley: Asset Performance Management (*left*) and a fieldworker using *InspectTech* (*right*). Images from Bentley Systems Inc.

D.5 *Asset Essentials*™

Asset Essentials™, produced by Dude Solutions (Cary, N.C.), is a cloud-based CMMS that enables several processes and tasks (Dude Solutions 2021). It can be used to create different types of maintenance work orders (for reactive, corrective, predictive and preventative maintenance) and allows asset managers to prioritize, schedule, and manage maintenance tasks based on the asset type, the location of the asset, or the inspector/evaluator. The work orders can be tracked using a map view in the software or by integrating it with Esri *ArcGIS* for managing and performing maintenance on geo-located assets. Cost tracking, maintenance history, and other information can be used to for making decisions based on total cost of ownership across different sites and various hierarchies. The software features predefined user interface and tools to help asset managers manage their budgets, key performance indices, and it can be used to create charts, graphs and reports. It also enables agencies to manage inventory of frequently used parts to streamline just-in-time maintenance and optimize procurement/replenishment processes. Users can upload up to 20 GB of documents (in .pdf format, in Microsoft *Word* or *Excel* format, or as plain text). The *Asset Essentials Mobile App*, which is designed for use on iOS or Android devices, enables inspectors, evaluators, and maintenance technicians to access the CMMS in the field. It allows users to scan barcodes on assets, gives them access to reference materials (schematics, photos, or other information), and tracks their work. This app can be downloaded at no cost from the Apple App Store or Google Play. Screenshots of the Asset Essentials system are shown in Figure D.7.

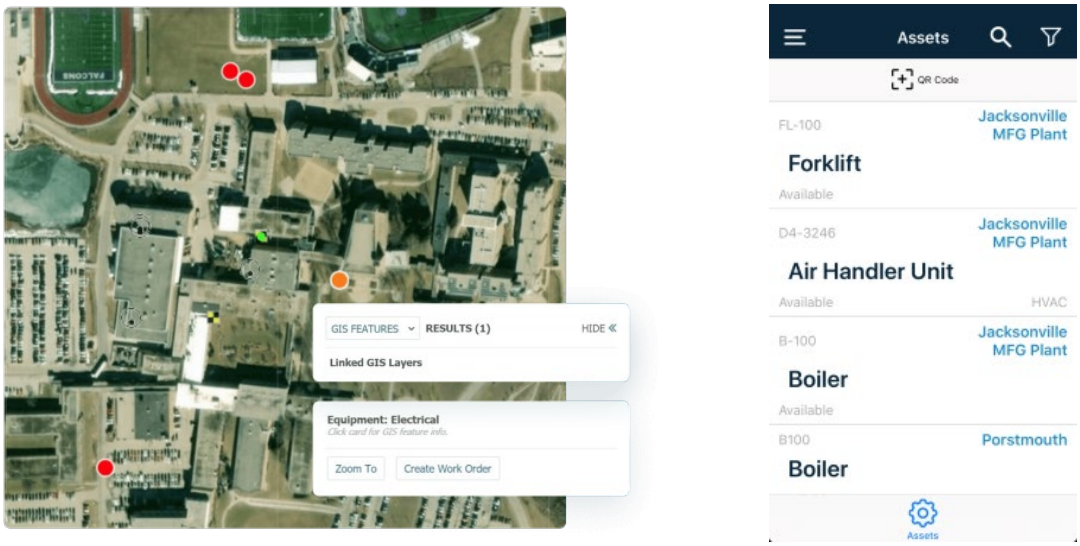


Figure D.7. *Asset Essentials*: GIS mapping (*left*) and mobile app (*right*).

D.6 *Cityworks AMS*

Cityworks AMS from Cityworks (Sandy, Utah) is a GIS-based enterprise system that uses the *ArcGIS* geodatabase for all asset classes (Cityworks, 2021). It incorporates applications with integrated map tools aid in visualizing scheduled work, ongoing maintenance activities, recurring maintenance problems, high-risk areas, and historical information. *Cityworks AMS* is used by transportation agencies for condition assessment, maintenance of assets, maintenance planning, management of work orders, management of work crews, regulatory compliance, citizen engagement, and the construction of risk models to help prioritize maintenance budgets and capital expenditures. Screen captures showing a work load map and work order locations are presented in Figure D.8.

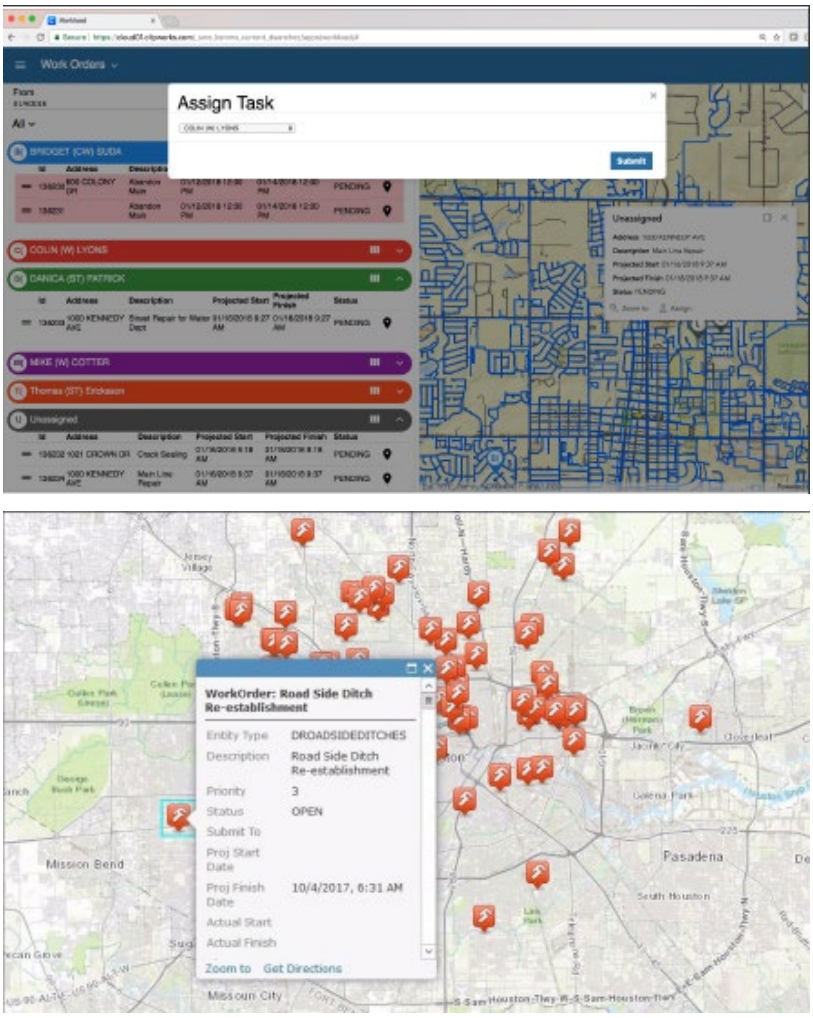


Figure D.8. *Cityworks AMS*: Workload Map (*top*) and Work Order Information (*bottom*). Images from Cityworks.

D.7 *VUEWorks*

VUEWorks, which was developed by Data Transfer Solutions (DTS; 2021) in Orlando Florida, is a web-enabled GIS, enterprise asset management software that is designed for state agencies and LPAs. The system includes various apps and modules. The *CitizenVUE* application is a platform that allows members of the community to submit service requests. The community member identifies the jurisdictional area, and the submissions are sent to the agency's *VUEWorks* asset management software. The agency can customize the splash screen of the application to display images from local files. A screenshot of the *CitizenVUE* app is shown in Figure D.9.

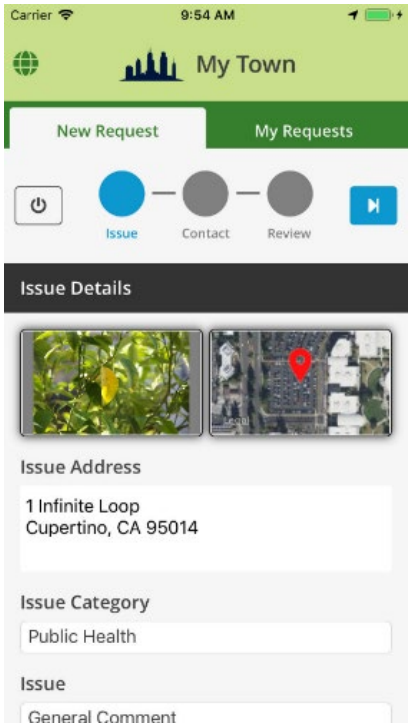


Figure D.9. *VUEWorks CitizenVUE* app. Image from DTS.

The *VUEWorks* system's *Work Order* module enables users to manage and plan work activities. A screenshot showing the management of work orders is shown in Figure D.10.

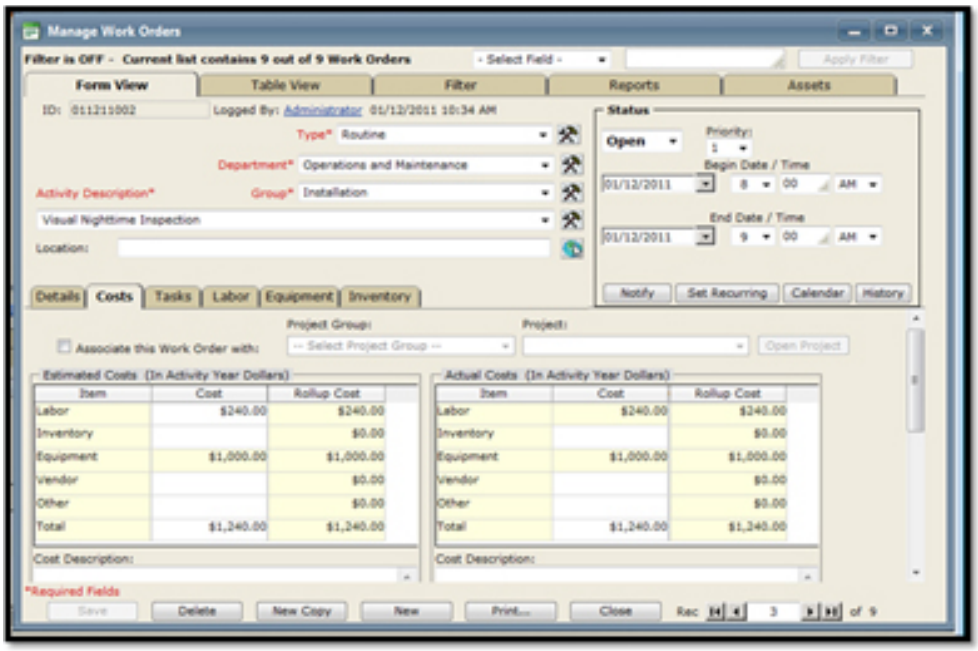


Figure D.10. Managing Work Orders in *VUEWorks*. Image from DTS.

The *Resource Manager* module, which is integrated with the *Work Order* module, allows time and costs to be tracked for workers, crews, contractors, outside vendors, equipment, and inventory items. A screenshot of the *Resource Manager* module is presented in Figure D.11.

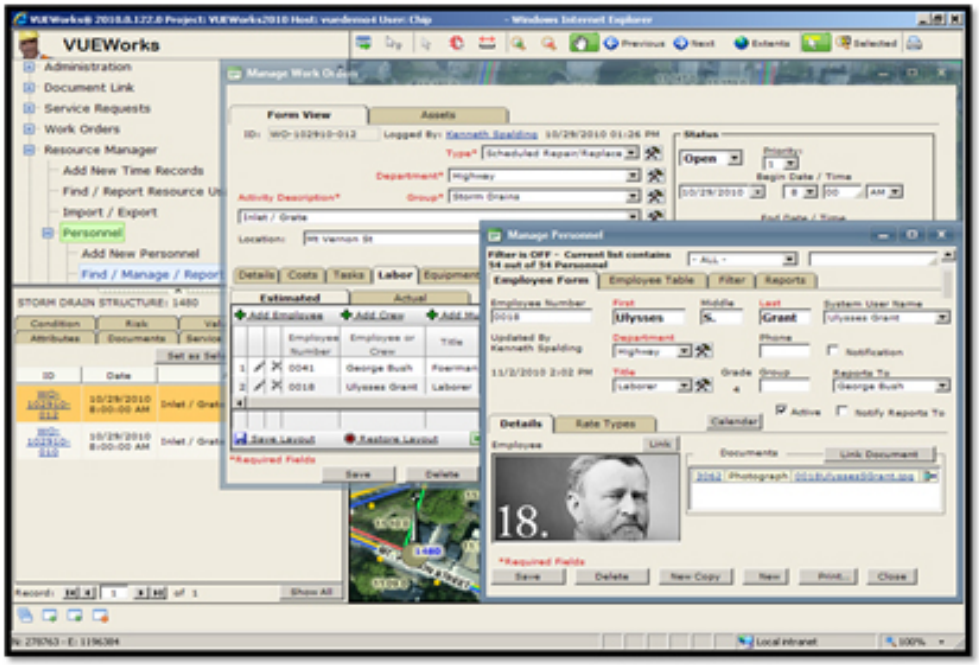


Figure D.11. *VUEWorks Resource Manager* module. Image from DTS.

The *Service Request* module is designed to allow staff members to manage issues reported by residents. A screenshot of this module is shown in Figure D.12.

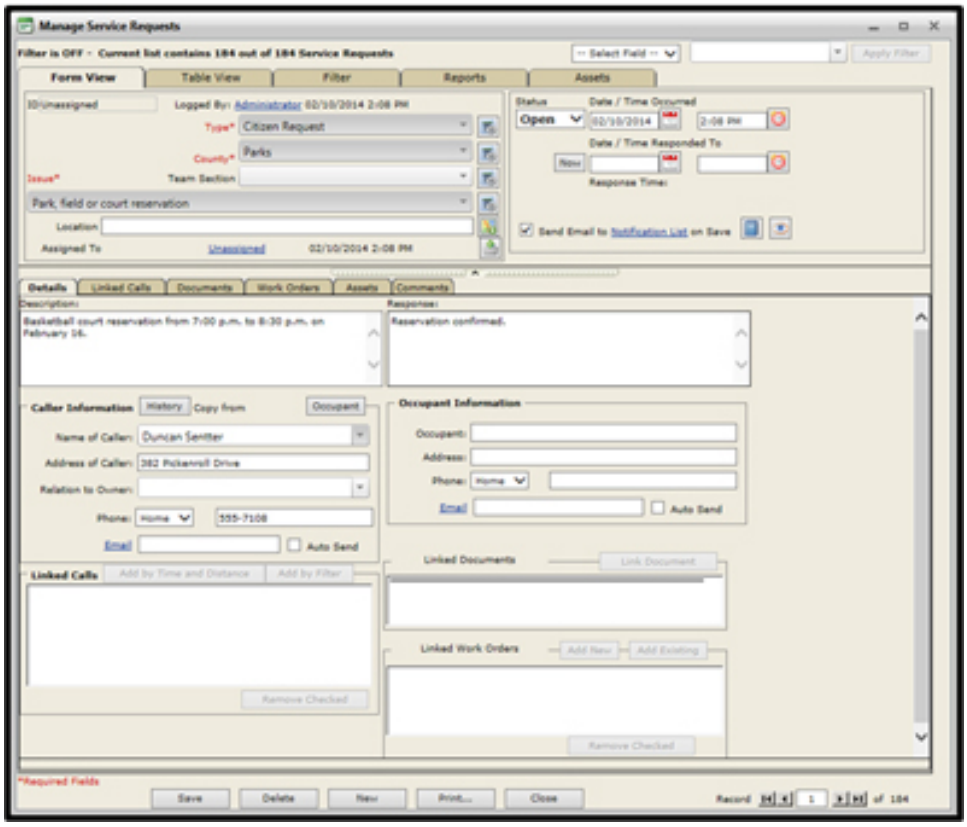


Figure D.12. *VUEWorks Service Request* module. Image from DTS.

