PROFESSIONAL SERVICES AGREEMENT BETWEEN CH2M HILL ENGINEERS, INC. AND THE CITY OF ANN ARBOR FOR SANITARY AND STORMWATER SYSTEMS ASSET MANAGEMENT PLANS

The City of Ann Arbor, a Michigan municipal corporation, having its offices at 301 E. Huron St. Ann Arbor, Michigan 48103 ("City"), and CH2M Hill Engineers, Inc. ("Contractor") a Colorado Corporation with its address at 9191 S. Jamaica Street, Englewood, CO, 80112-5946 agree as follows on this ____________ day of __________________, 20___.

The Contractor agrees to provide services to the City under the following terms and conditions:

I. DEFINITIONS

Administering Service Area/Unit means **Systems Planning Unit**

Contract Administrator means **Jennifer Lawson**, acting personally or through any assistants authorized by the Administrator/Manager of the Administering Service Area/Unit.

Deliverables means all Plans, Specifications, Reports, Recommendations, and other materials developed for and delivered to City by Contractor under this Agreement

Project means **Sanitary and Stormwater Systems Asset Management Plans**.

II. DURATION

This Agreement shall become effective on ______________, 20____, and shall remain in effect until satisfactory completion of the Services specified below unless terminated as provided for in Article XI.

III. SERVICES

A. The Contractor agrees to provide Professional Engineering Services ("Services") in connection with the Project as described in Exhibit A. The City retains the right to make changes to the quantities of service within the general scope of the Agreement at any time by a written order. If the changes add to or deduct from the extent of the services, the contract sum shall be adjusted accordingly. All such changes shall be executed under the conditions of the original Agreement.

B. Quality of Services under this Agreement shall be of the level of quality performed by persons regularly rendering this type of service. Determination of acceptable quality shall be made solely by the Contract Administrator.

C. The Contractor shall perform its Services for the Project in compliance with all statutory, regulatory and contractual requirements now or hereafter in effect as may be applicable to the rights and obligations set forth in the Agreement.

D. The Contractor may rely upon the accuracy of reports and surveys provided to it by the City (if any) except when defects should have been apparent to a reasonably competent professional or when it has actual notice of any defects in the reports and surveys.

IV. INDEPENDENT CONTRACTOR

The Parties agree that at all times and for all purposes under the terms of this Agreement each Party's relationship to any other Party shall be that of an independent contractor. Each Party will be solely responsible for the acts of its own employees, agents, and servants. No liability, right, or benefit arising out of any employer/employee relationship, either express or implied, shall arise or accrue to any Party as a result of this Agreement.

V. COMPENSATION OF CONTRACTOR

A. The Contractor shall be paid in the manner set forth in Exhibit B. Payment shall be made monthly, unless another payment term is specified in Exhibit B, following receipt of invoices submitted by the Contractor, and approved by the Contract Administrator.

B. The Contractor will be compensated for Services performed in addition to the Services described in Section III, only when the scope of and compensation for those additional Services have received prior written approval of the Contract Administrator.

C. The Contractor shall keep complete records of work performed (e.g. tasks performed/hours allocated) so that the City may verify invoices submitted by the Contractor. Such records shall be made available to the City upon request and submitted in summary form with each invoice.

VI. INSURANCE/INDEMNIFICATION

A. The Contractor shall procure and maintain during the life of this contract such insurance policies, including those set forth in Exhibit C, as will protect itself and the City from all claims for bodily injuries, death or property damage which may arise under this contract; whether the act(s) or omission(s) giving rise to the claim were made by the Contractor, any subcontractor or anyone employed by them directly or indirectly. In the case of all contracts involving on-site work, the

Contractor shall provide to the City, before the commencement of any work under this contract, documentation satisfactory to the City demonstrating it has obtained the policies and endorsements required by Exhibit C.

B. Any insurance provider of Contractor shall be admitted and authorized to do business in the State of Michigan and shall carry and maintain a minimum rating assigned by A.M. Best & Company's Key Rating Guide of "A-" Overall and a minimum Financial Size Category of "V". Insurance policies and certificates issued by non-admitted insurance companies are not acceptable unless approved in writing by the City.

C. To the fullest extent permitted by law, Contractor shall indemnify, defend and hold the City, its officers, employees and agents harmless from all suits, claims, judgments and expenses, including attorney's fees, resulting or alleged to result, from any acts or omissions by Contractor or its employees and agents occurring in the performance of or breach in this Agreement, except to the extent that any suit, claim, judgment or expense are finally judicially determined to have resulted from the City's negligence or willful misconduct or its failure to comply with any of its material obligations set forth in this Agreement.

VII. COMPLIANCE REQUIREMENTS

A. Nondiscrimination. The Contractor agrees to comply, and to require its subcontractor(s) to comply, with the nondiscrimination provisions of MCL 37.2209. The Contractor further agrees to comply with the provisions of Section 9:158 of Chapter 112 of the Ann Arbor City Code and to assure that applicants are employed and that employees are treated during employment in a manner which provides equal employment opportunity.

B. Living Wage. If the Contractor is a "covered employer" as defined in Chapter 23 of the Ann Arbor City Code, the Contractor agrees to comply with the living wage provisions of Chapter 23 of the Ann Arbor City Code. The Contractor agrees to pay those employees providing Services to the City under this Agreement a "living wage," as defined in Section 1:815 of the Ann Arbor City Code, as adjusted in accordance with Section 1:815(3); to post a notice approved by the City of the applicability of Chapter 23 in every location in which regular or contract employees providing services under this Agreement are working; to maintain records of compliance; if requested by the City, to provide documentation to verify compliance; to take no action that would reduce the compensation, wages, fringe benefits, or leave available to any employee or person contracted for employment in order to pay the living wage required by Section 1:815; and otherwise to comply with the requirements of Chapter 23.

VIII. WARRANTIES BY THE CONTRACTOR

A. The Contractor warrants that the quality of its Services under this Agreement shall conform to the level of quality performed by persons regularly rendering this type of service.

B. The Contractor warrants that it has all the skills, experience, and professional licenses necessary to perform the Services specified in this Agreement.

C. The Contractor warrants that it has available, or will engage, at its own expense, sufficient trained employees to provide the Services specified in this Agreement.

D. The Contractor warrants that it is not, and shall not become overdue or in default to the City for any contract, debt, or any other obligation to the City including real and personal property taxes.

E. The Contractor warrants that its proposal for services was made in good faith, it arrived at the costs of its proposal independently, without consultation, communication or agreement, for the purpose of restricting completion as to any matter relating to such fees with any competitor for these Services; and no attempt has been made or shall be made by the Contractor to induce any other perform or firm to submit or not to submit a proposal for the purpose of restricting competition.

IX. OBLIGATIONS OF THE CITY

A. The City agrees to give the Contractor access to the Project area and other City-owned properties as required to perform the necessary Services under this Agreement.

B. The City shall notify the Contractor of any defects in the Services of which the Contract Administrator has actual notice.

X. ASSIGNMENT

A. The Contractor shall not subcontract or assign any portion of any right or obligation under this Agreement without prior written consent from the City. Notwithstanding any consent by the City to any assignment, Contractor shall at all times remain bound to all warranties, certifications, indemnifications, promises and performances, however described, as are required of it under the Agreement unless specifically released from the requirement, in writing, by the City.

B. The Contractor shall retain the right to pledge payment(s) due and payable under this Agreement to third parties.

XI. TERMINATION OF AGREEMENT

A. If either party is in breach of this Agreement for a period of fifteen (15) days following receipt of notice from the non-breaching party with respect to a breach, the non-breaching party may pursue any remedies available to it against the breaching party under applicable law, including but not limited to, the right to terminate this Agreement without further notice. The waiver of any breach by any party to this Agreement shall not waive any subsequent breach by any party.

B. The City may terminate this Agreement, on at least thirty (30) days advance notice, for any reason, including convenience, without incurring any penalty, expense or liability to Contractor, except the obligation to pay for Services actually performed under the Agreement before the termination date.

C. Contractor acknowledges that, if this Agreement extends for several fiscal years, continuation of this Agreement is subject to appropriation of funds for this Project. If funds to enable the City to effect continued payment under this Agreement are not appropriated or otherwise made available, the City shall have the right to terminate this Agreement without penalty at the end of the last period for which funds have been appropriated or otherwise made available by giving written notice of termination to Contractor. The Contract Administrator shall give Contractor written notice of such non-appropriation within thirty (30) days after it receives notice of such non-appropriation.

D. The provisions of Articles VI and VIII shall survive the expiration or earlier termination of this Agreement for any reason. The expiration or termination of this Agreement, for any reason, shall not release either party from any obligation or liability to the other party, including any payment obligation that has already accrued and Contractor's obligation to deliver all Deliverables due as of the date of termination of the Agreement.

XII. REMEDIES

A. This Agreement does not, and is not intended to, impair, divest, delegate or contravene any constitutional, statutory and/or other legal right, privilege, power, obligation, duty or immunity of the Parties.

B. All rights and remedies provided in this Agreement are cumulative and not exclusive, and the exercise by either party of any right or remedy does not preclude the exercise of any other rights or remedies that may now or subsequently be available at law, in equity, by statute, in any agreement between the parties or otherwise.

C. Absent a written waiver, no act, failure, or delay by a Party to pursue or enforce any rights or remedies under this Agreement shall constitute a waiver of those rights with regard to any existing or subsequent breach of this Agreement. No waiver of any term, condition, or provision of this Agreement, whether by conduct or otherwise, in one or more instances, shall be deemed or construed as a continuing waiver of any term, condition, or provision of this Agreement. No waiver by either Party shall subsequently effect its right to require strict performance of this Agreement.

XIII. NOTICE

All notices and submissions required under this Agreement shall be delivered to the respective party in the manner described herein to the address stated in this Agreement or such other address as either party may designate by prior written notice to the other. Notices given under this Agreement shall be in writing and shall be personally delivered, sent by next day express delivery service, certified mail, or first class U.S. mail postage prepaid, and addressed to the person listed below. Notice will be deemed given on the date when one of the following first occur: (1) the date of actual receipt; (2) the next business day when notice is sent next day express delivery service or personal delivery; or (3) three days after mailing first class or certified U.S. mail.

If Notice is sent to the CONTRACTOR, it shall be addressed and sent to:

CH2M Hill Engineers, Inc.
Matthew Leach, PE
1103 Schrock Road, Suite 400
Columbus, OH 43229

If Notice is sent to the CITY, it shall be addressed and sent to:

City of Ann Arbor
Craig Hupy
301 E. Huron St.
Ann Arbor, Michigan 48103

XIV. CHOICE OF LAW AND FORUM

This Agreement will be governed and controlled in all respects by the laws of the State of Michigan, including interpretation, enforceability, validity and construction, excepting the principles of conflicts of law. The parties submit to the jurisdiction and venue of the Circuit Court for Washtenaw County, State of Michigan, or, if original jurisdiction can be established, the United States District Court for the Eastern District of Michigan, Southern Division, with respect to any action arising, directly or indirectly, out of this Agreement or the performance or breach of this Agreement. The parties stipulate that the venues referenced in this Agreement are convenient and waive any claim of non-convenience.

XV. OWNERSHIP OF DOCUMENTS

Upon completion or termination of this Agreement, all documents (i.e., Deliverables) prepared by or obtained by the Contractor as provided under the terms of this Agreement shall be delivered to and become the property of the City. Original basic survey notes, sketches, charts, drawings, partially completed drawings, computations, quantities and other data shall remain in the possession of the Contractor as instruments of service unless specifically incorporated in a deliverable, but shall be made available, upon request, to the City without restriction or limitation on their use. The City acknowledges that the documents are prepared only for the Project. Prior to completion of the contracted Services the City shall have a recognized proprietary interest in the work product of the Contractor.

Unless otherwise stated in this Agreement, any intellectual property owned by Contractor prior to the effective date of this Agreement (i.e., Preexisting Information) shall remain the exclusive property of Contractor even if such Preexisting Information is embedded or otherwise incorporated in materials or products first produced as a result of this Agreement or used to develop Deliverables. The City's right under this provision shall not apply to any Preexisting Information or any component thereof regardless of form or media.

XV. CONFLICTS OF INTEREST OR REPRESENTATION

Contractor certifies it has no financial interest in the Services to be provided under this Agreement other than the compensation specified herein. Contractor further certifies that it presently has no personal or financial interest, and shall not acquire any such interest, direct or indirect, which would conflict in any manner with its performance of the Services under this Agreement.

Contractor agrees to advise the City if Contractor has been or is retained to handle any matter in which its representation is adverse to the City. The City's prospective consent to the Contractor's representation of a client in matters adverse to the City, as identified above, will not apply in any instance where, as the result of Contractor's representation, the Contractor has obtained sensitive, proprietary or otherwise confidential information of a non-public nature that, if known to another client of the Contractor, could be used in any such other matter by the other client to the material disadvantage of the City. Each matter will be reviewed on a case by case basis.

XVII. SEVERABILITY OF PROVISIONS

Whenever possible, each provision of this Agreement will be interpreted in a manner as to be effective and valid under applicable law. However, if any provision of this Agreement or the application of any provision to any party or circumstance will be prohibited by or invalid under applicable law, that provision will be ineffective to the extent of the prohibition or invalidity without invalidating the remainder of the provisions of this Agreement or the application of the provision to other parties and circumstances.

XVIII. EXTENT OF AGREEMENT

This Agreement, together with any affixed exhibits, schedules or other documentation, constitutes the entire understanding between the City and the Contractor with respect to the subject matter of the Agreement and it supersedes, unless otherwise incorporated by reference herein, all prior representations, negotiations, agreements or understandings whether written or oral. Neither party has relied on any prior representations, of any kind or nature, in entering into this Agreement. No terms or conditions of either party's invoice, purchase order or other administrative document shall modify the terms and conditions of this Agreement, regardless of the other party's failure to object to such form. This Agreement shall be binding on and shall inure to the benefit of the parties to this Agreement and their permitted successors and permitted assigns and nothing in this Agreement, express or implied, is intended to or shall confer on any other person or entity any legal or equitable right, benefit, or remedy of any nature whatsoever under or by reason of this Agreement. This Agreement may only be altered, amended or modified by written amendment signed by the Contractor and the City. This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which together shall be deemed to be one and the same agreement.

FOR CONTRACTOR

By ______________________________
Type Name

Its

FOR THE CITY OF ANN ARBOR

By ______________________________
Christopher Taylor, Mayor

By ______________________________
Jacqueline Beaudry, City Clerk

Approved as to substance

____
Tom Crawford, Interim City Administrator

____
Craig Hupy, Service Area Administrator

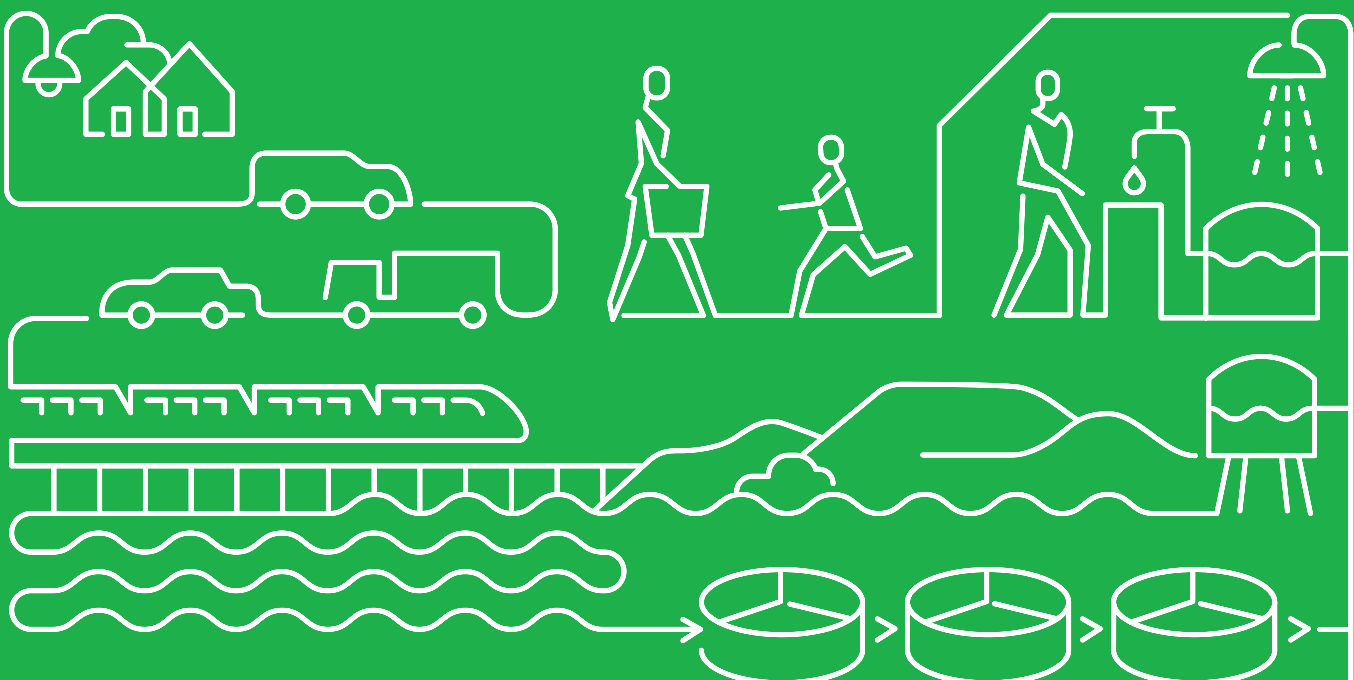
Approved as to form and content

____
Stephen K. Postema, City Attorney

EXHIBIT A
SCOPE OF SERVICES

(Insert/Attach Scope of Work & Deliverables Schedule)

Sanitary Sewer Collection System



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Tab B
Proposed Work Plan

Project Approach

Ann Arbor faces all-too-familiar challenges, increased cost of services, aging existing infrastructure, and the need to optimize investments in maintaining their assets. Like many utilities throughout North America, Ann Arbor has identified a need for an asset management (AM) process to prioritize capital projects for their CIP as well as to optimize their operations and maintenance (O&M) of their systems to minimize the life cycle costs.

The CH2M team has helped develop successful infrastructure Asset Management processes for many water utilities across Michigan and North America, including Oakland County WRC, Auburn Hills, Livonia, as well as for Columbus DPU, DC Water, Dayton Water and Northern Kentucky Sanitation District 1.

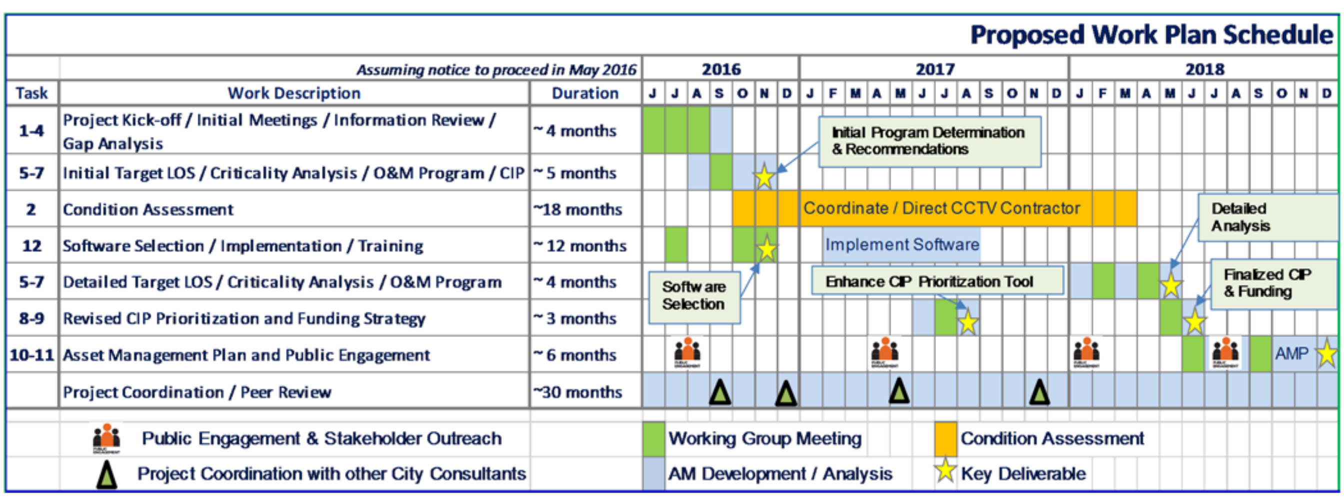
The CH2M team will provide Ann Arbor with an AM program for evaluating the physical assets of the sanitary collection system to ensure safe and reliable service, while maximizing each asset's useful life in the most economical manner. In this process, we plan to fully engage key stakeholders and emphasize effective content delivery and communication to the public. The effort is focused on developing a sustainable asset management program, as well as associated tools, processes, and data that prioritizes capital and operational expenditures in the maintenance, repair, rehabilitation, and replacement of the sanitary collection system infrastructure in a proactive manner. In order to achieve these results, the CH2M team has identified ***five keys to success*** for Ann Arbor to develop a leading practice AM program to address their project goals:

Our 5 Keys to Success

1. **Produce Early Wins**
2. **Optimize the O&M Program**
3. **Develop a Messaging Strategy Early in the Project**
4. **Maximize Collaboration with Related Projects and Key Stakeholders**
5. **Utilize CH2M's SCREAM software**

▶Produce Early Wins to Guide the Program and Win Staff and Key Stakeholder Support

The CH2M team understands that this is a very important project for the City of Ann Arbor and may last up to 3-years. However, 3-years is too long for the City to wait to receive recommendations and begin implementing the asset management plan final deliverable. A sustainable AM program needs to build on the success that Ann Arbor has already achieved and enhance their processes to achieve their ultimate goals. Within the first 6-months, our team will kick-off the program with a focused, initial effort to understand the City's systems, processes, data, IT systems as well as key stakeholder expectations. We will perform an initial gap assessment to better understand your utility and provide initial recommendations that the City can immediately implement. In addition, we will perform a criticality analysis of your



system based on existing data and institutional knowledge to provide an initial risk prioritization to help focus condition assessment and O&Ms on the pipes with the highest risk. It is our experience with other utilities that producing quick results that staff can quickly use helps to win their support of the AM program and adopt new process changes.

▶ Optimize the O&M Program

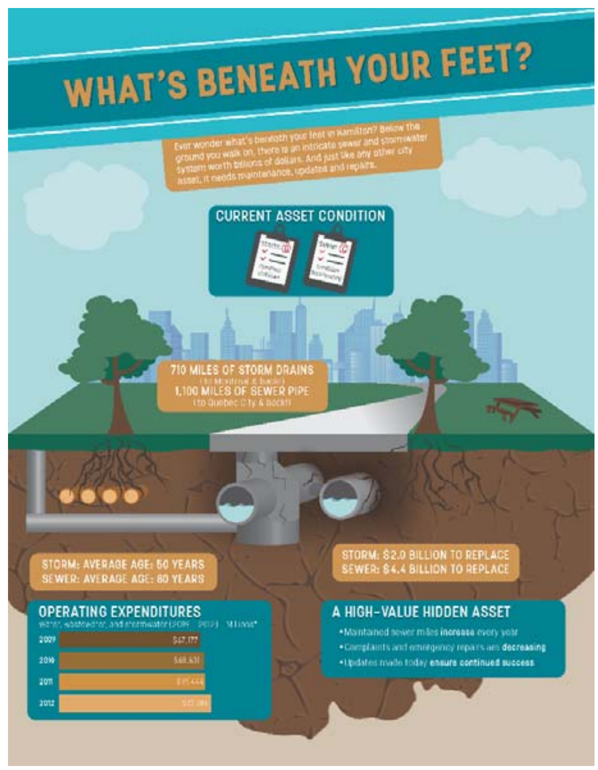
A sustainable AM program must include optimization of a utilities O&M program to efficiently and effectively maintain their system and achieve the most life out of their assets. The CH2M team includes experienced operators that can quickly assess your O&M practices, staffing and equipment. Our experience in operating over 100 water/wastewater system across North American gives us first-hand experience of knowing what really works and the proper intervals of doing the right maintenance and inspections. In addition, our team has helped to implement numerous field GIS applications to help streamline the O&M process and assist in collecting valuable data. Finally, our team will leverage our experience and carefully account for key staff operations and maintenance considerations when developing condition assessment procedures to be used by the City and City acquired contractors.

A GIS enabled hand-held device like that developed for the City of Newport can be developed specifically for Ann Arbor to enhance data gathering and Cityworks work order management.

▶ Develop a Messaging Strategy Early in the Project

Creating a messaging strategy early in the project to engage key stakeholders and educate the public will be vital. We have teamed with Lambert, Edwards and Associates (LE&A) who will bring a wealth of national and State of Michigan experience in developing a core messaging strategy and lead our public relations efforts. The graphic shown here is an example on the use of an infographic which can play an extremely important role in educated the public and winning key stakeholder's support for Ann Arbor AM program. This infographic was developed for this proposal based on the Ontario Hamilton asset management program mentioned in the pre proposal meeting. CH2M was the lead firm in developing the asset management program for the City of Hamilton.

In addition, our experience in developing AM programs across North America has shown that early engagement of internal stakeholders is vital to the long-term success of the asset management program. The CH2M team will develop a framework for effective communication between the City's Field Operations, Systems Planning, and Project Management Services Units. This will be critical as the program is implemented to ensure newly-developed tools are used effectively between the three Units and that data is collected, shared, and used in a cost-effective and consistent manner.



Infographics are powerful communications tools to help tell Ann Arbor's Asset Management Story to the public and stakeholders.

▶ Maximize Collaboration with Related Projects

Ann Arbor is proactively planning for their future through numerous studies and programs. Each of these play an important part in developing a sustainable asset management program. The CH2M team will coordinate with these other consultants and studies through the AM program. We will proactively meet with the City and their consultant to understand and align the AM program with these other efforts. For example, as part of the Columbus DPU AM program, CH2M was proactive in coordinating the AM program with other City priority program such as their Capacity, Management, Operations, and Maintenance (CMOM), wet weather and green infrastructure programs. Our team will coordinate and incorporate the results of the following projects at minimum:

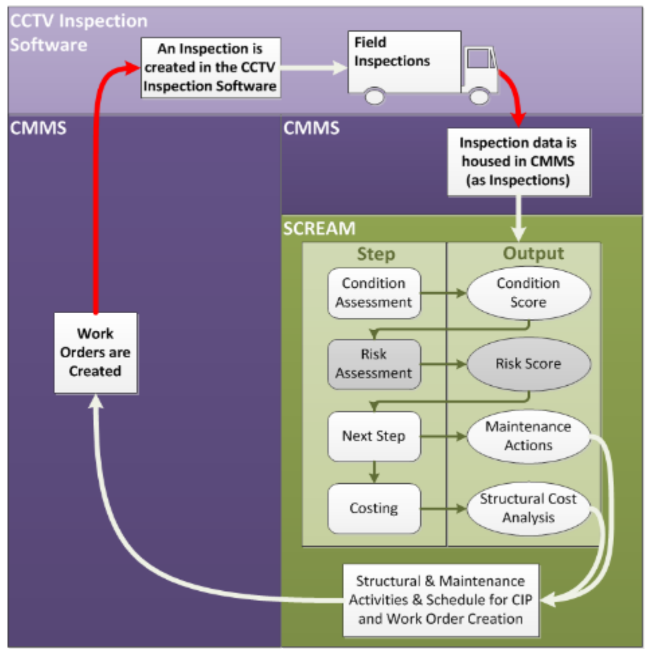
- City of Ann Arbor Sanitary Manhole I/I Reduction Investigation (anticipated to start soon)
- Sanitary Sewer Wet Weather Evaluation Project
- Green Infrastructure Asset Management Plan (anticipated to be completed soon)
- Stormwater Level of Service and Rate Analysis Study (anticipated to start soon)
- Water and Wastewater Capital Cost Recovery Study
- Washtenaw County Stormwater SAW Asset Management Program (ongoing)

We believe coordination with Washtenaw County is important because any potential deficiencies that may result in the County infrastructure within the City limits, e.g. the Allen Creek enclosure, may have significant level of service and potential cost ramifications to City residents and stakeholders. In addition, our team will work with the City to coordinate with other City departments and groups, such as the Planning, Project Management, and Field Operations departments in order to ensure that the asset management programs and procedures developed as part of this program can effectively be used by these service units. This will help to align the AM program with other departments and to help coordinate capital projects with other similar capital projects. As part of CH2M's CIP prioritization work on Ann Arbor's Water Master Plan, the CIP prioritization tool that we developed for the City was expanded to include multiple City departments to help align capital projects across the City.

▶ Utilize CH2M's SCREAM™ software to cost-effectively maximize the use of existing data

The CH2M team will initially utilize CH2M's Storm/Sanitary Condition Review Enhanced Assessment Method (SCREAM™) to quickly evaluate coding identified in the CCTV database. Our initial review will help to assess and potentially utilize the City's existing 6,700 CCTV records. We understand that the coding in these records are not necessarily reliable or complete. However, utilizing an automated tool such as SCREAM will help assess available data, potential coding errors and records to prioritize for further, detailed review in an efficient and timely manner. SCREAM uses advanced algorithms to produce a more granular view of the City's pipes than what PACP can provide. CH2M has also been successful in building SCREAM's logic into Innovyze's InfoMaster software, as well as working alongside many CMMS systems (including Cityworks) and ArcGIS.

The following pages describe our work plan and technical approach to complete tasks 1-12 as noted in the RFP, as well as an optional task 13 they may benefit the City's O&M program.



SCREAM integrates with CCTV software and CMMS to exchange info between the field and the office

Task 1 – Asset Inventory

As part of the initial discovery effort, our CH2M team will work with Ann Arbor staff to review the database structure, existing asset inventory, existing asset hierarchy in Cityworks / GIS, and data management workflows. We will perform a desktop analysis comparing the requirements and needs of the program, the current data management framework, and industry best practices and standards to develop recommendations for a data model. Our team has in-depth knowledge of sanitary sewer collection data models and will apply our expertise to produce a data model that covers all current and anticipated future needs of the systems. This will include consideration for condition assessment, risk scoring, Asset ID, maintenance activities, infrastructure deterioration modeling, use of an Asset Management software and other considerations that may arise as requirements.

Under the direction and oversight of our task leader **Murat Ulasir**, the majority of the data collection and inventory will be performed by highly qualified, local OHM staff and key CH2M staff. The effort will focus on existing data in Ann Arbor's GIS and Cityworks databases, and will include, for example, age, pipe slope, material, diameter, installation conditions, collapse history, CCTV records, and work order history. In addition, CH2M is a Cityworks Platinum Partner, an ESRI Silver Partner and

Authorized Integrator, and an Oracle Systems business partner, with extensive expertise in linking GIS spatial data with Oracle databases, as well as SQL server databases.

