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Accelerating Adaptation
in Canadian Communities

Clean Air Partnership

ABOUT CAP

Clean Air Partnership (CAP) is a registered charitable organization, established in 2000 with an accomplished track record of working with partners and local communities to achieve clean and sustainable urban environments, facilitate the exchange of ideas, and advance environmental initiatives. CAP employs a range of tools to achieve results including research, mapping, policy initiatives, and training events.

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CONTEXT

Since 2005, Clean Air Partnership (CAP) has produced numerous reports on climate change adaptation and delivered adaptation training workshops across Ontario. Through these efforts, and our other work on local climate change adaptation, CAP has connected with municipal representatives across Ontario and identified a number of key recurring gaps relating to climate change adaptation in Ontario municipalities.

There have been few publicized examples of ongoing municipal adaptation practices. However, actions to protect municipal infrastructure and health have, in fact, taken place, often in response to significant incidents and events that result in damage to persons or property. Generally, these actions have not been well documented nor have they been identified as climate change adaption activities

Municipalities have not optimized knowledge transfer through the sharing of experiences, challenges and lessons learned, and actions are often not monitored and evaluated to determine their outcomes. Additionally, motivation for local adaptation tends to be reactive rather than preventative and the business case for cost savings from prevention has not been adequately communicated.
Funded by Natural Resources Canada, Accelerating Adaptation in Canadian Communities is a series of nine case studies and three webinars. Through this program, CAP is trying to close these gaps to:

- Review and update understanding of the current state of climate change adaptation in Ontario municipalities.
- Find and describe the experiences of municipalities that have begun adaptation actions; and
- Motivate more municipalities to undertake actions through interactive webinars and informative case studies.

Through the completion of this series, numerous types of adaptation have been examined, including programs and initiatives, decision support tools and plans and policies. The drivers behind these adaptation options were both anticipatory and reactive. Municipal sectors covered include infrastructure, water conservation, public health, food, natural systems and planning. Reflecting Ontario's geography, the case studies cover all regions of the province.

FOREST FLOOR MAT TRANSPLANTING IN SUDBURY

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ○ Infrastructure ● Natural Systems ○ Planning ○ Water Conservation	○ Communications ● Environment ○ Finance/Purchasing ○ Infrastructure ● Parks & Rec ● Planning ○ Public Health ○ Water/Stormwater	○ Decision Support Tools ○ Delivery of Adaptation Options ○ Plans + Policies ● Programs + Initiatives	○ Anticipatory ● Reactive	○ Federal ● Municipal ○ Other ● Private ○ Provincial

PROFILE *The City of Greater Sudbury has employed 'regreening' efforts since 1978 to increase tree cover on 82,000ha that had historically been completely or partially denuded of vegetation by smelter emissions. To date, the City's Regreening Program has planted over 9 million trees and treated over 3400ha with crushed limestone, fertilizer and a grass/legume seed mix. Increasing forest survival, together with Sudbury's increasingly intense weather impacts, prompted the City to adapt to climate change using techniques and tools to strengthen existing tree cover by promoting diverse, healthy, self-sustaining forest ecosystems. In developing their urban forests, Sudbury has begun to incorporate tree species from more southern locations to ensure that forests are diverse enough to thrive under a changing climate. To further protect their forests from a changing climate, the City has adopted a forest floor transplant program.*

In 2009, the City partnered with two local mining companies, Vale and Xstrata Nickel, to develop and implement a Biodiversity Action Plan that identifies the actions required to diversify the ecosystems. One of these actions is to transplant forest floor mats from areas that would otherwise be destroyed by construction. The forest floor mats not only add plant and micro-organism diversity that promote healthy trees, but also help protect from climate impacts such as extreme heat, wind or precipitation events. A large-scale forest floor transplant program began in 2010 and is planned to last until the end of 2012.

GEOGRAPHIC CONTEXT The City of Greater Sudbury is located just north of Lake Huron approximately midway between Sault Ste. Marie and Ottawa. With a population of roughly 160,000, it is the largest municipality in northern Ontario.

Sudbury's forests are vulnerable to climate related impacts such as extreme heat, wind and precipitation events. In the heart of the Canadian Shield, Sudbury's landscapes consist of a thin layer of soil atop an expanse of rock. This environment presents several issues for resilient tree growth. Thin topsoil provides limited nutrition for trees and other vegetation and can restrict the establishment of newly planted vegetation. This can make trees particularly vulnerable to wind events as they have little to anchor to.

Additionally, a lack of soil can create increased vulnerability to extreme heat and precipitation since very shallow soils cannot hold much excess moisture, making trees vulnerable to drought and limiting their ability to manage flooding. Finally, the thin layer of soil holds little organic matter making seedlings vulnerable to freeze/thaw cycles.

CLIMATE CHANGE CONTEXT As changing precipitation patterns result in sudden, intense bursts, Sudbury's forests endure long dry periods. Projected to worsen, this trend also contributes to drought, significantly impacting seed germination in agriculture and forestry, and results in forest fires. Stressed from enduring drought conditions, trees become more vulnerable to damage from extreme heat or wind events and can no longer provide maximum environmental benefit.

Typical donor site with large trees already removed

More sporadic but intense precipitation events heighten the risk of flooding in Sudbury. Exacerbated by a hilly landscape, numerous lakes and waterways, and a relatively low level of absorption in the watersheds, Sudbury could suffer substantial damage from one isolated event. Extreme heat events pose an additional threat. Expected to increase in frequency as well as intensity, heat effects are amplified by large tracts of barren or poorly vegetated land within and surrounding the City.

Under a rapid growth emissions scenario, reflecting current trends (A1B),[1] Sudbury is expected to experience a 2.9°C increase in average annual temperature and a 68mm increase in average annual precipitation by the 2050's. The change in temperature will be most prevalent in the winter and spring months, with little or no change detected in the summer and fall seasons. Given the geographical sensitivity to climate impacts, these changes will have implications for Sudbury's new forests.

ISSUE Sudbury has undertaken extensive regreening efforts to combat the damage done by decades of mining and smelting and to protect the City from climate impacts. Though successful in creating more green space in an otherwise stripped landscape, the efforts now include developing the forest floor mats required to support a diverse, resilient forest. The forest floor plays many important roles in creating and maintaining a healthy and resilient forest. The accumulation of decaying leaves, soil, vegetation and animal excrement provide nutrition for growing trees. The mats also provide protection for new trees from heat, drought, wind and surface runoff. Finally, the diversity of organisms in the forest soil (e.g., fungi, invertebrates, microbes) contributes to the spread and germination of different plant species.

Forest floors can take decades to form naturally in areas where a base of natural material does not exist. To aid in the development of a resilient forest, Sudbury has applied this technique to accelerate the development of forest diversity and health to its relatively recent stands of trees. This resilience is key in adapting to climate change.

In 2004, the City's Regreening Program partnered with FNX Mining, allowing them to remove a number of mats from an area earmarked for mining exploration. These mats were transplanted under stands of trees in formerly barren areas in Sudbury. The mats were closely monitored to assess the survival of the herbaceous plants in the mats. Continual monitoring has confirmed that the original mats have successfully established themselves in the transplant locations and have begun to grow beyond the transplant area.

In 2008, a graduate student at Laurentian University published a study that examined strategies to increase plant life and accelerate understory growth in the newly planted forests. The study determined that forest floor transplants were the most effective technique to achieve these goals and provided recommendations to optimize understory growth and successful transplant integration.

Manually digging forest floor mats

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

Trays of forest floor placed in 4m by 4m plots

In 2010, the widening of Highway 69 south of Sudbury provided the City with an opportunity to pursue forest floor transplants on a larger scale. Relying on data and recommendations from the 2008 study, City staff took measures to ensure successful establishment in the new location. Consideration was also given to climate vulnerabilities and biodiversity issues, mats were carefully chosen to bring an optimal variety of healthy plants and associated soil organisms to the transplant location.

Since the Program started in 2010, the City has transplanted 6,100m^2 of forest floor material to strategic locations in hundreds of plots across the 84,000ha of impacted land. The primary goal of forest floor transplanting is to encourage forest floor growth in newly planted areas. However, while the transplanted mats will establish themselves in the new environment and may grow beyond the original borders of the transplant site, the sheer size of Sudbury's regreening efforts prohibit complete forest coverage with transplanted mats.

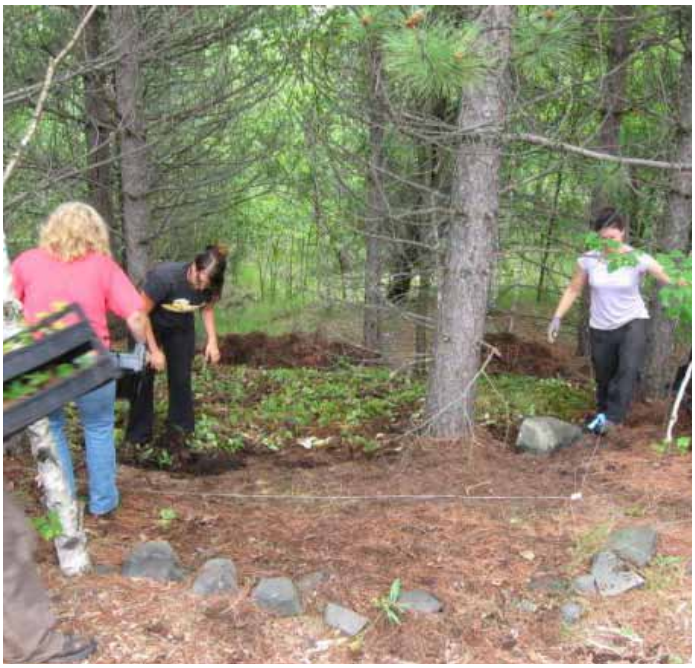
PROCESS Forest floor mats are relocated on formerly barren and semi-barren sites where trees are now growing, but where the vegetation below is sparse. The suitability of the sites is determined by assessing site conditions and establishing the probability of survival. Eligible sites are selected with a view to spreading the ecological benefits over the largest possible area. The progress of each plot is monitored annually to track forest floor expansion and biodiversity levels. By 2011, some species had spread horizontally from the transplanted mats by up to 120cm.

The mats used for transplant are selected for biodiversity, health and a lack of invasive or undesirable species. 1m by 1m forest floor mats about 10cm thick are hand cut with spades and flat shovels and are transported out of the highway construction site using trays placed atop all-terrain vehicles. Once in the municipal yard, the trays are thoroughly soaked overnight to reduce immediate vulnerability to drought.

At the transplant site, staff place the mats in 4m by 4m plots ensuring maximum soil contact between the newly transplanted mats and the existing forest floor. Leaves and other organic material are raked to the edge of the transplanted mats to prevent drying and provide additional cover for the new mat.

The forest floor transplants are one technique used in the Regreening Program. The public was consulted during the development of the Biodiversity Action Plan which includes the transplant strategy. The forest floor transplant program has been led and maintained by municipal staff involved in the Regreening Program.

FUNDING A program of this magnitude requires significant long-term funding. The forest floor transplants are funded through the City's Regreening Program. Currently, the City provides approximately 15% of the budget through the Regreening Program. The remaining funding comes from established partners: Vale and Xstrata Nickel that have committed long-term funding to the Program. These companies



Filling plot with vegetative mats

also provide maintenance support and liming to reduce soil acidity. Tree Canada also provides funding for the purchase of trees and shrubs to diversify the developing forest. In the past, the Program benefitted from substantial funding from the provincial and federal government that was used specifically to fund the labour required for the regreening work.

CHALLENGES The City of Sudbury has encountered a number of challenges in the implementation of the forest floor transplant program. Some examples include:

Financing Relying on the long-term financial support of the local mining companies and their own commitment, Sudbury continually searches for external financing to offset the costs of the Regreening Program in general and the forest floor transplants in particular.

Sourcing Forest Floor Mats It would be counter-productive to remove forest floor mats from existing mature forests outside of the impacted zone. Therefore, forest floor mats obtained from areas subject to conversion from forest to another use. The highway construction project south of Sudbury was an ideal opportunity to expand the forest floor transplant technique and build adaptive capacity in new forests. The construction will come to an end by 2014 at which point the construction sites will be too far south to make vegetation salvage feasible.

Ongoing Maintenance Requirements Once mats are transplanted, they are immediately vulnerable to weather impacts. Most significantly, mats can quickly dry out in hot weather or dry periods. To avoid these issues, municipal staff focus the plant salvage operations in spring and fall seasons. However, drought continues to be a significant challenge to the program. The City would consider hiring a water truck for extreme situations, however it is very costly to keep mats alive in this manner and many plots are located in areas that cannot be reached by vehicles.

Staffing Forest floor transplants require a significant human resources commitment from the municipality. As a mid-sized city, Sudbury has struggled to find the staff to implement the program. To overcome this challenge, the City has accessed employment programs to find short term staff. This strategy relies on the availability of government grants.

