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The Use of Geographic Information Systems in the Development of a User-Pay Stormwater Utility in the Mimico Creek Watershed

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By

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A Thesis

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ABSTRACT:

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User fee systems are becoming increasingly popular at local levels of government. By shifting the burden from a tax and spend, to user-pay delivery of services, local governments are able to provide and manage local services with greater efficiency and accountability. A stormwater utility concept has been created for dealing with the often-expensive construction, maintenance, upgrading, and management of storm sewers and associated infrastructure. By examining the various user-pay systems for stormwater management, local governments and researchers can make a more informed decision on whether or not it is an appropriate method to raise revenues. The collection of fees is not based on consumption, as in many other public utilities, but on the property owner's contribution to the problem. Therefore, any user-pay stormwater utility must be easily understood and defensible to the general public. As well, the utility creation, administration, and management process can be aided by the use of a Geographic Information System (GIS). Data can be easily collected, stored, and analyzed, as well as be displayed in a way that is easy to understand, not only by the managers and analysts, but by the general public as well.

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Chapter 1: Introduction

This research examines the use of data extracted from Geographic Information Systems (GIS) in the establishment and management of a user-fee based stormwater utility in the Mimico Creek Watershed in the City of Toronto Ontario.

Stormwater management costs, along with other public works improvements, have traditionally relied on tax revenues for financing. This practice has faced increased resistance in recent years and the competition for available municipal general revenues has left such activities without adequate levels of funding. Concurrently, there has been a gradual shift in funding of many municipal operations from the property tax base to user fees in an effort to relieve funding pressures. The stormwater utility is an effective alternative to traditional financing for stormwater and stormwater infrastructure management (Hargett, 1992).

1.1 Stormwater Utilities Defined

The Stormwater Utility is an innovative concept, but one that fits well with the program needs in most local stormwater management operations. The functions and costs for effectively managing stormwater drainage are similar to those needed to provide water supply and sanitary sewer programs. Administrative, planning, design, construction, maintenance, replacement, and regulatory activities are quite comparable, particularly in terms of the long lead-time required for system development and the importance of preventive maintenance. Since water and sewer have been financed through service charges for some time, it is not surprising that drainage utilities and service charges have been implemented in the same basic format (Florida Association of Stormwater Utilities, 1998).

"Stormwater Utility" can have many meanings. The term may imply a funding and accounting method, an organizational approach, a management concept, or a combination of all these. In reality a "utility" provides an umbrella under which the financial, organizational, and management approaches of each local stormwater program can be structured to achieve practical and efficient solutions. Responsibilities may be consolidated and focused. Substantial new funding may be generated. New technology, different management concepts, and upgraded support systems may be adopted, and a comprehensive, preventive program may be instituted (Cyre H.J, 2000).

A stormwater utility is user-oriented, with, costs allocated according to the services received. For example, charges may be related to a given land parcel's stormwater runoff. Therefore, each parcel of land within a local government jurisdiction is assessed a fee based on its runoff characteristics. The user fee system may also be tailored to local goals and conditions such as soil types, depth to groundwater, land use and financial needs (Priede, 1990).

While demand for stormwater drainage service may not be as universal as demand for water, nearly all properties use the public drainage systems. Even properties, which are not directly benefited in the sense of protection from flooding, receive a service from the municipal operation of an adequate and properly maintained drainage system. Those on the top of the hill are provided with a system that safely carries their runoff water away, while those at the bottom of the hill are protected from possible hazards and damages that might occur if the system were not provided. Those in the middle are served in both ways. All residents and property owners are served when the drainage system prevents flooding of streets, parks and public facilities (Cyre, 1982).

The greatest difference between stormwater management and other utilities is in terms of the problem-solving emphasis. Because drainage programs exist primarily to respond to problems, user charges, which reflect a properties' "contribution to the problem", are the norm rather than ones that reflect service or benefit.

1.2 Stormwater Funding in the Past

Major Improvements to drainage systems have often proven to be the most difficult public systems to finance, both because of the low priority the public places on them (except during and shortly after storms) and the lack of truly suitable funding methods. Most of those, which have been built, were financed through the issue of bonds, or "bonding". Bonding is essentially a public borrowing method whereby money is obtained to pay for an improvement, equipment, and/or associated services (such as construction and management) and repaid in future years. It is somewhat analogous to the home loan mortgage method of financing housing.

Historically, most drainage system improvements financed through bonding have been General Obligation (G.O.) Bond projects, with repayment guaranteed by the credit of the City or Municipality issuing the bonds. This essentially means that all non-dedicated revenues can be used to pay the debt (Cyre, 1982).

Property taxes, local sales and business taxes, and utility taxes normally provide the bulk of general revenues. However, the value of property, value of goods and services purchased, and gross business receipts have little to do with how much a property or individual contributes to urban runoff problems.

Insofar as drainage is concerned, financing through General Municipal Funds tends to create an imbalance of costs in comparison to contribution to drainage problems, benefit or services received. The complexity of drainage problems makes it difficult to accurately define who pays a disproportionate amount or receives more in benefit than they may be paying. It is clear, however, that there is no measurable basis of equity inherent in General Fund financing of stormwater management

In areas where drainage has been organized and financed as an enterprise utility, capital improvements may be funded through "revenue" bonds. Such bonds are repaid primarily from the service charges; although other fees and charges can be allocated to pay off revenue bonds as well as, G. O. bonds (Cyre, 1982).

1.3 User Charges and Stormwater

User, or "service" charges are perhaps the most quickly growing component of municipal revenues. In the late 1970's, many local governments were caught between a rapid inflation of their costs and efforts to restrict taxing authority. (Cyre, 1982)

In this atmosphere, user charge and service charge financing began to appear in many areas of the United States and Canada for a variety of purposes. Government services that could identify direct users were naturally among the first to apply these concepts. Libraries established admission or checkout fees, more recreational facilities (such as swimming pools) began charging users a fee, and field rentals for organized sports were increased. Numerous other municipal services, which were previously provided without direct charge quickly, became user-financed to some extent (Cyre, 1982, Pioneer Valley Planning Commission, 1998).

The philosophy behind user charges for stormwater management differs from those for other services in several ways:

- Unlike water supply, for example, a measurable commodity is not delivered to the customer, the service provided is similar to sanitary sewers (or solid waste disposal) in that something is carried away and disposed of;
- The demand for the "service" is not comparable to the demand for water supply, since most properties drain onto downhill neighbors fairly effectively without any public system. A broader definition of benefit resulting from service is needed in the case of drainage then for most other utilities.
- Finally, drainage programs are more oriented to solving or mitigating problems than are the other utility functions, which have focused on providing service to clients.

These differences are not as serious as might first be thought, however. Excepting most unusual circumstances, sanitary sewerage and garbage are not measured quantitatively to determine individual charges. Rather, sanitary sewer charges are often based on water consumption, and garbage rates on the number of cans or bags used rather than kilograms and type of refuse.

One of the purposes of utility user charges and rate structures is to attempt to equitably distribute the costs of the utility program. It has been recognized that charging in relation to each property's role in creating the problems is as equitable as charging for service or benefit.

Industrial and other dischargers who produce effluent requiring unusual treatment may bear the cost of solving that problem by paying more for treatment or even pre-treating the wastes before they are discharged into the public sewer.

Revenues derived from service charges can also be used to pay for administration, planning, design, operations and maintenance, revenue bonds for new construction and replacement of old systems, support services, regulatory functions and virtually anything else required In a drainage program, rate structures are flexible mechanisms that enable a municipality to tailor the cost distribution to fit the local program and be consistent with other local policies. As well, drainage utility revenues remain in the utility fund if not spent, rather then reverting for redistribution in the next year's budget, an important factor in long-term program stability (Pioneer Valley Planning Commission, 1998).

The challenge lies in conveying to the property owners that they are in fact getting something in return for the fees that they are being charged. It must be made clear to them that by paying to upgrade and /or maintain the storm sewer, they will be getting protection from flooding, as well as improved water quality in the receiving waters.

It must also be clear to the property owners how they are being charged, or if they can make improvements or modifications to their properties in order to pay a reduced fee.

1.4 Research Objectives and Scope

The objective of this research is to examine various user- pay systems for stormwater utilities, and determine the most feasible user pay system for the Mimico Creek Watershed.

The user pay systems that will be examined will include: a user pay system based solely on impervious lot area; a user pay system based on scientifically determined stormwater runoff coefficients; a user pay system based on the percentage of impervious area or development intensity of each lot; and, a user pay system based on runoff factors for both pervious and impervious area of each lot.

There are also factors that must be considered other than the fee calculation method for a user pay stormwater utility. These are factors such as: flat fees for stormwater runoff; development charges; user fee credits and exemptions.

Table 1.1 Description of Calculation Methods

Calculation Method	*Equivalent Residential Units*	*Rate Factor or Runoff Coefficients*	*Percentage of Impervious Area*	*Combined Charges*
Description	This method divides each property to be charged into units (ERUs), or fractions of units, based on the amount of impervious area on each property	This method uses a Scientifically determined runoff coefficients or rate factors in combination with gross property area	This method takes the percentage of impervious area on each property and divides each property into classes based on the % imperviousness	This method looks at both the amount of impervious and the amount of pervious area on each property to calculate the fee
Rational	The unit (ERU) is based on the average lot size for the municipality or service area, making this a context sensitive and flexible method for fee calculation	The runoff coefficient takes into account impervious as well as pervious area on the property for fee calculation	This method allows properties to be easily grouped together and assigned a charge per property or per square meter of property	The combined charges method takes into account that runoff occurs from pervious as well as impervious area, and assigns a charge based on both factors to each property

1.5 Context

Heavy rainfall events in the City of Toronto contribute to flooding, increased soil erosion and damage to natural habitat(s) in surrounding rivers and in Lake Ontario. In response, the City of Toronto is developing a comprehensive plan to manage the problems caused by wet weather. The City initiated work on the Wet Weather Flow Management Master Plan (WWFMMP) in 1997. Implementation of this plan is expected to play a major role in removing risks to human health and restoring the health of the surrounding environment, while contributing to public safety and reducing property damage.

The development of five Wet Weather Flow Management Strategies one for each of five study areas throughout Toronto, see Figure 1.1 on page 10.

The City is using a hierarchical approach to evaluating the various options:

- *At Source*: First, examine how to deal with stormwater where it falls.
- *Conveyance*: Next, deal with stormwater as it is being transported across the city.
- *End-of-Pipe*: Finally, deal with stormwater and combined sewage before it is discharged into our streams, rivers and Lake Ontario, (City of Toronto website, date unknown).

Although not specific to the City of Toronto Wet Weather Flow Management Master Plan, some examination into wet weather flows and stormwater management in the Mimico Creek watershed has been completed. Li and Banting (1999) used a Geographic Information System (GIS) to identify stormwater retrofit opportunities and implementation strategies in the Mimico Creek watershed. Various stormwater retrofit strategies/opportunities on the three hierarchical levels identified above were discussed, and their locations identified through the use of a GIS. Li and Banting then completed an economic evaluation and costing exercise on each of the selected alternatives in their proposed locations throughout the watershed area.

The scenarios highlighted by Li and Banting looked at a combination of: Downspout disconnection; Oil grit separators; Stormwater Exfiltration systems; and, New Quality Ponds. Detailed maps from this study can be found in figures 1-2 to 1-5 on pages 11 to 14. The costs of this scenario are calculated to be $10, 030, 738 over 25 years, with a solids removal efficiency of 32.5%.

This thesis will examine and various user-pay systems that could be used to pay for the stormwater retrofits proposed by Li and Banting (1999).

1.6 Outline

The following chapter is a review of the literature relevant to stormwater utilities, stormwater runoff, municipal user fees, and how Geographic Information Systems can be used to assist in formulating and developing policy.

The following chapters will examine the four different fee calculation methods (described above) in detail. For each of the calculation methods, data and technical requirements, water quality issues, implementation issues, and public understanding is examined.

The final chapter examines the four fee calculation methods in the context of the Mimico Creek Watershed. Each method will be evaluated and a single optimal or 'best' method will be selected for use in a stormwater utility. Evaluation is done on the data requirements, overall ability to raise revenues, and fairness to users.

Figure 1-1 Study Areas for City of Toronto's Wet Weather Flow Management Plan

(Adapted from City of Toronto Website
http://www.city.toronto.on.ca/wes/techservices/involved/wws/wwfmmp/planning.htm)