Ann Arbor staff will be asked to provide existing data dictionaries and similar documentation of the Cityworks asset records, GIS geodatabase, modeling databases, performance data, and similar systems that currently house asset information. The completeness and quality of the data will be discussed with Ann Arbor staff. The appropriate system of record will be identified for each piece of data so it is understood which system is the master repository and is used to maintain certain types of data. As part of the Request for Proposals, the City provided consultant teams with its existing sanitary sewer GIS database. The work plan components detailed under this task make use of this GIS information. Key subtasks are described below.

1.1 Review of Existing Asset Inventory for Each System

It is our understanding that the review of asset inventory as part of this proposal will exclude lift stations within the sanitary sewer collection system. **Table 1-1** summarizes the asset categories available in the City GIS. **Figure 1-1** further details the sanitary sewer asset inventories.

Table 1-1: Sanitary Sewer Asset Categories in City GIS

Asset Category	Quantity	Age	Condition	Last Inspected
Valves	9	Not available	Good	Not available
Manholes	11,613	Not available	Good	Not available
Laterals	~ 67 miles	Not available (less than 25% has dates)	Good	Not available
Sanitary Siphons**	9	Not available	Not available	Not available
Sanitary Sewers	~ 417 miles*	56 (average)	Good	Not available
Force Main**	7,800 ft	Not available	Not available	Not available

Notes:
**: the GIS based value is listed on the table. The RFP suggests that the length of sanitary sewer is approximately 370 miles*
***: Not explicitly called out in the City GIS database that was made available and was listed in the RFP*

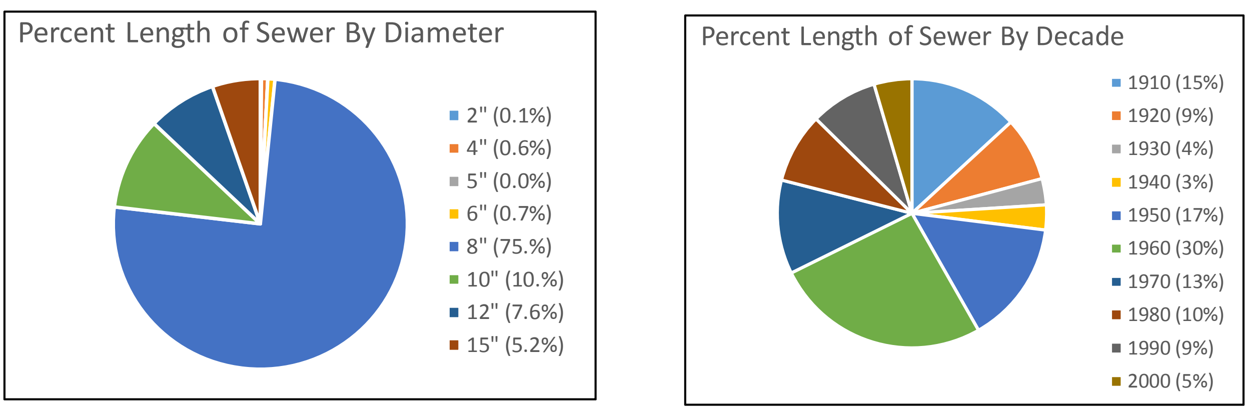


Figure 1-1 – Sanitary Sewer Asset Inventory Detail

Figure 1-1 suggests that the City experienced a growth spell in the 1910s followed by another growth spell between the 1950s and 1960s, during which nearly 50% of the sanitary sewer infrastructure was installed. In addition, based on City GIS data, 8-inch diameter sewer comprises nearly 75% of the sanitary sewer infrastructure.

As part of our review of existing inventory, we propose to extend our assessment and review of available data to assets not covered in **Figure 1-1** in a similar manner, i.e. extract key asset category information from available data.

Regular progress review and coordination meetings\calls will be held to ensure the effort is performed as efficiently and effectively as possible. Also, OHM's familiarity with Ann Arbor's sanitary sewer infrastructure will help inform our efforts due to our team's thorough knowledge of the asset types, typical failures, areas of concern, and differing installation conditions from past decades. This knowledge base of infrastructure systems and installation practices can be leveraged to expand condition information to other parts of the system for which no condition information is available. Furthermore, data gaps will become apparent, which is further discussed in the next section.

1.2 Identify Gaps in Data

Table 1-1, for example, suggests that a significant amount of condition data, material, as well as installation year, is missing from the data set. This information is pertinent particularly in evaluating trends in the data for asset condition and is helpful in extrapolating condition information to the rest of the system for which no historic condition data either exists or is planned on being collected in the future. We plan on identifying additional, relevant data gaps for the asset categories.

1.3 Recommend a Strategy to Obtain Missing Information

One simple means by which asset age can be approximated is through institutional knowledge of senior staff in the organization. Another means would be through an evaluation of construction ages of homes, potentially accessible through parcel data and researching historical aerial photography to determine when specific neighborhoods were constructed. As part of this task, we propose to further identify strategies for obtaining relevant information. Some of these strategies may include the following:

- Historic soil boring records or NRCS soil atlases for understanding soil conditions
- Institutional knowledge of senior staff
- City parcel data
- As-built records
- Records of nearby infrastructure (such as water main)
- Enabling field crews with best practices for updating data
- Washtenaw County historical imagery (goes back to ca. 1940s)

1.4 Adding Missing Asset Sub-Categories & Reporting Out Asset Inventories

The most optimum means of adding asset sub-category data as well as reporting out asset inventory can be impacted by two broad categories:

- The user profile – whether information needs to be reported out to field crews or planning personnel
- Toolsets – the type of asset management software and capabilities the City chooses.

As will be addressed in Task 12 of this proposal, for example, several asset management platforms exist, which not only offer data analysis and forecasting functionality but also means of appending and reporting out on asset inventory as well as existing and anticipated future asset condition. In addition, ESRI local government information models provide means by which asset data can be added or reported out depending on the target user profile. For example, the Water Utility Mobile Map template application allows field staff to gain access to utility information as well as communicate field observation back to office staff. We propose to evaluate these options with City staff as part of this task.

Task 2: Condition Assessment

The CH2M team will use a proven condition assessment framework and partner with Ann Arbor to develop a condition assessment approach that efficiently evaluates the sanitary collection system's data and builds on institutional knowledge. Prior to defining parameters affecting asset condition, the general mechanisms of asset failure need to be evaluated. In the context of sanitary infrastructure, the infrastructure component is considered failed if it does not fulfill its desired level of service functionality, whether it be social, economic, or environmental / regulatory. As such, ***we plan on utilizing a comprehensive condition assessment process including four different types of failure mechanisms*** as follows:

- Structural (such as severely corroded buried sanitary conveyance pipes or stream crossings (e.g. culverts), deformations in sewer pipes, erosion along pond shorelines, channel bank failures, and malfunctioning pond outlet structures)
- Environmental (such as flooding-induced hydrostatic forces on storm infrastructure, hydrogen sulfide induced corrosion in sewer pipes, and increased sediment loading caused by streambank erosion)
- Capacity (such as excessive inflow and infiltration into sanitary sewers)

Operations & Maintenance (such as sedimentation build up in sanitary infrastructure (including detention ponds), root balls in sanitary sewers)

Out of these failures, operations & maintenance induced ones are the more frequent, although, capacity and structural failure induced ones can have higher consequence of failure. Key subtasks are described below.

2.1 Review Existing City-Collected Condition Assessment Data

In the context of the above discussion, we plan on condition evaluating the sanitary infrastructure utilizing structural, environmental, capacity and O&M factors. Table 1-1 in Task 1 summarized condition information on infrastructure digitized in the City GIS system and information provided in the RFP (Request for Proposals). However, it is our understanding from the pre-bid meeting for the proposed work that the condition information contained in the GIS might not necessarily correspond to the true condition in the field. Besides, many other infrastructure asset categories did not have any data available for condition. For example, the Green Infrastructure asset management plan is being developed as we understand it, which may include inventory and condition assessment of roadside bioretention cells, rain gardens, sub-pavement infiltration areas, etc. On the sanitary sewer side, a manhole condition assessment work is being developed, intended to reduce excessive inflow and infiltration into the sanitary sewer system. We plan on integrating the findings of these studies into the work plan discussed in this proposal. In general, we plan on utilizing, at a minimum, the information below for developing a comprehensive condition assessment of the infrastructure:

- Sanitary Sewer Wet Weather Evaluation Project Final Report
- Sanitary Sewer Manhole I/I Reduction Investigation
- City's 2016-2021 Capital Improvements Plan
- GIS layers and database
- Historical maintenance records
- As-built plans for public sanitary sewers
- Documented system cleaning schedules
- 6,700 Digital CCTV Videos of sanitary sewer pipe conveyance segments (available since 2012, not PACP scored)

The value of this exercise would be that it would not take many resources to review large amounts of CCTV data in a short period of time. Erroneous or inconsistent defect coding can be quickly identified, prioritized, and evaluated by our trained PACP staff.

Automated Condition Assessment Tool

As part of this task, we plan on utilizing CH2M's proprietary condition assessment tool as well as the Storm/Sanitary Condition Review Enhanced Assessment Method (SCREAM) to quickly summarize coding identified in the CCTV tapes. As noted in the Request for Proposal and further detailed in Addendum 2, we understand that the City has 6,700 videos of pipe segments in their systems (approximately 5,500 for the sanitary collection system), which was collected since 2012. However, these videos and the associated data are not a trusted data source by City staff. In particular, the defect coding used to assess the pipe condition did not directly follow NASSCO's PACP standards. Our team will review the PipeLogix database and conduct a quality control (QC) review of a portion of the videos (100 segments) to assess the usability of this data. Base on this review, our team will provide recommendations to the City on how best to use this data. In particular, we have had other utilities that have made consistent miscoding of defects (i.e. fracture instead of crack). If this is the case, we have made this coding change in the database. If the miscoding is more random, the dataset can still potentially be used to help prioritize future condition assessments as noted in our approach below. While the database may not be accurate enough to be used for condition ratings, it can still identify the more severe issues in the buried assets.

2.2 Determine Asset Assessment Methodology

To lay the groundwork for the condition assessment, our **Condition Assessment Leads Kyle Curie and Reggie Rowe** will facilitate a targeted workshop with the Ann Arbor team. During the workshop, we will establish consensus regarding the goals and approach for the systems condition assessment and reach a common understanding of the data requirements for each major asset category. The outcome of the workshop will include the following:

- ***A list of asset condition attributes to be collected for each asset or component*.** We will use our team's extensive database of attributes for pipes, manholes, special structures, basins, etc. as a starting point at the workshop.
- ***Weighting criteria for the asset condition factors.*** Because certain factors may be considered more important or have greater impact on overall asset condition, the workshop will establish consensus-based weightings.

- ***Determination of "priority assets."*** We will conduct a more detailed assessment on priority assets. Lower priority or less critical assets will be evaluated by direct visual observation or desktop methods.
- ***Obtain staff input***. Staff input is critical to understanding asset condition and determining likelihood of failure. Some input will be obtained during this stakeholder workshop, and a process will be established to encourage and efficiently allow knowledge transfer.
- ***A process for prioritizing the data collection tasks***. We will initially use a "top-down" approach to initially assess the assets. All assets will be graded on a scale of 1 through 5, with 1 being excellent overall condition and 5 being failed. During the workshop, the understanding of the relative grading for condition will be finalized. This initial "top-down" approach will be used to provide a baseline for the entire system as well as to prioritize areas, pipe types (material, diameter, age) to be assessed.
- ***Condition assessment schedule.*** A condition assessment schedule will be developed based on the available existing and usable data, along with the initial prioritization to develop a schedule for condition inspections. We recommend developing a Tiered Adaptive Plan (TAP) to create a sustainable process for the City to continue to inspect their pipe assets beyond this initial project (**Exhibit 1**). This approach will help to efficiently rate the system and maximize the amount of condition data to be developed as part of this work. The schedule will extend beyond the completion of this project, so that the City's ongoing condition assessment efforts can be planned. If desired by the City, these inspections can be scheduled in Cityworks and setup on a selected schedule to ensure that all the systems' pipes will evaluated.
- ***Create a communication framework between the City's Public Works Units.*** We understand the value of effective organizational communication in ensuring that different branches of the organization rely on the same set of data and information when making critical infrastructure decisions. For that purpose, we plan to create a framework for effective communication between the City's Field Operations, Systems Planning, and Project Management Services Units. This will be critical in ensuring newly-developed tools and software packages that the City chooses to acquire as part of this proposal are used seamlessly between the three Units and that data are collected, shared, and used in a consistent manner.

Our Asset Management field staff have worked with many communities to create custom data collection methods to meet our clients' unique software and hardware needs. Our targeted key City staff and stakeholder workshop will help us establish data collection "ground rules" that will help ensure the data we collect can be seamlessly integrated with the City's Asset Management Software and GIS platforms.

In addition to the above, we plan on developing asset assessment methodologies in collaboration with City staff to ensure that staff can quickly assess the condition of assets in each system. Some examples of our assessment methodologies are summarized below for consideration.

Sanitary sewer infrastructure that will have a methodology developed for the following asset types:

- Sanitary Sewers (including mains, trunk sewers and interceptors)
- Force Mains
- Manholes
- Sanitary Laterals
- Valves

Plan for Obtaining Necessary Condition Assessment Data

The plan necessary for obtaining missing condition assessment data must consider the need to be able to use this data to reliably predict the condition of assets that are not assessed. For that purpose, we propose to utilize a statistical sampling procedure that is also used in social and clinical population studies, which rely on confidence intervals. For example, it is well established that, barring other unusual system characteristics, manhole installation years correlate with material and therefore, a decades-based manhole sampling strategy is reasonable. However, the sample must be random if it is to be used to infer the condition of the remaining manholes in the system and must also include a minimum sampling size depending on the size of the population (i.e. the number of manholes in the entire system) as well as the desired level of confidence in using the information from this sample to project out to the rest of the system.

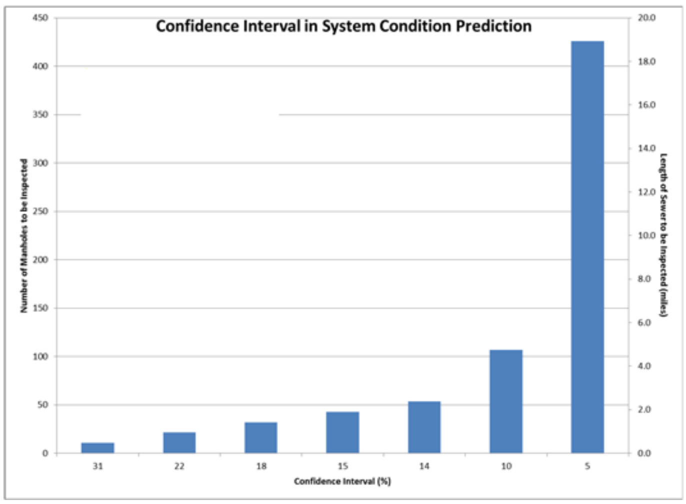
Figure 2-2 shows an example of a variation of manhole sample size against desired confidence interval. The example in this figure is for a population of approximately 11,000 manholes (or this number can represent storm manholes/catch basin inlets) and suggests that for a confidence interval of less than 5%, the sampling size would have to be nearly 450. It is important to note that for this process,

- The samples must be randomly chosen, and;
- Must reflect the distribution of the community infrastructure – a sample manhole/structure distribution is shown in **Figure 2-3** and reflects the communities existing infrastructure makeup.

Once this plan is followed, the assignment of condition to the rest of the manholes/structures infrastructure that has not been condition assessed, based on installation year, for example, can be done with reasonable degree of confidence.

A Word About Manholes

Manhole condition assessment is often overlooked or considered secondary to inspection of the interceptor pipes and trunk lines. Manholes represent the "links of the chain" of the conveyance system, and a manhole failure can have the same impact to the network and surroundings as a pipeline failure of the pipeline. For this reason, the methods and tools described in our approach would all include analyses, modules, and recommendations specific to these access structures.



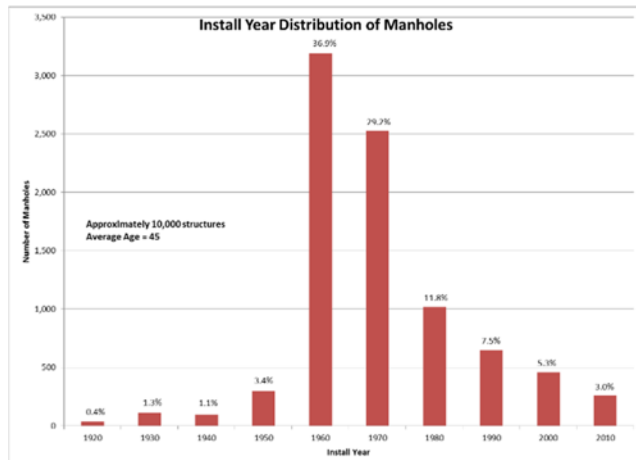


Figure 2-2 and 2-3: Selecting the Appropriate Sample Size

Throughout the project and as detailed in the remaining tasks for this project, our team will identify the answers to these questions and develop a schedule for obtaining condition information for the remainder of the system.

2.3 CCTV Contractor Selection Assistance and Coordination

The CH2M team understands that the City would like assistance on the procurement of a pipe televising contractor for the prioritized areas to assess noted above. Our team will work with the City to prepare a draft CCTV inspection specification for the selected contractor to meet that follows PACP/MACP guidelines. The specification will identify the format for the inspections, QC process and the process for turning over the data to the City. This specification will be reviewed by the City and used to select a qualified CCTV firm to conduct the prioritized inspections. Our team will assist the City through procurement and selection of a CCTV contractor through a separate contract from this project. Furthermore, our team is well versed in the type of televising options and their respective benefits. For example, two broad categories of televising options exist: 1) Clean first and televise later; or 2) Televise first, clean if needed. Either option has its pros and cons and our team is prepared to discuss these with the City team to select the most optimum option for consideration.

CCTV Contractor Coordination

The CH2M team will regularly meet with the selected CCTV contractor to assess the condition of the assets and ensure the data are being delivered in an acceptable format. Our team also includes experienced and NASSCO-certified PACP/MACP staff, who can quality control the data that is being collected by the sub-contractor. For example, our team utilizes ArcGIS online technology to track process of field assessment by sub-contractors as well as locations that are being evaluated on a nearly real time basis. A screen capture of this online tool is shown below. Team members **Kyle Curie and Tim Newton** will apply their background in operations to develop assessment criteria that identify O&M improvements. **The condition assessment criteria will be entered into CH2M's proprietary SCREAM database, which will expedite the data management and retrieval process.**

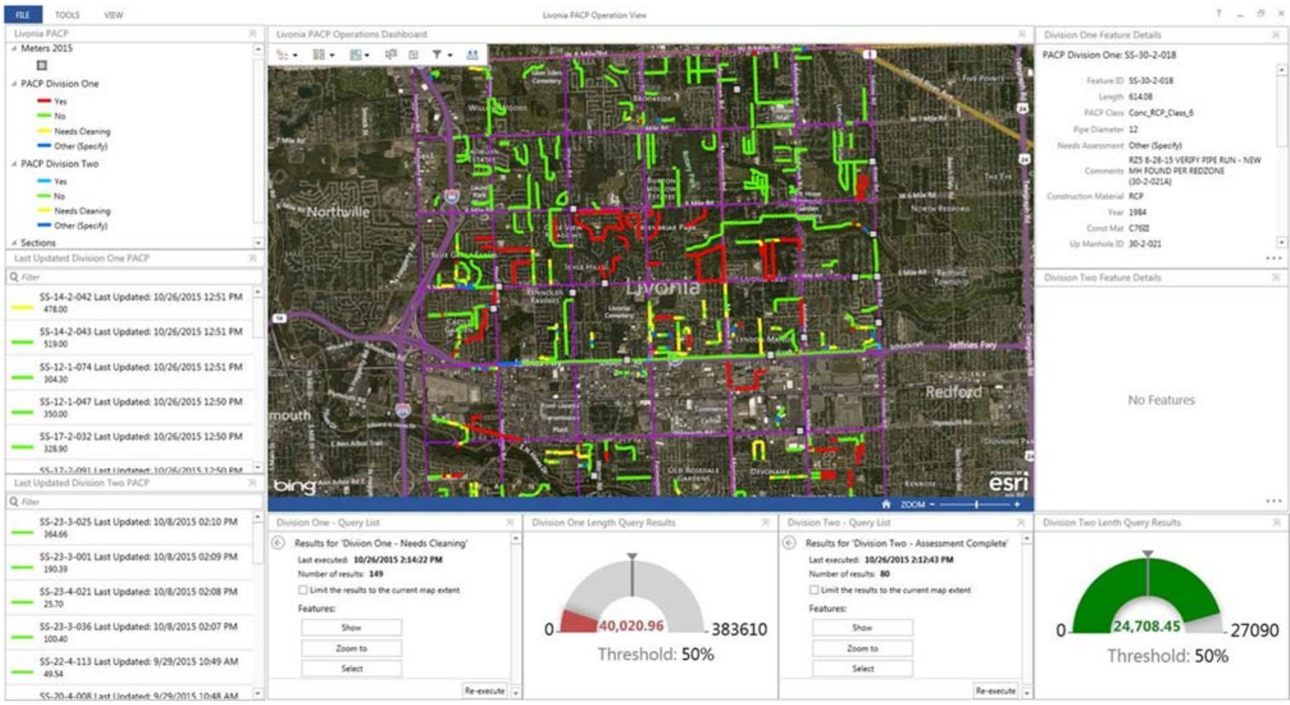


Figure 2-2: ArcGIS Online Infrastructure Inventor Tracking Tool

2.4 Performance of the Systems' Assets

A Condition Assessment technical memorandum will be developed that summarizes the findings of the condition assessment, analysis of the assets by asset class, and the critical and/or priority assets requiring maintenance, renewal, or replacement, as well as prioritizing assets for additional or immediate follow up. These initial findings of the Condition Assessment technical memorandum will be presented to Ann Arbor staff in a workshop, where additional feedback and comments will be gathered before finalizing the technical memorandum. Data from the analyses performed will be supplied to Ann Arbor as part of the Condition Assessment technical memorandum. The SCREAM database will be formatted so that it can be easily uploaded into Cityworks.

Our approach to asset failure goes beyond just assessing structural failures of the system.

Task 3 - Useful Life Calculation

Assessing the remaining asset life is a very important process as it has a significant impact on factors such as:

- Optimizing capital expenditures
- Optimizing operations and maintenance strategies

Therefore, careful consideration must be given to not only determining remaining asset life but also continuously assessing asset condition such that remaining life estimates are properly calibrated and adjusted.

In Task 2 of this work plan, we outlined various means by which assets can fail and also defined what asset failure means in the context of this work plan. As such, in Task 2, asset failures included not only structural, environmental, but also capacity and operations and maintenance failures. Therefore, our approach to asset failure goes beyond just assessing structural failures of the system. Our techniques will assess structural and O&M failures and estimate remaining useful life based on these failure modes. We assume capacity failures have already been accounted for by several recent sanitary studies completed by the city.

3.1 Operations & Maintenance Failure Data Review and Remaining Useful Life Analysis

As part of the base proposal, we propose to assess the operations and maintenance failure of the infrastructure by reviewing historic work order records, compiling institutional knowledge, and converting these findings to frequency of occurrence estimates utilizing a Pearson Type III type probability distribution method. As an optional task, given the availability and quality of historic records, we suggest a more rigorous operations and maintenance failure modeling. A description of this optional task is provided under optional tasks in this work plan.

3.2 Structural Condition Based Remaining Useful Life Analysis

There are several means by which structural condition based remaining useful life can be estimated. We propose to use these methods depending on availability of historic data for each asset type. In an effort to put the discussion and available methodologies into context, **Figure 3-1** was developed. This figure, in broad terms, outlines the process by which remaining useful life models for structural deterioration are developed. The subsequent sections discuss remaining useful life models in the context of this figure.

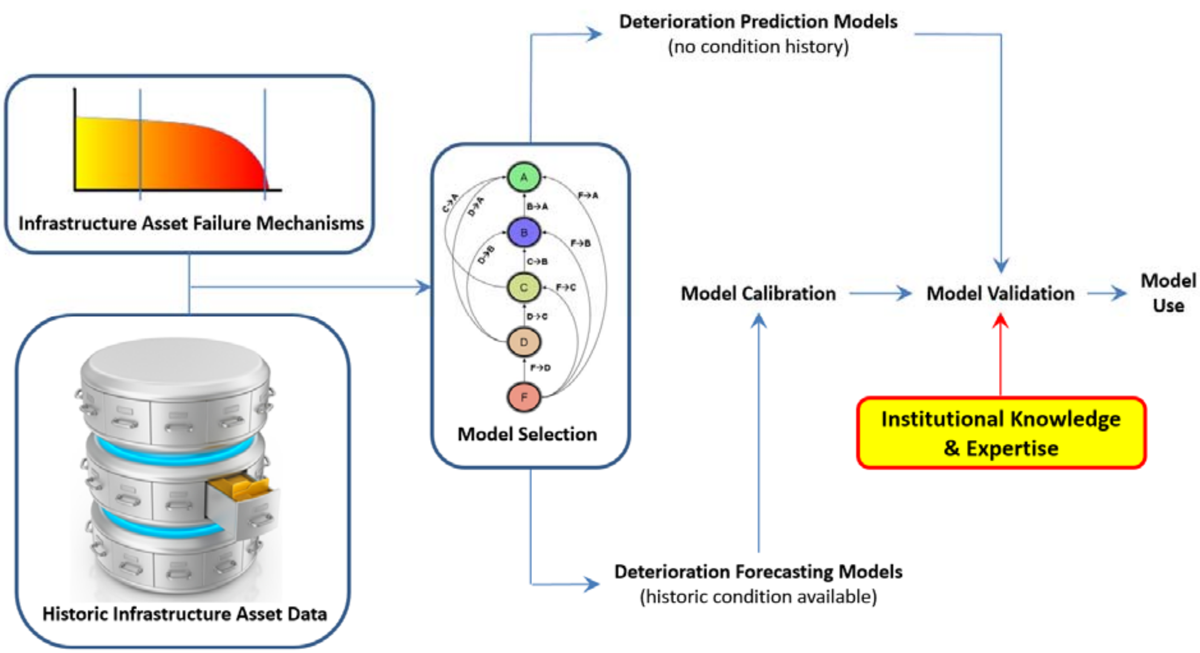


Figure 3-1: General Model for Remaining Useful Life Estimates

The simplest means for determining remaining useful life referred to as the straight line depreciation model and assumes that historic infrastructure condition data is available. This is an example of a deterioration prediction model in **Figure 3-1.**

Straight Line Depreciation Model

This model assumes a certain useful life of infrastructure based on type, material, manufacturer recommendations, industry standards, and studies completed on this subject. **Table 3-1**, for example, provides a general summary of such asset lives. The current asset age is then compared against such a table and, by assuming a straight line between current age and total asset life, an asset condition and remaining life is inferred.

Table 3-1: Estimated Useful Life of Sample Assets

Asset Category	Estimated Life (years)
Gravity Mains /Culverts (Concrete, Brick, Vitrified Clay, Ductile Iron)	100
Gravity Mains / Laterals /Culverts (Corrugated Metal)	65
Manholes (Brick and Concrete)	100
Catch Basins (Brick and Concrete)	50
Open Detention Basins	50
Infiltration Basins	100

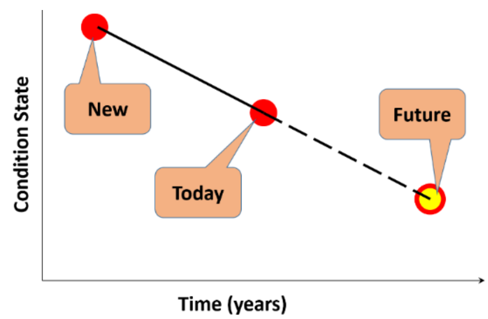
Care must be given when using such a table for prediction purposes and the model validation process, even if qualitative, must be utilized. Below are several cautionary circumstances when using tables such as the above:

- Concrete gravity mains: if the mortar of the concrete is maintained, concrete infrastructure has the ability to last way past 100 years
- Brick / clay material: Such material has a history of very long life, much past 100 years. However, they are brittle and cracks tend to occur early in the life of the infrastructure, mostly during installation or backfill.
- Iron material: Hydrogen sulfide and other corrosion factors, for example, can significantly reduce the life of this infrastructure
- Manholes: the top, cone section of the manhole tends to be much more impacted by freeze-thaw cycles and thus, has the potential to deteriorate much differently from the lower parts of the manhole
- Catch basins: these infrastructure, too, have the potential to be impacted by freeze-thaw cycles and the suggested remaining useful life values should be adjusted based on community specific observations and institutional knowledge

Condition Based Straight Line Depreciation Model

This method is considered a variation to the above detailed straight line depreciation model in that it is not the age of the infrastructure but its current condition, which dictates the remaining useful life. This method is one example of a deterioration forecasting model shown in **Figure 3.1. Figure 3-2** illustrates the condition based deterioration forecasting approach. Accordingly, an assumption is made that when the asset is originally installed (at year zero), it is in reasonably good condition. The age at which it is condition assessed corresponds to a condition state. A straight line between these two points' results in a condition based estimate of remaining asset useful life.

Figure 3-2: Condition Based Straight Line Depreciation Model



Advanced Structural Deterioration Models

More advanced infrastructure deterioration models can be employed on groups of infrastructure exhibiting similar behavior, e.g. infrastructure with similar material, size, location, failure type etc. Such models include non-homogeneous Markov chain process, non-homogeneous Poisson process, Linear Extended Yule Process, the time-based probabilistic Weibull or Herz models for modeling the aging processes of water and wastewater network pipes. However, many of these models require large amount of reliable, historic data and may not be suitable under all circumstances.

Task 4 – Analysis of Life Cycle and Replacement Costs of Assets

The development of a realistic AM Program hinges on both quality asset data, as well as relevant life-cycle costs for the assets. Costs from all aspects of an asset's life-cycle need to be carefully considered, including the O&M costs of an asset. Key subtasks are described below.

4.1 Review Cost Data

The CH2M team will analyze four key cost sources in order to develop costs for the AM Program:

- Existing Ann Arbor cost data—The CH2M team will evaluate the costs in Cityworks, as well as the City's performance financial data, to determine actual costs for projects.
- Ann Arbor cost tables—The CH2M team will review the 2015 Water and Wastewater Capital Cost Recovery Study as well as historical cost tables and bid tabulation data created by key Ann Arbor staff.
- Peer utility costs data—Other Michigan and Midwest utilities' cost tables will be reviewed and compared with Ann Arbor's costs.
- National cost trends—Cost tables established from national sources, such as USEPA, AWWA, WEF, ENR and others, will be reviewed and compared with Ann Arbor costs tables.

4.2 Determine Asset Values and Local Costs

The CH2M team will also utilize our SCREAM Costing software to compile these cost tables to develop Ann Arbor specific costs for repair, renewal and replacement of the assets. SCREAM will utilize the condition assessment data gathered from inspection, as well as O&M work completed and/or scheduled in CItyworks. SCREAM will then provide a comparison of current and life cycle costs to: Repair, Rehab, Replace or Run-to-failure (for low consequence assets). **Figure 4-1** below shows the comparison provided in SCREAM. This tool will also be used to quickly develop each Systems' asset values.