LESSONS LEARNED *There were several important lessons learned by the City during this process. These include:*

- **Partnerships are very important to implement this type of program.** In addition to external funding, Sudbury's partners have contributed to the maintenance of forest floor mats, acquisition of labour, specialized knowledge and education campaigns.
- **Increasing biodiversity and protecting young trees from climate impacts is essential in building resilience and adaptive capacity into urban forests and communities alike.**

IMAGES

All images courtesy of Stephen Monet, City of Greater Sudbury

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FURTHER INFORMATION

Sudbury's Biodiversity Action Plan

Natural Resources Canada Ressources naturelles Canada
Canada

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

YORK REGION DE-ICING STRATEGIES

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ● Infrastructure ○ Natural Systems ○ Planning ○ Water Conservation	○ Communications ● Environment ○ Finance/Purchasing ● Infrastructure ○ Parks & Rec ● Planning ○ Public Health ○ Water/Stormwater	○ Decision Support Tools ● Delivery of Adaptation Options ○ Plans + Policies ○ Programs + Initiatives	○ Anticipatory ● Reactive	○ Federal ● Municipal ○ Other ○ Private ○ Provincial

PROFILE *Adapting to Ontario's increasing winter variability requires more complex and dynamic municipal road maintenance strategies. Black ice, freeze thaw damage, and other impacts can occur with very little notice and create a safety hazard for residents, businesses and municipal staff. Addressing these conditions requires real-time information on weather and road conditions, appropriate equipment and the ability to reach affected areas.*

In an effort to maintain safe road conditions during inclement weather, York Region has adapted its tools and strategies to enable a more rapid road maintenance response. In particular, the Transportation and Community Planning Department has developed a Salt Management Plan, introduced new strategies for de-icing and anti-icing, and has adopted new tools that optimize the Region's response and resources.

GEOGRAPHIC CONTEXT York Region is located directly north of the City of Toronto, encompassing an area of 1776km^2 that includes the municipalities of Richmond Hill, Vaughan, Markham, Newmarket, Georgina, King, East Gwillimbury, Aurora and Whitchurch-Stouffville. The Region is home to approximately 1 million residents. By 2030, York Region is projected to grow to approximately 1.5 million residents.

Sitting squarely in Ontario's snowbelt region, York Region endures lake effect snow from three different sources: Lake Simcoe, Georgian Bay and Lake Ontario. Over the past 30 years the Region received significant average snowfall of 120-160cm each winter.

The presence of the Oak Ridges Moraine and the topographic features of the Region complicate municipal response to winter precipitation as they contribute to weather variability within York's boundaries. In any one precipitation event, some areas of York Region might receive freezing rain while others are experiencing driving snow. Under these conditions, managing the Region's 1,028km of paved arterial roads is difficult as teams need to address a variety of weather conditions simultaneously.

Finally, as a rapidly growing municipality, increasing urbanization has added to the challenge of maintaining safe roadways in winter months. As roads have grown steadily wider to accommodate an increasing number of vehicles, there is less space to store snow and higher usage of roadways which exacerbates hazardous driving conditions. These changes have changed the standard of maintenance and care required to achieve safe roads. For example, in some cases, snow removal is now necessary, where plowing was sufficient in the past.

CLIMATE CHANGE CONTEXT Like many Ontario communities, York Region is experiencing a long-term trend of warmer winters and more variable weather. Snow is increasingly replaced with more frequent episodes of freezing rain.

In addition, the Region is experiencing increasing incidents of extreme weather which includes impacts such as freeze/thaw, extreme cold and extreme heat.

Moreover, this variability is projected to continue and in some cases, increase in intensity. Under a rapid growth emissions scenario that reflects current trends (A1B),[1] York's annual average temperature is expected to increase by about 2.7°C by the 2050's. Under the same scenario, annual average precipitation is expected to rise by about 50mm by the 2050's with the majority of this change occurring in the winter and spring seasons. These projections reflect the weather trends that York Region has been experiencing lately, and imply that future weather will be equally variable, demanding dynamic road maintenance strategies.

ISSUE As York Region's winter weather becomes more variable, the municipality has worked to build resilience to climate change by developing new strategies and introducing new equipment and techniques to their maintenance routines.

In 2004, the Region developed a Salt Management Plan aiming to reduce the amount of salt introduced to the environment and watershed. The Plan delegates responsibility for program implementation to the Transportation and Works departments, and introduces new technologies and tools that may be used to create a dynamic and highly efficient road maintenance program. As a strategic document, the Plan also highlights future action areas.

Acting on the recommendations found in the Plan, York Region has implemented three noteworthy new techniques: the use of pre-treated rock salt; the installation of Road Weather Information Systems; and vehicle global positioning systems.

Pre- treated Rock Salt

De-icing is the common practice of applying rock salt to melt the snow and ice that have bonded to it. Though highly effective above -12°C, below that temperature, salt begins to lose its potency, melting ice and snow at a much slower rate. To combat this inefficiency and prepare for future extreme cold events York Region has been testing pre-treated salt in Georgina and East Gwillimbury (areas that are vulnerable to lake effect snow from Lake Simcoe). Starting in 2008, the Region began using rock salt that had been coated with a solution made primarily from beet juice. This treatment enables the salt to emit a higher temperature, meaning that it is effective at melting ice in colder temperatures. In 2011, the Region began to manufacture the treated salt using beet juice from a nearby refinery, and has initiated trials to test the salt's efficiency. Though the atypical warmth of this past winter (2011/2012) prevented the Region from testing the treated salt in temperatures below -12°C, York has noted that the use of their pre-treated salt has reduced the total amount of salt used by approximately 10%. Factoring in the added cost of the beet juice solution, the Region estimates savings of 8% on their road salt budget with this technique. York is currently considering the use of this tool within other District Maintenance Areas within the Region.

Road Weather Information System

In addition to pre-treated rock salt, York Region has also incorporated a Road Weather Information System (RWIS) into their road maintenance efforts since 2000. The RWIS technology consists of a puck-shaped device that monitors sub-surface temperature, ground temperature, salt concentration on roads, wind speed and precipitation levels in real-time. York Region implanted 4 RWIS pucks in the ground at strategic locations including:

- The highest point in York Region to get an indication of how elevation affects weather. This point is in the west end of the Region and monitors weather patterns for this area.
- Within the hills to get an idea of the Oak Ridges Moraine effect.
- At the base of the Oak Ridges Moraine to get a point of comparison that better reflects non-hilly areas of York Region.
- Near Lake Simcoe to monitor lake effect snow.

The RWIS system also accesses data from a local weather network, to provide real-time weather data for the puck location. Using this data, the pucks are able to produce 'do-nothing' scenarios which advise municipal staff of likely road conditions if they do not act. This function allows staff to better understand weather-related threats with regard to the current state of the roads. This real-time information enables York Region to monitor risky situations and to adapt its road care strategy easily in the face of new weather challenges.

York Region is currently in the process of obtaining approval to acquire additional RWIS pucks to be introduced in areas where the Region is concerned about ground water quality.

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

Pre-treated roadway

This effort will help the Region monitor salt use in these areas and prevent contamination of water supplies.

Geographic Positioning Systems (GPS)

Finally, to ensure that the real-time data informs an efficient response to climate conditions, the Region has linked the RWIS technology directly to patrol vehicles in each of the four districts. In addition to facilitating a real-time location monitoring and application rates of salt, this linkage speeds the Region's response in the face of a looming weather event.

These new technologies and tools have contributed to York Region's ability to address weather variability and improve safety on winter roads. To maintain this level of safety, the Region has begun using pre-wetting techniques[2] and has outfitted all snowplows with GPS.

PARTNERS York Region has relied on key partnerships to identify and implement this new technology because of the heavy research and development associated with this process. The Ontario Road Salt Management Group (ORSMG) housed within the Ontario Good Roads Association has been integral in identifying new technologies and opportunities. The use of pre-treated rock salt was the result of findings presented to this group by a local manufacturer. Additionally, the ORSMG offers members the opportunity to pool money to finance the testing of new technology that may prove beneficial for all.

The Ontario Ministry of Transportation (MTO) piloted and recommended the RWIS technology. Relying on findings from European studies, where the system has been used for over 20 years, the MTO adopted the system and released the findings of their studies to the ORSMG. Additionally, the MTO has vetted the use of pre-treated rock salt and a number of other tools and technologies.

Finally, through a competitive bidding process, the Region maintains an ongoing partnership with weather forecasting providers to access local, up-to-date weather which informs their road maintenance response.

FINANCING Each of the new tools and technologies are funded by the Roads Branch housed within York Regions Transportation and Community Planning Department. In cases where new technology or tools are under consideration, a business case is developed by staff and approved by Council. The funding for the new tools is then incorporated into the Roads Branch annual budget.

The tools and technologies highlighted in this case study represent a significant investment by the Region to ensure safer

[2] Pre-wetting refers to the practice of spraying roadways with a brine solution before a weather event to prevent ice formation during and after the event.

York Region Vehicle GPS and RWIS

winter transportation. As discussed, the addition of the beet juice solution to the rock salt has increased the cost of use by about 2%. However, this increase is more than offset by the 10% reduction in salt that it creates. The RWIS pucks cost between $50,000 -$80,000 to install depending on the location and potential connectivity of the site. In addition to this cost, York Region incurs an ongoing monthly fee to retain a weather provider. Finally, the Region must pay between $20-$40/month/vehicle to outfit them with GPS.

CHALLENGES York Region has encountered a number of challenges in the implementation of new de-icing tools and technology. Some examples include:

Financing New technologies and tools require an initial and sometimes ongoing monetary commitment from the Region to implement and integrate them into current strategies. New equipment, staff training and ongoing monitoring must be budgeted for. While safety is a key priority, finding additional funds to commit to new, and potentially untested technologies, is an ongoing struggle for the Roads Department.

Public Perception Public opinions on winter road care and maintenance are often split between road users that are primarily concerned with safety and those that demand environmentally sustainable practices. York Region has worked to find win-win situations that simultaneously reduce environmental impact and improve safety.

Research and Development Like many municipalities with limited resources, York has relied on partners like MTO and the ORSMG to conduct the research and development needed to vet new technologies. Recently, MTO has moved away from this role. This change puts more responsibility on the Region to conduct research before implementing new technologies. Moving forward, this will prove to be a challenge for York as they continue to evolve and adapt to climate change with the use of new tools and technology.

LESSONS LEARNED *York Region has learned several key lessons throughout the process of implementing new road maintenance tools and technologies including:*

- **Identifying and implementing new tools and technologies can help municipalities to protect their residents and businesses from weather related damage.**
- **Partnerships between municipalities can provide the opportunity to share research and development costs.** These partnerships will allow cost effective uptake of new technologies in a responsible way.
- **Communication to public and staff is important when showcasing new technology** as it can help to explain why the change is occurring and provides a forum for feedback if needed.

IMAGES

All images courtesy of York Region

FURTHER INFORMATION

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With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

GUELPH WATER CONSERVATION PROGRAMMING

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ○ Infrastructure ○ Natural Systems ○ Planning ● Water Conservation	○ Communications ● Environment ○ Finance/Purchasing ● Infrastructure ○ Parks & Rec ● Planning ○ Public Health ● Water/Stormwater	○ Decision Support Tools ○ Delivery of Adaptation Options ○ Plans + Policies ● Programs + Initiatives	● Anticipatory ○ Reactive	○ Federal ● Municipal ● Other ○ Private ● Provincial

PROFILE *The City of Guelph has established an extensive suite of adaptive water conservation programs, incentives and regulations to prevent municipal water shortages. Though water use within the municipality has historically been sustainable, City Planners and decision makers are aware that water availability will continually be at risk under increasing demand associated with a growing population and economy. Changing climate conditions will put additional strain on the system, exacerbating the issue.*

While the project was not designed as a climate change adaptation measure, it does help the City build resilience to a changing climate by managing competing demands for water and ensuring a secure, sustainable source of water for Guelph. To provide an overarching framework for the project, Guelph developed a Water Supply Master Plan. This document provides a strategy for municipal water conservation efforts to ensure that Guelph can adapt to meet existing and future water demands. Most importantly, the strategy commits the City to achieving a 20% reduction from 2006 average daily water consumption by 2025. Building on the WSMP, the 2009 Water Conservation and Efficiency Strategy Update, recommends a proactive suite of conservation projects needed to accomplish this task.

GEOGRAPHIC CONTEXT The City of Guelph (population 120,000) is located in Southeastern Ontario roughly 90km northwest of the City of Toronto. By 2030, Guelph is projected to grow to approximately 176,000.

Not being located on or near a significant body of surface water, Guelph relies on local finite groundwater sources for its water needs including, residential, industrial, institutional and municipal use. The municipality's water source consists of 18 urban supply wells, as well as water from the Arkell Spring Grounds (located outside of the City's urban boundary). This groundwater source leaves the City vulnerable to drought. Guelph's reliance on ground water and its growing population contribute to the City's vulnerability to water shortages.

CLIMATE CHANGE CONTEXT Within the last 15 years, Guelph has experienced steadily increasing temperatures and periods of drought. Though short-term reductions in precipitation and heat events do not generally have any impact on groundwater levels, they can negatively impact the quality and quantity of available water, when prolonged. Between 1997 and 2003, Guelph experienced drought conditions. Since then, the City has also experienced dry years in 2007 and 2011, demonstrating an ongoing threat to municipal water sources.

Under a rapid growth emissions scenario that reflects current trends (A1B)[1], Guelph's annual average temperature is expected to increase by about 2.7°C by the 2050's. Under the same scenario, annual average precipitation is expected to increase by 42.7mm by the 2050's, though the majority of the increase will be observed in winter and spring, with a

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

small decrease expected during the summer months. These projections correspond with the weather trends that Guelph has experienced over the last 15 years.

