Stormwater Asset Management Program

For the Town of Nottingham, NH

With assistance from

John Jackman

Draft, Mar 28, 2023

Contents

Executive Summary

Like many communities throughout the country, the Town of Nottingham (Town) is facing challenges presented by aging infrastructure, diminished state, and federal funding, increasing demands from stakeholders, and a more complex regulatory environment. As Nottingham endeavors to meet these challenges, there is an increased awareness that past management strategies are no longer sufficient to keep up with the demand. Nottingham needs an improved management system to deliver optimized investment strategies that satisfy stakeholders through reliable, data-based decision-making. The practice of asset management, as defined by ISO 55000 and promoted by the Environmental Protection Agency (EPA), American Water Works Association (AWWA), American Public Works Association (APWA), and many other organizations worldwide, presents the type of management system that Nottingham requires.

Asset management is a sustainable, continuous, and strategic approach to managing infrastructure investments and delivering service levels that satisfy stakeholders at minimal risk. Asset management systems embody the data-driven decision-making processes. More than software, an asset management system consists of an overarching set of principles, best practices, and applications of information that enable professionals within an organization to optimize processes and deliver services more cost-effectively based on priority and risk. For Nottingham, it represents an opportunity to:

- Increase training and resources to staff to become successful. Empower the staff to develop and maintain good data to make a better decisions.
- Sustainably build, maintain, operate, and reinvest in infrastructure in a manner that supports the common values of the community.
- Deliver the best value for the dollar spent to Town customers; and
- Provide a more accurate basis for long-term financial management that reflect Nottingham's credibility and accountability in its stewardship of infrastructure assets.

Building the framework for the asset management system requires a collaborative effort among Nottingham staff from all levels who are trained in the core areas of asset management. Nottingham's process began with workshops, inventory, data storage, performance tracking, learning software, vision statement and learning to analyze this information to optimize and predict future needs and personnel.

With this asset management program, Nottingham is taking the first step on a journey to optimize its investments in stormwater infrastructure at sustainable levels to provide its taxpayers the quality of service they expect while meeting state and federal MS4 requirements. To develop this program plan, the town commissioned a team of asset management professionals from John Jackman to lead its staff through a set of asset management workshops where essential insight and information contributed to the creation of this program.

Nottingham should consider this asset management program plan to be a living document. As the tasks in this plan are completed, Nottingham will identify new tasks and goals that will require updating this plan to continue the journey.

Horizontal Assets

- Stormwater Collection System
    - Catch basins
    - Drainpipes
    - Culverts
    - Outfalls
    - Stormwater Best Management Practices (BMP)

Elements of An Asset Management Program Plan

The following summarizes the core areas of asset management:

Table 1: Core Areas of Asset Management based on the International Infrastructure Management Manual (IIMM and NHDES Guidance Document

Core Area of Asset Management	Role in the Asset Management Framework
Mission Statement	A mission statement is **a concise explanation of the organization's reason for existence**. It describes the organization's purpose and its overall intention. The mission statement supports the vision and serves to communicate purpose and direction to employees, customers, vendors, and other stakeholders.
Level of Service	Stormwater resource assets exist to provide services that are essential to the safety and protection of the property of the Town and the public.

	The quality or *level* of these services may vary from community to community. This presents a basis for setting attainable, measurable, and sustainable Level of Service goals for the Town of Nottingham. The Town used the Specific, Measurable, Achievable, Realistic and Time Bound (SMART) process developed by the EPA, which was updated to the (SMARTER) adding Evaluation and Reassess to the process.
Inventory	A reliable inventory establishes the basis for all asset-related decisions. The Town must be confident in what it owns, what it costs (to purchase and maintain), and where it is located, as well as any other factors the Town feels are needed to make the right investment decisions. The Town needs to be able to access and maintain this inventory.
Condition and Performance	Adjunct to inventory, knowledge about asset condition and performance forms the basis for determining where capital investments need to be directed to meet the Level of Service goals.
Prioritization of Assets based on Risk and Criticality	Risk and criticality factors determine how assets are prioritized for investment, which is especially important when funding is limited. The risk is based on the likelihood and consequence financially, social impacts and environmental impacts
Life Cycle Costing for Capital Investment Planning providing Funding Strategy	Investment strategies are formulated using all the Life Cycle Costing information from previous core parts to establish and optimize funding requirements to meet the established Level of Service goals. Investment strategies form the basis for financial planning and rate setting.
Implementation Plan	Implementation is the training, development of SOP and training material provided during the program to help with staff with the ability to successfully continue with the asset management program.
Communication Plan	The communication plan provides direction and steps for the community in planning and advancing with their asset management program

Current Level of (Asset Management) Maturity

This asset management program references the International Infrastructure Management Manual (IIMM) to establish Nottingham's maturity level in each core area of asset management using the following scale:

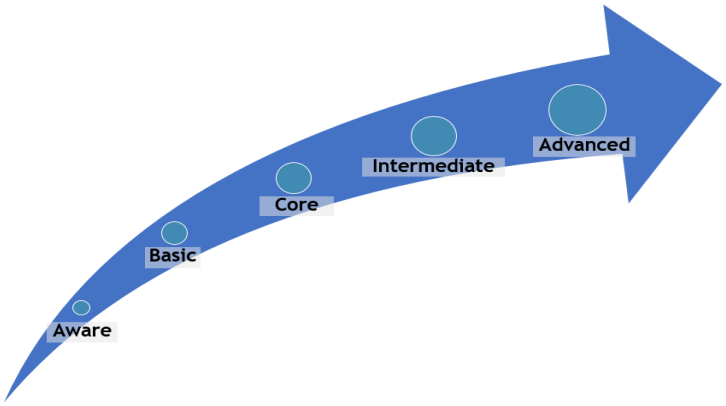


Figure 1: IIMM Asset Management Maturity Scale

This diagram is presented near the beginning of each core section with definitions for each level respective to the core area being assessed. At the low end of the scale, 'Aware' indicates that the organization understands the role of the core area but has not yet taken any formal action to implement; at the other end of the scale, 'Advanced' indicates that the organization has developed sophisticated processes to realize benefits within the core area for the asset class being assessed. While 'Advanced' may be necessary for some asset classes, in most cases 'Intermediate' will provide a sufficient level of maturity.

While the Town's maturity varies by a core area and asset class, the current overall level of maturity for Nottingham is assessed to be at the 'Basic' level with opportunities to move some areas to 'Intermediate' within 2 to 5 years. The increase in areas will be based on training and continue use of the program. The following provides a summary of each core area across all asset classes:

Table 2: Nottingham Maturity Levels by Core Areas

Core Area	Town Maturity Level	Description
Level of Service	Basic-Core	A Level of Service workshop was conducted with the NHDES, consultant, and town staff on the development of a formal Level of Service document. The document formalized the current Level of Services the Town provides. It was put into the SMARTER format so the Town can measure year to year on how they are doing. The Highway Department also completed the development of a Mission Statement
Inventory	Core-Intermediate	Inventory maturity varies between core and intermediate among the Town's various asset classes. Intermediate maturity may soon be achieved for many asset classes with current initiatives.

Condition and Performance	Core	Condition is being assessed for some asset classes as the inventory is being updated. The focus of the condition is based on age and material. The Town needs to develop processes to keep the data up to date.
Risk and Criticality	Basic - Core	There exists a capital investment risk assessment process for road class. This drives the risk for the stormwater assets.
Life Cycle Costing for Capital Investment Planning	Basic - Core	Capital Investment Planning is accomplished on an annual basis. The Life Cycle Cost data based on year installed and the year replaced as well as all the O&M performed during the life of the asset. Nottingham capital planning is driven by road reconstruction, which will drive the year of capital investment for the stormwater system.
Implementation Plan	Basic – Core	Implementation Plan is the development of both personnel and the asset management tools and understanding.
Communication Plan		Communication Plan is a development of both short term and long-term goals. Providing a step-by-step guidance to improve and grow the asset management program.

Best Industry Practices

Each core section presents a discussion on best industry practices as promoted by publications, such as the IIMM and the NHDES Guidance Document, that are recognized authorities in the field of asset management. The information presented in this section is designed to help guide the Town toward the proper outcome when implementing the tasks. The Town recognizes that specific practices that work for other organizations may need to be modified to reflect resource availability, current status, desired outcomes, and other aspects that are unique to Nottingham. There are many 'right ways' to build an asset management system as long as the principles found in best industry practices are followed.

Level of Service

Introduction to Level of Service

Levels of Service are used to define quality standards at which municipal services are provided to the community. They support strategic goals developed by the community and are a representation of the customer needs and expectations, Town policies, vision and mission statement, regulatory requirements, and financial capabilities of the municipality. Defining Levels of Service influences all asset management decisions. Along with creating an asset inventory and collecting asset attribute information, developing Levels of Service is a crucial first step of an asset management program.

Level of Service goals can be broken down into three subgroups: *External*, *Internal*, and *Asset*. External Level of Service goals is based on customer's and elected official's expectations, and local, state, and federal requirements. Examples of External goals include no disruption of service to critical customers such as schools, hospitals, and businesses; proper notifications for customers to make plans during scheduled shutdowns; making proper capital investments to reduce the number of odor complaints; limiting the length of time a hydrant is out of service; and not having any permit violations over the course of a year. Internal Level of Service goals goes together with External goals. Internal goals support the Town to achieve its external goals. The management staff's expectations drive the development of Internal Level of Service goals. The management staff needs to have the right equipment, data, and training sufficient personnel and financial capability. Asset Level of Service would be based on the design requirements of the asset or key performance indicators.

During the Level of Service workshop, which included NHDES, Town Manager, Finance Director, Highway Foremen and John Jackman, certain target levels of service were discussed (such as how staff responds to customer complaints). These levels of service are inherent to the Town's standard operating procedures. The Town had no prior documentation of any significance developed for the specific purpose of setting and tracking the level of service performance targets in an asset management framework. During the workshop, a Level of Service document was developed using the SMARTER process shown on Figure 3.

The Highway Department did not have a Mission Statement on March 20, 2023 the Board of Selectmen approved the following Mission Statement.

Mission Statement

The mission of the Town of Nottingham is to enhance the quality of life in the town of Nottingham by providing professional public works services to safely and efficiently manage the Town's infrastructure.

Level of Service Maturity Scale

Using the IIMM Level of Service maturity scale, the team determined that Nottingham is currently at the Basic stage. The following sections provide an explanation for the determined maturity level and summarize the Level of Service workshop held with the Town staff.