In addition, CH2M is leading a study for the Transportation Research Board and the Airports Cooperative Research Program (ACRP) to develop a process and tool to better understand and determine the total cost of ownership for assets. While this research is focused on airports, there is some commonalities with the water industry.

FIGURE 4-1 Life Cycle Cost Comparison in SCREAM

US Basin	Pipe Type	US MH	DS MH	Remaining Life	# R/R WOs to Date	Matl	Diam	Avg Depth	Struc Score	Length	Corrective Action	On off Road	Major Street	Total Num Laterals	Cost Factor	Repair Overwrtn
0001	Sewer	0001S0509	0001S0510	1		Vitrified Clay Pipe	8	4.0	98	246	Select Immediate Action	Off Road	False		1.00	x

Selected Immediate Option	Selected Immediate Option Cost	Selected Immediate Option Notes	Selected Lifecycle Option	Selected Lifecycle Option Cost	Selected Lifecycle Option Notes	Elevated Lat Cost
Rehab	$29,906	no repair - num trenches limit reached	Repair	$21,746	least expensive	False

Replace Immediate Costs	
Total Cost to Replace	$41,294
Replace Lifecycle Costs	
Present value lifecycle replace	**$43,063**

Repair Immediate Costs	
Num Lat in Trench	0
Feet of Trench Costed as Point	
Feet of Trench Costed as Sectional	80
Num Trenches	4
Point Open Trench	
Sectional Open Trench	$13,440
Lateral Reinstate	$0
Total Cost of Repair	$13,440
Repair Lifecycle Costs	
Present value lifecycle repair	**$21,746**

Rehab Immediate Costs	
Num Lat in Trench	0
Feet of Trench Costed as Point	
Feet of Trench Costed as Sectional	20
CIPP	$26,546
Point Open Trench	
Sectional Open Trench	$3,360
Lateral Reinstate - In Trench	$0
Lateral Reinstate - Out of Trench	
Total Cost of Rehab	$29,906
Rehab Lifecycle Costs	
Present Value lifecycle Rehab	**$36,237**

Maintenance Immediate Costs	
CSAP Inspection Frequency (in years)	7
CSAP Cleaning Frequency (in months)	120
Cost of Inspection	$369
Cost of Cleaning	$246
Maintenance Lifecycle Costs	
Present value lifecycle maintain	**$41,398**

Task 5- Determine Target Levels of Service for Asset Systems

The deficiencies and failures of storm and sanitary sewer pipes, structures, and basins present performance conditions that City staff must efficiently manage so that key repair, rehabilitation, replacement, and other capital investments are targeted, and that urgent needs are addressed in a timely manner to maintain the LOS the City desires to provide for its customers. The CH2M team will work with the City of Ann Arbor to develop a Level of Service (LOS) Statement, which will define the way in which its staff, managers, and operators desire the system to perform over the long term. The CH2M team will conduct an initial small group meeting with key staff to decide on the use of service levels and definitions of service levels. Following this initial meeting, the CH2M team will conduct a workshop with City staff to draft the LOS Statement. Key subtasks are described below.

5.1 Review Existing LOS and Performance Measures

The CH2M team will then review the City's current LOS, including the

- Sanitary Sewer Wet Weather Evaluation project,
- Existing Sanitary Sewer Level of Service and Rate Analysis studies

For existing performance measures, established key performance indicators (KPIs), and the actual or historical LOS and performance. This will be accomplished through interviews with key staff, as well as review of existing documentation, such as the existing distribution and sanitary sewer system's hydraulic models. The CH2M team will also evaluate State and Federal regulatory requirements that detailed in the City's MS4 and NPDES permits and Michigan Department of Environmental Quality (MDEQ) requirements, which will need to be included in developing the target LOS. **Exhibit 5-1** shows a breakdown of LOS characteristics, which ensures easy tracking of system performance. When thinking about the sanitary sewer infrastructure, for example, a unique category of LOS expectation is the desire of the community to see a targeted level of protection much higher than the currently acceptable MDEQ requirement of a once every ten year (or rather a 10% probability of occurrence in any given year) sanitary sewer overflows (Sanitary Sewer Wet Weather Evaluation Study).

5.2 Define Target LOS

The CH2M team will then develop a recommended list of service levels and KPIs for consideration by Ann Arbor, building primarily from existing measures, considering current data quality, availability, as well as industry standards and best practices. The goal is to develop a targeted set of measures that are both technically meaningful and best align with the

AM Program. This will include an initial set of targets for some or all of the chosen service levels that are in alignment with customer's and stakeholder's existing expectations, including anticipated willingness to pay. For our initial effort, we will consider such criteria as historical performance, current commitments, as well as available benchmark data for neighboring and national utilities with similar characteristics. Since LOS and KPIs are monitored to indicate system-wide performance, it is anticipated that no more than five primary levels of service will be established for the sanitary sewer collection system.

EXHIBIT 5-1
Desired characteristics of LOS help to ensure system performance is easily tracked and is useful for the overall operation of the utility.

Levels of Service	
Meaningful	Relevant to staff and stakeholders Provides a clear picture of performance
Measurable	Can be measured in a cost-effective manner Expressed as a qualitative or quantitative measure
Consistent	Consistent with industry practice Measurement is reproducible by others
Useful	Helps manage the utility Encourages improvement
Unique	Describes a specific attribute of utility services or activities Independent of other LOS

5.3 Gap Analysis

In addition, we will hold discussions with key City management and leadership team members to understand expectations and needs based on currently available information. We understand that Ann Arbor currently tracks and reports a variety of regularly measured service levels. Many of the measures can be easily integrated into the AM Program. At the conclusion of our review, we will develop a Gap Analysis TM and matrix assessing the current LOS and key performance indicators, to the target LOS. In addition, we will provide a comparison of the levels with peer utilities.

Task 6 Determine Criticality of Systems' Assets (Risk of Failure)

Risk is a key concept critical in determining appropriate maintenance activities as well as the rehabilitation and replacement of Ann Arbor's sanitary collection system assets. By quantifying and assessing the consequence and likelihood of failure, we will determine the risk profile for each systems assets.

6.1 Establish Risk Criteria

The CH2M team uses the widely accepted and traditional equation for risk: RISK = Likelihood of Failure (LoF) x Consequence of Failure (CoF), where LoF is how likely is it that an asset will fail due to condition or location and CoF is how critical an asset is to meeting the level of service of the collection or storm system.

An important principle in the process is the top-down and bottom-up approach (**Exhibit 6-1**), which is an iterative process. The process is based on recognizing the need for direction and support from the organization's leadership (i.e., vision, mission, goals, policies, etc.) and that decisions should be based on the best information available.

A set of risk scoring matrices will be used, one for the LoF of each asset and one for the CoF of each asset, with each having multiple areas. Each of the areas is also given a weighting, allowing adjustment of each area to be able to calculate a composite score that reflects the Ann Arbor importance placed on each of the areas of risk that are scored. A description of each increment of highest to lowest risk is used to help assure a common understanding.

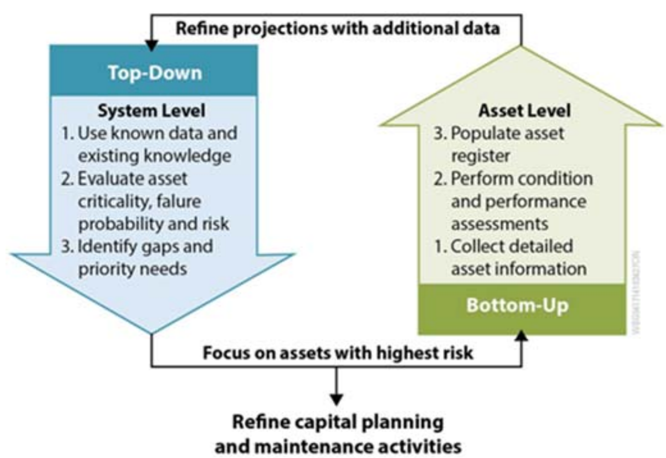


EXHIBIT 6-1
The top-down\bottom-up approach is an iterative process that initially utilizes the guidance of an organization's leadership to develop detailed data processes to better inform and direct the leadership with higher quality data.

6.2 Determine Likelihood and Consequence of Failure

Our team recognizes that determination of risk is a pivotal step in deciding whether an asset should be maintained, rehabilitated or replaced. However, the likelihood of failure component of risk is largely based on the current condition the asset. As with the majority of utilities, each asset does not currently have a condition rating or an associated inspection to develop this risk score. Therefore, the CH2M team will use a proven top-down, bottom-up iterative process to determine likelihood and consequence of failure ratings for each asset. The initial phase will utilize the institutional knowledge of the staff and existing data to produce a quick baseline risk score. The second phase will build from the initial phase and replace the baseline likelihood of failure score with an actual condition rating.

As noted in Task 2, the CH2M team will initially utilize a top-down approach to quickly assess the entire Ann Arbor system using existing data and the staff's extensive institutional knowledge obtained in a collaborative workshop setting. Matrices will be developed for LoF and CoF for both the sanitary sewer collection systems.

Rather than try to evaluate each reach of pipe in the City, many of which would be very similar, the systems will be broken into a smaller number of manageable pieces. For both sewer and storm pipes, this means distinguishing discrete reaches of large diameter pipes, and grouping the small diameter pipes into mini-basins for the sewers.

EXHIBIT 6-4
Results from the detailed phase graphically highlight the asset risk scores and LoF/CoF of the entire system as shown here

Risk scores will be quickly developed for each asset area utilizing a risk-based scoring approach for all assets, using CoF and LoF matrices. The scoring will be completed in an Excel-based risk model to provide an initial baseline and give an order-of-magnitude view of the systems' risk and potential AM program cost. The risk-model results will be linked with the City's GIS to graphically show the asset risk for the entire system. Documentation of the results, and the lessons learned about the available data, information, and systems will be used in subsequent data collection, as well as overall AM program development.

The second phase of determining the likelihood and consequence of failure ratings will commence in the last 6-months of the project. This is so that additional CCTV inspections and other ongoing condition assessment data can be utilized to create a more detailed likelihood of failure rating. The consequence of failure scores and components will also be reviewed to ensure they still align with the City's Target Levels of Service from Task 5. This detailed assessment will over-write the baseline ratings developed in the initial phase only if more current and detailed data is available. Otherwise, the rating will stay with the baseline. **Exhibit 6-4** provides a look at the detailed risk rating of a portion of a sanitary collection system.

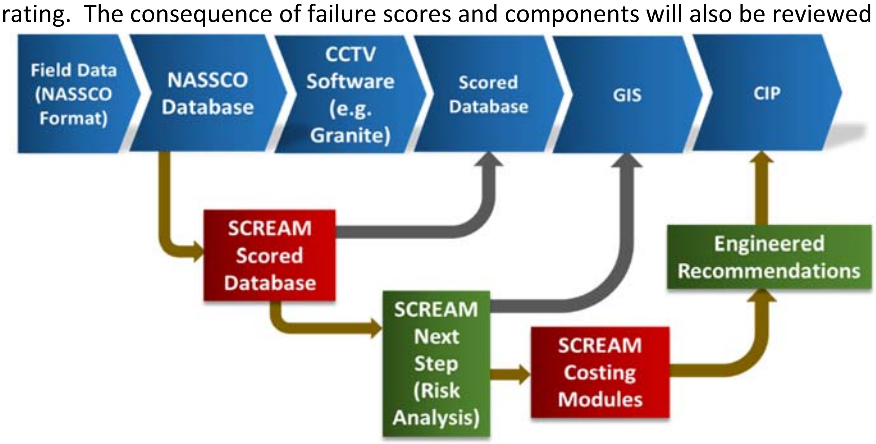


EXHIBIT 6-5: *SCREAM will be used to compile condition data, calculate risk scores and prioritize Ann Arbor's Next Steps.*

6.3 Calculate Criticality Ranking

CH2M's SCREAM software will be used to calculate criticality (risk) rating of each asset. The risk profile in SCREAM is built upon the same risk matrices that were described above, as well as in the condition assessment task. SCREAM provides an integrated method of managing asset condition data, assessing asset risk, utilizing asset life-cycle and replacement cost, determining prioritized improvements as well as maintenance efforts. As seen in **Exhibit 6-5**, SCREAM offers a repeatable process that can be used as input to the identification and prioritization of projects in Task 8.

Our team will need input from the appropriate City staff early in the review process to ensure the City's key concerns and institutional knowledge are captured and incorporated into the new reporting form. Depending on how the balance of condition assessment work is performed (i.e., in-house as opposed to contracting), the City may want to consider a Web-based interface for downloading and uploading field data. The CH2M team will present to the City the benefits and resource requirements of a Web-based system as an alternative to standard direct Cityworks server interface procedures.

6.4 Risk Mitigation

Risk is mitigated by reducing the LoF or the CoF. There are typically many ways to reduce risk, such as asset renewal or the modification of maintenance activities and operations protocols. In addition, risk can be mitigated by reducing the COF (for example, through development of contingency plans). **Exhibit 6-6** provides a few typical methods to mitigate risk.

Example Risk Reduction Option	Reduces Consequence	Reduces Likelihood
Capital Investments		
Rehabilitation		✓
Replacement		✓
New redundant asset	✓	
O&M Protocols		
Development of operating SOPs		✓
Improved planned maintenance procedures		✓
Enhanced monitoring through SCADA		✓
Other		
Demand management	✓	
Improved response and recovery	✓	
Reduce LOS with stakeholder involvement	✓	

EXHIBIT 6-6 *During the asset management process, the cost to reduce risk will be compared with the actual reduction in risk to ensure the improvement is worth the investment*

We will conduct a workshop with Ann Arbor to determine the most cost-effective and appropriate ways to mitigate risk. The workshop will focus on maximizing the life-cycle costs of asset ownership through a reliability focused approach. Each asset group will be reviewed for the appropriate preventative maintenance activities and tools and when an asset should be rebuilt or replaced. The cost of risk reduction is important to understand as the cost to reduce risk should not exceed the reduction in risk.

Task 7 – Formalize Optimal Operations and Maintenance (O&M) Program

Successful long-term management of the sanitary collection system may require changes to the City's current inspection, monitoring and maintenance programs. Developing the right program for the City allows planning and O&M teams to correct system deficiencies before they become emergencies, and make thoughtful proactive, planned expenditures to extend remaining useful life of the assets. Our extensive experience on inspection and monitoring activities allowed us to gain a rich repertoire of what works and does not work effectively and our team will bring these "lessons learned" to bear as part of this work. A sampling of lessons learned are listed below.

- Use of Go Pro type cameras improve video quality for reasonable cost
- GIS based tracking of field effort avoids redundancy in inspections and effectively tracks progress
- Proper use of technology (including GPS technology and tablets) can make data collection easier, especially when location and elevation are important.

Key subtasks are described below.

7.1 Review and Document Existing O&M Procedures

As part of this task we will review the current O&M program practices with the City's staff for each system. Based on our discussion with City staff members, our team will document the existing procedures in place. Our work on this task will also include the review of current methods of handling inspection data from the field inspections, through database data importing and/or storage. Sewer condition scores received will have been developed from CCTV inspections. Our team will review the quality control steps to ensure field efforts are not missing key asset attributes or are inconsistent. Our team has worked with many different field forms that come from different software products and vendors, and we have our own standard forms that efficiently integrate the flow of data from the field to the manager's or engineer's corrective action reports.

7.2 Recommend Revisions to the Existing Procedures & Gap Analysis

Our team will provide recommendations that include modifying schedules for inspection, cleaning, and corrosion monitoring of the sanitary interceptors, as well as employing new inspection and monitoring technologies that could more efficiently use existing City resources (See **Table 7-1** below).

Our task lead, **Tim Newton**, is an expert from CH2M's Operation and Maintenance division that specializes in wastewater system management and operates hundreds of utilities across the U.S. Tim's experience will help develop a pragmatic and cost-effective maintenance plan that the City can carry forward on their own, including guidance on inspection and maintenance intervals. For corrosion monitoring, we will evaluate O&M practices including the use of Odalogger™ and/or periodic jar testing to confirm and optimize required dosage rates for corrosion-inhibiting chemicals.

Our recommendations will be compared with the existing staffing, equipment, practices, and contracting ability to develop a Gap Analysis report. The goal is to create an optimized O&M program that will be sustainable.

A WORD ABOUT PRE-CLEANING FOR INSPECTIONS

In our experience, more than 90 percent of pipe structural defects and anomalies such as pipe wall delamination, corrosion, liner failure, offset or separated pipe joints, or partial failures occur above the active dry-day flow line. Cleaning is normally required where flows appear to be surcharged. However, we understand that cleaning efforts for inspection work should be minimized due to resources and time. We will prioritize cleaning recommendations, working with the City to clean only what is absolutely necessary. Our team's technical expertise on more than 50 large-diameter wastewater systems will provide the City the confidence that prioritizing is based on a broad range of experience.

7.3 Decision Making Process

As noted in Task 6, SCREAM was created to provide utilities with an easy way to prioritize O&M activities as well as capital expenditures. The decision tree logic shown in **Exhibit 7-1** will be reviewed with the City and customized to meet their O&M goal of maintaining the lowest average life cycle cost.

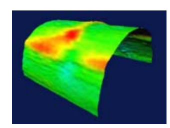
EXHIBIT 7-1 SCREAM Next Steps Decision Tree logic can be used to prioritize and automate future inspections and corrective actions.

Latest Inspection Type	High Defect Acceleration	Risk COF Grade	Structural Grade						
			0	1	2	3	4	5	6
CCTV	No	1	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
		2	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
		3	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
		4	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	CCTV 18 months	Priority 1	Immediate
		5	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	CCTV 18 months	Priority 1	Immediate
		Unknown	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
	Yes	1	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 4 years	CCTV 12 months	Priority 3	Immediate
		2	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 4 years	CCTV 12 months	Priority 3	Immediate
		3	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 4 years	CCTV 12 months	Priority 2	Immediate
		4	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	CCTV 12 months	Priority 1	Immediate
		5	CCTV 10 years	CCTV 7 years	CCTV 4 years	CCTV 18 months	Priority 2	Priority 1	Immediate
		Unknown	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 4 years	CCTV 18 months	Priority 2	Immediate

7.2 Optimized O&M Plan

The results of this task and the gap analysis report will be summarized into an Optimized O&M Plan. Our experience operating hundreds of systems will help to provide a realistic and achievable O&M program that is built on time tested practices. We will also provide recommendations on how to implement these practices into Cityworks to ensure your preventative maintenance and inspection activities are tracked. This data is extremely valuable, as we have found that O&M plans that can import work order history and past inspections become more optimized over time as your data history grows.

Table 7-1: Inspection and Monitoring Applications

Proven Technology	Application best suited for this Technology
Zoom-camera Top-side inspection of the incoming and outgoing interceptor pipelines from accessible manhole structures using pole-mounted zoom cameras	Large quantity of the interceptors can be quickly inspected without confined space entry. If the Tier 1 investigations show signs of deterioration or other concern, the asset will then be recommended for a more detailed assessment. 
Wastewater Grab Samples Wastewater grab samples and jar tests to evaluate reactions with different corrosion inhibiting chemicals	The jar testing can provide important data to determine the required dosage for each chemical type. Some examples include oxidants (e.g.; hypo), precipitants (e.g.; ferric), pH adjusters (e.g.; Thioguard™), inhibitors (e.g.; Bioxide™), oxygen addition (e.g.; Super Oxygenation), and even some fringe approaches (e.g.; Commander). 
CCTV Visual inspection by means of a crawler-mounted, or float-mounted camera deployed through the pipe	More detailed visual assessment of the entire pipeline. For most pipes the field investigation work will conclude at CCTV, but for those segments which are identified as high risk, specialized inspections may be recommended, including the following technologies. 
Rebar Potential Mapping Ultrasonic impulse delivered to the concrete wall through a mechanical probe to measure wall thickness and provide rebar potential mapping.	Isolated locations in large concrete pipes where rebar defects and/or corrosion are identified and are of concern for structural integrity 
Laser Profiling Laser is attached to a robotic platform and scans the inside of the pipe. Data is processed by computers to determine the exact inner dimensions.	Quantify the extent of corrosion and to inform the design of rehab (CIPP, sliplining) that need precise dimensions resulting in savings during construction bidding. 
Sonar Sonar ROV is deployed into a full pipe and scans the inside of the pipe. Data is processed by computers to determine the exact inner dimensions.	Quantify extent of debris and provide general dimensions of submerged pipes. 
Pipe Penetrating Radar Radar attached to hand-paddles or a robotic platform uses radar waves from inside the pipe to scan for sub-surface features beyond the pipe wall.	Detects the presence of rebar in RCP pipe, detects voids forming behind the pipe wall. This is important to catch sink holes before they collapse, because they can form behind a leaking pipe joint. 
Electromagnetic Electromagnetic probe dragged through a temporarily plugged pipe by topside winches	It measures the amount of current that escapes through cracks, joints, and other defects in non-metallic pipe. This can be used for exfiltration detection to find leaky joints that are not visible to CCTV. 

Task 8 – Formalize Optimal Capital Improvement Program

In assisting utilities over the past two decades with CIP prioritization, our approach is founded on standard industry principles and uses a decision analysis method for scoring and prioritizing candidate projects. In fact, CH2M helped to establish Ann Arbor’s current CIP prioritization model as part of a water system master planning project nearly 10-years ago and has continued to provide updates and modifications to this model. Key subtasks are described below.

CH2M helped to establish Ann Arbor’s current CIP prioritization model as part of a water system master planning project nearly 10-years ago and has continued to provide updates and modifications to this model.

8.1 Review Existing CIP Prioritization Model and Scoring Criteria

As part of this task, we will review the prioritization framework as it is currently being used by Ann Arbor and the current scoring criteria, weights, and performance scales used in the prioritization in particular for the sanitary collection system. This type of asset management planning effort provides an ideal opportunity to revisit and confirm or modify these important elements of the prioritization framework. As part of this refresh process, the CH2M team will bring examples of current criteria (**Exhibit 8-1**) and scales used by other utilities to support workshop dialogue with the Ann Arbor team on potential applicability of elements used by other utilities to the Ann Arbor context. As we did in the supporting the development of the initial prioritization framework in 2005, our team will work with the City to establish a multi-disciplinary team of City representatives so that input is secured from the diverse vantage points (e.g., engineering, planning, finance, utility management) within the City.

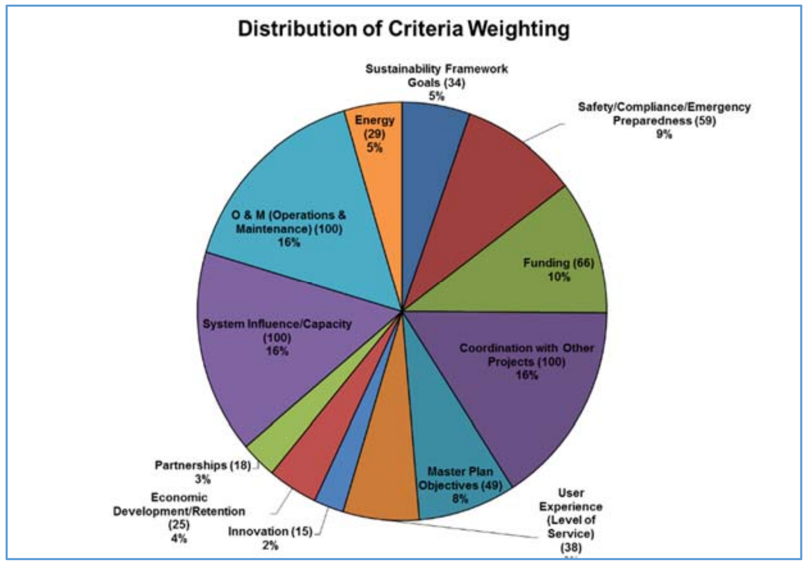


***EXHIBIT 8-1**: Facilitated Dialogue Will Be Used to Confirm or Modify Ann Arbor’s Current Sanitary Prioritization Framework*

The framework serves as the basis for which candidate projects are scored. Sources for the framework include the risk framework developed earlier to support prioritization for condition assessment of existing assets, other CIP prioritization models developed by Ann Arbor for other classes of assets. **Exhibit 8-2** illustrates the main steps in the decision analysis approach.

A decision analysis approach that provides greater precision for weighting goals and measuring the contribution of candidate projects has been found preferable to traditional voting and matrix methods for prioritizing projects by an increasing number of water and wastewater utility systems. The approach allows greater differentiation in both goals and performance measures, and can be used efficiently to conduct sensitivity analyses that show the variation in results that would occur with varied assumptions and scenarios.

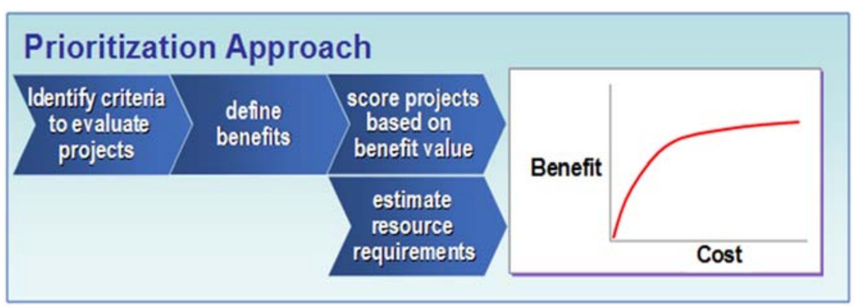


EXHIBIT 8-2: *A decision analysis approach has been found preferable to traditional voting and matrix methods for prioritizing projects by an increasing number of water and wastewater utilities, including Ann Arbor.*

8.2 Recommended Enhancements to the Existing Prioritization Framework

The CH2M team will provide recommendations technical memorandum of enhancements to the existing prioritization framework and tool application that will document the components required to address gaps between the processes and tools used by Ann Arbor today and the requirements obtained in the previous step. In particular, the components of Cityworks system that are underutilized or the selected AM software solution, which could address the identified needs, will be highlighted. Additionally, the interaction between the

Cityworks CMMS, GIS, and AM software software will be defined, along with the data exchange planned with the Excel-based risk and CIP development tools. Specific database fields needed to support requirements will be defined and the appropriate system of record identified.

This will provide practical evaluations of what works well and what will need to be modified as part of this project, as well as discussion for how an enhanced approach could better serve Ann Arbor, its customers, and other stakeholders. An example process flow for project identification and prioritization is shown below in **Figure 8-3**.

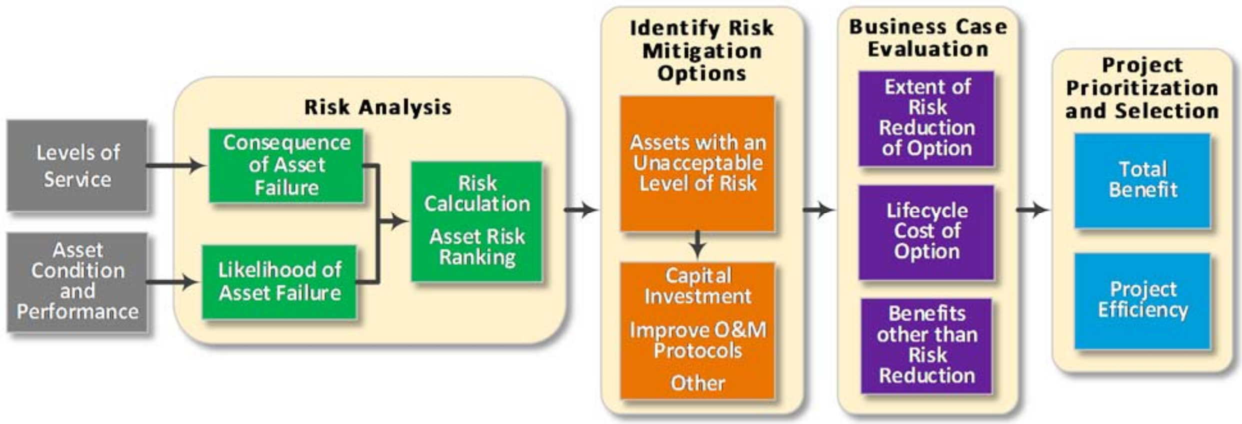


Figure 8-3 Overview of the Risk-Based Approach in the CIP Project Identification and Process

Once the Cityworks, GIS and/or AM software is configured, it can be used to generate a list of high-risk assets that become candidates for inclusion in the CIP. The list will be exported as the starting point of CIP development.

8.3 Identify Capital Improvement Projects

From a CIP perspective, a balance between a focus on existing assets (normally based in the O&M program) and new assets (normally based in master plans and related to growth and\or regulatory changes) has to be underpinned by enterprise values and objectives and is key in the overall prioritization process. We recommend continuing to use a Multi Criteria Prioritization (MCP) approach that accounts for the strategic objectives of the utility and scores the total benefit value of each individual project under consideration.

Our team fully intends to collect information on capital improvement projects that will be identified in ongoing and anticipated parallel studies, to assure that a comprehensive look is provided and rates are set appropriately.

The respective total benefit value and benefit-cost ratios are calculated for each project, which enables the utility to consider both of these metrics when determining the best value capital program over successive budgetary periods. The use of an MCP approach to establishes a cost\benefit comparison of all projects under consideration, which enables the production of a best value AM Program that meets the utility's strategic objectives. Exhibit 8-4 highlights the financial benefits that can be realized by implementing CIP prioritization, by identifying the highest-priority projects that should be front loaded within available financial resources. Key steps in the prioritization approach include:

1) Review and enhance Ann Arbor's CIP prioritization framework.
   a) Review and update of decision criteria and their importance or weighting.
   b) Review and update of performance scales for each of the decision criteria to measure the benefit of candidate projects.
   c) Import of costs from Task 4 to be used in benefit-cost analyses and cumulative cost outputs.
2) Selecting projects for prioritization based on work in previous tasks.
3) Applying the framework to selected projects using data collection forms to document the process.
4) Use of Ann Arbor's Excel-based multi-attribute utility prioritization model to support the development of the prioritized project list.
5) Review of prioritization results for verification of the prioritization framework.

8.4 Long-Term Strategy for Capital Reinvestment

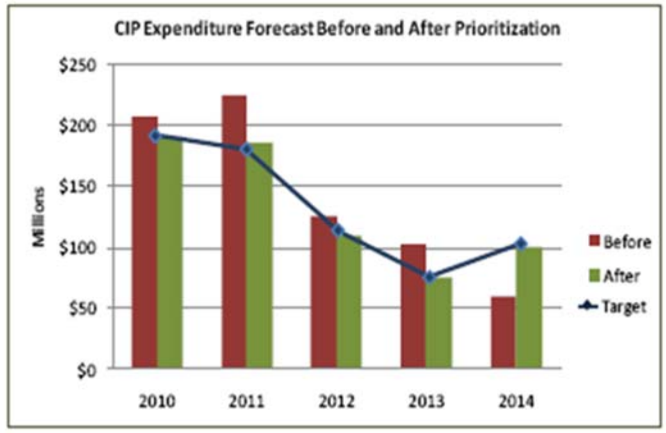


EXHIBIT 8-4
Prioritization Helps Clients Achieve Targets
CH2M's prioritization approaches and tools helped the Hampton Roads Sanitation District in Virginia Beach, VA to move $150 million in lower ranked projects out of the near-term years, allowing the District to keep expenditures within targets set by the general manager and financial team.