The *Valuation* module helps agencies to meet Government Accounting Standards Board Statement (GASB) No. 34 requirements to maintain infrastructure assets and to report their values and depreciation. A screenshot of the *Valuation* module is presented in Figure D.13.

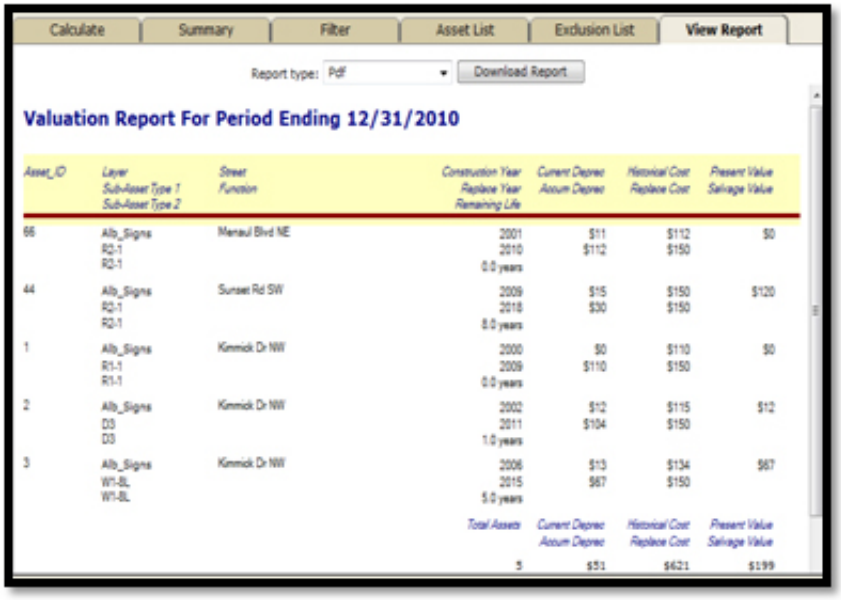


Figure D.13. *VUEWorks Valuation* module. Image from DTS.

The *Condition* module can be configured to collect, store, and analyze condition ratings for any asset (such as signs, pipes, roads, trees or other assets) and produce reports regarding their conditions. Agencies can specify and use their own condition inspection criteria or can import condition data that was collected using other software. A screenshot of the *Condition* module is shown in Figure D.14.

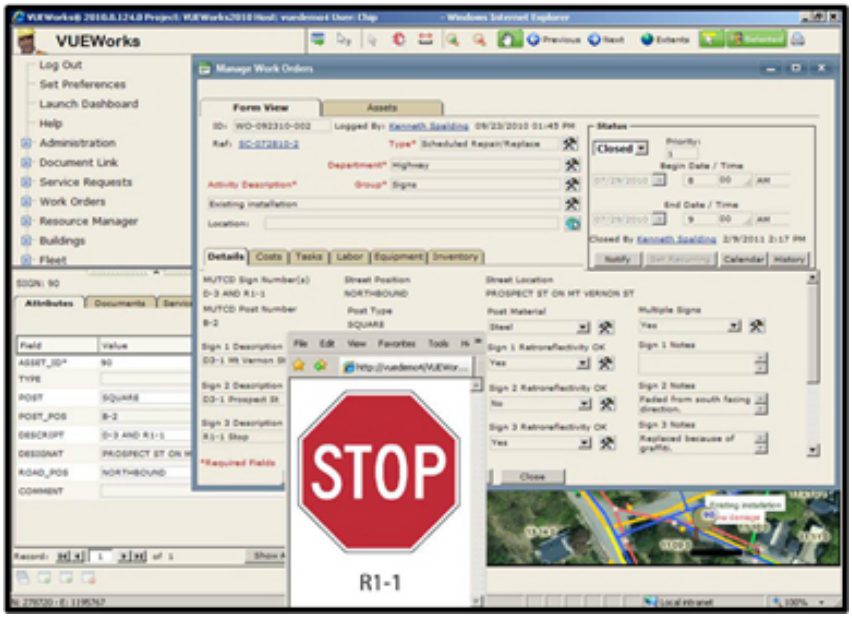


Figure D.14. *VUEWorks Condition* module. Image from DTS.

The *Risk* module enables users to create a risk model that enables limited resources and work activities to be prioritized. It allows the agency to ascertain the modes and/or probability of failure for different classes and types of assets as well as to configure the priorities by enabling the user to assign weight factors. A screenshot of the *Risk* module is presented in Figure D.15.

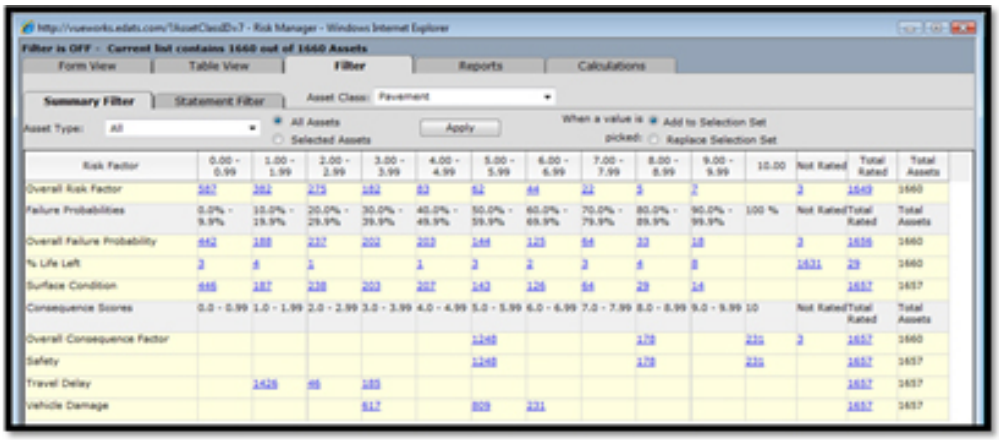


Figure D.15. *VUEWorks Risk* module. Image from DTS.

The *Budget Forecasting* module has configurable, multi-year capital improvement planning features that allow users to view their long-term budget needs based on deterioration curves for assets. A screenshot showing the *Budget Forecasting* module is shown in Figure D.16.

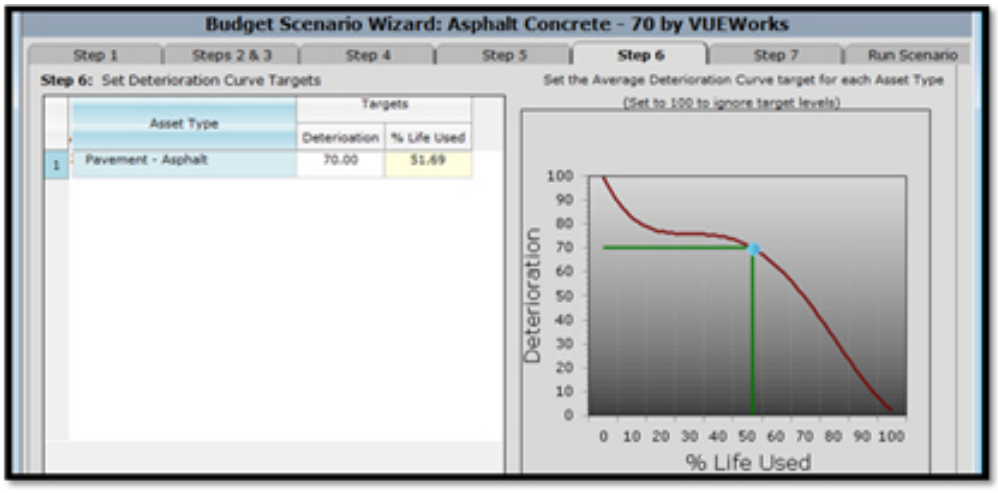


Figure D.16. *VUEWorks Budget Forecasting* module. Image from DTS.

The *Projects* module enables users to define projects, calculate cost estimates, group the estimates to calculate overall project budgets, and to compare the cost estimates to the actual costs incurred in the project by connecting to the *Work Order* module. The features in this module allow users to assign job costs for an entire asset or for only a portion of the asset and/or assign costs for repairs at multiple points along an asset. A screenshot of the *Projects* module is shown in Figure D.17.

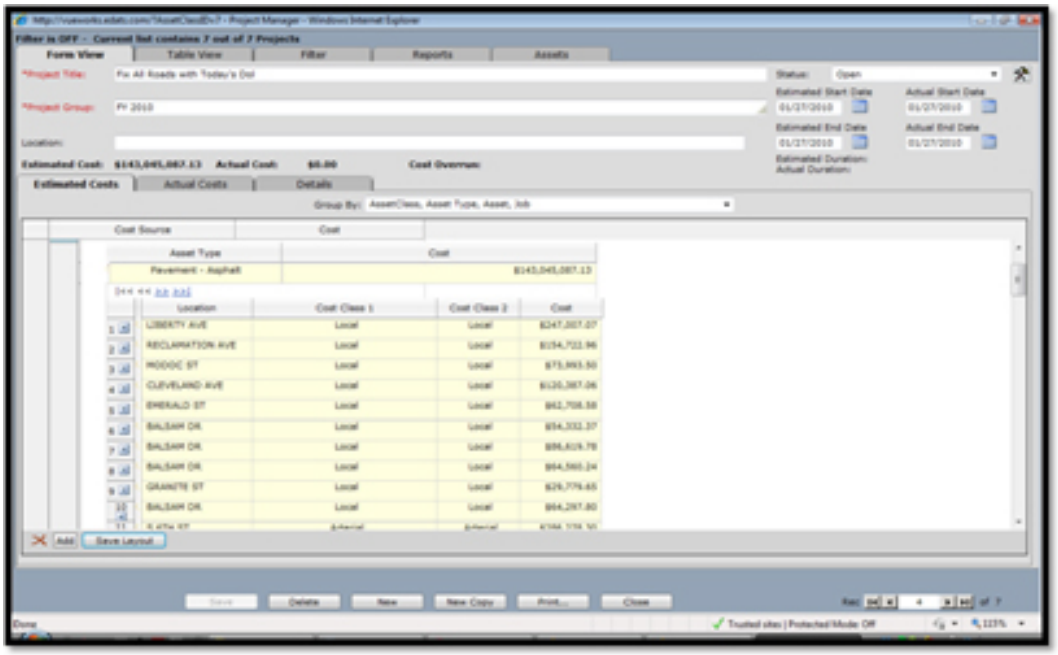


Figure D.17. *VUEWorks Projects* module. Image from DTS.

The *Facilities* module enables information such as historical service records, work records, links to other data, condition ratings, valuation, preventive maintenance scheduling and access to key operational documentation to be recorded for physical assets that are not found in a GIS but which still need. The types of facilities that can be managed are virtually limitless, including pumps, motors, fleet and building components. A screenshot of the *Facilities* module is presented in Figure D.18.

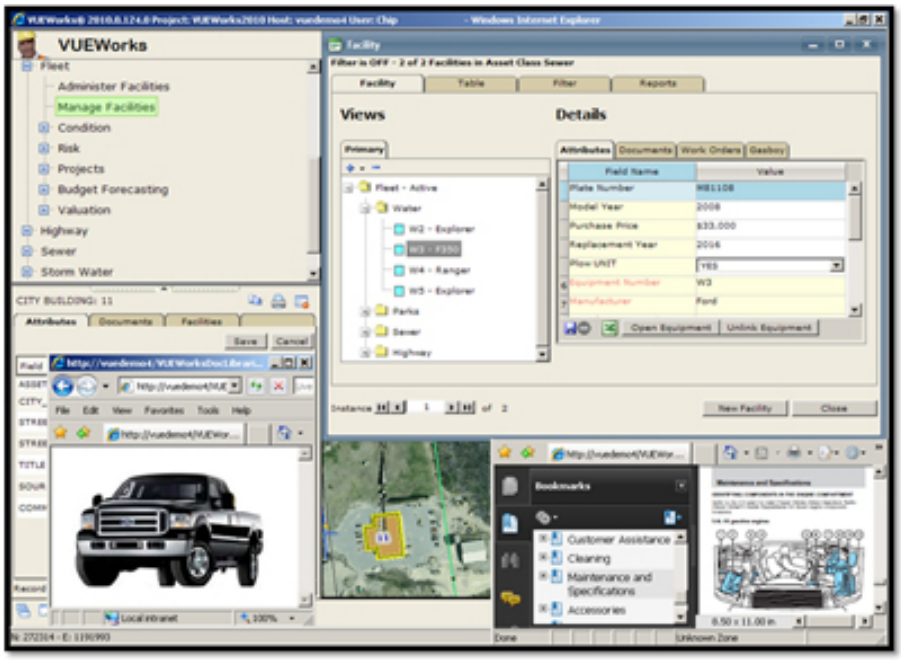


Figure D.18. *VUEWorks Facilities* module. Image from DTS.

The *VUEWorks* system also includes four mobile apps to facilitate data collection. The first of these is the *SidewalksVUE* app, which is used to collect sidewalk and curb ramp inspection data from multiple inspection teams in the field to ensure compliance with the Americans with Disabilities Act of 1990 (ADA). The data is recorded in a single database on a cloud-based server and can be used for later analysis with GIS mapping software or *Excel*.

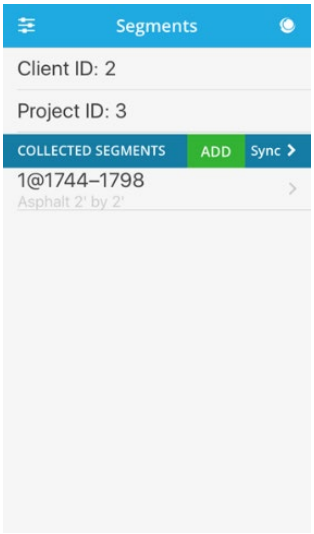


Figure D.19. *VUEWorks SidewalksVUE*. Image from DTS.

The *MobileVUE* app, which is built on ESRI *ArcGIS Mobile*, enables users to have access to maps and GIS data in the field – even if they are not able to connect to the web. It allows workers in the field to perform condition inspections of assets, add new assets to the inventory, and interact with the agency's GIS data from a tablet device.

Figure D.20. *VUEWorks MobileVUE* app. Image from DTS.

The *VUEWorks* system includes two additional mobile applications, *FieldVUE* and *FacilityVUE. FieldVUE* is a mobile application that requires Internet connection and can be used by workers in the field to take photographs and automatically submit a service request in *VUEWorks* with the location of the asset, a photo, and additional details (included as an optional comment). The app synchronizes with *VUEWorks*, and is compatible with GIS software to ensure that an accurate location of the asset is recorded in the request. *FacilityVUE* is a mobile application that enables users to collect and record asset information and inspection data at sites without WiFi access. Users can create and configure "bundles" in the desktop *VUEWorks Facility* module for use in the field, and the field data is synchronized with *VUEWorks* once an internet connection is re-established.

