Decision Making and Investment Planning

Managing Risk

This document is the tenth in a series of best practices that transform complex and technical material into non-technical principles and guidelines for decision making. For titles of other best practices in this and other series, please refer to ***<www.infraguide.ca>***.

National Guide to Sustainable Municipal Infrastructure

NRC · CNRC FCM Federation of Canadian Municipalities Fédération canadienne des municipalités Canada

Managing Risk

Version 1.0

Publication Date: July 2006

ISBN 1–897249–10–1

InfraGuide® – Innovations and Best Practices

Why Canada Needs InfraGuide

Canadian municipalities spend $12 to $15 billion annually on infrastructure but it never seems to be enough. Existing infrastructure is ageing while demand grows for more and better roads, and improved water and sewer systems responding both to higher standards of safety, health and environmental protection as well as population growth. The solution is to change the way we plan, design and manage infrastructure. Only by doing so can municipalities meet new demands within a fiscally responsible and environmentally sustainable framework, while preserving our quality of life.

This is what the *National Guide to Sustainable Municipal Infrastructure (InfraGuide)* seeks to accomplish.

In 2001, the federal government, through its Infrastructure Canada Program (IC) and the National Research Council (NRC), joined forces with the Federation of Canadian Municipalities (FCM) to create the National Guide to Sustainable Municipal Infrastructure (InfraGuide). InfraGuide is both a new, national network of people and a growing collection of published best practice documents for use by decision makers and technical personnel in the public and private sectors. Based on Canadian experience and research, the reports set out the best practices to support sustainable municipal infrastructure decisions and actions in six key areas: decision making and investment planning, potable water, storm and wastewater, municipal roads and sidewalks, environmental protocols, and transit. The best practices are available online and in hard copy.

A Knowledge Network of Excellence

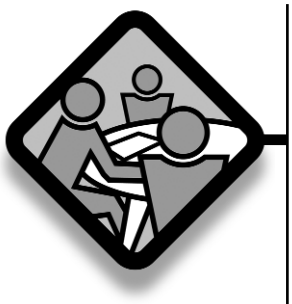
InfraGuide is a national network of experts and a growing collection of best practice publications for core infrastructure, offering the best in Canadian experience and knowledge of core infrastructure. With our founders — the Federation of Canadian Municipalities, the National Research Council and Infrastructure Canada, and our founding member, the Canadian Public Works Association — we help municipalities make informed, smart decisions that sustain our quality of life.

Volunteer technical committees and working groups—with the assistance of consultants and other stakeholders—are responsible for the research and publication of the best practices. This is a system of shared knowledge, shared responsibility and shared benefits. We urge you to become a part of the InfraGuide Network of Excellence. Whether you are a municipal plant operator, a planner or a municipal councillor, your input is critical to the quality of our work.

Please join us.

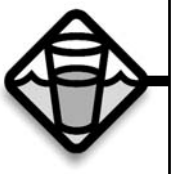
Contact InfraGuide toll-free at **1-866-330-3350** or visit our Web site at ***<www.infraguide.ca>*** for more information. We look forward to working with you.

The InfraGuide Best Practices Focus



Decision Making and Investment Planning

Current funding levels are insufficient to meet infrastructure needs. The net effect is that infrastructure is deteriorating rapidly. Elected officials and senior municipal administrators need a framework for articulating the value of infrastructure planning and maintenance, while balancing social, environmental and economic factors. Decision-making and investment planning best practices transform complex and technical material into non-technical principles and guidelines for decision making, and facilitate the realization of adequate funding over the life cycle of the infrastructure. Examples include protocols for determining costs and benefits associated with desired levels of service; and strategic benchmarks, indicators or reference points for investment policy and planning decisions.



Potable Water

Potable water best practices address various approaches to enhance a municipality's or water utility's ability to manage drinking water delivery in a way that ensures public health and safety at best value and on a sustainable basis. Issues such as water accountability, water use and loss, deterioration and inspection of distribution systems, renewal planning and technologies for rehabilitation of potable water systems and water quality in the distribution systems are examined.

Environmental Protocols

Environmental protocols focus on the interaction of natural systems and their effects on human quality of life in relation to municipal infrastructure delivery. Environmental elements and systems include land (including flora), water, air (including noise and light) and soil. Example practices include how to factor in environmental considerations in establishing the desired level of municipal infrastructure service; and definition of local environmental conditions, challenges and opportunities with respect to municipal infrastructure.

Storm and Wastewater

Ageing buried infrastructure, diminishing financial resources, stricter legislation for effluents, increasing public awareness of environmental impacts due to wastewater and contaminated stormwater are challenges that municipalities have to deal with. Storm and wastewater best practices deal with buried linear infrastructure as well as end of pipe treatment and management issues. Examples include ways to control and reduce inflow and infiltration; how to secure relevant and consistent data sets; how to inspect and assess condition and performance of collections systems; treatment plant optimization; and management of biosolids.