The results from the AM program, specifically the risk determination and O&M program tasks, will be modeled over the next 20-30 years to provide a prioritization of system needs and associated projects. The modeling of these projects will look at the LOS provided to Ann Arbor's customers along with the overall system risk. These items will be critical to ensure that the City is investing enough in their sanitary collection system to meet the City's long-term goals. A technical memorandum will be prepared documenting the long-term strategy for reinvestment in the City's buried sanitary sewer assets. In addition to identifying and prioritizing projects for this long-term period, the CH2M team will work closely with the City to provide a more detailed review of the sequencing of projects for the City's near-term budget and CIP planning cycle, so help provide more specifically inform revenue requirements for the City's immediate rate-setting and bonding programs for the utility systems. As indicated earlier in the proposed work plan, the operations and maintenances as well as priority and level of service decisions on Washtenaw County owned assets in the City will have an impact on future costs for the City as the City will likely be assessed for the future CIPs on these assets. Therefore, we plan on engaging with the Washtenaw County Water Resources Commissioner's office in an effort to better understand their CIP and LOS decisions in this regard.

Task 9 – Establish Sustainable Funding Strategy

Planning for long term CIP funding will require funding experts to work closely with your financial and budgeting staff. Our staff will work closely with the City and the Sanitary Rate Study consultant for Ann Arbor to identify the revenue requirements and expected revenues for each system. Our team will work with the City's rate consultant to assist in developing a funding strategy for the AM Program, once the magnitude of the program is developed.

9.1 Perform Gap Analysis

A critical component of any AM program is the ability to fund the recommended projects as well as developing a financing strategy so that Ann Arbor can afford the improvements. Upon development of the recommended prioritized projects, the CH2M team will provide the financial data from the program to the City in a format compatible with City's rate model for use in determining the financial impact to its ratepayers.

Our team will perform a gap analysis between their current funding structure and the systems needs as developed as part of the Risk and O&M tasks. During this analysis, our team will review the proposed LOS to determine if they are still affordable. The worst possible message to your staff and customers is to provide a "promise" for a specific LOS and then realize that to meet that LOS, it would be unaffordable. Careful understanding of the cost impacts to meet the initially agreed upon LOS is a key part of a sustainable financial strategy development. The gap analysis will develop an optimal mix of operational and capital expenditures while maintaining an acceptable level of risk and meeting the developed LOS. The long term funding strategy will look at costs associated with operations, preventative maintenance, rehabilitation, replacement and expansion of the City's sanitary collection system to meet the City's long-term goals and levels of service.

CH2M is currently serving in a similar financial role for the Montgomery County (Ohio) Buried Infrastructure R&R Program. Similar to Ann Arbor's Asset Management programs for its buried infrastructure, CH2M is developing a funding strategy to support the needed increased capital spending while maintaining reasonable rate increases. In the Montgomery County case, CH2M was asked to run R&R cost scenarios through rate models that had been developed by the County's financial consultant; for Ann Arbor, the CH2M team will work with the City to identify the most efficient method for estimating the rate impacts of the R&R scenarios. Depending on the City's preference, this might involve providing scenarios for the City or its financial consultant to run through the City's rate models, or it might involve a more proactive role for our team in the rate modeling process.

9.2 Recommend Optimal Funding Strategy

Particularly when addressing funding strategies for renewal and replacement programs, our funding teams integrate the financial strategies with previous and current condition assessments and risk assessments, and develop business processes to help integrate the prioritized lists of AM projects, and develop business processes that define how the engineering, financial, and technical elements should be updated to help inform annual updates to capital budgets and CIP improvement programs. Our funding team will review how Ann Arbor has previously funded its capital projects and how other utilities fund similar programs, given the agreed upon LOS, budgeting constraints, and desired reduction in risk for buried assets. In order to inform the City's consideration of how to define acceptable levels of risk, we are prepared to bring examples of how consequence and likelihood of failure scales have been customized to fit the contexts of other clients, such as Fairfax County, Virginia. Given that the City's buried assets are located in many jurisdictions, the CH2M team will help Ann Arbor develop policies and procedures that will more effectively coordinate with the other jurisdictions to take advantage of joint funding for work in areas that affect their assets (such as roads) and the City's assets. Better coordination can lead to lower overall costs for the City ratepayers.

The result is a prioritized set of capital improvements and initiatives that can be implemented given the available funds that Ann Arbor has and the level of rates and charges that are affordable to Ann Arbor customers, and a business process that can be used to update the analysis for future budget and CIP development cycles.

Task 10 – Generate Asset Management Plan

The goal of Task 10 is to synthesize the material created as part of this project to ultimately create a strategic asset management plan (AMP) for each system that:

- Minimizes the life-cycle cost of asset ownership,
- Extends the life of the assets through an effective maintenance program,
- Develops best management practices within the City's organization aligned to industry standards, and
- Uses a risk methodology to streamline identification and implementation of the recommended improvements.

10.1 Develop the Asset Management Plan (AMP)

AMPs, like other major planning documents, are important components that feed into an organization's short- and long-term capital and O&M planning processes. Our team will review existing major planning efforts and existing AMPs, such as the Green Infrastructure AMP for validation and alignment with these new AMPs. Our proposed approach for developing an AMP is based according to the International Organization for Standardization (ISO) 55000 series of standards in order to showcase Ann Arbor's efforts to adopt world-class AM principles as represented in those international standards. While we do not believe that it is necessary for Ann Arbor to pursue ISO 55000 certification and all of the prescribed processes, we do suggest using the ISO 55000 framework as the target for best practice.

The AMP for each system will also include a succinct executive summary that clearly articulates the purpose of the AMP and the City's AM program. It will provide an overview of the plan findings and results that can easily be understood by key stakeholders and the public. Our team will work with our Public Engagement consultant, LE&A, to develop the messaging and help tell Ann Arbor's asset management story to the public, along with carefully developed infographics to assist in understanding the complex nature of the AM program in a simplified fashion. **Exhibit 10-1** on the next page highlights our

AMP process that will build upon Ann Arbor's ongoing planning efforts.

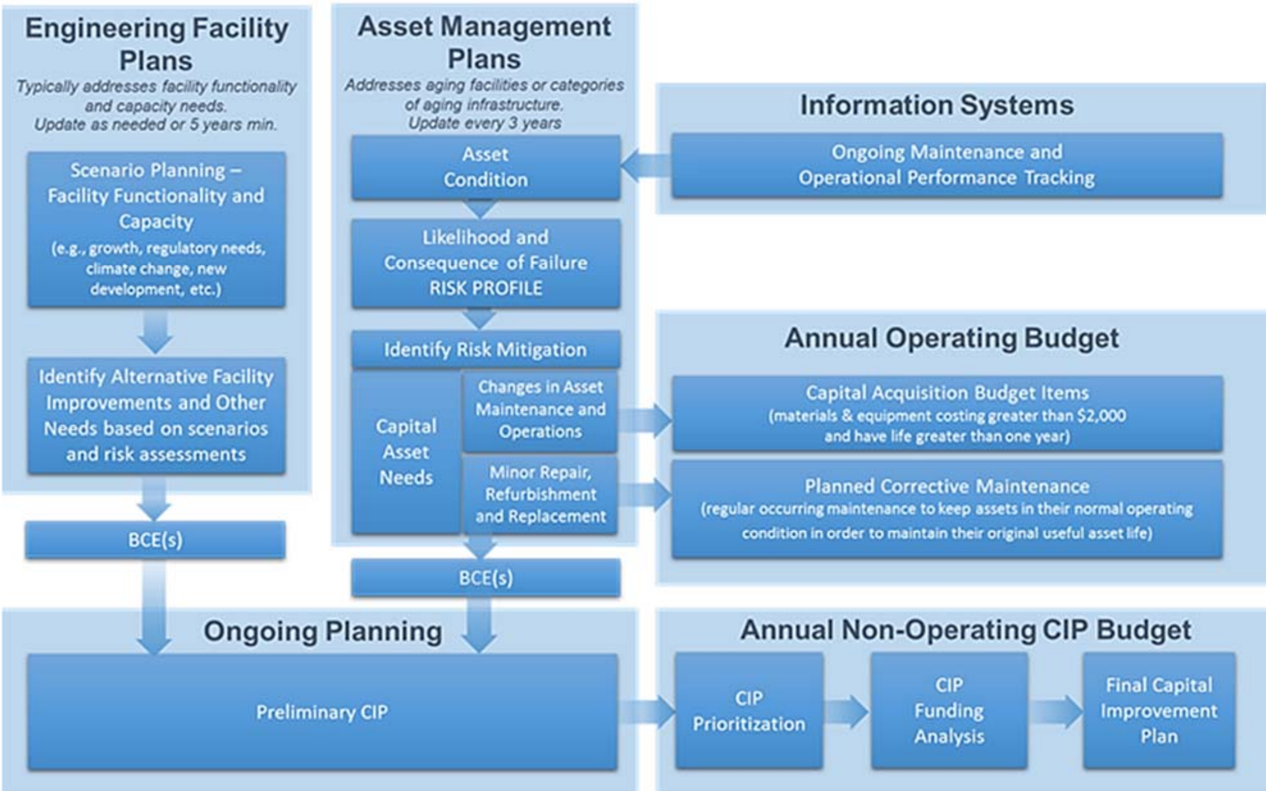


***EXHIBIT 10-1**: Our AMP process is based on industry best practices and will build upon Ann Arbor's ongoing planning efforts.*

10.2 Standard Operating Procedures

One of Ann Arbor's primary goals for this project is to maximize the use of asset data and effectively leverage its investment in Cityworks and an AM software to manage its assets. Best practices for the development and use of AMPs in the wastewater industry consists of the following:

- Concise documents assessing individual asset types (e.g., Interceptors, mains, manholes, basins, etc.)
- Clear ownership within the organization for each AMP
- Governance body for review and approval or rejection of each AMP, and clear accountability regarding the time horizon for the plan and update cycle, as well as quality and completeness expectations for each AMP
- Clear alignment of the objectives and actions of each AMP to the overall asset management strategy for the organization
- Clear articulation of customer service levels, and asset performance expectations relative to actual performance
- Up-to-date documentation of drivers, including regulatory changes, demand scenarios, influent water quality, and stakeholder expectations
- Updated documentation of the assets covered in the plan and assessment of asset likelihood and consequence of failure, resulting in a risk profile for the facility or grouping of assets
- Documentation of data sources and assessment of the quality and completeness of the data in these sources
- Listing of improvement initiatives required to optimize performance of the assets covered by the plan. Such listing should include clear documentation of the activities needed, as well as responsible parties and expected completion dates. These listings should be tracked for status and completion separate from the AMP update.
- Documentation of the CIP process for updating the prioritization tool and updating the financial analyses.

AMPs should ideally be updated every 3 to 5 years to maintain their effectiveness. Our team will leverage its knowledge of asset management best practices, and our experience on similar asset management programs, such as for the Rancho Water, Montgomery County, and DC Water to ensure a usable and sustainable AMP is created for Ann Arbor.

It is important to note that an AMP should not be limited to just the adoption of business processes, technologies, and frameworks. The AMP recognizes that certain aspects such as culture and change management can have a significant influence on the achievement of its AM objectives. The AMP therefore needs to incorporate plans devised to engage staff at all levels in the AM Program and achieve the highest level of benefits possible. According to ISO 55000, the International Infrastructure Management Manual (IIMM) and numerous other AM guidance recognize the importance of leadership, accountability, and organizational culture for the success and sustainability of an AM Program. Consistent, frequent, and enthusiastic support for the AM Program from all levels of management is necessary for Ann Arbor to ensure decisions in day-to-day activities, planning for capital projects, and making long-term investments are aligned with Ann Arbor's strategy and stakeholder interests.

> "Asset Management tools and technologies may be helpful, but the engagement of the workforce, the clarity of leadership, and the collaboration between different departments and functions are the real differentiators of a leading asset management organization."
>
> Institute of Asset Management

Task 11 – Public Engagement

Ann Arbor is a dynamic, diverse and informed community, with many engaged residents and other stakeholders who care deeply about all aspects of the city. As a result, it will be vital that the City and its partners establish this project as one grounded in transparency and accessibility from the start. Key subtasks are described below.

11.1 Communication and Engagement Strategy

The CH2M team's public relations team will be led by **Liz Kelly** – a seasoned utility executive who led many public engagement, community outreach, and internal communications efforts while leading Seattle Public Utilities asset management group. Our team also includes Lambert, Edwards & Associates (LE&A), a statewide, award-winning PR firm with offices in Detroit. Our team has developed the following overview of an expected approach. We will work closely with the City and key stakeholders to develop a detailed plan that makes efficient, effective use of all resources. The plan will incorporate the following items into a cohesive Engagement Strategy for the City to effectively tell their asset/utility management story to both external and internal stakeholders.

Audience

Communications will be developed to educate and inform stakeholders from introduction to completion. Anticipated priority stakeholders include:

- Residents (as necessary)
- Major employers/business owners
- Other area opinion leaders
- City employees (Internal Working Group)
- City policy makers
- Large utilities (e.g. the University of Michigan or Scio Township)

11.2 Establishing Core Messages

While not glamourous in the traditional sense of the word, Ann Arbor's sanitary sewer system represents vital and highly complex infrastructure that can often be taken for granted. Similarly, the process of setting improvement priorities for the system is a highly complex undertaking. As a result, all audience segments will expect and deserve effective, understandable messages – educational content – that keeps them informed of the project's pace and progress.

Our first step in this process will be to use a primer on infrastructure investment. The documentary ***Liquid Assets*** (produced by Penn State Public Broadcasting) is an excellent summary of the state of our buried infrastructure, and will provide an eye-opening and visually-rich demonstration for the public. An overview of the documentary can be viewed in the following link: http://liquidassets.psu.edu/index.html#overview

Initial efforts would likely focus on City personnel to ensure they are equipped with clear, concise and consistent messaging to directly answer questions pertaining to the project – before, during and after completion. For internal personnel, our public relations team will create messaging detailing all aspects of the project. We anticipate this effort to include messaging and visual tools capable of accurately and clearly conveying complex concepts to a broad audience. For consistency of messaging, our public relations team also will develop a series of documents for use throughout the project, including:

- Talking points
- Fact sheet
- FAQ
- Case studies
- Infographic Example (**see Exhibit 11-1**)

The above documents will be updated as necessary during the course of the project to provide relevant information.

11.3 Coordination with Staff, Key Stakeholders and Media

Gaining the community's trust from the onset of this project is crucial to obtaining and maintaining their support. For this reason, our team recommends scheduling a public education session to kick off this project, as well as periodic update meetings to keep the community well-informed of progress. In addition to gaining the community's trust through transparency, a public setting will allow the City, and our team to better understand the varying public perceptions, questions and priorities to consider in all communications going forward.

We will work closely with City officials in advance of public meetings – providing message points, collateral material, and event planning assistance, if requested.

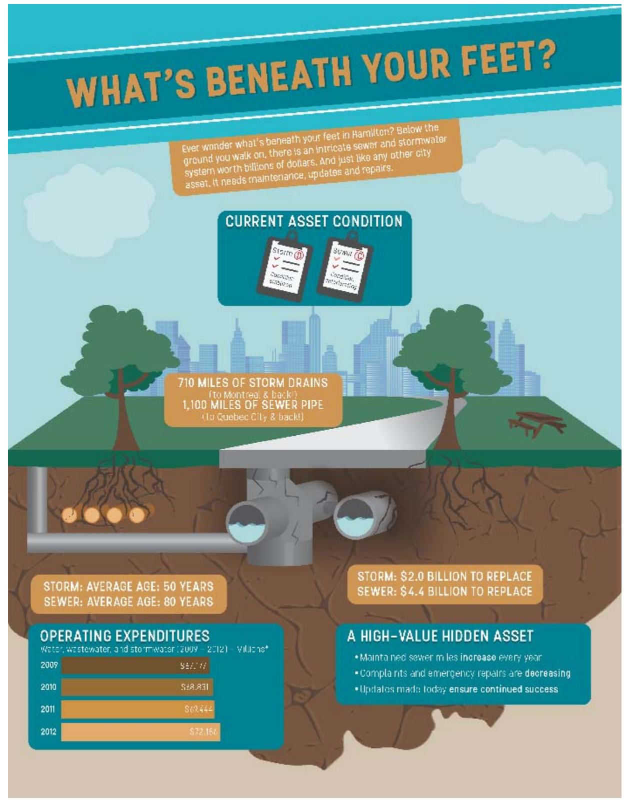


***Exhibit 11-1**: Example Infographic our team will develop to assist Ann Arbor to inform stakeholder of their AM program*

Media Relations

A project of this scope is sure to attract attention from the media. As such, the CH2M team suggests taking a proactive approach and utilizing the media as a communications tool – delivering key information to a wider audience. Recommended media relations activities include:

- Coordinating a meeting with select media and project team members – City personnel and project engineers – to provide an overview of the project
- Developing a press release announcing the project and providing important details for distribution to local media
- Coordinating media interviews with project team members
- Announcing key findings/updates periodically
- Identifying and using influential project advocates in the community for media opportunities
- Developing opinion pieces from various stakeholders for distribution to media

In advance of media relations activities, our team suggests conducting media training with City spokespeople.

Social Media

Social media channels such as Facebook, Twitter and LinkedIn provide organizations an opportunity to engage directly with their audience. Our team recommends using these channels proactively to keep the community informed. Working in unison with the City's social media team, if applicable, the CH2M team will create informative and educational content to be shared via the City's digital channels, including its website. Content will include:

- Project announcement and updates
- Informational meeting dates
- Links to news stories related to the project
- Project videos and photos
- Positive comments from key influencers (community advocates)

Task 12 – Asset Management Software selection and implementation

It is our understanding that the consultant team will purchase an asset management software for use during this project. As the project progresses, the CH2M team will evaluate asset management (AM) software's that would help achieve the City's ultimate vision for its AM program and capital improvement plan (CIP) development. The subsequent section outlines our proposed approach for helping the City choose the most appropriate software for not just this project but for City future needs and staff preference. We further understand that the consultant team is expected to transfer the license of the software to the City along with fully loaded project and infrastructure data.

12.1 Selection of Software for the City

Our team proposes to perform a software needs assessment in an effort to help the City decide on the most appropriate software for selection. We propose the following approach for the needs assessment and eventual purchase of the software:

1. Software Selection & Implementation Team
   We propose to identify the team that is dedicated to see the implementation of the software from conception to evaluation, implementation, and ownership
2. Identification of Needs
   This team will help identify the variety of requirements that the software needs to fulfill, which may include the following:
   a. Data management capabilities leveraging existing technology platforms at the City
   b. Capability to interface with City GIS, CityWorks, and perhaps other, financial systems
   c. Ability of software to interface with other City asset management efforts and infrastructure (e.g. water, signs, roads, parks, etc.)
   d. Decision making capability of software in
      i. Assisting with Gap Analyses
      ii. Balancing system recommendations with available resources
      iii. Performing long term financial planning
   e. Compliance with City terms and conditions
   f. Ability to meet user profile requirements (from the Planning, Project Management, and Field Operations unit) such as
      i. Functionality
      ii. Usability / User Friendliness
      iii. Flexibility
      iv. Performance
      v. Integration
3. Identification of Available Resources

   It is important to juxtapose needs with available resources such as
   a. IT infrastructure capabilities (including storage, mobile technology, already existing software etc.)
   b. Financial constraints (in addition to the purchase price of a software, many asset management applications include annual maintenance fees as well as implementation fees)
   c. Capabilities of existing tools – for example, CityWorks has infrastructure planning and asset management modules, which may accomplish some of the functionality the City desires

   At the end of this task, a matrix will be developed, summarizing the findings and answers to the questions listed in the previous steps. This matrix can be used in the subsequent tasks.

12.2 Selection of Software, Purchase and Licensing

As part of this process, our team will help the City invite and interview select vendors for more specific presentation of the capabilities of their applications. Our team has developed decision making matrices to aid in the selection of this software.

12.3 Implementation

As part of this project, once the software has been selected, our team will work with the City to implement the software on the City's IT system. Our team will utilize the selected software during the project so that the analyses and functionality developed for this project is already loaded into the City's software.

12.4 Training

It is our understanding that the City desires up to eight staff members to be trained in the selected software. Our team is experienced and well versed with the above stated process and has implemented asset management software application that gained wide acceptance in the industry. For example, our team

- Has utilized the Assetic (www.assetic.com) software in the City of Livonia Asset Management program
- Has been assisting the Oakland County Water Resources Commissioner in implementing Riva (www.rivamodeling.com)
- Has implemented Innovyze's InfoMaster (www.innovyze.com/products/infomaster/) software for Dekalb County, GA that was enhanced with CH2M's SCREAM logic.
- CH2M has implemented our SCREAM software for storm and sanitary system for many clients including: Boston Water and Sewer Commission; Columbus DPU; Northern Kentucky SD1; Aurora, CO; Puerto Rico Aqueduct and Sewer Authority; and Fairfax County, VA.
- CH2M has implemented numerous AM software solutions and enhanced existing CMMS and other existing Microsoft Excel and database tools to meet our client's needs for making asset decisions.

	Inspect assets in the field	Calculate condition scores	Calculate risk scores (bottom up)	Create re-inspection plan and schedule	Create maintenance plan and schedule	Create rehabilitation plan (for CIP)	Calculate rehab and maintenance costs	Calculate lifecycle costs	Prioritize rehab methods
Gravity lines	Any CCTV Software	SCREAM Scoring	SCREAM Risk	SCREAM Next Step	SCREAM Next Step	SCREAM Next Step	SCREAM Costing	SCREAM Costing	SCREAM Costing
Gravity assets (manholes, regulators etc.)	SCREAM or other standard software	SCREAM Scoring	SCREAM Risk	SCREAM Next Step	SCREAM Next Step	SCREAM Next Step	SCREAM Costing	SCREAM Costing	SCREAM Costing

It should be noted that SCREAM is not an off-the-shelf software program. It is rather an engineered software solution that can be utilized by Ann Arbor staff to as a tool to help manage asset data as well as to prioritize and cost multiple repair/rehab/replace options to maximize the life cycle cost of the asset. The software is free, however, CH2M does require the City to sign a Non-Disclosure Agreement to protect the algorithms and logic that was developed for this tool.

SCREAM can easily be used in conjunction with Ann Arbor existing CIP prioritization tool, as discussed further in task 8. SCREAM will help to identify needed maintenance activities and capital projects, while the CIP prioritization tool will help to develop the full CIP. CH2M has also been successful in building the SCREAM logic into "Off-the-Shelf Software" programs, such as Innovye's InfoMaster, to enhance the software's out-of-the-box logic.

Optional Task 13: Modeling Blockage Driven Failure to Support Operations & Maintenance Optimization

A sanitary system component is considered failed if it does not fulfill its desired level of service functionality, whether it be social, economic, or environmental / regulatory. Failure, on the other hand, can be defined as 1) Structural; 2) Environmental; 3) Capacity; or 4) Operations and Maintenance. Out of these, operations and maintenance failures, specifically caused by root ball, grease, or solid build up, are among the more frequent failures encountered in sanitary sewer systems, which have a likelihood of resulting in blockages, causing sanitary sewer backups.

The purpose of this optional task is to utilize asset inventory, work order, and historical operations and maintenance data to develop what is referred to as a stochastic model in order to:

- Estimate the conditional probability of failure due to the above stated operational and maintenance condition of the system, and
- Approximate the anticipated reduction of rates of failure given certain operational and maintenance improvements, e.g. increased frequency of system inspection/cleaning or utilization of advanced warning/monitoring technologies.

A stochastic model is a tool for estimating probabilities of potential outcomes by allowing for random variation in one or more inputs over time. The random variation is usually based on fluctuations observed in historical data for selected periods. For example, blockage due to a root ball can be considered a function of the location of the sewer, its age, material, and burial depth among other factors. Therefore, a stochastic model would, for example, take a pipe of a certain burial depth in a certain location and assign, randomly, variations in age and attempt to estimate the frequency of blockage failure over time.

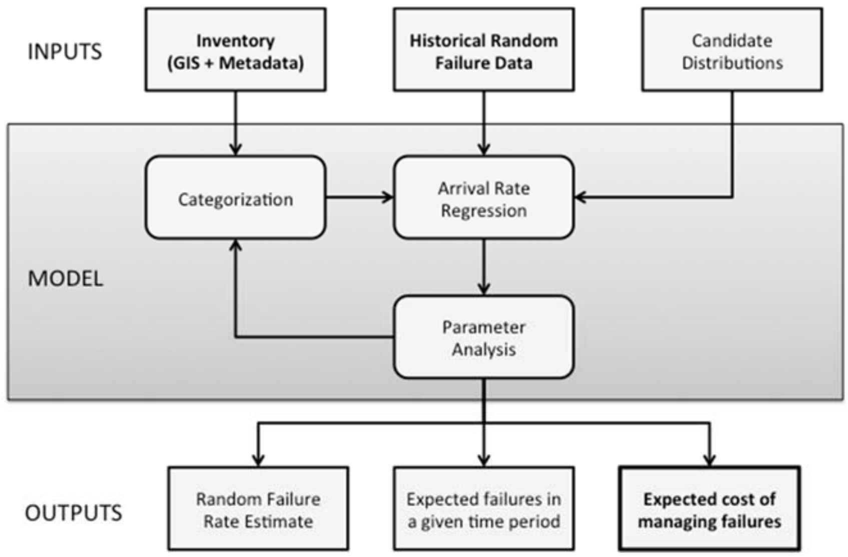


Figure 13-1: Failure rate model structure

Model Purpose

The proposed stochastic infrastructure model consists of two types of submodels: a failure rate model to estimate the number of likely failures in a given period; and a Markov state transition model to estimate the long-term performance of the network in response to alternative O&M strategies.

Failure rate submodels (**Figure 13-1**) are based on analysis of historical failures, and are used to establish the expected rate of failure (e.g. rate at which blockages will occur) for different types of pipes within a sewer network. When used to model large systems (such as sewer networks) these models are most applicable when applied to homogeneous subsets of the network – such as pipes of comparable age, size, material type, and customer type.

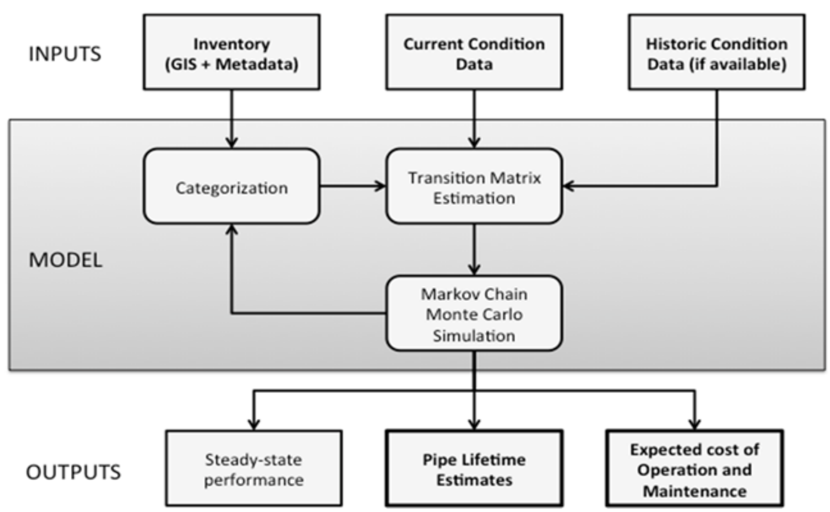


Figure 13-2: Markov chain model structure

Markov state transition models (Error! Reference source not found. **13-2**) help analyze of the types of blockages the system might encounter over time, the rate at which these blockages might occur, and the relationship between occurrence of blockages, failure triggers, and the impact of operations and maintenance activities at differing frequencies (e.g. frequency of sewer cleaning, inspection, etc.).

The categorization step in each model structure indicates a "binning" operation, in which subsets of the pipe network are grouped together for analysis. Each group is analyzed separately with an individual failure rate model and Markov chain simulation. This is done so that pipes with similar performance characteristics and degradation properties are evaluated together. These groupings are developed using data mining tools, and the applicability of their models is checked using cross-validation to ensure reliable outputs.

Data Requirements

Three types of data are useful for developing these models: asset inventories with metadata, records of past interventions, and condition assessment data. Asset inventories that include metadata such as GIS layers, installation dates, size, material type, geotechnical condition, and customer type are used for segregating the network into relatively homogeneous categories, as well as for identifying which factors indicate higher rates of degradation or rates of failure. Records of past interventions - particularly for blockages - are used for populating failure arrival models. Current condition assessment data is used in conjunction with both historical condition assessment data and historical intervention data to develop Markov degradation models.

Level of Effort

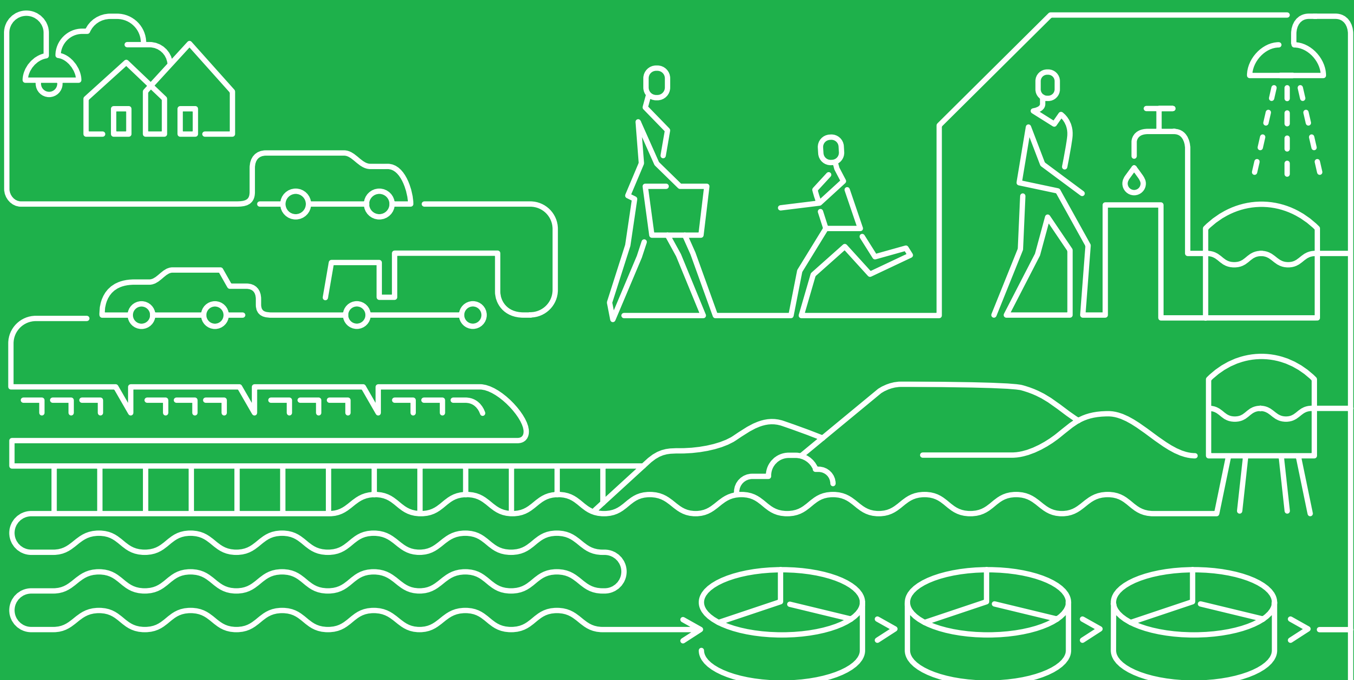
The level of effort hours for the CH2M team are presented below in **Exhibit 14-2**.