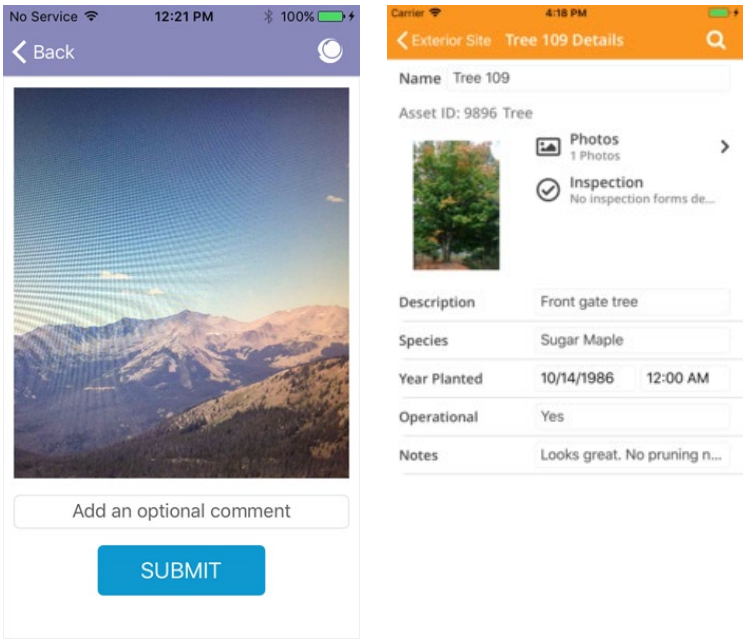


Figure D.21. VUEWorks mobile applications: *FieldVUE* (*left*) and *FacilityVUE* (*right*). Images from DTS.

D.8 *iWorQ*

iWorQ Systems Inc. (Logan, Utah) offers different cloud-based software tools and modules for LPAs as part of its *iWorQ* suite (iWorQ Systems Inc. 2021). Because *iWorQ* uses relational data tables to store information, it enables information recorded in one software application to be accessed by others. An agency's existing GIS data can be imported into *iWorQ* and accessed through *iWorQ*'s mapping tool, which. enables users to run searches, switch views, and view all of the agency's assets. Data fields can be customized to fit agency needs, and the applications have mobile capabilities that allow asset data and photographs to be added to the system from a smart phone or a tablet by users working in the field. Data is protected on *AWS GovCloud* (an Amazon web service region designed to host sensitive data and regulated workloads in the cloud and can aid customers in fulfilling US government compliance requirements), which is operated inside the USA by US citizens. The system is checked carefully to ensure that high compliance standards are maintained for the cloud computing services. No screen shots were available for this system, but the developer does offer demonstrations upon request.

The iWorQ suite includes a large number of applications. Among them are *Pavement Management*, *Sign Management*, *Asset Management*, *Sidewalk Management*, and *Planning & Zoning*. The *Pavement Management* application supports the tracking of information on road segments and can incorporate pavement condition data collected by walking, automated, or visual distress surveys. *Sign Management* application features an interactive map that helps users to easily place new signs to on the map and that can identify the optimal route to use for conducting inspections. It allows users to track ratings based on the *Manual on Uniform Traffic Control Devices* (*MUTCD*), record the conditions of signs and supports, view a history of work activity for each asset, and determine the remaining service life. The *Asset Management* application provides enterprise asset management tools that allows users to track their asset inventories as well as processes for collecting data, performing inspections, and developing data management plans and policies. *Sidewalk Management* application allows users to maintain an inventory of sidewalks and to store data such as type, location, length, and position as well as to view a history of work activity for the sidewalks. Using this module, users are able to monitor faulting (i.e., the difference in elevation of slabs on opposite sides of a transverse joint), cracks, and other distresses for each segment, which aids in the scheduling of repairs. The *Planning & Zoning* application enables LPAs to track agency-specific information and allows groups in different departments to work on the

same project. In this application, plan reviews, photographs, contractor documents, and inspection data can be uploaded and attached to the project.

Other applications developed by iWorQ include software for work management, fleet management, facility management, stormwater management, sewer management, backflow prevention, water system management, FEMA reporting, citizen engagement, citizen portals, external web maps, GIS mapping, permit management, code enforcement, license management, payment processing, and electronic document management.

D.9 *Softworks*

Softworks Inc. (Pickerington, Ohio) has been developing software for U.S. government offices and the private sector since 1984 (Softworks, Inc. 2021). Their *Softworks* suite of programs can run as stand-alone applications or can connect with other modules in the suite. Each module sends its data to a central data storage area so that the data can be shared with other modules. Agencies can start with one or a few modules and can add other modules at a later date. Softworks Inc. is one of the few software companies that will customize their existing systems, and they provide training seminars, on-site installation and training as well as customer support via telephone and e-mail. The software is periodically updated based on customer input, and agencies have the option in their maintenance agreements that permit Softworks Inc. to share their upgrades with other customers who also choose this option. While the company does not provide screen shots of the various modules, they do offer demonstrations of the software to potential customers. Brief descriptions of the features and modules in this system are provided below.

Softworks enables users to track projects and complaints through *Pavement Management/Work Order (Estimates)* and *Response Log* modules. It also allows expenses for labor, materials, and equipment for activities for specific projects or work orders to be recorded in a *Daily Crew Worksheet* module.

The *Pavement Management Systems* module helps to track road inspections, work orders, and project estimates. The "Force Account Project Assessment Form (Estimate)" in this module can be printed to show compliance with the requirements of Ohio House Bill 87 (Ohio Legislative Services Commission; 2021). Default overhead percentages are saved to the "System Variables" screen and can be modified for each estimate. The *Pavement Management System* module can connect with the *Daily Crew Worksheet* module, which allows cost estimates to be compared to actual costs (since the two modules use the same labor, equipment, and material databases).

The *Sign/Traffic Control Device Systems* module: This module has MUTCD codes and corresponding pictures from the 2009 MUTCD preloaded into the system. It includes a signs inventory (for "on road" and "off road" signs), sign maintenance, sign inspections, sign material usage, and labor. Reflectivity and status of all signs are easily accessible. Information on sign inventory, maintenance, and inspections can be easily exported to Excel. Users can retrieve latitude and longitude values using a GPS receiver or geo-coded photos, and the physical locations can be retrieved from the latitude and longitude values. Sign inventory can be created by taking geo-coded

photos of the signs, uploading the images, and selecting the folder to store the inventory. This module can also communicate with other GPS systems to track information on road assets. With ESRI *ArcGIS Explorer*, users can create maps and display all the relevant data for each sign. The "Sign Layer" can be saved, sent by email, or exported to ArcGIS Online. The information about each sign (maintenance activities, inspections, materials, photographs, extensive notes, and GPS data) can be viewed in the *Sign Master* file. The replacement of a sign can be recorded by adding a new sign from the "off road" sign inventory to the "Materials page" of the "on road" sign inventory, and users have the option of marking the replaced sign as "archived" once the sign number has been modified. The module with reduce the "off road" inventory and update the "Replacement Date" and "Number of Replacements" fields. Reflectivity values for signs can be recorded, and these values are shown on the "Summary Page." Inspection data can be recorded for a single sign or for a number of signs along the same road. The maintenance records in this module can also be used to track the labor costs and material used for each sign (including replacement signs). This module includes work order and priority analysis reports as well as a number of other standard reports, and it features pre-defined searches and brows capabilities.

The *Culvert-Bridge Inventory Systems* module allows users to create and maintain an inventory of culverts and bridges. Users can obtain latitude and longitude values from a GPS receiver or geo-coded photos, and the physical location of the bridge or culvert can be determined from the latitude and longitude values. Geo-coded photos of each structure can be uploaded, and the user can select a folder to store the inventory and images. To ensure that data entry remains consistent, users can select roads and townships from a pop-up list. Data fields include the following: Culvert/Bridge Number, Township, Route Number, Road Name, Log Point, Material Makeup, Headwall Spec–Left, Headwall Spec–Right, Culvert Shape, Culvert Length, Culvert Diameter, Drainage Area, Skew Spec, Runoff Index, Direction of Flow, Cover, Installation Date, Size Adequate (Y/N), Date Last Repaired/Replaced, Special Code, Date of Last Update, Estimated Cost, Road Width, Berm Width, Shoulder Width, Slope, Left Extension, Right Extension, Height From Flow Line, Headwall Condition–Inlet, Headwall Condition–Outlet, Distance-EOP, Culvert/Bridge Condition, Sufficiency Rating, Sufficiency Date, and an open-ended memo field. Users can export the inventory and inspection files to Microsoft Excel as well as view it on maps. Reports can be printed by route, road name, material, shape, installation date, subdivision, structure, size, and condition. In addition to these reports, the module allows users to enter

information and print the Ohio CR-87 form (Culvert Inventory Report), and the Ohio CR-86 form (Culvert Inspection Report). The module enables active work and previous maintenance work for culverts/bridges to be recorded, along with notes regarding the culverts/bridges or the maintenance work.

The *Guardrail Inventory Systems* module allows the user to create and maintain an inventory of guardrails. As in other modules, users can obtain latitude and longitude values to determine the physical location, and geo-coded photos of the structures and the associated data and notes are saved to a folder. The module records active and historical maintenance of all guardrails, along with miscellaneous notes regarding the guardrails. As with other modules, roads and townships can be selected from a pop-up list. Data stored in this module include Township, Route Number, Road Name, Survey Date, Beginning Log Point, Ending Log Point, Material Makeup, Post Material, Rail Type, Side of Road, Height, Offset, Post Spacing, Begin Trans. Rail, End Trans. Rail, Guardrail Condition, Custom Code, Blockout (Y/N), Beginning Log-Feet, End Log-Feet, End Treatment, and fields for comments and open-ended memo. Reports can be generated by route, material, rail type, total feet, and guardrail number.

The *Fleet Maintenance* module can be used to track completed and planned maintenance work on vehicles, and users can enter fuel use directly or import information from automated fuel systems (such as *Gasboy* or *Petro Vend*). The *Garage and Parts Inventory* module enables tracking of parts and other consumables. The *Time Management* module stores details about schedules and allows employees to report their time on time sheets. The *Ohio Accident Statistics* module enables users to download and analyze highway crash information obtained from the Ohio Department of Public Safety.

Softworks also includes modules to help agencies with their payroll and accounting tasks. The agency's budget is managed using the *Government Accounting System* module. *The Payroll Management System* module stores payroll-related information, including balances for sick time, vacation time, comp time, holiday pay, and bonuses for each employee. *The A/R-Receipt Management* module is designed to handle receivables and walk-in sales, and the *Fixed Asset Inventory* module is used to create and maintain an inventory of non-consumable items.

D.10 *MasterSuite*

MasterSuite by MasterMind Systems (Elmore, Ohio) is a suite of software that allows in-field inventorying and inspection of assets without the need for internet access in addition to desktop post-processing and customizable reports (MasterMind Systems 2021). Mastermind System also provides road data collection services, and they are qualified through ODOT to perform traffic safety studies. *MasterSuite* software includes a number of modules for different asset classes. *VideoMaster*™ software is linked to the suite and provides high-definition 360° video mapping and high-resolution photographic images to support the use of the software modules in the field. The suite also includes *LocationMaster*™ software, which is a virtual distance measuring instrument (DMI) that does not require vehicle installation (and thus can be used in place of most GPS antennas) and can be used to measure distances when in a vehicle or on foot.

SignMaster™ software is designed for creating/maintaining a sign inventory, as well as to manage, budget, and review traffic sign attributes (including GPS, milepoint, face material, support type, annual daily traffic (ADT), reflectivity strips, costs, and dates). It allows in-field inventorying and inspection (including collection of retro-reflectivity data) as well as desktop post-processing. Photographs in the field can be taken with any attached camera can be recorded in the inventory. The system updates the GPS coordinates based on the worker's current location and displays all traffics signs that are within a designated distance of the current GPS location. The software comes preloaded with a signcode dictionary for all MUTCD traffic signs (including a graphic representation and signcode), and users can add, edit, or remove unneeded dictionary items (such as sign face material, post material, reason for the work, etc.). Signs can be moved on the GIS map by dragging them to a new location, and the software will automatically update the GPS coordinates. The software has search features that enable users to easily search, map, and view traffic signs based on certain criteria, and reporting features allow users to generate reports for work and inspections.

CurveMaster™ software is designed for recording and mapping horizontal curves, recording ball bank passes, creating an inventory and storing information on curve signage for each location (such as point of curvature, point of tangent, apex, GPS location, advisory speed, acting speed, direction, and status). This software can automatically determine and propose curve signage for each location that is required to comply with the FHWA December 31, 2019 Horizontal Alignment Warning Sign Deadline. *CurveMaster*™ also enables users to analyze data on

horizontal curves and curve signage and can be used to generate a graphical report that displays the curve and details about proposed signage. This module can be used by itself or as a supplement to curve studies performed by MasterMind, LLC.

StripeMaster™ software is designed for management of centerline striping no-passing zones. No-passing zones can be viewed as graphical reports or GIS maps to facilitate T-marking and road indexing. The software allows users to manually modify the stripe-to-gap ratio according to the agency requirements and to manually change zone attributes (including route, zone type, description, field date, GPS location, beginning milepoint, and ending milepoint). The software allows the zones to be automatically corrected so that the zones can be adjusted to better meet the required zoning laws. Users can also generate a route report that shows the accumulated solid line for the route, which enables the lineal footage, paint, and bead quantities for centerline markings to be calculated, and any work in the zones can be documented for later analysis.

MarkingMaster™ is designed for mapping, monitoring, displaying, creating budgets for, and maintaining auxiliary and long line pavement markings (center lines, edge lines, etc.). Data can be recorded for attributes including route, GPS location, milepoint, material, type, condition, cost, years striped). Dictionary items such as condition rating, cost, material, type, can be added, edit, or removed from the dictionary, as needed. *MarkingMaster* supports in-field data collection and inspection as well as desktop post-processing. GPS coordinates can be adjusted, and GPS coordinates for any auxiliary markings that have been manually moved on the GIS map will be automatically updated. This software allows all inspection work and dates to be recorded, and the information and the collected inspection data can be used to generate reports for all inspections.

CulvertMaster™ is designed to create an inventory and to record and manage data for culverts (such as route, GPS location, milepoint, material, type, condition, shape, and length). *CulvertMaster* can be used in the field as well as for desktop post-processing. Users can record all inspection work and dates, and related information. It allows culverts to be searched, displayed, and mapped, and users can run reports for all culvert inspections and work. The GPS coordinates for a culvert can be adjusted, and GPS coordinates for any culverts that have been manually moved on the GIS map will be automatically updated.

RailMaster™ allows users to locate, track, view, and maintain inventory for guardrails, bridge rails, and right-of-way hazards. It can be used to record data on guardrail and bridge attributes (such as GPS location, milepoint, post material, guardrail type, assembly end, approach

rail, and block out type) or hazard attributes (GPS location, milepoint, hazard type, side of road, offset, and work type needed). Dictionary items such as guardrail type, block out size, guardrail end assemblies, or other items can be added, modified, or removed from the dictionary. *RailMaster* can be used to collect data in the field as well as for desktop post-processing of information. It allows users to display information, perform searches, and to map guardrails, bridges, and hazards. It enables GPS coordinates to be adjusted in the field with no need to leave the vehicle, and it updates the GPS coordinates for hazards that have been moved on the GIS map.

