A Guide to Sustainable Asset Management for Canadian Municipalities

Prepared for the
Federation of Canadian Municipalities

September 2002

R.V. Anderson Associates Limited

Federation of Canadian Municipalities

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ACKNOWLEDGEMENTS

A number of individuals representing various organizations provided review and editorial comments. The input of the following individuals and the organizations they represent are appreciated for their invaluable contribution to this document.

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Elisa Speranza (CH2M HILL - Boston and a representative of the American Water Works Association)

Rick Findlay (Pollution Probe - Ottawa)

Wayne D. Wood (City of Brantford)

Jennifer Phillips (FCM - in her recent position with the National Guide to Sustainable Municipal Infrastructure)

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Foreword

Most municipal governments in Canada are struggling with how to maintain, fix or replace aging infrastructure. They should find comfort in the methods outlined in this guide. Here are the practical steps that help answer some fundamental questions in relatively short order – what do we have in the way of infrastructure assets, what are they worth, and what should we be budgeting this year and over the next decade to properly sustain these assets?

The guide shows municipal managers and elected representatives how to answer these questions in the space of weeks or months rather than years, and then plan strategically. But it also provides a reality check. Managing municipal services such as water systems and road networks does not come cheap, especially when we look 10 or 20 years ahead and factor in the cost of replacing large pieces of these systems. While these high costs may be no surprise to veterans of municipal operations, the magnitude of the long-term cost should give pause for thought.

Further, municipal officials need to be mindful of the future implications for the sustainable investment in infrastructure that arise from the way communities are growing. A trend in many Canadian communities is low-density sprawl over more space, which creates rising concerns about financial impacts. As greenfield development consumes more farmland and natural areas, municipal infrastructure and assets must be expanded to serve these areas. The expansion means not just new water lines and sewers, but new roads, street lighting and other infrastructure. Based on these community growth trends, the reality for most Canadian municipalities is the need to budget more every year than the historical growth would suggest is necessary for maintenance and replacement of an asset like the water system.

The benefit of this guide is how clearly it illuminates questions of financial sustainability and reveals unnoticed costs. Reflecting on the points made in the guide, it becomes clear that land-use planning, financial planning, and responsible management of infrastructure assets are parts of a whole. The implications for the sprawl model are significant. When we apply the processes outlined in the guide, can we claim -- strictly from a financial perspective – that these growth patterns are sustainable? Will revenues from development charges, service charges, and property taxes actually outweigh the long-terms costs of maintenance and replacement?

The fact is that new infrastructure represents a financial liability. But even if this growth pattern and attendant infrastructure could be paid for without tax increases or expensive borrowing, is it environmentally and socially sustainable? How much more energy will be needed to pump water across a larger municipal region? How many more tonnes of greenhouse gases will be generated every year by the longer trips and new traffic we have stimulated on our larger road network?

We know that the municipal sector accounts for roughly 25 per cent of Canada's greenhouse gas (GHG) emissions. Municipal governments have a great role and responsibility to reverse current trends, reduce the 25 per cent figure and contribute to solutions to climate change. Therefore, I am encouraged by the tools described in this guide. Armed with the real financial costs of managing our existing municipal infrastructure, we can plan with a smart growth ethic in mind that considers urban form and growth patterns. Rather than accepting proposals for greenfield development, we can look for ways to meet housing, cultural, recreation or economic development needs within the limits of current physical boundaries. This shift in approach will require a search for alternatives that replace the idea of "growth" with more appropriate concepts of redevelopment, filling in gaps, and finding creative ways to reuse existing space and maximize existing infrastructure.

Louise Comeau
Director
Centre for Sustainable Community Development
Federation of Canadian Municipalities

PREFACE

… AHEAD OF THE WAVE

A few years ago the operations manager of a major municipal government in Ontario initiated a process to develop a strategy for managing existing water and wastewater infrastructure in the community. The asset base was aging and needed a specific management strategy to keep it operational. A multi-year asset management program was initiated that included detailed data gathering activities, analysis of system needs, and development of capital works programs to upgrade existing infrastructure.

A year into the program a major failure occurred in the wastewater system with damaging results in the community. An immediate characterization of the asset base was needed so that a strategy and investment program could be brought forward to reduce the possibility of an even greater failure than the one just faced. A more timely response was required than could be delivered by the multi-year program. The manager likened the situation to the helplessness felt by a swimmer in the undertow of a massive wave -- where treading water accomplishes little. An immediate intervention was needed to get ahead of the wave.

The result was a new "top down" strategy, focused on developing a high-level understanding of the asset base from which reasonable recommendations could be made. Infrastructure condition and needs were assessed at a macro level, and average annual investment requirements calculated using readily available information only. The concept of sustainability was incorporated into the analysis through consideration of full, life cycle demands of the assets over time. It quickly became evident that this process did not circumvent, but rather complemented and enhanced the traditional "bottom-up" asset management approach.

The immediate benefit of this simple strategic planning process is the ability to introduce sustainable and accountable practices into a municipal organization in cost-effective, manageable steps. The methods presented in this document grew from experiences in the City of Hamilton. They evolved in an environment of creative debate and dialogue among City staff, the consultant, and others seeking similar answers. The evolution is continuing in Hamilton and municipalities worldwide, with new lessons and challenges regularly refining the application of the principles established.

While the methodology presented herein was originally developed for water and wastewater systems, it can be used for sustainable asset management of all municipal public works assets, including road systems.

The intent of this guide is to address the financial or economic sustainability of infrastructure assets. A more complete examination of sustainability as it relates to municipal infrastructure would need to address the social and environmental dimensions. Future growth, land-use forecasts, regional impacts, and development strategies are among the elements that would complete such a discussion. Although these aspects are beyond the scope of this guide, they should be essential considerations in the broad planning and management of infrastructure.

The title of this guide -- *Ahead of the Wave* -- recognizes the growing maintenance or replacement demands generated by existing municipal assets. It is rooted in the understanding that municipal assets represent a significant investment of public monies in communities across Canada that must be protected. Furthermore, public health and safety depend on maintaining this infrastructure in good repair, and failure to stay ahead of this swelling wave of deteriorating facilities will have a significant impact on all Canadians. Finally, this guide is rooted in the recognition that a sustainable level of investment is a prerequisite to sustainable asset management, and that this is the challenge facing municipalities today.

The guide is written for decision-makers and asset managers to address the issues noted above – to learn from those who have navigated the process and who continue to be challenged in developing asset management strategies that stay *"ahead of the wave".*

Reg Andres, P.Eng.
Vice President
R.V. Anderson Associates Limited

PART 1

The Management of Municipal Assets

… a changing environment

… a new approach

Municipal Assets

Changing Management Demands

Development of Canada's municipal water and wastewater infrastructure began more than 150 years ago in the middle of the nineteenth century. As Canada's cities grew, these systems kept pace and grew in size and sophistication to address rising demands and evolving health and environmental concerns associated with increasing concentrations of human activity (e.g. typhoid epidemics and massive fires).

Figures 1-1 and 1-2 illustrate how water and wastewater infrastructure investment in Canada developed in phases according to the periods of physical growth experienced by the cities and the prevailing management issues of the day.

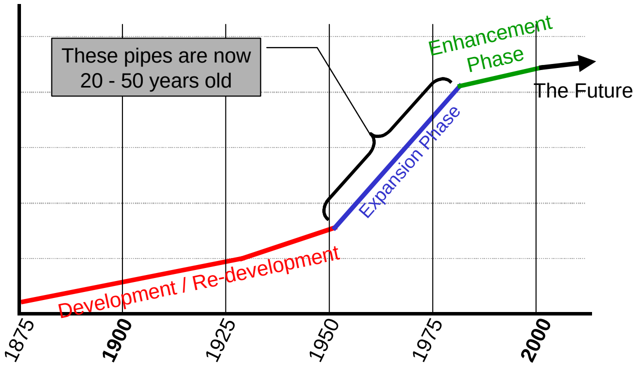


Figure 1-1
DEVELOPMENT PHASES

As these figures illustrate, today's asset managers must balance the demands of physical growth, increasingly stringent environmental protection regulations, and public health protection with the realities of financial constraints. While all of these issues are important to ensure sound infrastructure management, at times they overshadow the primary goal of maintaining public health and safety.

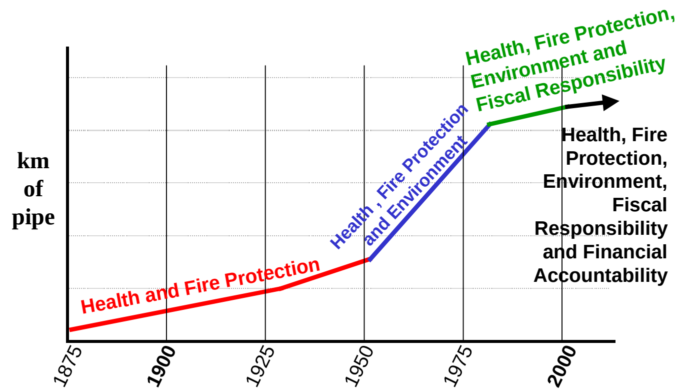


Figure 1-2
MANAGEMENT ISSUES

Projecting into the future, two key factors will significantly influence the strategies for managing these assets.

Deterioration: municipalities in Canada are entering an era during which a significant and growing proportion of the water and wastewater infrastructure is completing its first full life cycle – the result of the normal process of aging. This deterioration will result in many new challenges for the asset manager.