EXHIBIT 14-2 - Level of Effort

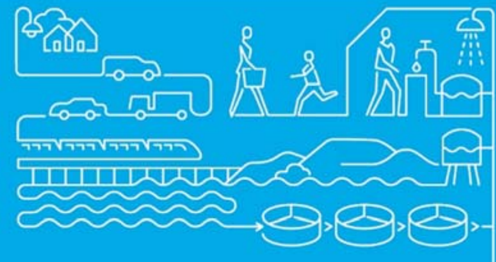
City of Ann Arbor
Sanitary Collection Asset Management Program
Tuesday, February 02, 2016
Assumed 30-month duration

Tasks	Title	Decker	Lifton	Haskins	Matichich	Kelly	Kennedy	Sanford	Kauffman	Rowe	Newton	Bishton	Gnadnt	Office/Admin Support	Ulasir	Curie	Cousins	Kerkez	Kacvinsky	Hunt	DiBenedetto	Miller	Total Hours
1	**Asset Inventory**	**28**	**2**				**34**		**52**	**12**				**20**	**144**	**68**	**108**	**32**	**28**				**528**
1.1	Review Existing Asset Inventory	8					16		24						32	20	40		12				152
1.2	Identify Gaps	8	2				10		16	4					40	16	20		8				124
1.3	Recommend Strategy to Obtain Missing Information	8					8		12	8				20	40	16	8		8				128
1.4	Assistance in Adding Missing Information	4													32	16	40	32					124
2	**Condition Assessment**	**28**	**4**	**2**			**100**	**40**	**16**	**20**				**20**	**104**	**236**	**52**						**622**
2.1	Review Existing Condition Assessment Data	8					40	8	8	4					24	100	20						212
2.2	Determine Asset Assessment Methodology	8	2				8	24	8	8					32	40							130
2.3	CCTV Contractor Selection / Coordination	4					40			4					16	80	20						164
2.4	Condition Performance of System Assets	8	2	2			12	8		4				20	32	16	12						116
3	**Useful Life Determination**	**20**	**4**	**2**			**12**	**24**	**8**	**12**					**100**	**20**	**28**		**32**				**262**
3.1	O&M Failure Data Review	4						8	8	4					24	20	20		16				104
3.2	Remaining Useful Life Analysis	16	4	2			12	16		8					76		8		16				158
4	**Life Cycle and Replacement Costs of Assets**	**24**	**4**	**2**			**12**		**12**				**72**	**20**	**12**				**8**				**166**
4.1	Review Cost Data	8					8		8				24		4								52
4.2	Determine Asset Values and Local Costs	16	4	2			4		4				48	20	8				8				114
5	**Determine Target Levels of Service**	**80**	**2**	**4**		**100**			**16**					**20**	**36**		**16**		**12**				**286**
5.1	Review Existing LOS and Performance Measures	16				16			8						4		8		4				56
5.2	Define Target LOS	24				32									8				4				68
5.3	Gap Analysis	40	2	4		52			8					20	24		8		4				162
6	**Determine Criticality of System Assets**	**320**	**6**				**72**		**16**	**22**				**20**	**52**		**104**						**612**
6.1	Establish Risk Criteria	40					8		8	4					4		8						72
6.2	Determine Likelihood and Consequence of Failure	100					32		8						16		40						196
6.3	Calculte Criticality Ranking	100					24			4					16		40						184
6.4	Determine Risk Mitigation Strategies	80	6				8			14				20	16		16						160
7	**Formalize Optimal O&M Program**	**34**		**6**			**80**		**24**	**36**	**124**			**20**	**16**	**40**							**380**
7.1	Review and Document Existing O&M Procedures	4					16		8	4	40				4	16							92
7.2	Recommend Revisions to Procedures / Gap Analysis	8		2			8		8	8	20				4	16							74
7.3	Decision Making Process	6					32			16	40				4								98
7.4	Optimized O&M Plan	16		4			24		8	8	24			20	4	8							116
8	**Optimize Capital Improvement Program**	**60**		**6**	**80**							**114**		**20**	**28**		**20**		**24**				**352**
8.1	Review Existing CIP Priortization Model / Criteria	8			8							8			4								28
8.2	Recommendations to the Existing Prioritization Model	8			16							16			8		8		8				64
8.3	Identify Capital Improvements Projects	16			24							32			8		8		8				96
8.4	Long-Term Strategy for Capital Reinvestment	28		6	32							58		20	8		4		8				164
9	**Establish Sustainable Funding Strategy**	**24**		**2**	**56**							**84**		**20**	**12**								**198**
9.1	Peform Gap Analysis	8			24							20			4								56
9.2	Recommend Optimal Funding Strategy	16		2	32							64		20	8								142
10	**Generate Asset Management Plan**	**72**	**6**	**6**	**6**	**100**		**16**	**8**	**8**	**16**	**4**		**20**	**64**	**16**	**16**		**16**	**8**	**16**	**24**	**422**
10.1	Develop System AMP	40	6	6	6	60		8	4	4	8	4		20	32	8	8		8	8	16	24	270
10.2	Develop Standard Operating Procedures	32				40		8	4	4	8				32	8	8		8				152
11	**Public Engagement**	**40**	**2**	**4**		**16**									**52**					**76**	**136**	**144**	**470**
11.1	Communication and Engagement Strategy	4	2	4		8									8					20	40	40	126
11.2	Establish Core Messaging	4				8									8					16	32	20	88
11.3	Coordination with Staff, Key Stakeholders and Media	32													36					40	64	84	256
12	**AM Software Selection and Implementation**	**20**	**2**	**2**			**90**		**90**	**10**				**20**	**28**		**72**	**324**					**658**
12.1	Software Selection Assistance	8	2	2			16		16	4				20	8		16	32					124
12.2	Software Purchase / Licensing	4					2		2						4			32					44
12.3	Implementation	4					40		40	4					8		40	200					336
12.4	Training	4					32		32	2					8		16	60					154
	TOTAL EMPLOYEE HOURS	**750**	**32**	**36**	**142**	**216**	**400**	**80**	**242**	**120**	**140**	**202**	**72**	**200**	**648**	**380**	**416**	**356**	**120**	**84**	**152**	**168**	**4956**

Stormwater Conveyance System



Tab B
Proposed Work Plan



Project Approach

Ann Arbor faces all-too-familiar challenges, increased cost of services, aging existing infrastructure, and the need to optimize investments in maintaining their assets. Like many utilities throughout North America, Ann Arbor has identified a need for an asset management (AM) process to prioritize capital projects for their CIP as well as to optimize their operations and maintenance (O&M) of their systems to minimize the life cycle costs.

The CH2M team has helped develop successful infrastructure Asset Management processes for many water utilities across Michigan and North America, including Oakland County WRC, Auburn Hills, Livonia, as well as for Columbus DPU, DC Water, Dayton Water and Northern Kentucky Sanitation District 1.

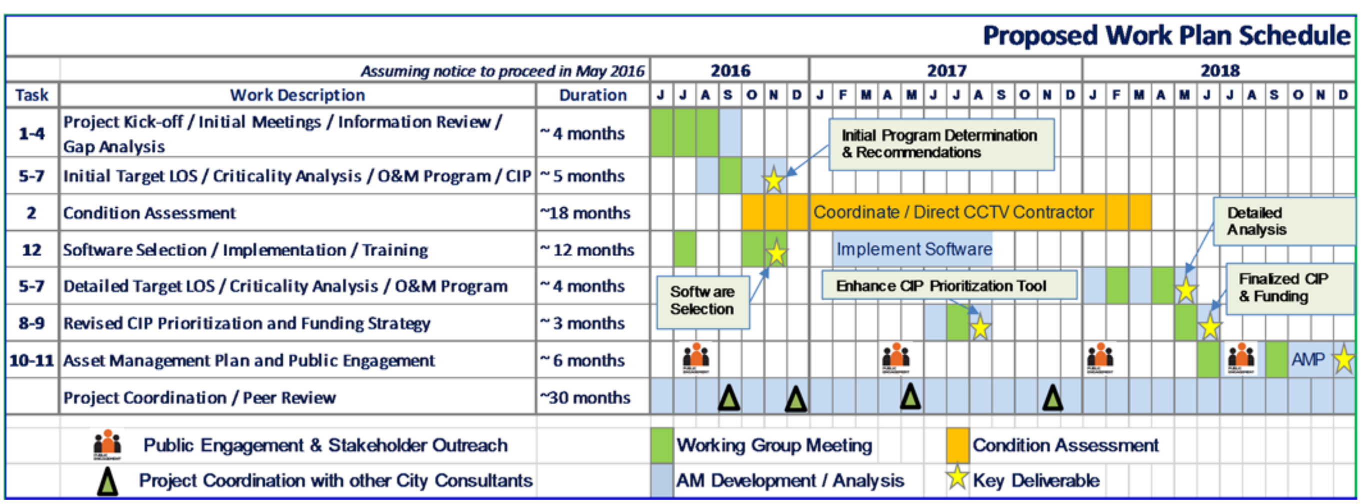
The CH2M team will provide Ann Arbor with an AM program for evaluating the physical assets of stormwater system to ensure safe and reliable service, while maximizing each asset's useful life in the most economical manner. In this process, we plan to fully engage key stakeholders and emphasize effective content delivery and communication to the public. The effort is focused on developing a sustainable asset management program, as well as associated tools, processes, and data that prioritizes capital and operational expenditures in the maintenance, repair, rehabilitation, and replacement of the stormwater system infrastructure in a proactive manner. In order to achieve these results, the CH2M team has identified ***five keys to success*** for Ann Arbor to develop a leading practice AM program to address their project goals:

Our 5 Keys to Success

1. ***Produce Early Wins***
2. ***Optimize the O&M Program***
3. ***Develop a Messaging Strategy Early in the Project***
4. ***Maximize Collaboration with Related Projects and Key Stakeholders***
5. ***Utilize CH2M's SCREAM software***

Produce Early Wins to Guide the Program and Win Staff and Key Stakeholder Support

The CH2M team understands that this is a very important project for the City of Ann Arbor and may last up to 3-years. However, 3-years is too long for the City to wait to receive recommendations and begin implementing the asset management plan final deliverable. A sustainable AM program needs to build on the success that Ann Arbor has already achieved and enhance their processes to achieve their ultimate goals. Within the first 6-months, our team will kick-off the program with a focused, initial effort to understand the City's systems, processes, data, IT systems as well as key stakeholder expectations. We will perform an initial gap assessment to better understand your utility and provide initial



recommendations that the City can immediately implement. In addition, we will perform a criticality analysis of your system based on existing data and institutional knowledge to provide an initial risk prioritization to help focus condition assessment and O&Ms on the pipes with the highest risk. It is our experience with other utilities that producing quick results that staff can quickly use helps to win their support of the AM program and adopt new process changes.

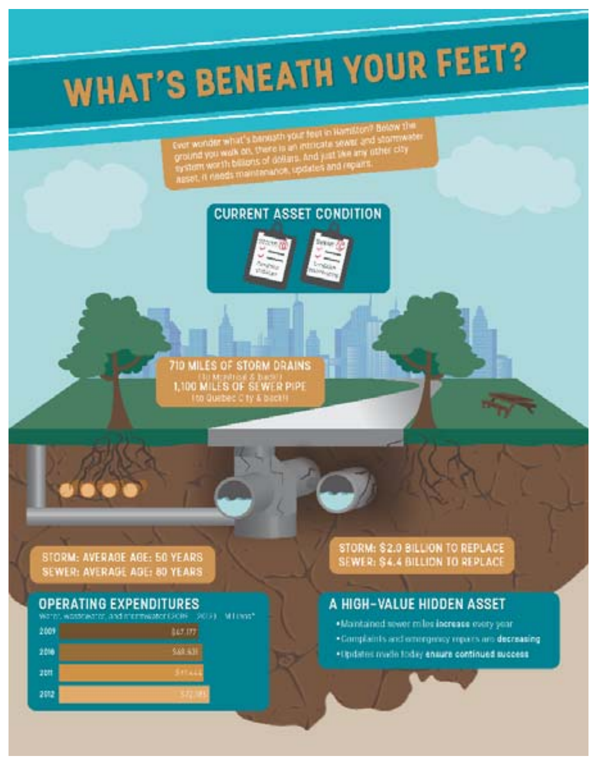
- **Optimize the O&M Program**

A sustainable AM program must include optimization of a utilities O&M program to efficiently and effectively maintain their system and achieve the most life out of their assets. The CH2M team includes experienced operators that can quickly assess your O&M practices, staffing and equipment. Our experience in operating over 100 water/wastewater system across North American gives us first-hand experience of knowing what really works and the proper intervals of doing the right maintenance and inspections. In addition, our team has helped to implement numerous field GIS applications to help streamline the O&M process and assist in collecting valuable data. Finally, our team will leverage our experience and carefully account for key staff operations and maintenance considerations when developing condition assessment procedures to be used by the City and City acquired contractors.

A GIS enabled hand-held device like that developed for the City of Newport can be developed specifically for Ann Arbor to enhance data gathering and Cityworks work order management.

- **Develop a Messaging Strategy Early in the Project**

Creating a messaging strategy early in the project to engage key stakeholders and educate the public will be vital. We have teamed with Lambert, Edwards and Associates (LE&A) who will bring a wealth of national and State of Michigan experience in developing a core messaging strategy and lead our public relations efforts. The graphic shown here is an example on the use of an infographic which can play an extremely important role in educated the public and winning key stakeholder's support for Ann Arbor AM program. This infographic was developed for this proposal based on the Ontario Hamilton asset management program mentioned in the pre proposal meeting. CH2M was the lead firm in developing the asset management program for the City of Hamilton.



Infographics are powerful communications tools to help tell Ann Arbor's Asset Management Story to the public and

In addition, our experience in developing AM programs across North America has shown that early engagement of internal stakeholders is vital to the long-term success of the asset management program. The CH2M team will develop a framework for effective communication between the City's Field Operations, Systems Planning, and Project Management Services Units. This will be critical as the program is implemented to ensure newly-developed tools are used effectively between the three Units and that data is collected, shared, and used in a cost-effective and consistent manner.

- **Maximize Collaboration with Related Projects**

Ann Arbor is proactively planning for their future through numerous studies and programs. Each of these play an important part in developing a sustainable asset management program. The CH2M team will coordinate with these other consultants and studies through the AM program. We will proactively meet with the City and their consultant to understand and align the AM program with these other efforts. For example, as part of the Columbus DPU AM program, CH2M was proactive in coordinating the AM program with other City priority program such as their Capacity, Management, Operations, and Maintenance (CMOM), wet weather and green infrastructure programs. Our team will coordinate and incorporate the results of the following projects at minimum:

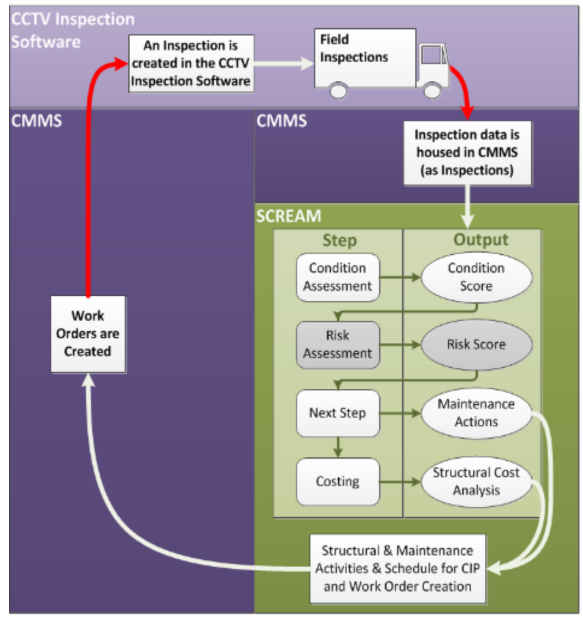
- Green Infrastructure Asset Management Plan (anticipated to be completed soon)
- Stormwater Level of Service and Rate Analysis Study (anticipated to start soon)
- Washtenaw County Stormwater SAW Asset Management Program (ongoing)

We believe coordination with Washtenaw County is important because any potential deficiencies that may result in the County infrastructure within the City limits, e.g. the Allen Creek enclosure, may have significant level of service and potential cost ramifications to City residents and stakeholders. In addition, our team will work with the City to coordinate with other City departments and groups, such as the Planning, Project Management, and Field Operations departments in order to ensure that the asset management programs and procedures developed as part of this program can effectively be used by these service units. This will help to align the AM program with other departments and to help coordinate capital projects with other similar capital projects. As part of CH2M's CIP prioritization work on Ann Arbor's Water Master Plan, the CIP prioritization tool that we developed for the City was expanded to include multiple City departments to help align capital projects across the City.

- **Utilize CH2M's SCREAM™ software to cost-effectively maximize the use of existing data**

The CH2M team will initially utilize CH2M's Storm/Sanitary Condition Review Enhanced Assessment Method (SCREAM™) to quickly evaluate coding identified in the CCTV database. Our initial review will help to assess and potentially utilize the City's existing 6,700 CCTV records. We understand that the coding in these records are not necessarily reliable or complete. However, utilizing an automated tool such as SCREAM will help assess available data, potential coding errors and records to prioritize for further, detailed review in an efficient and timely manner. SCREAM uses advanced algorithms to produce a more granular view of the City's pipes than what PACP can provide. CH2M has also been successful in building SCREAM's logic into Innovyze's InfoMaster software, as well as working alongside many CMMS systems (including Cityworks) and ArcGIS.

The following pages describe our work plan and technical approach to complete tasks 1-12 as noted in the RFP, as well as an optional task 13 they may benefit the City's O&M program.



SCREAM integrates with CCTV software and CMMS to exchange info between the field and the office

Task 1 – Asset Inventory

As part of the initial discovery effort, our CH2M team will work with Ann Arbor staff to review the database structure, existing asset inventory, existing asset hierarchy in Cityworks / GIS, and data management workflows. We will perform a desktop analysis comparing the requirements and needs of the program, the current data management framework, and industry best practices and standards to develop recommendations for a data model. Our team has in-depth knowledge of storm sewer data models and will apply our expertise to produce a data model that covers all current and anticipated future needs of the systems. This will include consideration for condition assessment, risk scoring, Asset ID, maintenance activities, infrastructure deterioration modeling, use of an Asset Management software and other considerations that may arise as requirements.

Under the direction and oversight of our task leader **Murat Ulasir**, the majority of the data collection and inventory will be performed by highly qualified, local OHM staff and key CH2M staff. The effort will focus on existing data in Ann Arbor's GIS and Cityworks databases, and will include, for example, age, pipe slope, material, diameter, installation conditions, collapse history, CCTV records, and work order history. In addition, CH2M is a Cityworks Platinum Partner, an ESRI Silver Partner and Authorized Integrator, and an Oracle Systems business partner, with extensive expertise in linking GIS spatial data with Oracle databases, as well as SQL server databases.

Ann Arbor staff will be asked to provide existing data dictionaries and similar documentation of the Cityworks asset records, GIS geodatabase, modeling databases, performance data, and similar systems that currently house asset information. The completeness and quality of the data will be discussed with Ann Arbor staff. The appropriate system of record will be identified for each piece of data so it is understood which system is the master repository and is used to maintain certain types of data. As part of the Request for Proposals, the City provided consultant teams with its existing stormwater GIS database. The work plan components detailed under this task make use of this GIS information. Key subtasks are described below.

1.1 Review of Existing Asset Inventory for Each System

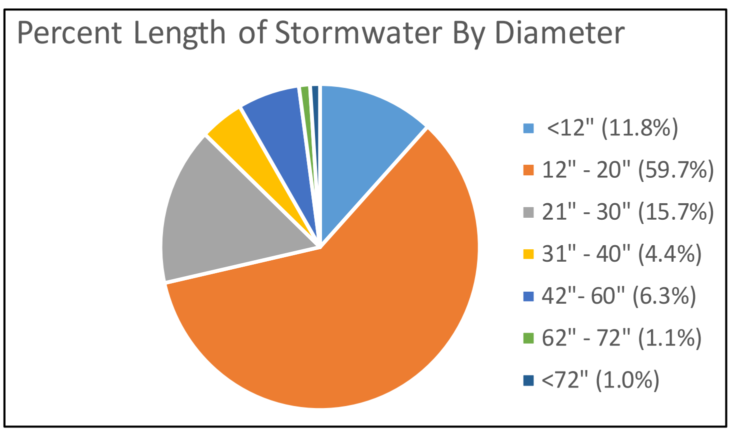
It is our understanding that the review of asset inventory as part of this proposal will exclude County-owned and MDOT-owned stormwater assets. **Table 1-1** summarizes the asset categories available in the City GIS. **Figure 1-1** further details the storm sewer asset inventories.

Table 1-1: Stormwater Asset Categories in City GIS

Asset Category	Quantity	Age	Condition	Last Inspected
Stormwater conveyance	~560 miles*	44 (average of available data)	Not available	Not available
Laterals	~5 miles	Not available (less than about 30% of data is available)	Not available (less than about 20% of data is available)	Not available
Manholes	9,986	47 (average, based on available data)	Not available	Not available
Storage Basins	761	15 (average)	Not available	Not available
Catch Basins/Inlets	15,931*	45 (average, based on available data)	Not available	Not available
Curb Connections	2,948	Not available (more than ~50% of data was missing)	Not available	Not available
Creeks & Open Channels**	22 miles	Not available	Not available	Not available
Stream Crossings**	155	Not available	Not available	Not available
Outfalls**	357	Not available	Not available	Not available
Green Infrastructure**	Over 100	Not available	Not available	Not available

Notes:
**: the GIS based value is listed on the table. The RFP suggests that*
- the length of stormwater conveyance is approximately 293 miles
- the number of catch basins/inlets is 15,000
***: Not explicitly called out in the City GIS database that was made available and was listed in the RFP*

Figure 1-1 – Stormwater Asset Inventory Detail



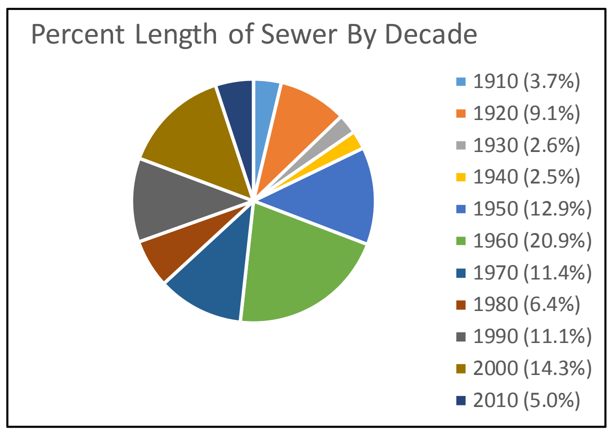


Figure 1-1 suggests that the City experienced a growth spell between the 1950s and 1960s, during which nearly 35% of the stormwater conveyance was installed. Furthermore, based on City GIS data, 12" – 20" stormwater conveyance constitutes nearly 60" of the stormwater infrastructure.

As part of our review of existing inventory, we propose to extend our assessment and review of available data to assets not covered in **Figure 1-1** in a similar manner, i.e. extract key asset category information from available data.

Regular progress review and coordination meetings\calls will be held to ensure the effort is performed as efficiently and effectively as possible. Also, OHM's familiarity with Ann Arbor's storm sewer infrastructure will help inform our efforts due to our team's thorough knowledge of the asset types, typical failures, areas of concern, and differing installation conditions from past decades. This knowledge base of infrastructure systems and installation practices can be leveraged to expand condition information to other parts of the system for which no condition information is available. Furthermore, data gaps will become apparent, which is further discussed in the next section.

1.2 Identify Gaps in Data

Table 1-1, for example, suggests that a significant amount of condition data, material, as well as installation year, is missing from the data set. This information is pertinent particularly in evaluating trends in the data for asset condition and is helpful in extrapolating condition information to the rest of the system for which no historic condition data either exists or is planned on being collected in the future. We plan on identifying additional, relevant data gaps for the asset categories.

1.3 Recommend a Strategy to Obtain Missing Information

One simple means by which asset age can be approximated is through institutional knowledge of senior staff in the organization. Another means would be through an evaluation of construction ages of homes, potentially accessible through parcel data and researching historical aerial photography to determine when specific neighborhoods were constructed. As part of this task, we propose to further identify strategies for obtaining relevant information. Some of these strategies may include the following:

- Historic soil boring records or NRCS soil atlases for understanding soil conditions
- Institutional knowledge of senior staff
- City parcel data
- As-built records
- Records of nearby infrastructure (such as water main)
- Enabling field crews with best practices for updating data
- Washtenaw County historical imagery (goes back to ca. 1940s)

1.4 Adding Missing Asset Sub-Categories & Reporting Out Asset Inventories

The most optimum means of adding asset sub-category data as well as reporting out asset inventory can be impacted by two broad categories:

- The user profile – whether information needs to be reported out to field crews or planning personnel
- Toolsets – the type of asset management software and capabilities the City chooses.

As will be addressed in Task 12 of this proposal, for example, several asset management platforms exist, which not only offer data analysis and forecasting functionality but also means of appending and reporting out on asset inventory as well as existing and anticipated future asset condition. In addition, ESRI local government information models provide means by which asset data can be added or reported out depending on the target user profile. For example, the Water Utility Mobile Map template application allows field staff to gain access to utility information as well as communicate field observation back to office staff. We propose to evaluate these options with City staff as part of this task.

Task 2 - Condition Assessment

The CH2M team will use a proven condition assessment framework and partner with Ann Arbor to develop a condition assessment approach that efficiently evaluates the stormwater system's data and builds on institutional knowledge. Prior to defining parameters affecting asset condition, the general mechanisms of asset failure need to be evaluated. In the context of stormwater infrastructure, the infrastructure component is considered failed if it does not fulfill its desired level of service functionality, whether it be social, economic, or environmental / regulatory. As such, ***we plan on utilizing a comprehensive condition assessment process including four different types of failure mechanisms*** as follows:

- Structural (such as severely corroded buried stormwater conveyance pipes or stream crossings (e.g. culverts), deformations in sewer pipes, erosion along pond shorelines, channel bank failures, and malfunctioning pond outlet structures)
- Environmental (such as flooding-induced hydrostatic forces on storm infrastructure, hydrogen sulfide induced corrosion in sewer pipes, and increased sediment loading caused by streambank erosion)

- Capacity (such as excessive inflow and infiltration into storm sewers)

Operations & Maintenance (such as sedimentation build up in stormwater infrastructure (including detention ponds) or other blockages in storm sewers). Out of these failures, operations & maintenance induced ones are the more frequent, although, capacity and structural failure induced ones can have higher consequence of failure. Key subtasks are described below.

2.1 Review Existing City-Collected Condition Assessment Data

In the context of the above discussion, we plan on condition evaluating the stormwater infrastructure utilizing structural, environmental, capacity and O&M factors. Table 1-1 in Task 1 summarized condition information on infrastructure digitized in the City GIS system and information provided in the RFP (Request for Proposals). However, it is our understanding from the pre-bid meeting for the proposed work that the condition information contained in the GIS might not necessarily correspond to the true condition in the field. Besides, many other infrastructure asset categories did not have any data available for condition. For example, the Green Infrastructure asset management plan is being developed as we understand it, which may include inventory and condition assessment of roadside bioretention cells, rain gardens, sub-pavement infiltration areas, etc. We plan on integrating the findings of these studies into the work plan discussed in this proposal. In general, we plan on utilizing, at a minimum, the information below for developing a comprehensive condition assessment of the infrastructure:

- City's 2016-2021 Capital Improvements Plan
- GIS layers and database
- Historical maintenance records
- As-built plans for public sewers
- Documented system cleaning schedules
- 6,700 Digital CCTV Videos of sewer pipe conveyance segments (available since 2012, not PACP scored)

Automated Condition Assessment Tool

As part of this task, we plan on utilizing CH2M's proprietary condition assessment tool as well as the Storm/Sanitary Condition Review Enhanced Assessment Method (SCREAM) to quickly summarize coding identified in the CCTV tapes. As noted in the Request for Proposal and further detailed in Addendum 2, we understand that the City has 6,700 videos of pipe segments in their systems (approximately 1,200 for the stormwater system), which was collected since 2012. However, these videos and the associated data are not a trusted data source by City staff. In particular, the defect coding used to assess the pipe condition did not directly follow NASSCO's PACP standards. Our team will review the PipeLogix database and conduct a quality control (QC) review of a portion of the videos (100 segments) to assess the usability of this data. Base on this review, our team will provide recommendations to the City on how best to use this data. In particular, we have had other utilities that have made consistent miscoding of defects (i.e. fracture instead of crack). If this is the case, we have made this coding change in the database. If the miscoding is more random, the dataset can still potentially be used to help prioritize future condition assessments as noted in our approach below. While the database may not be accurate enough to be used for condition ratings, it can still identify the more severe issues in the buried assets.

The value of this exercise would be that it would not take many resources to review large amounts of CCTV data in a short period of time. Erroneous or inconsistent defect coding can be quickly identified, prioritized, and evaluated by our trained PACP staff.

2.2 Determine Asset Assessment Methodology

To lay the groundwork for the condition assessment, our **Condition Assessment Leads Kyle Curie and Reggie Rowe** will facilitate a targeted workshop with the Ann Arbor team. During the workshop, we will establish consensus regarding the goals and approach for the systems condition assessment and reach a common understanding of the data requirements for each major asset category. The outcome of the workshop will include the following:

- ***A list of asset condition attributes to be collected for each asset or component.*** We will use our team's extensive database of attributes for pipes, manholes, special structures, basins, etc. as a starting point at the workshop.
- ***Weighting criteria for the asset condition factors.*** Because certain factors may be considered more important or have greater impact on overall asset condition, the workshop will establish consensus-based weightings.

- ***Determination of "priority assets."*** We will conduct a more detailed assessment on priority assets. Lower priority or less critical assets will be evaluated by direct visual observation or desktop methods.
- ***Obtain staff input***. Staff input is critical to understanding asset condition and determining likelihood of failure. Some input will be obtained during this stakeholder workshop, and a process will be established to encourage and efficiently allow knowledge transfer.