Transit

Urbanization places pressure on an eroding, ageing infrastructure, and raises concerns about declining air and water quality. Transit systems contribute to reducing traffic gridlock and improving road safety. Transit best practices address the need to improve supply, influence demand and make operational improvements with the least environmental impact, while meeting social and business needs.

Municipal Roads and Sidewalks

Sound decision making and preventive maintenance are essential to managing municipal pavement infrastructure cost effectively. Municipal roads and sidewalks best practices address two priorities: front-end planning and decision making to identify and manage pavement infrastructures as a component of the infrastructure system; and a preventive approach to slow the deterioration of existing roadways. Example topics include timely preventative maintenance of municipal roads; construction and rehabilitation of utility boxes; and progressive improvement of asphalt and concrete pavement repair practices.

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ACKNOWLEDGEMENTS

The dedication of individuals who volunteered their time and expertise in the interest of the *National Guide to Sustainable Municipal Infrastructure (InfraGuide)* is acknowledged and much appreciated.

This best practice was developed by stakeholders from Canadian municipalities and specialists from across Canada, based on information from a scan of municipal practices and an extensive literature review. The following members of InfraGuide's Decision Making and Investment Planning Technical Committee provided guidance and direction in the development of this best practice. They were assisted by InfraGuide Directorate staff and by CH2M HILL.

Pete Steblin, Chair
City of London
London, Ontario

Dave Burgess, Mayor
City of Brandon
Brandon, Manitoba

Doug Drever
City of Saskatoon
Saskatoon, Saskatchewan

Gary Guthrie
City of Abbotsford
Abbotsford, British Columbia

Ed S. Kovacs
City of Cambridge
Cambridge, Ontario

Luc Lahaie
City of Laval, Laval, Quebec

Betty Matthews-Malone
Haldimand County, Cayuga, Ontario

Osama Moselhi
Concordia University
Montréal, Quebec

Konrad Siu
City of Edmonton
Edmonton, Alberta

George Trainor
Councillor, City of Charlottetown
Charlottetown, Prince Edward Island

In addition, the Decision Making and Investment Planning technical committee would like to express its sincere appreciation to the following individuals and institution for their participation in working groups.

Fred Busch, Mayor
District of Sicamous
Sicamous, British Columbia

Rob Costanzo
City of Surrey, Surrey
British Columbia

Andrew Henry
City of London, London, Ontario

Michael Hill
City of Hamilton, Hamilton, Ontario

Jeff Johnston
Town of Markham, Markham, Ontario

Iqbal Kalsi
Manager, Public Health Protection
Northern Health, Terrace, British Columbia

Osama Moselhi
Concordia University
Montréal, Quebec

Steve Muxlow
Aviva Insurance Company of Canada
Toronto, Ontario

The Decision Making and Investment Planning technical committee would also like to thank the following individual for their participation in peer review:

Simaan AbouRizk
University of Alberta
Edmonton, Alberta

Nicolas Chebroux
Multi Risques International
Montréal, Quebec

Keith Fletcher
City of Abbotsford
Abbotsford, British Columbia

Steve Hrudey
University of Alberta
Edmonton, Alberta

Paul Marsh
Delcan Corporation
Markham, Ontario

Pat McNally
City of London, London (Ontario)

Maureen Looby
Township of Middlesex Centre, Ontario

Craig Smith
Regional Municipality of Waterloo, Ontario

Acknowledgements

This and other best practices could not have been developed without the leadership and guidance of InfraGuide's Governing Council, the Relationship Infrastructure Committee, and the Municipal Infrastructure Committee, whose members are as follows.

Governing Council:

Joe Augé
Government of the Northwest Territories,
Yellowknife, Northwest Territories

Sherif Barakat
National Research Council Canada (NRC)
Ottawa, Ontario

Brock Carlton
Federation of Canadian Municipalities (FCM)
Ottawa, Ontario

Jim D'Orazio
Greater Toronto Sewer and Watermain
Contractors Association, Toronto, Ontario

Douglas P. Floyd
Delcan Corporation
Toronto, Ontario

Derm Flynn
Town of Appleton, Appleton
Newfoundland and Labrador

John Hodgson
City of Edmonton
Edmonton, Alberta

Joan Lougheed
Councillor, City of Burlington
Burlington, Ontario

Saeed Mirza
McGill University, Montréal, Quebec

Umendra Mital
City of Surrey, Surrey, British Columbia

René Morency
Régie des installations olympiques
Montréal, Quebec

Vaughn Paul
First Nations (Alberta) Technical Services Advisory
Group, Edmonton, Alberta