Financial accountability: the world-wide trend toward higher degrees of accountability demands transparent decision-making and a demonstration of wise and effective management of public funds. Expectations of greater accountability are expressed at the same time as pressures are exerted on local governments to reduce spending and taxes, but still maintain safe and reliable municipal services.

Sustainability
A New Management Strategy

The most significant factor affecting the future management of water and wastewater assets in Canadian municipalities is the completion of the first life cycle of existing infrastructure.

Sustaining municipal services will require a new management approach that balances a growing portfolio of aging infrastructure with increased demands arising from new growth – all while staying within the financial means of the community. Neither stopping growth nor ignoring the problem of aging facilities is an acceptable management option. This problem is not unique to Canada. Municipalities in the United States, Australia and New Zealand are pursuing similar approaches to dealing with this growing issue.

Sustainability

The concept of sustainability has evolved in meaning and understanding over time, but is broadly understood, in terms of sustainable communities, as *"…meeting the needs of the present generation without compromising the ability of future generations to meet their own needs".*

Within the municipal sector, sustainable community development requires consideration of the following:

(i) social well-being of the community, including public health and safety;
(ii) environmental integrity, including protection of natural resource values and functions; and
(iii) financial/economic viability of the community.

This guide focuses on the third consideration – financial and economic sustainability of municipal infrastructure assets.

Three concepts must be incorporated in a new strategy for managing municipal assets that support sustainable communities.

(i) Asset Value: Municipal infrastructure serves a fundamental and essential role in supporting communities. Despite their significant value (in the billions of dollars in some municipalities), many people fail to recognize the financial and health risks of neglecting "invisible" assets such as water and sewer systems. Similarly, the inputs to those systems, particularly raw water sources, are often considered to be free and excluded from financial accounting and management practices.

Water and sewer facilities, and the water sources they draw from and discharge to, must be managed as assets. All assets have a capital value as well as an inherent value arising from their role in achieving some greater objective. In this case, it is to sustain public health and safety. The cost of failing to meet this objective can be measured in terms of lives. Attaching values in terms of human lives and dollar figures to these resources reminds people of their significance and the importance of sustaining them.

> ***"… manage water and sewer facilities as assets"***

(ii) Life cycle: The management of municipal assets has traditionally included the planning, construction, operation and maintenance of the facilities providing a basic service such as the supply and distribution of potable water and the collection and treatment of sewage. The concept of sustainability implies this must be taken a step further to include a consideration of these facilities to the end of their useful life. This approach is generally referred to as "life cycle" management.

> ***"… consider facilities to the end of their useful life"***

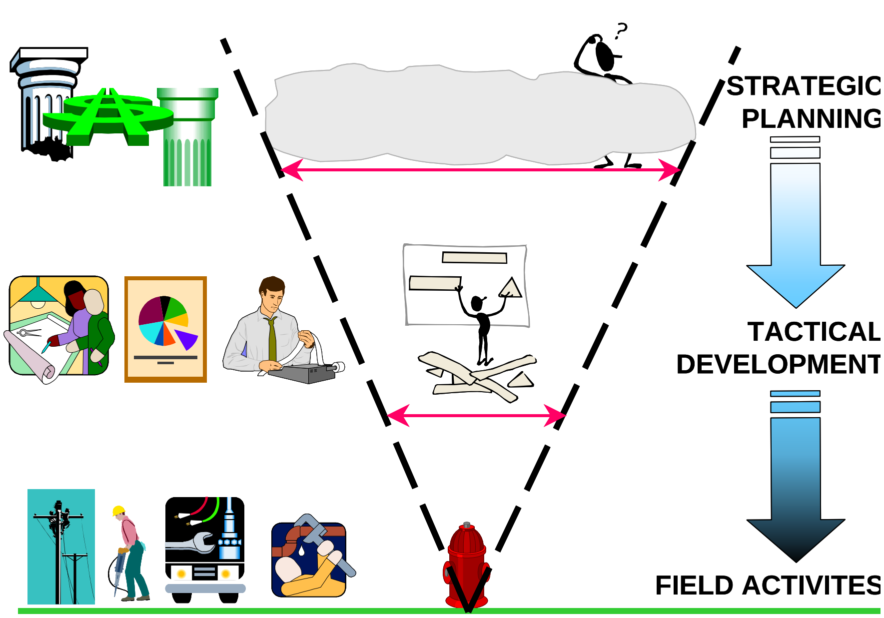
Framework
Sustainable Asset Management

(iii) Financial and Technical Integration: Life cycle assessments consider financial issues such as long-term investment protection, cost efficiency, cost-benefit of best approaches, priorities, and asset depreciation and replacement costs. Technical and financial evaluations must be fully integrated when establishing investment levels for capital projects, operations and maintenance, and replacement reserves to ensure adequate funding over the entire life of the asset - from inception to its ultimate replacement.

> ***"… fully integrate technical and financial evaluations"***

Figure 1-3 illustrates three components of municipal infrastructure management, including strategic planning, tactical development and field activities. The fundamental difference between current asset management practices and sustainable asset management lies at the strategic planning level. A brief review of the three levels is used to identify the sustainability gap.

Field Activities comprise all physical works, including the collection of data used for operational and planning purposes. Maintenance management systems are often used to monitor and control daily work activities (e.g. work order systems) and to house system inventories (data). Also included are the programs for monitoring, cleaning, repairing and operating the system.



1. Sustainability model
priority planning, risk management, life cycle costing, long-term capital planning, policy planning

2. Work Management and System Models – Long term coordination and integration, capital and financial management, system modeling, needs assessments and master planning studies

3. Data and Work Management Systems
Inventories, maintenance management, work history, condition assessment, customer service

Figure 1- 3
Sustainable Asset Management Framework

Tactical Development includes the preparation of capital plans that identify the projects to expand, improve and maintain the system in response to technical, public and political demands. Projects and programs developed at the tactical level are implemented at the field level. Activities include studies employing 10 to 20 year planning horizons to identify long-term infrastructure improvement, expansion and replacement projects. Projects are prioritized and funds allocated to recommended activities through the annual budget setting process. The linking of technical and financial requirements relates generally to balancing these needs in the context of setting projects' priorities.

Strategic Planning is a function of broader municipal priorities. It involves the review of priority planning between departments, policy planning, risk management, long range financial planning and life cycle costing. A key differentiation with tactical development is capital planning on the basis of programs instead of projects. It is a level of management considering broader municipal objectives.

History has shown that the traditional approach of managing on the basis of project priorities can result in important and necessary infrastructure needs going unmet indefinitely due to budget constraints. This approach often overlooks provision or planning for long-term revenue generation and allocation. There is no consideration of the technical and financial demands of the system over its life cycle.

A "sustainable" asset management approach differs from the traditional model by identifying the annual capital works program needed to achieve the desired outcome. A sustainable approach considers the full life cycle investment needs (i.e. sustainable funding) to develop a long term plan to balance the technical and financial needs for the infrastructure and then determines, on an annual basis, the program spending needed to sustain the level of service provided by the infrastructure over the life of the asset.

Strategic Planning:
Sustainable Asset Management

For many municipalities, size and resource limitations have dictated that asset management is confined to field activities and tactical development. Where strategic planning occurs, it is often completed in isolation from tactical and field level activities that may themselves be carried out by different departments (e.g. Engineering Branch and Operations Branch.) It is difficult to avoid an ultimate disconnect between the technical planners and the financial planners within organizations where these activities are managed in different departments. Such circumstances give rise to the term "silo structure," in which departments and planning functions operate in isolation of each other.

In a sustainable asset management process, these "silos" are broken down. Strategic planning activities are linked to tactical development and field activities and integrated with financial planning. The key to implementing sustainable asset management is the strategic planning process. A "top-down" financial analysis has the following advantages:

- simple to initiate and cost effective;
- immediate results independent of complex, time consuming data collection (bottom-up) activities;
- effective in communicating results and needs to decision-makers; and
- complements or supports detailed analysis as data becomes available.

Strategic Planning Process:
Developing Investment Profiles

The strategic planning component of sustainable asset management, as described in this guide, achieves the goals described in the previous section by answering the following questions:

1. What do we have?
2. What is it worth?
3. What condition is it in?
4. What do we need to do to it?
5. When do we have to do it?
6. How much will it cost?

The development of a sustainability model can be achieved by answering these six questions in the context of water, wastewater and road systems or other municipal assets. The model can be used to undertake analytical evaluations, including the effectiveness of various investment strategies.

Figure1-4: *Sustainable Capital Planning*, portrays the sustainability model as an investment profile with links to financial management (i.e. capital planning) processes. What follows is a description of the six-step strategic planning process of sustainable asset management.