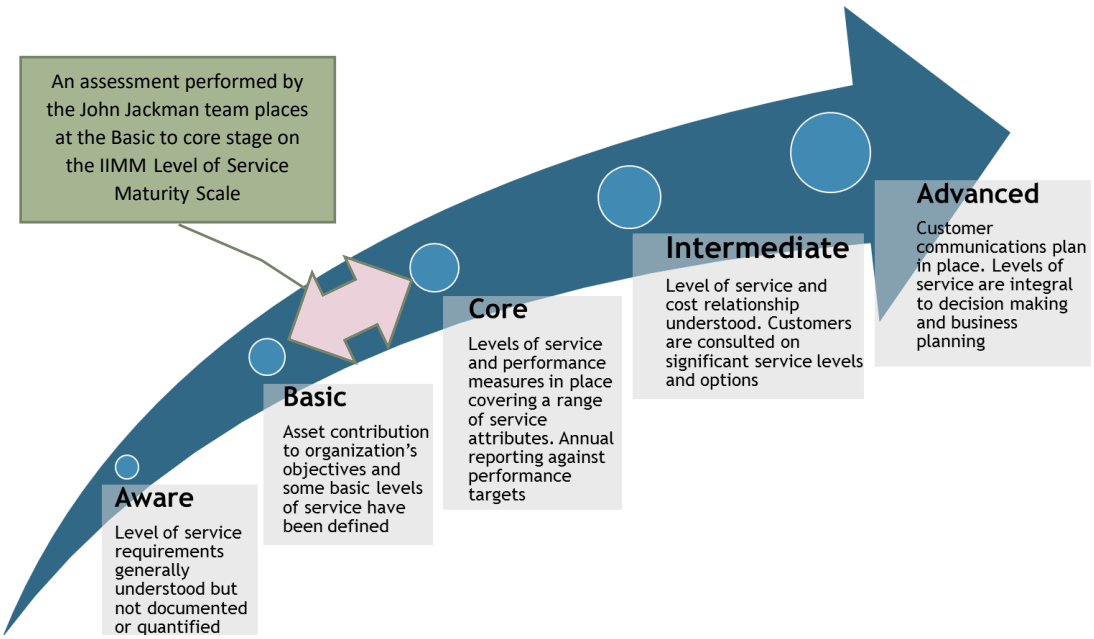


Figure 2: The International Infrastructure Management Manual (IIMM) Level of Service Maturity

Level of Service Workshop Summary

The workshop started by looking at different level based on type of road and location to help develop core concepts of Level of Service. The handouts were given to focus on how to start developing Levels of Service and the important concepts that should be considered during this process. The workshop was focused on stormwater asset, but it also included other asset maintained by the Public Works, began developing example Levels of Service for the Town of Nottingham. The external goals focus on customer, but most concerns were not about drainage (Customer Services) and subsequent Internal goals (Operation & Maintenance) to support the External goal. Among the groups participating, it was understood that many goals are currently being met inherently (only the internal goals are currently measured using a combination of Google forms while other goals proposed may be future goals.

Nottingham NH

SMARTER - LEVEL OF SERVICE

Measurable **Achievable** **Realistic** **Time Bound** **Evaluation** **Reassess**

Figure 3: SMARTER Level of Service Goals

Goals	Asset Category		Measure/Units	Achieved 2020	2021 Target	Units/Time	2020 Attainment	Corrective Measures/Comments
Customer Service	Stormwater	Public Outreach	# of Public Events held	0	1	Yearly		Provide brochures for Town Hall scoop the poop
	Stormwater	Response time to complaints	Time to respond	No Record	24	hours		Evaluate if the need is the correct time based on customer responds
	Stormwater	Public Outreach	Update Stormwater Website	0	1	Yearly		Review Website and update with new material with consultant and Town Regulation Yearly
Operation & Maintenance	Culverts	Inspection	Percent inspected	TBA	85%	Yearly		
	Catch Basin and Drain Manholes	Clean & inspect	# of Units cleaned/inspection	5	5	Yearly		This is contracted out; goal will be to have contractor put all data into the Asset Management software
	GIS	Maintain and update the GIS	100% of new drainage	95% current	100% of new and continue updating old	Every 2 Years		Bring new points into the GIS using GPS unit and provide data to Consultant for QA/QC
	New Stormwater Development	Review proposed designs for new or replacement storm drain systems	percentage of new development	100%	100%	Yearly		The plans are review by both consultants and Town staff and will review issues from past plans.
Financial	Financial needs to maintain and meet the Level of Service required by customers and regulatory requirements	The stormwater system operates cost effectively	Review of long-term investment plan	1	1	Yearly		This will include staff administration and budget committee
		Fund, Inspect and replace. culverts that are in the road reconstruction area	Review cost of the contracted services and make sure budget meets the need	100%	100%	Yearly		Review budget for outside services annual to meet the Level of service agreed about for the town.
		Review budget for outside services and consultants	Review contract and services needed	1	1	Yearly		Yearly review contract before budget period

Tasks

Short-Term Tasks

- Review and update the current Level of Service Document with the Public Works advisory board on a yearly basis using the data collected throughout the year.
- Continue working on system-wide Levels of Service for different asset groups based on current budget and staffing. Develop a workflow so the Levels of Service will be measured.
- Develop a target Level of Service for different asset groups which will allow for measurable performance. Provide this in a document form that can incorporate input by staff. This will help in directing resources based on the overall goals of the organization.
- Determine which Levels of Service will require capital investment and additional staff.

Long-Term Tasks

- Have elected officials adopt or approve the Level of Service document as part of this process and provide access to the public.
- Develop resources needed to meet the target Levels of Service.
- All capital investment projects are developed using Level of Service goals and are measured to evaluate the return on the investment. The asset management planning process will identify potential projects, develop options for each project, evaluate options and prioritize projects and project scoping.
- The project delivery workload and life cycle cost that emerges from initial asset management plans can be higher than the normal planned capital project delivery.
- Provide opportunities for the public to give feedback on the different Levels of Service provided. The goal is to help educate the public on costs associated with Levels of Service and receive feedback on the expectation.
- Develop a sustainable budget based on expected Levels of Service with better data.

Resource Requirements

Resources for Short-Term Tasks

- Provide focus training to current staff on Level of Service. In the training, focus on a clear understanding of the Levels of Service specifics, how they are going to be measured, how they are going to achieve the goals, why they are relative to their job, provide a timeline, and how they will be evaluated. This training will provide the understanding and expectation to be successful in meeting the Level of Service expectation.

Inventory

Introduction

Establishing an Asset Inventory is a critical first step in the development of an asset management system. An asset inventory documents what assets the organization owns, where those assets are located, and captures relevant data such as the assets' physical properties, year installed, criticality, replacement cost and expected O&M and other factors that go into determining valuation, life cycle costing, and risk for decision support. Nottingham has completed collecting the necessary data for improved financial reporting, improved capital planning and budgeting, and cost-effective operation and maintenance.

Inventory Maturity Scale

Nottingham has been steadily progressing with the maturity of the Asset Inventory for their stormwater infrastructure over the years. A staff self-assessment indicates that the Town is somewhere between the Basic and Core levels of the IIMM Inventory Maturity Scale for their horizontal Asset Inventory.

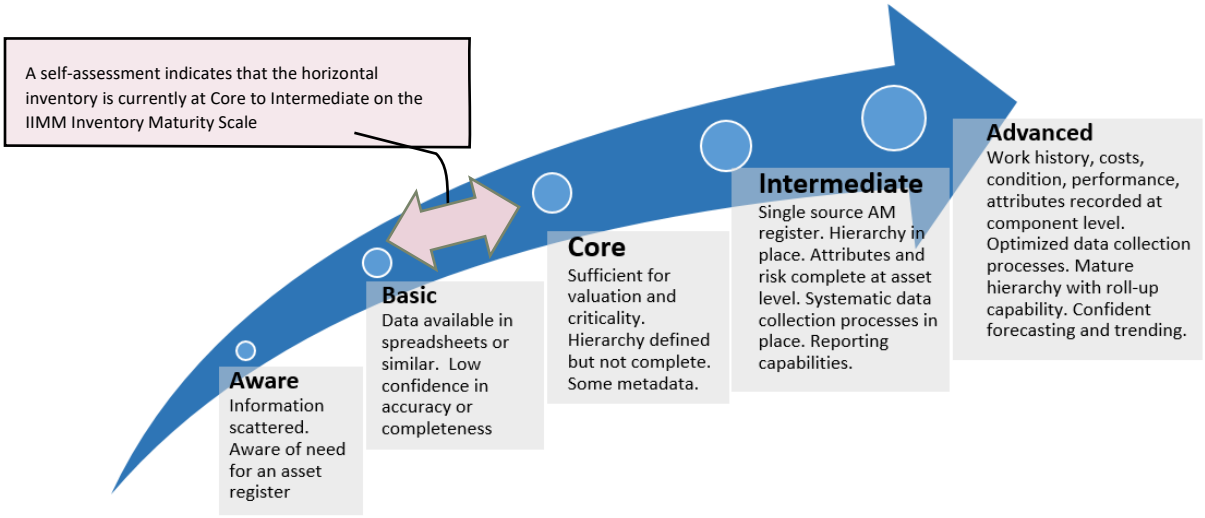


Figure 4: The International Infrastructure Management Manual (IIMM) Inventory Maturity Scale

Recommendations for how the Town should continue to advance the maturity of the asset inventory, include: developing a workflow for maintaining inventory; utilizing the asset management software and updating the attributes to include condition, risk, and service area for each asset. Once a year update the GIS with new assets and update the Asset Management GIS as well.

Current Status Summary

Stormwater Collection System

Inventory of the stormwater system is about 97% complete using GPS with one foot accuracy including elevation. The GIS system includes Town, State, and private stormwater systems. The attributes for private stormwater infrastructure are missing installed years and diameter, this information should be

collected and added to GIS when available. For the past three years, the Town filed work orders documenting the condition and need for work during the cleaning of the catch basins. Each year the forms have improved and provided better data. During this work, the Town was able to evaluate the process and improve it for future years.

One of the attributes of stormwater infrastructure is a simple condition rating form, which is used in prioritizing capital needs. Appendix E Google Form.

Best Practices in the Industry

One of the core elements of an inventory system is to arrange the assets and components in a hierarchical structure for example road corridor with road surface, water assets, wastewater assets, signs, sidewalks, and stormwater assets. The specifics of the structure are defined through needs that will vary by organization, department, and asset category, but generally follow a structure similar to this:

Tasks

Short-Term Tasks

- Most short-term tasks will be focused on preparing for and beginning the development of a single asset inventory structure that is consistent across all asset groups. This inventory should be created in such a way that finance, engineering, and operation stakeholders can all utilize and manage the data.
- Document the business drivers for the data to be collected. Consider the following:
    - Funding Requirements
        - State Revolving Fund Requirements
        - Budget increase
        - Grants
    - Internal Business Requirements
        - Asset Criticality
        - Risk Mitigation
- Before collecting additional information for the inventory, determine what information is required for every component across all Town facilities. Examples of global component data include:
    - Asset Identification Number
    - Year Installed
    - Failure Mode
    - Consequence of Failure
    - Probability of Failure
    - Risk
    - Redundancy
    - Current Value Cost
    - Remaining Useful Life
    - Replacement Cost
- Develop a consistent identification numbering system across all assets and components so it will be easy to add new assets & components in the future.
- Assign resources dedicated to maintain, update and make use of the data in the Inventory.

Long-Term Tasks

- Collect advanced asset and component inventory information such as failure mode, probability of failure, consequence of failure, and risk. This will be contingent upon the completeness of condition, and criticality criteria, and scoring methods.
- Create a fully functioning single source asset inventory that is being utilized by finance, engineering, and operations.
- Attributes are complete and accurate at the asset level.
- Systematic and documented data collection processes established.
- Asset inventory is capable of being utilized for generating reports.