Ric Robertshaw
Public Works, Region of Peel
Brampton, Ontario

Dave Rudberg
City of Vancouver
Vancouver, British Columbia

Van Simonson
City of Saskatoon
Saskatoon, Saskatchewan

Basil Stewart, Mayor
City of Summerside
Summerside, Prince Edward Island

Serge Thériault
Government of New Brunswick
Fredericton, New Brunswick

Tony Varriano
Infrastructure Canada (INFC), Ottawa, Ontario

Alec Waters
Alberta Infrastructure Department
Edmonton, Alberta

Wally Wells
The Wells Infrastructure Group Inc.
Toronto, Ontario

Municipal Infrastructure Committee:

Al Cepas
City of Edmonton, Edmonton, Alberta

Wayne Green
Green Management, Ontario

Haseen Khan
Government of Newfoundland and Labrador
St. John's, Newfoundland and Labrador

Ed S. Kovacs
City of Cambridge, Cambridge, Ontario

Saeed Mirza
McGill University, Montréal, Quebec

Umendra Mital
City of Surrey, Surrey, British Columbia

Carl Yates
Halifax Regional Water Commission
Halifax, Nova Scotia

Relationship Infrastructure Committee:

Geoff Greenough
City of Moncton
Moncton, New Brunswick

Joan Lougheed
Councillor, City of Burlington
Burlington, Ontario

Osama Moselhi
Concordia University
Montréal, Quebec

Anne-Marie Parent
Parent Latreille and Associates
Montréal, Quebec

Konrad Siu
City of Edmonton
Edmonton, Alberta

Wally Wells
The Wells Infrastructure Group Inc.
Toronto, Ontario

Founding Member:

Canadian Public Works Association (CPWA)

EXECUTIVE SUMMARY

Municipal infrastructure is essential to a community's economic well-being and public safety. Given this dependency, a community should be aware of and manage the various risks that can adversely affect the performance of its infrastructure over time. Risk management has the potential to minimize the cost to provide a healthy, safe, affordable, and publicly acceptable service.

In this best practice, risk is referred to as the probability and severity of a particular circumstance or a combination of circumstances that will negatively affect a municipality's ability to meet its objectives. Risk management, therefore, is the analysis and collective actions to be taken to reduce risk to an acceptable level.

This document provides an overview of the risk management process and its value in the development of efficient management programs and corporate policies for sustainable municipal infrastructure assets. It recommends the principles of a best practice to incorporate risk management into an asset management strategy. Risk emanates from uncertainty and is generally considered to encompass both threats and opportunities. *The Guide to the Project Management Body of Knowledge* (PMBoK Guide, 2004), defines risk as *". . . an uncertain event or condition that, if it occurs, has a positive or a negative effect on a project objective . . ."*. As such the potential severity of impact of a risk and the probability of its occurrence are key elements in quantification of risk.

Risk is defined in this best practice as the likely exposure to a threat that negatively impacts the ability of infrastructure assets to meet the objectives of the community it serves. Risk management is a set of activities, procedures, methods and systems used to identify, quantify and mitigate undesirable exposure to loss in capital and/or quality of service so as to meet community objectives.

Every organization should have clearly understood and documented objectives that its infrastructure assets should meet in their performance. Failure to fully meet the objectives results in exposure to risk. Tolerance for risk must be considered in a range of categories and circumstances. Clearly this can vary from one community to another.

Development and implementation of risk management programs require four main steps or phases: 1) risk identification, 2) risk quantification, 3) risk mitigation, and 4) evaluation and feedback. It should be noted that the first step is knowledge based and experience driven, and aims at identifying items, events and/or issues that are perceived to give rise to risk. Various categories of risk, driven by external and internal events along with source of risk analysis are outlined in the best practice for this step. The second step aims at establishing numerical indices for each of the identified risk items, calculated simply as the product of the severity impact and the probability of occurrence associated with the risk item being considered. Risk quantification is also referred to as risk analysis and it may be simple and of limited scope or it may be elaborate and involve simulation techniques. This step is described in **Sections 3.1** and **3.2** of this best practice. In the third step, strategies and methods are developed to mitigate the risk, identified and quantified in the previous two steps. This includes doing nothing, particularly in cases where the calculated risk indices are relatively low or deemed acceptable. It should be noted here that what is acceptable for one community may not be so for another. Last step could be viewed a continuous improvement process that benefits from past applications of the risk management program used. A wide range of risk mitigation strategies are described in detail in this best practice.

Risk emanates from uncertainty and is generally considered to encompass both threats and opportunities.

Risk management is a set of activities, procedures, methods and systems used to identify, quantify and mitigate undesirable exposure to loss in capital and/or quality of service so as to meet community objectives.