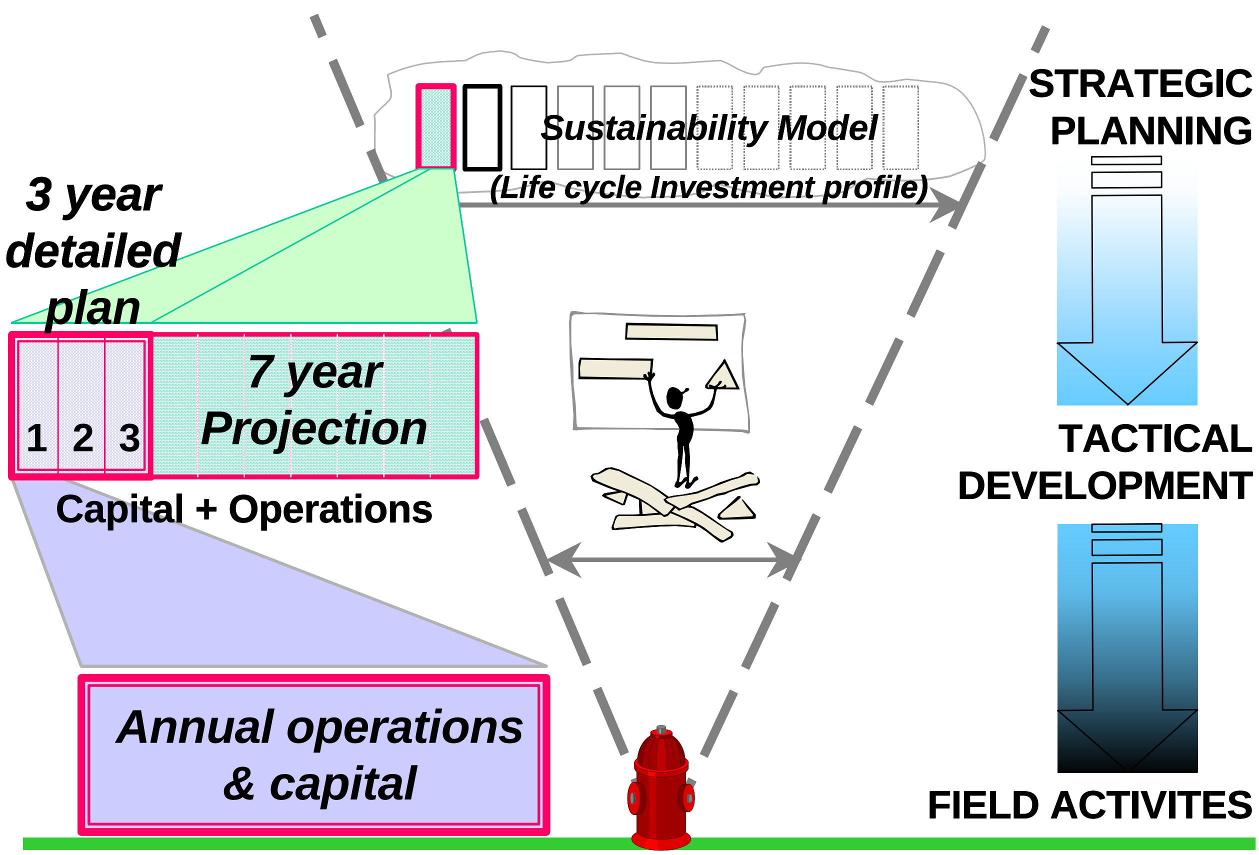


Figure 1- 4
Sustainable Capital Planning

Sustainability in Asset Management Practices

Traditional asset management activities as practiced in many municipalities include a component of infrastructure data management and a component of work management activities (ref. Figure 1-5: Sustainable Asset Management).

With the aid of the sustainability model (i.e. representation of the characteristics of the infrastructure systems), the asset manager can evaluate the long-term technical and financial performance of the assets.

This evaluation analyzes strategies for priority planning, life cycle profile management, long-term capital planning, risk management, corporate policy development and other issues of interest in managing municipal assets.

A sustainability model built on the basis of some broad assumptions about the assets, without the need of extensive data, has proven useful in its initial application as a management tool.

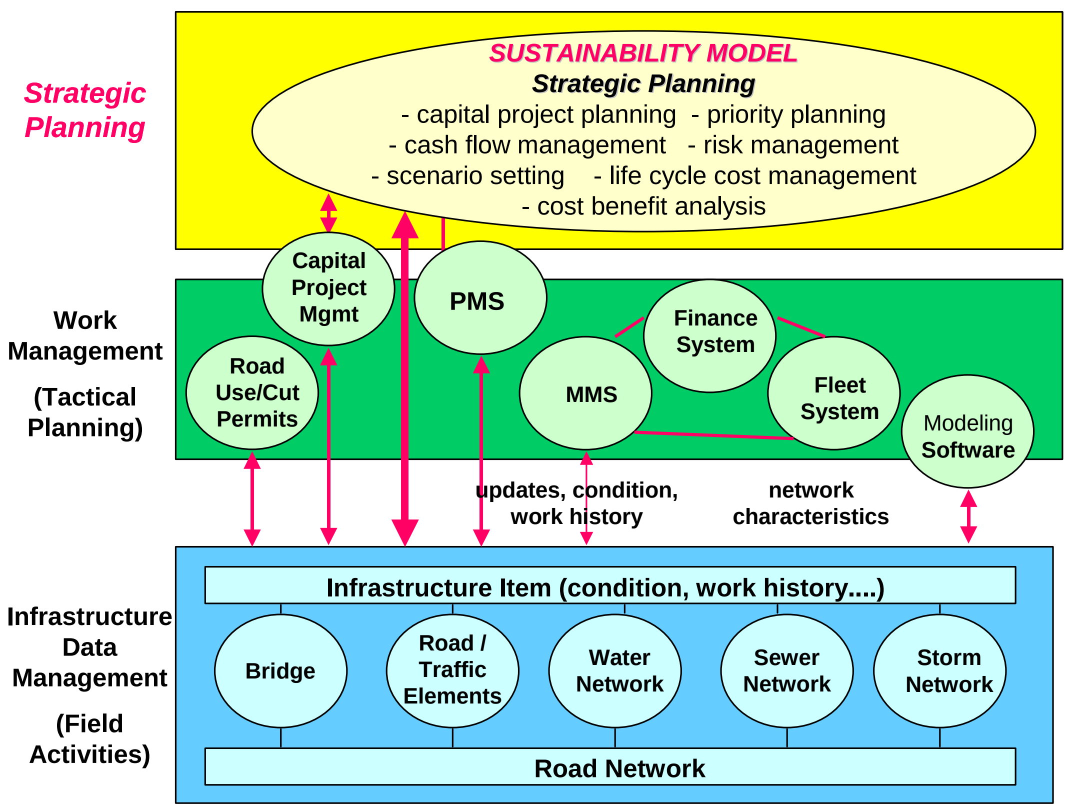


Figure 1-5
SUSTAINABLE ASSET MANAGEMENT

PART 2

A Guide to Strategic Planning for Asset Managers

… a phased implementation process

… strategic planning process (6 steps)

Sustainable Asset Management

A Phased Implementation Process

Integrating life cycle management practices into a municipal organization is a process of progressive steps. Each step or phase in the process introduces an increased level of detail into the sustainability model and moves another step closer to institutionalizing applications of the model in strategic decision-making.

The focus of this guide is how to take the first step toward strategic planning.

Phase 1 - Development of Initial Sustainability Model

The first phase or introduction to sustainable asset management is intended to initiate the municipal government in the concepts of building a simple model of its assets. This model is used to develop a life cycle profile of the assets for an initial understanding of their condition and corresponding financial investment needs over a full life cycle.

The initial model does not require a detailed representation of the assets for this purpose and, therefore, is built with limited system data or best available indicators in the absence of data.

Age is a reasonable indicator of condition for many assets. If specific age data is not available, population demographics can provide a suitable age profile based on the assumption that infrastructure was constructed in a community to keep pace with growth (how to develop this profile using data on population growth is explained more fully under Step 3, p. 2-4).

Together with cost and life expectancy information, a first level life cycle cost profile can be created with these parameters.

This guide is intended to enable municipalities to make this first entry into sustainable asset management by implementing the initial model with a small investment in time and resources. At the same time, it is intended to provide an initial insight into the importance and benefits of sustainable asset management.

Phase 2 – Detailed Applications of the Sustainability Model

With an initial understanding of the sustainability model, the extent to which the model can be used to assist in asset management decisions is simply an issue of the level of system detail in the model. In the case of a water system, if a single pipe length represents the initial model, it can be refined to identify the various pipe sizes and materials of construction in the model to enable a more detailed prediction of replacement and investment needs by pipe size and material. The use of specific inventory data enhances or calibrates the model and it becomes capable of more accuracy in predicting life cycle cost profiles.

Phase 3 – Integrated Organization

The municipal government will ultimately fully integrate life cycle management as an institutionalized practice. It will be evident in on-going calibration and use of the model, documented policies, programs and procedures that address issues of sustainability and, finally, possible structural changes to the organization to better coordinate and manage these processes.

Strategic Planning – 6 Steps

Step 1 – What do we have?
Building the Sustainability Model

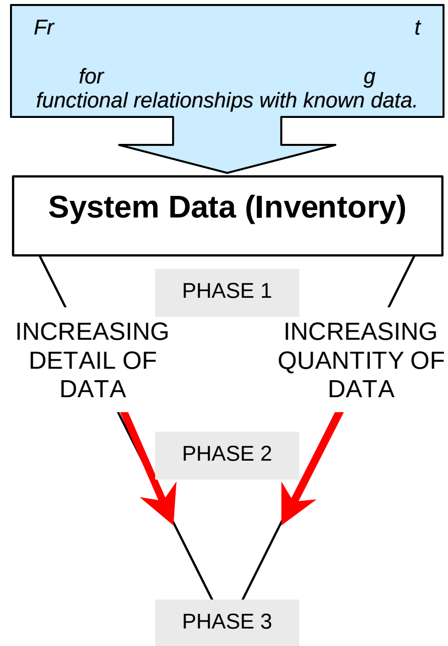
The first step in building the sustainability model is to define the system components. This is a basic inventory of the infrastructure assets. The initial model should be limited in the level of definition detail.

The concept for the form of the data is that of a "tree" structure. A serviced population could define a water system, providing an initial sense of the overall size of the system.