Resource Requirements

Resources for Short-Term:

- Invest in staff training focused on asset information because staff will need to locate and identify assets. To accurately value assets, sufficient data will be needed to calculate replacement cost and remaining life. Provide administrative staff to assist in record keeping and utilization of the Asset Management Software.
- Using the Asset management software provided will help update and store the vertical and horizontal Inventory. The software will have the capability to utilize the information in the Inventory to analyze life cycle costs and risk. It will also provide asset history, attributes, and other information to staff in the field and can be ground verified.

Current Status Summary

To meet the Core to Intermediate level requirement for valuation sufficiency, all Town stormwater assets have data including; estimated year installed, diameter, and material. Completing these fields are currently 95% complete and continue to be a work in progress. Efforts are also underway to determine criticality based on diameter, roadway and impact to emergency response. The Town has a single asset register for the horizontal assets in the GIS (asset management software).

Stormwater Collection System

Condition and Performance

Introduction

Within an asset management-driven organization, the task of condition and performance monitoring is a continuous process that should save money by identifying potential costly failures before they occur. Condition monitoring assesses the physical state of the asset and is usually achieved through visual inspection techniques. The stormwater system will utilize the use of the following for asset assessment: zoom cameras, crawler camera, cleaning inspections, and reports of capacity failure during heavy rain or snowmelt events.

Some of the benefits of assessing condition and performance include:

- Determining what corrective actions may be required
- Reducing the probability of failure by identifying potential failures before they occur
- Understanding where the asset is in its life cycle
- Setting target levels of performance aligned with Levels of Service
- Using life expectancy, condition, and performance as a basis for making capital improvement decisions
- Predicting future life cycle cost requirements
- Measuring the effectiveness of maintenance

An asset may be determined to be in a state of failure if it is no longer capable of delivering Level of Service targets. Assessing condition and performance over time allows the town to identify trends and patterns to predict when an asset may fail and, therefore, prepare ahead of time to either avoid or reduce the impact on Levels of Service.

An understanding of how assets fail needs to be established before an organization can take these actions. With this understanding established, the town can focus condition and performance assessment resources to assess against specific modes of failure. Three major failure modes of failure commonly recognized in Asset Management are:

Physical Failure:	Service Failure:	Economic Failure:
The asset breaks, cracks, corrodes, etc. beyond repair. Most often attributed to structural, mechanical or electrical issues. May result due to a lack of maintenance.	The asset no longer meets the levels of service that is required even if the physical condition is good. This could include failure to meet customer expectations or failure to meet regulatory requirements.	The asset is no longer the most cost-effective solution for the function required. The asset may be inefficient or obsolete. A stormwater example could be impervious pavement in areas requiring sanding.

Table 3: Modes of Failures

Assessing condition and performance can be conducted in several different ways, and at different levels of detail. Three assessment methods are as follows:

- **Desktop Assessment** – Using age, location, maintenance history, etc. to focus and prioritize condition and performance improvement efforts.
- **Visual Assessment**
  - Horizontal assets: Taking pictures during Spring snow melt and heavy run off.
- **Performance Monitoring**
  - Horizontal assets: Hydraulic modeling, water quality, flooding, road deterioration, etc.

With this asset management plan, Nottingham is tasked with developing condition and performance assessment standards. Assessment standards should answer these questions:

1. How often do we inspect?
2. What method should be used?
3. Which assets do we prioritize?

4. What do we inspect/what information do we collect?

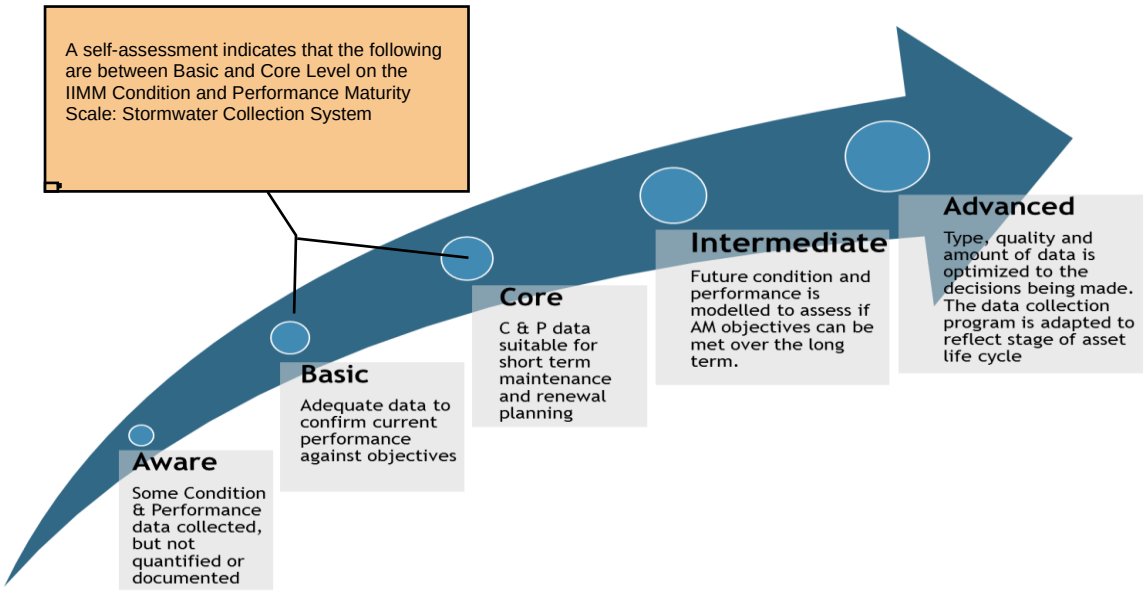


Figure 5: The International Infrastructure Management Manual (IIMM) Condition and Performance Maturity Scale

Condition and Performance Maturity Scale

The Town staff conducted a self-assessment to determine where Nottingham is on the IIMM Condition and Performance Maturity Scale. The staff determined that the stormwater collection system is between Basic and Core level of maturity. As the Town has developed inspection and condition forms for work orders that include culverts. Using this information for providing work orders for the up in coming year for repairs. Over this time the need for funding of these project has increased along with professional engineering needs.

The following sections provide an explanation for the determined maturity level and summarize Nottingham's current methods for collecting condition and performance information on their horizontal assets.

Best Practices in the Industry

As previously mentioned, assessment standards should be developed with four questions in mind:

1. How often will inspection occur?
2. What method should be used?
3. Which assets do we prioritize?
4. What do we inspect/what information do we collect?

Assessment standards should be consistent, widely accepted throughout the organization, and implemented as business practices. The remainder of this section provides information regarding various techniques (from simple to more sophisticated) that Town staff may consider, but in no way

commits Nottingham to a specific method. One strategy to consider is to adopt a more sophisticated method for the most critical assets, while simpler methods can be used for less critical assets.

Simple Method

There are several different condition scoring methods that can be utilized. Common condition rating scales use either a 1-5, 1-10, or 1-100 scale. With the use of Asset Management Software these scales can all be used providing for different types of failures. The IIMM promotes a simple condition scoring that uses a 1-5 scale where 5 represents the worst condition and 1 represents the best condition. An example of a simple condition scoring method can be seen below.

Table 4: Simple Condition Scoring

Grade	Condition	Comment
5	Immediate Attention	Defect requires immediate attention
4	Poor	Severe defects that will become grade 5 defects within the near future
3	Fair	Moderate defects that will continue to deteriorate
2	Good	Defects that have not begun to deteriorate
1	Excellent	No to minor defects

Simple methods are great for when resources are limited and when asset criticality is low. They may be well suited for long-term financial planning, but lack the detail required to take any specific action without collecting additional information.

Appendix I is a detailed Stormwater Structure Condition form developed to improve data collection.

Tasks

Short-Term Tasks

Tasks

Tasks are divided into short- and long-term; the short-term tasks are designed to be action items that the Town should commence immediately, with emphasis on:

1. Completing initial data collection efforts. Develop and utilize simple condition forms linked to the assets. There is training material available on the google drive this link will get you to your sign in page https://drive.google.com/drive/my-drive.
2. Completing and adopting the draft standards and goals presented in this plan; and

3. Developing processes and workflows for the long-term management of the system.

Long-term tasks are presented to provide a view of probable next steps after the short-term tasks are completed. Perhaps the most important long-term task that touches on every core area of the asset management system is the selection and implementation of an asset management software (google). The software selected will provide the platform for many of the other long-term tasks. The list of long-term tasks will be modified after the short-term tasks are completed.

Resource Requirements

Resources for Short-Term

- Investing in staff training at all levels.
    - Understanding failure modes, and process expectations of equipment.
    - Provide networking with other professional groups in operation and maintenance fields.
- Investment in tools and analysis that will help in condition assessment and predictive maintenance (for example a GoPro camera with lighting to inspect reach of pipe).

Resources for Long-Term

- Dedicate a group or employee to oversee the condition and performance assessment criteria development and data collection process. Using Crawl or zoom camera for inspection of pipe to provide internal inspection and put into Pipe Assessment Certification Program (PACP).
- Invest personnel time in an asset management program that will store condition and performance information, as well as condition assessment forms and criteria.

Current Status Summary

Stormwater

The Town is also responsible for all infrastructure including the stormwater system. The condition rating for the pipes is based on age and material. Other critical stormwater assets such as stormwater inlets, culverts, and outfalls require their own condition standards and inspection methods. The Town uses google forms for inspecting culverts. Inspection is done once per year and a repair list is developed for the upcoming year to address issues. The condition assessment always includes a minimum of 4 pictures to help in the future of understanding the condition rating.

Short-Term Tasks

- Corrugated Metal Pipe (CMP) may have a higher priority.
- Conduct condition inspection using a GoPro camera of the culverts, which is over a fifty-years-old and schedule to replace it at the time the road work is scheduled.

Long-Term Tasks

- Assign condition scores to all horizontal assets using the previously developed assessment standards.
- Use condition and performance data to assess if future objectives can be met over the long-term.
- Develop a plan to deal with future liabilities.

Table 5 – Draft Culvert Condition Scoring Method

	Excellent (1)	Good (2)	Fair (3)	Poor (4)	Fail (5)
Pipe	Excellent condition, new pipe	No signs of corrosion	Pipe is beginning to show signs of corrosion	Significant corrosion that could soon lead to failure	Pipe corrosion has resulted in physical break down of the pipe
Headwall (if applicable)	Newly constructed headwall, no imperfections	Headwall is intact and structurally sound	Headwall is starting to see signs of surface wear and erosion	Headwall I is significantly eroded or beginning to fall, no longer structurally sound	Pieces of headwall I have fallen into the channel I, headwall is at high risk of collapse
Outfall Area	Outfall area is undisturbed	No signs of erosion	Minor erosion occurring downstream of the outfall	Noticeable and significant erosion around the pipe and downstream of the outfall	Severe erosion around the outfall pipe, could result in loss of property and significant safety concerns
Channel	Channel I is adequately sized and positioned to handle high flows	Channel is serving its intended purpose and not causing any harm to surround ng area	Channel is obstructed, not containing the flow, or may have signs of structural damage	Channel is causing flooding or pooling of water, causing erosion which could lead to slope instability	Channel is not properly delivering flow to receiving water, needs to be reconstructed

This culvert condition scoring method draft should be reviewed by the Town staff to make sure these criteria align with what the individuals in the field are looking for when filling out an outfall inspection form. Providing descriptions for excellent, good, fair, poor, and fail ensures consistency throughout the organization. When more than one person is completing outfall inspections, it is important that all individuals have the same understanding of each condition score. Utilize the training video and material for new staff and annual review as needed. The videos are located on the google drive and can be share with staff.