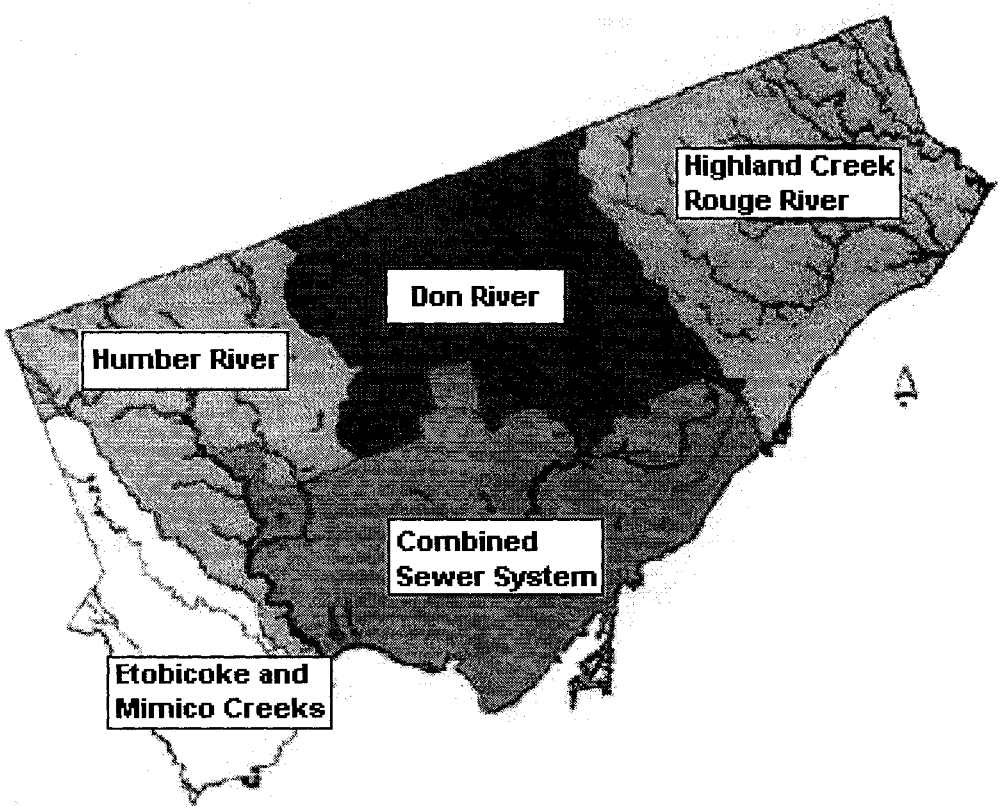


Figure 1-2 Mimico Creek Soils Map *(Adapted from Li and Banting, 1999)*

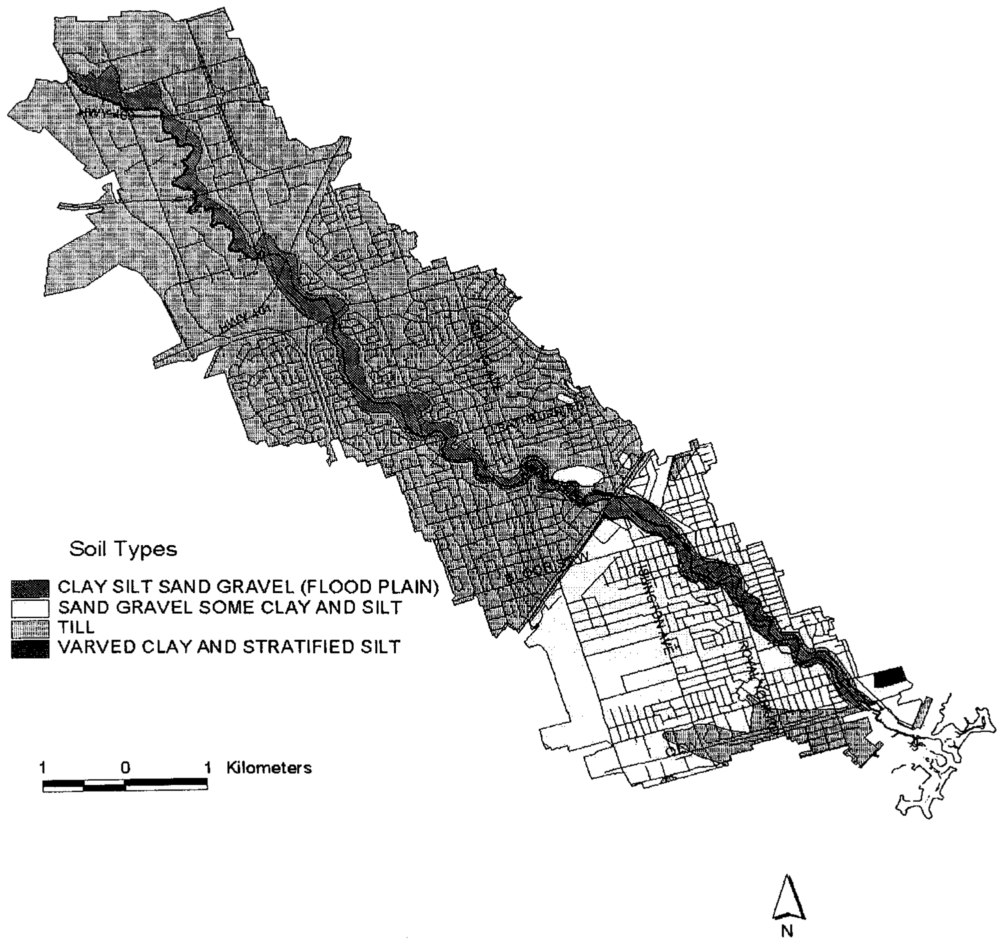
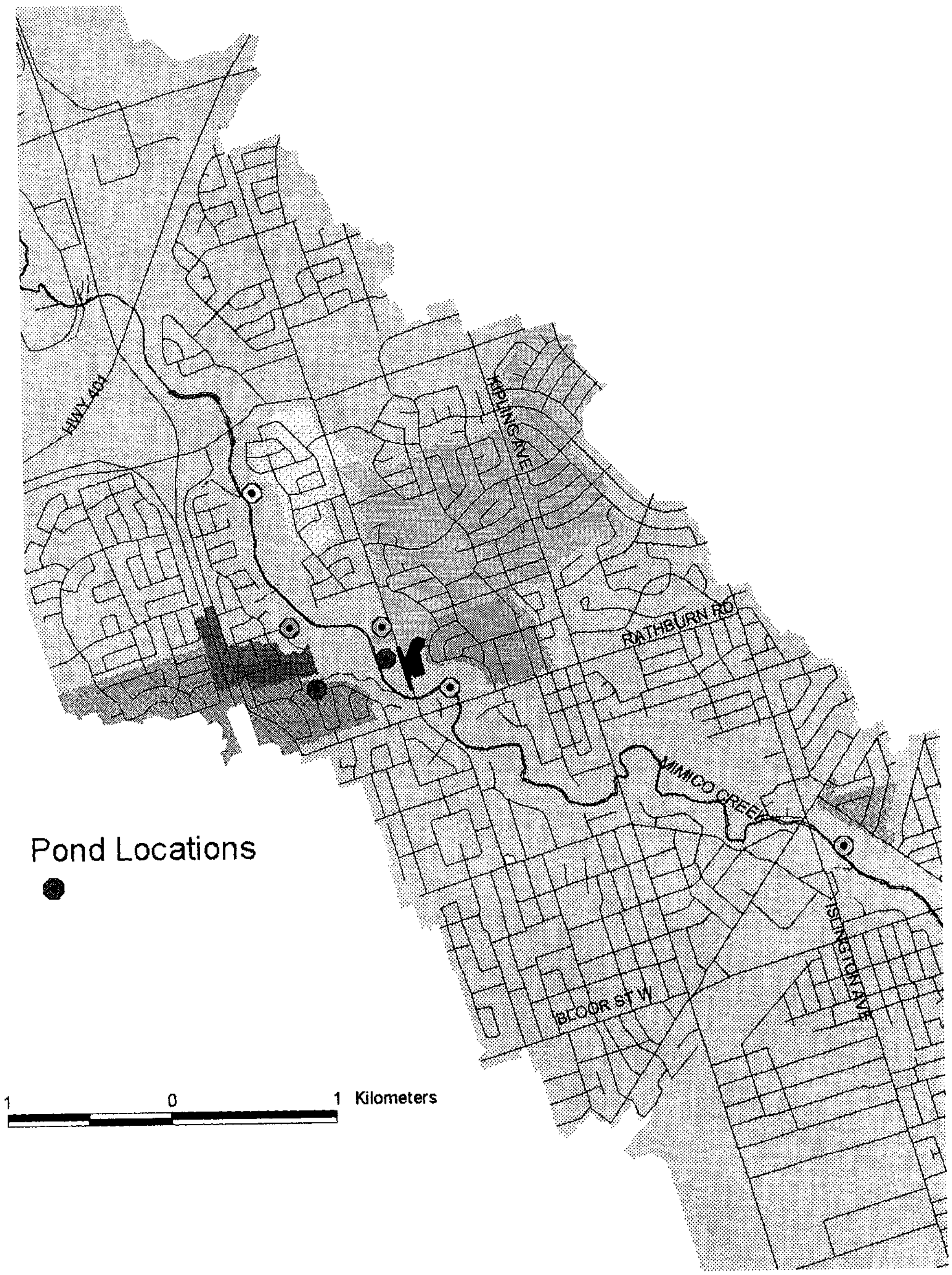


Figure 1-3 Mimico Creek Land Use Map ***(Adapted from Li and Banting, 1999)***

Figure 1-4 Mimico Creek Areas Suitable For Downspout Disconnection (Adapted from Li and Banting, 1999)

Figure 1-5 Areas Suitable for Stormwater Treatment Pond Construction (Adapted from Li and Banting, 1999)



Chapter 2: Literature Review

The United States Environmental Protection Agency (EPA) has examined the issue of user fees, and the public response to them. In the paper, *Building Support for Increasing User Fees*, (EPA Office of Water, Publication 430/09-89-006), the EPA regarded the issue of user fees not being used simply as another way to collect revenues from the public, but as being part of an overall management plan or system from which the public benefits. The paper recognizes that public education and understanding make it much easier for policy makers to set and/or increase user fees as may be necessary provided that the public is kept informed about the issues. The paper does not suggest any particular methods for conveying the information, or provide any examples of how user fees are implemented or made part of a management plan or system.

Another way to view public acceptance for user fees is suggested by Robert Collinge (1997); this paper, the author discussed policy instruments available to governments and regulatory bodies when charging the public for the use of common property resources. The suggested mix of policy instruments in this paper included user fees and some form of rebate. This mix would allow the policy maker to use market signals through willingness to pay, as well as give the public a chance to control how much they pay, through the rebates offered. It was suggested that the public will be more accepting of user fees by being involved in determining exactly how much they would be charged.

The Hickling Corporation (Division of Economics and Policy, 1992). The authors discussed several Remedial Action Plans for the Great Lakes Area, and some of the options available for funding. It was suggested that economic evaluations of each of the remedial action plans should include an examination into the various revenue streams that the remedial plan may receive. These revenue streams might include instruments such as transfers from higher levels of government, and charges from those who are directly involved in the remedial action plan, (those involved in the remedial action plan would be polluters, or those who receive benefit from the remedial action plan being in place). The authors also suggested that such a system of transfers and/or charges should be able to fully recover the costs of the remedial action plan. The authors also made the point that in any funding mechanism that was derived, particularly a user pay/beneficiary pay, there might be some difficulties in arriving at a dollar value for the benefits received, and how to distribute those costs.

In summary, when examining the issue of user fees, particularly for common property resources, the concepts of public education, public control, and fair determinations of user fees must all be kept in mind if the public is to willingly accept user fee systems. As well, the utilities setting the fees must ensure that they can raise the proper amount of revenues, and that the property owners or rate payers are kept informed as to any increases or opportunities for decreases in the fees being charged.

Aside from a policy tool for cost recovery, user fees can also be seen as providing a deterrent for polluting or using a certain service. Kinnamen and Fullerton (2000), examined user fees associated with local garbage collection in the United States. Through a survey of US municipalities, the authors concluded that user fees do in fact reduce the amount of garbage produced per household, (the authors acknowledged that illegal dumping might be taking place however). The authors also make it clear that local municipal user fees could often better represent the ability of the constituents to pay.

The idea of user fees deterring pollution or use of a facility is re-enforced by Hockett et al. (1995). In this paper the authors surveyed 100 counties in North Carolina and found that by levying increased tipping fees on garbage disposal, residents and businesses reduced the amount of waste generated. The authors also indicated that user fees might have varying success depending on the type of land use that they were targeted towards, in the case of this study it was retail eating establishments. The authors found that the larger the establishment, and the greater the retail sales, the greater the impact a tipping fee might have on decreasing waste generation, presumably because they were the establishments creating larger amounts of waste, and therefore paying higher fees.

The user fee as deterrents for pollution idea appears to be valid. There are issues of illegal activity that may begin in response to a fee, or an increase in fees that would need to be addressed. It is likely however, that this would be dependent on the type of user fee being implemented. It is also clear that the actual dollar amount of the user fee may have a positive or increasing effect on the amount of pollution that is prevented.

With regard to user fees as a pollution reduction specifically for stormwater management, Elliot (1998), highlighted several options for stormwater management and treatment in the City of Christchurch New Zealand. The author choose to focus on stormwater management ponds as a method of stormwater quality improvement, and found that, while effective at improving the quality of the water discharged, the ponds by themselves could contribute little to the overall improvement of sediments in streambeds and pond outflows without other controls. The author concluded that the best way to improve both water and sediment quality of any receiving waters was quite simply source controls and reductions. In the case of stormwater quality, it would be the landowners in the watershed who, possibly through user fees, could improve the quality or reduce the quantity of stormwater running off of their property.

Apogee Research International (1991) discussed the complexities in the management of urban stormwater and also demonstrated that source controls were the most promising option for the reduction or improvement of stormwater in urban environments. The author also discussed some of the other advantages of the user-pay approach to stormwater management. Some of the benefits were that (re-enforced by previous works reviewed here): user pay systems tend to be a politically and publically more acceptable way to raise new revenue; user charges provide a predictable stream of revenues which would allow for longer term planning; and, that user fees can create a demand incentive by allocating costs according to contribution to runoff volume.

Combining some of the concepts discussed above, Cameron et al. (1999) provided an examination into the considerations noted when considering a user-pay stormwater management system, in this case, for the City of Ottawa in Ontario Canada. The work provided a legislative overview for Ontario municipalities and found that under the Municipal Act, municipalities would have the powers necessary for implementing such a user-pay system. The authors also introduced the idea of 'Best Management Practices' (BMP's) in the stormwater utility. The BMPs are thought to be a way in which the residents and ratepayers can influence the amount that they are charged, as well as improving the quality and reducing the quantity of stormwater that runs off of their property.

In order to gain the benefits of a stormwater utility, one must first be developed for the area in question. The Task Force on User-Fee-Funded Stormwater Utilities (1994) provided a step-by-step method for the creation of a user-fee-funded stormwater utility in the United States. Included in this publication were the reasons for the creation of a utility, most of which were mentioned above. As well, the paper addressed some of the other more practical considerations in creating a stormwater utility such as: (1) the set-up and management of utility itself including the management and engineering of the utility; (2) the ways in which the public should be involved, such as the information that should be shared with the public, and the various aspects of the operation and maintenance of the utility that they can be involved in; and, (3) the rate setting structures that have been used in the past, including information on setting, charging, and collecting the revenues for the utility from the users.

The authors also provided several case studies from around the United States and the ways that they were able to implement user charges for the stormwater utility without the charges being viewed simply as another tax.

Brown (2002) discussed the design, implementation and administration of a stormwater utility in the City of Columbus Ohio. The author provided a great level of detail into the day-to-day management of the Columbus stormwater utility, including details about system repairs and system upgrades to staff remuneration levels. The author then discussed the rate setting structure used by the utility in Columbus as well as the revenues generated by the charges. This discussion included how the City implemented a past rate increase and the fact that the utility had surplus revenues in past years. The author also mentioned the fact that the City of Columbus used a discount rate, meaning that, residents could reduce their monthly charge by reducing the amount of stormwater runoff from their property through source controls and 'best management practices'.

Lindsey (1990) discussed other issues that a stormwater utility may encounter after implementation. The author examines issues related to the equity of user pay stormwater utilities, and identified the fact that stormwater user charges were in general politically more acceptable than higher taxes. It is also found that user fees (as opposed to tax increases) might produce a greater benefit for some land uses in an urban area, in this case residential properties, and might be more costly for industrial, commercial, and agricultural land uses.