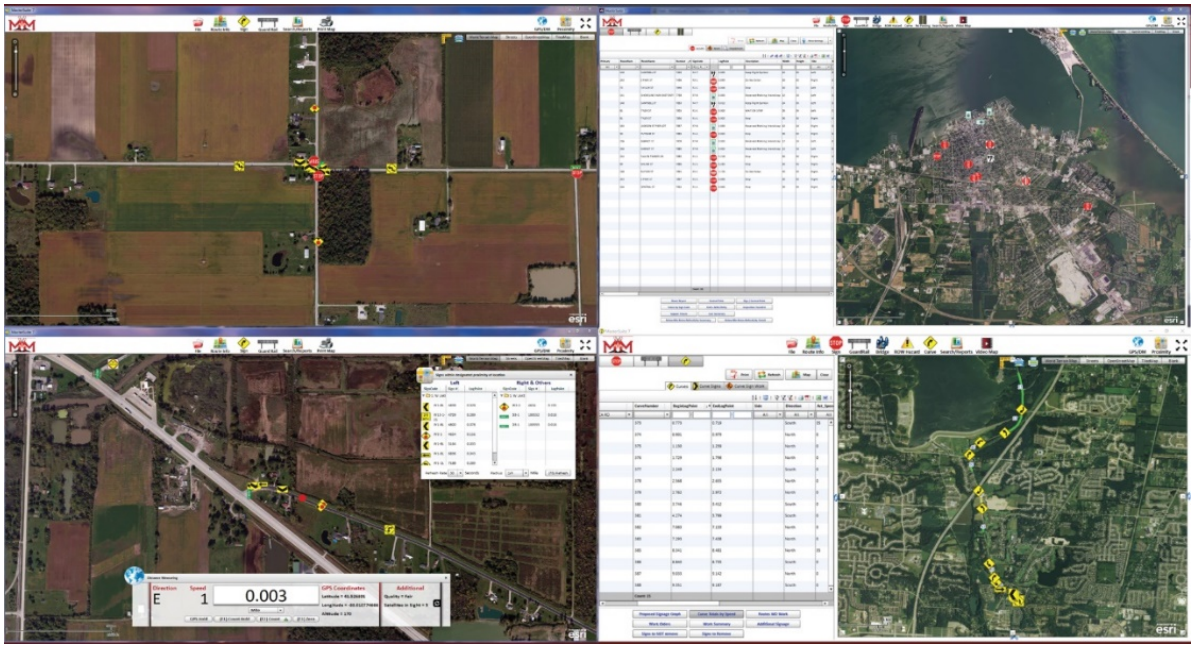


Figure D.22. Various screenshots from *MasterSuite.* Image from MasterMind Systems.

D.11 *AgileAssets*

Agile Assets Inc., based in Austin Texas, is specialized in the development of infrastructure asset management software for government and private organizations (Agile Assets 2021). The company produces a full suite of software products that are available by subscription. These software products fall into three broad areas: planning and analysis modules, a maintenance module, and mobile applications.

Portfolio Analyst™ is the first of Agile Assets' six planning and analysis modules. Using the data on the assets stored in the system, *Portfolio Analyst*™ allows the user to analyze multiple scenarios across multiple time frames, which aids in determining the best strategies for allocating transportation budgets over the short term and long term. This module generates graphs and charts that show the impacts of different options. A screenshot of this module is shown in Figure D.23.

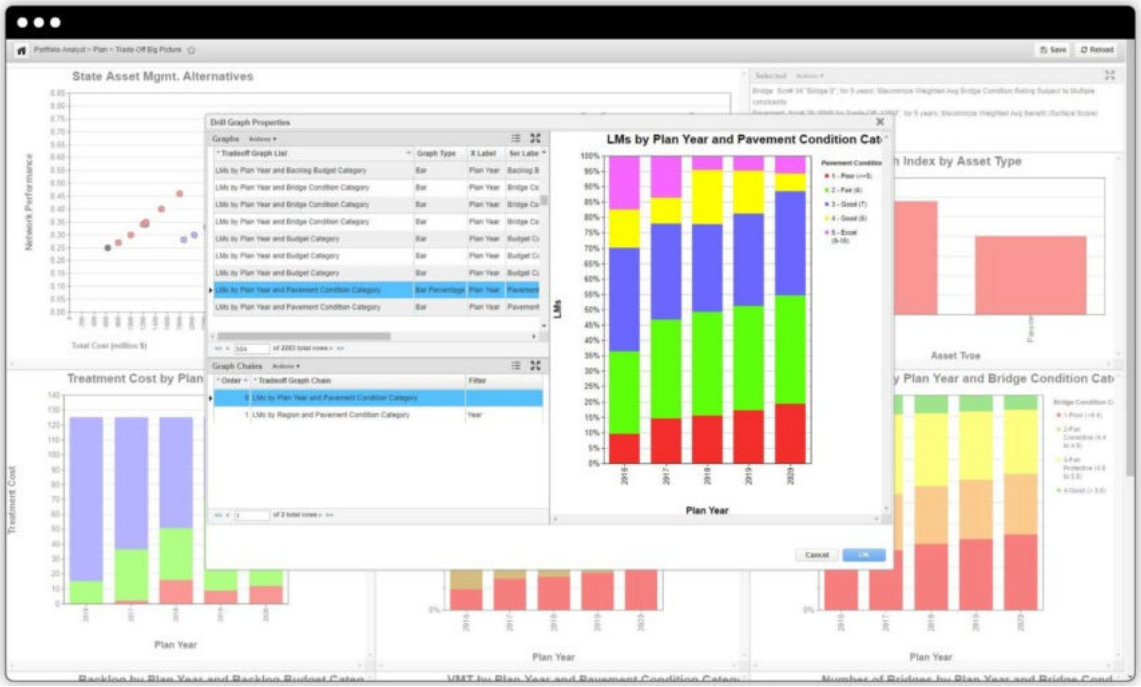


Figure D.23. AgileAssets' planning/analysis modules: *Portfolio Analyst*™. Image from AgileAssets.

Summit™ is as data visualization module that allows users to translate large, complex data sets and metrics into visual form (by generating charts, graphs, maps, tables, and other visual devices) to enable them to see trends and patterns in the data, identify statistical outliers, and gain

new insights about the data and metrics without having to enlist the aid of a data scientist. It also allows the user to import and analyze data from any source and to cross-reference the data imported from different departments or sources. This module also supports the calculation of investments or performance measures and can thus support options for decisions involving different scenarios. In addition, *Summit*™ facilitates sharing by allowing access to be given to people outside and inside the department to examine and analyze the data. The information in this module is encrypted and uses enterprise-grade security to keep the information secure. A screenshot of the *Summit*™ module is shown in Figure D.24.

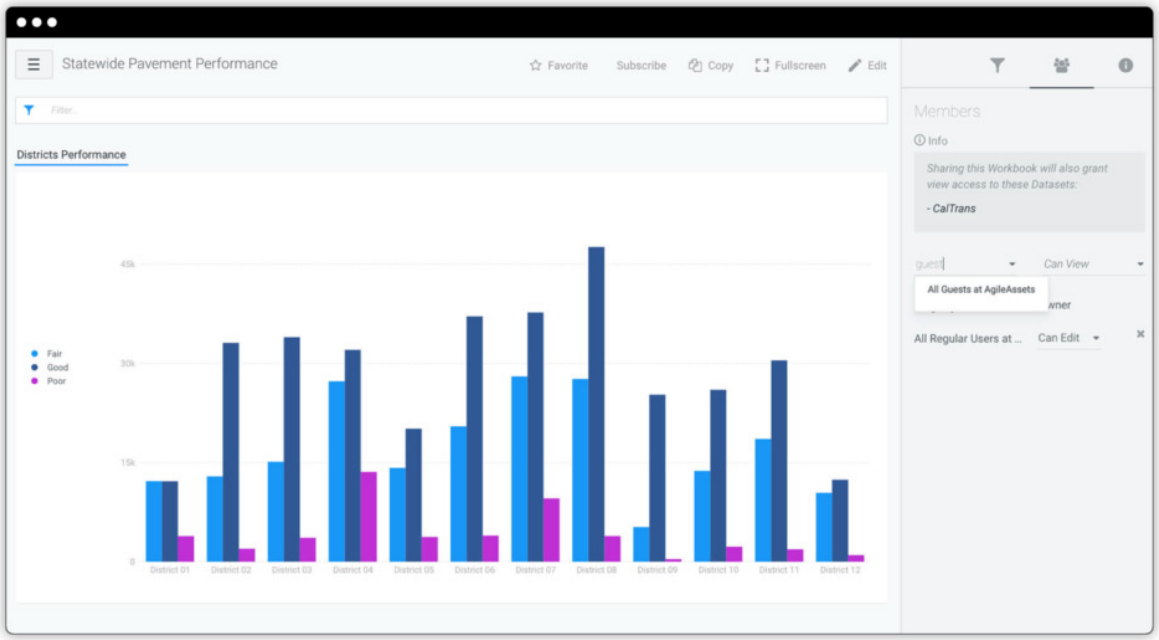


Figure D.24. AgileAssets' planning/analysis modules: *Summit*™. Image from AgileAssets.

Pavement Analyst™ is an advanced pavement management system designed for use by state and national transportation agencies. It enables transportation managers to consider different scenarios for achieving a performance target or for allocating funds for different preservation strategies, and it enables users to evaluate and develop the best performance models to use based on the available pavement condition data. This module also facilitates the optimization of work plans that use predictive models to determine when to apply preventive maintenance to keep pavement structures in good repair. This module also supports the creation of reports. Figure D.25 presents two screenshots from this module.

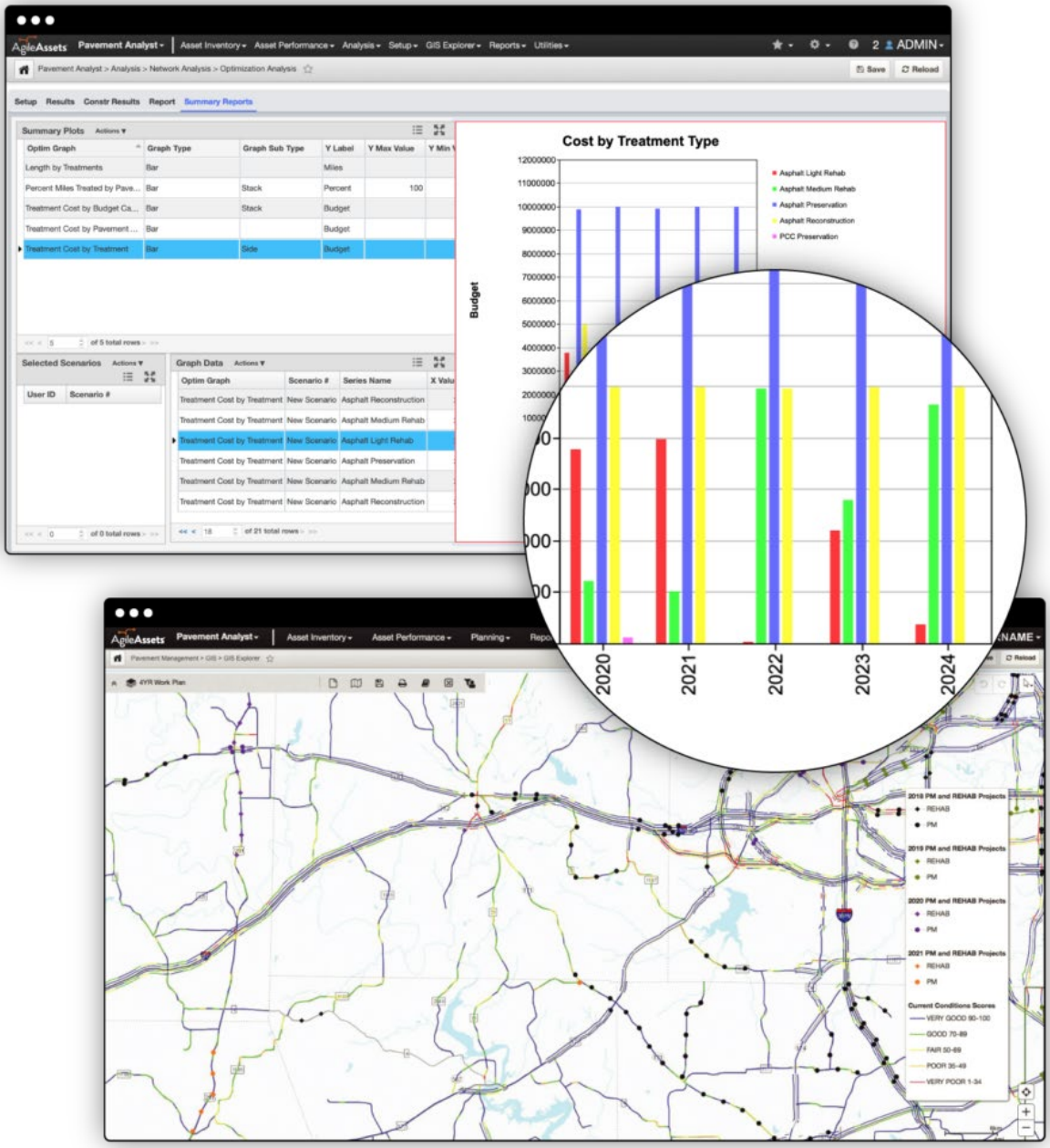


Figure D.25. AgileAssets' planning/analysis modules: *Pavement Analyst*™. Image from AgileAssets.

Pavement Express™ is a streamlined, turnkey pavement management system that is tailored for use by LPAs. Users of this module can present and share interactive dashboards/reports that reveal the rationale behind strategic decisions and show the impact of different scenarios, which facilitates the selection of the optimal mix of pavement projects that will achieve the

agency's objectives in terms of funding, pavement performance, or other factors. The attributes and performance of the pavement network can be displayed on embedded GIS maps in order to provide geolocation and enable spatial analysis. A screenshot from *Pavement Express*™ is provided in Figure D.26.

Figure D.26. AgileAssets' planning/analysis modules: *Pavement Express*™. Image from AgileAssets.

Structures Analyst™ is a planning/analysis module for multiple types of structural assets, including bridges, culverts, overhead signs, retaining walls, and other structures. It uses multi-year, multi-constraint predictive analysis to produce optimized work plans. The outcome of the analysis for various treatment options is displayed, along with information about the best time to apply the treatments to preserve elements, components, and the parent structure. The module supports element-level analysis, allowing the user to evaluate condition data, deterioration models, treatments, and treatment improvement models for both National Bridge Inventory components and National Bridge Elements, which enables more detailed predictions regarding condition deterioration to be obtained, which supports better planning of bridge work. This module also generates interactive reports that display the performance of the structures in the agency's network

in comparison to various performance measures. A screenshot showing element probability models in *Structures Analyst*™ is shown in Figure D.27.

Figure D.27. AgileAssets' planning/analysis modules: *Structures Analyst*™. Image from AgileAssets.

Safety Analyst™ is a transportation planning and analysis module designed to help agencies improve roadway safety through the use of advanced analytics. It allows users to easily calculate and manage various performance measures for Highway Safety Improvement Program (HSIP) reporting as well as to meet the requirements of data and analysis guidelines under the Model Inventory of Roadway Elements (MIRE) and the Model Minimum Uniform Crash Criteria (MMUCC). It supports transportation asset management plans required by FHWA and facilitates the development of safety programs that comply with the AASHTO Highway Safety Manual, MAP-21, the FAST Act, HSIP Final Rules, MIRE, and MMUCC. However, this module can be configured to meet agency-specific requirements as well. Users can generate reactive and proactive models for locations with high numbers of crashes, screen the results by using a sliding window and peak searching methods, and view breakdowns of responsible factors or contributing factors for various hotspot locations. The module includes GIS/linear reference system (LRS) integration to enable users to conduct location-aware screening as well as to map and analyze hotspots. Using

this module, transportation agencies can evaluate and identify candidate safety projects based on their predicted impact and can then select the treatments that can maximize the level of service and can help to resolve safety issues. In addition to its analysis features, this module also can be used to generate reports. Screenshots from *Safety Analyst*™ are shown in Figure D.28.