Resource Considerations

Resources for Short-Term

- Invest in staff training at all levels.
    - Build from current methods, condition scoring, and the likelihood of failure.
    - Understand what the scoring is telling the town and what actions should be taken.

Risk and Criticality (Prioritization of Assets)

Introduction

When assets fail, they can threaten the ability of the stormwater system (and the organization) to sustain its levels of service. However, different assets present different levels of risk to the organization, and

different assets have varying levels of criticality. Therefore, it is important to determine the risk and criticality of these assets to make better operation, capital planning, and resource allocation decisions.

Criticality and risk are often used in similar contexts but have distinct differences. Criticality only expresses the severity of a consequence *if* failure were to occur. Risk expresses both the probability of failure or likelihood that a consequence will occur and the severity of the consequence. Based on this definition, the risk is a product of the likelihood of failure (LoF) and consequence of failure (CoF). LoF and CoF are often measured using a 1-10 grading scale, where 1 is the least likely to fail or has the least consequence and 10 is the most likely to fail or has the highest consequence. Multiplying LoF and CoF then creates a risk range from 1 – 10. Factors that are considered when determining LoF include age, condition, and failure history. Factors that are considered when determining CoF include financial, environmental, health and safety, and social consequences. Once LoF and CoF values have been assigned to assets, they can then be plotted onto a risk matrix . For CoF for stormwater the use of Appendix F to help in building this matrix.

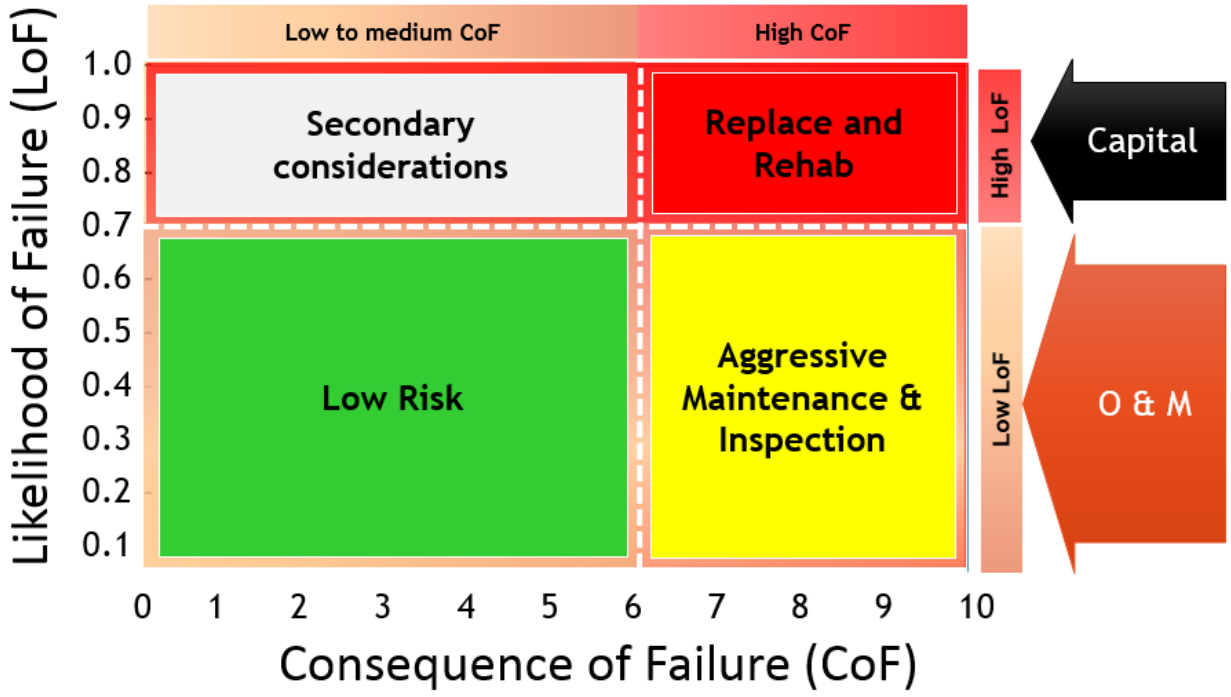


Figure 6: Risk Matrix

In the above example risk matrix, the LoF scale ranges from 0.1 – 1, and the CoF scale ranges from 0 – 10. This means that the highest risk score is a 10. Different scales can be used when developing risk matrices, but the equation Risk = LoF x CoF still holds true if the highest value for both LoF and CoF remains the most likely to fail and the worst consequence.

In Figure 6, dashed lines were drawn at an LoF of 0.7 and a CoF of 6, splitting up the risk matrix into four quadrants. Once an organization has assigned LoF and CoF values to their assets and plotted them onto the risk matrix, the risk matrix can illustrate the action that the organization should consider taking. The lower left quadrant shows the low risk assets where normal, routine maintenance is all that is required. The lower right quadrant is where assets with a very high CoF, but low LoF reside. Assets in this area should receive frequent assessment and monitoring with intense scrutiny on O&M. Even though the likelihood of those assets failing are low, those assets will age and the likelihood of failure will increase over time, whereas the high consequence of failure for these assets will stay relatively the same year after

year. Assets that fall in the top right corner of the matrix are the highest risk assets, which should be the highest priority when considering capital planning efforts. Assets in the top left quadrant, due to their low CoF, should become second considerations when determining what assets to rehab and replace with capital funds. The organization is aware that these assets will likely fail soon, but if the consequence of those assets failing is minimal, then the organization would be wise to not spend significant amounts of money to lower the LoF. The dashed lines in this figure are shown only as an example and will vary from community to community. Each community has a different level of risk tolerance and can adjust those dashed lines as they see fit.

Although the standard risk equation is Risk = LoF x CoF, other factors such as redundancy can be added to that equation. Regarding horizontal assets, redundancy or increase the structure size for added capacity can reduce the organization's risk significantly. If an organization only needs to operate one pump at a time for a given function, but has two pumps capable of fulfilling that function, there is a low probability that both pumps will be out of service at the same time. In this scenario, when one pump fails, the redundant or backup pump can be brought online while the failed pump is repaired or replaced. With redundancy added to the equation, the new risk equation is Risk = LoF x CoF x Redundancy Factor.

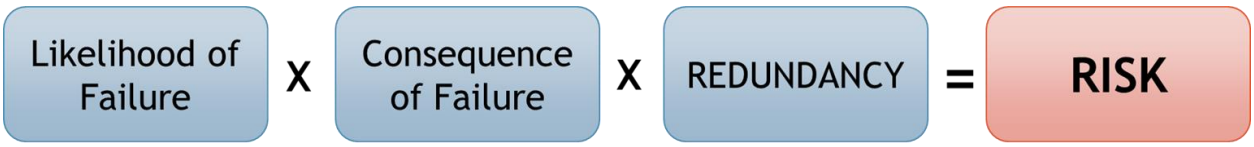


Figure 7: Risk Equation

Business risk exposure (BRE), like risk, can be calculated using an equation. The equation to calculate BRE is BRE = LoF x Consequence Cost. The only difference between BRE and risk is that BRE requires associating an exact cost to the consequences of an asset if it were to fail. Consequence cost can be calculated by summing direct costs to the town (the cost that affects the organization's budget), direct customer costs (the cost for loss of service), and community costs (cost to growth, opportunities, and image). The ability to assign a value to the CoF provides a better understanding of the consequences at stake and creates a more accurate way to rank asset criticality. Quantifying the products of risk is the desired approach, however, this is more difficult to do for the LoF. Since age and condition are not always the best failure modes for predicting asset failure, factors like rate of failure occurrence, the severity of the failure, and detectability need to be considered.

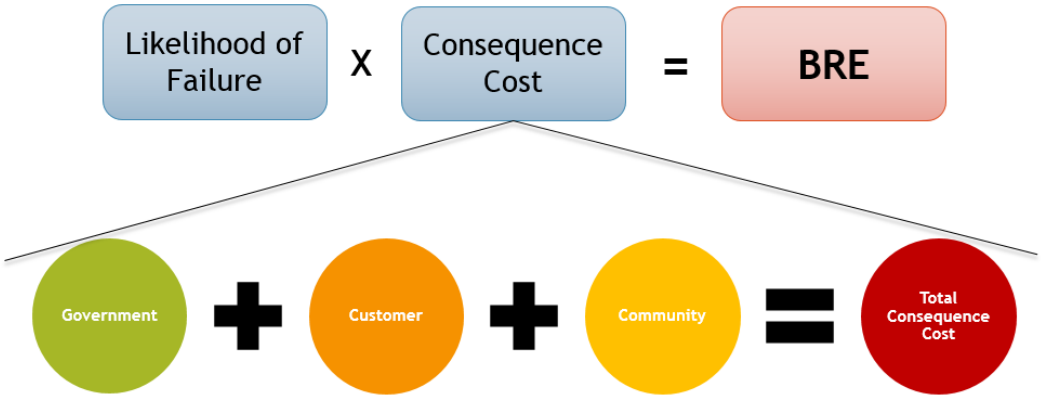


Figure 8: BRE Equation with Consequence Cost Quantification

Rate of failure occurrence, the severity of the failure, and detectability are factors that need to be considered when conducting a failure mode effect and criticality analysis (FMECA) assessment approach. This approach can deliver a risk priority number (RPN) when age and condition are not dependable factors to determine risk. To calculate the RPN, use the equation in Figure 8. Of the three factors that create the equation, detectability is the factor that the organization has the most control over and perhaps has the most influence over the RPN. Detectability ranks the probability to detect a failure before it occurs. Detectability consists of identifying inhibitors and correcting them before failure occurs. Also, a low occurrence does not necessarily equate to a high detectability probability. This approach calls for assets to be broken down into maintainable units, a drainage system is made up of a large number of culverts and waterways. drainage area may have one or several culverts feeding one culvert which will have an overall larger impact. By know this inspection can prioritize which assets are looked at for indication of failures.. The current condition, remaining useful life, and maintenance cost of the maintainable unit is not considered when calculating the RPN. The following 10-step procedure outlines how to set up an FMECA.

1. Identify maintainable units (MU)
2. Establish ranking scales and definitions
3. Gather all information about the MU's to clearly identify the function, asset relationships, failure history, criticality, etc.
4. Define what constitutes a failure for the MU – may entail defining what failure is for the system and the function of the MU
5. Determine Failure Modes
6. Determine causes that lead to each failure mode (contributes to determining the detectability value)
7. Determine effects/consequences of the failure for each mode
8. Score each asset for severity, occurrence, and detectability
9. Assess RPN
10. Determine how the RPN can be reduced for high RPN MU's

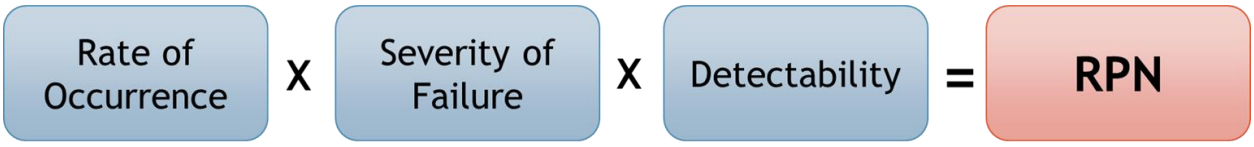


Figure 9: Risk Priority Number Equation

Risk Maturity Scale

The Town staff conducted a self-assessment to determine where Nottingham is on the IIMM Risk Maturity Scale. The staff determined that stormwater assets are between the Basic and Core levels.