Risk management should be an integral part of the decision-making process both at the strategic corporate level and at the tactical operational levels.

Risk management should be an integral part of the decision-making process both at the strategic corporate level and at the tactical operational levels. As such it is used as a useful tool in budget appropriation and allocation and in developing procurement policies as well as in decision taking at the project level, including selection of the most suitable construction methods. Six case studies are included in this best practice to demonstrate the value added in and benefits of integrating risk management principles at the corporate and project levels. This best practice draws from and impacts upon the principles, procedures and methods outlined in a number of InfraGuide Decision Making and Investment Planning (DMIP) best practices, particularly: *Managing Infrastructure Assets* (InfraGuide, 2004), *Developing Levels of Service* (InfraGuide, 2002), *Investment Parameters for Municipal Infrastructure* (InfraGuide, 2004) and *Public Consultation* (InfraGuide, 2005).

1. General

1.1 Introduction

Municipal infrastructure is essential to a community's economic well-being and public safety. Given this dependency, a community should be aware of and manage the various risks that can adversely affect the performance of its infrastructure over time.

Risk is defined as the combination of the probability and severity of a potential circumstance that would negatively affect a municipality's ability to meet its objectives. Risk management is the collective assessment of risk and the actions taken to address risk.

By using a risk management approach, a community can rationally assess the potential risks to its infrastructure and then develop an appropriate course of action to control those risks. Risk management has the potential to minimize the cost to provide a healthy, safe, affordable, and publicly acceptable service. Risk management is only one component of an overall asset management strategy.

It has become widely accepted for communities to develop an asset management program to evaluate their infrastructure in many different ways, including risk management. In doing so, communities can incorporate their tolerance for risk into decisions to rehabilitate or replace existing infrastructure and make new investments. This document recommends the principles to incorporate risk management into an asset management strategy. Further information on parameters to consider when planning for municipal infrastructure investments can be found in the InfraGuide best practice: *Investment Parameters for Municipal Infrastructure* (InfraGuide, 2003).

1.2 Purpose and Scope

Programs designed to manage public infrastructure should include processes to understand and manage the risk that arises from infrastructure procurement, operation, and deferral of planned investments. There is a range of categories of risk that can prevent the infrastructure assets from delivering the desired levels of service to the public.

This best practice document covers the subject of risk management as it relates to municipal infrastructure. It is intended to outline risk management issues and concepts, and provide a basic process to manage risk to a municipality's assets. The document concludes with case studies that illustrate risk management experiences.

1.3 How to Use This Document

This document complements the other best practices that have been developed for decision-making and investment planning and is one of a number of practices developed by InfraGuide to assist communities deliver sustainable infrastructure. It is recommended that an individual best practice be read and understood in the context of other relevant best practices.

In this best practice, the subject of risk management for municipal infrastructure is discussed in the following sections:

Section 2: Rationale (An overview of risk management)

Section 3: Principles of Risk Management

Section 4: Applications and Limitations

Six case studies are included in the Appendices to outline situations where municipal organizations have experienced serious risk exposure due to inadequate identification and management of risk.

Risk management has the potential to minimize the cost to provide a healthy, safe, affordable, and publicly acceptable service.

1.4 Glossary

Asset Management — The combination of management, financial, economic, engineering, and other practices applied to physical assets with the objective of providing the required level of service in the most cost-effective manner.

Best Practices — State-of-the-art methodologies and technologies for planning, design, construction, management, assessment, maintenance, and rehabilitation that consider local economic, environmental, and social factors.

Capital Cost — Expenditures used to create new assets, rehabilitate, or replace existing assets or increase the performance of existing assets beyond their original design standards or service potential.

Decision Tree — A graphic representation of decisions and their possible consequences (including resource costs and risks) used to create a plan to reach a particular goal.

Indemnify — To compensate for a loss, in whole or in part, by payment, repair, or replacement.

Infrastructure — Refers to those physical basic installations and facilities such as potable water, storm and wastewater, municipal roads and sidewalks, and transit, on which the continuation or growth of a community depends

Levels of Service — Levels of service reflect the social and economic goals of the community and may include any of the following parameters:

- Safety
- Customer satisfaction
- Quality
- Quantity
- Capacity
- Reliability
- Responsiveness
- Environmental acceptability
- Availability
- Cost and affordability

Life Cycle Cost —Costs over the full life cycle of an asset, from planning, design, construction, acquisition, through operation, maintenance and rehabilitation to replacement or reconstruction and to disposal.

Life cycle costing — A method of expressing cost in which both capital costs and operations and maintenance costs that are considered in comparing different alternatives. "Present worth" is one way to express life cycle costs. The present worth represents the current investment that would have to be made at a specific discount (or interest) rate to pay for the initial and future cost of the works.