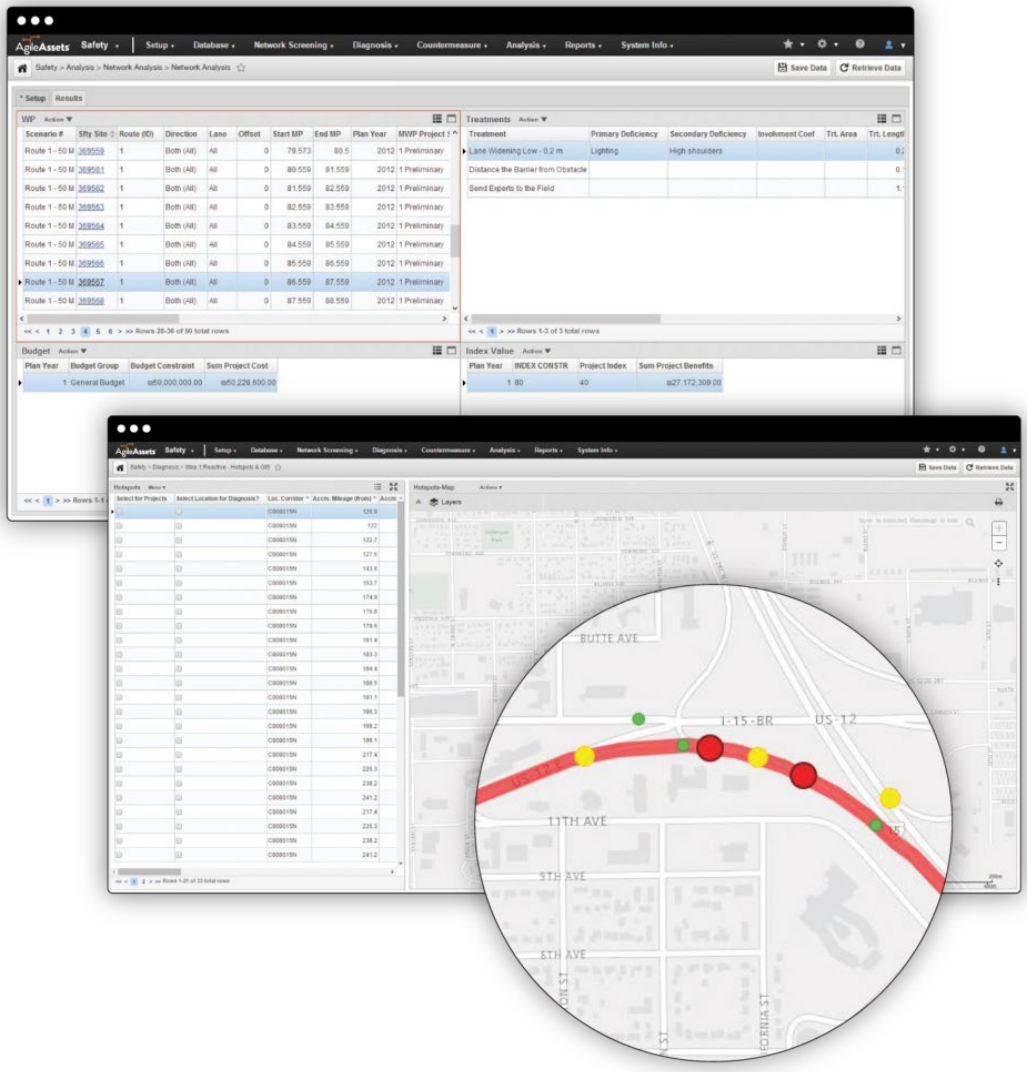


Figure D.28. AgileAssets' planning/analysis modules: *Safety Analyst*™. Image from AgileAssets.

Maintenance Manager™, the first of AgileAssets' maintenance operations modules, integrates planning, scheduling, work recording, and reporting. It has comprehensive GIS functionality, which allows users to display any asset, location of an event (repairs, rehabilitation,

inspections, accidents, storm damage, etc.), work history for the asset, and current work orders on a map. Users can efficiently combine projects, produce work plans, and determine the required costs to reach the agency's target levels of service. By using this module, transportation managers are able to estimate the agency's maintenance needs and optimize the allocation of available budgets based on jurisdiction, functional class, and maintenance service level.

Figure D.29. AgileAssets' operations module: *Maintenance Manager*™. Image from AgileAssets.

Structures Inspector™ is an operations module that allows users to record information on inventories, inspections, and conditions for assets such as bridges, culverts, overhead signs, retaining walls, and other secondary structures. The locations of assets can be displayed based on their status, condition, or other characteristics, enabling users to examine nearby features that might have an impact on the condition of the structure or how the inspections of the structures are managed. This module can automate the scheduling of inspections according to the anticipated inspection cycle and the date of the most recent inspection, and it allows users to assemble and modify inspection teams and assign candidate structures to teams based on specific structural units, regions, or areas. Once this is accomplished, the module will give the team members access to the data on their assigned structures and will enable them to record the inspection information (either at the office using this module or in the field, using the *Structures Inspector*™ mobile application). This module supports element-level and sub-element-level inspection requirements (including AASHTO standards) and meets regulatory compliance requirements (such as those for annual FHWA reporting). When integrated with *Structures Analyst*™ and *Maintenance Manager*™, it can be used to schedule maintenance based on urgent needs or future plans. Transportation managers can also generate "watch lists" according to documented susceptibilities, identify and track structures that have been deemed to be deficient, and manage inspections after events. Screen captures of this module are shown in Figure D.30.

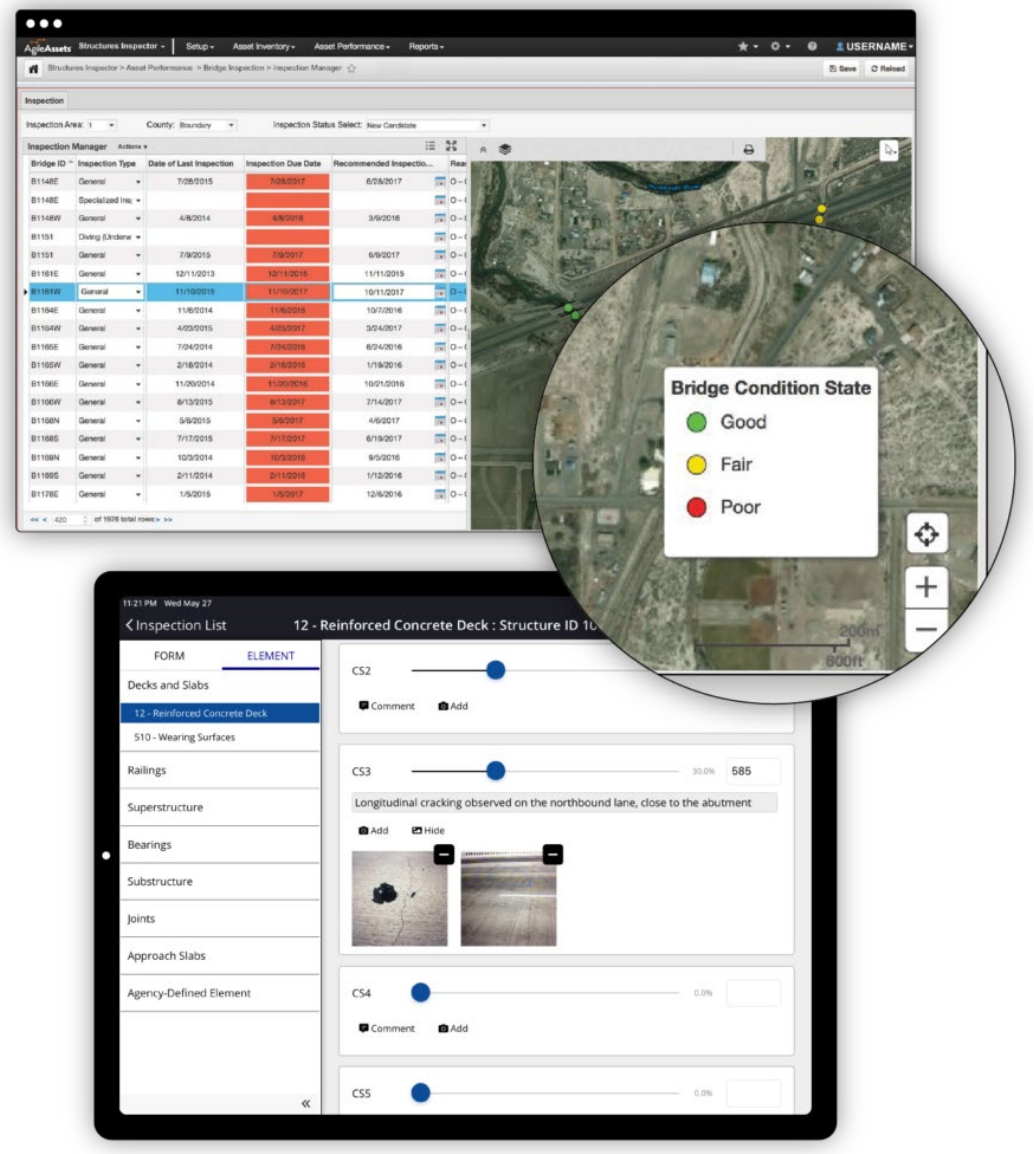


Figure D.30. AgileAssets' operations module: *Structures Inspector*™. Image from AgileAssets.

Fleet & Equipment Manager™ is an operations module that maintains an inventory of vehicles and equipment and facilitates management of these assets. It enables agencies to keep detailed records of vehicle use, monitor the inventory of parts and their use to make certain that sufficient supplies are kept on-hand, and automatically adjust the workflow based on internal rules. Data on labor, parts, and related costs can be collected and analyzed for budgetary purposes. The module allows fuel use to be entered manually, and users have access to various fuel management systems. The asset inventory can be searched to identify vehicles and other equipment and to access information about them. Equipment of a particular class code can be entered into the system,

and the module can auto-fill relevant fields in the inventory. Vehicles or equipment can be transferred to a different department or leased out, and the module will calculate the rental rate based on operations and maintenance costs. The module also features an online reservation system to allow users to request a vehicle, and the vehicle can be easily assigned and dispatched. The module facilitates maintenance and repairs to vehicles and equipment by providing tools for scheduling preventive maintenance, creating repair orders, and managing warranties. Analysis and reporting tools display utilization percentages for the previous month and year, flag equipment that is due for replacement, and track orders for replacement equipment. Users can create and make modifications to ready-to-use reports to gain a better understanding of vehicle and equipment maintenance and repairs, labor hours, parts and materials, utilization, and fuel use to make better decisions about preventive maintenance, repairs, and purchases and to circulate the information to decision-makers. This module can be accessed in the field using the *Fleet Maintenance Manager*™ mobile application. A screenshot of *Fleet & Equipment Manager*™ is presented in Figure D.31.

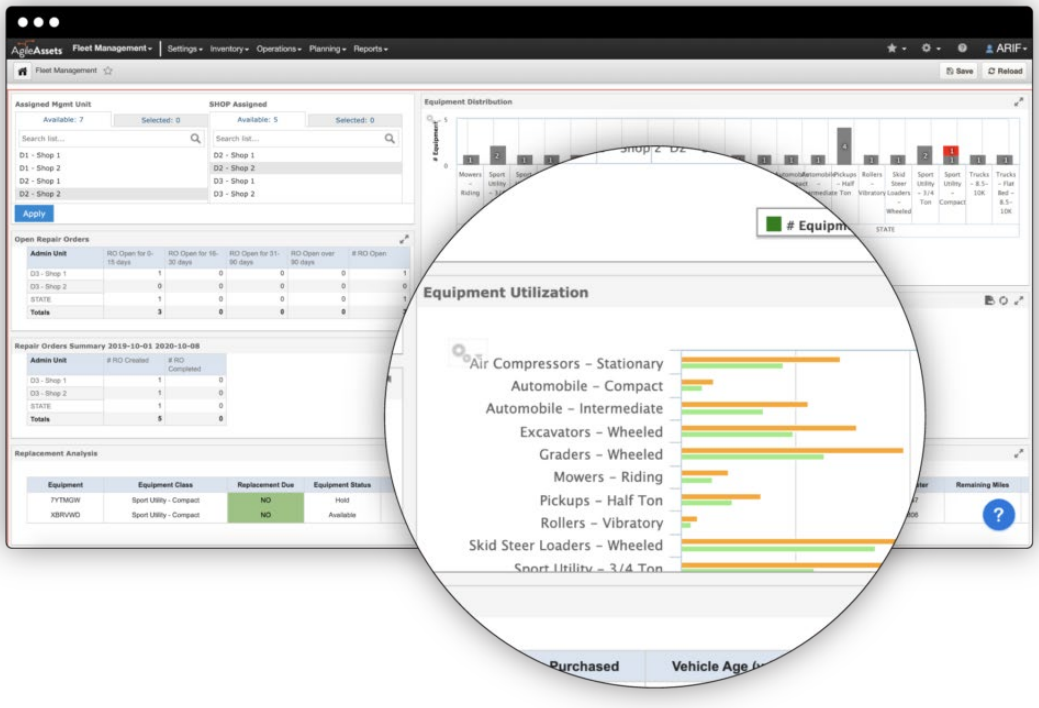


Figure D.31. AgileAssets' operations module: *Fleet & Equipment Manager*™. Image from AgileAssets.

Sign Manager™ module is used to create a sign inventory and collect data on the location, condition, and maintenance history of the signs as well as to search and display sign information in GIS/LRS format and conduct analyses of the sign data to support decision making. Users can define hierarchies for signs, and preventive maintenance can be delineated by the type of sign. The module also streamlines maintenance work, allowing users to create work orders, translate annual plans or problem reports into work orders, assign crews and schedule work, and to record information on labor hours, equipment, and material usage.