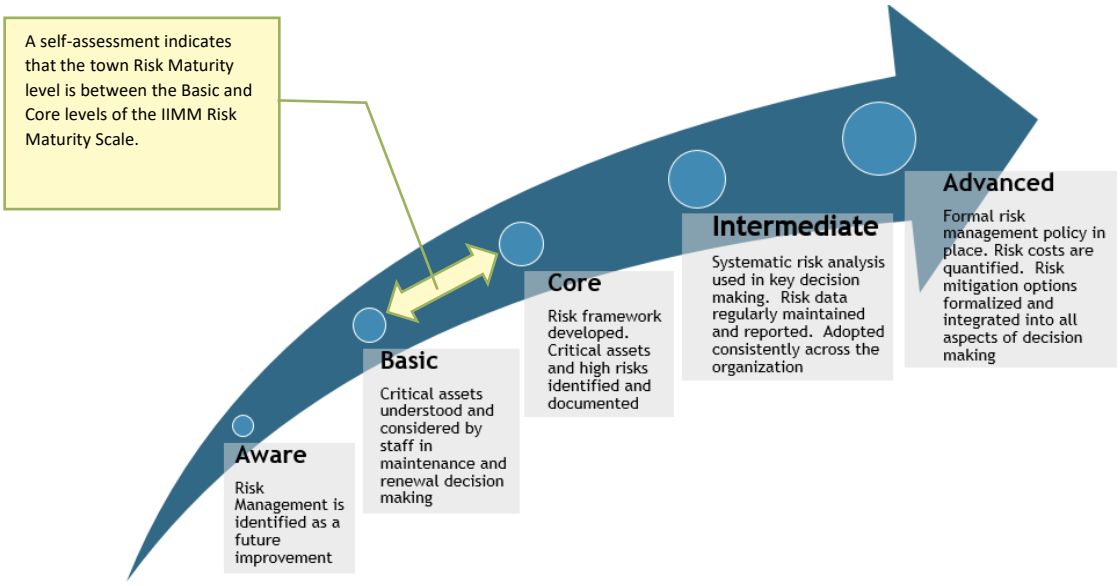


Figure 10: The International Infrastructure Management Manual (IIMM) Risk Maturity Scale

The following sections provide an explanation for the determined maturity level and summarize the Town's current methods for collecting risk and criticality information on horizontal assets.

Horizontal Assets Current Status Summary

Horizontal assets such as stormwater pipes, and stormwater structures currently utilizes ArcMap for calculating the risk factors for the assets. However, over time the Town's staff will collect this information in their day-to-day operation & maintenance. These work orders will be linked to the assets and will reflect the condition based on the number of work order per asset. This will assist in providing the Probability of Failure (PoF). The other factor used in development of the PoF is the age of the pipe.

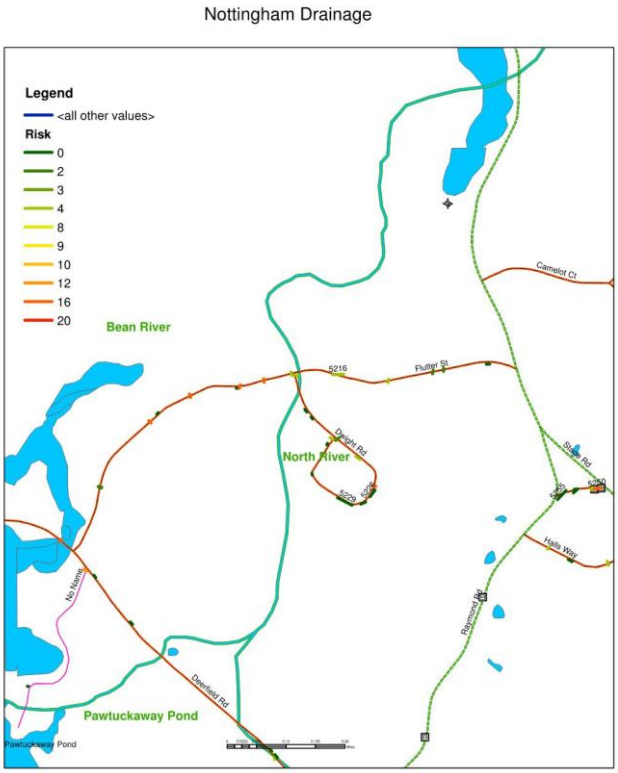


Figure 11: Risk Matrix of the Stormwater Pipes

This is a map color coding culverts based on Risk. With the use of this map can help select the assets in the different risk levels and provide a visual location of the drainage pipes. The method used to develop risk is based on several factors in Nottingham. The Risk looks at age, number of work orders on an asset, diameter, location, material, and the depth of the pipe. This will take years to develop to a point that the data provides future financial decision can be made for capital improvement projects. The main reason for this is the process of balancing financial, environmental, and social needs of the community.
Risk calculations need to be reevaluated several times to make sure it reflects the risk tolerance of the community.

Tasks

Short-Term Tasks

- Develop a better understanding of the consequence of failure criteria for drainage system based on road traffic, property damage, environmental cost, and cost to repair or replace.
- Begin developing additional risk assessment criteria for all critical horizontal asset types.
- Develop GIS information that will help in the development of consequence of failure based on associated customers, environment, and other asset types.
- Assign dollar values to developed criteria so criticality can be compared. This will need to be continuously evaluated as better planning and awareness helps to reduce criticality.
- Develop a workflow to be able to update criticality based on new information.

Long-Term Tasks

- Assign risk values to all critical horizontal asset types.
- Have risk information stored and tracked in the Town's asset management software.
- Quantify business risk exposure by identifying risk costs to the town, customers, and community.

Appendix D - Financial Report on the Stormwater pipe

: Life Expectancy and future Investment Cost for Drainage Pipe

Resource Requirements

Resources for Short-Term

- Continue to utilize Google Form in developing consequence of failure criteria that meets the staffing and resource of the town.
- Invest in internal inspection of pipes over the age of 75 years and based on real field data to help understand any unknown risk that might be in the systems.
- Maintain all new assets in GIS with all necessary data. Include capital cost and Life expectancy for all future financial needs.

Life Cycle Costing for Financial Planning

Introduction

Accurate capital investment plans are a trait of healthy, sustainable communities that achieve a social and environmental level of service goals through effective investment strategies based on life cycle costing. The strategies developed in this manner allow municipalities and agencies to budget appropriately, manage debt, and set rates that are aligned with public expectations. The effectiveness of these strategies is directly related to the successful implementation of the various components of asset management as established in an asset management plan. Inventory (including replacement costs), levels of service, condition\performance data, and risk\criticality all have important roles to play. Processes designed to maintain data reliability are therefore essential for maintaining a sustainable community as illustrated in the graphic below. The core presents how Nottingham can develop life cycle cost-based investment strategies to sustain its status as a healthy community.

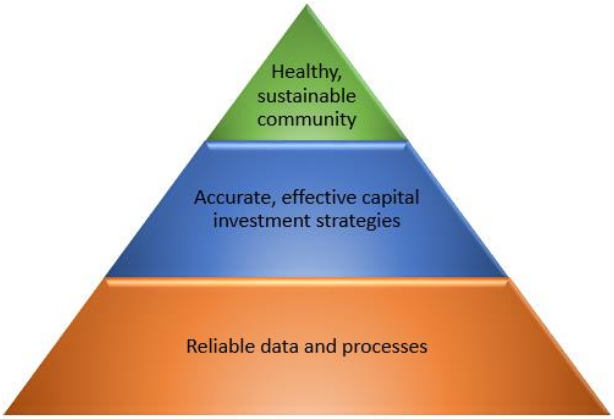


Figure 13: A trait of a healthy, sustainable community is accurate capital investment strategies built on a foundation of reliable data and processes.

Maturity Status Details of Horizontal Assets

Stormwater system: Capital investment decisions are largely made based on staff knowledge and available budget on an annual basis. Storm events often reveal risk-prone areas that drive reaction-based investment decisions. While efforts are underway to improve inventory and assess conditions in order to drive a more proactive decision-making process, the maturity level of the stormwater system currently stands between Aware and Basic. There is training material and videos on how to utilize Nottingham's Asset Management software to develop better management and financial planning using risk data.

LCC Maturity Scale

The Town conducted a workshop with highway foreman and staff on the process of tracking the cost and capital investments. Through this workshop to develop a good LCC the cost of all work orders on assets needed to be tracked. It will be important to continue training for new employee to maintain success in this data collection process. This would allow the ability to capture the full LCC. The town staff conducted a self-assessment to determine where Nottingham is on the IIMM LCC Maturity Scale. The staff determined that both the Stormwater assets are between the Basic levels.

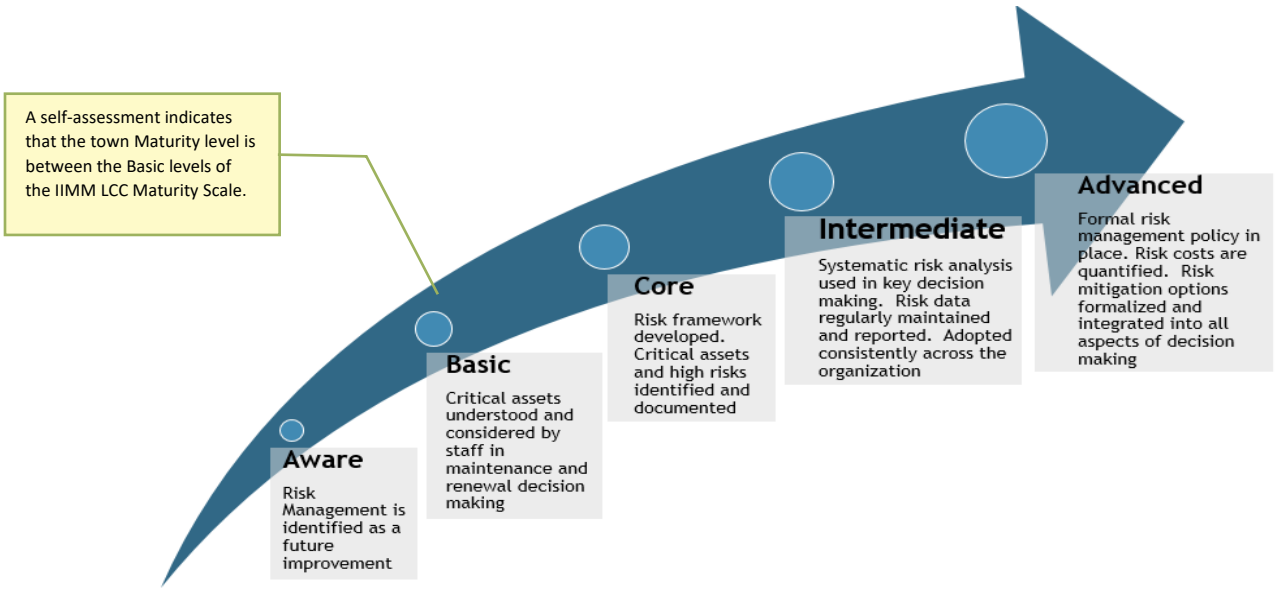


Figure 14: The International Infrastructure Management Manual (IIMM) LCC Maturity Scale

Tasks

Short-Term Tasks

- Develop workflows in the daily routine to include work order linked to the assets.