ISSUE Though Guelph has historically had ample water available, the fact that they are totally reliant on a limited supply of ground water has been an ongoing concern. In 1990, the City initiated a multi-phase Water Supply Study to analyze the water system and determine its current and future capacity. The study, completed in 1991, identified four focus areas for the City, including:

- Water conservation
- Water supply/distribution expansion
- Water resource evaluation
- Water resource protection

Setting the stage for a concerted municipal effort, Guelph launched a series of studies and environmental assessments. The studies helped municipal staff to establish a basic understanding of their current water use, supply and capacity, prompting staff to focus on water conservation and supply expansion.

In 1998, following public and stakeholder consultations, City staff developed a comprehensive Water Conservation and Efficiency Plan. The Plan, the City's first attempt at a cohesive water management strategy, recommended several water conservation programs and tools to be implemented over subsequent years. The Water Conservation and Efficiency Plan was never approved by Council and received only $250,000 per year to plan and execute water conservation programs. Despite these limitations, several successful programs were initiated under the Plan, including:

- *Outside Water Use Program* (2001): A ban on outside water use during peak summer hours. This program faced initial resistance from the public, but has since been accepted as an important water saving measure.
- *Royal Flush Toilet Rebate* (2003): Since it was established in 2003, the City's toilet replacement rebate program has processed 12,778 rebates. In 2011 alone, it encouraged 2500 multi-residential homes and 1100 single-family homes to convert to a low-flow appliance.

Early planning and program efforts by the City filled knowledge gaps and expanded existing programs to capitalize on early success. Existing and future climate conditions, well interference and water quality degradation were highlighted as factors that could reduce the water yield from the system. Moreover, rising population levels and continuing development represented exacerbating issues that Guelph needed to consider in their planning.

Recognizing these additional challenges, the City of Guelph developed the Water Supply Master Plan (WSMP) in 2006 to establish a sustainable water supply that would continue to serve the City's growing needs. As a first step toward this overall goal, the WSMP clearly states Guelph's commitment to reduce total water usage by 20% before 2025. Following this, the WSMP outlines a strategy to reach the goal, based on several key tools:

- Public education and awareness
- Water audit programs
- Rebate programs to encourage water conservation
- Regulations, including by-laws

Since 2006, the City of Guelph has initiated several programs recommended in the WSMP that complement existing conservation and efficiency activities. These programs have achieved measurable success resulting in an 11% reduction of overall water-use between 2006 and 2011 alone.

Among the more successful programs are:

- *Residential Water Conservation Programs*: The City's Greywater Re-use, Home Humidifier and Smart Wash washing machine rebate were very successful. In 2011 alone, the programs were responsible for saving approximately 460m^3 of water per day.
- *Leak Detection Pilot Program*: Assessing over 250km of municipal watermains, this program repaired 11 leaks, conserving 1300m^3 of water capacity daily.
- *Industrial, Commercial and Institutional Efficiency Audits and Incentives to reduce water demand*: In total, these efforts have reduced water use by approximately 700m^3 per day.
- *Civic Facility Water Efficiency Retrofits*: To lead by example, the City of Guelph is retrofitting municipally owned facilities including the Guelph Transit Bus Wash, civic arenas and improvements to irrigation systems at City run sports fields to reduce the amount of water required for operation.

In addition to these savings, water conservation programs result in further savings of $250,000 annually in chemicals and electricity that the City would have spent on water treatment. They have also been able to delay the $19 million expenditure required to expand the City's water and wastewater systems by reducing volumetric loading at the plant and preserving this previously utilized capacity for new growth.

Since the 1990s Guelph's water conservation programming has ensured a secure source of water for the City, produced significant economic savings for both the public and municipality, and protected Guelph from climate related water shortages.

PROCESS After the limited success of the Water Conservation and Efficiency Plan, the City developed the WSMP as a detailed blueprint for the municipal water system. In 2006, the WSMP was endorsed by Council and City staff began to implement the extensive strategy. To ensure co-operation for the water conservation measures from the public, stakeholders and key municipal departments, staff initiated an Advisory Committee made up of representatives from local businesses, residents, NGO's, universities, community groups, developers and the Grand River Conservation Authority. Meeting monthly, this group reviewed the draft plans during the development of the Water Conservation and Efficiency Strategy Update in 2009. Since then, this group has been formalized as the City's Water Conservation and Efficiency Public Advisory Committee with staff continuing to consult this Committee on conservation programming.

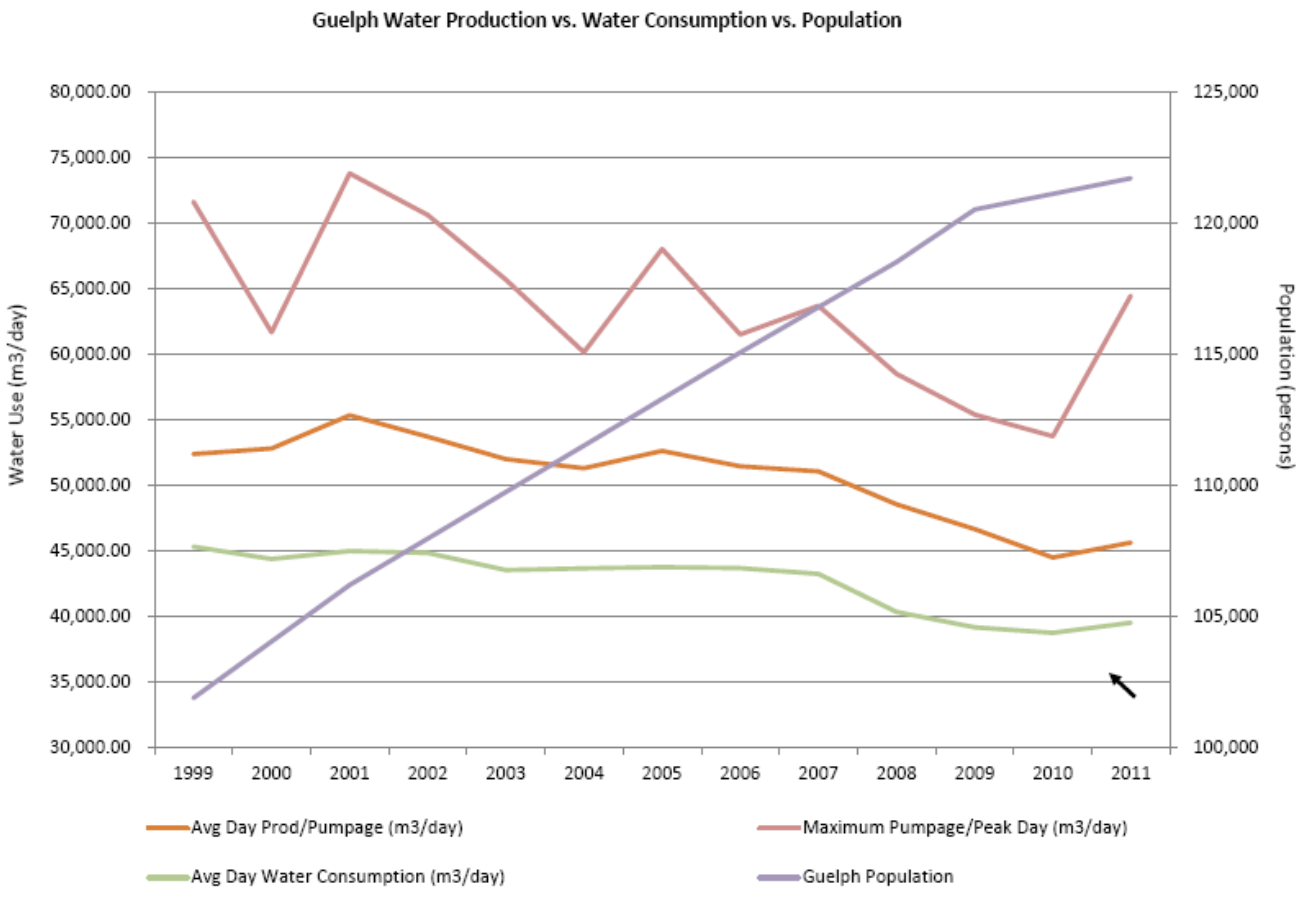
Because public engagement is critical to the success of water conservation programs, the City of Guelph has continued to focus significant time and resources fostering it, including:

- Establishment of information centres focused on water conservation
- Release of the WSMP for public comment
- Creation and maintenance of the Advisory Committee

FINANCING The City's Water Conservation Program, as approved by Council through the 2009 Water Conservation and Efficiency Strategy Update, has a total annual budget of $1.8 million that is funded by water and wastewater user rates.

An additional $300,000 is obtained annually from charges on new development within Guelph. A portion of the total development costs is committed to water conservation programming, especially with regard to rebates on inefficient toilets and washing machines.

Finally, the City of Guelph has received significant external funding from the Federation of Canadian Municipalities (FCM) and the Government of Ontario. In 2009, FCM con-



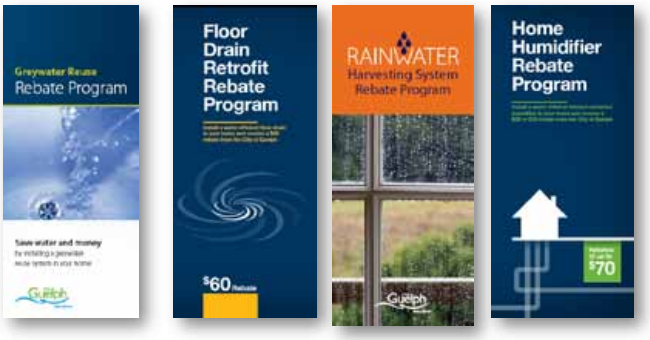
Guelph water resources and usage

tributed $70,000 to the field test for the Greywater Re-Use Program. The City has also attained $89,000, from Ontario's Showcasing Water Innovation Program, towards the integration of water reuse and rainwater harvesting at the City's transit bus-washing operations, and $920,000 towards a reducing energy demands and water loss associated with the production and transmission of potable water.

CHALLENGES The City of Guelph has encountered a number of challenges in the implementation of its water conservation programming including:

Public Perception Water conservation relies on actions by the public and industry and can be subject to conservation fatigue in desired audiences. Under these circumstances, it is difficult to ensure engagement of public and industry on an issue that the public may not always greatly understand.

Leading the Way Many of the programs and regulations that Guelph initiated were the first of their kind in Canada and North America. This meant that the City researched new technologies and developed new standards with little external support and was unable to benefit from lessons learned from others experiences.



Water Supply Master Plan strategies

LESSONS LEARNED *There were several important lessons learned by the City of Guelph throughout this process. These include:*

- Since public participation is essential to the success of a program of this nature, **public consultation must take place early in the process.** Sharing details about program direction, implementation and impact on individuals can help engage both residents and industry.
- **Planning is critical to the success of the program.** With continually changing demand for water, the development of the WSMP allowed the City to weigh different growth scenarios and determine the best strategy to address them.
- **Opinions can change.** When the Outside Water Use By-law was introduced, there was significant public resistance. Since then, the social norm has changed and the by-law has become a successful water conservation tool.
- **Base programs on good data.** The development of the WSMP helped Guelph develop a solid base of data regarding water availability and use. This process allowed Guelph to create forward looking programs that will reduce water consumption over the long-term.

IMAGES All images courtesy City of Guelph

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Guelph Water Conservation and Efficiency Strategy Update (2009)

Guelph Growth Management Strategy

Water Supply Master Plan

Water Supply Master Plan Fact Sheet

Natural Resources Canada Ressources naturelles Canada
Canada

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

SYNDROMIC SURVEILLANCE SYSTEM FOR HEAT-RELATED ILLNESSES

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ● Health ○ Infrastructure ○ Natural Systems ○ Planning ○ Water Conservation	○ Communications ● Environment ○ Finance/Purchasing ○ Infrastructure ○ Parks & Rec ○ Planning ● Public Health ○ Water/Stormwater	● Decision Support Tools ○ Delivery of Adaptation Options ○ Plans + Policies ○ Programs + Initiatives	● Anticipatory ○ Reactive	● Federal ● Municipal ● Other ○ Private ○ Provincial

PROFILE *Extreme heat events are expected to be more common and intense in Ontario communities. Across the province, health units are working with partners and stakeholders to better prepare their communities to adapt to these events, and to prevent and reduce heat related illnesses and deaths. Heat Alert and Response Systems along with educational campaigns, have been adopted by several communities to detect and respond to extreme heat events and to raise awareness about adverse health outcomes of heat, especially among the most vulnerable populations. While public health interventions may include direct actions such as the use of cooling centres and water distribution programs, recent efforts have focused on health care system capacity during a heat-related event.*

Syndromic surveillance analyses medical data to detect disease outbreaks. In Southeastern Ontario, four health units are participating in a pilot project where an existing syndromic surveillance system has been adapted to monitor real-time environmental heat and heat-related illnesses. The system is being used to detect heat-related morbidity in 11 hospitals within the combined region. The results of this pilot project will support public health professionals by providing them with more detailed evidence-based information regarding which populations are vulnerable to heat-related illnesses, and by helping them to provide efficient and effective care during extreme heat events.