Our Asset Management field staff have worked with many communities to create custom data collection methods to meet our clients' unique software and hardware needs. Our targeted key City staff and stakeholder workshop will help us establish data collection "ground rules" that will help ensure the data we collect can be seamlessly integrated with the City's Asset Management Software and GIS platforms.

- ***A process for prioritizing the data collection tasks.*** We will initially use a "top-down" approach to initially assess the assets. All assets will be graded on a scale of 1 through 5, with 1 being excellent overall condition and 5 being failed. During the workshop, the understanding of the relative grading for condition will be finalized. This initial "top-down" approach will be used to provide a baseline for the entire system as well as to prioritize areas, pipe types (material, diameter, age) to be assessed.

- ***Condition assessment schedule.*** A condition assessment schedule will be developed based on the available existing and usable data, along with the initial prioritization to develop a schedule for condition inspections. This approach will help to efficiently rate the system and maximize the amount of condition data to be developed as part of this work. The schedule will extend beyond the completion of this project, so that the City's ongoing condition assessment efforts can be planned. If desired by the City, these inspections can be scheduled in Cityworks and setup on a selected schedule to ensure that all the systems' pipes will evaluated.
- ***Create a communication framework between the City's Public Works Units.*** We understand the value of effective organizational communication in ensuring that different branches of the organization rely on the same set of data and information when making critical infrastructure decisions. For that purpose, we plan to create a framework for effective communication between the City's Field Operations, Systems Planning, and Project Management Services Units. This will be critical in ensuring newly-developed tools and software packages that the City chooses to acquire as part of this proposal are used seamlessly between the three Units and that data are collected, shared, and used in a consistent manner.

In addition to the above, we plan on developing asset assessment methodologies in collaboration with City staff to ensure that staff can quickly assess the condition of assets in each system. Some examples of our assessment methodologies are summarized below for consideration.

Stormwater infrastructure that will have a methodology developed for the following asset types:

- Storm Sewers (including mains, trunk sewers and interceptors)
- Manholes, Catch Basins and Curb Connections
- Retention / Detention Basins
- Stream Crossings / Culverts
- Outfalls
- Open Channels and Creeks
- Green Infrastructure

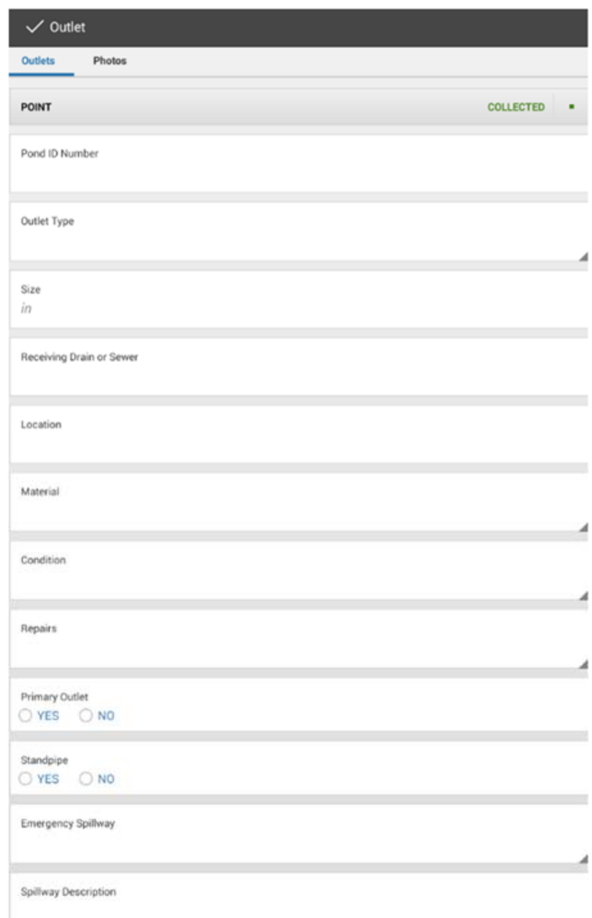


Figure 2-1: *Detention Pond Condition Assessment Sample Form*

Our team has developed a useful field data collection technique using GIS-generated tables to evaluate multiple components of detention ponds, resulting in an overall condition score of 1-5, similar to other gray infrastructure components. A screen capture of an inventory form is shown in **Figure 2-1.**

Plan for Obtaining Necessary Condition Assessment Data

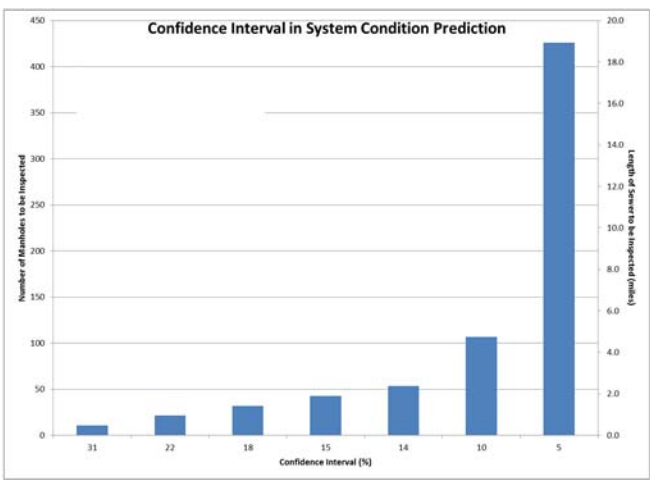
The plan necessary for obtaining missing condition assessment data must consider the need to be able to use this data to reliably predict the condition of assets that are not assessed. For that purpose, we propose to utilize a statistical sampling procedure that is also used in social and clinical population studies, which rely on confidence intervals. For example, it is well established that, barring other unusual system characteristics, manhole installation years correlate with material and therefore, a decades-based manhole sampling strategy is reasonable. However, the sample must be random if it is to be used to infer the condition of the remaining manholes in the system and must also include a minimum sampling size depending on the size of the population (i.e. the number of manholes in the entire system) as well as the desired level of confidence in using the information from this sample to project out to the rest of the system.

Figure 2-2 shows an example of a variation of manhole sample size against desired confidence interval. The example in this figure is for a population of approximately 11,000 manholes (or this number can represent storm manholes/catch basin inlets) and suggests that for a confidence interval of less than 5%, the sampling size would have to be nearly 450. It is important to note that for this process,

- The samples must be randomly chosen, and;
- Must reflect the distribution of the community infrastructure – a sample manhole/structure distribution is shown in **Figure 2-3** and reflects the communities existing infrastructure makeup.

Once this plan is followed, the assignment of condition to the rest of the manholes/structures infrastructure that has not been condition assessed, based on installation year, for example, can be done with reasonable degree of confidence.

Throughout the project and as detailed in the remaining tasks for this project, our team will identify the answers to these questions and develop a schedule for obtaining condition information for the remainder of the system.



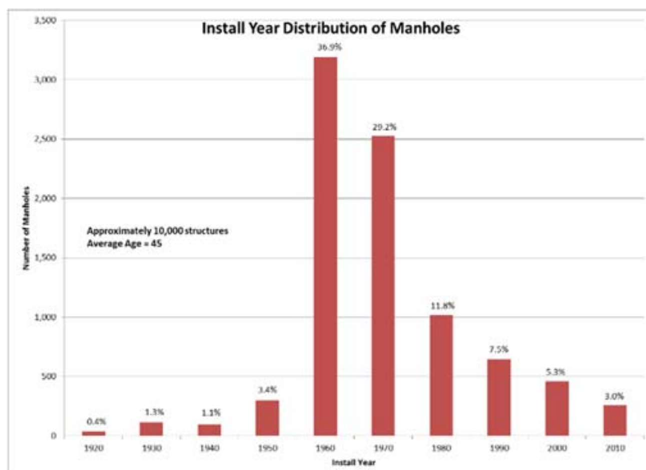


Figure 2-2 and 2-3: Selecting the Appropriate Sample Size

2.3 CCTV Contractor Selection Assistance and Coordination

The CH2M team understands that the City would like assistance on the procurement of a pipe televising contractor for the prioritized areas to assess noted above. Our team will work with the City to prepare a draft CCTV inspection specification for the selected contractor to meet that follows PACP/MACP guidelines. The specification will identify the format for the inspections, QC process and the process for turning over the data to the City. This specification will be reviewed by the City and used to select a qualified CCTV firm to conduct the prioritized inspections. Our team will assist the City through procurement and selection of a CCTV contractor through a separate contract from this project. Furthermore, our team is well versed in the type of televising options and their respective benefits. For example, two broad categories of televising options exist: 1) Clean first and televise later; or 2) Televise first, clean if needed. Either option has its pros and cons and our team is prepared to discuss these with the City team to select the most optimum option for consideration.

CCTV Contractor Coordination

The CH2M team will regularly meet with the selected CCTV contractor to assess the condition of the assets and ensure the data are being delivered in an acceptable format. Our team also includes experienced and NASSCO-certified PACP/MACP staff, who can quality control the data that is being collected by the sub-contractor. For example, our team utilizes ArcGIS online technology to track process of field assessment by sub-contractors as well as locations that are being evaluated on a nearly real time basis. A screen capture of this online tool is shown below. Team members **Kyle Curie and Tim Newton** will apply their background in operations to develop assessment criteria that identify O&M improvements. **The condition assessment criteria will be entered into CH2M's proprietary SCREAM database, which will expedite the data management and retrieval process.**

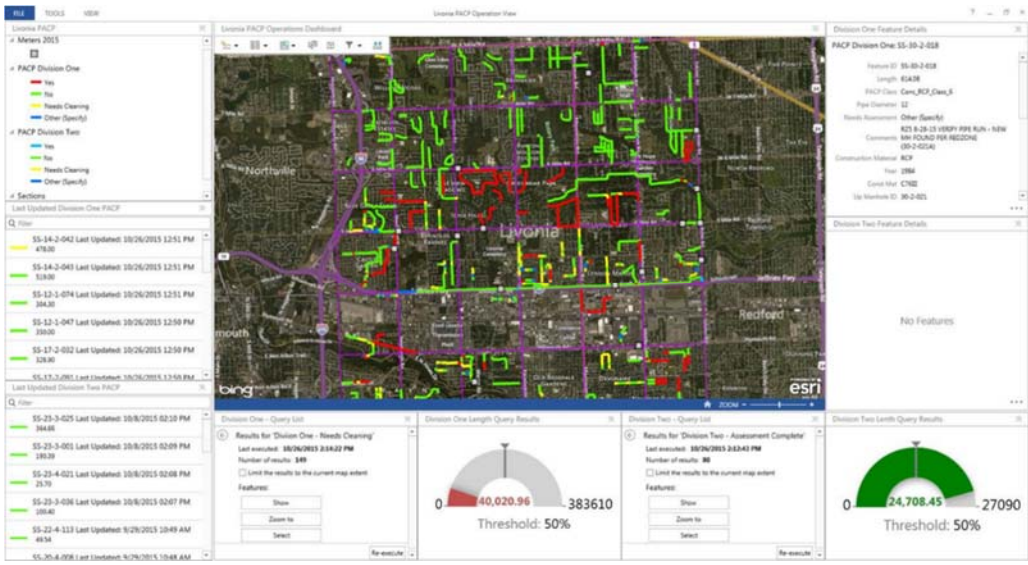


Figure 2-2: *ArcGIS Online Infrastructure Inventor Tracking Tool*

2.4 Performance of the Systems' Assets

A Condition Assessment technical memorandum will be developed that summarizes the findings of the condition assessment, analysis of the assets by asset class, and the critical and/or priority assets requiring maintenance, renewal, or replacement, as well as prioritizing assets for additional or immediate follow up. These initial findings of the Condition Assessment technical memorandum will be presented to Ann Arbor staff in a workshop, where additional feedback and comments will be gathered before finalizing the technical memorandum. Data from the analyses performed will be supplied to Ann Arbor as part of the Condition Assessment technical memorandum. The SCREAM database will be formatted so that it can be easily uploaded into Cityworks.

Task 3 - Useful Life Calculation

Assessing the remaining asset life is a very important process as it has a significant impact on factors such as:

- Optimizing capital expenditures
- Optimizing operations and maintenance strategies

Therefore, careful consideration must be given to not only determining remaining asset life but also continuously assessing asset condition such that remaining life estimates are properly calibrated and adjusted.

In Task 2 of this work plan, we outlined various means by which assets can fail and also defined what asset failure means in the context of this work plan. As such, in Task 2, asset failures included not only structural, environmental, but also capacity and operations and maintenance failures. Therefore, our approach to asset failure goes beyond just assessing structural failures of the system. Our techniques will assess structural and O&M failures and estimate remaining useful life based on these failure modes. We assume capacity failures have already been accounted for by several recent stormwater studies completed by the city.

Our approach to asset failure goes beyond just assessing structural failures of the system.

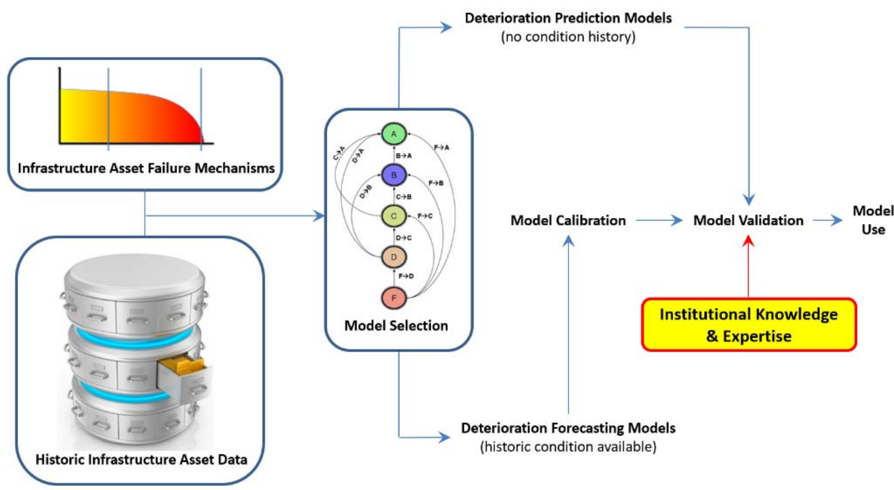
3.1 Operations & Maintenance Failure Data Review and Remaining Useful Life Analysis

As part of the base proposal, we propose to assess the operations and maintenance failure of the infrastructure by reviewing historic work order records, compiling institutional knowledge, and converting these findings to frequency of occurrence estimates utilizing a Pearson Type III type probability distribution method. As an optional task, given the availability and quality of historic records, we suggest a more rigorous operations and maintenance failure modeling. A description of this optional task is provided under optional tasks in this work plan.

3.2 Structural Condition Based Remaining Useful Life Analysis

There are several means by which structural condition based remaining useful life can be estimated. We propose to use these methods depending on availability of historic data for each asset type. In an effort to put the discussion and available methodologies into context, **Figure 3-1** was developed. This figure, in broad terms, outlines the process by which remaining useful life models for structural deterioration are developed. The subsequent sections discuss remaining useful life models in the context of this figure. The simplest means for determining remaining useful life referred to as the straight line depreciation model and assumes that historic infrastructure condition data is available. This is an example of a deterioration prediction model in **Figure 3-1.**

***Figure 3-1:** General Model for Remaining Useful Life Estimates*



Straight Line Depreciation Model

This model assumes a certain useful life of infrastructure based on type, material, manufacturer recommendations, industry standards, and studies completed on this subject. **Table 3-1**, for example, provides a general summary of such asset lives. The current asset age is then compared against such a table and, by assuming a straight line between current age and total asset life, an asset condition and remaining life is inferred.

Care must be given when using such a table for prediction purposes and the model validation process, even if qualitative, must be utilized. Below are several cautionary circumstances when using tables such as the above:

- Concrete gravity mains: if the mortar of the concrete is maintained, concrete infrastructure has the ability to last way past 100 years
- Brick / clay material: Such material has a history of very long life, much past 100 years. However, they are brittle and cracks tend to occur early in the life of the infrastructure, mostly during installation or backfill.
- Iron material: Hydrogen sulfide and other corrosion factors, for example, can significantly reduce the life of this infrastructure

Table 3-1: Estimated Useful Life of Sample Assets

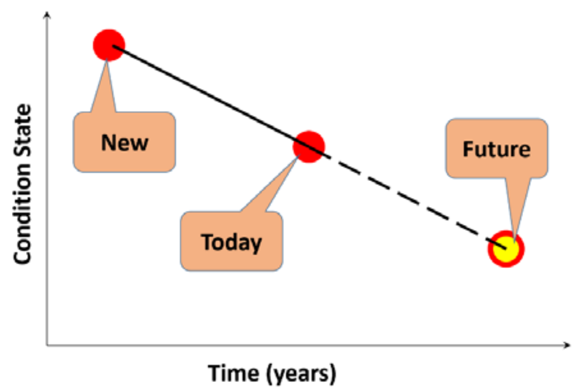
Asset Category	Estimated Life (years)
Gravity Mains /Culverts (Concrete, Brick, Vitrified Clay, Ductile Iron)	100
Gravity Mains / Laterals /Culverts (Corrugated Metal)	65
Manholes (Brick and Concrete)	100
Catch Basins (Brick and Concrete)	50
Open Detention Basins	50
Infiltration Basins	100

- Manholes: the top, cone section of the manhole tends to be much more impacted by freeze-thaw cycles and thus, has the potential to deteriorate much differently from the lower parts of the manhole
- Catch basins: these infrastructure, too, have the potential to be impacted by freeze-thaw cycles and the suggested remaining useful life values should be adjusted based on community specific observations and institutional knowledge

Condition Based Straight Line Depreciation Model

This method is considered a variation to the above detailed straight line depreciation model in that it is not the age of the infrastructure but its current condition, which dictates the remaining useful life. This method is one example of a deterioration forecasting model shown in **Figure 3.1. Figure 3-2** illustrates the condition based deterioration forecasting approach. Accordingly, an assumption is made that when the asset is originally installed (at year zero), it is in reasonably good condition. The age at which it is condition assessed corresponds to a condition state. A straight line between these two points' results in a condition based estimate of remaining asset useful life.

Figure 3-2: Condition Based Straight Line Depreciation Model



Advanced Structural Deterioration Models

More advanced infrastructure deterioration models can be employed on groups of infrastructure exhibiting similar behavior, e.g. infrastructure with similar material, size, location, failure type etc. Such models include non-homogeneous Markov chain process, non-homogeneous Poisson process, Linear Extended Yule Process, the time-based probabilistic Weibull or Herz models for modeling the aging processes of water and wastewater network pipes. However, many of these models require large amount of reliable, historic data and may not be suitable under all circumstances.

Task 4 – Analysis of Life Cycle and Replacement Costs of Assets

The development of a realistic AM Program hinges on both quality asset data, as well as relevant life-cycle costs for the assets. Costs from all aspects of an asset's life-cycle need to be carefully considered, including the O&M costs of an asset. Key subtasks are described below.

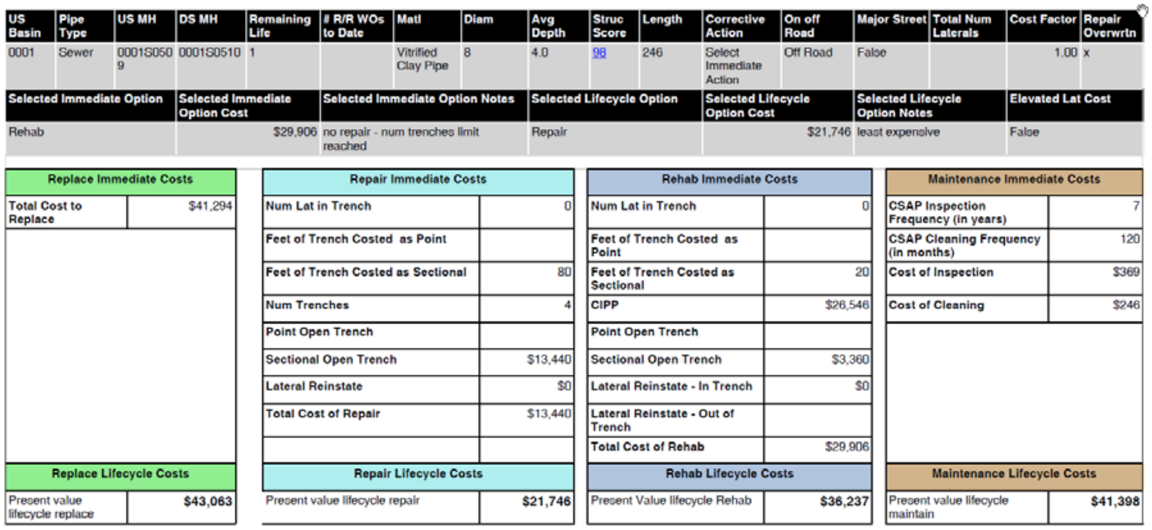
4.1 Review Cost Data

The CH2M team will analyze four key cost sources in order to develop costs for the AM Program:

- Existing Ann Arbor cost data—The CH2M team will evaluate the costs in Cityworks, as well as the City's performance financial data, to determine actual costs for projects.
- Ann Arbor cost tables—The CH2M team will review the 2015 Water and Wastewater Capital Cost Recovery Study as well as historical cost tables and bid tabulation data created by key Ann Arbor staff.
- Peer utility costs data—Other Michigan and Midwest utilities' cost tables will be reviewed and compared with Ann Arbor's costs.
- National cost trends—Cost tables established from national sources, such as USEPA, AWWA, WEF, ENR and others, will be reviewed and compared with Ann Arbor costs tables.

4.2 Determine Asset Values and Local Costs

The CH2M team will also utilize our SCREAM Costing software to compile these cost tables to develop Ann Arbor specific costs for repair, renewal and replacement of the assets. SCREAM will utilize the condition assessment data gathered from inspection, as well as O&M work completed and/or scheduled in CItyworks. SCREAM will then provide a comparison of current and life cycle costs to: Repair, Rehab, Replace or Run-to-failure (for low consequence assets). **Figure 4-1** below shows the comparison provided in SCREAM. This tool will also be used to quickly develop each Systems' asset values. In addition, CH2M is leading a study for the Transportation Research Board and the Airports Cooperative Research Program (ACRP) to develop a process and tool to better understand and determine the total cost of ownership for assets. While this research is focused on airports, there is some commonalities with the water industry.



US Basin	Pipe Type	US MH	DS MH	Remaining Life	# R/R WOs to Date	Matl	Diam	Avg Depth	Struc Score	Length	Corrective Action	On off Road	Major Street	Total Num Laterals	Cost Factor	Repair Overwrtn
0001	Sewer	0001S0509	0001S0510	1		Vitrified Clay Pipe	8	4.0	98	246	Select Immediate Action	Off Road	False		1.00	x

Selected Immediate Option	Selected Immediate Option Cost	Selected Immediate Option Notes	Selected Lifecycle Option	Selected Lifecycle Option Cost	Selected Lifecycle Option Notes	Elevated Lat Cost
Rehab	$29,906	no repair - num trenches limit reached	Repair	$21,746	least expensive	False

Replace Immediate Costs	
Total Cost to Replace	$41,294
Replace Lifecycle Costs	
Present value lifecycle replace	$43,063

Repair Immediate Costs	
Num Lat in Trench	0
Feet of Trench Costed as Point	
Feet of Trench Costed as Sectional	80
Num Trenches	4
Point Open Trench	
Sectional Open Trench	$13,440
Lateral Reinstate	$0
Total Cost of Repair	$13,440
Repair Lifecycle Costs	
Present value lifecycle repair	$21,746

Rehab Immediate Costs	
Num Lat in Trench	0
Feet of Trench Costed as Point	
Feet of Trench Costed as Sectional	20
CIPP	$26,546
Point Open Trench	
Sectional Open Trench	$3,360
Lateral Reinstate - In Trench	$0
Lateral Reinstate - Out of Trench	
Total Cost of Rehab	$29,906
Rehab Lifecycle Costs	
Present Value lifecycle Rehab	$36,237

Maintenance Immediate Costs	
CSAP Inspection Frequency (in years)	7
CSAP Cleaning Frequency (in months)	120
Cost of Inspection	$369
Cost of Cleaning	$246
Maintenance Lifecycle Costs	
Present value lifecycle maintain	$41,398

FIGURE 4-1 *Life Cycle Cost Comparison in SCREAM*

Task 5- Determine Target Levels of Service for Asset Systems

The deficiencies and failures of storm sewer pipes, structures, and basins present performance conditions that City staff must efficiently manage so that key repair, rehabilitation, replacement, and other capital investments are targeted, and that urgent needs are addressed in a timely manner to maintain the LOS the City desires to provide for its customers. The CH2M team will work with the City of Ann Arbor to develop a Level of Service (LOS) Statement, which will define the way in which its staff, managers, and operators desire the system to perform over the long term. The CH2M team will conduct an initial small group meeting with key staff to decide on the use of service levels and definitions of service levels. Following this initial meeting, the CH2M team will conduct a workshop with City staff to draft the LOS Statement. Key subtasks are described below.

5.1 Review Existing LOS and Performance Measures

The CH2M team will then review the City's current LOS, including:

- The 2007 Stormwater Study and pending update,
- The Stormwater Level of Service and Rate Analysis study that the City expect will be ongoing concurrently with this proposed work,
- The Green Infrastructure Asset Management Plan

For existing performance measures, established key performance indicators (KPIs), and the actual or historical LOS and performance. This will be accomplished through interviews with key staff, as well as review of existing documentation, such as the existing hydraulic models. The CH2M team will also evaluate State and Federal regulatory requirements that detailed in the City's MS4 and NPDES permits and Michigan Department of Environmental Quality (MDEQ) requirements, which will need to be included in developing the target LOS. **Exhibit 5-1** shows a breakdown of LOS characteristics, which ensures easy tracking of system performance. The 2007 Stormwater Study, on the other hand, outlined what was referred to as a Level B LOS recommendations out of four LOS categories and the identification of

EXHIBIT 5-1
Desired characteristics of LOS help to ensure system performance is easily tracked and is useful for the overall operation of the utility.

Levels of Service	
Meaningful	Relevant to staff and stakeholders Provides a clear picture of performance
Measurable	Can be measured in a cost-effective manner Expressed as a qualitative or quantitative measure
Consistent	Consistent with industry practice Measurement is reproducible by others
Useful	Helps manage the utility Encourages improvement
Unique	Describes a specific attribute of utility services or activities Independent of other LOS

which was largely based on criteria outlined in **Exhibit 5-1**.

One unique aspect of developing LOS criteria for the Stormwater system in particular is the fact that some stormwater infrastructure are County owned but their failure can have significant consequences in the City system and City residents. Therefore, our intent as part of this work is to engage in close collaboration with the Washtenaw County on their Stormwater Asset Management plan and facilitate an understanding for LOS expectations.

5.2 Define Target LOS

The CH2M team will then develop a recommended list of service levels and KPIs for consideration by Ann Arbor, building primarily from existing measures, considering current data quality, availability, as well as industry standards and best practices. The goal is to develop a targeted set of measures that are both technically meaningful and best align with the AM Program. This will include an initial set of targets for some or all of the chosen service levels that are in alignment with customer's and stakeholder's existing expectations, including anticipated willingness to pay. For our initial effort, we will consider such criteria as historical performance, current commitments, as well as available benchmark data for neighboring and national utilities with similar characteristics. Since LOS and KPIs are monitored to indicate system-wide performance, it is anticipated that no more than five primary levels of service will be established for the stormwater system.

5.3 Gap Analysis

In addition, we will hold discussions with key City management and leadership team members to understand expectations and needs based on currently available information. We understand that Ann Arbor currently tracks and reports a variety of regularly measured service levels. Many of the measures can be easily integrated into the AM Program. At the conclusion of our review, we will develop a Gap Analysis TM and matrix assessing the current LOS and key performance indicators, to the target LOS. In addition, we will provide a comparison of the levels with peer utilities.

Task 6- Determine Criticality of Systems' Assets (Risk of Failure)

Risk is a key concept critical in determining appropriate maintenance activities as well as the rehabilitation and replacement of Ann Arbor's s system assets. By quantifying and assessing the consequence and likelihood of failure, we will determine the risk profile for each systems assets.

6.1 Establish Risk Criteria

The CH2M team uses the widely accepted and traditional equation for risk: RISK = Likelihood of Failure (LoF) x Consequence of Failure (CoF), where LoF is how likely is it that an asset will fail due to condition or location and CoF is how critical an asset is to meeting the level of service of the collection or storm system.

An important principle in the process is the top-down and bottom-up approach (**Exhibit 6-1**), which is an iterative process. The process is based on recognizing the need for direction and support from the organization's leadership (i.e., vision, mission, goals, policies, etc.) and that decisions should be based on the best information available.

A set of risk scoring matrices will be used, one for the LoF of each asset and one for the CoF of each asset, with each having multiple areas. Each of the areas is also given a weighting, allowing adjustment of each area to be able to calculate a composite score that reflects the Ann Arbor importance placed on each of the areas of risk that are scored. A description of each increment of highest to lowest risk is used to help assure a common understanding.

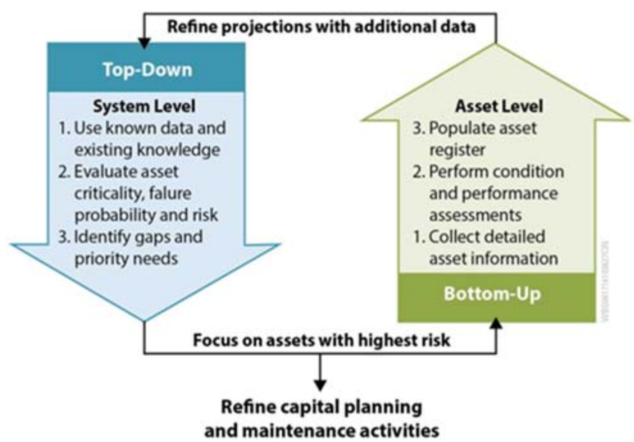


EXHIBIT 6-1

The top-down\bottom-up approach is an iterative process that initially utilizes the guidance of an organization's leadership to develop detailed data processes to better inform and direct the leadership with higher quality data.

6.2 Determine Likelihood and Consequence of Failure

Our team recognizes that determination of risk is a pivotal step in deciding whether an asset should be maintained, rehabilitated or replaced. However, the likelihood of failure component of risk is largely based on the current condition the asset. As with the majority of utilities, each asset does not currently have a condition rating or an associated inspection to develop this risk score. Therefore, the CH2M team will use a proven top-down, bottom-up iterative process to determine likelihood and consequence of failure ratings for each asset. The initial phase will utilize the institutional knowledge of the staff and existing data to produce a quick baseline risk score. The second phase will build from the initial phase and replace the baseline likelihood of failure score with an actual condition rating.

EXHIBIT 6-3
Results from the initial phase risk model will be connected to Ann Arbor's GIS to graphically highlight the asset risk scores of the entire system as shown here for the City of Dayton.