Long-Term Tasks

- Develop efficient ways to collect cost for work orders including contractor, inventory, labor and other cost associated with the assets.

Best Practices in the Industry

The list of authoritative organizations and publications on life cycle costing and capital investment planning in asset management includes ISO 55001, the Institute of Public Works Engineering Australasia (IPWEA) International Infrastructure Management Manual (IIMM), the Institute of Asset Management (IAM), and the EPA Fundamentals of Asset Management publications. While all these references promote similar best practices, this asset management plan references the IIMM and EPA publications. Both authorities promote common definitions of Life Cycle Costs:

Life cycle cost = original cost + operating costs + maintenance costs + renewal costs + decommissioning costs – salvage value.

According to the IIMM, elements of financial forecasts for a long-term financial plan should:

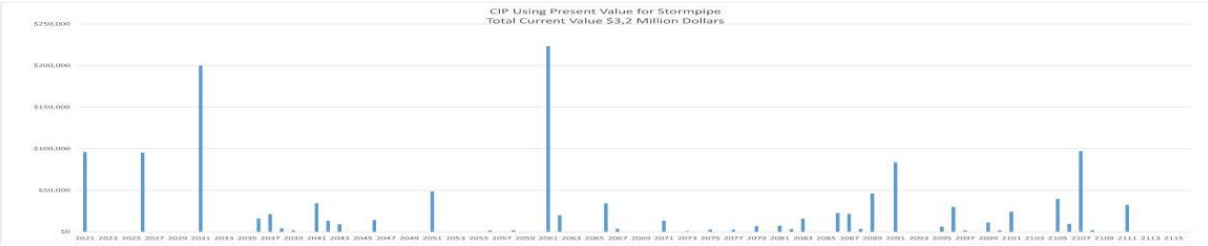
- Include operational, maintenance, renewal, and disposal costs
- Forecast for a significant period (10 years minimum)
- Be a financial outcome of the AM strategies
- Be based on provable replacement or unit costs
- Be updated annually
- Be related to recorded key assumptions and confidence levels

Figure 15 – CIP for the next 90 Years with Present Value (2021?) of 3.2 million dollars

This data is better managed using Asset Management Worksheet

This allows users to filter by locations, years and condition.

A video in the training folder will help in the use of this module.



Implementation Plan

Introduction

In the process of developing an asset management plan there was a series of trainings put on for Nottingham to be able to maintain the asset management program. In Nottingham this was an important step as throughout the project there were many changes occurring.

As part of the implementation plan, Appendix E? provides a list of trainings and training material, which includes videos and manuals. An additional resource for Nottingham is the Asset Management Conference put on by the NHDES each year in the Fall.

Tasks

Short-Term Tasks

- Continue to use the basic work order for tracking cost and labor.
- Utilize mobile devices to collect data in the field.

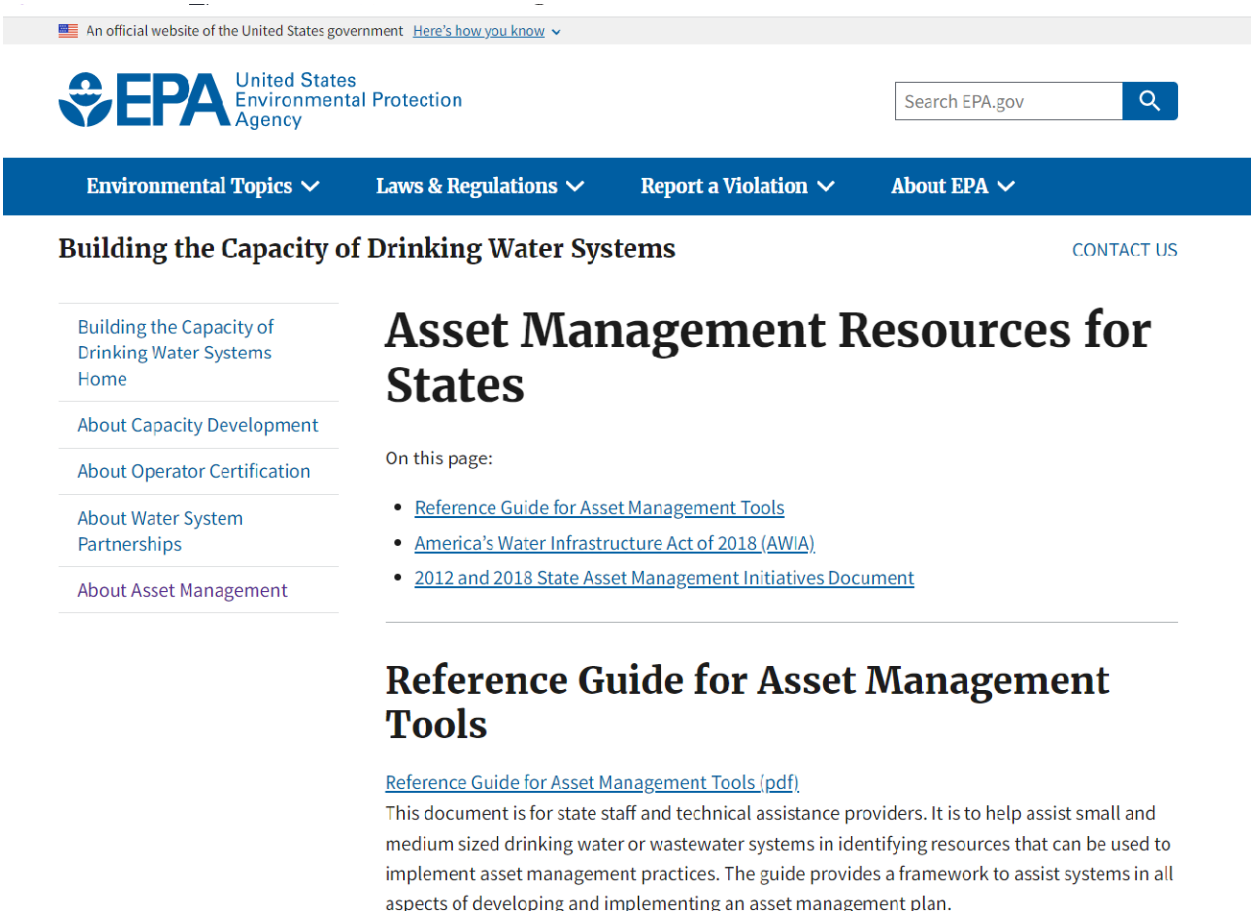
Long-Term Tasks

- Develop the use of other modules in the asset management software.
- Provide training throughout the organization.

Communication Plan

Introduction

The communication plan for Nottingham will utilize the Town web site and town newsletter they put out. Articles will be developed, one on the Asset Management Program and a second one on the control of Knotweed (Appendix E). These will go into the Town Newsletter. The web site will have a small writeup on the Asset Management program and provide a link to the EPA site on Asset Management. https://www.epa.gov/dwcapacity/asset-management-resources-states



Tasks

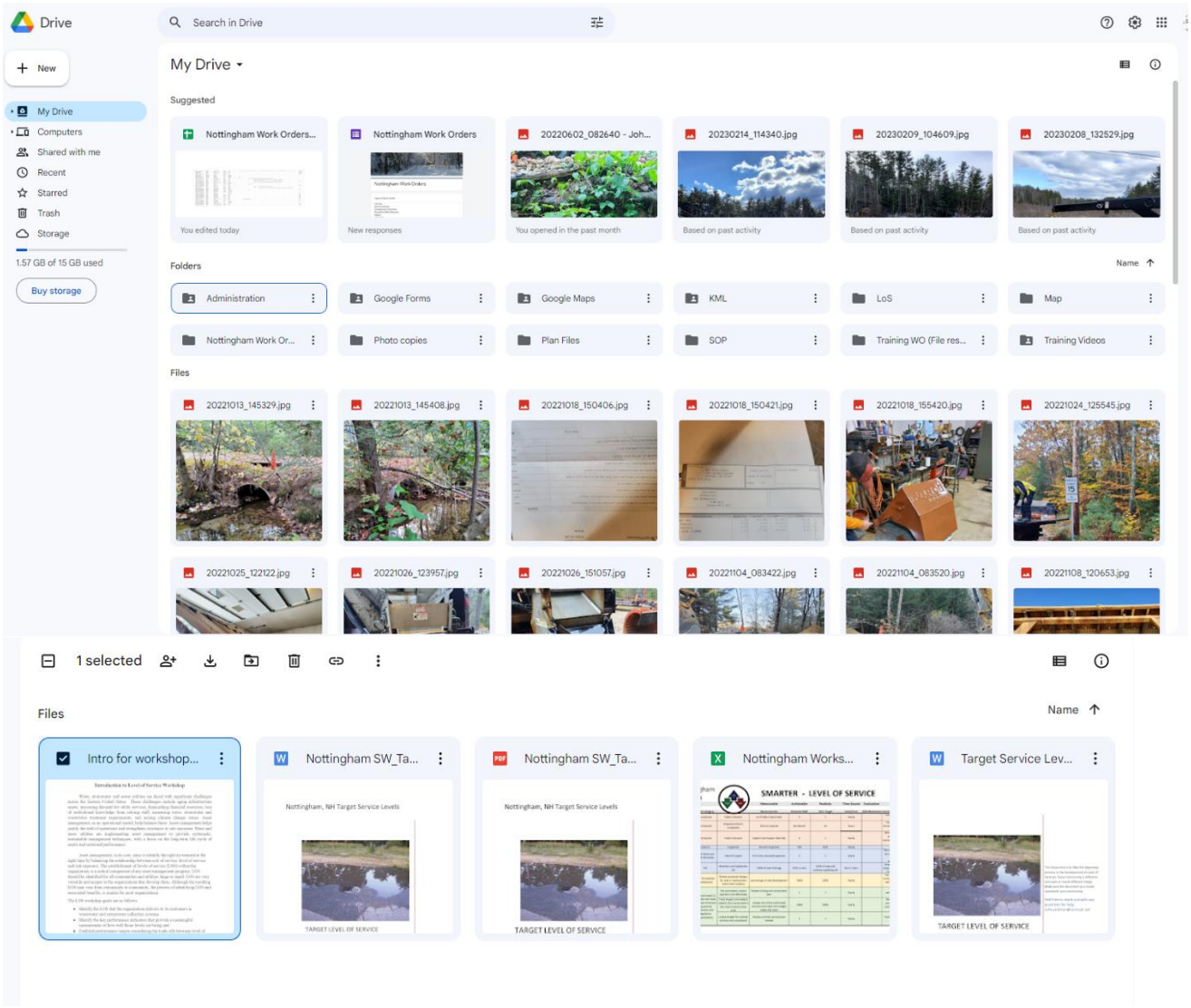
Short-Term Tasks

The Environmental Protection Agency maintains a significant amount of information regarding asset management for water and wastewater utilities on the EPA website for both local officials and consumers including manuals that can be downloaded. At this juncture, the Town will provide links to the web site under the title of Asset Management on the Water & Wastewater Department section of the Town's Web Site. From here citizens and local officials can read great introductions to asset management and download pamphlets that provide more depth into the subject. Even though this is a stormwater asset management program, all the same principles apply.