GEOGRAPHIC CONTEXT The four health units participating in this pilot project are located in Southeastern Ontario and include:

- Hastings & Prince Edward Counties,
- Leeds, Grenville & Lanark District,
- Peterborough County-City, and
- Kingston Frontenac and Lennox & Addington (KFL&A)

These agencies cover an area of close to 24,000km^2 and serve a population of approximately 655,000.

The four units vary in geographical makeup and population sizes with Leeds and Hastings Units serving largely rural areas, while Peterborough and KFL&A Units serve a mixture of urban and rural areas.

CLIMATE CHANGE CONTEXT Like many Ontario communities, Hastings County, Leeds & Grenville, Peterborough and KFL&A are becoming increasingly concerned about extreme heat. This is an especially pressing concern given that under a rapid growth emissions scenario that reflects current trends (A1B)[1], these communities will experience a 2.8 °C increase in average annual temperature by the 2050's. Increases in the duration of extreme heat events using the Heat Wave Duration Index (HDI) have also been projected. This index is defined as the maximum period of consecutive days that are 5°C above the climate normal. These findings provide strong motivation for managing health capacity in the face of a heat event.

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

ISSUE More frequent and intense heat events will become a risk that Ontario communities must address. In many cases, these events can result in an increased risk to health, or death. The institutional capacity to handle these events has evolved as a key concern. If temperatures are sustained above 30°C for long periods of time, heat related illnesses will become more likely and health care providers want to be assured that they can accommodate the increase in patient load. To increase capacity in Ontario, Health Canada has partnered with KFL&A and three other health units, to monitor heat-related morbidity in Eastern Ontario.

Syndromic Surveillance System as a Base

The pilot project relies on a syndromic surveillance system developed in 2004 by KFL&A health unit, in conjunction with the Ministry of Health and Long-term Care. Designed to track infectious disease outbreaks, the real-time system monitors information provided by patients during their initial triage evaluation by health staff.[2] Analyzing this data, including the chief complaint and primary symptoms, along with de-identified information about the patient and circumstances of their arrival,[3] the surveillance system can identify symptomatic trends.[4] When mapped, this data can help health units pinpoint vulnerable populations and locations and to track the effectiveness of heat-related intervention strategies in real-time. Given the program's reliance on syndromic surveillance, the pilot project was limited to four health units where the system had already been established.[5]

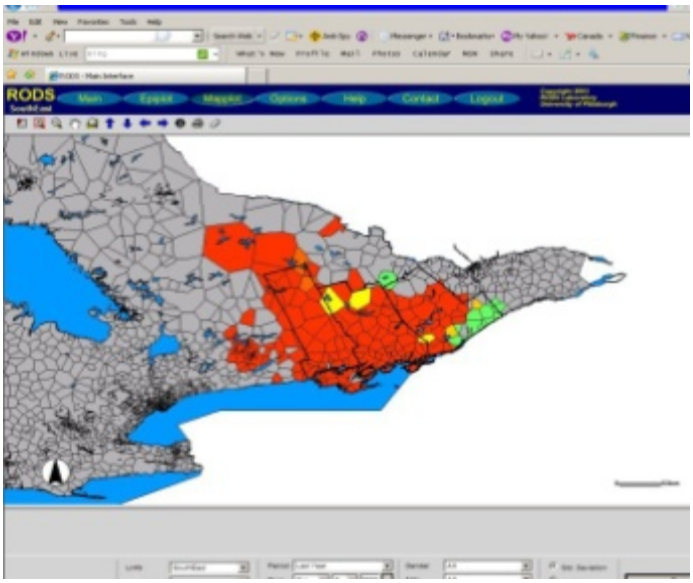
Refining the Surveillance System to Address Heat

To specifically consider heat-related morbidity, an algorithm has been developed to narrow the focus of the syndromic surveillance system, considering only symptoms commonly associated with heat-related illnesses. Some examples include:

- Sunburn
- Sun stroke
- Heat stroke
- Exhaustion

Additionally, heat monitors based on Wet-Bulb Globe Temperature (WBGT) sensors were installed strategically over each region to capture real-time heat data that includes measurements of air temperature, humidity, wind speed and solar load. Combining the readings from each sensor produces a WBGT index which can be used to assess heat stress.

Project staff integrated heat data collected from each region into the syndromic surveillance system to get a better understanding of the spatial distribution of heat-related illnesses, but also of the relationship between heat and adverse health indicators such as an increase in the number of emergency department visits. This information can be used to determine the locations that are most likely to need assistance in managing and responding to a heat event. Theoretically, through mapping, public health units can deploy intervention strategies including water bottle distribution, door to door checks and cooling centres based on geographic need. The syndromic surveillance for heat project is currently in the process of being validated through an extensive testing period. During this process, the system is used for event monitoring and the identification of trends during heat events. However the data gathered has not been used to inform health response yet. To validate the data, the results are analyzed using data from the 11 participating hospitals after a heat event to ensure that the system accurately identified trends and high-risk areas. Partners hope that the validation process will be completed by 2013. At that point, the data from the WBGT sensors, in conjunction with the data from the refined syndromic surveillance units, will be used by the participating health units to inform their heat response plans during heat events.



EDSS System
- Courtesy KFLA Public Health

[2] Including emergency departments and urgent care facility staff

[3] These include gender, time, etc.

[4] Complete automation of the syndromic surveillance system is possible with automated anomaly and spatial detection

[5] As listed above, these include: Kingston Frontenac Lennox & Addington; Hastings & Prince Edward Counties; Leeds, Grenville and Lanark District; Peterborough County-City

Next Steps With syndromic surveillance and wet bulb globe technology in place, the four health units would be able to delve further into heat morbidity patterns. KFL&A has begun to develop several new layers for the map which could help participating health units to pinpoint their vulnerable populations with greater accuracy and focus current heat alert and response strategies. These include a socioeconomic layer and age-based mapping focusing on the very young and old.

Since 2009, many other communities have introduced syndromic surveillance in their public health strategies. Currently, approximately 75 hospitals have been integrated into the system based at KFL&A. To expand the network of heat morbidity mapping, it would be beneficial for each community to integrate wet bulb globe technology into the network. However, municipalities may still be able to conduct mapping by combining the detection of heat-related illnesses (through the syndromic surveillance system) with heat alert systems from Environment Canada.

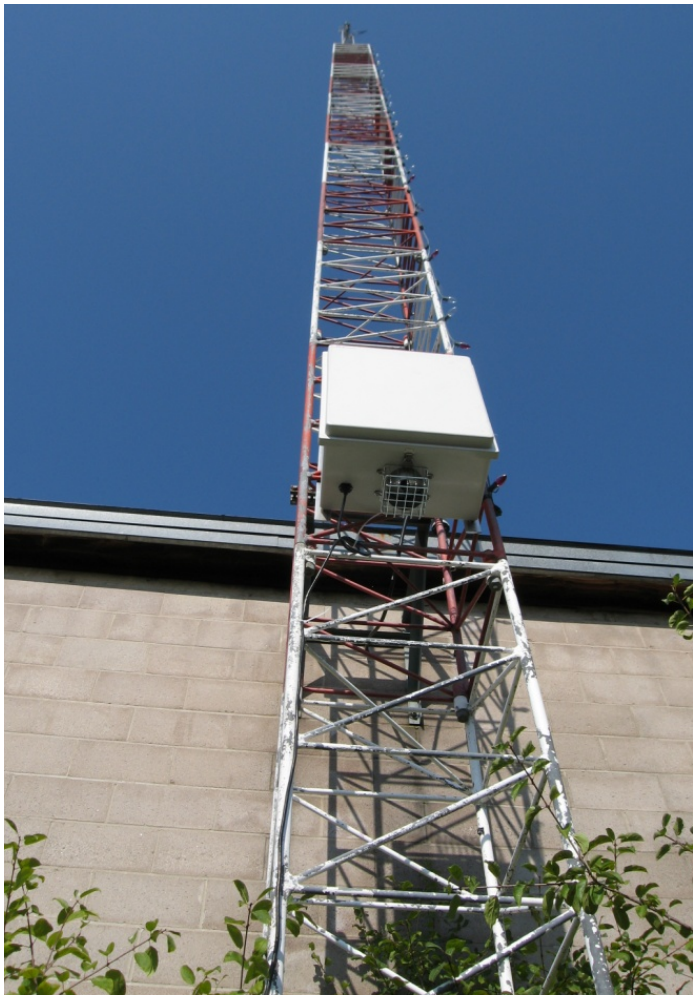
PARTNERS The system relied on a partnership between Health Canada and KFL&A Health Unit.

Health Canada approached KFL&A to adapt the existing system to specifically consider heat-related morbidity. To facilitate this transition, Health Canada contributed funding to acquire and integrate real-time heat data into the syndromic surveillance system. Their support for the program will also help facilitate expansion efforts in the future.

As the developer of the syndromic surveillance system, KFL&A was the primary partner in the heat morbidity mapping program. Engaging three other health units that had established syndromic surveillance systems in their regions, KFL&A played a leadership role in acquiring data needed for the program.

CHALLENGES A number of challenges were encountered in the development and validation of the syndromic surveillance system for heat program. Some examples include:

Financing Long-term financing remains a significant challenge for the program. Though Health Canada has committed to supporting the expansion of the program, there will be little external financial support available for the maintenance of the program (including data analysis, staff time and maintenance of equipment) in each health unit. Some of the larger units may be able to undertake this additional cost, but smaller units may not be able to.



Wet Bulb Globe Temperature Sensor - Courtesy Geof Hall

Community Capacity While the monitoring program can help a health unit to identify vulnerable areas and populations within their boundaries, the region must have the institutional capacity to address the identified issues. In smaller communities, the use of heat morbidity mapping may not reduce risk if the health units or municipal emergency response departments do not have the capacity to respond to alerts and employ primary prevention strategies.

Symptom Limitations To identify heat related morbidity, the program tracks the most common symptoms of heat-related illnesses. Though this system can correctly identify heat related illness in most cases, at present it does not account for other co-morbidities which are not statistically validated. For instance, certain illnesses that are exacerbated by heat (e.g. heart attacks) are not currently tracked as their statistical significance within the larger picture of a heat-related event is not clear using current emergency department triage methods. This exclusion currently underestimates heat-related illness when the system is used

LESSONS LEARNED *Over the development of the heat morbidity mapping program, many important lessons have been learned. These include:*

- **Public engagement is a necessary aspect of any heat vulnerability identification and reduction efforts.** To ensure maximum public participation, heat vulnerability information should be available to the public using visual tools such as maps. Communicating risk to the public in this way could help them protect themselves from heat health risks and determine where to go to get assistance if needed.

- **The future of this program relies on dedicated organizations to ensure the constant flow of data.** Because there are currently no long-term funding sources available to maintain and expand this program, its future will be dependent on the dedication and commitment of public health units to continue uptake of the technology, and continued support from Health Canada.

- **An investment in technology will help to increase adaptive capacity for the future.** By integrating real-time heat data into existing syndromic surveillance networks, KFL&A and three other health units will enhance their ability to respond to extreme heat events and better protect their communities.

FURTHER INFORMATION

Map of Health Units

Queen's Public Health Informatics

Natural Resources Canada Ressources naturelles Canada
Canada

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

PIONEER PARK STORMWATER MANAGEMENT REHABILITATION

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ● Infrastructure ○ Natural Systems ○ Planning ○ Water Conservation	○ Communications ● Environment ○ Finance/Purchasing ● Infrastructure ○ Parks & Rec ● Planning ○ Public Health ● Water/Stormwater	○ Decision Support Tools ○ Delivery of Adaptation Options ○ Plans + Policies ● Programs + Initiatives	○ Anticipatory ● Reactive	● Federal ● Municipal ● Other ○ Private ● Provincial

PROFILE *Like many municipalities in the Greater Toronto Area, Richmond Hill is working to upgrade or replace its stormwater management infrastructure. Climate change has brought about increasingly variable weather and growing urbanization has diminished the capacity and life of existing structures. As a result, older areas of the Town (built in the 1800's) are more vulnerable to flooding.*

In 2008, Richmond Hill Council approved a 10-year Stormwater Capital Plan to invest in improving the Town's stormwater management system. The first major project undertaken was the rehabilitation of the Pioneer Park Stormwater Management Facility, a 26ha open parcel of land that receives stormwater from a nearby community, providing flood and erosion control. In addition to increasing flood capacity, the Town took the opportunity to design water quality and erosion control features into the new facility design. Infrastructure life cycle improvements were a key feature implemented through innovative operations practices.

Since its completion, the Pioneer Park Facility has provided flood, water quality and erosion protection for approximately 740ha of land. As the climate changes, more extreme precipitation events are expected. Updating this facility helps the Town of Richmond Hill to reduce flood damage to critical infrastructure and protect residents.

GEOGRAPHIC CONTEXT The Town of Richmond Hill is located within the Greater Toronto Area, just north of the City of Toronto, centred between Markham and Vaughan. With a population of approximately 190,000, it sits along the southern boundary of York Region.