The next level of detail could define the system as pipes and above-grade structures (plants, pumping stations, reservoirs). In the absence of actual inventory data, it is appropriate to estimate this data using functional relationships. For example, pipe length can be estimated from population data by assuming one kilometre of pipe per 250 serviced residents. Sizes of treatment plants can be estimated using similar population data.

As the model is refined or calibrated, it is simply broken into more detail. The next level of detail for the pipes could include size and materials. Ultimately pipes could be identified down to street-by-street definition, if this level of detail were necessary for detailed evaluations.

It is important to note that the lack of detailed inventory is not a barrier to the development of an initial model or representation of the system. Although the inventory will be needed at some point, it is entirely appropriate to build the initial model with limited data.



Maximum Level of Detail for Phase 1 Inventory

Water Systems

- Watermains– length & size
- Hydrants – number (may be a function of WM length)
- Valves – number (may be a function of WM length)
- Other broad grouping of assets

Wastewater Systems

- Sewer pipes – length & size
- Manholes – number (may be a function of sewer length)
- Pumping stations – number & capacity
- Treatment plants – number & capacity
- Storage tanks – number & capacity
- Other broad grouping of assets

Road Systems

- Road types or sections:
  - Urban – overall lane kilometres
  - Semi-Urban – overall lane kilometres
  - Rural – overall lane kilometres
- Road classes:
  - Arterials – overall lane kilometres
  - Collectors – overall lane kilometres
  - Local – overall lane kilometres

Strategic Planning – 6 Steps

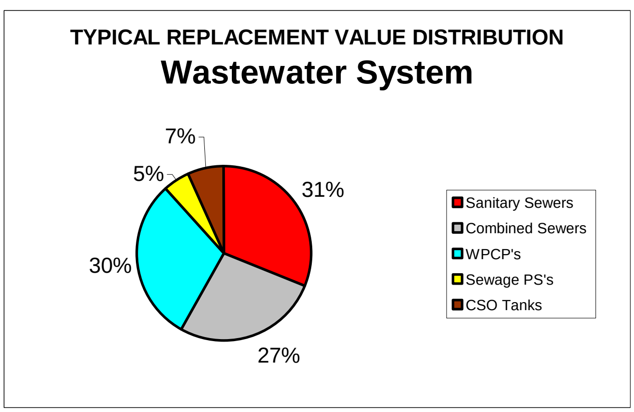
Step 2 – What is it worth?
Building the Sustainability Model

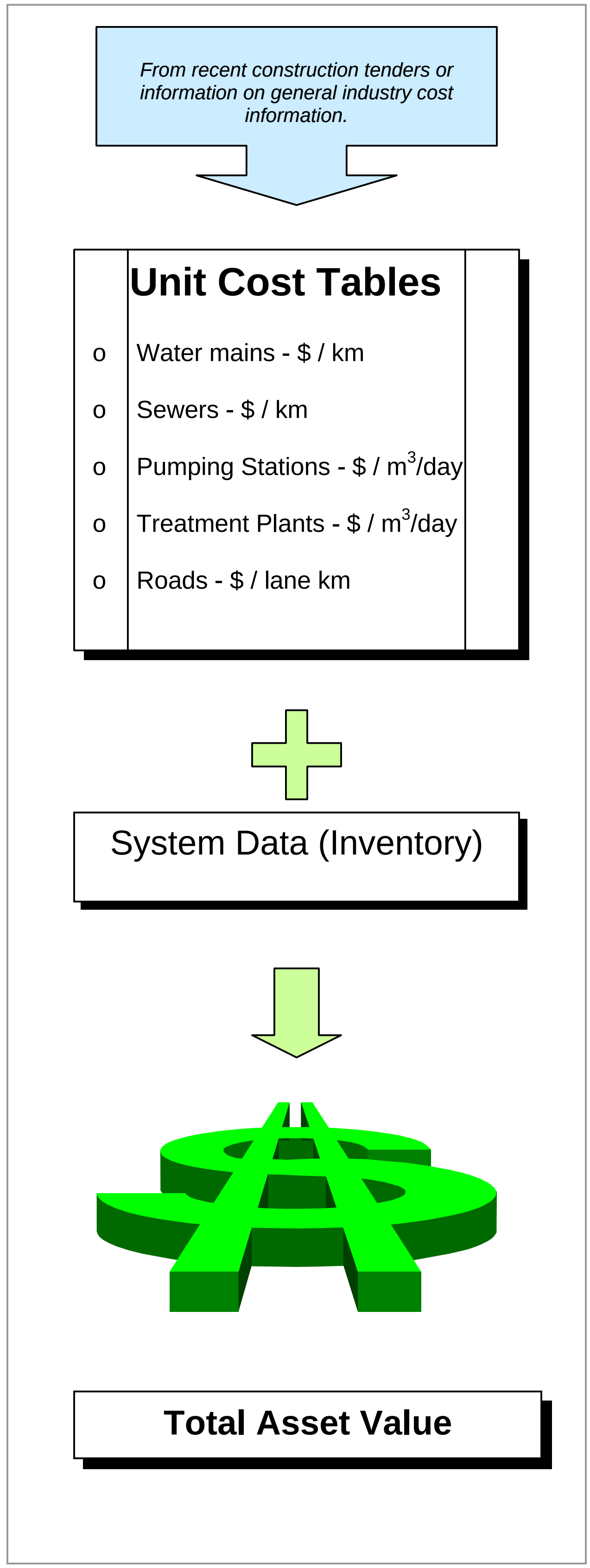
This is the next logical step to the inventory of the assets. It involves the application of current construction cost estimates to available system data to determine the replacement value of existing assets. As with Step 1, this activity can be straightforward when kept at a macro level using available data.

There are methods of valuation other than current replacement costs for assets. But for the purposes of this model, this method provides a suitable basis for the types of evaluation carried out.

Calibrating the model is a case of upgrading the unit cost tables to reflect local conditions that affect construction costs (e.g. soil conditions, bedrock depth, isolated areas).

The representation of the asset values in graphical form provides early insights into the nature of the asset and the relative importance of individual components. For instance, the value of assets buried underground typically exceeds that of above-grade built assets.





Strategic Planning – 6 Steps

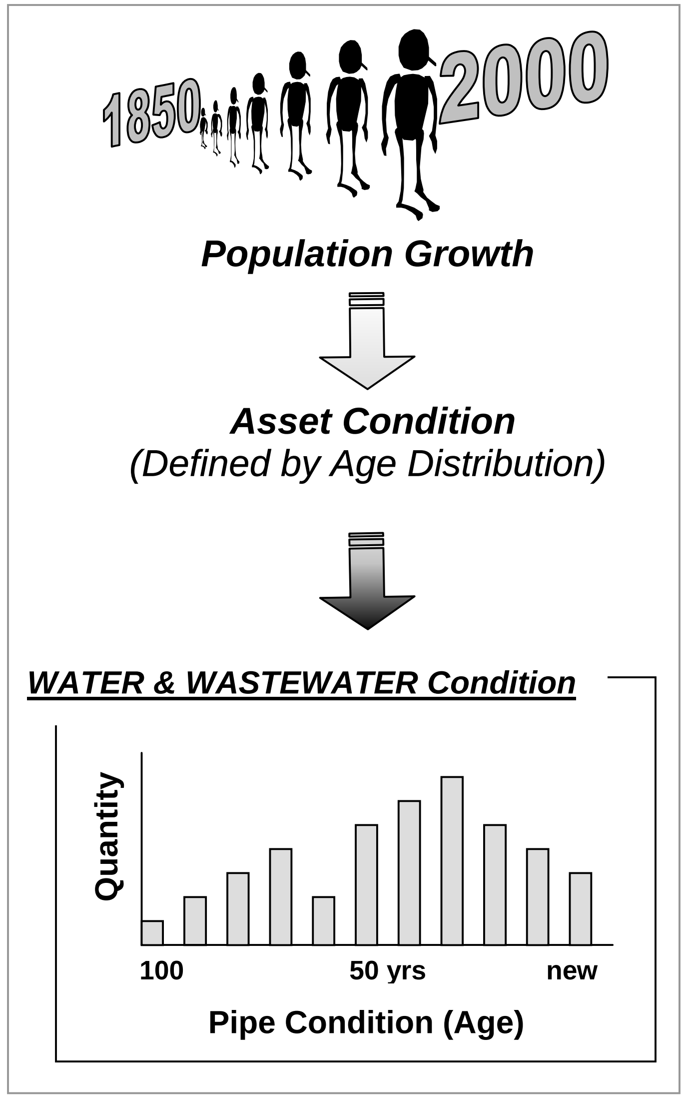
Step 3 – What condition is it in?
Building the Sustainability Model

The objective of this step is to obtain an understanding of the general condition of the entire asset base to enable assessment of future demands for minor and major repairs, rehabilitation and replacement.