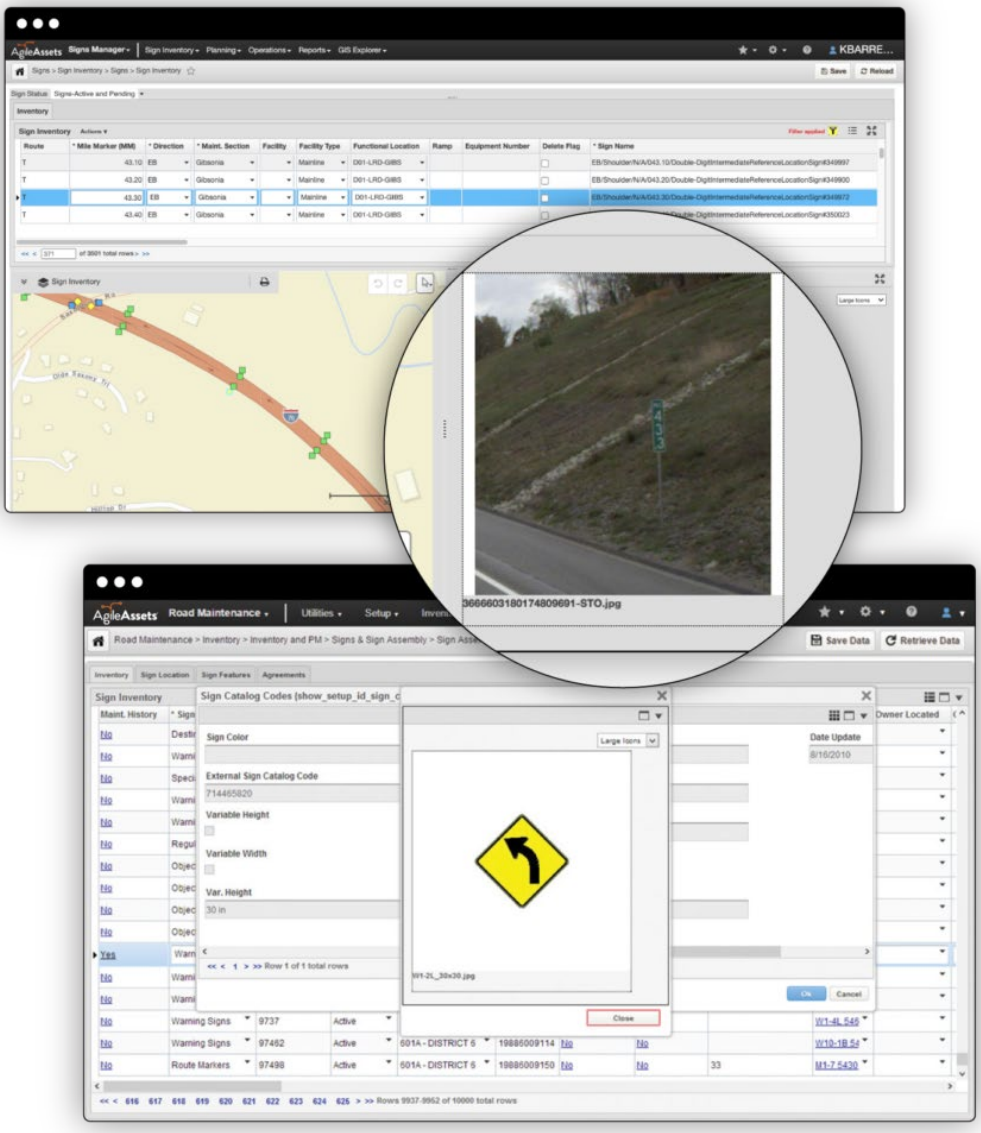


Figure D.32. AgileAssets' operations module: *Sign Manager*™. Image from AgileAssets.

The *Signal and ITS Manager*™ module is designed to maintain an inventory of signals and intelligent transportation system (ITS) assets, to store condition information, and to provide a history analysis of these assets. It permits users to define hierarchies of signal assets, which can facilitate maintenance and inspections and can also allow assets in different classes to be analyzed separately. GIS/LRS search and visualization features allow users to display signal and ITS assets according to condition, physical location, or work activity. The maintenance process for each type of asset can be customized, and workflow can be configured to create work requests as well as to generate work orders from annual plans or reports of problems. This module also supports the scheduling of work orders and can be used to record labor hours, equipment use, and material use.

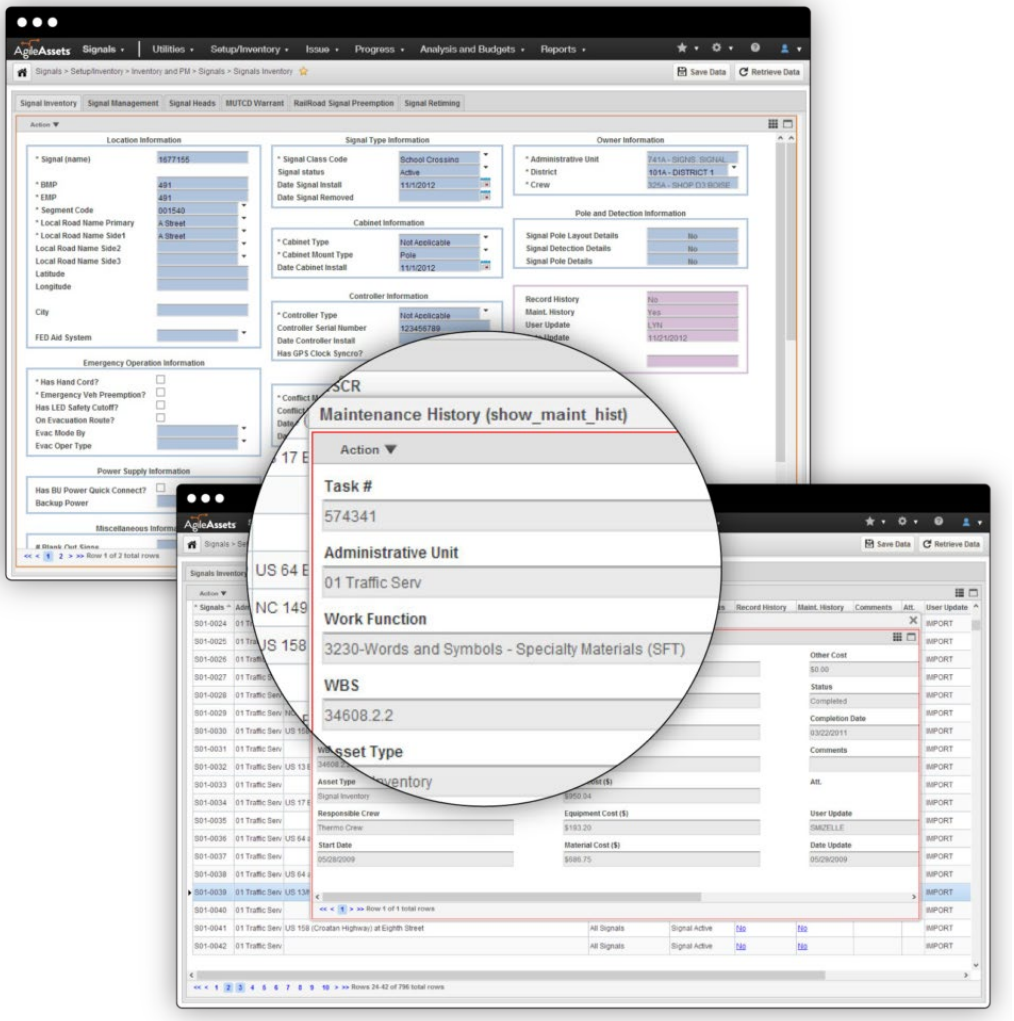


Figure D.33. AgileAssets' operations module: *Signal and ITS Manager*™. Image from AgileAssets.

With the *Facilities Manager*™ operations module, agencies can define hierarchies for assets at their sites and facilities, use GIS maps to show the location of assets, and indicate custom preventive maintenance actions for each type of asset or for particular items in the inventory. The module enables the user to break down annual plans and workflow into work orders and to schedule the work. It allows work orders to be prioritized and specific crews or workers to be assigned to work orders. Once the work is completed, the labor hours, equipment use, and materials can be recorded in the system, and the work outcomes can be compared to efficiency standards. Screenshots from *Facilities Manager*™ are presented in Figure D.34.

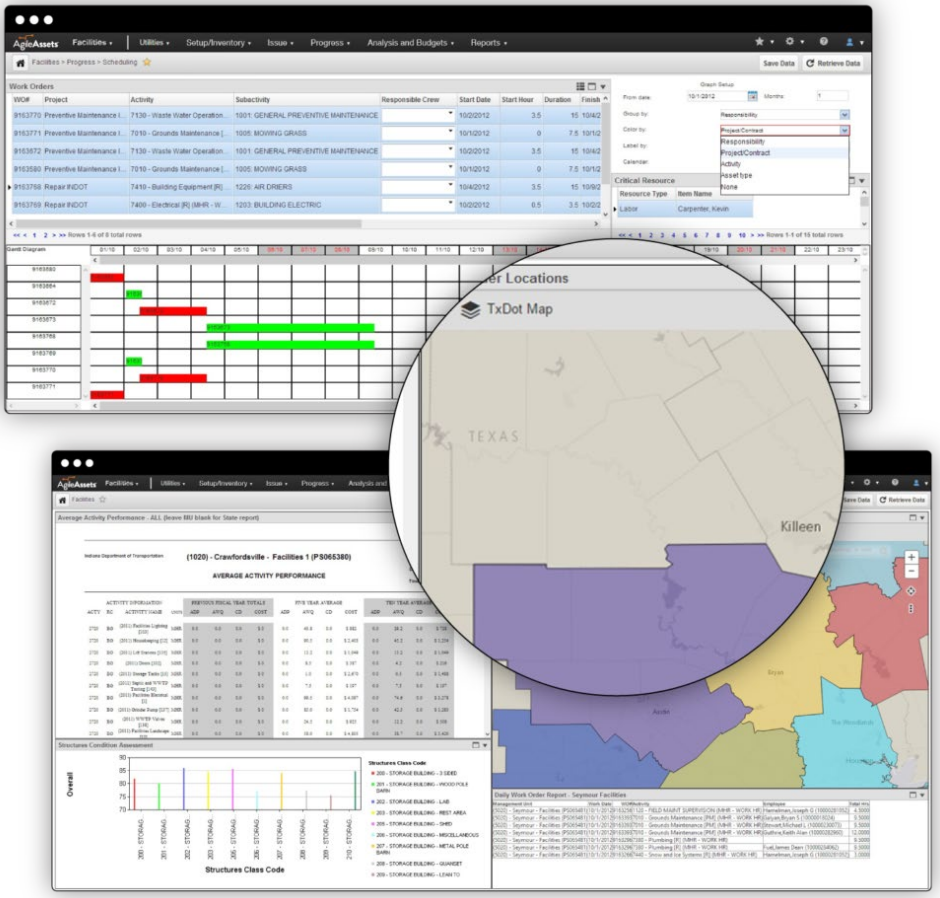


Figure D.34. AgileAssets' operations module: *Facilities Manager*™. Image from AgileAssets.

AgileAssets offers four offline-capable mobile applications for field work: *Work Manager*™, *Structures Inspector*™, *Fleet Maintenance Manager*™, and *Materials Manager*™. The first of these is *Work Manager*™, an app for managing field work that is a companion mobile

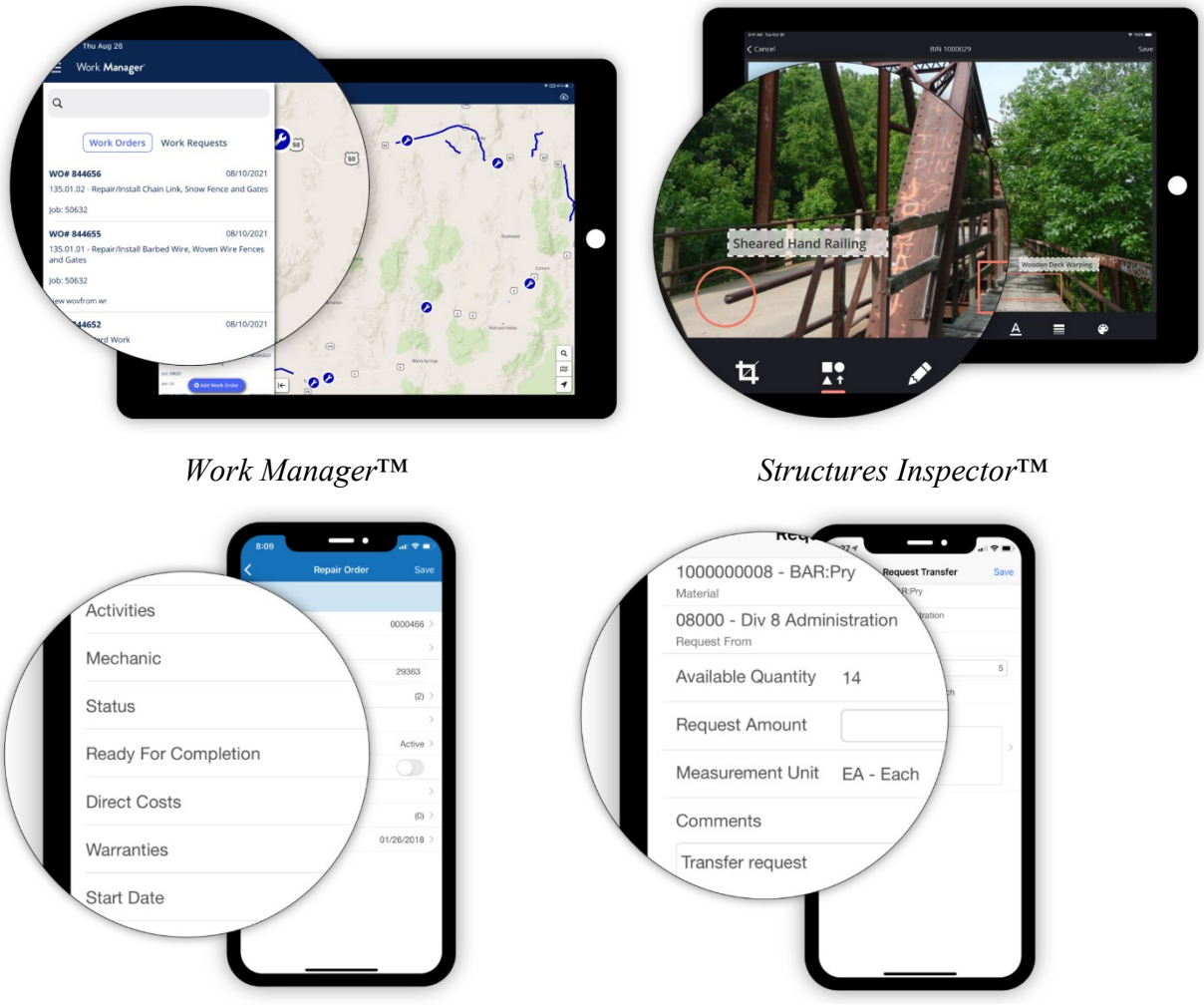
application to *Maintenance Manager*™, *Sign Manager*™, *Signal and ITS Manager*™, and *Facilities Manager*™ web applications. *Work Manager*™ features a user-friendly map interface that makes it easy for workers in the field to locate assets and work sites, and it allows work on signs, signals, and ITS maintenance to be recorded using the same application. Users can create and modify work orders, record activities, track costs, and document accomplishments while in the field. The module allows new assets to be created in the field as well enables information on existing assets to be edited in the field using the user-friendly map interface to save time. For inspections of assets in the field, the inspectors can easily create, edit, flag, and start simple inspections from a location pin on the map. This app supports the collection of data in the field using data collection forms that are defined by the user to ensure that data is collected in accordance with agency guidelines. This app also supports the creation and editing of day cards and can be used to record which workers are assigned to operate specific equipment. This app supports Microsoft *Windows*®, Apple iOS®, and Android™ operating systems for tablets and smartphones.

Structures Inspector™ is a comprehensive app for managing structures. It allows transportation agencies to capture and assess information on current and past inspections, asset inventories, and condition ratings for bridges, culverts, overhead signs, retaining walls, and other secondary structures. Asset managers can view the locations of these assets and run queries based on current status, condition, or other attributes to look for factors close to the asset that might impact the condition of the structure or the inspection process. The module can automatically schedule inspections of candidate structures/assets based on the agency's inspection cycle and the date of the last inspection, create teams to conduct the inspection and assign specific structures to team members so that all members of the same team can access information on their assigned structures and start the inspections. *Structures Inspector*™ can be integrated with *Structures Analyst*™ and *Maintenance Manager*™ to prioritize inspections of structures based on either immediate needs or long-term plans. This mobile app can help to improve productivity, as inspection information can be easily recorded in the field and transferred directly to the CMMS (if accessible) or uploaded to the CMMS upon return to the office. This app supports Apple iOS®, and Android™ operating systems for tablets and smartphones.