Richmond Hill's location contributes to its vulnerability to flooding. Half of the municipality sits on the Oak Ridges Moraine, a geological landform containing hills, valleys and rivers created by the last ice age. The hilly nature of the Moraine affects winds, temperatures and storm systems, meaning that south end of the Town could be experiencing rain while the north experiences snow. This tendency demands a more complex municipal response to weather events.

Richmond Hill has transformed from a mostly rural municipality to an urban area over the past twenty five years. The amount of impermeable surfaces has increased (pavement, roofs, etc) resulting in greater volumes of runoff. Moreover, the design of the Town has amplified flooding as water collects in its natural valleys.

CLIMATE CHANGE CONTEXT Flooding is of particular concern because Richmond Hill, as part of the Greater Toronto Area, has experienced heavy flooding in the past, and expects more intense precipitation events in the future. Moreover, climate projections indicate more frequent and intense events are more likely in the future. Under a rapid growth emissions scenario, reflecting current trends

(A1B),[1] Richmond Hill is expected to have a 52mm increase in average annual precipitation by the 2050's. This change will be especially prevalent in the winter and spring months, while the summer season may see a decrease in precipitation. Given the vulnerability that Richmond Hill's geographic features create, this expected trend in precipitation levels may cause additional flood risks for the Town.

ISSUE As a municipality that has expanded rapidly since the mid-1980's, Richmond Hill has an advantage over many of the older cities in Ontario, with the majority of its infrastructure designed and built between 1985 and 2005. In the more recently developed areas, infrastructure has been designed to accommodate a 1 in 100 year precipitation event, consistent with the Town's standard. However, older areas of the town, urbanized as early as the late 1800's, were not subject to stormwater management standards when constructed.

In an effort to improve its stormwater management infrastructure, Richmond Hill established a 10 year Capital Plan for stormwater management upgrades. Richmond Hill has embarked on a program to upgrade one major stormwater management facility each year for the next ten years. The program, which includes 6 rehabilitation projects and 5 sediment removal endeavours, will help achieve a consistent standard for stormwater management across the City. Approximately $17m was allocated for the completion of this work from an existing Reserve Fund.

The first project, the rehabilitation of the Pioneer Park Stormwater Management Facility, was initiated in 2008.

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

In close proximity to York Central Hospital and adjacent to Major Mackenzie Drive, a major thoroughfare for emergency vehicles, the facility provides flood protection for critical infrastructure and a large residential area. Located on the headwaters of the Don River, the Pioneer Park Retention Pond was originally built as a dam that provided flood protection for 26ha of residential development. Infrastructure deterioration of the dam eventually created wetland-like conditions, increasing sediment collection and raising water temperatures which were harmful to the local fish populations.

Given the proximity of the facility to critical infrastructure and residential areas, a cost benefit analysis reaffirmed it as a priority for the Town. A comprehensive review of the contributing area confirmed that the Town could expand the capacity of the pond to accommodate runoff from 740ha of tributary area to protect a larger area from flooding. Moreover, the design incorporated water quality, erosion control and biodiversity measures. In particular, its features included:

- Expanded water quantity control. Brought the structure to a 100 year standard.
- Retention volume to accommodate 30,000m^3, above which is a spillway designed to handle twice the regional storm flow rate.
- Extended protected length of Don River tributary.
- Creation of watercourse and wetland habitat – restoring fish passage for endangered species.
- Installation of oil-grit separator to pre-treat sediment making it less likely to enter the wet cell of the system.
- Installation of control structures to facilitate water level adjustment.
- Longer flow pass to receiving waterway reduces the difference in temperature between runoff and waterway.
- Erosion control by slowing water flow.

Control Structure

Started in 2008, the Facility was completed in 8 months. The new features mean that during a 5 to a 100 year storm, runoff will be controlled within the river valley and released at a manageable rate. For larger events, excess runoff will spill over the berms and into culverts underneath Major Mackenzie Drive. This technique will ensure that in the event of intense precipitation, critical infrastructure will be protected. In the event of a regional storm event (Hurricane Hazel), the entire Pioneer Park Facility will be flooded to protect nearby infrastructure.

Since its implementation, the Town of Richmond Hill has been monitoring Pioneer Park's progress to ensure that the Facility is performing to the expected standards. From 2008-2012, the Town undertook water quality monitoring, operational monitoring of the low-flow bypass channel, confirmation of fish passage, verification of stream channel stability, water level monitoring, sediment surveys, and regular inspections. This project has received both an Ontario Public Works Association Technical Innovation Award and the Federation of Canadian Municipalities and Insurance Bureau of Canada's Watershed Award.

PROCESS The preparation of a multi-year, multi-million dollar Capital Plan was a complex process that required the cooperation and support of a number of different partners. To begin with, a committee was formed, including partners from related agencies and municipal departments. Meeting regularly, this committee established a set of criteria by which each stormwater management facility was evaluated. This list of criteria was approved by town council and passed on to a team of consultants that evaluated all assumed municipal stormwater facilities against the established criteria. The results of these studies influenced the prioritization of the Capital Plan.

Once the Capital Plan was complete, the Town began the Pioneer Park rehabilitation almost immediately. Under Richmond Hill's capital program, municipal projects are undertaken in a three year cycle.

- Year 1: Feasibility studies and environmental assessments are completed
- Year 2: Design
- Year 3: Construction

Following this guideline, the Town begins the feasibility and environmental assessment of a new Capital Plan project each year. Currently in its fifth year since the completion of the Plan, the Town is in the midst of construction on the third project with assessment and design underway for two new projects.

Bank Stabilization: Pre- and post-treatment

FINANCING A long-term, multi-project plan requires a significant funding source. To finance the 10 year Capital Plan, Town Council allocated approximately $17m from an existing Reserve Fund. However, these funding sources will not be enough to see the Capital Plan through to completion given the size and cost of each project. The Pioneer Park rehabilitation alone required $6.3m, well over the $4.5m that the Town initially estimated.

Of the $17m allocated from the Reserve Fund, $2.925m was allocated to Pioneer Park. The remaining $3.375m was provided by the Province of Ontario's Municipal Infrastructure Investment Initiative ($2.25m), the Federal Government's Gas Tax Fund ($1.125m) as well as in-kind contributions from the Toronto and Region Conservation Authority.

While Pioneer Park has been completed, the Town recognizes that additional long-term financing options are required to complete the other stormwater projects outlined in the Capital Plan. The Town hopes to establish a stable funding source, renew the Capital Plan and implement a mechanism to ensure appropriate funding into the future to complete these projects.

Construction: December, 2010

CHALLENGES The Town of Richmond Hill has encountered a number of challenges in the implementation of their 10 year Capital Plan and the rehabilitation of the Pioneer Park Stormwater Facility. Some examples include:

Financing A significant amount of the financing for the Pioneer Park rehabilitation relied on the availability of government grants. Richmond Hill continues to search for a long-term sustainable financing program to complete other projects outlined in the Capital Plan.

New Technology As the first major stormwater facility rehabilitation in Canada, the Pioneer Park project had to make use of relatively new technology. With few examples to learn from, the Town has had to employ a trial and error strategy to address any issues that arise with regard to the new structure. The monitoring programs are an important tool to ensure that the technology continues to perform optimally.

LESSONS LEARNED *Richmond Hill identified several important lessons learned that they acquired throughout this process. These include:*

- **Municipalities need a champion with an open mind about stormwater management.** In order to implement the 10 year Capital Plan and complete the rehabilitation of Pioneer Park Retention Pond, Richmond Hill relied on champions who were open to new technology, adept at recognizing issue areas and able to garner support for the project at all levels of decision making.

- **With limited resources, prioritization ensures safety for the most number of people.** Since Pioneer Park provided expanded protection to a large area of the Town, it was given a high priority and undertaken first.

- **Have everyone on board to secure funding and support.** Due to the scope of the Capital Plan and the size and costs associated with each project, it is necessary to have a broad and active support base within the municipality. In Richmond Hill, the Water Resources Section leads the process with support from a variety of other departments. Implementation success is often linked to having a lead department work with coordination support from relevant departments.

IMAGES

All images courtesy Town of Richmond Hill

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Town of Richmond Hill. Pioneer Park Benefits.

Town of Richmond Hill. Pioneer Park Landscape Plan

Natural Resources Canada Ressources naturelles Canada
Canada

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

ALTERNATIVE LAND USE SERVICES

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ○ Infrastructure ● Natural Systems ○ Planning ○ Water Conservation	○ Communications ● Environment ○ Finance/Purchasing ○ Infrastructure ○ Parks & Rec ○ Planning ● Public Health ● Water/Stormwater	○ Decision Support Tools ○ Delivery of Adaptation Options ○ Plans + Policies ● Programs + Initiatives	● Anticipatory ○ Reactive	○ Federal ● Municipal ○ Other ● Private ○ Provincial

PROFILE *The role of rural partners in the provision of environmental benefits for local municipalities, including stormwater management, water filtration, green space, wetland restoration and biodiversity, has been largely overlooked thus far. Where adaptation efforts are generally directed at either urban or rural areas, few projects have used collaborative efforts to address impacts in both regions. Such efforts build adaptive capacity in municipalities. Wetland protection is a useful adaptation measure in that it can build resilience against flood events and help provide clean, secure drinking water. Concurrently, the removal and storage of greenhouse gases results in simultaneous mitigation.*

In 1999, two Manitoba-based not-for profit organizations, the Delta Waterfowl Foundation (DWF) and Keystone Agricultural Producers, partnered to explore the concept of working with local farmers to provide environmental services to nearby municipalities on a cost for service basis. This spurred the creation of The Alternative Land Use Services (ALUS) program.

GEOGRAPHIC CONTEXT Norfolk County is located on the northeastern edge of Lake Erie, approximately 80km southwest of Hamilton. With a population of approximately 65,000, Norfolk is one of the smaller counties in Ontario.

Much of the landscape in Norfolk County is highly erodible and very porous. With much of the area cleared as cropland, there is little vegetation to prevent soil erosion. This process creates water quality issues in both surface and ground water. Additionally some 72% of wetlands in the region have been drained due to the replacement of natural landscapes with agricultural land-uses. This trend, along with land clearance, has reduced the overall amount of green infrastructure that can contribute to storm water management.

CLIMATE CHANGE CONTEXT As a primarily rural region, an extreme wind or rain storm could devastate agricultural yields. Using the Canadian Climate Change Scenarios Network, under a rapid growth emissions scenario that reflects current trends (A1B[1]), climate change projections for Norfolk County show a 47.4mm increase in annual average precipitation by the 2050's with most of this increased precipitation falling during the winter and spring seasons. Because this precipitation is likely to fall in more intense, isolated events, crops are vulnerable to drought during the summer months. Compounding this, under the A1B scenario, Norfolk County is expecting a 2.7°C increase in annual temperature by the 2050's, with differences most observable during the summer months.

ISSUE While agricultural land-uses can result in the reduction of natural spaces and the draining of wetlands, the provision of environmental benefits and farming can coexist. Farmers can act as community stewards, creating and maintaining green spaces that contribute storm water

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

Norfolk County cold water stream headed for Lake Erie.

management, drainage opportunities, water filtration and many other benefits to surrounding regions. Until recently, governments attempted to achieve these benefits by enforcing land use regulations to influence farming behaviour. However, this strategy is limited in achieving the kind of green infrastructure needed to protect many rural communities from increasing climate impacts.

Working with farmers in Manitoba, DWF explored the need for incentives that would complement existing regulation, encouraging farmers to use their land in a manner that provided sustainable environmental benefits for the surrounding area. The ALUS program was designed to fulfill this mandate and works to create networks between willing farmers and municipal or regional supporting groups to initiate these services in Canadian communities.

In 2001, the Canadian Federation of Agriculture passed a resolution endorsing ALUS at the national level. This resolution garnered interest in several provinces including Alberta and Prince Edward Island, with the latter approaching ALUS to initiate a province-wide ecological service program in 2009.

In 2003, a pilot program was established in Norfolk County. Partnering with members of the Norfolk County Stewardship program, which included farmers and representatives from several environmental groups, ALUS established itself within the community, recruiting local farmers to participate and working with them to determine the best action plan for their property. In 2007, the program began to expand, with demonstration projects established to attract support from new farmers and provide examples for interested parties.

Given the hydrogeology of Norfolk County and the environmental impacts that have been common in the region, overarching themes of stormwater management and water quality were present in the majority of projects. However, each action plan was designed with the features and abilities of the individual farm in mind. Some examples of projects include:

- Restoration of wetlands to slow water flow and filter runoff
- Buffering of water courses providing cooling, water filtration and erosion reduction
- Planting hedgerows to slow wind and thus crop evapotranspiration rates, increase pollination and reduce wind erosion.
- Use of prairie tall grasses important for water filtration, reducing erosion and as cattle feed
- Installation of water control structures to help farmers regulate drainage on their land while increasing storm water management capacity.

To maximize environmental benefit and maintain long-term engagement with their farm partners, each action plan is designed to incorporate win-win actions, benefitting the farmer and community simultaneously.

Program participation also has marketing and branding benefits, adding value to the crops or livestock that participating farmers produce. Currently there are 108 farmers participating in the Norfolk County ALUS program, contributing approximately 800 acres of land, dedicated to producing environmental benefits. The program has benefitted the area in a number of significant ways. Participating farmers have committed to buffering 36 priority sites, including drinking water sources for nearby towns. During the first year, 32 of these sites were successfully buffered, where farmers planted vegetated swales along watercourses. This effort has reduced erosion in the region. ALUS has also sparked ecological tourism as people travel to the area to visit four demonstration farms that have been established.