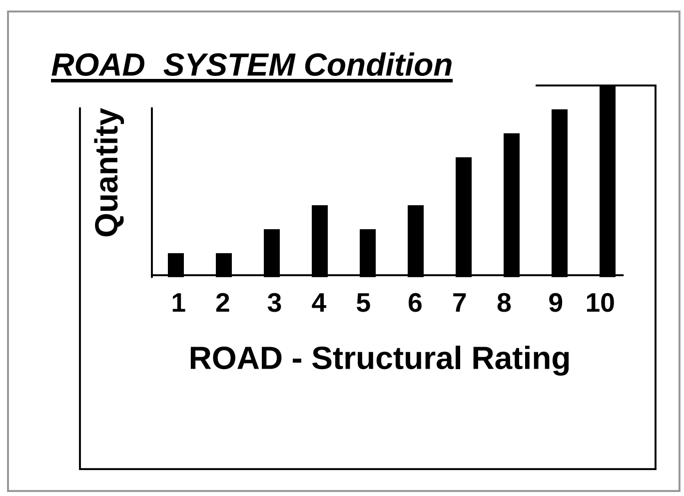
For this step, condition indicators that can be measured over time should be used. In most situations, age is an appropriate indicator of asset condition for the initial assessments. Where the age of assets is unknown, it is reasonable to assume they were built to keep pace with population growth. Census data and historic mapping can be used to determine the growth of infrastructure in different time periods. Most municipalities know the total length of pipe in their water system (or can roughly calculate it using an established formula). A municipality can then take that total length and divide it up by age (decade) based on the percentage of population growth that occurred in the corresponding decade. For instance, if a given municipality saw 10 per cent of its population growth in the 1950s, then we can say that 10 per cent of the total pipe length was installed in the 1950s. While other factors can be used, assessing infrastructure condition as a function of age enables simple characterization of the overall asset. This is especially true for water and sewer assets.

In the case of roads, typical structural adequacy ratings from road needs studies are good condition-rating indicators.

At this stage, it is important to avoid the tendency to embark on a major data collection exercise to determine and assign a condition for each component of the asset base.



Asset Condition
(Defined by Structural Rating)



Strategic Planning – 6 Steps

Step 4 – What do we need to do to it?
Building the Sustainability Model

The purpose of this step is to identify the type of investments required during the life cycle of each group of assets.

Four general categories are used to group the different investment activities required over the life of the assets:

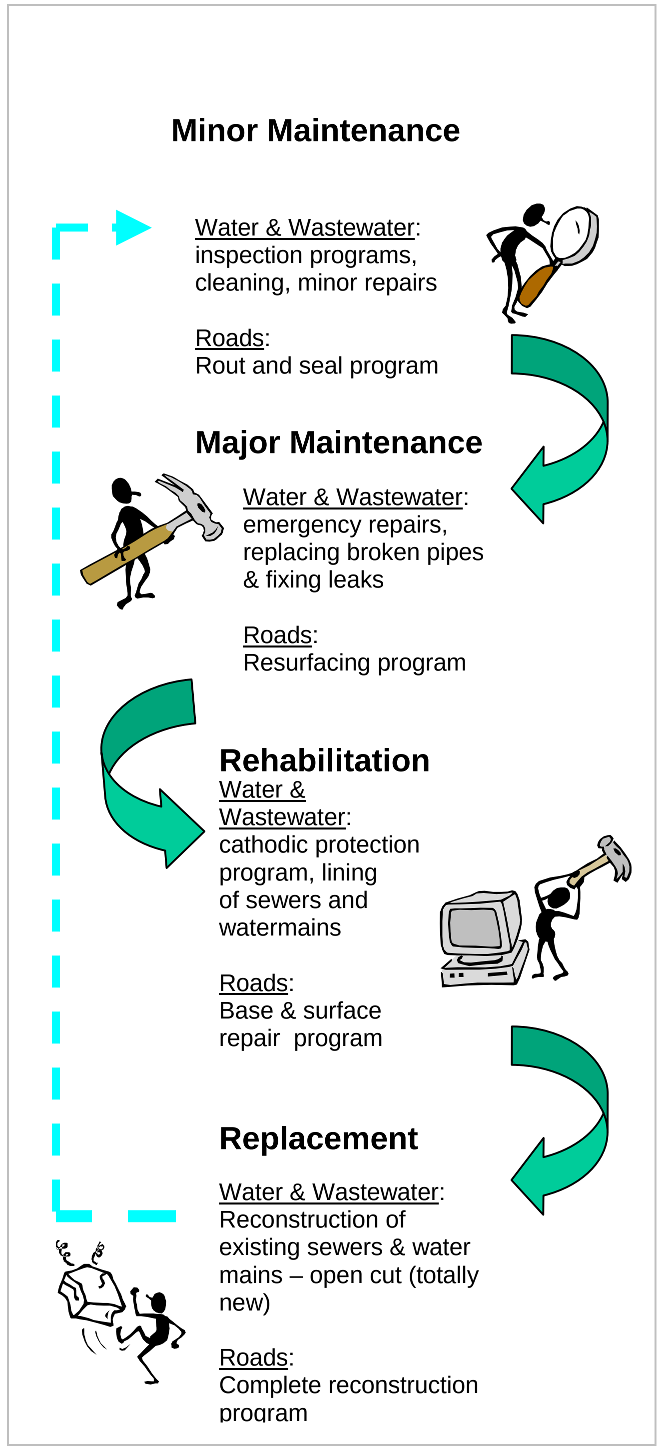
- minor maintenance,
- major maintenance,
- rehabilitation, and
- replacement.

Minor maintenance includes all regularly scheduled maintenance activities such as inspection programs, cleaning, lubricating and minor repairs for water and wastewater systems. In road systems, a rout and seal program is typically identified. These would be modified to adapt to specific practices of the municipal government.

Major maintenance typically includes activities such as repairing broken mains, replacing motors or pumps, and similar unscheduled or unplanned emergency activities carried out to maintain service for water and wastewater systems or resurfacing programs for road systems. Again, these would address specific municipal practices.

Rehabilitation is generally a one-time event designed to extend the life of the asset, such as lining a sewer or installing cathodic protection in a water system. A base and surface repair program for road systems qualifies as rehabilitation.

Replacement is the unavoidable event that occurs at the end of the service life of all assets. For water and wastewater systems, replacement usually means open-cut installations. For roads, a complete reconstruction takes place.



Strategic Planning – 6 Steps

Step 5 – When do we need to do it?

Building the Sustainability Model

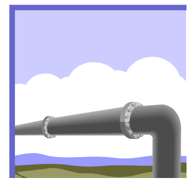
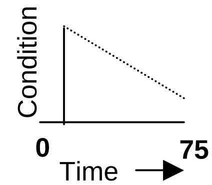
Having determined the full range of investment activities required over the life of an asset, the greater challenge is to predict when it will reach the end of its service life and how quickly its condition will deteriorate. This is not an exact science, and for the purposes of the sustainability model, assumptions are necessary.

The objective of this step is to generate a life cycle investment profile for each asset component by assigning a time interval for the cost events identified in step four. For example, minor maintenance costs are annual cost events incurred every year of the asset's life. Major maintenance costs would be treated in a similar fashion but may increase over time.

The timing of rehabilitation events are assigned on the basis of industry information and estimated in relation to the life of the asset.

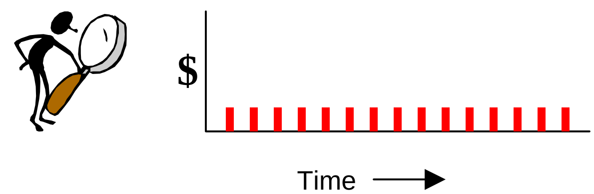
The replacement cost is a single cost event that takes place at the end of the expected service life of the asset.

Estimates can be refined over time through tactical and field activities that target collection of relevant data (e.g. the age of pipes replaced and frequency of meter repairs and pump breakdown).

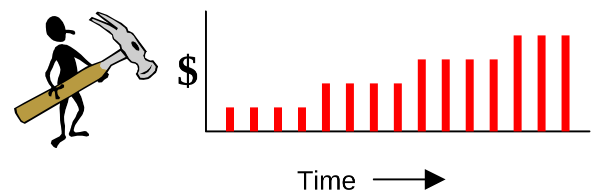
ASSET	Life Expectancy	Rate of Deterioration
	75 YEARS	

Component Life Cycle Profile

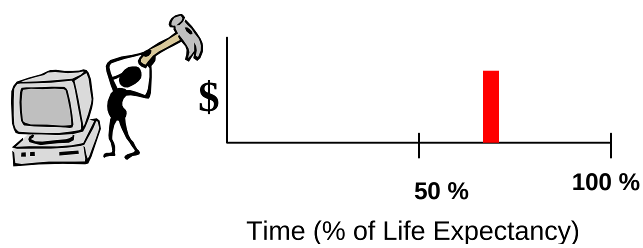
Minor Maintenance (annual cost events)



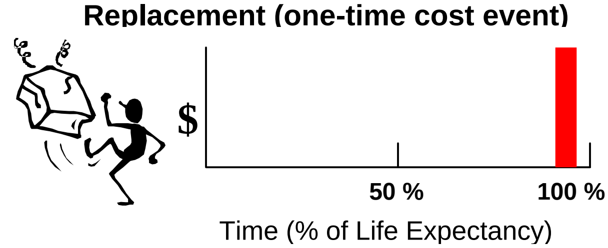
Major Maintenance (annual cost events)



Rehabilitation (one-time cost event)



Replacement (one-time cost event)