As noted in Task 2, the CH2M team will initially utilize a top-down approach to quickly assess the entire Ann Arbor system using existing data and the staff's extensive institutional knowledge obtained in a collaborative workshop setting. Matrices will be developed for LoF and CoF for stormwater system.

Rather than try to evaluate each reach of pipe in the City, many of which would be very similar, the systems will be broken into a smaller number of manageable pieces. For both sewer and storm pipes, this means distinguishing discrete reaches of large diameter pipes, and grouping the small diameter pipes into mini-basins for the sewers.

Risk scores will be quickly developed for each asset area utilizing a risk-based scoring approach for all assets, using CoF and LoF matrices. The scoring will be completed in an Excel-based risk model to provide an initial baseline and give an order-of-magnitude view of the systems' risk and potential AM program cost. The risk-model results will be linked with the City's GIS to graphically show the asset risk for the entire system **(Exhibit 6-3).** Documentation of the results, and the lessons learned about the available data, information, and systems will be used in subsequent data collection, as well as overall AM program development.

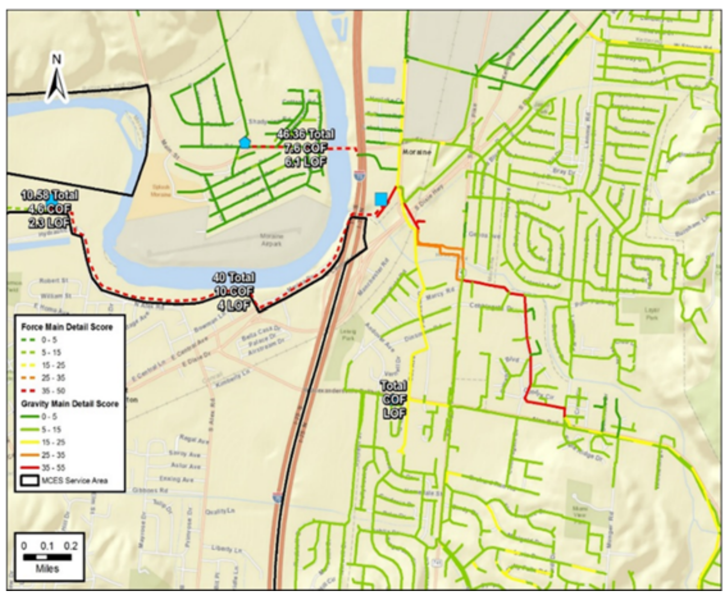


EXHIBIT 6-4
Results from the detailed phase graphically highlight the asset risk scores and LoF/CoF of the entire system as shown here.

The second phase of determining the likelihood and consequence of failure ratings will commence in the last 6-months of the project. This is so that additional CCTV inspections and other ongoing condition assessment data can be utilized to create a more detailed likelihood of failure rating. The consequence of failure scores and components will also be reviewed to ensure they still align with the City's Target Levels of Service from Task 5. This detailed assessment will over-write the baseline ratings developed in the initial phase only if more current and detailed data is available. Otherwise, the rating will stay with the baseline. **Exhibit 6-4** provides a look at the detailed risk rating of a portion of stormwater system.

6.3 Calculate Criticality Ranking

CH2M's SCREAM software will be used to calculate criticality (risk) rating of each asset. The risk profile in SCREAM is built upon the same risk matrices that were described above, as well as in the condition assessment task. SCREAM provides an integrated method of managing asset condition data, assessing asset risk, utilizing asset life-cycle and replacement cost, determining prioritized improvements as well as maintenance efforts. As seen in **Exhibit 6-5**, SCREAM offers a repeatable process that can be used as input to the identification and prioritization of projects in Task 8.

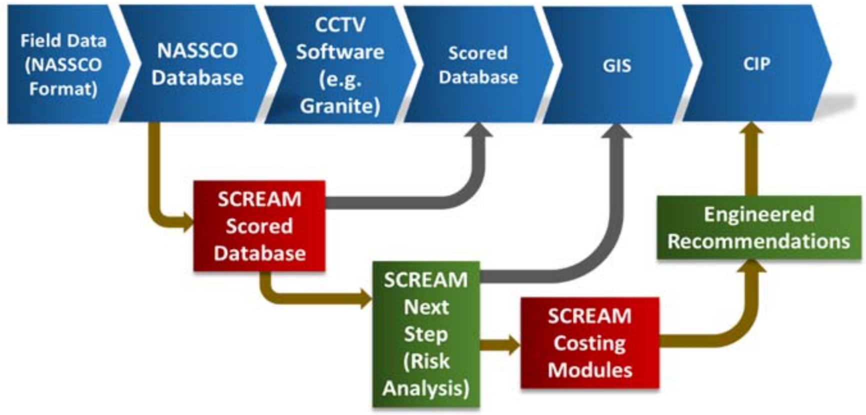


EXHIBIT 6-5: *SCREAM will be used to compile condition data, calculate risk scores and prioritize Ann Arbor's Next Steps.*

Our team will need input from the appropriate City staff early in the review process to ensure the City's key concerns and institutional knowledge are captured and incorporated into the new reporting form. Depending on how the balance of condition assessment work is performed (i.e., in-house as opposed to contracting), the City may want to consider a Web-based interface for downloading and uploading field data. The CH2M team will present to the City the benefits and resource requirements of a Web-based system as an alternative to standard direct Cityworks server interface procedures.

6.4 Risk Mitigation

Risk is mitigated by reducing the LoF or the CoF. There are typically many ways to reduce risk, such as asset renewal or the modification of maintenance activities and operations protocols. In addition, risk can be mitigated by reducing the COF (for example, through development of contingency plans). **Exhibit 6-6** provides a few typical methods to mitigate risk.

Example Risk Reduction Option	Reduces Consequence	Reduces Likelihood
Capital Investments		
Rehabilitation		✓
Replacement		✓
New redundant asset	✓	
O&M Protocols		
Development of operating SOPs		✓
Improved planned maintenance procedures		✓
Enhanced monitoring through SCADA		✓
Other		
Demand management	✓	
Improved response and recovery	✓	
Reduce LOS with stakeholder involvement	✓	

EXHIBIT 6-6 *During the asset management process, the cost to reduce risk will be compared with the actual reduction in risk to ensure the improvement is worth the investment*

We will conduct a workshop with Ann Arbor to determine the most cost-effective and appropriate ways to mitigate risk. The workshop will focus on maximizing the life-cycle costs of asset ownership through a reliability focused approach. Each asset group will be reviewed for the appropriate preventative maintenance activities and tools and when an asset should be rebuilt or replaced. The cost of risk reduction is important to understand as the cost to reduce risk should not exceed the reduction in risk.

Task 7 – Formalize Optimal Operations and Maintenance (O&M) Program

Successful long-term management of the stormwater system may require changes to the City's current inspection, monitoring and maintenance programs. Developing the right program for the City allows planning and O&M teams to correct system deficiencies before they become emergencies, and make thoughtful proactive, planned expenditures to extend remaining useful life of the assets. Our extensive experience on inspection and monitoring activities allowed us to gain a rich repertoire of what works and does not work effectively and our team will bring these "lessons learned" to bear as part of this work. A sampling of lessons learned are listed below.

- Use of Go Pro type cameras improve video quality for reasonable cost
- GIS based tracking of field effort avoids redundancy in inspections and effectively tracks progress

- Proper use of technology (including GPS technology and tablets) can make data collection easier, especially when location and elevation are important.

Key subtasks are described below.

7.1 Review and Document Existing O&M Procedures

As part of this task we will review the current O&M program practices with the City's staff for each system. Based on our discussion with City staff members, our team will document the existing procedures in place. Our work on this task will also include the review of current methods of handling inspection data from the field inspections, through database data importing and/or storage. Sewer condition scores received will have been developed from CCTV inspections. Our team will review the quality control steps to ensure field efforts are not missing key asset attributes or are inconsistent. Our team has worked with many different field forms that come from different software products and vendors, and we have our own standard forms that efficiently integrate the flow of data from the field to the manager's or engineer's corrective action reports.

7.2 Recommend Revisions to the Existing Procedures & Gap Analysis

Our team will provide recommendations that include modifying schedules for inspection and cleaning of the stormwater infrastructure, as well as employing new inspection and monitoring technologies that could more efficiently use existing City resources (See **Table 7-1** below).

Our task lead, **Tim Newton**, is an expert from CH2M's Operation and Maintenance division that specializes in wastewater system management and operates hundreds of utilities across the U.S. Tim's experience will help develop a pragmatic and cost-effective maintenance plan that the City can carry forward on their own, including guidance on inspection and maintenance intervals. For corrosion monitoring, we will evaluate O&M practices including the use of Odalogger™ and/or periodic jar testing to confirm and optimize required dosage rates for corrosion-inhibiting chemicals. Our recommendations will be compared with the existing staffing, equipment, practices, and contracting ability to develop a Gap Analysis report. The goal is to create an optimized O&M program that will be sustainable.

A WORD ABOUT PRE-CLEANING FOR INSPECTIONS

In our experience, more than 90 percent of pipe structural defects and anomalies such as pipe wall delamination, corrosion, liner failure, offset or separated pipe joints, or partial failures occur above the active dry-day flow line. Cleaning is normally required where flows appear to be surcharged. However, we understand that cleaning efforts for inspection work should be minimized due to resources and time. We will prioritize cleaning recommendations, working with the City to clean only what is absolutely necessary. Our team's technical expertise on more than 50 large-diameter wastewater systems will provide the City the confidence that prioritizing is based on a broad range of experience.

7.3 Decision Making Process

As noted in Task 6, SCREAM was created to provide utilities with an easy way to prioritize O&M activities as well as capital expenditures. The decision tree logic shown in **Exhibit 7-1** will be reviewed with the City and customized to meet their O&M goal of maintaining the lowest average life cycle cost.

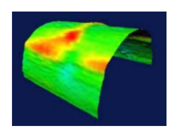
EXHIBIT 7-1 *SCREAM Next Steps Decision Tree logic can be used to prioritize and automate future inspections*

Latest Inspection Type	High Defect Acceleration	Risk COF Grade	Structural Grade						
			0	1	2	3	4	5	6
CCTV	No	1	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
		2	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
		3	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
		4	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	CCTV 18 months	Priority 1	Immediate
		5	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	CCTV 18 months	Priority 1	Immediate
		Unknown	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	Priority 3	Immediate
	Yes	1	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 4 years	CCTV 12 months	Priority 3	Immediate
		2	CCTV 10 years	CCTV 10 years	CCTV 10 years	CCTV 4 years	CCTV 12 months	Priority 3	Immediate
		3	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 4 years	CCTV 12 months	Priority 2	Immediate
		4	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 3 years	CCTV 12 months	Priority 1	Immediate
		5	CCTV 10 years	CCTV 7 years	CCTV 4 years	CCTV 18 months	Priority 2	Priority 1	Immediate
		Unknown	CCTV 10 years	CCTV 10 years	CCTV 7 years	CCTV 4 years	CCTV 18 months	Priority 2	Immediate

7.2 Optimized O&M Plan

The results of this task and the gap analysis report will be summarized into an Optimized O&M Plan. Our experience operating hundreds of systems will help to provide a realistic and achievable O&M program that is built on time tested practices. We will also provide recommendations on how to implement these practices into Cityworks to ensure your preventative maintenance and inspection activities are tracked. This data is extremely valuable, as we have found that O&M plans that can import work order history and past inspections become more optimized over time as your data history grows.

TABLE 7-1 Condition Assessment and Monitoring Options

Proven Technology	Application best suited for this Technology	
Zoom-camera Top-side inspection of the incoming and outgoing interceptor pipelines from accessible manhole structures using pole-mounted zoom cameras	Large quantity of the interceptors can be quickly inspected without confined space entry. If the zoom-camera investigations show signs of deterioration or other concern, the asset will then be recommended for CCTV assessment.	
CCTV Visual inspection by means of a crawler-mounted, or float-mounted camera deployed through the pipe	More detailed visual assessment of the entire pipeline. For most pipes the field investigation work will conclude at CCTV, but for those segments which are identified as high risk, specialized inspections may be recommended, such as the following technologies.	
Rebar Potential Mapping Ultrasonic impulse delivered to the concrete wall through a mechanical probe to measure wall thickness and provide rebar potential mapping.	Isolated locations in large concrete pipes where rebar defects and/or corrosion are identified and are of concern for structural integrity	
Laser Profiling Laser is attached to a robotic platform and scans the inside of the pipe. Data is processed by computers to determine the exact inner dimensions.	Quantify the extent of corrosion and to inform the design of rehab (CIPP, sliplining) that need precise dimensions resulting in savings during construction bidding.	
Sonar Sonar ROV is deployed into a full pipe and scans the inside of the pipe. Data is processed by computers to determine the exact inner dimensions.	Quantify extent of debris and provide general dimensions of submerged pipes.	
Pipe Penetrating Radar Radar attached to hand-paddles or a robotic platform uses radar waves from inside the pipe to scan for sub-surface features beyond the pipe wall.	Detects the presence of rebar in RCP pipe, detects voids forming behind the pipe wall. This is important to catch sink holes before they collapse, because they can form behind a leaking pipe joint.	
Electromagnetic Electromagnetic probe dragged through a temporarily plugged pipe by topside winches	It measures the amount of current that escapes through cracks, joints, and other defects in non-metallic pipe. This can be used for exfiltration detection to find leaky joints that are not visible to CCTV.	

Task 8 – Formalize Optimal Capital Improvement Program

In assisting utilities over the past two decades with CIP prioritization, our approach is founded on standard industry principles and uses a decision analysis method for scoring and prioritizing candidate projects. In fact, CH2M helped to establish Ann Arbor's current CIP prioritization model as part of a water system master planning project nearly 10-years ago and has continued to provide updates and modifications to this model. Key subtasks are described below.

CH2M helped to establish Ann Arbor's current CIP prioritization model as part of a water system master planning project nearly 10-years ago and has continued to provide updates and modifications to this model.

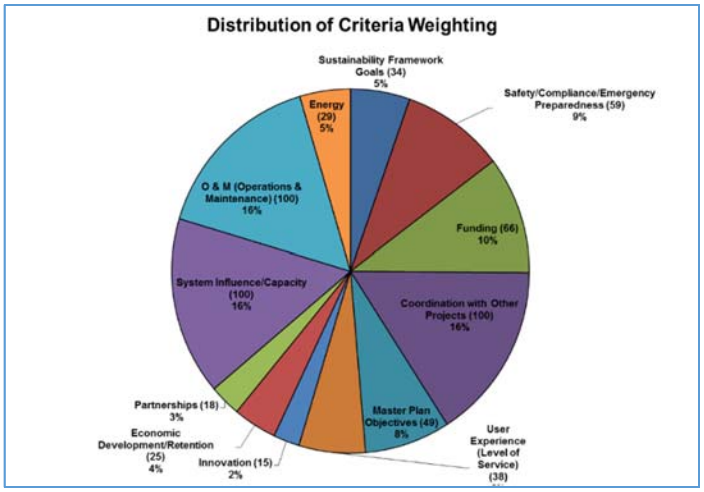


***EXHIBIT 8-1**: Facilitated Dialogue Will Be Used to Confirm or Modify Ann Arbor's Current Sanitary Prioritization Framework*

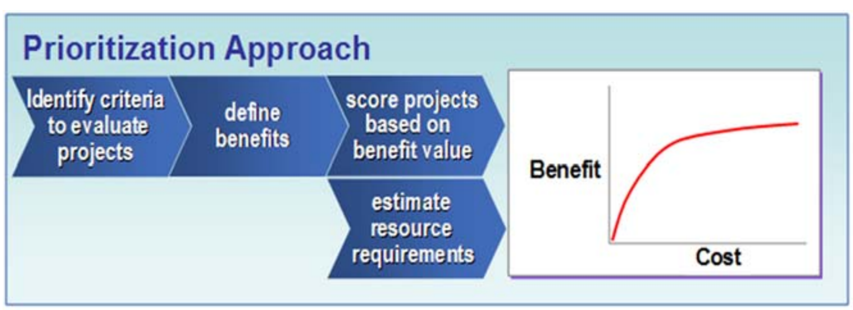
8.1 Review Existing CIP Prioritization Model and Scoring Criteria

As part of this task, we will review the prioritization framework as it is currently being used by Ann Arbor and the current scoring criteria, weights, and performance scales used in the prioritization in particular for the stormwater system. This type of asset management planning effort provides an ideal opportunity to revisit and confirm or modify these important elements of the prioritization framework. As part of this refresh process, the CH2M team will bring examples of current criteria (**Exhibit 8-1**) and scales used by other utilities to support workshop dialogue with the Ann Arbor team on potential applicability of elements used by other utilities to the Ann Arbor context. As we did in the supporting the development of the initial prioritization framework in 2005, our team will work with the City to establish a multi-disciplinary team of City representatives so that input is secured from the diverse vantage points (e.g., engineering, planning, finance, utility management) within the City.

The framework serves as the basis for which candidate projects are scored. Sources for the framework include the risk framework developed earlier to support prioritization for condition assessment of existing assets, other CIP prioritization models developed by Ann Arbor for other classes of assets. **Exhibit 8-2** illustrates the main steps in the decision analysis approach.

A decision analysis approach that provides greater precision for weighting goals and measuring the contribution of candidate projects has been found preferable to traditional voting and matrix methods for prioritizing projects by an increasing number of water and wastewater utility systems. The approach allows greater differentiation in both goals and performance measures, and can be used efficiently to conduct sensitivity analyses that show the variation in results that would occur with varied assumptions and scenarios.

***EXHIBIT 8-2:** A decision analysis approach has been found preferable to traditional voting and matrix methods for prioritizing projects by an increasing number of water and wastewater utilities, including Ann Arbor.*

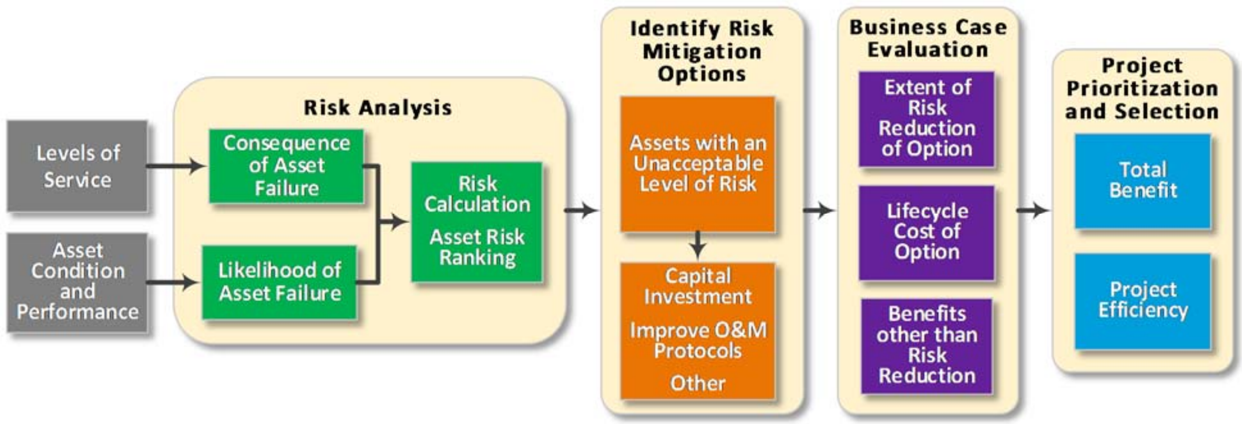


8.2 Recommended Enhancements to the Existing Prioritization Framework

The CH2M team will provide recommendations technical memorandum of enhancements to the existing prioritization framework and tool application that will document the components required to address gaps between the processes and tools used by Ann Arbor today and the requirements obtained in the previous step. In particular, the components of Cityworks system that are underutilized or the selected AM software solution, which could address the identified needs, will be highlighted. Additionally, the interaction between the Cityworks CMMS, GIS, and AM software software will be defined, along with the data exchange planned with the Excel-based risk and CIP development tools. Specific database fields needed to support requirements will be defined and the appropriate system of record identified.

This will provide practical evaluations of what works well and what will need to be modified as part of this project, as well as discussion for how an enhanced approach could better serve Ann Arbor, its customers, and other stakeholders. An example process flow for project identification and prioritization is shown below in **Figure 8-3**.

Figure 8-3. *Overview of the Risk-Based Approach in the CIP Project Identification and Process*



Once the Cityworks, GIS and/or AM software is configured, it can be used to generate a list of high-risk assets that become candidates for inclusion in the CIP. The list will be exported as the starting point of CIP development.

8.3 Identify Capital Improvement Projects

From a CIP perspective, a balance between a focus on existing assets (normally based in the O&M program) and new assets (normally based in master plans and related to growth and\or regulatory changes) has to be underpinned by enterprise values and objectives and is key in the overall prioritization process. We recommend continuing to use a Multi Criteria Prioritization (MCP) approach that accounts for the strategic objectives of the utility and scores the total benefit value of each individual project under consideration.

Our team fully intends to collect information on capital improvement projects that will be identified in ongoing and anticipated parallel studies, to assure that a comprehensive look is provided and rates are set appropriately.

The respective total benefit value and benefit-cost ratios are calculated for each project, which enables the utility to consider both of these metrics when determining the best value capital program over successive budgetary periods. The use of an MCP approach to establishes a cost\benefit comparison of all projects under consideration, which enables the production of a best value AM Program that meets the utility's strategic objectives. Exhibit 8-4 highlights the financial benefits that can be realized by implementing CIP prioritization, by identifying the highest-priority projects that should be front loaded within available financial resources. Key steps in the prioritization approach include:

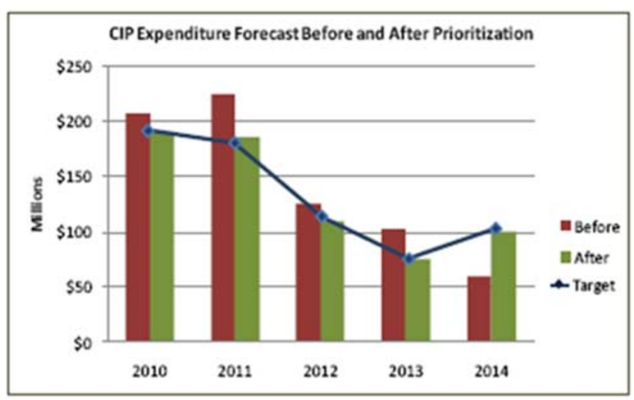


EXHIBIT 8-4: *Prioritization Helps Clients Achieve Targets CH2M's prioritization approaches and tools helped the Hampton Roads Sanitation District in Virginia Beach, VA to move $150 million in lower ranked projects out of the near-term years, allowing the District to keep expenditures within targets set by the general manager and financial team.*

1) Review and enhance Ann Arbor's CIP prioritization framework.
   a) Review and update of decision criteria and their importance or weighting.

b) Review and update of performance scales for each of the decision criteria to measure the benefit of candidate projects.

c) Import of costs from Task 4 to be used in benefit-cost analyses and cumulative cost outputs.

2) Selecting projects for prioritization based on work in previous tasks.

3) Applying the framework to selected projects using data collection forms to document the process.

4) Use of Ann Arbor's Excel-based multi-attribute utility prioritization model to support the development of the prioritized project list.

5) Review of prioritization results for verification of the prioritization framework.

8.4 Long-Term Strategy for Capital Reinvestment

The results from the AM program, specifically the risk determination and O&M program tasks, will be modeled over the next 20-30 years to provide a prioritization of system needs and associated projects. The modeling of these projects will look at the LOS provided to Ann Arbor's customers along with the overall system risk. These items will be critical to ensure that the City is investing enough in their stormwater system to meet the City's long-term goals. A technical memorandum will be prepared documenting the long-term strategy for reinvestment in the City's buried sanitary and storm assets. In addition to identifying and prioritizing projects for this long-term period, the CH2M team will work closely with the City to provide a more detailed review of the sequencing of projects for the City's near-term budget and CIP planning cycle, so help provide more specifically inform revenue requirements for the City's immediate rate-setting and bonding programs for the utility systems. As indicated earlier in the proposed work plan, the operations and maintenances as well as priority and level of service decisions on Washtenaw County owned assets in the City will have an impact on future costs for the City as the City will likely be assessed for the future CIPs on these assets. Therefore, we plan on engaging with the Washtenaw County Water Resources Commissioner's office in an effort to better understand their CIP and LOS decisions in this regard.

Task 9 – Establish Sustainable Funding Strategy

Planning for long term CIP funding will require funding experts to work closely with your financial and budgeting staff. Our staff will work closely with the City and the Stormwater Rate Study consultant for Ann Arbor to identify the revenue requirements and expected revenues for each system. Our team will work with the City's rate consultant to assist in developing a funding strategy for the AM Program, once the magnitude of the program is developed.

9.1 Perform Gap Analysis

A critical component of any AM program is the ability to fund the recommended projects as well as developing a financing strategy so that Ann Arbor can afford the improvements. Upon development of the recommended prioritized projects, the CH2M team will provide the financial data from the program to the City in a format compatible with City's rate model for use in determining the financial impact to its ratepayers.

Our team will perform a gap analysis between their current funding structure and the systems needs as developed as part of the Risk and O&M tasks. During this analysis, our team will review the proposed LOS to determine if they are still affordable. The worst possible message to your staff and customers is to provide a "promise" for a specific LOS and then realize that to meet that LOS, it would be unaffordable. Careful understanding of the cost impacts to meet the initially agreed upon LOS is a key part of a sustainable financial strategy development. The gap analysis will develop an optimal mix of operational and capital expenditures while maintaining an acceptable level of risk and meeting the developed LOS. The long term funding strategy will look at costs associated with operations, preventative maintenance, rehabilitation, replacement and expansion of the City's stormwater system to meet the City's long-term goals and levels of service.

CH2M is currently serving in a similar financial role for the Montgomery County (Ohio) Buried Infrastructure R&R Program. Similar to Ann Arbor's Asset Management programs for its buried infrastructure, CH2M is developing a funding strategy to support the needed increased capital spending while maintaining reasonable rate increases. In the Montgomery County case, CH2M was asked to run R&R cost scenarios through rate models that had been developed by the County's financial consultant; for Ann Arbor, the CH2M team will work with the City to identify the most efficient method for estimating the rate impacts of the R&R scenarios. Depending on the City's preference, this might involve providing scenarios for the City or its financial consultant to run through the City's rate models, or it might involve a more proactive role for our team in the rate modeling process.

9.2 Recommend Optimal Funding Strategy

Particularly when addressing funding strategies for renewal and replacement programs, our funding teams integrate the financial strategies with previous and current condition assessments and risk assessments, and develop business processes to help integrate the prioritized lists of AM projects, and develop business processes that define how the engineering, financial, and technical elements should be updated to help inform annual updates to capital budgets and CIP improvement programs. Our funding team will review how Ann Arbor has previously funded its capital projects and how other utilities fund similar programs, given the agreed upon LOS, budgeting constraints, and desired reduction in risk for buried assets. In order to inform the City's consideration of how to define acceptable levels of risk, we are prepared to bring examples of how consequence and likelihood of failure scales have been customized to fit the contexts of other clients, such as Fairfax County, Virginia. Given that the City's buried assets are located in many jurisdictions, the CH2M team will help Ann Arbor develop policies and procedures that will more effectively coordinate with the other jurisdictions to take advantage of joint funding for work in areas that affect their assets (such as roads) and the City's assets. Better coordination can lead to lower overall costs for the City ratepayers.

The result is a prioritized set of capital improvements and initiatives that can be implemented given the available funds that Ann Arbor has and the level of rates and charges that are affordable to Ann Arbor customers, and a business process that can be used to update the analysis for future budget and CIP development cycles.

Task 10 – Generate Asset Management Plan

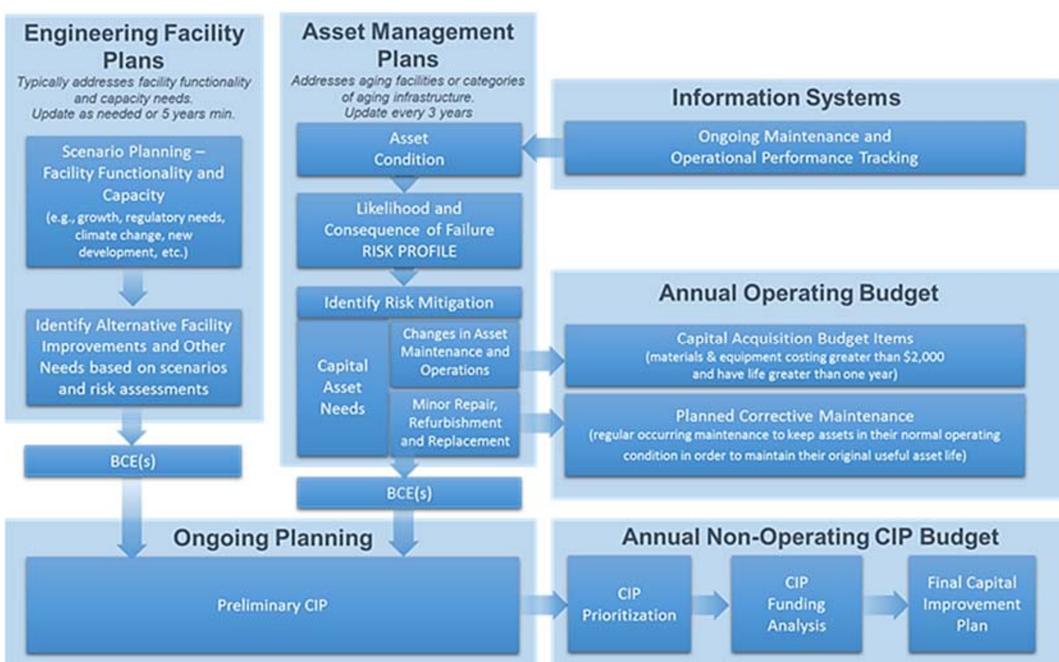
The goal of Task 10 is to synthesize the material created as part of this project to ultimately create a strategic asset management plan (AMP) for each system that:

- Minimizes the life-cycle cost of asset ownership,
- Extends the life of the assets through an effective maintenance program,
- Develops best management practices within the City's organization aligned to industry standards, and
- Uses a risk methodology to streamline identification and implementation of the recommended improvements.

10.1 Develop the Asset Management Plan (AMP)

AMPs, like other major planning documents, are important components that feed into an organization's short- and long-term capital and O&M planning processes. Our team will review existing major planning efforts and existing AMPs, such as the Green Infrastructure AMP for validation and alignment with these new AMPs. Our proposed approach for developing an AMP is based according to the International Organization for Standardization (ISO) 55000 series of standards in order to showcase Ann Arbor's efforts to adopt world-class AM principles as represented in those international standards. While we do not believe that it is necessary for

EXHIBIT 10-1: *Our AMP process is based on industry best practices and will build upon Ann Arbor's ongoing planning efforts.*



Ann Arbor to pursue ISO 55000 certification and all of the prescribed processes, we do suggest using the ISO 55000 framework as the target for best practice.