Glen-Marie Lange (1998) introduced the concept of value added to water resources, that is was through proper allocation and management practices; an organization would actually add value to water resources in a geographic area. The author also distinguished between two types of consumers of the 'value added' resource; those who would afford to pay the full cost (including value added), and those who would only afford the initial cost of the resource (before the value added stage).

In conclusion, it becomes clear that issues of equity in fees will arise in the implementation of a user fee system, particularly in common property resources where there is no single owner or beneficiary. The management of a utility will have to keep the possibility of inequities in mind whenever fees are levied or changed. They could however address these inequities using a credit system or fee reduction mechanisms as discussed in some of the cases above.

Establishing a stormwater utility, or any utility for that matter, requires a means for gathering and maintaining information. This information can be used for designing management strategies as well as for cost estimates and rate setting. One way to collect, analyze, and manage the amount of information needed for a stormwater utility would be through the use of a Geographic Information System. Li and Banting (1999) used a Geographic Information System (GIS) to identify stormwater retrofit opportunities and implementation strategies in the Mimico Creek watershed in the City of Toronto. Various stormwater retrofit strategies/opportunities were discussed, and their locations identified through the use of a GIS. The authors then completed an economic evaluation and costing exercise on each of the selected alternatives in their proposed locations throughout the watershed area.

As well as retrofit opportunities, a Geographic Information System can be used to identify other opportunities for stormwater treatment and control. Kim et al. (1993) also advocated the use of a Geographical Information System (GIS) for the purposes of stormwater management. GIS was used in this case to model the flows of stormwater after rain events, and to estimate pollutant loading from various land uses in an urban environment. The authors used a very rigorous land use classification system (18 classes in total), which aided in the demonstration of a GIS as a tool for the identification of pollution sources, and a way to manage and reduce those sources (or their contribution to stormwater pollution). The authors, however, looked at stormwater management only from a land use perspective, not from an individual lot or property perspective, (this is however mentioned as a topic for future investigation).

Another example of the opportunities available using a GIS for stormwater management and pollution analysis was identified by Ha and Bae (2001). The authors combined Geographical Information with LANDSAT images for the analysis of land use changes and their effect on stormwater quality along the Han River in Korea. Along with the changes in land use (land use in this case was agricultural or developed urban land uses), the authors also examined the effects of a wastewater treatment plant on the watershed area using a GIS as well. By combining two types of information (LANDSAT images and vector data) the study demonstrated the effectiveness of GIS as a large-scale stormwater quality analysis tool.

The issue of scale is raised in several of the works reviewed above. Clearly this is where using a Geographic Information System is of great benefit to a stormwater utility manager. The GIS allows the manager to look at the utility from a watershed point of view, all the way down to a single lot or property. Also, the types of data that can be combined in a GIS, such as satellite imagery, and land use data make it a very useful and powerful tool for present analysis and forecasts for future needs or issues.

As well as land use analysis, a Geographic Information System can be used to study the actual utility systems and infrastructure itself. S Djordjevic et al. (1999), highlighted the technical capabilities that Geographic Information Systems could offer to decision makers. Using a 'dual drainage' model inside a GIS, the authors showed how urban stormwater flows could be traced both above ground and in the sewers. This modelling technique was demonstrated to be very useful for planners and engineers who might be looking for areas in a sewer system that might need upgrading or repairs, as well as simple monitoring of stormwater flows. Although the authors demonstrated that the method was a very useful tool, it was also highly technical and would certainly require specialized training and education. Also, the method is much more of an analysis method than a management method, and therefore may find limited use in local decision-making.

As well as examining at flows of water, a Geographic Information System can also be used to study chance events and the transport of pollutants in sewer and storm water flows. In a paper by Wennberg et al (1998), shows that by combining a Geographical Information System with another analysis tool, (The MOUSE system), urban flood modelling and pollutant transport can be done for emergency preparedness planning. The MOUSE system (developed by DHI Water and Environment) is a package capable of computing water levels, drainage pipe flows, and, in conjunction with a Digital Elevation Model, can be used to identify urban areas that may be susceptible to flooding. Also, the MOUSE system, again in conjunction with a GIS, could be used to model advection and dispersion of pollutants through a sewer system. Similar to other methods that can be used in conjunction with a GIS for stormwater and sewer planning the method that the authors highlight in this work was a highly technical and specialized method, which would require specialized training and skills to use.

Hromadka II and Yen (1996) concluded that a Geographic Information System be used for stormwater management and analysis. The authors used a Geographic Information System to create a series of map layers that could be used in the modelling of stormwater quality in urban areas. The authors introduced the idea of pollutant recovery periods (defined as the time period in days wherein a pollutant accumulates from 0 to its maximum build up), pollutant build up rates (defined as the reciprocal of the pollutant recovery period), total pollutant wash off runoff amount (the runoff amount that will provide a 100% wash off of pollutants), and pollutant wash off rates (the reciprocal of the total pollutant wash off runoff amount) as part of a stormwater management plan. The authors however gave little information as to how a GIS could be used to model stormwater processes, only that GIS was a compliment to any stormwater management planning process.

While the technical capabilities of using a Geographic Information System for stormwater management are widely agreed upon, there are some other issues regarding GIS that should be addressed. Sussman (1997) highlights the often-difficult time that organizations might face when trying to implement a Geographic Information System (GIS), into an existing administrative and organizational structure. The author also concluded that the larger the organization, the more difficult the transition might be. This may support the creation of separate administrative bodies for utilities and/or new initiatives. The author also highlighted the benefits of a GIS in an organization. These benefits were thought to be a move from a retroactive decision-making (action than decision), to a more rational (decision than action) model. Also, the introduction of a GIS in an organization, particularly a municipal government, allowed for scenario testing of new policies and initiatives, as illustrated in the works reviewed above.

Chapter 3: Methodology

During the course of this research, a number of different calculation methods for stormwater user charges were explored. While the calculation methods vary, the data used for each of the calculations were from the same source. Also, within each of the calculation methods, certain features and consequences of each method were examined. This chapter introduces the data collection methods, as well as indicates how the features of each of the following chapters are important for the evaluation of a stormwater fee calculation system. There is also an examination of where fee calculation fits into the overall process of designing a stormwater utility. For the purposes of this research, it was assumed that a stormwater utility is considered to be a viable option.

3.1 Evaluation of Stormwater Management Options

This project requires a systematic process to review and model the effects of stormwater management options. This process must take into account costs, data requirements, and relationships among data, scenario modeling, and scenario outcomes. As well, the process must keep in mind the intended outcome (s): social equity vs. revenue maximization vs. data collection, management and calculation effort. There must also be room in the process for review and feedback loops. This process is indicated in Figure 3.1. on Page 27

The steps to be followed are as follows:

3.1.1 - Step 1: Decide an Approach

- What is the desired outcome of the stormwater management policy?
- What is driving the policy?
    - Cost recovery?
    - Environmental goals?
    - Political or ideological goals?
- Are top-down (government or municipal driven) or bottom-up (community driven) management and design approaches more appropriate?
- What will the planning scale of the stormwater management project/policy be?

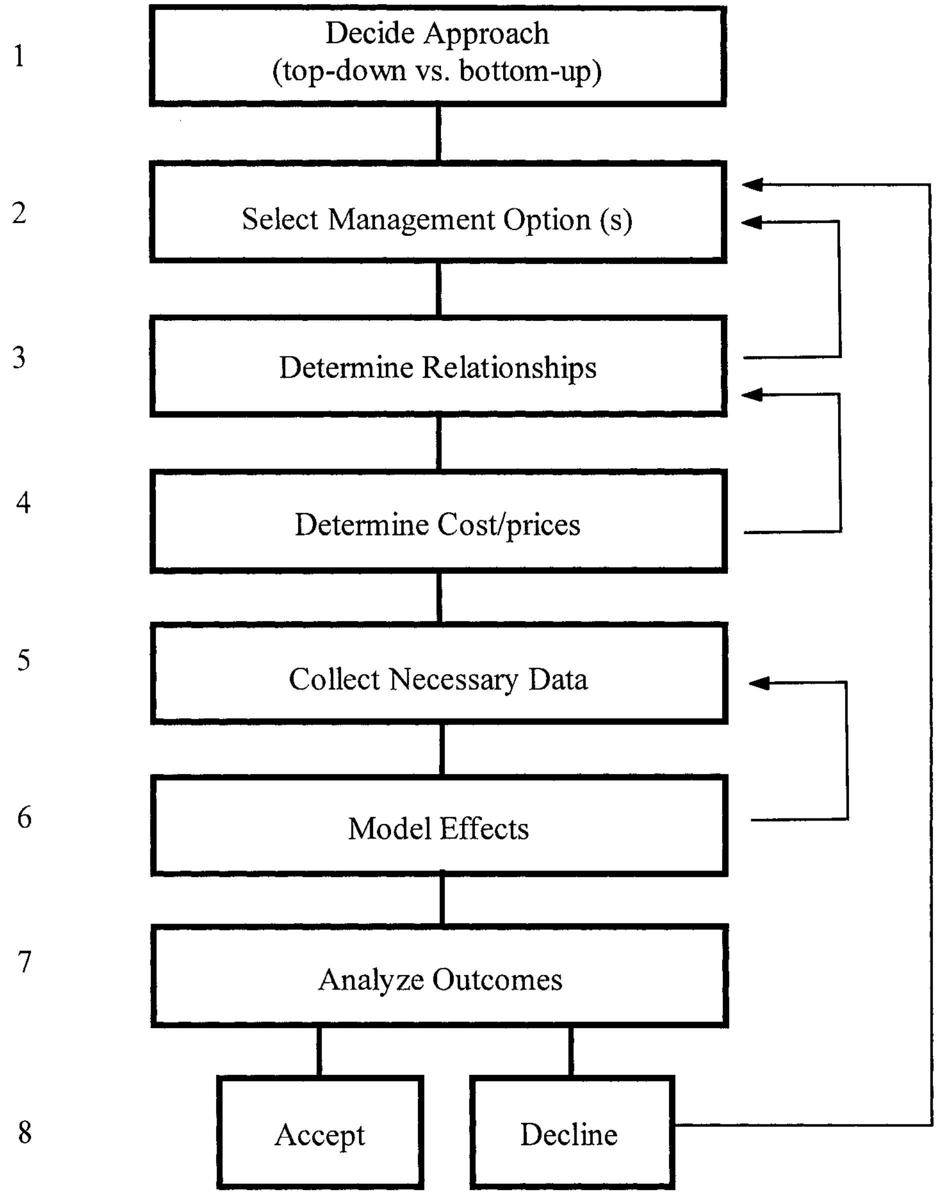
In the case of Step 1 in this model, the questions have already been answered as part of a previous study (Li and Banting, 1999). The desired outcome of the stormwater management policy is water quality improvement through capital improvements. The driver is the City of Toronto's desire for cleaner lake water through cleaner stormwater discharges. The approach being taken in this case is top down, as the City of Toronto Government is driving it. The planning scale in this case is the Mimico Creek Watershed within the City of Toronto.

3.1.2 - Step 2:Select Management Options

- What is the best management option to be pursued?

Is there more than one option that may be able to achieve the management goals?

Figure 3-1 - Stormwater Utility Analysis Framework



The possible management options that have been outlined by Li and Banting (1999) are as follows:

1. Roof Leader (downspout) disconnection
2. Oil Grit Separator(s) and/or Water Quality Inlets
3. Stormwater Exfiltration Systems
4. Road Ditches
5. Quantity Pond Retrofits
6. New Quality Ponds
7. Stormwater Quality Tanks/Tunnels
8. Flow Balancing Systems

This research examined two different scenarios, using two different sets of management options. This was done in order to demonstrate the degree to which stormwater treatment costs and the resulting user fees could vary.

The first of the scenarios looked at a combination of: Downspout disconnection; Oil grit separators; Stormwater Exfiltration systems; and, New Quality Ponds. This is the original plan for stormwater management improvements in Mimico Creek completed by Li and Banting (1999). The costs of this scenario are calculated to be $10, 030, 738 over 25 years, with a solids removal efficiency of 32.5%

The second scenario is being done only for illustrative purposes and will include all of the management options selected by Li and Banting (1999) above, but will also look at servicing all industrial lands in the Mimico Creek Watershed with Stormwater Quality

Tanks and Tunnels. The costs of this scenario are calculated to be $94, 832, 613 over 25 years, with a solids removal efficiency of 40.32% (all figures derived from Li and Banting, 1999).

3.1.3 - Step 3: Determine Relationships

A decision matrix (similar to Table 3.1 below) could be used to determine relationships between policy option(s) and lot level data. In this example, the horizontal axis of the matrix contains policy options/management strategies, and the vertical axis contains lot level data that would need to be collected.

Table 3.1 - Stormwater Utility Decision Matrix (example)

	Volume Reduction	Pollutant Reduction	Infrastructure Maintenance	Capital Improvements	Flow Modelling	Cost Recovery	Other Goals...
Lot Size m^2	✓	✓	✓	✓	✓		✓
Land use		✓	✓	✓			
% Impervious				✓			
Industry Type				✓			
Building Age				✓			
Soil Type				✓			
Tax Rates				✓			
Vegetative Cover %							
Downspout Disconnection				✓			
Property Value				✓			
Household Income				✓			
Other Variables...				✓			

Lot Level Data (Vertical Axis)

- Data should be easily measurable and understandable;
- Requirements will vary depending on policy option or management strategy;
- The Process may require explanation to the general public;

- Data must be accurate and precise as fees will need to be calculated based on them.

Policy/Management Options (Horizontal Axis)

- Options need to be clear in their overall objective(s)
    - In the context of this research, objectives could be stormwater quality improvement, quantity reduction, a cost recovery exercise for the municipality, or to sustain a certain level or quality of stormwater management practices;
- Options do not need to be mutually exclusive, more than one option may be necessary at one time
- Option costs ($) will need to be kept in mind

- Identification any data needs that may not be already in decision matrix
- Review of management options

As can be seen from the checkmarks in the decision matrix, there are a large number of possible options available to decision makers. The selection of the *Capital Improvements* policy option involves an examination of: lot size, land use, % imperviousness, industry types, building ages, vegetative cover, whether or not downspouts have been disconnected, the property value (for taxation purposes), and household incomes (for ability to pay user fee purposes), and probably many more. It can also be seen that by selecting the *lot size* as a factor in the management plan, there are other management goals that can possibly be achieved or influenced than just Capital Improvements. Lot size (as well as other data) can influence flow modeling, stormwater quantity reductions, stormwater quality improvements, and infrastructure maintenance policies as well.