Strategic Planning – 6 Steps

Step 6 – How much will it cost?
Building the Sustainability Model

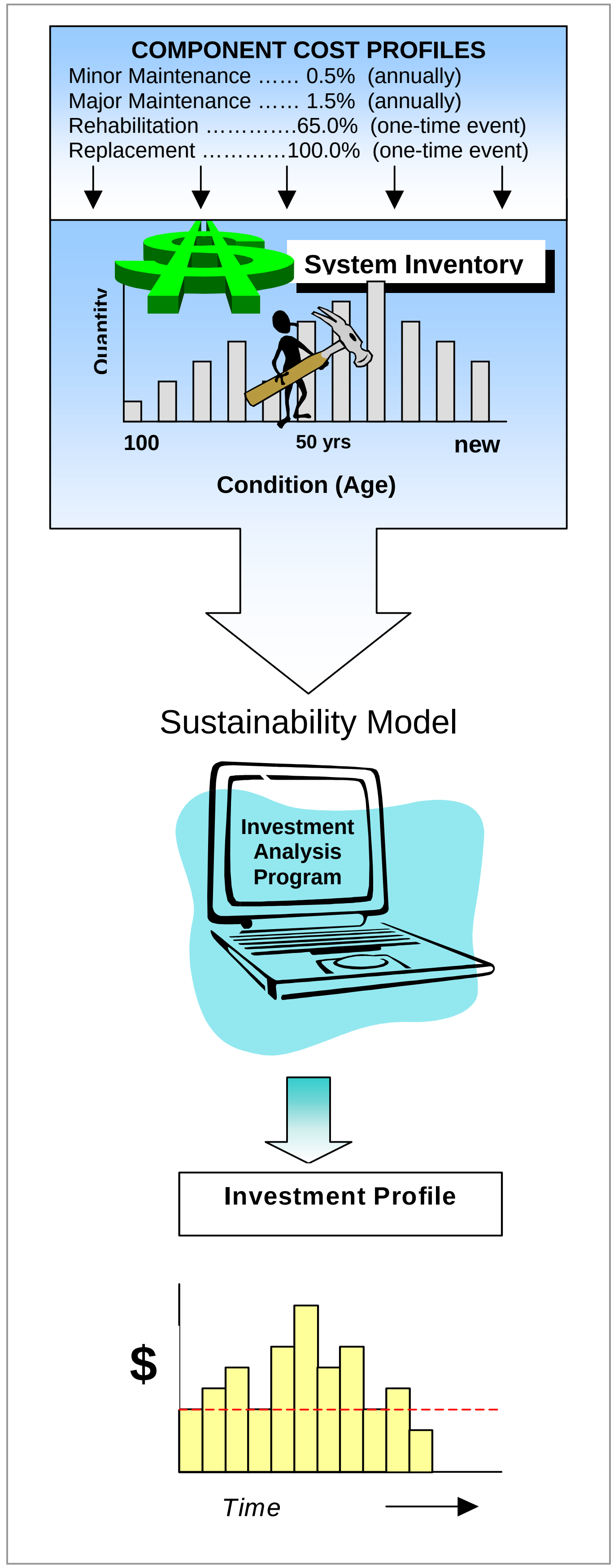
The final step in building the sustainability model is to estimate the cost of each investment event as a percentage of the total asset value (i.e. replacement cost).

Rehabilitation costs, as a percentage of total asset value, are estimated from general industry knowledge for this type of work. Maintenance costs may be obtained from industry benchmarking exercises, research studies or estimated from the municipality's own budgets.

Combining the timing information from Step 5 with the costs determined in Step 6 results in individual component life cycle profiles for the assets, which, in conjunction with all the related data and information, comprise the "sustainability model".

Using computer tools to manage and manipulate the model, specific evaluations can be made to assist management decisions. One of the basic analysis routines is to determine long-term investments that need to be funded. Any number of funding scenarios, cost-modifying activities and the like can be analyzed for making sustainable asset management decisions.

The advantage of using a sustainability model is its ability to provide dynamic representation of the assets over time, and to manage data to analyze specific aspects of the assets (e.g. the impact of changing major maintenance practices on the overall life of the asset).



Sustainable Asset Management
Tools, Applications, Implications

Tools: Computer Programs

When we refer to building a sustainability model in this document we do not mean a computer model. Rather, it is a representation of an asset in a combination of inventory databases, cost tables, age profiles (tables), and related information in tabular, database or graphical form. While the sustainability model is not a computer program, it does require this technology to store, retrieve, assemble, analyze and report the information that makes up the sustainability model.

The nature of the analytical evaluation and data manipulations can become complex. Spreadsheet programs can be used in the initial analysis. Building a sustainability model with a spreadsheet program, however, has limitations and at some point a more sophisticated database management program will be required.

At the present time, few database management programs, specifically designed for strategic planning analysis in the context of sustainable asset management, exist on the market. This situation is anticipated to change. The emergence of these types of analytical needs will result in the development of such models.

To illustrate the application of an investment valuation computer model, the following is a brief summary of the desired functionality of such a program.

An asset management software program needs to use an advanced object-oriented design to support three primary functions in conjunction with sustainable asset management.

Data Management: Information needs to be received from different databases allowing users to configure how the value and condition of the infrastructure is determined and how detailed the valuation and maintenance model should be.

Analysis: The model should support complex formulas for sourcing, calculating and estimating the numbers needed to perform long-range planning. Computing these financial algorithms should be able to be done simply with any aggregation of the data to perform and demonstrate results for comparative analysis. Support for multiple management strategies would allow an organization to test different policies for preserving its assets. Changing the strategies in the model would allow for a determination of effect on condition and budget implications.

Reporting: An important aspect of analyzing different strategies and management scenarios is the ability to present and view the results in effective and communicative pictorials. The program needs to provide for viewing of the information in easy-to-read charts and graphs. Users need to navigate between graphs and trail the formula and components used to calculate a number.

Applications

This guide outlines the development of a sustainability model for the purpose of strategic planning in the context of sustainable asset management. The applications for the model are as diverse as the challenges that asset managers meet in the course of delivering the municipal services for which they are responsible. A variety of operational planning, financial, policy and related decisions need to be made on a regular basis. What follows below is a sampling of some of the management applications for the sustainability model.

Full Cost Accounting

One of the elemental applications for the sustainability model is its ability to determine life cycle costs for operations, maintenance, rehabilitation and replacement capital to sustain an asset over its full life. This provides the basis for long-term financial planning to ensure revenues (i.e. rates) are adequate.

Policy Development
The sustainability model is an effective tool to identify policies that support cost effective management strategies, to test the effects of current policies or to identify the impacts of contemplated policies.

Program Planning
Understanding the dynamic of an asset in terms of the types of investment needs it will require over time allows the asset manager to develop sustainable maintenance, rehabilitation and replacement program budgets and corresponding program activities over time.

Design Standards
Specific design standards as they relate to issues of durability, longevity and associated costs can be reviewed. For example, the cost effectiveness of the design standard for a specific road base can be compared with another standard that may cost more, but would last longer.

Budget Planning Process
During the budget planning process municipal staff are often challenged with identifying the impacts of contemplated revisions, inclusions or exclusions of activities in a budget. The sustainability model offers a tool that can quickly analyze impacts and provide for more informed decisions in the budget planning process.

Communications
Perhaps the most valuable attribute of this tool is its ability to capture and provide a clear understanding of a municipality's infrastructure, and the level of investment required to sustain it over time. Its power to convey urgent messages to funding agencies, elected officials, and the public has been clearly demonstrated.

Implications

Implementing sustainable asset management has some potential implications in terms of changes to traditional, institutionalized practices in a municipal organization. Areas of change may include:

- Decision-making, with respect to the investment/budget plan for an asset, must consider the needs of the infrastructure systems over the full service life of the assets.

- Investment plans for an asset must be defined in terms of programs as opposed to projects.

- Revenue streams need to be approved on the basis of long-term program needs.

- Policies and programs supporting sustainability need to be identified and approved.

- The organizational structure may need to change to support new management approaches and responsibilities.

PART 3

Case Study in Strategic Planning

…Water and Wastewater Assets – City of Hamilton, Ontario

R.V. Anderson Associates Limited

A Case Study

Water and Wastewater Assets
City of Hamilton, Ontario

Hamilton is a municipality located on the westerly shore of Lake Ontario with an approximate population of 470,000. In 1997 the City embarked on a multi-year asset management program designed to help develop a management strategy to address the needs of the municipal government's aging infrastructure. The program began with a typical approach of detailed data collection and program development. During this process the need for more immediate outcomes resulted in a strategic shift in the program. A top-down approach was initiated and in 2000, the City of Hamilton became the first municipality to implement the sustainable asset management system. In fact, it used the strategic planning activity described in this guide. At the time of the asset management study, Hamilton was a regional jurisdiction with seven area municipalities. The Region was responsible for the entirety of water and wastewater (collection and distribution, treatment, etc.) systems.

What follows is a summary of the development of the six steps for strategic planning and the outcomes and analytical results of the sustainability model.

Step 1 – What do we have?

During the 1990s, Hamilton implemented an advanced maintenance management system to track and support its operations and maintenance activities. Over a period of several years the water and wastewater systems were inventoried and the data was loaded into the maintenance management system (MMS).

For purposes of this study, the inventory was reasonably complete except for age data. The detail selected to aggregate the data and the source of the data are presented below.

SYSTEM COMPONENTS	DETAIL SELECTED TO AGGREGATE DATA	SOURCE OF DATA
Water System		
1. Pipes	Lengths for individual pipe diameters from 100 mm diameter to 2,250 mm diameter, by community	MMS database
2. Water services	Number by community	Water billings
3. Hydrants	Number by community	MMS database
4. Valves	Number by community	MMS database
5. Treatment plants	Number	MMS database
6. Pumping stations	Number	MMS database
7. Reservoirs	Number	MMS database
Sewer System		
1. Pipes	Lengths in size groupings (>300 mm, 350-600 mm diameter, 625-900 mm diameter, 975-1200 mm diameter, 1350-3000 mm diameter, by community	MMS database
2. Sanitary laterals	Number by community	Water billings
3. Manholes	Number by community	MMS database
4. Treatment plants	Number	MMS database
5. Pumping stations	Number	MMS database
6. CSO tanks	Number	MMS database

Step 2 – What is it worth?