PARTNERS Because of its structure, the ALUS program is heavily reliant on partners to operate. All projects are carried out on private land, requiring the consent and participation of the landowners/farmers. This can be difficult to achieve and, in the case of Norfolk, required the establishment of farmer-to-farmer contacts for potential participants, providing advice, support and information. In particular where

additional buy-in was required, other tools were required to distribute information and market the program, including workshops, advertising campaigns and public meetings.

In Norfolk County, the absence of an established market for environmental services means that sustainable actions must be externally funded through grants and contributions from benefitting municipalities.

Though they can draw on the collective environmental knowledge of participating farmers, ALUS staff have also partnered with local biologists and ecologists who provide technical advice on actions that will produce the greatest benefit given the characteristics of the individual community. Additional technical support is provided by partners in local conservation authorities and representatives from provincial or federal governments.

Though the program's activities and daily business are overseen by a management team, a Partnership Advisory Committee made up of representatives from major partners provides policy guidance, financial oversight and individual project approval. Meeting every six weeks or so, this group operates as a de facto steering committee. The Committee has seventeen members including representatives from Norfolk Land Stewardship Council, Long Point Region Conservation Authority, Delta Waterfowl Foundation, farmer liaisons and the Ontario Ministry of Natural Resources among others.

FINANCING To finance the program including local engagement, incentive payments, administration and marketing, ALUS draws funding from several partners. DWF provides the bulk of initial financing and maintains a large stake in the organization, contributing leadership and technical support throughout the life of the program.

Once each chapter has been launched, they are encouraged to find their own local financing sources. In Norfolk's case, the program had 18 additional funding partners that maintained the program and directly financed the work that was done on each farm. The financial support is distributed to individual projects through the PAC.

Farmers are paid current, local, land-rental rates, so the amount of financial incentive varies per community. These payments continue for as long as the farmer provides environmental services. The length of this contract necessitates a long-term funding strategy. ALUS aims to eventually have each program completely supported by marketing innovative products such as ecological credits, although this system is in its infancy and has yet to be implemented.

As primary beneficiaries, municipal partners and their residents are encouraged to participate and contribute to ALUS. So far, with the exception of the provincially funded PEI program, ALUS has had to rely on a wide range of financial assistance, and, at times conduct fundraising to fill funding gaps.

CHALLENGES ALUS has encountered a number of challenges in the development and implementation of their program. Some examples include:

Financing Long-term financing remains a significant challenge for the program. Though DWF has committed funding to the program since the start, the expansion of the program promises new costs and funding demands that must be met. Ideally, municipalities and residents that benefit from the environmental services provided would undertake a portion of their funding requirements.

Urban/Rural Disconnect Having different environmental, social and economic pressures, urban and rural areas can have differ-

Vic Janulis' farm drain, pre- and post-treatment and with grassed buffer on drain

Texas Longhorns grazing in Native Tallgrass Prairie, Late August

ing goals. This is particularly observable in the environmental realm where it is easy to view the costs and harder to observe the benefits of land use. In Norfolk County and in other areas, the ALUS program has struggled to connect the two groups to find mutually beneficial solutions to environmental issues.

Existing environmental regulation Several existing regulations have created barriers to farmer involvement in environmental initiatives. For example, the Species at Risk Act regulates adjustments farmers can make, and can prohibit harvesting land that houses endangered species. Because of this, farmers can be reluctant to undertake new programs for fear that they will be seen as a violation of the Act.

LESSONS LEARNED *Over the development of the ALUS program, many important lessons have been learned. These include:*

- **Public participation in a program of this kind is essential**. In rural communities this can take time and change can be slow.
- **Economics count**. Economic incentives have been most effective at encouraging farmer participation. Similarly, avoiding costly climate impacts due to ALUS programming has proven to be an effective lure for municipalities.
- **Local champions can accelerate networking and community engagement efforts**.

SOURCES

Interview with Bryan Gilvesy, Chair of the Norfolk Partnership Advisory Committee , ALUS. February 6th, 2012

Interview with Dr. Bob Bailey, Vice President. Delta Waterfowl Foundation. February 7th, 2012

Interview with Mark McNeil, Business Development and Research Coordinator, ALUS. February 8th, 2012

FURTHER INFORMATION

Alternative Land Use Services

Natural Resources Canada Ressources naturelles Canada

Canada

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

MARKHAM GREENPRINT SUSTAINABILITY PLAN

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ○ Infrastructure ○ Natural Systems ● Planning ○ Water Conservation	● Communications ● Environment ● Finance/Purchasing ● Infrastructure ● Parks & Rec ● Planning ● Public Health ● Water/Stormwater	○ Decision Support Tools ○ Delivery of Adaptation Options ● Plans + Policies ○ Programs + Initiatives	● Anticipatory ○ Reactive	○ Federal ● Municipal ○ Other ○ Private ○ Provincial

PROFILE *As municipalities renew their Strategic Plans, many are considering environmental factors as essential aspects of a creating a forward looking and vibrant future for their community. Like many Ontario municipalities the Town of Markham wanted to develop a high-level strategic document that established the blueprint for their future emphasizing environmental, cultural/social and economic goals. Having experienced various climate impacts, Markham designed the Greenprint to maintain environmental health and establish adaptive actions and programs that would provide protection from future climate related risk. The Greenprint is a community-driven strategy that provides guidelines for Markham's growth over a 50 – 100 year time period.*

In rural areas, many environmental benefits have typically been achieved through regulation. This strategy limits agricultural operations and has resulted in a reluctance to invest in sustainable land use. ALUS works with farmers and municipalities or regions, to offer incentives for farmers who use their land to provide environmental benefits for the surrounding community. In Norfolk County, Ontario, ALUS has partnered with local farmers to establish a pilot program that provides many of these benefits to surrounding communities.

GEOGRAPHIC CONTEXT The Town of Markham is located northeast of the City of Toronto about 20km north of Lake Ontario. With a population of approximately 300,000 it is one of the fastest growing municipalities in Ontario.

With sections of both the Don and Rouge Rivers flowing through the Town, Markham is vulnerable to flooding, both seasonally and as a result of less regular extreme events. In 2005, Markham experienced flooding along both rivers and suffered damages to businesses, residences and municipal infrastructure. Flooding will continue to be a concern for policymakers given the expected urban development and climate changes occurring in the region.

CLIMATE CHANGE CONTEXT Climate projections for Markham taken from Environment Canada indicate an increasing trend for extreme weather events and a gradual increase in temperature and precipitation levels. Under a rapid population growth and medium emissions scenario (A1B),[1] Markham is expected to experience a 2.7°C increase in average annual temperature and a 47mm increase in average annual precipitation by the 2050's. The change in precipitation will be especially prevalent in the winter and spring months, while the summer and fall seasons will see little change, if any. These changes could result in a greater incidence of floods and extreme heat, both of which are concerns for Markham.

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

ISSUE In 2008, the Town of Markham developed the Greenprint as an umbrella strategy to streamline municipal targets. To do this, the Greenprint aligns the goals stated in other plans (such as the Official Plan, the Transportation Master Plan and the Growth Management Strategy, among others) with a shared vision of a sustainable Markham, based on the three pillars of environment, economy and society. Under the Greenprint, each Department's Strategic Plan will have to demonstrate how their goals align with the three pillars.

The Greenprint further identifies twelve priority areas stemming from the three pillars. The priorities are:

- Social equity
- Identity and culture
- Individual health
- Shelter
- Food security
- Access and mobility
- Education and skills
- Economic vibrancy
- Materials management
- Water efficiency
- Ecosystem integrity
- Energy and climate

In the development phase, each priority was explored in detail to establish its importance to the Greenprint. This process provided valuable context, explaining how and why each priority was important to Markham, and where work was needed. Examples include:

- **Definition** of the priority
- **Global Context** to explain why this priority matters to Markham on a broader scale
- **Local Context** to explain what these global trends mean for Markham
- **How Do We Measure Up?** A section which explores how Markham is currently performing on important indicators
- **Objectives** for the municipality, given their performance on each priority. These objectives were followed by a list of initial, short-term and long-term recommendations for Markham to pursue in order to achieve their goals. A climate change lens was applied to incorporate adaptation into many of the recommendations.

As a living document, the Greenprint will be periodically updated to keep pace with Markham's changing goals and objectives. This approach has allowed Markham to pursue shared goals, such as climate change adaptation, in an efficient manner.

Three pillar approach to sustainability

As a strategic document, the Greenprint operates as a guideline for Markham's Departments as opposed to a prescriptive document. Though municipal staff are obligated to implement the objectives and recommendations, the plan does not dictate how action should be taken. Instead, Departments submit work plans and proposals that must state how they are taking action to support the Greenprint. Moreover, the design of the Greenprint means that proposed actions are weighed to ensure that they positively support other goals and endeavours recommended by the Plan.

The Greenprint is the first step for Markham towards mainstreaming climate adaptation. Since 2011, Markham's Sustainability Office has undertaken an inventory to gain a better understanding of the actions that are currently underway in each department. This exercise will help the municipality to determine where additional resources are required and will assist staff with the development of a detailed implementation plan.

When developing the recommendations for the Greenprint, several themes emerged including emergency measures and response, building adaptive capacity and building resilience. These themes are reflected in many adaptation related recommendations included within. Some examples are:

- Encouraging biodiversity
- Upgrading stormwater capacity throughout the Town
- Education campaigns to ensure that businesses and residents understood climate risks and adaptation opportunities
- Improving food security through ensuring access to local, sustainably grown food
- Encouraging and building infrastructure to accommodate active transportation
- Improving the sustainability of urban natural systems to provide benefits in storm water management and the reduction of the urban heat island

PROCESS The Town of Markham established its Sustainability Office (SO) in 2008 to develop the Greenprint and to take it from planning to action. As part of the Chief Administrative Officer's (CAO) Office, the SO can collaborate with other Departments without the additional demands of a municipal department. To assist the SO, the Greenprint Steering Committee (GPSC) was set up to oversee the document's development. It was composed of Markham's mayor, a regional councillor and two local councillors, with support provided by the CAO and other staff as required. The GPSC met regularly during its development to provide feedback on the document and the consultation plans. With six people dedicated to this Office during the development of the Plan, the SO now has four full time staff that manage the action inventory and implementation of the Greenprint since the Plan's completion in 2011.

To develop the Greenprint, staff from the SO worked with consultants from HB Lanarc to initiate two separate engagement campaigns designed to inform stakeholders and facilitate their participation and collaboration. To develop the structure and shape of the Greenprint, the SO sought to engage staff from other departments by hosting a series of workshops and by communicating with them to illicit their feedback on the priorities and recommendations.

To engage the public, businesses and other important stakeholders, the Town hosted several events. These included:

- Contests and other events to engage Markham's youth.
- A world café workshop which promoted community input through strategic dialogue.
- Sustainability fair to give the public the opportunity to learn more about the Greenprint's twelve priorities and provide feedback.
- Stakeholder workshops to engage developers, businesses, NGOs and other important stakeholders.

Additionally, staff used email updates, questionnaires and online surveys to facilitate feedback from public stakeholders.

Working with the consultant team, SO staff used the information gained from these events to develop a draft of the Greenprint. Once completed, this draft was released for consultation at 27 community meetings and 32 staff meetings.

After finalizing the Greenprint, it was then submitted to Council for approval. By gaining this approval, SO staff ensured that the Greenprint would continue to receive municipal support for implementation of the plan, and that municipal departments were obligated to see this plan through to completion.

FUNDING The Greenprint cost $700,000 to complete over the three year period. Approximately $450,000 was funded by Gas Tax, $160,000 was contributed by the Federation of Canadian Municipalities and the final $100,000 was contributed by Markham. This money was allocated by the Town Council. Of much greater concern to Markham is a longer-term funding plan that will ensure implementation of the Greenprint.

Sustained funding is required to implement the programs, plans, studies and infrastructure upgrades that are detailed in the plan over a 50 to 100 year period. In response to this, the Greenprint includes a financial framework that details the sources of funding that the Town will rely on. These include:

Community Consultation

- Tax dollars
- Development fees
- User rates
- Reserve fund
- Federal gas tax
- Government partners such as the Green Municipal Fund
- Private partnerships
- Cost sharing with York Region

Using a combination of these funding sources, Markham will be able to fund adaptation projects in all areas of the municipality.

CHALLENGES The Town of Markham encountered a number of challenges during the development of the Greenprint. Some examples include:

Public and Corporate Engagement During the design and development of the Greenprint, the SO made great efforts to communicate the benefits and implications of the plan to the public and other municipal departments. This was a necessary undertaking as the successful implementation of such a high-level, strategic plan will require buy-in and participation from these partners. The SO had difficulty achieving this buy-in from staff in other departments as they indicated that they did not feel that they had been given enough of an opportunity to participate in the development of the Greenprint.

Funding Though sustainability and climate adaptation are priorities for the Town, Markham has found it challenging to find additional funding to pursue next steps including a departmental inventory and action plan. Markham is still searching for a way to accommodate these additional costs.