3.1.4 - Step 4: Determine Costs/Prices

Determining costs of policy options is perhaps the most difficult stage of the stormwater utility development process. In order to accurately determine the costs and prices associated with a policy option, decision makers would have to consider the following:

- Determine the total costs (both time and money) of the policy selected, given the planning scale and time frame;
- Determine any combinations of technologies that may be required to achieve the selected policy option;
- Determine how fees can be calculated for the users (property owners in this case) given the policy option selected and the cost of the lot data that need to be collected;
- At this step in the process, a review of the lot-policy relationships may be necessary if there is any difficulty in determining fees/pricing.

For this research, the costs of each of the technologies over a 25 year planning period have been estimated by Li and Banting (1999) and are as follows:

- Roof leader disconnection will cost $429, 000
- Oil Grit Separators will cost $1, 327, 000
- Stormwater Exfiltration Systems will cost $7, 321, 000
- Stormwater Quality Ponds will cost $953, 000
- Total cost will be $10, 031,000 over 25 years, with a solids removal efficiency of 33%

For the second scenario that is to be explored, the additional technology, Stormwater Quality tanks and Tunnels will add another $84, 802, 000

- The costs of this scenario are calculated to be $94, 833, 000 over 25 years, with a solids removal efficiency of 40%

There are also the administrative and operating costs that would be associated with the stormwater utility. Administrative costs are those costs associated with billing, customer services, and database maintenance. The total administrative costs are estimated to be $14.46 per property per year, adding up to a total of $317, 064.42 per year, or $7, 926,610.50 for 25 years. These costs were arrived at by taking the average administrative costs for 11 stormwater utilities in the United States in 1988. These amounts were then brought to present value using an 8% discount rate, and converted into Canadian dollars using a 40% exchange rate.

The final series of costs to be addressed are the implementation costs. These are one time costs for the set up of the utility. Data collection, consultant reports, and computer and other support systems are a part of this cost. These are estimated to be $86.48 per hectare, or $337, 917, 10 in total. This cost was taken from Hargett (1992). Costs were originally given in U.S. dollars and converted to Canadian dollars using a 40% exchange rate, and brought to present value using a 8% discount rate.

With administrative, implementation, and capital costs taken into account, the total costs for Scenario 1 (that scenario proposed by Li and Banting) would be: $18, 295, 265.60. The total costs for Scenario 2 (the hypothetical scenario for this work) would be: $103, 097, 140.60

3.1.5 - Step 5: Collect Necessary Data

Once the initial policy options and plans and the associated costs have been established, decision makers will want to see the effects of their choices modelled before they commit to a course of action.

- An inventory of existing datasets will need to be completed to ensure that the policy-lot relationships can be modeled, and fees calculated;
- Any data that may be needed to carry out scenario modeling will then need to be collected;

For this project, the data sets had already been collected by Li and Banting (1999), and were readily available.

- The data were collected and prepared for use with the GIS package Arc View, and City of Toronto Records.
- Orthophotos of the selected areas were examined to help determine the total amount of impervious area of each property. In this project, the measure of imperviousness for each property was defined as the building envelope only.
- The building envelopes were traced as polygons on a separate layer. Arc View was then used to calculate the area of the polygons. For a demonstration of this method see Figure 3.2 on Page 34.

Figure 3-2 - The Use of Orthophotos for the Determination of Impervious Lot Area

3.1.6 - Step 6: Model Policy Effects

It is at this point in the Stormwater decision process that is the focus of this work. The costs of the capital improvements are assumed to be recovered through the formation of a user fee based stormwater utility. The types of user fee systems and calculations examined were:

1. Equivalent Residential Units;
2. Runoff coefficients;
3. Intensity of Development; and,
4. Total Land Area.

For each of the fee systems, 15 different properties were selected at random from the Mimico Creek Watershed. This was done in order to give examples of actual fees that different properties with different attributes might be subject to under the 2 scenarios described above.

Also, the total amount of fees collected will be calculated for each fee structure over 25 years. This was done in order to give an idea of exactly how much revenue could be raised for the Mimico Creek Watershed using these calculation methods.

3.1.7 - Step 7: Analyze Outcomes

To analyze the various outcomes, there needs to be a number of criteria examined for each fee calculation method.

The criteria to be looked at for the calculation methods is as follows:

- The data requirements for each method;
- The ability for the public to understand the fee calculation method;
- How the method deals with undeveloped properties and open space;

- How the calculation method addresses the issue of water quality;
- The measures necessary for implementation of the fee structure;
- The technical accuracy that can be achieved from each method;
- How flexible the method is; and,
- Opportunities for fee reductions and credits within the fee calculation.

These criteria were selected in order to give a good illustration of each method and provide an understanding of how each fee calculation method may work.

3.1.8 - Step 8: Comparison of Scenarios

The advantage of using a GIS for stormwater management modelling is that a large number of scenarios can be modelled in a short period of time (providing that data exists to do so). Therefore, it becomes possible to compare the scenarios and their outcomes to one another.

The considerations that are taken into account when asked to compare the scenarios are as follows:

Consideration 1: Data Needs

- What is the total amount of data necessary to carry out the scenario?
- How precise do the data have to be?
- How much will the data cost (Time and dollar costs)?

Consideration 2: Fairness/Equity

- Who pays for the management/fee option?
- Who benefits from the management/fee option?
- What are thought to be the redistributive effects of each option?

Consideration 3: Ease of Implementation

- How many households in total will be affected by the policy?
- How many capital improvements are necessary? And, How much will they Cost?
- What is the expected time frame for implementation?
- How flexible are these values?

Consideration 4: Certainty of Goals

- How easy is it to measure the success/failure of the management option?
  - How long will it take for an accurate measurement?
  - What are the indicators necessary for an accurate measure?
- Are the revenues required for the option available?

Consideration 5: Would the Option be Worthwhile?

- How much will the option cost?
- What will the fee (or range of fees) for the user be?
- Is a user fee the best option for this management option?

3.1.9 - Step 9: Accept or Reject

- If one or more outcomes are acceptable and practical, it will be accepted and implemented
- If all outcomes are rejected, management options should be reviewed

It is not expected that the questions in each stage will be systematically answered in the comparison of each of the scenarios. This is due to the fact that different decision makers may look for different attributes to arrive at their final decision. The questions above should however, serve as considerations to support a comparison of alternate management/user-pay fee systems.

3.2 Data Quality and Geographic Information Systems

When dealing with any dataset, the possibility of error is always an issue. Using a data set with errors or missing data can lead to questionable or even false conclusions for the researcher. In Geographic Information Systems, data errors can occur in many places. The potential for reducing errors can begin with looking at the dataset in the context(s) of accuracy and precision.

Accuracy is the degree to which information on a map or in a database matches true or accepted values. Accuracy is also an issue pertaining to the quality of data and the number of errors contained in a dataset or map. In discussing a GIS database, it is possible to consider horizontal and vertical accuracy with respect to geographic position, as well as attribute, conceptual, and logical accuracy.

Precision refers to the level of measurement and exactness of description in a GIS database. Precise locational data may measure position to a fraction of a unit. Precise attribute information may specify the characteristics of features in great detail. It is important to realize, however, that precise data--no matter how carefully measured--may be inaccurate. Surveyors may make mistakes or data may be entered into the database incorrectly. The level of precision required for particular applications varies greatly. Engineering projects such as road and utility construction require very precise information measured to the millimetre or tenth of an inch. Demographic analyses of marketing or electoral trends can often make do with less, say to the closest zip code or precinct boundary.

It should be noted that, high precision does not indicate high accuracy nor does high accuracy imply high precision (Foote et al., 1995).

3.3 Types of Errors in Geographic Information Systems

3.3.1 - Positional accuracy and precision

This applies to both horizontal and vertical positions. Beware of the dangers of false accuracy and false precision, that is reading locational information from map to levels of accuracy and precision beyond which they were created. This is a very great danger in computer systems that allow users to pan and zoom at will to an infinite number of scales. Accuracy and precision are tied to the original map scale and do not change even if the user zooms in and out. Zooming in and out can however mislead the user into believing--falsely--that the accuracy and precision have improved (Foote et al., 1995).

3.3.2 - Attribute accuracy and precision

The non-spatial data linked to location may also be inaccurate or imprecise. Inaccuracies may result from mistakes of many sorts. Non-spatial data can also vary greatly in precision. Precise attribute information describes phenomena in great detail. For example, a precise description of a person living at a particular address might include gender, age, income, occupation, level of education, and many other characteristics. An imprecise description might include just income, or just gender (Foote et al., 1995).

3.3.3 - Conceptual accuracy and precision

GIS depends upon the abstraction and classification of real-world phenomena. The user determines what amount of information is used and how it is classified into appropriate categories. Sometimes users may use inappropriate categories or misclassify information. For example, classifying cities by voting behaviour would probably be an ineffective way to study fertility patterns. Even if the correct categories are employed, data may be misclassified (Foote et al., 1995).

3.3.4 - Logical accuracy and precision

Information stored in a database can be employed illogically. Information stored in a GIS database must be used and compared carefully if it is to yield useful results. GIS systems are typically unable to warn the user if inappropriate comparisons are being made or if data are being used incorrectly (Foote et al., 1995).

In conclusion, it would be a mistake to believe that highly accurate and highly precision information is needed for every GIS application. The need for accuracy and precision will vary radically depending on the type of information and the level of measurement needed for a particular application. The user must determine what will work. Excessive accuracy and precision is not only costly but can also cause considerable work for the researcher.

For information on, and sources of the datasets used in this research, please refer to Appendix 2

Chapter 4: Charges Based on Impervious Area

All property, even undeveloped land, yields stormwater runoff, but runoff is dramatically increased by the impervious surfaces created by development – specifically buildings and pavement. This tight correlation has led to the widespread use of impervious surface as the basis of stormwater fee structures. Rather than measure actual runoff, the vast majority of stormwater utilities charge their customers according to the amount of impervious surface on their property. How they go about calculating impervious surface accounts for some of the differences in fee structures.

Phone companies charge by the minute. Water utilities charge by the gallon or litre. Some stormwater utilities charge by the square meter or foot of land area. Others have a charge per every 500 square feet or every 2,000 square feet, while others charge by the acre or fraction thereof. Many stormwater utilities, however, develop their own billing unit specific to the stormwater utility. This is called an ERU – equivalent runoff unit – and becomes part of the rate, which is expressed as $X per ERU.

Like many other aspects of stormwater utility fee structures, the size of an ERU and how it is calculated varies from utility to utility. The ERU is computed as either the average residential lot size or the average amount of impervious surface on each residential lot.

For this reason, some utilities define the ERU as an "equivalent residential unit" or use another term such as EDU (equivalent dwelling unit) SFU (single family unit) or SFE (single family equivalent). It is generally believed that utility customers can more easily understand charges when expressed in terms of a single-family residence. Using single-family units also facilitates billing since they often represent between 60% and 80% of all parcels (Pioneer Valley Planning Commission, 1998).

Where ERUs are used, charges for multifamily, commercial, industrial and other properties are calculated by dividing the size of the property to be assessed by the size of the utility's ERU to get an ERU multiple. For example, in a scenario where the ERU was 10,000 square feet, a 100,000 square foot commercial property might be defined as having 10 ERUs. It is important to note that there is no uniform definition of an ERU – each utility sets its own definition and uses it to make billing calculations in its own way. The one consistent element of ERU use is its function as a tool for applying a rate. This is convenient for implementing rate changes: a utility's fee structure and assessment formulas may remain the same while the dollar amount per ERU is adjusted.

Some considerations that a utility may want to focus on are: Is the use of an ERU calculated as a residential unit average preferable to other base units, such as a charge per square foot, per acre, or for every 2,000 square feet of property? Should the billing unit be based on total property size or amount of impervious surface? What would the size of an ERU be for the utility under consideration if calculated as average residential parcel size? What is the range of deviation from this average?

4.1 Description:

The impervious area (roof area, parking areas, driveways) and the gross area (total area) are the only parameters used to measure the actual contribution to runoff. The impervious area was determined in this case through measurements of building footprints from aerial photographs. The charge for each property is determined by multiplying the impervious area for each property by the stormwater rate.

4.2 Data Requirements:

All stormwater utility fee systems require lot-level data to make billing calculations. This particular rate calculation method requires data only on the impervious surface area for each property. If not readily available, the data on impervious surface area can be extracted using aerial photographs with property lines overlaid in a GIS. In particular, the data requirements for determining the ERUs for the watershed are as follows:

- A Measurement of Impervious Area for each property; or,
- Ariel Photographs;
- Current and projected land use (optional, not used in this example); and,
- Service addresses and property boundaries
    - The owners name and address will need to be determined during the billing system development and implementation phase. (Fort Wayne Stormwater Task Force, 1993)

4.3 Calculation Method:

Service charges were calculated by multiplying the impervious area (in meters ^{2}) of each property by a rate calculated as part of the cost of service and rate study analysis (See Li and Banting, 1999). Although not in this case, the rate structure can be modified by developing two (2) major categories, single-family residential (detached single-family homes) and non-single family residential (all other land uses).

The calculation procedure is as follows (This procedure is also illustrated in Figure 4.1 below):

1. Using aerial photography, the impervious area (in meters ^{2}) of each property was determined and created as a layer on Arc View (a Geographic Information System);
2. The statistical mean of impervious surfaces on 18,877 properties (this is the number of properties in the Mimico Creek Watershed with impervious surfaces in the watershed) was then calculated; this number represented one ERU (equivalent runoff unit). It should be noted that not all properties were included in calculating the statistical mean. Those properties (open space) with impervious area were not included. The total number of lots, including open space in the watershed is equal to 21,927.
3. The total impervious area (building area in this case) was then divided by the ERU value for the watershed. The runoff unit was calculated to be 302.49 m^2;
4. From this the charge for that property was calculated for a 25 year period (the term of the plan implementation);
5. Values were then divided by the gross area for each property to arrive at a cost per square meter for each property; this was used later as a measure of efficiency.

The results of this calculation method for 15 properties in the Mimico Creek Watershed are summarized in Table 4.1 (page 47).