For each of the system components industry figures were used to develop a cost table in which costs for 'lumped' components like pumping stations and reservoirs were averaged. The results were reported in a simple table as follows:

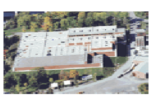
WATER MAINS	
Less than 200 mm	$ 417,505,000
250 – 300 mm	$ 197,069,000
400 – 500 mm	$ 149,764,000
600 – 750 mm	$ 67,955,000
Greater than 750 mm	$ 144,508,000
TOTAL	***$ 976,801,000***

WATER SERVICES	
124,315 services at ~$2000 per service	
	$ 248,630,000

HYDRANTS	
11,232 hydrants at ~$5,000 each	
	$ 56,160,000

VALVES	
14,097 valves at ~$3,000 each	*Cost included in estimate for water mains*
	$ 42,291,000

PUMPING STATIONS	
24 stations at ~ $1.5 million each	$ 36,000,000
	$ 36,000,000



TREATMENT PLANT	
Woodward Ave WTP	$ 375,000,000
	$ 375,000,000

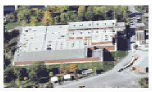
STORAGE RESERVOIR	
16 water storage reservoirs at $4.5M each	$ 72,000,000
	$ 72,000,000

TOTAL ESTIMATED VALUE (Water) $1,806,882,000

SEWER MAINS	
Sanitary sewers	$ 446,235,178
Combined sewers	$ 389,089,838
TOTAL	***$ 835,325,016***

MANHOLES	
34, 463 manholes at $5,000 each	*Cost included in estimate for sewer mains*
	$ 172,315,000

SEWAGE PUMPING STATIONS	
65 stations at ~$1,050,000 each	$ 68,250,000
	$ 68,250,000

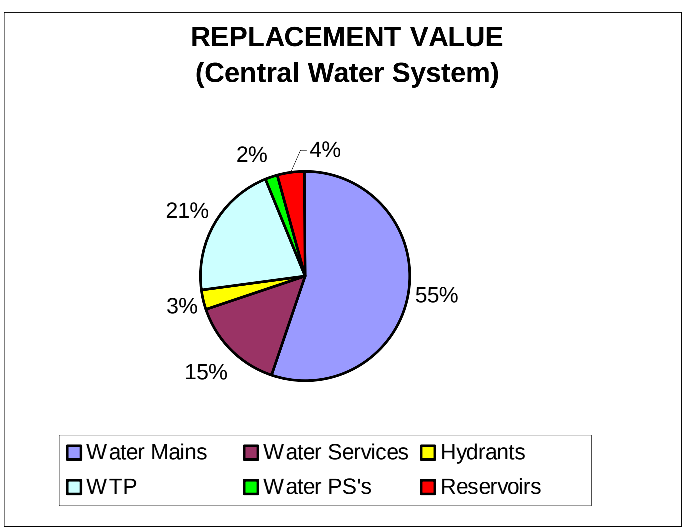


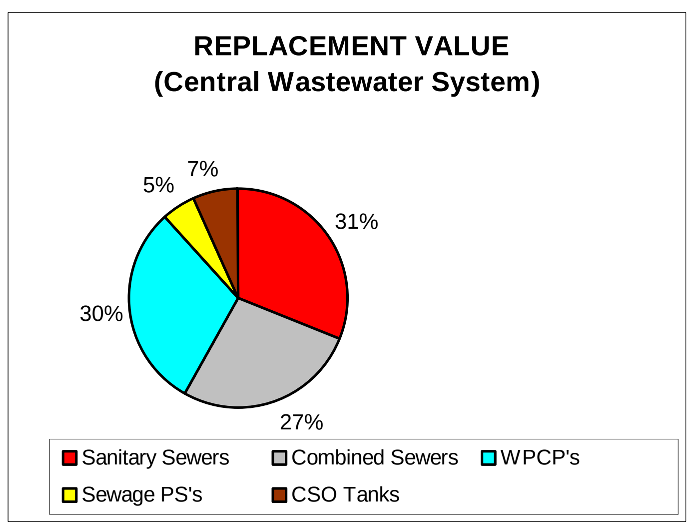
WASTEWATER TREATMENT PLANTS	
Woodward Ave WPCP	$ 400,000,000
Dundas WPCP	$ 30,000,000
Waterdown WPCP	$ 6,000,000
	$ 436,000,000

CSO STORAGE TANKS	
5 CSO tanks at $19.5 million each	$ 97,600,000
	$ 97,600,000

TOTAL ESTIMATED VALUE (Wastewater) $1,437,175,016

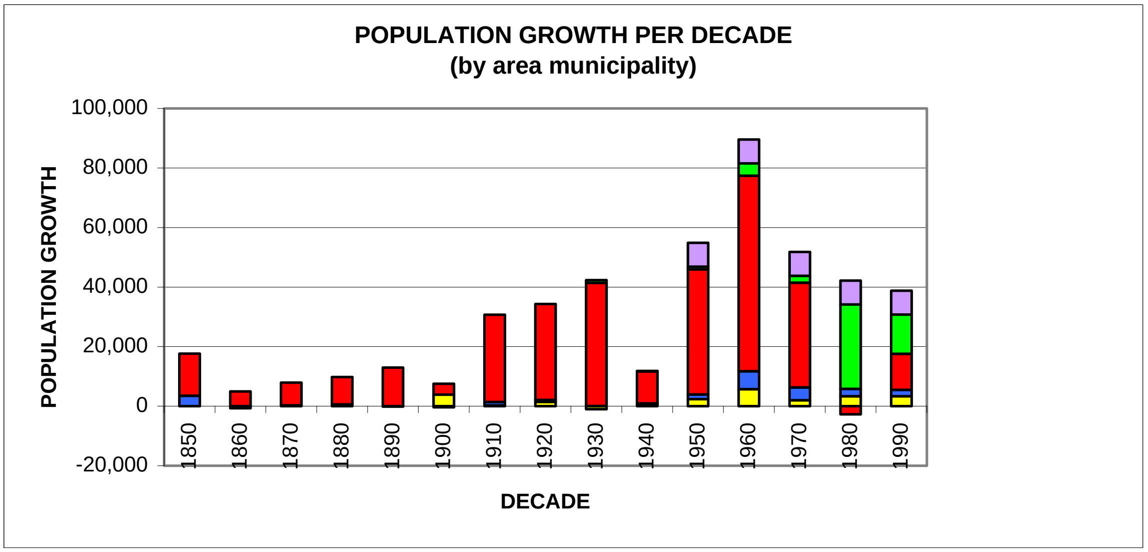
The combined assets of water and wastewater systems totaled more than $3.2 billion. This fact alone was revealing for the asset managers and corporate decision-makers in terms of the responsibility they had for a significant municipal investment. The representation in the pie charts below demonstrated another fact – that over two-thirds of these assets are buried underground.





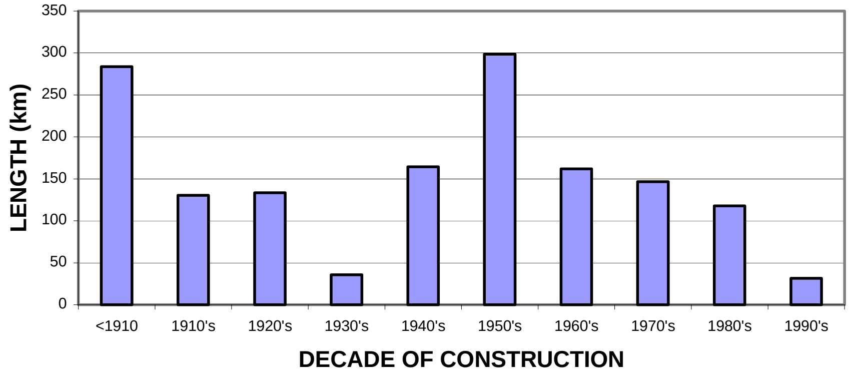
Step 3 – What condition is it in?

Development of a condition assessment or characterization of the overall condition of the water and sewer assets was accomplished using age as an indicator. At the time, Hamilton was conducting an extensive inspection of its sewers using closed-circuit television (CCTV), an inspection program that is on-going. The inspection reports include a pipe-by-pipe condition assessment. But this method was deemed too detailed for the initial assessment required for this asset management study. A much simpler method was needed to characterize the condition of the system as a whole. Age was selected as this general indicator. Since there was no "age of infrastructure" field in the database, population growth was used as an indicator of age on the assumption that as the community grew, the infrastructure also grew in proportion.



The population distribution over the past 150 years is represented in a bar chart and when the percentage growth per decade is translated into sewer pipe lengths per decade, the age distribution of the sewer system is presented on a similar looking bar chart (see Step 3, p. 2-4 for more on this process). The assumption is made that any pipes over 100 years old are included in the first decade of this bar chart as a backlog of aging pipes. The fact that some of these pipes may have already been replaced is not significant enough to change the basic picture of the age distribution of the piped sewer system. Age distribution for the water system would be similar since the same population profile is used as the age indicator.

AGE DISTRIBUTION OF SEWERS



Step 4 – What do we need to do to it?

Over the life of the water and wastewater assets, four primary cost events were identified, including minor maintenance, major maintenance, rehabilitation and replacement.