Coordination As an overarching plan, the Greenprint is an excellent example of mainstreaming climate adaptation in a municipality. However, coordinating action and reporting are challenging as they involve so many partners. Even with a dedicated office to manage these activities, Markham has struggled to coordinate the Greenprint's next steps. In smaller municipalities, such a setup may not be possible.

Though Markham staff are pleased that the inventory process yielded significant activity that directly supports one or more recommendations.

LESSONS LEARNED *There were several important lessons learned by Markham during this process. These include:*

- **Managing the expectations of partners** is an important aspect of moving forward on a large-scale strategic document of this nature as it **can help to generate buy-in and can ensure success**.
- **Having a three pillar model was an important design that helped the Town to identify key priorities and objectives**.
- **A simplified and participatory development process will facilitate collaborative plan development** as all partners will have a clear understanding of their roles and expectations.

IMAGES

All images courtesy Town of Markham

FURTHER INFORMATION

Markham Greenprint

Natural Resources Canada Ressources naturelles Canada
Canada

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

THUNDER BAY COGENERATION

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ● Infrastructure ○ Natural Systems ○ Planning ○ Water Conservation	○ Communications ● Environment ● Finance/Purchasing ● Infrastructure ○ Parks & Rec ● Planning ○ Public Health ● Water/Stormwater	○ Decision Support Tools ○ Delivery of Adaptation Options ○ Plans + Policies ● Programs + Initiatives	● Anticipatory ○ Reactive	● Federal ● Municipal ○ Other ○ Private ○ Provincial

PROFILE *Aging infrastructure in many Canadian municipalities provides an opportunity for investment in new or retrofitted infrastructure to contribute to municipal resilience in the face of climate change. As municipalities repair or retrofit their assets, adapting design to accommodate expected climate impacts can increase municipal preparedness and reduce the likelihood of damage suffered during future climate events.*

In 2005, Thunder Bay's sole waste water treatment plant was retrofitted, enabling it to more efficiently manage increasing volumes of waste water and to improve the effluent quality that re-enters the watershed. Thunder Bay used this opportunity to invest in a new waste water treatment facility that reduces pollution and contributes to both climate change mitigation and adaptation efforts.

GEOGRAPHIC CONTEXT The City of Thunder Bay is located on the north-western shore of Lake Superior. With a population of roughly 110,000, it is one of the largest municipalities in Northern Ontario.

Thunder Bay's relative isolation from other cities increases its vulnerability to climate impacts. In the event of an extreme weather event overwhelming the City's capacity to respond, external aid is between 7.5hrs (Kenora, population 15,000) and 11hrs (Sault Ste. Marie, population 80,000) away. In this respect, critical infrastructure must be built and maintained with the explicit understanding that damage may result in loss of access to external aid (as in the case of damage to highways) or that repairs may require parts or labour that must travel (as in the case of a major failure in the electricity grid). An important feature of Thunder Bay's emergency management plan therefore, is that critical infrastructure has a high level of built-in resilience to reduce the risk of damage during an extreme event.

Additionally, located on Lake Superior and discharging into the watershed, Thunder Bay's waste water treatment plant has a significant effect on the health of the lake ecosystem. Changes in temperature, pH, bacterial or pollution levels caused by the facility can have widespread negative impacts on the region's ecosystem.

CLIMATE CHANGE CONTEXT Thunder Bay experiences many climate impacts that are directly related to their proximity to Lake Superior. Flooding, lake-effect snow, lake temperatures and fluctuating lake levels can all impact the municipality's infrastructure at different times of the year. Climate projections for Thunder Bay indicate an increasing trend for extreme weather events and a gradual increase in temperature and precipitation levels as well. Under a rapid growth emissions scenario, reflecting current trends (A1B),[1]

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

Thunder Bay is expected to experience a 2.8°C increase in average annual temperature and a 50mm increase in average annual precipitation by the 2050's. The change in precipitation will be especially prevalent in the winter and spring months, while the summer and fall seasons will see little change, if any.

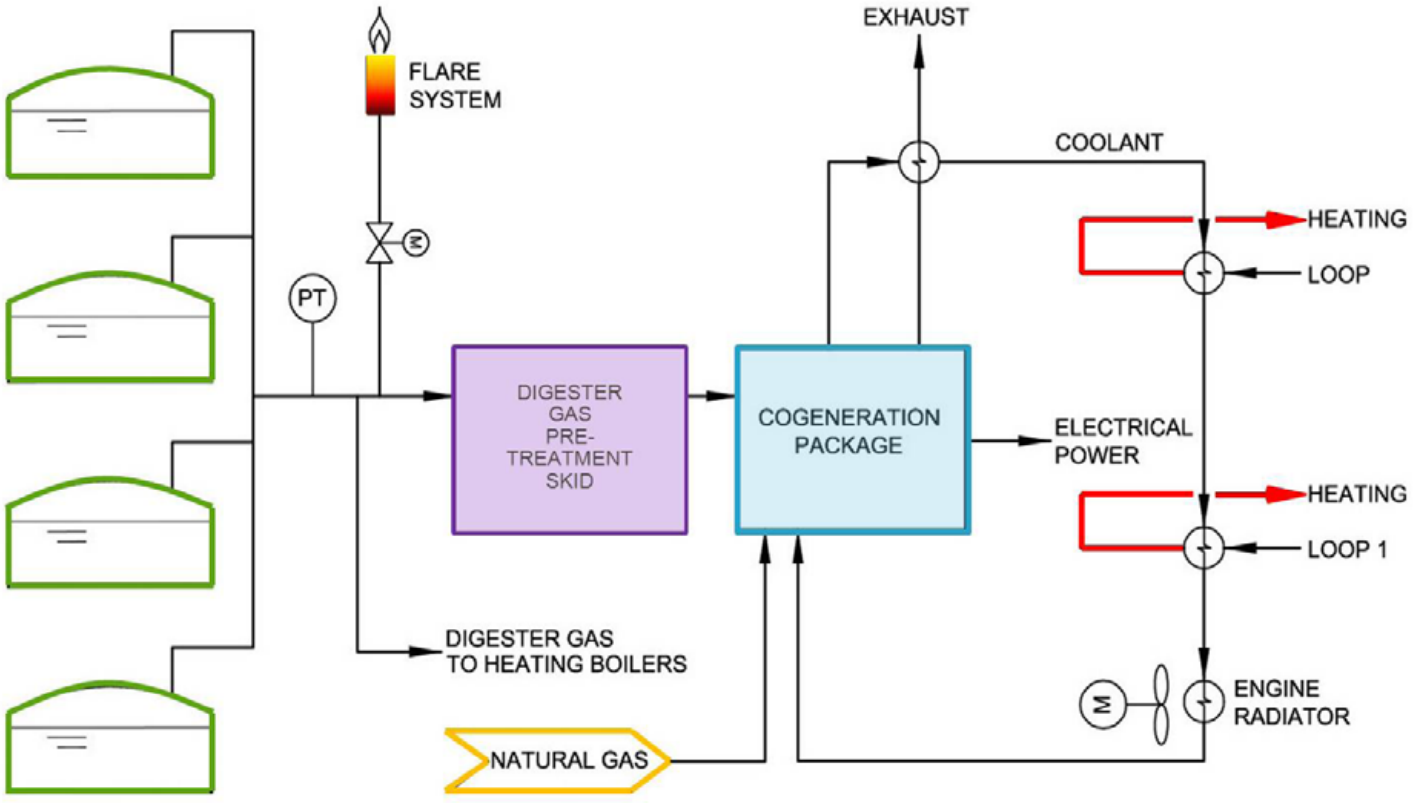
ISSUE Over a five year period, Thunder Bay initiated a four step program to upgrade their waste water management facility. The ultimate goal was to design and build a more efficient waste water facility that would improve facility capacity and water quality while reducing reliance on external power. Adapting to climate change was not explicit in the development, but by decreasing reliance on external energy sources in the plant, adaptation resiliency was achieved as an ancillary co-benefit.

Pollution Prevention and Control Plan

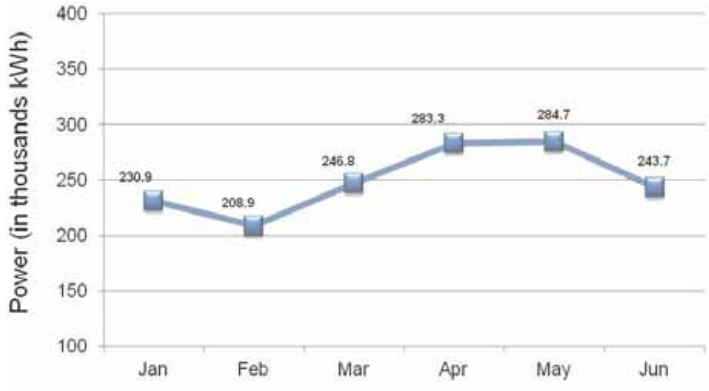
In 1999, the City of Thunder Bay hired a consultant to prepare a Pollution Prevention and Control Plan (PPCP). The study examined municipal waste water facilities, collection systems and water resources; sought to identify limitations in the existing infrastructure and developed recommendations to address these shortcomings. Highlighting the need to treat an increasing volume of wastewater, the PPCP established the framework for a treatment plant with greater capacity. Municipal staff then worked with consultant engineers to design the new facility so that it integrated well with overarching municipal goals including energy efficiency and reduction of chemical use.

Secondary Treatment Plant

The recommendations from the PPCP led to the decision to invest in a secondary treatment plant, UV disinfection system and cogeneration facility for the waste water treatment plant on Atlantic Avenue. In 2005, Thunder Bay constructed an additional treatment plant adjacent to the original plant. The waste is treated once in the primary facility and then again in the secondary treatment plant. The new plant removes ammonia and carbonaceous materials from the waste water, improving the quality of effluent released from the plant into the watershed. The secondary treatment plant demanded more energy and additional chemicals to treat the waste water, but improved the quality of the effluent by approximately 80%. To minimise reliance on external energy supplies, Thunder Bay designed a cogeneration facility at the primary plant to produce electricity.



Cogeneration System Schematic



1,500,000 kWh generated on-site through cogeneration in first 6 months of 2011

Cogeneration

To increase energy independence in the secondary treatment plant, Thunder Bay designed and constructed a cogeneration system within the facility in 2010. This system uses gas captured from digesters, where the waste is stored before treatment process, to generate electricity which is then used to power the treatment process. Cogeneration has three major benefits for a wastewater treatment plant. First, the system reduces the municipality's greenhouse gas emissions. The cogeneration system captures digester gas from the waste that is processed at the plant. This gas is then used in the generation process instead of being burned off as a waste product.

Secondly, the system produces electricity. The captured gas is passed through a cleaning system and then fed into an engine as fuel. Currently, the cogeneration system at the Atlantic Avenue plant produces approximately 9,000 kW per day or about 18% of the electricity used by the facility. As the system requires waste to produce fuel, cogeneration can offset a greater portion of the plants electricity use as the municipal population grows. This is an adaptive process. Although electricity must still be brought in to the facility, the cogeneration system provides some energy independence for the facility generally, and provides complete independence for certain processes within the facility. Over the first six months of operation, the plant realized $142,500 in avoided electrical costs.

Finally, the cogeneration system is designed to capture all heat produced by the engine. Heat exchangers collect heat from the coolant and reuse it to heat the plant, reducing the amount of energy required to operate the facility. Again, this is an adaptive process.

These functions reduce the plant's reliance on the electricity grid and also reduce the environmental impact that wastewater treatment has in the region. The reduction in demand lessens potential strain on the electricity grid due to summer cooling demands, and can contribute to the prevention of power outages. Thunder Bay prioritized reducing the plant's environmental impact because they recognized that their watershed was already vulnerable to climate change. By limiting the plant's environmental impact, the local ecosystem will be better able to absorb the impacts of climate events. Moreover, when under contract with Ontario's Renewable Energy Standard Offer Program, electricity generation produces real monetary savings. By undertaking these four projects, Thunder Bay has helped to offset the cost and energy requirements of the new technology, whilst also providing both climate change mitigation and adaptation services.

PROCESS To facilitate an upgrade of this magnitude, staff from the Engineering and Environment Divisions of the Infrastructure and Operations Department developed a business case that demonstrated the long-term benefits and costs. Additionally, the design team identified key short term environmental goals surrounding energy independence and pollution reduction. Using this data, Thunder Bay designed a facility that would achieve the needed reductions while simultaneously reducing costs. Following a presentation to Council, the team received approval to undertake the project.

FUNDING Thunder Bay capitalized on available funding from the Canadian government under the Canadian Strategic Infrastructure Fund to fund this multi-stage, multi-million dollar project. To qualify for this $25 million grant, Thunder Bay had to demonstrate that they were spending at least $75 million overall. Thunder Bay's contribution consisted of the capital budget dedicated to the PPCP, the construction of the secondary treatment plant and contributions to the UV treatment and cogeneration systems.

To justify and offset the cost of the upgrades, municipal staff calculated the savings that the upgrades would create in terms of reductions in energy and chemical use. This was added to environmental savings related to higher quality effluent, healthier lake water (also used as source water) and a reduction in greenhouse gas emissions.