4.4 Public Understanding:

Of all the rate structures, this method is likely to be the easiest understood by the general public. As the example above indicates, the contribution to stormwater runoff, and therefore the charge levied, is directly proportional to the impervious area of each lot. The impact of paving or developing land is very easy to explain and could be easily understood by the landowners and ratepayers

4.5 Undeveloped Property:

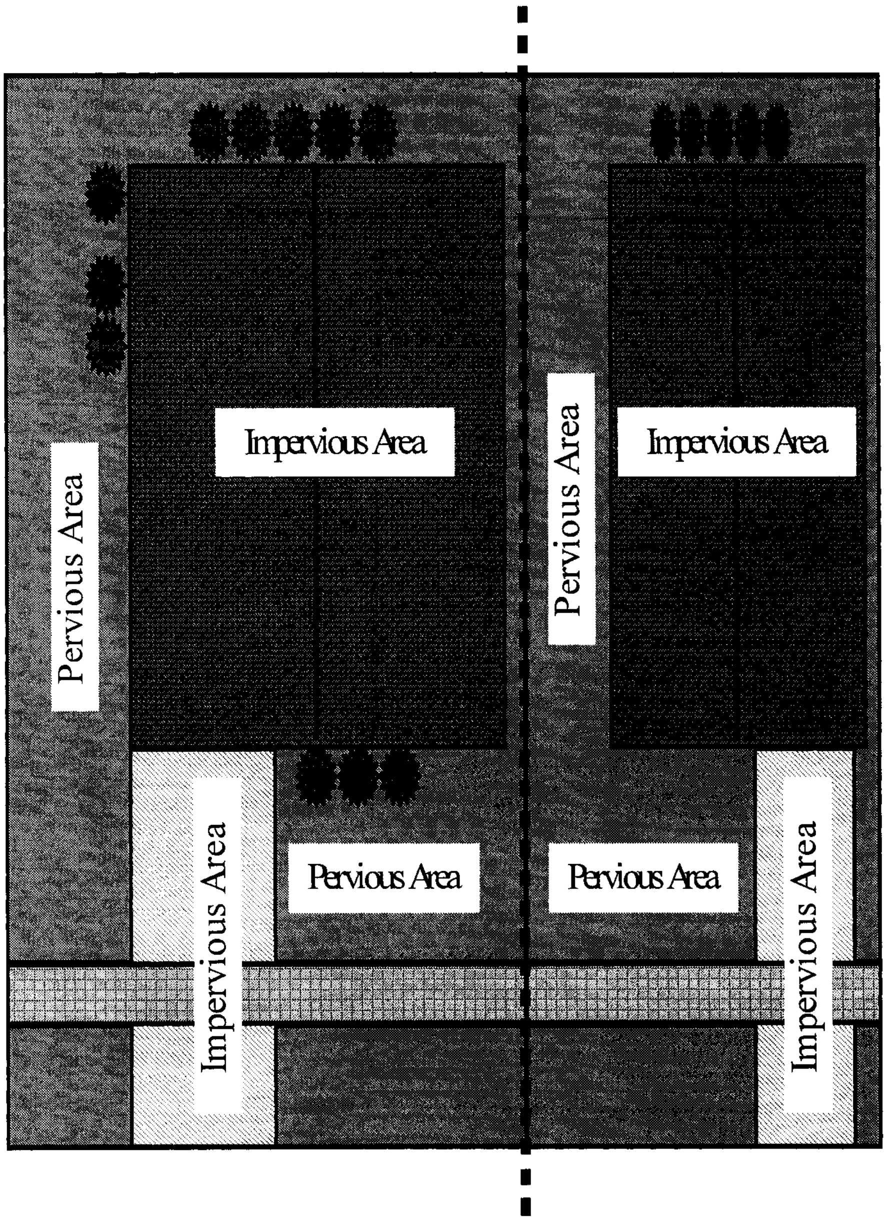
This method for rate setting makes it difficult to include undeveloped property and open space, since there is often no impervious area on undeveloped properties. This could represent a large amount of lost revenue for the utility since there is always going to be some stormwater runoff from undeveloped properties.

Undeveloped property could however be treated as a special case and have a charge based only on gross property area. Another option may be to use a different rate calculation method.

4.6 Water Quality Measures:

As urban centers continue to expand they become `heat islands' where the atmosphere and surface are significantly warmer than in rural areas. Gradually, pervious surfaces such as farmland and forest are being replaced by impermeable surfaces such as rooftops, streets and parking lots

Figure 4-1: Examples of Pervious and Impervious Area



Surfaces such as these, built primarily with asphalt and concrete, act as thermal energy collectors and transfer the thermal energy to stormwater runoff as it passes over the impervious surface.

Heated runoff, which reaches the receiving water environment, can have severe impacts on aquatic biota. This becomes a particular concern in receiving waters that have thermally sensitive water uses such as cold-water fisheries. An increase in water temperature above ambient levels can result in (i) direct biological impacts or (ii) changes in water quality leading to biological impacts. Disruption of aquatic life cycles (egg maturation, spawning) and increased levels of bacteria such as *e-coli* were examples of direct biological impacts.

Reduced levels of dissolved oxygen, which are insufficient for fish and aquatic insect survival, and increased metal and hydrocarbon solubility that are toxic to aquatic life are examples of changes in water quality leading to biological impacts or, indirect impacts (Van Buren et al., 2000).

As can be seen, impervious area has been found to be a significant indicator of water quality impairment, therefore it could be said that this method does take into account water quality when setting rates.

4.7 Implementation:

The ease and cost of implementation of a rate structure based on impervious area is strongly related to the data available and the cost of acquiring any additional data that may be necessary. While the method itself is not complex, the measurement of impervious area on each property is a time consuming, labour intensive task, particularly in large or densely populated areas.

There are ways available to simplify this task however. One common method is to separate all properties in the area into two categories

- Single Family Residences – These can include duplexes as well as single-family detached homes. It may not be cost effective to measure the impervious area of each and every property; in many cases a statistical sample should be sufficient. This information can then be used in the calculation method given above and used to arrive at a base unit or Equivalent Runoff Unit;
- Non- Single Family Residences – These can include, but are not limited to Apartments, Condominiums, Other Multi-Family Units, Commercial Property, Churches, Schools, Public Buildings, Office buildings, Industrial Properties, Roads and Highways, and Parking lots (Fort Wayne Stormwater Task Force, 1993)

Each of these units is individually measured for the amount of impervious area that exists within their property boundary. They can then have a rate based on the ERU set for single-family residences, or be charged a separate rate.

4.8 Technical Accuracy:

Since fees to be charged to each property are based on the amount of impervious area, and this measure is widely accepted as a major contributor to increased runoff, this method is likely to have a high degree of technical accuracy and be defensible to the public.

4.9 Possibilities for GIS Analysis

In this example, it is possible to use GIS to determine where the fees in the Mimico Creek Watershed will be distributed. In figure 4-2 on page 51, it is possible to see the geographic distribution of the charges among the properties in the Mimico creek Watershed.

Some of the questions that may need to be addressed would be:

- What is the distribution of the fees?
- Which properties will be paying the highest charge?
- Are there any opportunities or a need to adjust ERU levels?
- Are there any opportunities to create classes of properties based on ERU levels, i.e. ERU>=1?

How are the charges distributed among the different land uses in Mimico Creek?

4.10 Flexibility:

The flexibility of the impervious area method can be summarized as follows:

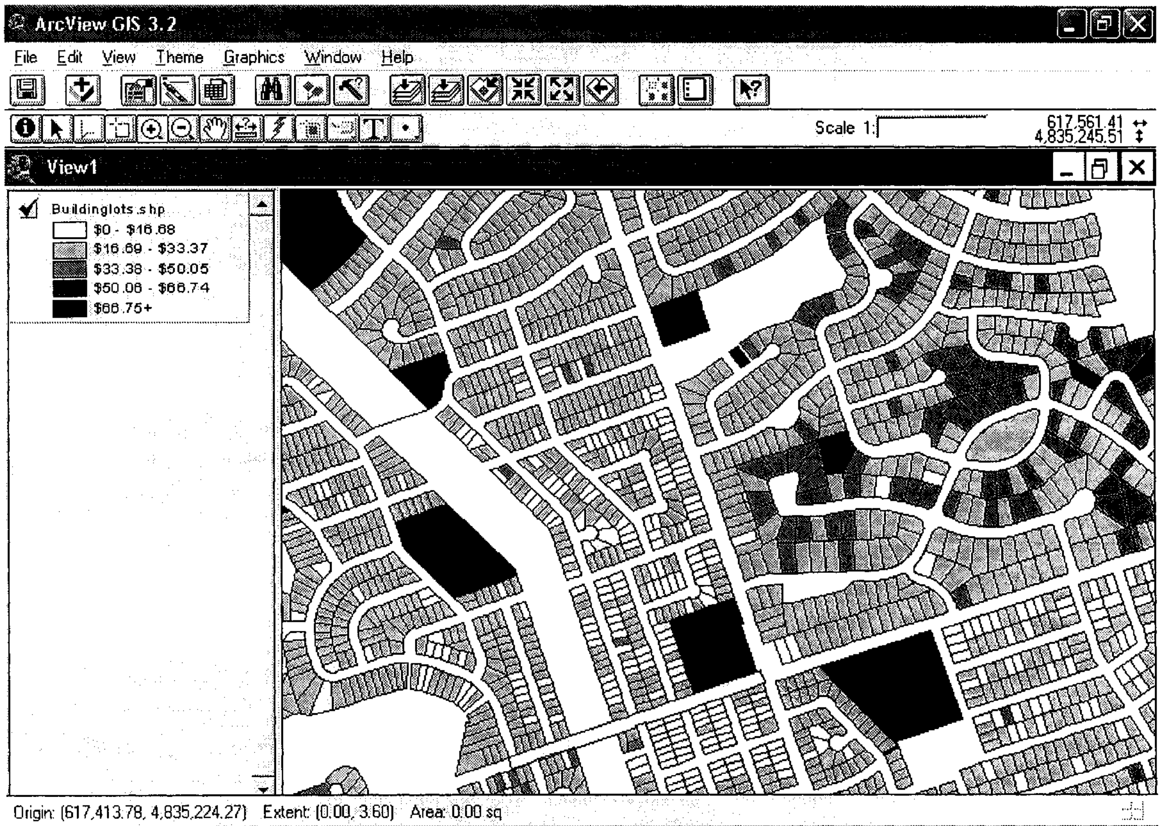
Any credits for management practices or socio-economic effects can be incorporated into the billing system after the rate structure has been developed. Decision makers however, will need to keep in mind the potential lost revenues through credits when doing this.

Table 4.1: Example Runoff Charges For Properties in the Mimico Creek Watershed Using the *Equivalent Runoff Unit* Method

(Table data generated from a random sample of 15 different properties in the Mimico Creek Watershed, Total Dollar amount generated using ERU calculation formula over the entire watershed area 21,927 properties)

Property #	*Impervious Area (m^2)*	*Gross Property Area (m^2)*	*Equivalent Runoff Unit (m^2)*	*Property Equivalent Runoff Unit (Impervious Area divided by Equivalent Residential Unit)*	*Annual Charge Per Unit Scenario 1, ($33.37 per ERU)*	*Annual Charge Per Unit Scenario 2 ($188.07 per ERU)*	*Charge Per Unit over 25 Years Scenario 1*	*Charge Per Unit over 25 Years Scenario 2*	*Charge per Square Meter over 25 Years Scenario 1*	*Charge per Square Meter over 25 Years Scenario 2*
1	286.27	3215.86	302.5	0.946	$31.56	$177.91	$789.00	$4,447.86	$0.010	$0.055
2	11135.06	535295.2	302.5	36.811	$1,228.34	$6,923.04	$30,708.50	$173,076.12	$0.002	$0.013
3	72.22	652.91	302.5	0.238	$7.94	$44.76	$198.50	$1,119.02	$0.012	$0.069
4	3048.94	44507.88	302.5	10.079	$336.33	$1,895.56	$8,408.25	$47,388.94	$0.008	$0.043
5	0	2505.32	302.5	0	$0.00	$0.00	$0.00	$0.00	$0.000	$0.000
6	6370.42	13532.78	302.5	21.059	$702.43	$3,960.57	$17,560.75	$99,014.15	$0.052	$0.293
7	12220.99	22958.87	302.5	40.401	$1,348.48	$7,598.22	$33,712.00	$189,955.40	$0.059	$0.331
8	3508.98	11574.66	302.5	11.6	$387.09	$2,181.61	$9,677.25	$54,540.30	$0.033	$0.188
9	913.14	6096.05	302.5	3.018	$100.71	$567.60	$2,517.75	$14,189.88	$0.017	$0.093
10	251.29	51602.81	302.5	0.83	$27.69	$156.10	$692.25	$3,902.45	$0.001	$0.003
11	2188.34	9938.53	302.5	7.234	$241.65	$1,360.50	$6,041.25	$34,012.46	$0.024	$0.137
12	10374.03	45844.97	302.5	34.295	$1,144.42	$6,449.86	$28,610.50	$161,246.52	$0.025	$0.141
13	7694.94	16672.89	302.5	25.438	$848.86	$4,784.12	$21,221.50	$119,603.12	$0.051	$0.287
14	11906.84	27653.34	302.5	39.362	$1,313.50	$7,402.81	$32,837.50	$185,070.28	$0.047	$0.268
15	27145.7	192626.3	302.5	89.74	$2,994.62	$16,877.40	$74,865.50	$421,935.05	$0.016	$0.088
Total For Watershed							***$18,295,265.60***	***$103,097,140.60***		

Figure 4-2: Annual User Fees for Lots in the Mimico Creek Watershed (*zoomed in*)



The updating of new construction projects and changes to existing properties would need to be considered, and could be updated easily through the building permit application process. The municipality or governing body would have to require the builder to give a measure of the impervious area to be added or subtracted from the property in question. This data could then be added into the database of properties directly, without the need of new aerial photographs or extensive labour spending.

The impervious area method is very compatible with the development and use of a Geographic Information System. This system can enable any data gathered through the development of the stormwater charges to be shared with other departments within the municipality, and vice-versa (Fort Wayne Stormwater Task Force, 1993).

4.11 Opportunities for Credits:

In the USA, some local governments have incorporated credits against charges for onsite controls of volumes of runoff (i.e. quantity of runoff) through the use of Best Management Practices (BMPs). A 1988 survey of 25 US utilities found that 16 (64%) provided some type of credit for onsite management. In 1996, 26% of user pay programs included credits or incentives for onsite management (Cameron, et al., 1999).

It should be kept in mind that any monies awarded as credits or reductions will have to be raised through increased charges to other properties or taken out of any surplus revenues that the utility may generate.

In the case of the Equivalent Residential Unit (ERU) method credits could be awarded for the following:

- Downspout disconnection – This measure would effectively reduce the impervious area of the property by the area equivalent to the building(s) on site;
- Changes from impervious to pervious materials for driveways and walkways;
- Credits could also be awarded based on socio-economic factors, such as income, age group (seniors on a fixed income for example)

In this example, the total revenue generated by the ERU calculation method are exactly equal to the revenue needed for the stormwater retrofits and administrative expenses. If decision makers were to apply credits for this example, the rate per ERU would have to be increased, at the risk of seeming arbitrary to the residents. Without this, the stormwater utility would risk running a deficit if it were to offer credits for on-site management practices.