Maintenance — All actions necessary to retain an asset in as near as practicable to its original condition renewal.

Operation —The active process of using an asset to deliver service, which will consume resources such as manpower, energy, chemicals and materials.

Pareto Rule — A principle derived by Italian economist Vilfredo Pareto that is commonly referred to as the 80/20 rule. The principle is that a small number of causes or issues (20%) are responsible for a large percentage (80%) of effects. In the context of this best practice it suggests that 20% of the assets give rise to 80% of the risk. The principle when employed in management decision-making uses "Pareto Charts" to refine the actual percentages based on experience with the issues.

Probability — The likelihood of an event occurring.

Risk — The combination of the probability and impact severity of a particular circumstance that negatively impacts the ability of infrastructure assets to meet the objectives of the municipality.

Risk Assessment — The analysis of the severity of the potential loss and the probability that the loss will occur, leading to quantification of impacts.

Risk Management — The collective assessment of risks and management actions taken to control them.

Risk Transfer — Having another party accept responsibility to manage a defined risk.

2. Rationale

Background: The Concept of Risk as it Relates to Infrastructure Assets

Risk is the combination of the probability and impact severity of a particular circumstance that negatively impacts the ability of infrastructure assets to meet the objectives of the municipality. Risk management is the collective assessment of risks and management actions taken to control them. It is an essential part of an overall asset management program. Every public organization that owns, operates, or acts as the approving authority for infrastructure assets will be exposed to some degree of risk. There is not, and cannot, be a condition of "zero" risk.

Unforeseen risk will often result in unplanned expense and diversion of resources from planned programs. Risks must be understood, identified, quantified, analyzed, and managed. There are many categories of risk that will be identified in **Section 3.1** of this best practice document. This document focuses on risk as an important element of an asset management program.

It is important to understand and document the organizational objectives of the public organization in terms of the service to be delivered to the customer or user of the infrastructure assets. These objectives should be derived for each individual organization, and are described in greater detail later in this document. If the objectives of the organization are not fully understood and documented, it is not possible to quantify the impact of a risk-hazard on the organization. It is therefore paramount that corporate or community goals and strategic alignment and mission objectives of a municipality do not function at cross purposes.

Organizational objectives have a broader *essential* application to the building of asset management programs, and assist to draft, test, and recommend level of service design standards and performance to be delivered by the assets. Organizational objectives must be understood to establish the levels of service that are to be delivered by the assets. The targets for asset condition and performance are directly dependent on the levels of service to be delivered, and the risk associated with the assets is directly related to the condition and performance of the assets. If a temporary loss of service in an area is acceptable, assets can be allowed to deteriorate to a point that represents high probability of failure.

As organizational objectives are derived, the tolerance of the organization for risk should be understood. This will require the categorization of risks and the generic understanding of acceptable levels of risk in a variety of circumstances.

Principles of risk management may be applied at every management level for the purpose of:

- Identifying corporate objectives;
- Determining a strategic/business plan;
- Identifying and evaluating risks;
- Avoiding or eliminating risks where practical; and
- Developing risk mitigation strategies compatible with the community's tolerance to exposure to undesirable outcomes. This may include contractually transferring risks (to some degree to other parties, where possible).

Risk is the combination of the probability and impact severity of a particular circumstance that negatively impacts the ability of infrastructure assets to meet the objectives of the municipality.

3. Principles of Risk Management

3.1 The Risk Management Process

The risk management process for a municipality can range from the simple to the complex depending on the size of its infrastructure portfolio, community needs, and financial resources. Whatever the approach, the risk management process has a logical, chronological sequence of steps, which are illustrated in **Figure 3–1**. The steps involved in risk management are described in the following sections of this document. **Figure 3–1** describes this flow and indicates the section of this document where the process step is described.

3.1.1 Policy Review and Infrastructure Assessment

Overall Policy Review

To implement risk management as part of an asset management strategy, it is essential to develop policies that are understandable, affordable, and acceptable at all critical levels of management, and are supported or formally endorsed by the elected council. The risk management process begins with the review of the applicable municipal policies and standards relating to infrastructure and an assessment of the current physical condition and performance of its infrastructure. Policies will derive from the municipality's corporate objectives, and will include derivation of levels of service, design standards, and a clear understanding of what assets the municipality has responsibility for. The policy review will shape and govern how infrastructure risks will be managed. The review should focus on developing a thorough understanding of the service levels expected of a municipality's existing and future infrastructure. These service levels can include such parameters as reliability, environmental impact sustainability, affordability, and quantification of service. Further information about defining service levels can be found in the InfraGuide best practice: *Developing Levels of Service* (InfraGuide, 2003).