Provide at Town Office hand out on does and don't of stormwater. Located a Map of culverts and ownership so new homeowners understand their respond's ability to maintain their own culvert.

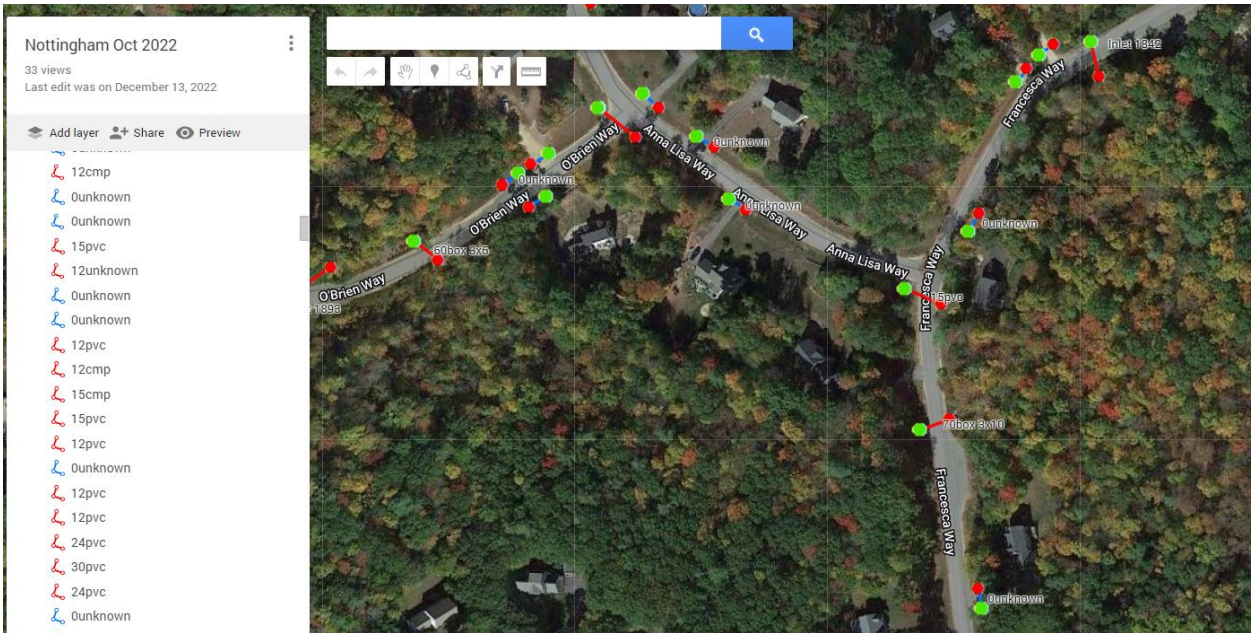
Appendix A - Screen Shot of Nottingham's Google Drive

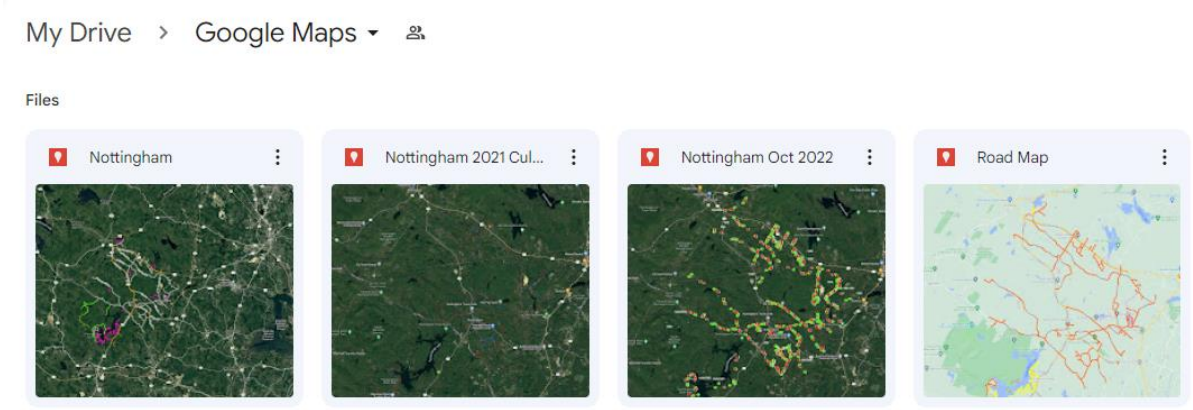
The google drive is the one of the locations that data is stored and accessed from. The work orders, google maps, training videos, SOP and pictures from work orders are all located here. The google drive also lets you share with staff and control access. The drive is designed to be backed up on a remote computer set up by staff. Because the drive is located on the web it allows access by tablets and cell phones.



Appendix B - Screen Shot of Nottingham Google Map Drainage

The maps below are different maps that are available to the staff. The large map shows ownership of the culverts. We also have maps based on risk with red being high risk and green being low risk. The third main color is blue and those are private culvert that are not rated.





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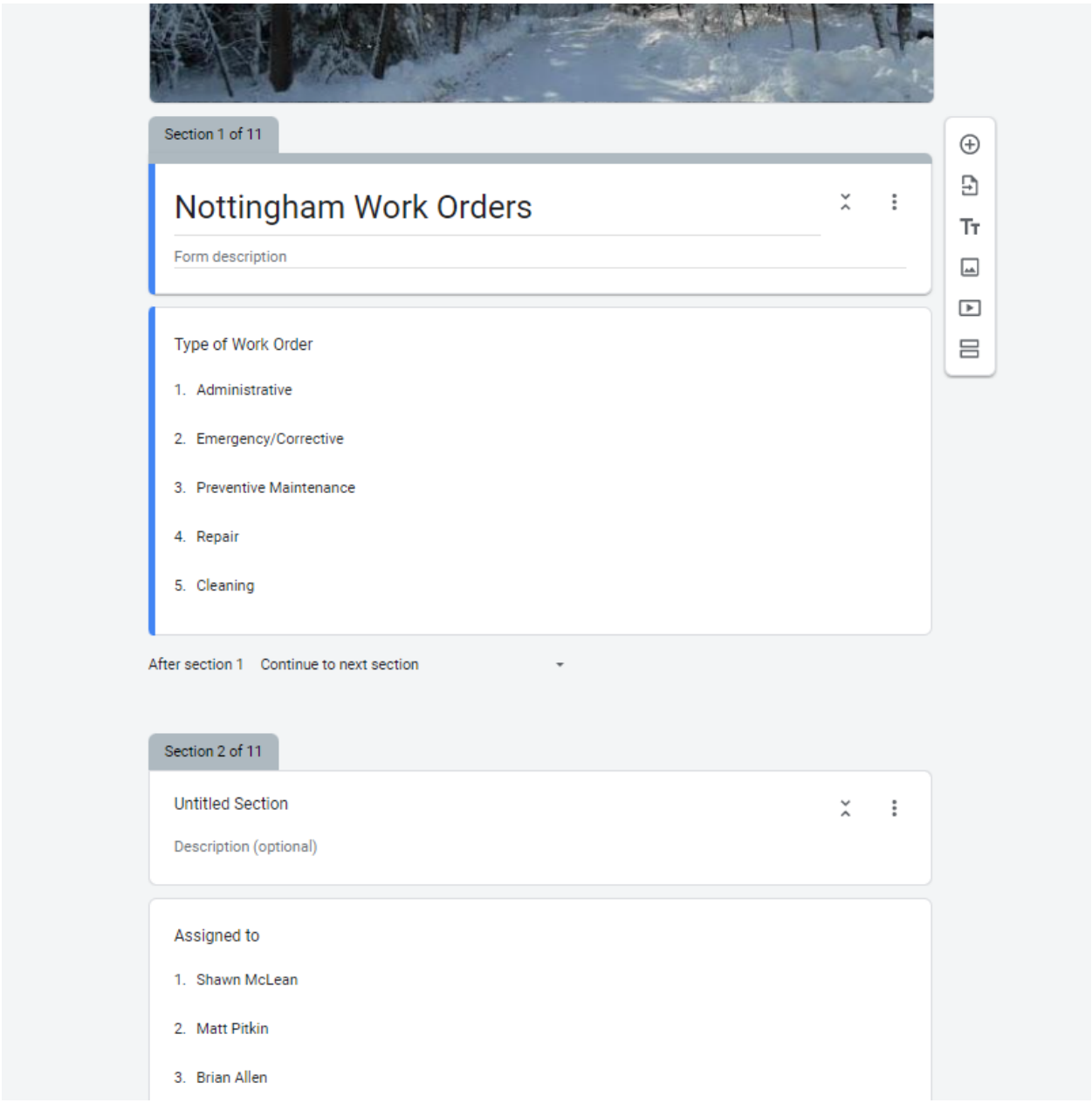
Appendix C -Google Work Order Form

This is a screenshot of the beginning of the work order form used by Nottingham staff. The form is about 16 pages long and designed to work easily out in the field. The data goes into a google sheet and filter on developed to allow the staff to evaluate work order by assigned, asset type, and work order type.



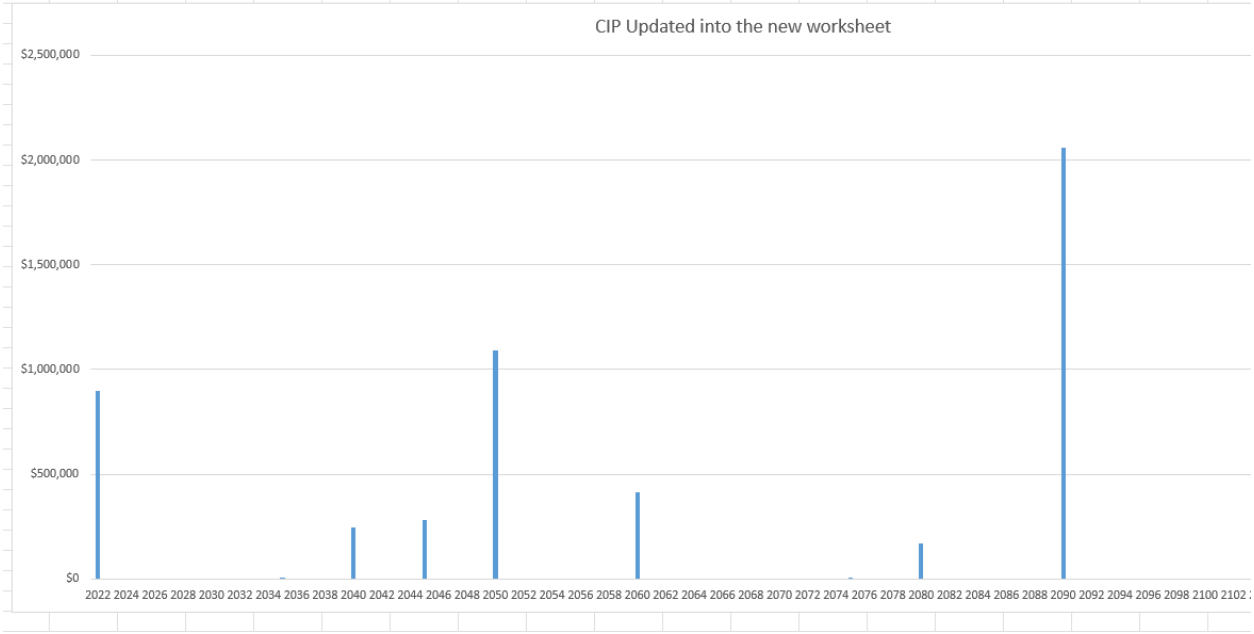
Appendix D - Financial Report on the Stormwater pipe

Below are two screenshots of the Asset Management worksheet. This worksheet brings data in from the GIS and is imported into the asset management sheet. The reason for the worksheet is to allow the staff to update the cost and risk every year based on the data collected.