4.12 Conclusions:

Equivalent runoff units (ERUs) can provide estimates of the total environmental impact of stormwater runoff from developed properties. In this manner, they provide a comparable measure of the total impact of stormwater runoff from each land-use category. These environmental effects take into account both the quantity and quality of runoff (Cameron, et al., 1999).

The impervious area method is a very simple and easy to understand method, and can be very cost effective for municipalities that are highly developed as well as those that have a high percentage of residential properties. The property data required are minimal, and can be easily generated through the use of aerial photographs. Due to the ease of data gathering, this method of charging for stormwater runoff has been widely adopted in the United States.

Chapter 5: Charges Based on Rate Factors and Gross Property Area

A rate factor or runoff coefficient is a number representing how much stormwater runs off a parcel for a particular land use during a storm event. Runoff coefficients and rate factors are used to strengthen the relationship between what a landowner is billed and the amount of runoff produced on the parcel. Similar to Intensity Development Factors (IDFs which will be explored in the next chapter), runoff coefficients can be used as rationale for separating properties into customer classes and are incorporated into billing equations. Most assessment methods use either one or the other, not both. Utility customers more easily understand IDFs, while runoff factors provide a more accurate indication of runoff quantity (Pioneer Valley Planning Commission, 1998).

One example of how a runoff coefficient for each parcel is calculated is by using the percentages of pervious, semi-pervious, and impervious areas of the parcel in the following formula:

Equation 5.1 –Example of a Runoff Coefficient Calculation.

C = (% impervious area) **x** (0.95% pervious area **x** 0.20) + (% semi-pervious area **x** 0.50)

Impervious areas are those surfaces that do not absorb stormwater including paved surfaces and buildings. Semi-pervious areas are surfaces like gravel that can absorb some stormwater but absorb it slowly. Pervious surfaces are surfaces that absorb stormwater under normal conditions; these can include lawns and undeveloped properties (Center for Urban Policy and the Environment, date of publication unknown).

Samples of runoff coefficients can be found in Table 5.1 below.

Table 5.1: Sample Runoff Coefficients

(Adapted from: Cornell University, School of Civil and Environmental Engineering, date unknown)

Type of Area or Development	*Runoff Coefficient(s)*
Type of Development	
Urban business	0.70—0.95
Commercial office	0.50—0.70
Residential development	
Single-family homes	0.30—0.50
Condominiums	0.40—0.60
Apartments	0.60—0.80
Suburban residential	0.25—0.40
Industrial development	
Light industry	0.50—0.80
Heavy industry	0.60—0.90
Parks, greenbelts, cemeteries	0.10—0.30
Railroad yards, playgrounds	0.20—0.40
Unimproved grassland or pasture	0.10—0.30
Type of surface areas	
Asphalt or concrete pavement	0.70—0.95
Brick paving	0.70—0.80
Roofs of buildings	0.80—0.95
Grass-covered sandy soil	
Slopes 2% or less	0.05—0.10
Slopes 2% to 8%	0.10—0.16
Slopes over 8%	0.16—0.20
Grass-covered clay soils	
Slopes 2% or less	0.10—0.16
Slopes 2% to 8%	0.17—0.25
Slopes over 8%	0.26—0.36

5.1 Description:

This rate structure is based on the gross area (total area) of each property, and an intensity of development classification, in this example, the runoff factor. The stormwater charge for each property is determined by multiplying the gross area of the property by the runoff factor. This unit is then multiplied by the stormwater rate.

5.2 Data Requirements:

This particular rate calculation method requires less data than the ERU. In this example, the gross property area, and the runoff coefficients were provided by the City of Toronto, and would likely be available from most municipal or local government offices. It should be noted that different methods for calculating runoff coefficients would have different data requirements. The different data requirements for these calculations may add additional expenses and time requirements to the data collection process.

The following data are required in the development of a billing system based on gross area and intensity of development:

- Property records to determine the total area of each property
- Runoff coefficients, if already available
- Service address, and approximate property boundary.
    - Owner's name and address will be determined for all consolidations, during the billing system implementation phase.

5.3 Calculation Method:

A general procedure for determining the Equivalent Runoff Unit (ERU) and Service Charge for the Gross Area and Intensity of Development Method is as follows:

1. Determine the area to be used for the runoff coefficient, this area could be as precise as a single property, however in this case runoff coefficients for each sub watershed were used, with runoff coefficients provided by the City of Toronto;
2. Assign a rate factor (RF) to each sub watershed. The determination of the RF should be based on actual hydrological properties as much as possible. The runoff coefficient of "C" factor is commonly used for the rate factor. Values may range from 0.10 for open space properties to 0.90 for commercial or industrial lots.
3. Determine the gross area (A) for each parcel in each category from the property attribute table in the GIS.
4. Link each parcel to its sub watershed, which has an assigned rate factor;
5. For each parcel or category, the Equivalent Residential Unit (ERU) = RF x A (m^2)
6. ERU x the rate being charged ($\$/m^2$) is the amount to be billed to each parcel on a periodic basis. The rate charged per ERU is based on the rate study and cost of service analysis for the municipality. In this example, the minimum charges to cover the total costs of implementation and retrofits would be $0.04/square meter for Scenario 1, and $0.22/square meter for Scenario 2

5.4 Public Understanding:

The public may have difficulty understanding the method used for this rate structure. It may be difficult for a non-engineer to fully grasp the relationship between the rate factors and their contribution to runoff.

5.5 Undeveloped Property:

This rate method offers the ability to charge undeveloped property. Separate rate factors can be assigned to undeveloped properties. In this example, undeveloped and open space properties are assigned a rate factor (runoff coefficient) equal to 0.10.

5.6 Water Quality:

Pollutant indices can be related to rate factors and land use classifications or sub watersheds to incorporate consideration of the impact of land use or sub watershed on water quality.

5.7 Implementation:

The ease and cost of implementation of a rate structure based on gross area and runoff coefficients is directly proportional to the data requirements and the availability of existing data. In many cases, the information could likely be derived using existing data from municipal planning departments and/or property records from local government offices, (runoff coefficients, for example, would be available from the sewer design plans). The costs could be estimated on a "per parcel" basis considering the difficulty of extracting the necessary data from these sources. If either of these sources does not provide adequate (accurate, reliable, up-to-date) information, then gross area may have to be measured from available record or maps and overlaid onto aerial photographs and zoning maps. In either case, the cost of implementation may increase to a point such that the impervious method may be more cost-effective.

The cost of the implementation of this rate structure will generally be less than that of the Impervious Area Method, assuming either one or a combination of databases contain all of the necessary data.

5.8 Technical Accuracy:

Since the fees to be charged to each parcel are directly related to the size of each parcel, and if the rate factors are based on hydrological principles, this method has a moderate degree of technical accuracy. Care should be taken to ensure that any grouping of certain categories of parcels is done in a logical and straightforward manner. The use of engineering or scientific judgment may leave this method susceptible to challenge in some specific cases.

5.9 Possibilities for GIS Analysis

By examining figure 5-1 on page 63, it is possible to use GIS to determine where the fees in the Mimico Creek Watershed will be geographically distributed. Although, in this case, the runoff coefficients are only as detailed as the sub-catchment level not the individual property. However it would be possible for a lot level analysis to be done through the use of the zoom tool available in most GIS packages, or through the overlay of other GIS datasets and maps.

Table 5.2: Example Runoff Charges For Properties in the Mimico Creek Watershed Using the *Rate Factor* Method

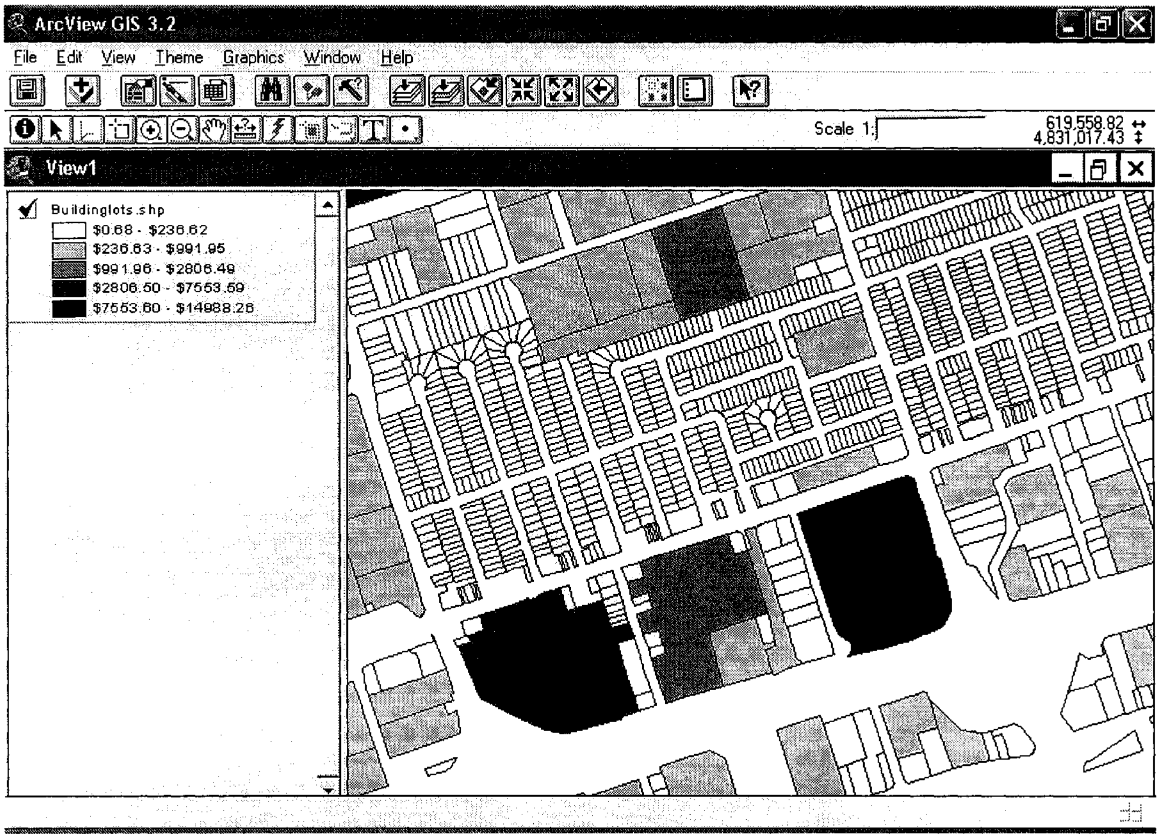
(Table data generated from a random sample of 15 different properties in the Mimico Creek Watershed)

Property #	*Impervious Area*	*Gross Property Area*	*Runoff Coefficients*	*Property Equivalent Runoff Unit*	*Annual Charge per unit (Scenario 1)*	*Annual Charge Per Unit (Scenario 2)*	*Charge Per Unit over 25 Years (Scenario 1)*	*Charge Per Unit over 25 Years (Scenario 2)*	*Charge per Square Meter (Scenario 1)*	*Charge per Square Meter (Scenario 2)*
1	286.27	3215.86	0.7	2251.10	$90.04	$495.24	$2,251.10	$11,818.29	$0.028	$0.154
2	11135.06	535295.2	0.6	321177.14	$12,847.09	$70,658.97	$321,177.14	$1,686,180.01	$0.024	$0.132
3	72.22	652.91	0.2	130.58	$5.22	$28.73	$130.58	$685.56	$0.008	$0.044
4	3048.94	44507.88	0.3	13352.36	$534.09	$2,937.52	$13,352.36	$70,099.91	$0.012	$0.066
5	0	2505.32	0.1	250.53	$10.02	$55.12	$250.53	$1,315.29	$0.004	$0.022
6	6370.42	13532.78	0.5	6766.39	$270.66	$1,488.61	$6,766.39	$35,523.55	$0.020	$0.110
7	12220.99	22958.87	0.9	20662.98	$826.52	$4,545.86	$20,662.98	$108,480.66	$0.036	$0.198
8	3508.98	11574.66	0.7	8102.26	$324.09	$1,782.50	$8,102.26	$42,536.88	$0.028	$0.154
9	913.14	6096.05	0.6	3657.63	$146.31	$804.68	$3,657.63	$19,202.56	$0.024	$0.132
10	251.29	51602.81	0.5	25801.41	$1,032.06	$5,676.31	$25,801.41	$135,457.38	$0.020	$0.110
11	2188.34	9938.53	0.35	3478.49	$139.14	$765.27	$3,478.49	$18,262.05	$0.014	$0.077
12	10374.03	45844.97	0.7	32091.48	$1,283.66	$7,060.13	$32,091.48	$168,480.26	$0.028	$0.154
13	7694.94	16672.89	0.6	10003.73	$400.15	$2,200.82	$10,003.73	$52,519.60	$0.024	$0.132
14	11906.84	27653.34	0.5	13826.67	$553.07	$3,041.87	$13,826.67	$72,590.02	$0.020	$0.110
15	27145.7	192626.3	0.5	96313.15	$3,852.53	$21,188.89	$96,313.15	$505,644.04	$0.020	$0.110
Totals for Watershed							*$19,256,720.46*[♰]	*$105,911,962.55*		

[♰] For information on surplus revenues see Section 9.1.2 on page 101

Figure 5-1 – Annual User Fees per property in the Mimico Creek by Runoff Co-efficient

(Runoff coefficient =0.7, Charge per square meter = $0.04)



Some of the questions that may need to be addressed would be:

- What is the distribution of the fees?
- Are runoff coefficients at the catchment level sufficient for the fee calculation?
- Are runoff coefficients at the catchment level fair for the fee calculation?
- How are the charges distributed among the different land uses in Mimico Creek?

5.10 Flexibility:

To ensure a stable, equitable, continuous funding source for stormwater programs, rate structures must be flexible in order to incorporate local basin and geographical requirements, provide for updating on a continuous basis, and be compatible with related systems such as GIS, and existing billing systems.

The updating for new construction can be accomplished with minimum adjustment of the normal planning procedures for most cities. For example, the computation of gross area and selection of an appropriate rate factor can be a requirement of obtaining a building permit for new developments, and the city staff can input the new data into the system in a manner similar to adding a new water service account (Fort Wayne Stormwater Task Force, 1993).

5.11 Opportunities for Credits:

In the case of the rate factor method, credits could be awarded for the following:

Depending on the calculation of the runoff coefficients, credits could be awarded for certain criteria within the runoff coefficient such as soil type, % imperviousness, vegetative cover and other factors. As with any other fee calculation method, credits could also be awarded based on socio-economic factors, such as income, age group (seniors on a fixed income for example). These would likely be calculated separately from the initial charge. It should be kept in mind that any monies awarded as credits or reductions will have to be raised through increased charges to other properties or taken out of any surplus revenues that the utility may generate.