In addition to understanding the policies, design standards, and expected service levels, a municipality must understand, in quantifiable terms, the current physical condition and performance of its infrastructure. Depending on the size of a municipality's infrastructure inventory, the identification, recording and condition assessment can be a significant, though valuable, undertaking. In most cases, a municipality's infrastructure must be classified in some meaningful way, such as age (by decade), material, or condition to enable the risk management process to be effective. Further information on infrastructure asset management can be found in the InfraGuide best practice: *Managing Infrastructure Assets* (InfraGuide, 2004).

Setting Organizational Objectives

Defining and understanding overall objectives is essential to allow the measurement of the impacts of infrastructure failure or compromised performance. It is important that the objectives

Figure 3–1: The Risk Management Process

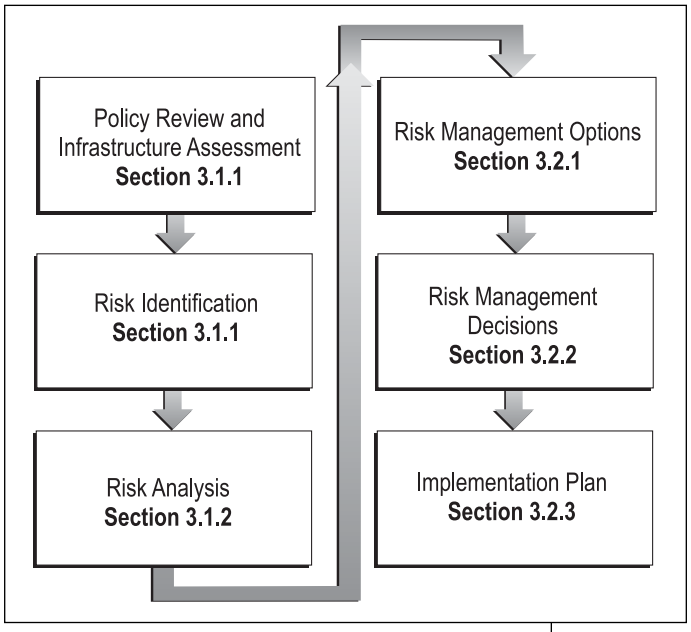

Figure 3–1
The Risk Management Process

The risk management process begins with the review of the applicable municipal policies and standards relating to infrastructure and an assessment of the current physical condition and performance of its infrastructure.

be developed and tested for feasibility, and affordability, and that they meet reasonable public expectations. It is desirable that the objectives be communicated to, and supported by, all levels of management. Ideally they should be understood and endorsed by Council. If not already existing in corporate and community plans, these objectives will be derived for each individual organization and in most cases will include, but not necessarily limited to, the following points, as they may assist in the development of organizational objectives.

- **Levels of service, performance objectives and design standards** for the assets that are practical, understandable, publicly acceptable, affordable, achievable, and measurable.
- **Objectives to Deliver the Commitment to the Principles of Sustainability** (financial, environmental, and social — see InfraGuide Sustainable Principles and Guidelines).
- **Customer Service and Reliability** objectives.
- **Clear financial objectives**, and a financial strategy to operate and proactively maintain and sustain the assets over their life cycle.
- **Compliance with regulatory requirements** for performance, reliability, health, safety and environment.

Design standards communicate the intent of an agency in terms of the desired performance and capacity of its infrastructure. They must correspond to the community objectives in terms of the environment, health and safety, and cost.

Setting Levels of Service and Design Standards

It is not possible to determine the necessary level of performance that must be prescribed by an asset management strategy if the authority responsible for the assets does not determine the level of service to be delivered by the assets. Drafting, testing, and establishing levels of service that are documented, publicly acceptable, affordable, measurable, and understandable is essential to the asset management program. This process requires an extended time frame requiring the input and support of all of the municipal stakeholders.

The process to establish levels of service is the subject of another best practice document: *Developing Levels of Service* (InfraGuide, 2003). Design standards communicate the intent of an agency in terms of the desired performance and capacity of its infrastructure. They must correspond to the community objectives in terms of the environment, health and safety, and cost. Design standards for new infrastructure should document required capacity and performance, and the circumstances within which the level of performance is expected. They can also provide for secondary systems to deal with infrequent high demands. An example of this would be the design of a storm water collection system to convey runoff from rainfall intensities with a 1:5 year statistical return period without surcharging. In more recently applied designs, this collection system is augmented with a major overland flow system capable of handling the runoff from major storms having a 1:100 year return period. This provides a cost-effective way to improve the protection of property and public safety at a relatively low incremental cost.

Design standards that incorporate the most durable materials and excellent construction practices may have a marginally higher initial capital cost while providing a lower life cycle cost, and an associated lower risk of compromised performance. Analysis that considers the incremental cost of increasing capacity beyond regulated standards, can be measured against the probability of an event that causes capacity problems. Designing redundancy into pipe networks to allow “looping” or redirection of service can be a legitimate strategy to address catastrophic failure of a critical line. Design standards should include consideration of ease of inspection and maintenance without extended service disruption.