CHALLENGES Thunder Bay encountered a number of challenges during the design and retrofit of the Atlantic Avenue waste water treatment plant. Some examples include:

Regulatory Uncertainty

During the design and planning stages, the federal government was considering the establishment of a carbon market. The City of Thunder Bay had to make assumptions about the potential for offsetting costs. This uncertainty made it difficult for Thunder Bay to generate accurate long-term cost projections thus increasing the risk that the facility may become a fiscal burden for the municipality in the future. Developing a business plan that carefully considered potential incomes and costs related to the establishment of a carbon market as well as a plan that excluded these items, helped Thunder Bay to consider the implications of such a regulatory move.

Uncertainty Surrounding Incentives Programs

During the design stage, the Ontario Government's Renewable Energy Standard Offer Program was undergoing review. The program provided a guaranteed price for all energy generators that was added on to the market value of electricity. Unsure of how the program and pricing formula would change, Thunder Bay had difficulty estimating the annual costs that the new facility would incur or the income that it could generate. Since long-term cost-benefit analysis is important to the business case of new technology, uncertainty regarding the incentives program made it difficult to establish the business case.

Technological Glitches

Though technological glitches are a common occurrence when implementing a new technology, this process was exacerbated by the fact that the technology had not been tested in many communities before it was installed in Thunder Bay. Thus there were few examples that Thunder Bay could replicate to smooth the process of getting their cogeneration plant online. Though easily remedied, these glitches required expertise and parts that delayed the project.

LESSONS LEARNED *There were several important lessons learned by the City during this process. These include:*

- **A realistic business case is absolutely essential to get a large and costly project implemented**.
- **Timing is vital.** This project was well timed to capitalize on available federal funding and upgrades that were occurring in other parts of the plant.
- **Sewage treatment plants are complex facilities, with many distinct processes.** Building resilience in a plant may not happen in one attempt, but instead over time as each individual processes is adapted.
- **A champion within municipal staff can help to establish a good business case for investing in municipal infrastructure**.

SOURCES

Thunder Bay Funding for Atlantic Avenue Plant

Thunder Bay Pollution Prevention and Control Plan

Ultraviolet Disinfection for Wastewater

Natural Resources Canada Ressources naturelles Canada

Canada

With federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program.

PETERBOROUGH FLOOD REDUCTION PROGRAMING

SECTOR	DEPARTMENT	ADAPTATION TYPE	DRIVER	FUNDING SOURCE
○ Food ○ Health ● Infrastructure ○ Natural Systems ○ Planning ○ Water Conservation	● Communications ● Environment ○ Finance/Purchasing ● Infrastructure ○ Parks & Rec ● Planning ○ Public Health ● Water/Stormwater	○ Decision Support Tools ○ Delivery of Adaptation Options ● Plans + Policies ● Programs + Initiatives	○ Anticipatory ● Reactive	○ Federal ● Municipal ○ Other ○ Private ○ Provincial

PROFILE *In June of 2002, the City of Peterborough experienced a 1 in 100 year storm event requiring provincial disaster assistance. In July of 2004, a rainstorm rated as a 1 in 290 year event overwhelmed the City for a second time, causing over $100 million in direct damage. A state of emergency was declared to clean up and restore major functions of the City.*

Following the 2004 event, the City of Peterborough initiated the Flood Reduction Master Plan (FRMP) process. The development of this plan and the recommendations expressed in it provided a framework for municipal action. Since the completion of the report, Peterborough has undertaken a series of studies to assess vulnerability and has begun to take action, updating stormwater management designs and infrastructure to protect the City from future flooding damage. Although climate change was not an explicit consideration in the FRMP, the actions undertaken to build resilience to future flooding also build adaptive capacity for the community.

GEOGRAPHIC CONTEXT The City of Peterborough is located 135km northeast of Toronto on the Otonabee River. With a population of roughly 80,000, the City of Peterborough is one of the larger municipalities in Eastern Ontario.

Because of its hydrogeology and location on the Otonabee River, Peterborough is particularly vulnerability to flooding. Many parts of the City have been built in valleys where water naturally collects making these areas prone to annual flooding. In addition, a high water table limits the volume of water that can be absorbed during a precipitation event, increasing the probability of flooding. Additionally, built along the Otonabee river and its seven tributaries; Peterborough regularly experiences riverine flooding during precipitation events. Moreover, when the City was originally designed, key municipal infrastructure such as culverts, schools and an emergency management operations centre were constructed in flood-prone areas, increasing the probability of flood damage.

CLIMATE CHANGE CONTEXT Like many Ontario communities, Peterborough has experienced increasingly frequent and intense, wind, heat and precipitation events. Though extreme events are a concern for any municipality, the City's design and geographic features make it particularly vulnerable to flooding events. Climate change may exacerbate the existing situation. Under a rapid growth emissions scenario (A1B),[1] Peterborough can expect an increase in annual average precipitation of about 50mm by the 2050's. This increase will be most noticeable in the winter and spring seasons. Under this scenario, the City can expect a 2.8°C increase in annual average temperature during this time period.

[1] The A1B scenario assume rapid population growth and reliance on a variety of energy sources thus producing a medium level of greenhouse gas emissions.

ISSUE The two intense precipitation events of 2002 and 2004 cost the City hundreds of millions of dollars in direct damages as well as significant additional costs in terms of lost wages, damage to businesses and undermined public trust.

In 2004 the City hired UMA Engineering to assess the causes of the damage and identify restorative actions. The FRMP was developed over eight months and published in May 2005. It provided the City with an understanding of the initial steps required to reduce flooding damage and a list of the tools needed to begin that process. Based on comprehensive analysis of the City's urban drainage network which includes the storm sewer system, overland flow routes and sanitary sewer, UMA identified four primary causes of flooding damage:

- Extreme rainfall events
- Meager storm sewer capacity
- Ineffective overland flow routes
- Infiltration of storm water into the sanitary system

Using modelling and mapping techniques and public consultation, UMA identified vulnerable infrastructure and regions in the City. The FRMP also provided solutions that the City could consider, information gaps, priorities for decision makers and a recommended action plan.

Since the completion of the FRMP, Peterborough has been working to implement the recommendations. To gain a better understanding of their specific vulnerabilities, Peterborough tendered in-depth studies of seven watershed areas[2] within the City to external consulting companies.[3] The studies were intended to augment the initial city-wide study completed by UMA, and focus on identifying specific rehabilitation actions and the formation of an Action Plan. The final Plan contains approximately 70 rehabilitation projects (some of which are listed below). Infrastructure upgrades started in 2004 before the completion of the FRMP, and are scheduled for completion by 2050.

The projects themselves are designed to improve the storm water management capacity of Peterborough's infrastructure. Depending on location, function and projected flow patterns, selected infrastructure is upgraded to accommodate greater flows. Stormwater management infrastructure is upgraded to the current provincial standard, underground infrastructure is updated to accommodate a 5 year storm and all overland flow infrastructure will be retrofitted to accommodate a 100 year storm, with particularly vulnerable infrastructure updated to accommodate a storm of similar intensity to that of 2004. Examples of the proposed actions include:

- Diverting Jackson Creek which currently runs through the downtown core
- Retrofitting the storm sewer system in the Curtis Creek watershed to add more capacity and steer excess water away from developments
- Culvert replacements
- Upgrading overland flow channels and re-directing them to avoid development

Each year, municipal staff determine which of the listed projects will be undertaken given project prioritization as well as budgeting, human resources and to optimize interdepartmental synergies. To date, around 40 projects have been completed by the City, including those studies recommended by the FRMP, diversion projects, storm sewer retrofits and culvert replacements.

In addition to infrastructure upgrades, the City has offered financial incentives to encourage the disconnection of foundation drains from the sanitary sewer system, use of rain barrels and the installation of backwater valves in previously affected areas. The combination of concerted municipal and public action has resulted in improved resilience to flood events on both private and public property.

Flooding in Downtown Peterborough, 2004.
- Courtesy of City of Peterborough Emergency Management Division

[2] The 7 watershed areas were defined by the creeks that run through the city: Jackson, Bears, Riverview, Thompson, Curtis, Byersville/ Harper and North Meadow

[3] Several consulting companies were hired to conduct Peterborough's watershed assessments. These included: AECOM, Triple M Consulting, Greenland Consulting and XCG Consulting Group

PROCESS In the aftermath of the 2004 storm, municipal staff undertook an initial damage assessment to determine priority areas for intervention, and began emergency repairs to critical infrastructure. The projects recommended in the FRMP were prioritized by the consultants based on cost-benefit analyses. Once submitted, they were re-prioritized by the steering committee based on several criteria including: safety implications; development impact; interconnectivity with other municipal goals and projects; and projections of growth and development.

Upon its completion, the FRMP was endorsed by Council. Due to the severity of the recent flood, Council was very eager to accelerate action and the plan passed quickly without issue. At this time, Council also approved a long-term funding strategy, making flood reduction programming a municipal priority.

Once Council approval had been given, the City moved forward, commissioning numerous studies to fill data gaps and provide an adequate base from which to launch the Action Plan. These included:

- Complete environmental assessments and flow monitoring of the seven watersheds
- Storm and sanitary system survey and digitization of maps
- Digital elevation modelling to support environmental assessments
- Soils and groundwater study
- Inspection of storm and sanitary sewer pipes
- Survey of current watercourse management and maintenance plans
- City-wide policy review
- Emergency management and preparedness review

In 2010, using the information from these studies, the Technical Committee finalized the prioritized list of recommended actions. As the Action Plan progresses, the Technical and Steering Committee meet annually to determine the projects to be undertaken. The structure and participatory nature of this decision making process ensures that the projects' stormwater management improvement occurs in the most effective and efficient ways possible.

FINANCING In the immediate aftermath of the flood, emergency repairs were paid for out of the Ontario Disaster Relief Assistance Program. To implement the actionable items recommended in the FRMP and subsequent studies, a significant long-term funding source was required.

In 2005-2006, Peterborough City Council committed to providing $5 million annually to finance the needed improvements. Of this amount, $2.5 million was committed from existing property tax, with the other half raised through the Sanitary Sewer Reserve Fund (SSRF), a surcharge appearing on residential water bills. This funding is solely dedicated to accomplishing the capital projects that are listed in the Action Plan and will continue until their completion.

The FRMP also highlighted the inadequacy of former maintenance routines. Since the flood, operations budgets have increased as the City has devoted more resources to infrastructure maintenance. This has been accommodated through an increased municipal operating budget. Where needed, maintenance costs for sanitary sewer infrastructure are supplemented by the SSRF.

PARTNERS The process of upgrading an urban drainage network is complicated by the need to achieve buy-in from municipal and public stakeholders, and is dependent on both public behavioural change and municipal action to achieve success.

To achieve public buy-in, UMA held two rounds of public consultation. During the first round, public forums were facilitated in each ward of the City. The purpose of these meetings was to engage the public, using their experiences and input to determine vulnerability and identify feasible adaptation options. During this phase, all public recommendations were explored. In the second round of public consultation UMA and City staff highlighted the causes of flooding, results of the City-wide Environmental Assessment, and the proposed Action Plan with residential audiences. These latter forums provided an opportunity for municipal staff to field questions and provide details about the proposed actions.

At the municipal level, a Steering Committee was formed to ensure cooperation and input from council and staff. This Committee met monthly to discuss the progress of ongoing projects, prioritize projects and determine appropriate next steps. Members of this Committee included the heads of each Department and the Chief Administrative Officer.

Peterborough also formed a Technical Committee to advise the municipality on technical aspects of the Program; contribute to the identification and completion of secondary studies; and provide input on the prioritization of projects. This Committee included representatives from Environment Canada and Parks Canada, related Provincial Ministries, conservation Authorities, academic institutions and key municipal departments.

CHALLENGES The City encountered a number of challenges in the implementation of the FRMP. Some examples include:

Financing Though City Council has committed to providing long-term funding to complete the Action Plan, financing remains a significant challenge for the City. Several projects exceed the annual funding and must be stretched over longer terms. Additionally, because the projects are financed using tax dollars, they are dependent on a continued public commitment.

Public Perception After suffering damage from two recent flooding events, residents were distrustful of the municipal government. Impatience from the public was and continues to be an issue for municipal staff who encounter resistance from neighbourhood groups and individual residents. This condition is exacerbated by the fact that much of the retrofit work is conducted underground and it is therefore difficult to convince residents that change is occurring.

Location During the 2004 storm, Peterborough's downtown area suffered the majority of damage. It has been challenging for the City to repair and rehabilitate infrastructure in this area without a major disruption to local businesses and the resultant economic impact.

LESSONS LEARNED *There were several important lessons learned by the City of Peterborough throughout this process. These include:*

- **Public participation in a program of this kind is essential**. Not only can residents contribute to the identification of hazards and solutions, but some solutions, such as the commissioned studies and public forums, require public participation or funding.
- **Digitizing plans and blueprints for all infrastructure is helpful during restoration efforts after a disaster.**
- **Emergency management plans should be reviewed regularly to ensure they can address changing threats**.
- The formation of **Steering and Technical Committees can accelerate action** by allowing key partners to participate in the decision making process.

FURTHER INFORMATION

Citizen Participation in Flood Reduction Planning: Strategic Choices in Peterborough, Ontario
City of Peterborough Flood 2004 Fact Sheet
Flood Reduction Master Plan Progress Report
Peterborough Flood Reduction Master Plan

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