Fleet Maintenance Manager™, the companion mobile application to the AgileAssets® *Fleet & Equipment Manager*™ web application, allows users to access and record information on

vehicles while working in the field. Users can search the asset inventory by vehicle VIN, name, license plate, or barcode to quickly identify a vehicle in the fleet, access maintenance histories and warranty information for a vehicle, or enter additional information (such as data on labor, materials, and equipment). The app also enables users to add vehicle repair orders to the system and make modifications to non-approved repair orders. The app can be used on Microsoft® Windows, Apple® iOS, and Android™ OS tablets and smartphones.

Materials Manager™, which is the companion mobile application to the AgileAssets® *Maintenance Manager*™ web application, is designed to streamline materials management processes and workflows. This app can be used to scan bar codes to identify assets in the materials inventory, examine inventories and available materials, record the latest quantities on hand, document transfers and purchases of materials, perform reconciliations of inventory, and record costs. The *Materials Manager*™ app is compatible with Apple® iOS devices. Screenshots of the four mobile applications are shown in Figure D.35.



Work Manager™ *Structures Inspector*™

Fleet Maintenance Manager™ *Materials Manager*™

Figure D.35. AgileAssets' four mobile applications. Images from Agile Assets.

D.12 *SAM IS*®

The *Smart Asset Management and Inventory System* (*SAM IS*) platform, developed by Vanasse Hangen Brustlin, Inc. (VHB; 2021) in Watertown, Massachusetts, is a cloud-hosted system that helps agencies to inventory, inspect, maintain, and manage their physical assets using their existing GIS data by exploiting Esri's *ArcGIS Online* platform to enable the agencies to incorporate new information into existing databases, devise new features, and cross-reference information in other layers to produce better spatial data. Because data is securely transferred and stored in the cloud, *SAM IS*® frees up storage space on the agency's local server. It provides users with online access to their data as well as the tools needed to analyze the data. Information is displayed on dynamic dashboards, and users can easily export their maps and pavement plans into existing formats, online maps, or custom reports. Available modules for this platform include *Pavement*, *Sidewalks*, *Stormwater*, *Culverts & Bridges*, *Environmental Compliance*, *Signs*, and *Buildings*.

The *Pavement* module enables users in the field to collect information about condition surveys as well as progress made on repair work. This information is connected to the appropriate segment of pavement and can be used to produce a summary of activity for that segment. Data on a pavement segment can be easily reviewed while the segment is displayed on a map interface. Information and data on pavement condition can be presented via maps, dashboards, and customizable reports, which enable the user to present recommendations based on available data as well as demonstrate a need for funding the recommended actions and indicate the impact of the investment. A screenshot from the *SAM IS*® *Pavement* module is presented in Figure D.36.

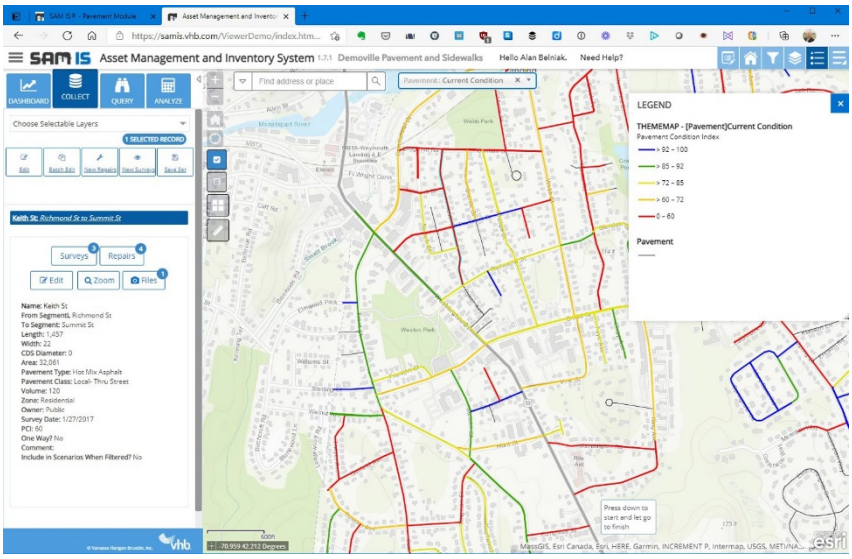


Figure D.36. *SAM IS® Pavement* module. Image from VHB.

The *Sidewalk* module is used to collect information on sidewalk features, curb characteristics, point data for ramps, and other information on sidewalks using the module's mobile application. The module allows agencies to assign and oversee repair work and record completed improvement activities to ensure compliance with the Americans with Disabilities Act (ADA) and create a work history. It also enables sidewalk data to be viewed on a map and to be shared and presented to justify funding for recommended improvements to pedestrian lanes. A screenshot of the *Sidewalks* module is presented in Figure D.37.

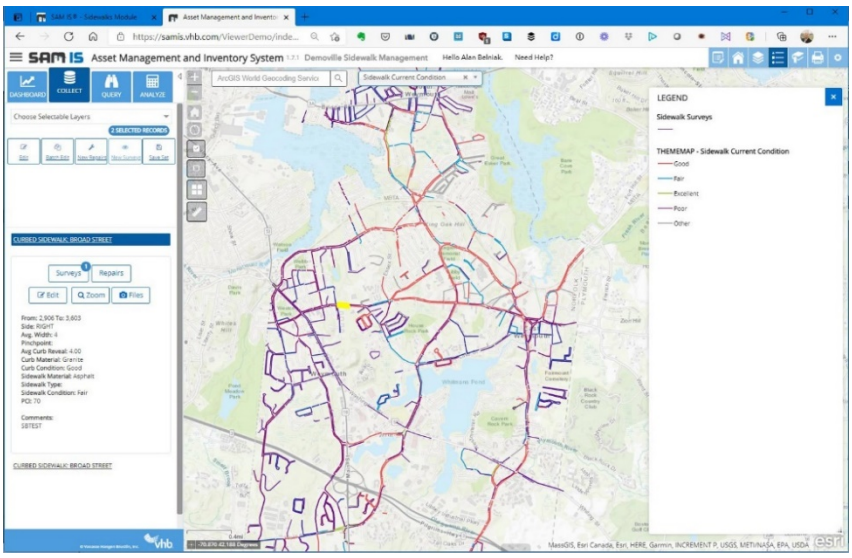


Figure D.37. *SAM IS® Sidewalks* module. Image from VHB.

The *Stormwater* module is used to collect data on stormwater systems, including outfalls, catch basins, manholes, pipes, subsurface structural best management practices (BMPs), surface BMPs, channels (such as swales or ditches), and culverts. It includes tools for collecting field data for inspections and maintenance work, allowing users to screen outfalls and delineate catchments. Data is displayed on a map-based interface that allows users to view different environmental layers (such as total daily maximum load watersheds, impaired waters and their pollutants, floodplains, and outstanding resource waters). Users can update a calendar of events and store documents such as stormwater management plans (SWMPs), documents prepared for outreach and educational purposes, and annual reports. The data can also be exported for use in annual reports, notices of intent, and SWMPs. A screen capture from the *Stormwater* module is presented in Figure D.38.

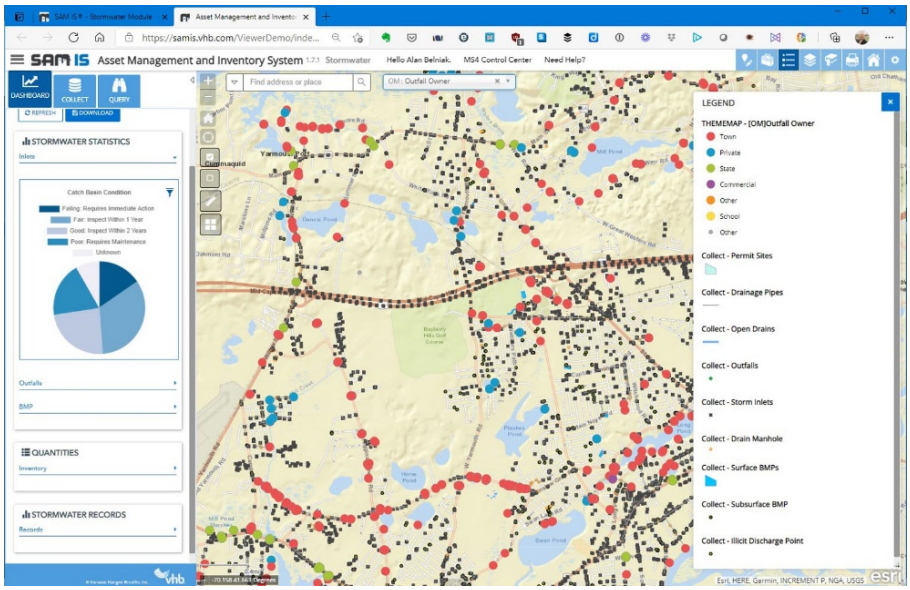


Figure D.38. *SAM IS*® *Stormwater* module. Image from VHB.

The *Culverts and Bridges* module provides current and historical information on maintenance work, inspections, repair work, or replacement of the bridges and culverts in an agency's inventories. The module incorporates dashboards and themed maps of the overall network, and current data and future needs can be communicated by using various template reports and graphs. A screenshot from the *Culverts and Bridges* module is provided in Figure D.39.

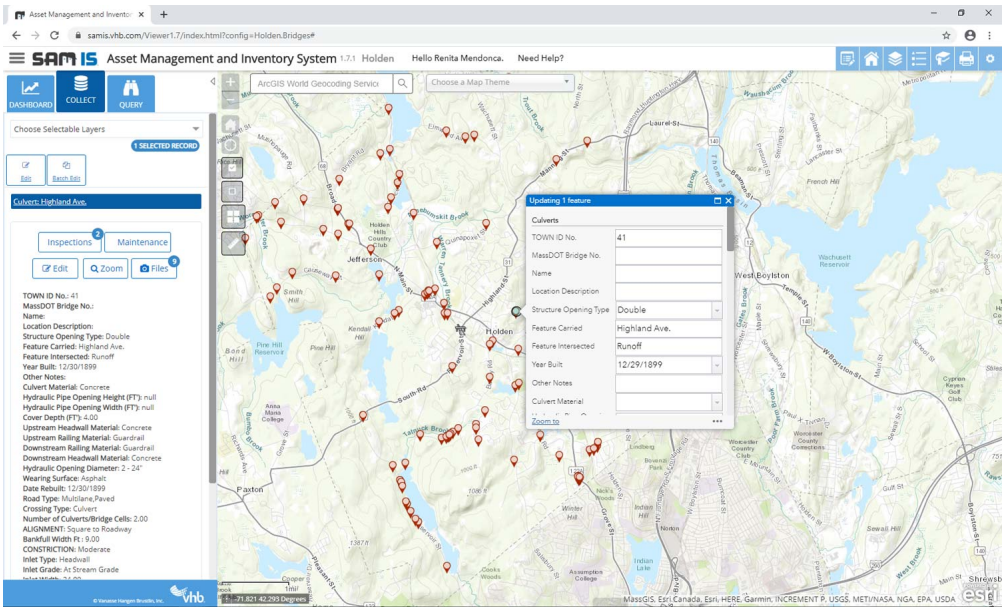


Figure D.39. *SAM IS® Culverts and Bridges* module. Image from VHB.

The *Environmental Compliance* module includes tools and guidelines on how to operate and manage inspection and monitoring programs at multiple facility locations that can be accessed on mobile devices such (phones and tablets) and deployed in the field for physical inspections. Agencies can use the module to search for conditions at their facilities that are not compliant with activity and use limitations (AULs) and examine site-specific AUL conditions. After inspections are complete, the module gathers the information into an "AUL Site Inspection Summary Report" that includes an extensive summary of the current conditions at a facility and summarizes AUL restrictions and any current obligations. Users can also generate different surveys and tasks that can help inspectors to decide if the requirements of an AUL have been met or if additional maintenance work is needed. A screenshot from the *Environmental Compliance* module is shown in Figure D.40.

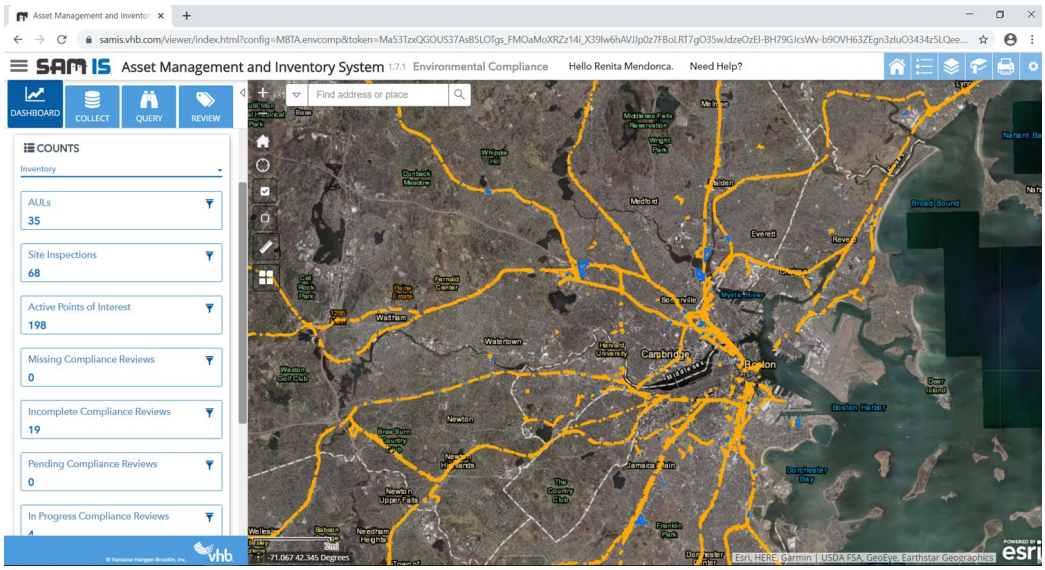


Figure D.40. *SAM IS® Environmental Compliance* module. Image from VHB.

The *SAM IS® Signs* module helps agencies collect asset data and condition data for all types of sign poles and faces – for roadside signs, overhead signs, or signs that share poles or mounts – including data related to the MUTCD. Information on signs and poles can also include photographs, diagrams, and documents (such as permits). The module supports data collection for standard MUTCD signs as well as for non-standard signs posted in the agency's jurisdiction and supports the collection and analysis of sign retroreflectivity for planning purposes. With the *Signs* module, an agency can conduct an analysis to determine if its signs meet compliance criteria. The analysis can also help the agency to understand the costs to replace signs and poles, maintain a sufficient inventory of signs and poles, verify the location of current signage, and support the formulation plans to increase safety and wayfinding in their jurisdictions by establishing priorities according to sign type and/or safety effect. *The SAM IS®* platform uses Esri's ArcGIS Online and can use the agency's existing GIS data, and the module allows users to overlay the data with other layers to view planned projects and conduct an analysis to assess the need for signage in a given area. A screenshot from the *Signs* module is shown in Figure D.50.