Understanding the Assets

Risks arising from the operation of the assets cannot be assessed or managed if a policy is not in place to validate asset inventory and determine the general physical condition and performance of the assets. This requires a program to group the assets into representative network sections that are of similar age (by decade), material, and condition.

Critical elements in the network need to be considered separately for risk assessment due to their strategic importance. Put another way, assets need to be understood from both a corporate strategic perspective that is senior-directed and from a "bottom up" operational perspective. A good example of this approach is more explicitly described in InfraGuide best practice *Development of Water Distribution System Renewal Plan* (InfraGuide, 2003).

Appropriate management of risk will depend on the source of the risk. It is useful to identify categories of events, circumstances, and sources of risk that could impact assets in a manner that prevents the organizational objectives from being achieved. Risk can arise from different sources, both external and internal, as described in the following sections.

Categories of Risk

In the risk management field, there are thought to be five (5) general categories of risk. Within each of these categories, a municipality can identify the specific impacts that are applicable to its own infrastructure. These impacts may include financial, environmental, damage to reputation, and penalties from legal or non-compliance with regulations. Categories of risk are:

Events External to the Organization

1. **Naturally-Occurring Events**, such as fire, storms, floods, earthquakes, and lightning strikes. The timing of these types of events is unknown and uncontrollable but their probability and severity can, to some degree, be statistically predicted for some.
2. **External impacts** as a result of indirect consequences of *failure by an outside party*. Examples include power failure, material supply failure, spills, industrial discharges, unauthorized sewer downloads, labour strikes and traffic accidents.
3. **External aggression**, or deliberate acts of vandalism, and/or terrorism that results in destruction of critical assets and potential injury and loss of life.

Events Internal to the Organization

4. The **physical deterioration** or failure of assets. The condition of the assets and the deterioration to failure can be predicted and determined. This category of risk is the most predictable and manageable.
5. **Operational risks** arising from the manner in which the assets are designed, managed and operated to meet the organizational objectives. This category includes risks arising from design standards, management policies, operator behavior, and maintenance practices. This category of risk generates policies that clarify internal responsibility, and contractual procedures used to transfer responsibility, and some level of risk, to contractors and service providers.

Within each category, specific risks can be identified that may affect various parts of a municipality's infrastructure. An example of a specific risk in the category of Physical Deterioration, might be ground settlement causing a joint failure of an existing water main, failure of the roadway and storm water surcharging

This implementation step requires the organization to assess each of the five categories of risk and determine their applicability to the local circumstances that exist. Initial thinking should be done on appropriate criteria for risk analysis and risk forecasting for each category of risk. Any other categories of risk unique to the circumstances, or environment, that prevail in the asset location or organization should be similarly assessed.

Natural Events

Examples of naturally occurring events include earthquakes, severe weather, and pandemics. These kinds of events can be reasonably expected over the lifetime of the assets, but the timing and magnitude are unpredictable.

The appropriate level of service for the design of an asset can be based on its resistance to natural events. This applies to earthquake

Assets need to be understood from both a corporate strategic perspective that is senior-directed and from a "bottom up" operational perspective.

loading, wind resistance, snow loading, and rainfall volumes and intensities. Design standards are tested for affordability, and health and safety objectives.

Many communities are obligated to develop emergency response plans to be able to respond as promptly and effectively as possible when these natural events occur. In the case of British Columbia, the lead agency for emergency response for many types of events is the responsibility of the Province. In Ontario, each local municipality must develop and implement an emergency response plan.

Natural events can have health impacts on the community that relate to the operation of the infrastructure. A recent example is the concern for the spread of the West Nile Virus, by mosquitoes breeding in storm water in treatment ponds, ditches, catch basins and pipe networks. The proactive injection of larvicides into the appurtenances of the storm water collection system has been used successfully to control these kinds of risks. These kinds of strategies should be incorporated in contingency plans and emergency response plans and coordinated with city, provincial and federal health agencies. Information on emergency response planning can be obtained from the Office of Emergency Preparedness, Planning and Training at Health Canada at ***<http://www.psepc-sppcc.gc.ca/>.***

Power failures, labour strife, or rail line spills, are examples where the triggering event is unpredictable making it difficult to calculate a probability. However, on the other side of the coin, the severity of the impacts they can impose can be understood and mitigated by certain management and operational practices.

External Events Caused by a Third Party

External impacts arising from a failure of service provided by an outside organization are, in many circumstances, similar to natural events. Power failures, labour strife, or rail line spills, are examples where the triggering event is unpredictable making it difficult to calculate a probability. However, on the other side of the coin, the severity of the impacts they can impose can be understood and mitigated by certain management and operational practices.