ASSET MANAGEMENT WORKSHEET

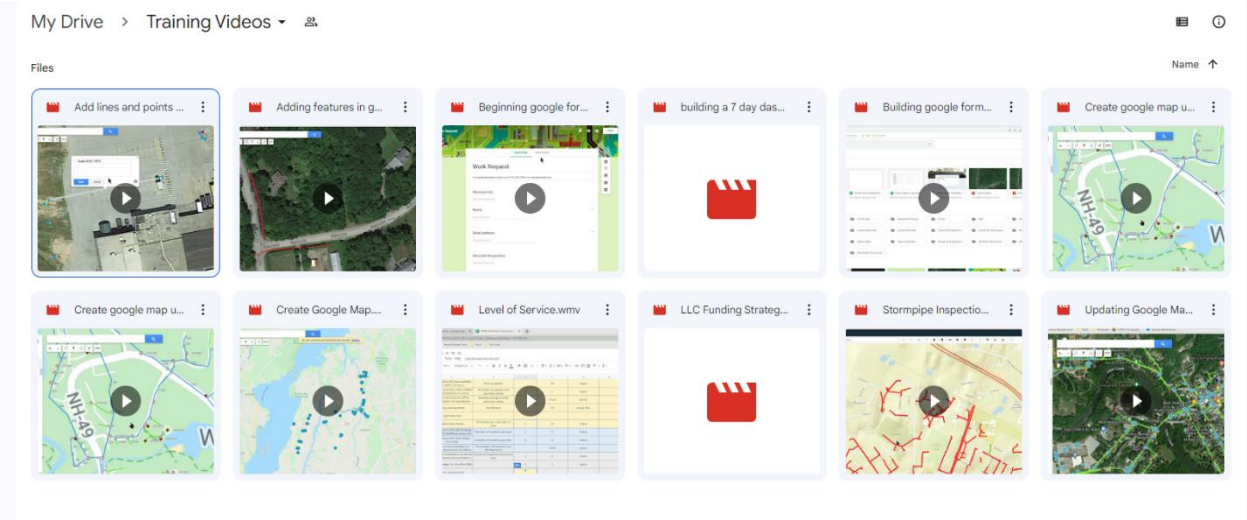
Location Nottingham Culverts
Current Year 2022

Location	Item Description										Financial Data		
Location	Type	Diameter	Material	Length	Watershed	Asset ID	DPW ID		Year Installed	O&M Condition	Expected Life	Lining Cost	Present Value Replacement	Remaining Life
Berry Rd	0	70	box 3x10	18	North River	5514	0	18	0	2	80	$0	$26,292	0
Berry Rd	0	70	box 3x10	19	North River	5515	0	19	2000	2	80	$0	$28,715	58
Francesca Way	0	70	box 3x10	46	North River	5402	0	46	1970	2	80	$0	$68,256	28
Francesca Way	0	60	box 3x6	51	North River	5397	0	51	2000	2	80	$0	$51,189	58
Obrien Way	0	60	box 3x6	45	North River	5423	0	45	2000	2	80	$0	$44,938	58
Maple Ridge Rd	0	48	box 5x18	39	Little River	5196	0	39	1970	2	80	$12,481	$17,551	28
Kennard Rd	0	100	cmp	24	Little River	5585	0	24	1960	2	50	$0	$47,859	0
Cooper Hill	0	80	CMP	39	0	5822	0	39	1990	2	50	$0	$78,563	18
Kelsey Rd	0	72	cmp	19	Little River	5731	0	19	1970	2	50	$6,037	$28,298	0
Deerfield Rd	0	60	pvc	38	Bean River	5472	0	38	1970	2	90	$0	$37,833	38
South Summer St	0	60	pvc	35	North River	5792	0	35	2000	2	90	$0	$34,829	68
Church St	0	48	pvc	41	North River	5252	0	41	2000	2	90	$12,997	$18,277	68
Flutter St	0	48	pvc	37	North River	5215	0	37	2000	2	90	$11,807	$16,603	68
Gerrish Dr	0	48	pvc	35	North River	5771	0	35	2000	2	90	$11,155	$15,687	68
Halls Way	0	48	pvc	48	North River	5249	0	48	2000	2	90	$15,295	$21,508	68
Kennard Rd	0	48	pvc	33	Little River	5583	0	33	1970	2	90	$10,677	$15,015	38
Kennard Rd	0	48	pvc	31	Little River	5584	0	31	2000	2	90	$9,920	$13,950	68



Appendix E - Sample of Training Videos located on google drive.

There are about 20 training videos that are designed to help staff with the asset management program and to utilize google tools. These videos can be accessed using the phone or tablet in the field.



Appendix E - Sample of Article for Newsletter

Japanese knotweed (*Polygonum cuspidatum*)—sometimes known as Japanese bamboo or more ruefully as Godzilla weed—is one of the world's most invasive plants. If you've ever attempted to get rid of Japanese knotweed, you already know of its monster-like qualities. Japanese knotweed is a shrublike, semi-woody perennial with bamboo-like stems that can grow up to 10 feet tall. It is so tenacious that it has been known to grow through solid masonry foundations, and its roots can penetrate up to 6 feet deep and spread as much as 65 feet.

Why is the town of Nottingham interested in Japanese knotweed. This invasive plant grows throughout the town of Nottingham, and it's spread through the swales along the roadside and from private property. This plant fills in swales along the roadside creating poor drainage and damage to the roads adjacent to it. The town of Nottingham has been working for two years to get rid of the knotweed and has a separate line item in the budget to support this program. The program has been very successful in eliminating much of the knotweed growing along the roadside. But it is important to have the residents of the town participate in helping the control of this invasive plant.

You can treat Japanese knotweed yourself, and there are several approaches you can use. It is possible to get rid of Japanese knotweed naturally via smothering, cutting, and digging. But there's a good chance you'll need an herbicide for Japanese knotweed, especially if the plant has become established. Plus, it often requires multiple attacks to kill Japanese knotweed permanently.

What You'll Need

Equipment / Tools

- Pruners
- Rake
- Tarps or black sheet plastic
- Rocks or other weights
- Shovel
- Garden sprayer
- Rubber gloves and protective clothing

Materials

- Wood chips or mulch
- Plastic garbage bags
- Herbicide

Instructions

How to Smother Japanese Knotweed with Tarps

Covering Japanese knotweed with tarps suppresses the plant's growth and ultimately kills it. This method is best to do in the spring to catch the plant at the start of its growing season. Be aware that while this gets rid of Japanese knotweed naturally and with relatively low effort, it can take several years.

1. Prepare the Area

Prepare the area by using pruners to cut mature weed canes (the tall stems) down to the ground and removing any debris. Bag all the debris to prevent it from taking root.

Then, cover the entire area with a thick layer of cushiony material, such as mulch, leaves, or grass clippings. The canes have sharp edges that can easily puncture plastic sheeting or tarps.

2. Cover the Area

Cover the plant area completely with thick-grade black sheet plastic or heavy non-canvas tarps. If you must overlap pieces, make sure to overlap them by at least 2 feet. The plastic should extend 5 to 10 feet outside the boundary area of the knotweed growth.

Use rocks or other heavy materials to weigh down the tarps, so they don't move or blow away. This covering will need to remain in place for a long time, so you can put wood chips or mulch over it for a nicer appearance.

3. Trample Any New Shoots

As new shoots emerge over time, they might push up the tarps. However, you can easily trample them by walking over the tarps. What growth does occur under the tarps won't amount to much because it lacks sunlight.

4. Remove the Covering and Replant

After roughly five years, the smothered knotweed and roots should be completely dead. You can now remove the covering and replant the area with whatever groundcover, shrubs, or garden plantings you want.

How to Remove Japanese Knotweed by Cutting

Japanese knotweed can be suppressed, though usually not fully eradicated, by cutting it back.[1] This process often must be used in conjunction with other methods to get rid of Japanese knotweed completely.

1. Cut the Plant Down

Use pruners to cut the plant down to the ground throughout the growing season, so it's not able to photosynthesize efficiently. Because the cuttings can easily sprout new roots and take hold in the soil, make sure you gather them all up and bag them for disposal.

2. Monitor and Repeat

Inspect the area weekly, and clip off any new shoots that appear. This is an essential step, as cutting tends to stimulate Japanese knotweed into new growth. So, you should not cut Japanese knotweed unless you stay on top of the new shoots, or you might end up with a more serious infestation than you started with.

After initially cutting the stems, you can use a lawnmower set at a low height to trim off new growth as it appears. It will likely require weekly cutting over many months to completely eradicate Japanese knotweed.

How to Remove Japanese Knotweed by Digging Up the Roots

Another way to get rid of Japanese knotweed naturally is to dig up the ground where the weed shoots come up most vigorously. This is typically used concurrently with other methods.

1. Find the Rhizome Clumps

Locate and dig up the plant's rhizome clumps (underground stems that send up shoots). In mature plants, these rhizome clumps are often very woody and can easily reach widths of a foot or more.

2. Bag Rhizomes for Disposal

Try to get as much of the rhizomes as possible, and bag them for disposal. Even the tiniest piece left behind can sprout a new plant.

Appendix F – Consequence Table

Consequence Factors	Point Criteria	Point Value	Factor Weight	Impact Description
Pipe Function	Collector	1	1	Quantity/Cost
	Transmission	10		
Proximity to sewer piping	>10'	1	1	contamination risk
	<10'	10		
Watershed Size	0-1 ac	1	1	Quantity
	1-5 ac	3		
	5-10 ac	7		
	>10 ac	10		
Pipe Size	≤12"	1	1	Cost/Population Affected
	12" to ≤24"	4		
	24 to ≤30"	7		
	>30"	10		
Depth	≤5'	1	1	Cost
	5' to ≤10'	3		
	10' to 15'	7		
	15'+	10		
Traffic Control	Off Road	1	1	traffic control requirements
	On Road - Detour	3		
	On Road - No Detour	6		
Watershed Landcover	Forested	1	1	flow mitigation
	Grass	4		
	Gravel	6		
	Impervious	10		
Watershed Water Quality	Clean	1	1	contamination risk
	Moderate	5		
	Poor	10		
Type of Detention Pond	Stormwater Ponds	3	1	contamination risk
	Stormwater Wetlands	5		
	Bioretention Systems	7		