5.12 Conclusions:

The gross area and rate factor method provides a measure of the quantity of stormwater runoff from different land-use categories. More impervious land (i.e. a parking lot) has a higher quantity rate factor or runoff coefficient than less impervious land (i.e. agricultural land). This variable allows higher charges to be levied against land-use categories, which generate greater volumes of stormwater runoff (Cameron et al., 1999).

The gross area and rate factor method is cost-effective method for localities that have significant undeveloped area (such as rural counties) and adequate land use and property records. This method is one of the first rate structures used for establishing storm water utilities. Computerized municipal records and the use of a GIS would greatly simplify the data management and provide significant cost savings. This method may be cost effective for cities in which an existing utility billing system is not in place since a new series of accounts is required to include undeveloped land.

Chapter 6: Charges Based on % Impervious Coverage

The term 'Intensity Development Factor' refers to the fact that the more intensely developed a parcel is, the greater the amount of impervious surface, and the more runoff it will have. IDF is represented as the percentage of a parcel typically developed in a particular land use category. For example, a factor of .85 for commercial property means that on average, 85 percent of a parcel in that classification is developed – covered by building footprints, parking, driveways and other impervious surfaces. Residential property with a factor of .20 will have 20% of the lot covered by impervious surface. Assigning IDFs to land use categories involves measuring the percentage of impervious surface on a statistically valid sample of properties, and averaging the results.

When a parcel's gross area is multiplied by its IDF, the result is a reasonable estimate of the amount of impervious surface on the property. IDFs are not necessary in assessment formulas that use actual measurements of impervious surface on individual parcels. They are sometimes used as a factor in creating customer classifications (Pioneer Valley Planning Commission, 1998).

Some things to be considered when examining the use of intensity development factors for user charges might be: What is the composition of land use types to be covered by the utility under consideration? Should IDFs be used indirectly, as a factor in creating billing or rate classes or directly, as a component of billing equations? How should customers be classified?

All assessment methods acknowledge that different types of land uses yield different amounts of runoff, and therefore apply different rates or assessment formulas to them. Some divide customers into just two classes: residential and non-residential property. Others recognize three – single family, multi-family residential and non-residential – or four, adding an undeveloped category. Still other utilities break out customers into as many as eight categories, with a different rate or assessment formula for each. In the example below, properties are broken into classes based on their building-to-lot-area ratio group. The rates used by the City of Denver were used for each class in the following example. The rates used in Denver have been multiplied by $1.40 to account for currency differences

The 'Ratio Group' represents the ratio of impervious surface area of a land parcel to the total parcel area In Denver, the 'rate' for a specific group is multiplied by the amount of impervious area (square feet) and divided by 100 to determine the annual service charge for a given land parcel

Table 6.1 – Rate Table for Stormwater Service Charge: Denver, Colorado

Ratio Group	*Rate ($)*
.00 - .10	0.37
.11 - .20	0.47
.21 - .30	0.57
.31 - .40	0.67
.41 - .50	0.77
.51 - .60	0.77
.61 - .70	0.87
.71 - .80	0.97
.81 - .90	1.07
.91 - 1.00	1.17

Customer classifications may correspond either to land use categories (i.e. single family residential, commercial, industrial, etc.) or intensity of development (i.e. undeveloped, light, moderate, heavy). (Pioneer Valley Planning Commission, 1998)

Stormwater utility fee structures use customer classifications in order to allow a simplified billing system to recognize basic differences in runoff contributions by land use. Some issues that may influence customer classes are: What is the composition of land use types to be covered by the utility under consideration? What types of customer classes should be considered? How many customer classes would be reasonable and appropriate?

6.1 Description:

The impervious area (roof area, parking areas, driveways, etc.) and the gross area (total area) are used to calculate the percentage of imperviousness for each property. The percentage of imperviousness is organized into ranges, which are charges per square meter of impervious area.

6.2 Data Required:

Notwithstanding the use of a single-family or dwelling unit equivalency, stormwater utility fee structures can be uniform or variable for residential customers, and are almost always based on a uniform rate related to impervious area for non-residential customers (Florida Association of Stormwater Utilities, 1998). The following are required in the development of a billing system based on impervious area and percentage of imperviousness:

- Property records to determine the total number of parcels in each existing land use
- Gross area of each parcel
- Aerial photography
- Impervious area of each parcel
- Land use map for each property
- Service address, and approximate property boundary.
    - Owner's name and address will be determined for all consolidations, during the billing system implementation phase (Fort Wayne Stormwater Task Force, 1993).

6.3 Calculation Method:

A general procedure for determining the rates to be charged for the Impervious Area and Percent of Impervious Coverage Method is as follows:

1. Prepare a rate table comparing % imperviousness to dollar charges for a range (this is often done in increments of 10s i.e. 0-10% = $\$0.37/\text{meter}^2$, 11-20% = $\$0.47/\text{meter}^2$). The ranges to be used may be based on the data obtained relating to land use and the number of parcels in each land use. The determination of the rates to be used for each range should be based on actual hydrological properties and cost of service as much as possible.

Equation 6.1 – Calculation of % Imperviousness

IMPERVIOUS AREA/GROSS AREA x 100 = PERCENTAGE OF IMPERVIOUSNESS

2. Grouping similar parcels, such as residential lots, into one or more distinct categories and computing the average area of a representative sample of each category could simplify this task.
3. The rate for each parcel is selected from the rate table. In this example, the rate is the charge per $meter^2$ of impervious surface.
4. The impervious area is multiplied by the appropriate rate from the table to obtain the annual charge. Divide this fee by twelve to obtain the monthly charge, if desired.

6.4 Public Understanding:

The public is likely to have a poor understanding of the method used for this rate structure. It may be difficult for people to understand the relationship between the rates for the various ranges and the contribution to runoff, and how each was determined through engineering or scientific analyses.

Since the measurable parameters of impervious and gross area are used to compute the fees to be charged, the perceived equity and fairness of the Impervious Area and Percent and Impervious Coverage Method appears to be good. The individual rates of each parcel or category will vary based on the amount of impervious area of each parcel, but the selection of the factors used in the rate table may seem to be arbitrary.

Some situations are likely to occur in which one lot with a smaller gross area but higher imperviousness will be charged more than another lot with more gross area, but less impervious area. This situation may be difficult to explain or justify in terms of the contribution to runoff.

Land use is perceived to be a factor in contribution to runoff, but the incorporation of land use as a component in the development of rate factors is not clear, and as a result was not done for this example.

6.5 Undeveloped Property:

This method for rate setting makes it difficult to include undeveloped property and open space, since there is often no impervious area on undeveloped properties or open space. This could represent a large amount of lost revenue for the utility since there is always going to be some stormwater runoff from undeveloped properties.

Undeveloped property would have to be treated as a special case and have a charge based only on gross property area, or a different rate calculation method may be used.

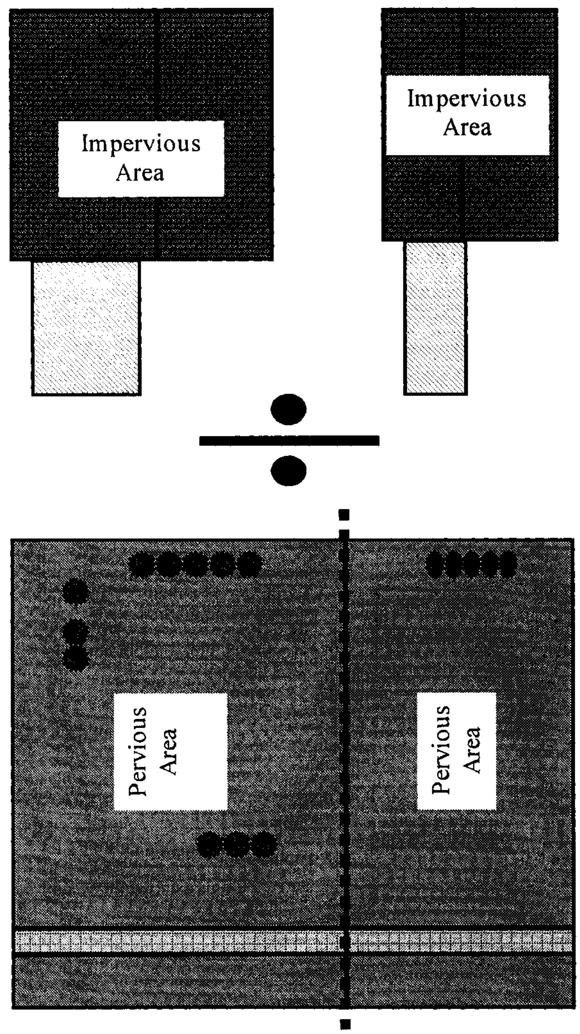
6.6 Water Quality:

Impervious area has been found to be a significant indicator of water quality impairment, (Van Buren et al., 2000), therefore it could be said that this method does take into account water quality when setting rates. Also, pollutant indices can be related to the ranges in the rate table to incorporate consideration of the impact of each parcel on water quality.

6.7 Implementation:

As is the case with other methods, the ease and cost of implementation of a rate structure based on this method is directly proportional to the data requirements and the availability of existing data. In most cases, the cost and complexity of the implementation of this method will be higher than other methods, since data are required

Figure 6-1: Impervious Area Divided by Gross Property Area



for both gross area and impervious area, for each parcel. The information is usually derived from property records from local government offices and aerial photographs.

6.8 Technical Accuracy:

This method is not necessarily more accurate than other methods, due to the use of engineering or scientific judgment in developing the rate factor table. Therefore, this method may be less accurate defensible than methods that are based on more precise and concrete measurements. Although the rate table should be based on hydrological principles, it may be difficult to demonstrate that the increments of increased charges for each range are related to a corresponding increase in the cost of service. Care should be taken to ensure that any grouping of certain categories of parcels is done in a logical and straightforward manner (Fort Wayne Stormwater Task Force, 1993).

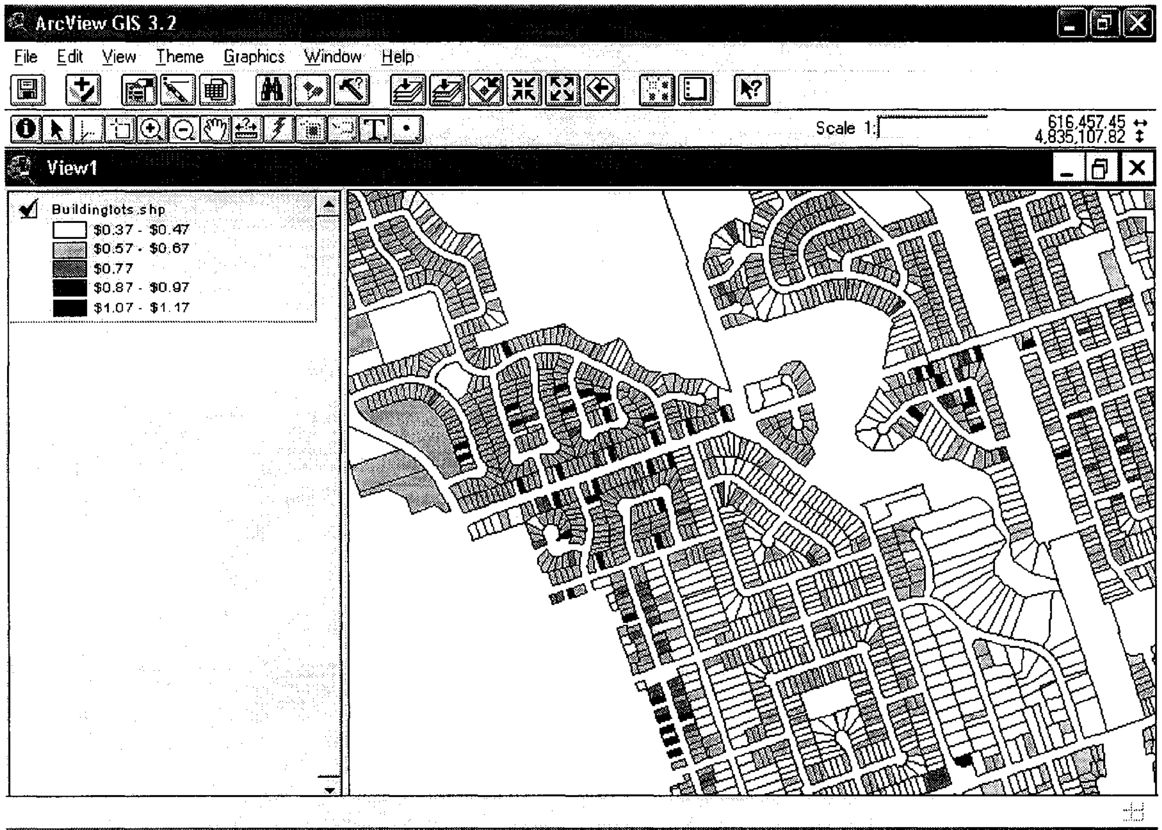
6.9 Opportunities for GIS Analysis

In figure 6-2 on page 74, it is possible to use GIS to determine where the fees in the Mimico Creek Watershed will be distributed since the % imperviousness of each lot is directly related to the fee being charged. It is also possible to adjust the different property classes for % imperviousness if it is found that the groups need to be modified.

Some of the questions that may need to be addressed would be:

- What is the distribution of the fees?
- How many properties are paying each fee level?
- Are there any opportunities or a need to adjust the fee level or property classes?
- How are the charges distributed among the different land uses in Mimico Creek?

Figure 6-2: Property User Charges per Square Meter based on % Imperviousness



6.10 Flexibility:

To ensure a stable, equitable, continuous funding source for stormwater programs, rate structures must be flexible in order to incorporate local geographical requirements, provide for updating on a continuous basis, and be compatible with related systems such as Geographical Information Systems (GIS) and existing billing systems.

The flexibility of the Impervious Area and Percent of Impervious Coverage Method is relatively high, due to the capability to add more ranges, and/or adjust the rates for each range as required to improve the perceived equity. Other common rate modifications, such as credits for on-site detention, can be implemented as desired.

The updating and maintenance of the system can be accomplished with minimum adjustment of the normal planning procedures for most cities. For example, the computation of gross and impervious area and the selection of an appropriate range can be a requirement of obtaining a building permit for new developments, and the city staff can input the new data into the system in a manner similar to adding a new water service account.