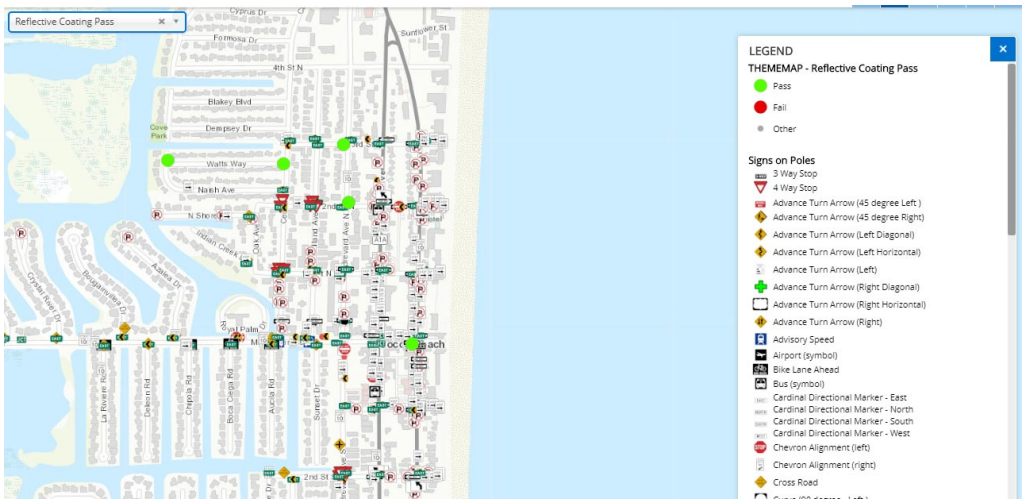


Figure D.50. *SAM IS® Signs* module. Image from VHB.

The *SAM IS® Buildings* module allows design documents, plans, photos, work orders, plats, and other information for a building to be uploaded. Users with access to the building history can use the search function to find information on the contractor, cost, and date of work. The *Buildings* module provides a single data source that provides information on all of an agency's buildings, allowing the buildings to be managed by managers from multiple locations rather than having the information for each building only available at the building site. Having comprehensive information on buildings enables managers to determine the maintenance needs for each building, which can help the manager to schedule maintenance work. Once work has been completed, the work can be recorded. In addition, analytical results from this module can be used support the budget planning process. Building data and decisions can be visualized as a table or as a map, and reports or maps can be printed or exported to share the results with others. A screenshot from the *Buildings* module is presented in Figure D.51.

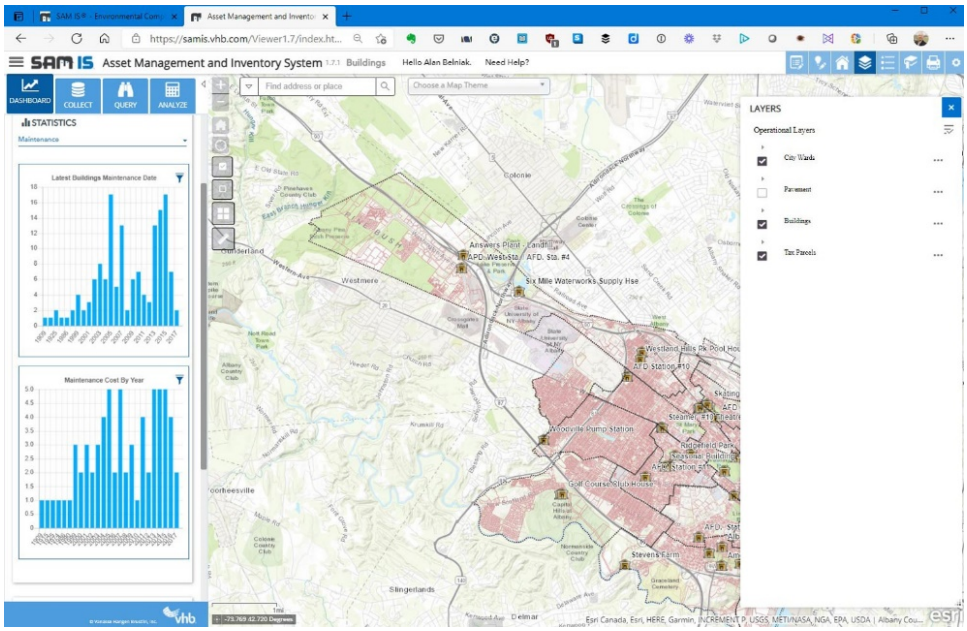


Figure D.51. *SAM IS® Buildings* module. Image from VHB.

D.13 Tutorial Videos and Documentation

Table D.1 includes links to tutorial videos and documentation for the various systems and modules mentioned in this appendix.

Table D.1. Links to Web Pages and Tutorials for Asset Management Software.

System	Module/App	Web page	Tutorials/Demos
ArcGIS (Esri)	*ArcGIS Pro*	https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview	https://learn.arcgis.com/en/paths/try-arcgis-pro/ https://www.youtube.com/watch?v=ivumvfx86O0
	ArcGIS Explorer application	https://www.esri.com/en-us/arcgis/products/arcgis-explorer/overview https://doc.arcgis.com/en/explorer/iphone/help/get-started.htm	https://www.youtube.com/watch?v=cJ0MW8l8-RA https://www.youtube.com/watch?v=tafPbsi3lbQ
	ROW Asset Inventory	https://solutions.arcgis.com/local-government/public-works/inventory-assets/	--
	Street Intersection Inventory	https://solutions.arcgis.com/local-government/help/street-intersection-inventory/	--
	Sign Inventory	https://solutions.arcgis.com/local-government/help/sign-inventory/	--
	Signal Inventory	https://solutions.arcgis.com/local-government/help/signal-inventory/	--
	Pavement Markings Inventory	https://solutions.arcgis.com/local-government/help/pavement-marking-inventory/	--
	Bridge Inventory	https://solutions.arcgis.com/local-government/help/bridge-inventory/	--
	Guardrail Inventory	https://solutions.arcgis.com/local-government/help/guardrail-inventory/	--
	Streetlight Inventory	https://solutions.arcgis.com/local-government/help/streetlight-inventory/	--
	Traffic Calming Inventory	https://solutions.arcgis.com/local-government/help/traffic-calming-inventory/	--
	Sidewalk Inventory	https://solutions.arcgis.com/local-government/help/sidewalk-inventory/	--
	Street Furniture Inventory	https://solutions.arcgis.com/local-government/help/street-furniture-inventory/	--

	Street Tree Inventory	https://solutions.arcgis.com/local-government/help/street-tree-inventory/	--
	Railroad Crossings Inventory	https://solutions.arcgis.com/local-government/help/railroad-crossing-inventory/	--
	Cycling Infrastructure Inventory	https://solutions.arcgis.com/state-government/help/cycling-infrastructure-inventory/	--
	ArcGIS Collector mobile application	https://www.esri.com/en-us/arcgis/products/arcgis-collector/overview	https://learn.arcgis.com/en/paths/try-collector/
	ArcGIS Field Maps mobile application	https://www.esri.com/en-us/arcgis/products/arcgis-field-maps/overview	https://learn.arcgis.com/en/paths/field-mobility/
PAVER (Colorado State University)	*PAVER™ 7* Single Install and Network Version	http://www.paver.colostate.edu/	--
	PAVER FieldInspector™	http://www.paver.colostate.edu/software.php	--
AssetWise (ODOT/ Bentley Systems)	*AssetWise Asset Reliability Inspections CONNECT Edition*	https://www.transportation.ohio.gov/wps/portal/gov/odot/working/data-tools/resources/assetwise-inspection-system	https://www.youtube.com/watch?v=AyU_5avjfUo https://www.youtube.com/playlist?list=PLxpoBQq_MZGs-13F_DJfThQo3bLHd9ldo
Asset Essentials (Dude Solutions)	*Asset Essentials*	https://www.dudesolutions.com/products/asset-essentials	https://help.dudesolutions.com/Content/Documentation/Maintenance/Asset%20Essentials%20Gov/Asset_Essentials_Video_Learning_Path.htm
CityWorks AMS (CityWorks)	*CityWorks AMS*	https://www.cityworks.com/solutions/asset-management/	https://www.youtube.com/watch?v=6CrIesbUbf4 https://www.youtube.com/watch?v=cO5Bjmaii9w
VUEWorks® (DTS)	*CitizenVUE* app	https://www.vueworks.com/our-services/modules/	https://www.vueworks.com/our-services/modules/
	Work Order module		--
	Service Request module		--
	Valuation module		--
	Risk module		--
	Budget Forecasting module		--
	Projects module		--
	Facilities module		https://www.youtube.com/watch?v=L5zito3YKbM
	MobileVUE mobile application		--
	SidewalksVUE mobile application		--

	FieldVUE mobile application		--
	FacilityVUE offline mobile application		--
iWorQ (iWorQ Systems Inc.)	*iWorQ*(cloud-based)	https://iworq.com/systems/	https://www.youtube.com/watch?v=89QFj7JsDLg https://iworq.com/summit-video-2019/ https://iworq.com/summit-video-2018/
	Pavement Management (cloud-based)	https://iworq.com/systems/pavement-management-software/	
	Sign Management (cloud-based)	https://iworq.com/systems/sign-management-software/	
	Asset Management (cloud-based)	https://iworq.com/systems/asset-management-software/	
	Sidewalk Management (cloud-based)	https://iworq.com/systems/sidewalk-management-software/	
	Planning & Zoning (cloud-based)	https://iworq.com/systems/planning-zoning-software/	
SoftWorks (SoftWorks Inc.)	*SoftWorks* central data area	https://softworks.org/	https://www.youtube.com/watch?v=c68FN2lgE3c
	Sign/Traffic Control Device Systems module	https://softworks.org/sign-management-system/	https://www.youtube.com/watch?v=v5EQpUjzQX0
	Culvert-Bridge Inventory Systems module	https://softworks.org/culvert-bridge-management-system/	https://www.youtube.com/watch?v=Rz54O7KfCF8
	Guardrail Inventory Systems module	https://softworks.org/guardrail-management-system/	https://www.youtube.com/watch?v=OMOaCb1ObPQ
	Pavement Management Systems module	https://softworks.org/pavement-management/	https://www.youtube.com/watch?v=JvFQqoLMkMM
	Ohio Crash Statistics module	--	--
	Fleet Maintenance module	https://softworks.org/fleet-management/	https://www.youtube.com/watch?v=BqoVfiHXBDA
	Garage and Parts Inventory module	https://softworks.org/garage-and-parts-inventory/	https://www.youtube.com/watch?v=A4z0ZQo46pE
	Government Accounting System	https://softworks.org/accounting-2/	https://www.youtube.com/watch?v=j5pf2RHiNqU
	Payroll Management System	https://softworks.org/payroll-management/	https://www.youtube.com/watch?v=ufz3KZ92sM4
	A/R-Receipt Management module	https://softworks.org/accounts-receivable-management-system/	https://www.youtube.com/watch?v=pw__B5munyc
	Fixed Asset Inventory module	https://softworks.org/fixed-asset-inventory/	https://www.youtube.com/watch?v=vrlA5OgWZKw&list=UUX6RZzqPYAIbjqX33UsEd2w
MasterSuite (MasterMind LLC)	*MasterSuite*	https://www.onlinemastermind.com/software-mastermind.html	https://www.onlinemastermind.com/general-tutorials-mastermind.html
	SignMaster™	https://www.onlinemastermind.com/software-mastermind.html#signmaster	https://www.onlinemastermind.com/signmaster-tutorials-mastermind.html
	CurveMaster™	https://www.onlinemastermind.com/software-mastermind.html#curvemaster	https://www.onlinemastermind.com/curvemaster-tutorials-mastermind.html

	StripeMaster™	https://www.onlinemastermind.com/software-mastermind.html#stripemaster	https://www.onlinemastermind.com/curvemaster-tutorials-mastermind.html
	MarkingMaster™	https://www.onlinemastermind.com/software-mastermind.html#markingmaster	https://www.onlinemastermind.com/markingmaster-tutorials-mastermind.html
	VideoMaster™	https://www.onlinemastermind.com/software-mastermind.html#videomaster	https://www.onlinemastermind.com/videomaster-tutorials-mastermind.html
	LocationMaster™	https://www.onlinemastermind.com/software-mastermind.html#locationmaster	https://www.onlinemastermind.com/locationmaster-tutorials-mastermind.html
	CulvertMaster™	https://www.onlinemastermind.com/software-mastermind.html#culvertmaster	https://www.onlinemastermind.com/culvertmaster-tutorials-mastermind.html (under construction)
	RailMaster™	https://www.onlinemastermind.com/software-mastermind.html#railmaster	https://www.onlinemastermind.com/railmaster-tutorials-mastermind.html
AgileAssets	(Overview)	https://www.agileassets.com/	https://www.youtube.com/watch?v=lezp13ibeUI
	Portfolio Analyst™ module	https://www.agileassets.com/products/cross-asset-tradeoff-analysis/	https://www.youtube.com/watch?v=aN65wmY8QsI
	Summit™ module	https://www.agileassets.com/products/data-visualization/	--
	Pavement Analyst™ module	https://www.agileassets.com/products/pavement-management-system/	https://www.agileassets.com/videos/pavement-analyst/ https://www.youtube.com/watch?v=Yrvr0rxtgPQ
	Pavement Express™ module	https://www.agileassets.com/products/pavement-express/	https://www.agileassets.com/videos/demo-agileassets-pavement-express/
	Structures Analyst™ module	https://www.agileassets.com/products/roadway-safety-management-system/	https://www.agileassets.com/videos/agileassets-integration-of-bms-and-mms/
	Safety Analyst™ module	https://www.agileassets.com/products/roadway-safety-management-system/	https://www.youtube.com/watch?v=ZU0xe3JFjSg
	Maintenance Manager™ module	https://www.agileassets.com/products/maintenance-management-system/	https://www.youtube.com/watch?v=55MuJ-CJGec
	Structures Inspector™ module	https://www.agileassets.com/products/bridge-inspection/	https://www.prweb.com/releases/agileassets_v7_5_improves_flexibility_field_productivity_for_tunnel_inspections_asset_maintenance/prweb17071093.htm
	Fleet & Equipment Manager™ module	https://www.agileassets.com/products/fleet-management-system/	https://www.youtube.com/watch?v=BiecZtrBHXQ
	Sign Manager™ module	https://www.agileassets.com/products/traffic-sign-management-system/	--
	Signal and ITS Manager™ module	https://www.agileassets.com/products/signal-its-management-system/	https://www.youtube.com/watch?v=n-IdfS-KlGg
	Facilities Manager™ module	https://www.agileassets.com/products/facilities-management-system/	--

	Work Manager™ app	https://www.agileassets.com/products/mobile-solutions/	https://www.agileassets.com/videos/agileassets-work-manager-v7-5-enhancements/
	Structures Inspector™ app	https://www.agileassets.com/products/mobile-solutions/	--
	Fleet Maintenance Manager™ app	https://www.agileassets.com/products/mobile-solutions/	--
	Materials Manager™ app	https://www.agileassets.com/products/mobile-solutions/	https://www.youtube.com/watch?v=GXfhBtO7C1E
SAM IS® (VHB)	*Pavement* module	https://www.samisbyvhb.com/module-pavement.asp	--
	Sidewalks module	https://www.samisbyvhb.com/module-sidewalks.asp	--
	Stormwater module	https://www.samisbyvhb.com/module-stormwater.asp	--
	Culverts & Bridges module	https://www.samisbyvhb.com/module-culverts-bridges.asp	--
	Environmental Compliance module	https://www.samisbyvhb.com/module-environmental-compliance.asp	--
	Signs module	https://www.samisbyvhb.com/module-signs.asp	--
	Buildings module	https://www.samisbyvhb.com/module-building.asp	--