Minor Maintenance generally includes planned events such as inspections, monitoring, cleaning and flushing, hydrant flushing, pressure tests, CCTV inspections and visual inspections.

Major Maintenance includes maintenance and repair activities that are usually unplanned, but which can be anticipated over the course of a year in a general way. This type of maintenance would include such events as repairing water main and sewer breaks, repairing valves, replacing individual sections of pipe, and sealing.

Rehabilitation refers to that singular moment in the life of an asset when a major activity is required to upgrade or rehabilitate the asset in order that it continue providing service for some additional period of time. In the case of Hamilton's water system, the major activity was cleaning and lining. For the sewer system, rehabilitation included a sewer re-lining program.

Replacement is an event that inevitably arrives sometime in the life of any asset. When the useful service life of an asset is reached, it must be replaced. Some components of an asset will last longer than others, but even for these components an eventual end of life must be anticipated.

Step 5 – When do we need to do it?

Estimates were made of the service life of the various asset components in Hamilton's water system. Using the actual performance of the municipal assets coupled with research information, service life estimates were calculated for the sustainability model. These estimates are presented below.

COMPONENTS		**EXPECTED SERVICE LIFE**
Central Water Supply System		
Water mains		100 years
Water services		100 years
Hydrants		100 years
Valves		100 years
Water treatment plant, pumping stations	Structural components (concrete structures, buildings, etc.): 70% of total	75 years
	Mechanical/electrical systems: 30% of total	25 years
Reservoirs	Structural components	75 years
	Repainting (towers)	15 years
Central Wastewater System		
Sewers		100 years
Manholes		100 years
Water treatment plant, pumping stations	Structural components (concrete structures, buildings, etc.): 70% of total	75 years
	Mechanical/electrical systems: 30% of total	25 years
CSO storage Tanks	Structural components (concrete structures, buildings, etc.): 70% of total	75 years
	Mechanical/electrical systems: 30% of total	25 years

Step 6 – How much will it cost?

Based on the service life estimates, life cycle cost profiles were developed for each system component by mapping the service life estimates and the four primary cost events identified below.

Minor Maintenance is an annual cost event. Hamilton budgeted regularly for this maintenance at the rate of approximately 0.5 per cent of the value of the assets. Hamilton's budget formula was measured against empirical formulae established by the American Water Works Association (AWWA) in a recent study and found to be comparable.

Major Maintenance is an annual cost event. The AWWA empirical formulae were applied to Hamilton's water system, an exercise that yielded a recommended investment level of 2.4 per cent of the replacement value of the overall water system. Since sewers were considered to need slightly higher investment than the water supply assets, a combined investment for operations and maintenance (O&M) was estimated to represent 2.5 per cent of the total water and wastewater inventory value. And since the annual minor maintenance cost was determined to be 0.5 per cent, the annual major maintenance cost was the balance of the overall O&M estimate, or two per cent of asset value.

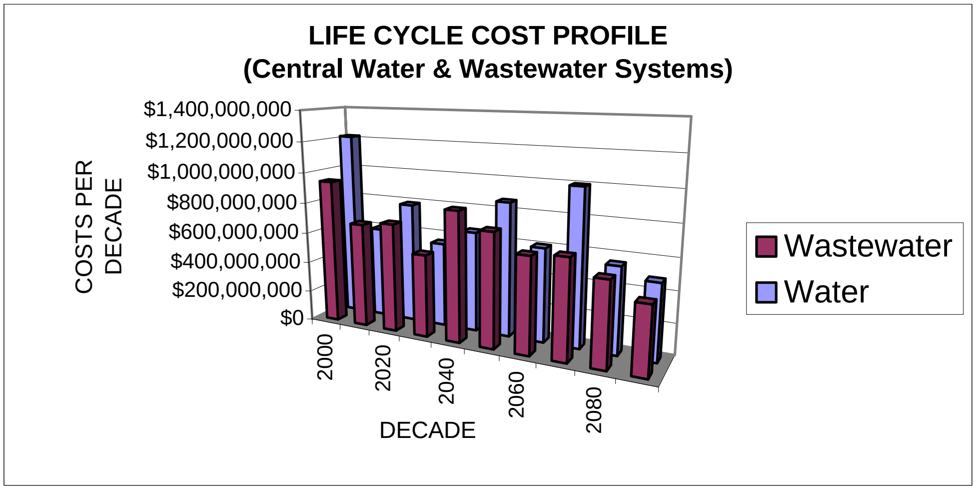
Rehabilitation estimates, for the purposes of the study, were calculated as a one time cost event, expressed as a percentage of asset value (or replacement value) as follows:

- Water system rehabilitation investment of 60 per cent of the water system *replacement value,* occurring two-thirds of the way through full life expectancy.
- Sewer system rehabilitation investment of 75 per cent of the sewer system *replacement value,* occurring three-quarters of the way through full service life.

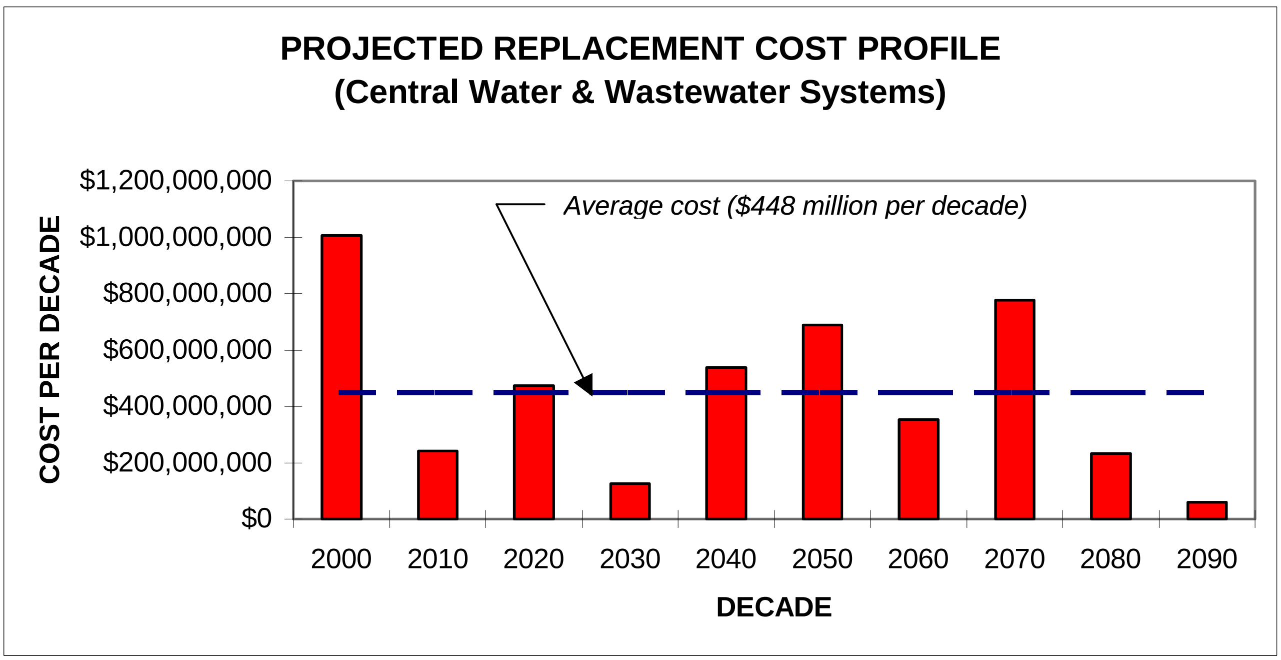
Replacement costs are equal to 100 per cent of the asset value, assuming construction costs in current dollars.

When the individual component cost events were combined, a life cycle cost profile was developed for the overall system. This cost profile was representative of the inherent characteristics of the water and wastewater systems. It can be presented in a variety of ways, providing a different perspective or representation of the asset for purposes of financial planning, design and program decisions, policy development, and related strategic planning activities.

The chart below is the life cycle profile representing Hamilton's water and wastewater systems. Each system is represented separately on the same chart for comparison purposes.



The same information can be disaggregated or combined and portrayed in any format that would help to understand the investment needs and financial planning required to sustain the systems. Below is a chart showing only the "replacement" component of the combined water and wastewater systems. This instructive representation indicates that the existing water and sewer systems alone, quite separate from new or growth related investments, require annual average investments in the replacement program sufficient to total approximately $448 million per decade over the next 100 years.



This chart reflects the fact that Hamilton's water and wastewater infrastructure is a mature system, having been in existence since the mid-1800s and expanded over the years. The peaks and troughs in the chart reflect periods of expansion or relative inactivity in the historical development of the system. For instance, the high replacement costs in the first decade looking ahead reflect a backlog of needs in the replacement program to deal with the oldest parts of the system, installed up to a hundred years earlier. Lower values in the second and fourth decades probably reflect the low growth in the system during the first and second world wars. Subsequent decades echo expansions of the system during the long post-war boom. As a result of this assessment, the average annual investment required over a 100-year life cycle to meet Hamilton's replacement program needs is estimated to be $44.8 million. Even in those years when the system demands are less than this average, a strategy of building reserves can be planned to ensure financial resources are in place when demand exceeds the average. This is the start of sustainable strategic planning that will minimize significant financial problems in years to come.

The City of Hamilton's asset management strategy is based on an aggressive, coordinated re-investment strategy where the right dollars are invested at the right time and on the right piece of infrastructure. The sustainable asset management process is an essential tool in successfully implementing this program and achieving these goals.