For example, investment in standby power generators at essential facilities protects the organization from certain ill effects from power failure. The August 13, 2003 blackout in the Northeastern U.S. and Ontario is an example of how communities can be affected by a widespread power outage. First Energy's East Lake plant shut down unexpectedly triggering a series of problems on its transmission line that triggered a cascade effect that caused the cross-border blackout. According to the Anderson Economic Group, the economic cost to government agencies due to overtime wages and emergency services was as high as US$100 million.

Developing a diversity of supply sources for critical materials needed to maintain critical services is also an important way to mitigate impacts caused by a third party. This may involve contingency plans for supply failure. Another example of a management approach is to develop contracts to minimize the likelihood and severity of labour stoppages. In many cases, agencies plan to provide for emergency support in situations that may threaten health and safety. All of these initiatives should of course be cost analyzed and the cost/benefit ratio developed based on the risk reduction achieved.

Risk from Aggression

In managing this category of risk, it is essential to know the strategic importance and criticality of each of the elements of the public infrastructure in the system.

Levels of security and protection can then be designed around various assets. Like any other risk management activity, the measures should be priced against the benefit of preventing negative effects. Obviously, high costs may be tolerable on the most strategically important assets, those that simply cannot be taken out of service, while elaborate security strategies may not be justifiable where assets are less critical or where prompt response is possible to redirect and restore service.

Redundancy designed into critical elements of the most strategically important assets becomes a valid issue for cost benefit analysis. There are a number of recently developed tools for the water and wastewater industries

that support detailed, comprehensive vulnerability analyses to identify risks and management responses to reduce them. Emergency response plans are an essential part of risk management for all categories of risk but are particularly important for category 1 and 3 risk.

Aging Infrastructure and Related Deterioration

The potential for infrastructure failure or reduction in level of service can increase depending on age and condition. This risk will arise from the deterioration of assets. The risk begins from the day the assets are commissioned. This category of risk is the most predictable, and the easiest to manage effectively. However, it is also the easiest to overlook or defer, especially during times of scarce finances, when more immediate priorities can be found. This explains the current infrastructure deficit in Canada and other countries.

Risk management for this category of risk requires knowing the representative condition and the historic deterioration rates of the various groups of assets. Condition assessment identifying defects is critical to the management of risks arising out of the deterioration and possible failure of the assets. Every defect presents a hazard leading to potential for failure of the asset, or compromised performance. Knowing the present and projected condition of asset groups and determining their relative criticality will allow organizations to assess and manage risks in an objective and rational way.

Operational Risks

Risk of failure can be affected by asset design, construction and operating procedures. This category of risk offers great opportunities to minimize risk exposure through sound policies and management practices. However, low probability and high consequence from failure are most susceptible to complacency problems. The high consequence part is often forgotten in the equation.

Proactive condition and performance assessment and inspection of assets at regular intervals and operation protocols such as periodic valve and hydrant operations can reduce risk exposure. Preventative maintenance programs to reduce likelihood of failure or reduced performance are also necessary.

3.1.2 Risk Analysis

In the risk analysis stage, the identified risks are assessed in terms of the predictability and probability of an event occurring and affecting a municipality's infrastructure. Next, the potential impact or severity on the infrastructure and the affected objectives related to a particular risk occurring is analyzed. In addition to the scientific probability and severity analysis, an understanding of how stakeholders perceive risk is needed.[1] The perception of risk is often dependent on the needs, issues and concerns of stakeholders. The Canadian Standards Association recommend a comprehensive and systems approach, with particular emphasis on dialogue with stakeholders. It cannot be emphasized enough that stakeholders must be engaged early in any risk management process. If this is left until later, there is greater potential for conflict, and risk communication becomes ineffective when decisions already made have to be defended with stakeholders. Further information on public consultation and stakeholder involvement can be found in the InfraGuide best practice: *Public Consultation* (InfraGuide, 2005).

In terms of technical analysis of risk, a common approach is to define a range of possible outcomes to ensure that all have been captured and to standardize the outcomes enabling all of the stakeholders to participate in risk management discussions and decisions. In addition, a range of numerical values can be assigned to each of the defined outcomes. These values can be used to calculate a number for a particular risk, which can be compared relative to other risks affecting a municipality's infrastructure.

The perception of risk is often dependant on the needs, issues and concerns of stakeholders. The Canadian Standards Association recommend a comprehensive and systems approach, with particular emphasis on dialogue with stakeholders. It cannot be emphasized enough that stakeholders must be engaged early in any risk management process.

1. Risk Management: *Guideline for Decision-Makers*, Canadian Standards Association, CAN/CSA-Q850-97