The AMP for each system will also include a succinct executive summary that clearly articulates the purpose of the AMP and the City's AM program. It will provide an overview of the plan findings and results that can easily be understood by key stakeholders and the public. Our team will work with our Public Engagement consultant, LE&A, to develop the messaging and help tell Ann Arbor's asset management story to the public, along with carefully developed infographics to assist in understanding the complex nature of the AM program in a simplified fashion. **Exhibit 10-1** on the next page highlights our AMP process that will build upon Ann Arbor's ongoing planning efforts.

10.2 Standard Operating Procedures

One of Ann Arbor's primary goals for this project is to maximize the use of asset data and effectively leverage its investment in Cityworks and an AM software to manage its assets. Best practices for the development and use of AMPs in the wastewater industry consists of the following:

- Concise documents assessing individual asset types (e.g., Interceptors, mains, manholes, basins, etc.)
- Clear ownership within the organization for each AMP
- Governance body for review and approval or rejection of each AMP, and clear accountability regarding the time horizon for the plan and update cycle, as well as quality and completeness expectations for each AMP
- Clear alignment of the objectives and actions of each AMP to the overall asset management strategy for the organization
- Clear articulation of customer service levels, and asset performance expectations relative to actual performance
- Up-to-date documentation of drivers, including regulatory changes, demand scenarios, influent water quality, and stakeholder expectations
- Updated documentation of the assets covered in the plan and assessment of asset likelihood and consequence of failure, resulting in a risk profile for the facility or grouping of assets
- Documentation of data sources and assessment of the quality and completeness of the data in these sources
- Listing of improvement initiatives required to optimize performance of the assets covered by the plan. Such listing should include clear documentation of the activities needed, as well as responsible parties and expected completion dates. These listings should be tracked for status and completion separate from the AMP update.
- Documentation of the CIP process for updating the prioritization tool and updating the financial analyses.

AMPs should ideally be updated every 3 to 5 years to maintain their effectiveness. Our team will leverage its knowledge of asset management best practices, and our experience on similar asset management programs, such as for the Rancho Water, Montgomery County, and DC Water to ensure a usable and sustainable AMP is created for Ann Arbor.

It is important to note that an AMP should not be limited to just the adoption of business processes, technologies, and frameworks. The AMP recognizes that certain aspects such as culture and change management can have a significant influence on the achievement of its AM objectives. The AMP therefore needs to incorporate plans devised to engage staff at all levels in the AM Program and achieve the highest level of benefits possible. According to ISO 55000, the International Infrastructure Management Manual (IIMM) and numerous other AM guidance recognize the importance of leadership, accountability, and organizational culture for the success and sustainability of an AM Program. Consistent, frequent, and enthusiastic support for the AM Program from all levels of management is necessary for Ann Arbor to ensure decisions in day-to-day activities, planning for capital projects, and making long-term investments are aligned with Ann Arbor's strategy and stakeholder interests.

> "Asset Management tools and technologies may be helpful, but the engagement of the workforce, the clarity of leadership, and the collaboration between different departments and functions are the real differentiators of a leading asset management organization."
>
> Institute of Asset Management

Task 11 – Public Engagement

Ann Arbor is a dynamic, diverse and informed community, with many engaged residents and other stakeholders who care deeply about all aspects of the city. As a result, it will be vital that the City and its partners establish this project as one grounded in transparency and accessibility from the start. Key subtasks are described below.

11.1 Communication and Engagement Strategy

The CH2M team's public relations team will be led by **Liz Kelly** – a seasoned utility executive who led many public engagement, community outreach, and internal communications efforts while leading Seattle Public Utilities asset management group. Our team also includes Lambert, Edwards & Associates (LE&A), a statewide, award-winning PR firm with offices in Detroit. Our team has developed the following overview of an expected approach. We will work closely with the City and key stakeholders to develop a detailed plan that makes efficient, effective use of all resources. The plan will incorporate the following items into a cohesive Engagement Strategy for the City to effectively tell their asset/utility management story to both external and internal stakeholders.

Audience

Communications will be developed to educate and inform stakeholders from introduction to completion. Anticipated priority stakeholders include:

- Residents (as necessary)
- Major employers/business owners
- Other area opinion leaders
- City employees (Internal Working Group)
- City policy makers
- Large utilities (e.g. the University of Michigan or Scio Township)

11.2 Establishing Core Messages

While not glamourous in the traditional sense of the word, Ann Arbor's stormwater system represents vital and highly complex infrastructure that can often be taken for granted. Similarly, the process of setting improvement priorities for the system is a highly complex undertaking. As a result, all audience segments will expect and deserve effective, understandable messages – educational content – that keeps them informed of the project's pace and progress.

Our first step in this process will be to use a primer on infrastructure investment. The documentary ***Liquid Assets*** (produced by Penn State Public Broadcasting) is an excellent summary of the state of our buried infrastructure, and will provide an eye-opening and visually-rich demonstration for the public. An overview of the documentary can be viewed in the following link: http://liquidassets.psu.edu/index.html#overview

Initial efforts would likely focus on City personnel to ensure they are equipped with clear, concise and consistent messaging to directly answer questions pertaining to the project – before, during and after completion. For internal personnel, our public relations team will create messaging detailing all aspects of the project. We anticipate this effort to include messaging and visual tools capable of accurately and clearly conveying complex concepts to a broad audience. For consistency of messaging, our public relations team also will develop a series of documents for use throughout the project, including:

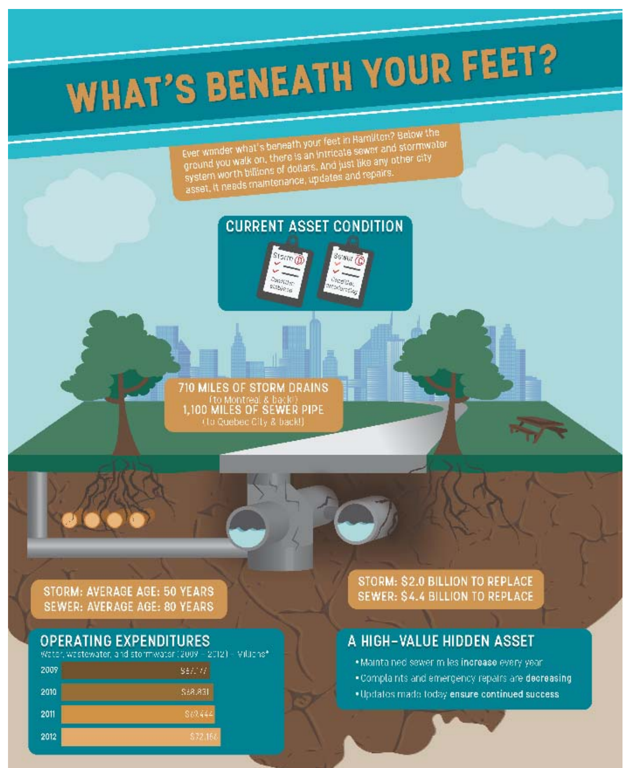


***Exhibit 11-1**: Example Infographic our team will develop to assist Ann Arbor to inform stakeholder of their AM program*

- Talking points
- Fact sheet
- FAQ
- Case studies
- Infographic Example (**see Exhibit 11-1**)

The above documents will be updated as necessary during the course of the project to provide relevant information.

11.3 Coordination with Staff, Key Stakeholders and Media

Gaining the community's trust from the onset of this project is crucial to obtaining and maintaining their support. For this reason, our team recommends scheduling a public education session to kick off this project, as well as periodic update meetings to keep the community well-informed of progress. In addition to gaining the community's trust through transparency, a public setting will allow the City, and our team to better understand the varying public perceptions, questions and priorities to consider in all communications going forward.

We will work closely with City officials in advance of public meetings – providing message points, collateral material, and event planning assistance, if requested.

Media Relations

A project of this scope is sure to attract attention from the media. As such, the CH2M team suggests taking a proactive approach and utilizing the media as a communications tool – delivering key information to a wider audience. Recommended media relations activities include:

- Coordinating a meeting with select media and project team members – City personnel and project engineers – to provide an overview of the project
- Developing a press release announcing the project and providing important details for distribution to local media
- Coordinating media interviews with project team members
- Announcing key findings/updates periodically
- Identifying and using influential project advocates in the community for media opportunities
- Developing opinion pieces from various stakeholders for distribution to media

In advance of media relations activities, our team suggests conducting media training with City spokespeople.

Social Media

Social media channels such as Facebook, Twitter and LinkedIn provide organizations an opportunity to engage directly with their audience. Our team recommends using these channels proactively to keep the community informed. Working in unison with the City's social media team, if applicable, the CH2M team will create informative and educational content to be shared via the City's digital channels, including its website. Content will include:

- Project announcement and updates
- Informational meeting dates
- Links to news stories related to the project
- Project videos and photos
- Positive comments from key influencers (community advocates)

Task 12 – Asset Management Software selection and implementation

It is our understanding that the consultant team will purchase an asset management software for use during this project. As the project progresses, the CH2M team will evaluate asset management (AM) software's that would help achieve the City's ultimate vision for its AM program and capital improvement plan (CIP) development. The subsequent section outlines our proposed approach for helping the City choose the most appropriate software for not just this project but for City future needs and staff preference. We further understand that the consultant team is expected to transfer the license of the software to the City along with fully loaded project and infrastructure data.

12.1 Selection of Software for the City

Our team proposes to perform a software needs assessment in an effort to help the City decide on the most appropriate software for selection. We propose the following approach for the needs assessment and eventual purchase of the software:

1. Software Selection & Implementation Team

   We propose to identify the team that is dedicated to see the implementation of the software from conception to evaluation, implementation, and ownership
2. Identification of Needs

This team will help identify the variety of requirements that the software needs to fulfill, which may include the following:

a. Data management capabilities leveraging existing technology platforms at the City
b. Capability to interface with City GIS, CityWorks, and perhaps other, financial systems
c. Ability of software to interface with other City asset management efforts and infrastructure (e.g. water, signs, roads, parks, etc.)
d. Decision making capability of software in
    i. Assisting with Gap Analyses
    ii. Balancing system recommendations with available resources
    iii. Performing long term financial planning
e. Compliance with City terms and conditions
f. Ability to meet user profile requirements (from the Planning, Project Management, and Field Operations unit) such as
    i. Functionality
    ii. Usability / User Friendliness
    iii. Flexibility
    iv. Performance
    v. Integration

3. Identification of Available Resources

It is important to juxtapose needs with available resources such as

a. IT infrastructure capabilities (including storage, mobile technology, already existing software etc.)
b. Financial constraints (in addition to the purchase price of a software, many asset management applications include annual maintenance fees as well as implementation fees)
c. Capabilities of existing tools – for example, CityWorks has infrastructure planning and asset management modules, which may accomplish some of the functionality the City desires

At the end of this task, a matrix will be developed, summarizing the findings and answers to the questions listed in the previous steps. This matrix can be used in the subsequent tasks.

12.2 Selection of Software, Purchase and Licensing

As part of this process, our team will help the City invite and interview select vendors for more specific presentation of the capabilities of their applications. Our team has developed decision making matrices to aid in the selection of this software.

12.3 Implementation

As part of this project, once the software has been selected, our team will work with the City to implement the software on the City's IT system. Our team will utilize the selected software during the project so that the analyses and functionality developed for this project is already loaded into the City's software.

12.4 Training

It is our understanding that the City desires up to eight staff members to be trained in the selected software. Our team is experienced and well versed with the above stated process and has implemented asset management software application that gained wide acceptance in the industry. For example, our team

- Has utilized the Assetic (www.assetic.com) software in the City of Livonia Asset Management program
- Has been assisting the Oakland County Water Resources Commissioner in implementing Riva (www.rivamodeling.com)
- Has implemented Innovyze's InfoMaster (www.innovyze.com/products/infomaster/) software for Dekalb County, GA that was enhanced with CH2M's SCREAM logic.
- CH2M has implemented our SCREAM software for storm and sanitary system for many clients including: Boston Water and Sewer Commission; Columbus DPU; Northern Kentucky SD1; Aurora, CO; Puerto Rico Aqueduct and Sewer Authority; and Fairfax County, VA.
- CH2M has implemented numerous AM software solutions and enhanced existing CMMS and other existing Microsoft Excel and database tools to meet our client's needs for making asset decisions.

It should be noted that SCREAM is not an off-the-shelf software program. It is rather an engineered software solution that can be utilized by Ann Arbor staff to as a tool to help manage asset data as well as to prioritize and cost multiple repair/rehab/replace options to maximize the life cycle cost of the asset. The software is free, however, CH2M does require the City to sign a Non-Disclosure Agreement to protect the algorithms and logic that was developed for this tool.

SCREAM can easily be used in conjunction with Ann Arbor existing CIP prioritization tool, as discussed further in task 8. SCREAM will help to identify needed maintenance activities and capital projects, while the CIP prioritization tool will help to develop the full CIP. CH2M has also been successful in building the SCREAM logic into "Off-the-Shelf Software" programs, such as Innovye's InfoMaster, to enhance the software's out-of-the-box logic.

	Inspect assets in the field	Calculate condition scores	Calculate risk scores (bottom up)	Create re-inspection plan and schedule	Create maintenance plan and schedule	Create rehabilitation plan (for CIP)	Calculate rehab and maintenance costs	Calculate lifecycle costs	Prioritize rehab methods
Gravity lines	Any CCTV Software	SCREAM Scoring	SCREAM Risk	SCREAM Next Step	SCREAM Next Step	SCREAM Next Step	SCREAM Costing	SCREAM Costing	SCREAM Costing
Gravity assets (manholes, regulators etc.)	SCREAM or other standard software	SCREAM Scoring	SCREAM Risk	SCREAM Next Step	SCREAM Next Step	SCREAM Next Step	SCREAM Costing	SCREAM Costing	SCREAM Costing

Optional Task 13: Modeling Blockage Driven Failure to Support Operations & Maintenance Optimization

A stormwater system component is considered failed if it does not fulfill its desired level of service functionality, whether it be social, economic, or environmental / regulatory. Failure, on the other hand, can be defined as

- Structural
- Environmental
- Operations and Maintenance, or
- Capacity

Out of these, operations and maintenance failures, specifically caused by root ball, grease, or solid build up, are among the more frequent failures encountered in stormwater systems, which have a likelihood of resulting in blockages, causing flooding.

The purpose of this task is to utilize asset inventory, work order, and historical operations and maintenance data to develop what is referred to as a stochastic model in order to:

- Estimate the conditional probability of failure due to the above stated operational and maintenance condition of the system, and
- Approximate the anticipated reduction of rates of failure given certain operational and maintenance improvements, e.g. increased frequency of system inspection/cleaning or utilization of advanced warning/monitoring technologies.

A stochastic model is a tool for estimating probabilities of potential outcomes by allowing for random variation in one or more inputs over time. The random variation is usually based on fluctuations observed in historical data for selected periods. For example, blockage due to a root ball can be considered a function of the location of the sewer, its age, material, and burial depth among other factors. Therefore, a stochastic model would, for example, take a pipe of a certain burial depth in a certain location and assign, randomly, variations in age and attempt to estimate the frequency of blockage failure over time.

Model Purpose

The proposed stochastic infrastructure model consists of two types of submodels: a failure rate model to estimate the number of likely failures in a given period; and a Markov state transition model to estimate the long-term performance of the network in response to alternative O&M strategies.

Failure rate submodels (**Figure 13-**) are based on analysis of historical failures, and are used to establish the expected rate of failure (e.g. rate at which blockages will occur) for different types of pipes within a sewer network. When used to model large systems (such as sewer networks) these models are most applicable when applied to homogeneous subsets of the network – such as pipes of comparable age, size, material type, and customer type.

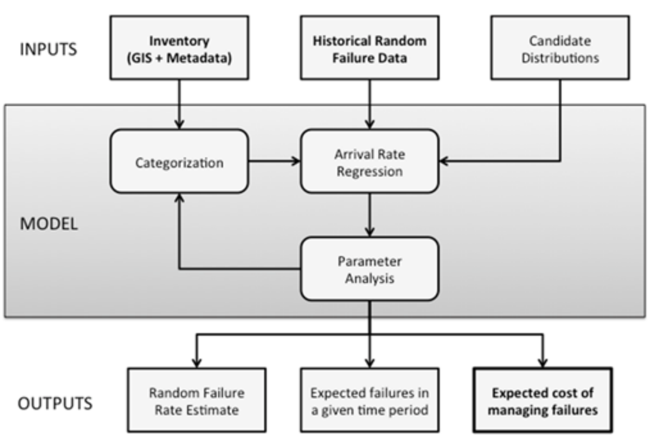


Figure 13-1: Failure rate model structure

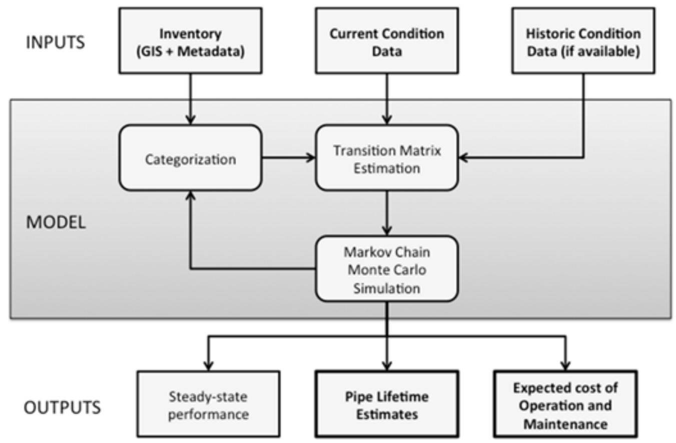


Figure 13-2: Markov chain model structure

Markov state transition models (**Figure** 13-) help analyze of the types of blockages the system might encounter over time, the rate at which these blockages might occur, and the relationship between occurrence of blockages, failure triggers, and the impact of operations and maintenance activities at differing frequencies (e.g. frequency of cleaning, inspection, etc.).

The categorization step in each model structure indicates a "binning" operation, in which subsets of the pipe network are grouped together for analysis. Each group is analyzed separately with an individual failure rate model and Markov chain simulation. This is done so that pipes with similar performance characteristics and degradation properties are evaluated together. These groupings are developed using data mining tools, and the applicability of their models is checked using cross-validation to ensure reliable outputs.

Data Requirements

Three types of data are useful for developing these models: asset inventories with metadata, records of past interventions, and condition assessment data. Asset inventories that include metadata such as GIS layers, installation dates, size, material type, geotechnical condition, and customer type are used for segregating the network into relatively homogeneous categories, as well as for identifying which factors indicate higher rates of degradation or rates of failure. Records of past interventions - particularly for blockages - are used for populating failure arrival models. Current condition assessment data is used in conjunction with both historical condition assessment data and historical intervention data to develop Markov degradation models.

EXHIBIT B
COMPENSATION

General

Contractor shall be paid for those Services performed pursuant to this Agreement inclusive of all reimbursable expenses (if applicable), in accordance with the terms and conditions herein. The Compensation Schedule below/attached states nature and amount of compensation the Contractor may charge the City:

(insert/Attach Negotiated Fee Arrangement)

City of Ann Arbor

Sanitary and Stormwater Systems Asset Management Program

Tuesday, February 02, 2016

Assumed 30-month duration

Tasks	Title	James Decker Project Manager Risk and O&M Lead	Gareth Lifton Technical Advisor	Scott Haskins Technical Advisor	Mike Matichich CIP / Rate Analysis Lead	Liz Kelly AMP and Public Engagement Lead	Courtney Kennedy Condition Assessment Consultant	Jeff Sanford Condition Assessment Consultant	Justin Kauffman Cityworks Lead	Reggie Rowe Risk and O&M Consultant	Tim Newton O&M Lead	Keith Bishton Financial Consultant	Michael Gnadt Lifecycle Cost Consultant	Office / Admin Support	Murat Ulasir Deputy Project Manager Systems Analysis Lead	Kyle Curie Condition Assessment Consultant	Michael Cousins GIS Lead	Lindsey Kerkez IT Lead	Greg Kacvinsky Risk and O&M Consultant	Don Hunt Public Engagement Lead	Joe DiBenedetto Public Engagement Consultant	Bob Miller Public Engagement Consultant	Total Hours	Total Task Labor Costs	Task Expense Costs	Task Travel Costs	Total Task Costs
1	**Asset Inventory**	**46**	**2**				**26**		**74**	**4**				**28**	**192**	**104**	**156**	**48**	**60**				**740**	**$108,609**		**$4,500**	**$113,109**
1.1	Review Existing Asset Inventory	12					10		32						48	32	48		24				206	$31,361		$3,000	$34,361
1.2	Identify Gaps	16	2				8		26					6	48	32	32		20				190	$28,854			$28,854
1.3	Recommend Strategy to Obtain Missing Information	14					8		16	4				22	48	16	16		16				160	$23,893		$1,500	$25,393
1.4	Assistance in Adding Missing Information	4													48	24	60	48					184	$24,501			$24,501
2	**Condition Assessment**	**28**	**8**				**136**		**28**	**40**				**28**	**160**	**300**	**72**						**800**	**$119,025**		**$5,000**	**$124,025**
2.1	Review Existing Condition Assessment Data	8					60		16	4					40	120	24						272	$39,861		$2,000	$41,861
2.2	Determine Asset Assessment Methodology	8	4				16		12	20				6	40	40							146	$24,093		$2,000	$26,093
2.3	CCTV Contractor Selection / Coordination	4					50			8					32	120	24						238	$34,057			$34,057
2.4	Condition Performance of System Assets	8	4				10			8				22	48	20	24						144	$21,014		$1,000	$22,014
3	**Useful Life Determination**	**14**	**6**				**24**		**16**	**12**				**16**	**148**	**24**	**28**		**48**				**336**	**$53,719**			**$53,719**
3.1	O&M Failure Data Review	6					4		16	4					48	24	16		24				142	$22,385			$22,385
3.2	Remaining Useful Life Analysis	8	6				20			8				16	100		12		24				194	$31,334			$31,334
4	**Life Cycle and Replacement Costs of Assets**	**30**	**8**				**16**		**20**				**104**	**28**	**14**				**12**				**232**	**$37,065**		**$1,500**	**$38,565**
4.1	Review Cost Data	14					10		12				24		6								66	$11,081			$11,081
4.2	Determine Asset Values and Local Costs	16	8				6		8				80	28	8				12				166	$25,984		$1,500	$27,484
5	**Determine Target Levels of Service**	**132**		**8**		**140**			**20**					**28**	**42**		**16**		**36**				**422**	**$77,403**		**$4,500**	**$81,903**
5.1	Review Existing LOS and Performance Measures	24				20			12						6		8		12				82	$14,697			$14,697
5.2	Define Target LOS	40				40									12				12				104	$19,565		$2,500	$22,065
5.3	Gap Analysis	68		8		80			8					28	24		8		12				236	$43,141		$2,000	$45,141
6	**Determine Criticality of System Assets**	**460**	**8**	**4**			**86**		**16**	**42**				**28**	**88**		**150**						**882**	**$134,629**		**$6,000**	**$140,629**
6.1	Establish Risk Criteria	60					12		8	8					8		14						110	$17,440		$2,000	$19,440
6.2	Determine Likelihood and Consequence of Failure	160					30		8						24		60						282	$41,617		$2,000	$43,617
6.3	Calculte Criticality Ranking	120					30			10					24		60						244	$36,570			$36,570
6.4	Determine Risk Mitigation Strategies	120	8	4			14			24				28	32		16						246	$39,002		$2,000	$41,002
7	**Formalize Optimal O&M Program**	**48**		**8**			**98**		**40**	**30**	**192**			**28**	**16**	**48**							**508**	**$83,704**		**$6,500**	**$90,204**
7.1	Review and Document Existing O&M Procedures	8					20		16	4	60				4	20							132	$21,457		$1,000	$22,457
7.2	Recommend Revisions to Procedures / Gap Analysis	12					14		12	6	32				4	20							100	$16,218		$1,500	$17,718
7.3	Decision Making Process	8					40			14	60				4								126	$21,809		$2,000	$23,809
7.4	Optimized O&M Plan	20		8			24		12	6	40			28	4	8							150	$24,220		$2,000	$26,220
8	**Optimize Capital Improvement Program**	**92**		**8**	**116**							**160**		**28**	**36**		**18**		**40**				**498**	**$87,295**		**$5,000**	**$92,295**
8.1	Review Existing CIP Priortization Model / Criteria	12			16							16			4								48	$8,924			$8,924
8.2	Recommendations to the Existing Prioritization Model	12			28							24			8		4		8				84	$15,688		$2,000	$17,688
8.3	Identify Capital Improvements Projects	28			32							40			12		8		16				136	$23,941		$1,000	$24,941
8.4	Long-Term Strategy for Capital Reinvestment	40		8	40							80		28	12		6		16				230	$38,741		$2,000	$40,741
9	**Establish Sustainable Funding Strategy**	**40**		**8**	**88**							**100**		**28**	**14**								**278**	**$50,996**		**$4,000**	**$54,996**
9.1	Peform Gap Analysis	16			40							40			6								102	$19,598		$2,000	$21,598
9.2	Recommend Optimal Funding Strategy	24		8	48							60		28	8								176	$31,398		$2,000	$33,398
10	**Generate Asset Management Plan**	**108**	**8**	**8**	**8**	**140**	**8**		**12**	**6**	**28**	**6**		**28**	**88**	**18**	**20**		**36**	**12**	**24**		**558**	**$100,676**		**$4,500**	**$105,176**
10.1	Develop System AMP	60	8	8	8	80	4		8	6	8	6		28	48	6	8		16	12	24		338	$61,574		$2,500	$64,074
10.2	Develop Standard Operating Procedures	48				60	4		4		20				40	12	12		20				220	$39,102		$2,000	$41,102
11	**Public Engagement**	**16**	**4**	**4**		**32**								**16**	**28**					**88**	**104**		**292**	**$50,480**		**$3,000**	**$53,480**
11.1	Communication and Engagement Strategy	4	4	4		16									8					32	40		108	$20,153		$1,000	$21,153
11.2	Establish Core Messaging	4				16									8					24	36		88	$15,656		$1,000	$16,656
11.3	Coordination with Staff, Key Stakeholders and Media	8												16	12					32	28		96	$14,672		$1,000	$15,672
12	**AM Software Selection and Implementation**	**36**	**4**				**124**		**120**					**28**	**36**		**108**	**360**					**816**	**$116,936**	**$100,000**	**$5,500**	**$222,436**
12.1	Software Selection Assistance	12	4				16		16					28	12		24	40					152	$20,968		$1,500	$22,468
12.2	Software Purchase / Licensing	8					4		4						8			40					64	$8,842	$100,000		$108,842
12.3	Implementation	8					64		60						8		60	220					420	$59,576		$2,000	$61,576
12.4	Training	8					40		40						8		24	60					180	$27,551		$2,000	$29,551
	TOTAL EMPLOYEE HOURS	**1050**	**48**	**48**	**212**	**312**	**518**		**346**	**134**	**220**	**266**	**104**	**312**	**862**	**494**	**568**	**408**	**232**	**100**	**128**		**6362**	**$1,020,537**	**$100,000**	**$ 50,000**	**$ 1,170,537**
	MULTIPLIER	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05					
	LOADED HOURLY RATE	$ 147.32	$ 258.55	$ 347.24	$ 257.60	$ 242.69	$ 175.38	$ 227.65	$ 195.20	$ 240.74	$ 159.91	$ 149.02	$ 164.43	$ 88.45	$ 162.66	$ 122.00	$ 122.00	$ 122.00	$ 167.75	$ 183.00	$ 152.50	$ 122.00					
	TOTAL EMPLOYEE LABOR DOLLARS	$ 154,681	$ 12,410	$ 16,668	$ 54,612	$ 75,719	$ 90,844	$ -	$ 67,539	$ 32,259	$ 35,181	$ 39,640	$ 17,100	$ 27,596	$ 140,210	$ 60,268	$ 69,296	$ 49,776	$ 38,918	$18,300	$19,520						
	TOTAL FIRM LABOR DOLLARS	$624,249													$358,468					$37,820							

TOTAL PROJECT COST: $1,170,537

EXHIBIT C
INSURANCE REQUIREMENTS

Effective the date of this Agreement, and continuing without interruption during the term of this Agreement, Contractor shall provide certificates of insurance to the City on behalf of itself, and when requested any subcontractor(s). The certificates of insurance shall meet the following minimum requirements.

A. The Contractor shall have insurance that meets the following minimum requirements:

1. Professional Liability Insurance or Errors and Omissions Insurance protecting the Contractor and its employees in an amount not less than $1,000,000.

2. Worker's Compensation Insurance in accordance with all applicable state and federal statutes. Further, Employers Liability Coverage shall be obtained in the following minimum amounts:

   Bodily Injury by Accident - $500,000 each accident
   Bodily Injury by Disease - $500,000 each employee
   Bodily Injury by Disease - $500,000 each policy limit

3. Commercial General Liability Insurance equivalent to, as a minimum, Insurance Services Office form CG 00 01 07 98 or current equivalent. The City of Ann Arbor shall be an additional insured. There shall be no added exclusions or limiting endorsements which diminish the City's protections as an additional insured under the policy. Further, the following minimum limits of liability are required:

$1,000,000	Each occurrence as respect Bodily Injury Liability or Property Damage Liability, or both combined
$2,000,000	Per Job General Aggregate
$1,000,000	Personal and Advertising Injury

4. Motor Vehicle Liability Insurance, including Michigan No-Fault Coverages, equivalent to, as a minimum, Insurance Services Office form CA 00 01 07 97 or current equivalent. Coverage shall include all owned vehicles, all non-owned vehicles and all hired vehicles. Further, the limits of liability shall be $1,000,000 for each occurrence as respects Bodily Injury Liability or Property Damage Liability, or both combined.

5. Umbrella/Excess Liability Insurance shall be provided to apply in excess of the Commercial General Liability, Employers Liability and the Motor Vehicle coverage enumerated above, for each occurrence and for aggregate in the amount of $1,000,000.

B. Insurance required under A.3 above shall be considered primary as respects any other valid or collectible insurance that the City may possess, including any self-insured retentions the City may have; and any other insurance the City does possess shall be considered excess insurance only and shall not be required to contribute with this insurance. Further, the Contractor agrees to waive any right of recovery by its insurer against the City.

C. Insurance companies and policy forms are subject to approval of the City Attorney, which approval shall not be unreasonably withheld. Documentation must provide and demonstrate an unconditional 30 day written notice of cancellation in favor of the City of Ann Arbor. Further, the documentation must explicitly state the following: (a) the policy number; name of insurance company; name and address of the agent or authorized representative; name and address of insured; project name; policy expiration date; and specific coverage amounts; (b) any deductibles or self-insured retentions which shall be approved by the City, in its sole discretion; (c) that the policy conforms to the requirements specified. Contractor shall furnish the City with satisfactory certificates of insurance and endorsements prior to commencement of any work. Upon request, the Contractor shall provide within 30 days a copy of the policy(ies) to the City. If any of the above coverages expire by their terms during the term of this contract, the Contractor shall deliver proof of renewal and/or new policies to the Administering Service Area/Unit at least ten days prior to the expiration date.