6.11 Opportunities for Credits:

It should be kept in mind that any monies awarded as credits or reductions will have to be raised through increased charges to other properties or taken out of any surplus revenues that the utility may generate. As in the case of the % Imperviousness rate method, credits could be awarded for the following:

- Downspout disconnection – This measure would effectively reduce the impervious area of the property by the area equivalent to the building(s) on site;
- Changes from impervious to pervious materials for driveways and walkways;
- Credits could also be awarded based on socio-economic factors, such as income, age group (seniors on a fixed income for example)

6.12 Conclusions:

The Impervious Area and Percent of Impervious Coverage Method is appropriate for localities which have a significant percentage of highly developed, non-residential land and a minimum of undeveloped land. This method can shift more of the financial burden on highly developed properties, without regard to land use. The measurement of impervious area is a labor-intensive task, but significant savings could result from the development of flat rates to be used for single-family residences or other land use groupings. The Impervious Area and Percent of Impervious Coverage Method is rarely used by municipalities currently operating stormwater utilities in the United States, since data regarding both impervious area and gross area are required (Fort Wayne Stormwater Task Force, 1993).

Table 6.2: Example Runoff Charges For Properties in the Mimico Creek Watershed Using the *% Impervious Coverage* Method

(Table data generated from a random sample of 15 different properties in the Mimico Creek Watershed, Rates taken from city of Denver rate tables (year unknown), adjusted to Canadian dollars (multiplied by $1.40)

Property #	*Impervious Area*	*Gross Property Area*	*% Impervious*	*Property Equivalent Runoff Charge*	*Charge per unit (annual)*	*Charge Per Unit over 25 Years*	*Charge per Square Meter*
1	286.27	3215.86	8.90	$0.52	$148.29	$3,707.20	$0.05
2	11135.06	535295.2	2.08	$0.52	$5,767.96	$144,199.03	$0.01
3	72.22	652.91	11.06	$0.66	$47.52	$1,188.02	$0.07
4	3048.94	44507.88	6.85	$0.52	$1,579.35	$39,483.77	$0.04
5	0	2505.32	0.00	$0.52	$0.00	$0.00	$0.00
6	6370.42	13532.78	47.07	$1.08	$6,867.31	$171,682.82	$0.51
7	12220.99	22958.87	53.23	$1.08	$13,174.23	$329,355.68	$0.57
8	3508.98	11574.66	30.32	$0.80	$2,800.17	$70,004.15	$0.24
9	913.14	6096.05	14.98	$0.66	$600.85	$15,021.15	$0.10
10	251.29	51602.81	0.49	$0.52	$130.17	$3,254.21	$0.00
11	2188.34	9938.53	22.02	$0.80	$1,746.30	$43,657.38	$0.18
12	10374.03	45844.97	22.63	$0.80	$8,278.48	$206,961.90	$0.18
13	7694.94	16672.89	46.15	$1.08	$8,295.15	$207,378.63	$0.50
14	11906.84	27653.34	43.06	$1.08	$12,835.57	$320,889.34	$0.46
15	27145.7	192626.3	14.09	$0.66	$17,861.87	$446,546.77	$0.09
Totals for Watershed					***$5,164,254.70***	***$129,106,367.40***	

Chapter 7: Combined Charges

The method described in this section is a combination of the impervious area and the gross area method, incorporating undeveloped property. Proposed by The Fort Wayne Stormwater Task Force (1993) the method described in this chapter has never been implemented. A combined rate structure may be appropriate and worth investigating for certain municipalities. The fairest rate structure would be one that addressed every conceivable factor which might be found on a parcel and which influenced the rate, quality or quantity of runoff generated by that parcel. However, such a design may be expensive to administer due to the data management requirements. The key is to strike a balance so that enough factors are considered so as to be fair, and that the structure is simple enough to be explained easily and to be administered cost-efficiently (Florida Association of Stormwater Utilities, 1998).

7.1 Description:

The basic purpose of this rate structure is to implement the impervious area rate method described earlier, while incorporating an intensity of development factor for all undeveloped properties.

There are basically only two different rate structures for stormwater utilities based on cost of service and contribution to runoff:

- Rates based on impervious area (the first method described);

- Rates based on gross area and intensity of development (the second method described);

There are numerous variations of these two basic methods; most of the variations are designed to increase the fairness of the financial burden placed on the residential versus non-residential properties.

This approach will require a two-step process in the development of this rate design. The base rate will include a charge for the pre-developed (undeveloped or open space) gross area for all properties in the service area. This base rate will be determined by establishing 'Pre-Development Units' (PDUs), similar to equivalent residential units described earlier, and multiplying the number of PDUs per property by a $ rate factor. The second tier of the rate design will include a charge for impervious area for all developed properties. This rate will be determined as outlined in the Equivalent Runoff Unit rate method described earlier.

7.2 Data Requirements:

Undeveloped properties (those properties with no buildings or improvements on them) do not naturally have impervious areas and, in some cases, have not been altered from their natural state. If the reference area includes impervious areas only, then undeveloped properties simply have to be identified in the utility billing database but no additional information is required. If the reference area includes pervious area as well, then total parcel area must be defined for each undeveloped property (Florida Association of Stormwater Utilities, 1998).

The following are used in the development of a billing system based on impervious area and gross area:

- Property records to determine the total number of parcels in each existing land use
- Gross area of each parcel
- Aerial photography
- Impervious area of each developed parcel
- Service address, and approximate property boundary.
  - Owner's name and address will be determined for all consolidations, during the billing system implementation phase.

7.3 Calculation Method:

A general procedure for determining the rates to be charged for the Impervious Area and Gross Area, Incorporating Undeveloped Properties Method is as follows:

Step One:

1. Determine the average residential gross area and define this area as one pre-development unit (PDU).
2. Establish the rate per PDU from the cost of service analysis and compute the number of PDUs for each parcel.
   - In this example the PDU Rate is equal to $8.68 per PDU in scenario 1, and $48.89 per PDU in scenario 2. This rate was selected simply because open and undeveloped spaces represent 26% of the total watershed area, (charge per PDU = ERU Rate x 0.26)

Step Two:

6. Determine impervious area for all developed parcels. Determine the average residential impervious area and define this area as one equivalent residential unit (ERU).
7. Establish the rate per ERU from the cost of service analysis, in the Mimico Creek Example $33.37/year for scenario 1, and $188.07/year in scenario 2;
8. Compute the number of ERU's per parcel.

Equation 7.1 – Hypothetical Calculation for the Combined Charges Method

(# Of PDUs x Rate per PDU) + (# of ERUs x Rate per ERU) =

TOTAL CHARGE for each parcel

The fees to be charged to each parcel can be adjusted by other modifying factors, if desired. The specific computations would be developed on a case-by-case basis.

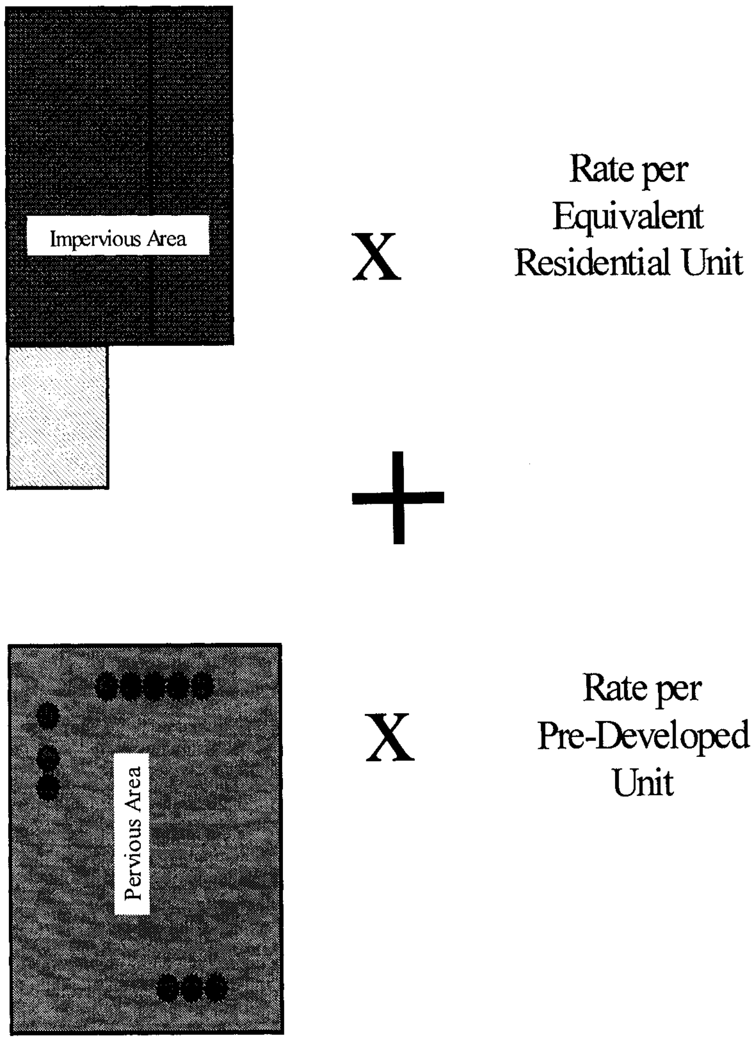
7.4 Public Understanding:

The public will generally have a good understanding of the method used for this rate structure. It may be difficult however, for the general public to understand the purpose of the dual rate concept.

7.5 Open Space:

This method takes into account open spaces by assigning a rate to each open space unit or pre-developed unit. This calculation method ensures that all property in the watershed area is charged at a certain defensible rate, regardless of whether it is pervious.

Figure 7-1: Calculation Method For Combined Runoff Charges



7.6 Water Quality Measures:

The relationship between impervious surfaces and water quality are explained in detail in Chapter 4, however, of all the rate structures examined, this method lends itself best to the addition of specific water quality considerations because of its multiple tiered approach. This would allow a third tier used for measuring water quality to be added in the future if desired.

7.7 Implementation:

As is the case with other methods, the ease and cost of implementation of a rate structure based on this method is directly proportional to the data requirements and the availability of existing data. It is expected that the implementation of this method may be slightly higher than other methods, since data are required for both gross area and impervious area for each parcel. The information is usually derived from property records from local government offices and aerial photographs. The cost can be estimated on a "per parcel" basis after considering the difficulty of extracting the necessary data from these sources (Fort Wayne Stormwater Utility Task Force, 1993).

7.8 Technical Accuracy:

This method attempts to incorporate the best elements from both the impervious area and intensity of development methods previously discussed. However, this method remains untested because it has never been implemented. If the rates are based on hydrological principles and actual cost of service, this method has a degree of technical accuracy defensibility. It may be difficult to demonstrate that the rates for each area are related to a corresponding increase in the cost of service.

Care should be taken to ensure that any grouping of certain categories of parcels is done in a logical and straightforward manner. However, the use of flat rates for certain categories would negate much of the benefits of this method relating to accuracy (Fort Wayne Stormwater Utility Task Force, 1993).

7.9 Opportunities for GIS Analysis:

Figure 6-2 on page 89 shows how charges would be distributed among pervious lot area, and impervious lot area in the Mimico Creek Watershed. It is possible to use GIS to determine where the fees in the Mimico Creek Watershed will be distributed by identifying a specific number of ERUs and/or PDUs. Some of the questions that may need to be addressed would be:

- What is the distribution of the fees?
- Which properties will be paying the most based on their number of ERUs and/or PDUs?
- Are there any opportunities or a need to adjust ERU or PDU levels?
- Are there any opportunities to create classes of properties based on PDU or ERU levels, i.e. ERU>=1 or PDU>=1?
- How are the charges distributed among the different land uses in Mimico Creek?

7.10 Flexibility:

To ensure a stable, equitable, continuous funding source for stormwater programs, rate structures must be flexible in order to incorporate local basin and geographical requirements, provide for updating on a continuous basis, and be compatible with related systems such as GIS, and existing billing systems.

The flexibility of the impervious area and gross area incorporating undeveloped properties method is relatively high, due to the capability to adjust the rates, or add further rate modifications as required to improve the perceived equity.

The updating and maintenance of the system can be accomplished with minimum adjustment of the normal planning procedures for most cities. For example, the computation of gross and impervious areas can be a requirement of obtaining a building permit for new developments, and the city staff can input the new data into the system (Fort Wayne Stormwater Utility Task Force, 1993).

7.11 Opportunities for Credits:

As in the case of the Equivalent Residential Unit (ERU) method, credits could be awarded for the following:

- Downspout disconnection – This measure would effectively reduce the impervious area of the property by the area equivalent to the building(s) on site;
- Changes from impervious to pervious materials for driveways and walkways;
- Credits could also be awarded based on socio-economic factors, such as income, age group (seniors on a fixed income for example)

Table 7.1: Example Runoff Charges For Properties in the Mimico Creek Watershed Using The Combined Charges Method

(Table data generated from a random sample of 15 different properties in the Mimico Creek Watershed)

Property #	Impervious Area	Gross Property Area	Total Pervious Area per Lot	Total PDU's	Total ERU's	Charge per Property PDU's (Scenario 1)	Charge per Property ERU's (Scenario 1)	Total Annual Charge Per Property (Scenario 1)	Total Charge Per Property Over 25 Years (Scenario 1)	Charge per Square Meter
1	286.27	3215.86	2929.59	2.07	0.95	$18.00	$31.58	$49.59	$1,239.63	$0.02
2	11135	535295	524160.18	371.12	36.81	$3,221.33	$1,228.39	$4,449.72	$111,243.11	$0.01
3	72.22	652.91	580.69	0.41	0.24	$3.57	$7.97	$11.54	$288.40	$0.02
4	3048.9	44507.9	41458.94	29.35	10.08	$254.79	$336.35	$591.15	$14,778.65	$0.01
5	0	2505.32	2505.32	1.77	0.00	$15.40	$0.00	$15.40	$384.92	$0.01
6	6370.4	13532.8	7162.36	5.07	21.06	$44.02	$702.77	$746.79	$18,669.69	$0.06
7	12221	22958.9	10737.88	7.60	40.40	$65.99	$1,348.19	$1,414.18	$35,354.58	$0.06
8	3509	11574.7	8065.68	5.71	11.60	$49.57	$387.10	$436.67	$10,916.80	$0.04
9	913.14	6096.05	5182.91	3.67	3.02	$31.85	$100.74	$132.59	$3,314.70	$0.02
10	251.29	51602.8	51351.52	36.36	0.83	$315.59	$27.72	$343.31	$8,582.82	$0.01
11	2188.3	9938.53	7750.19	5.49	7.23	$47.63	$241.41	$289.04	$7,226.07	$0.03
12	10374	45845	35470.94	25.11	34.30	$217.99	$1,144.44	$1,362.43	$34,060.82	$0.03
13	7694.9	16672.9	8977.95	6.36	25.44	$55.18	$848.89	$904.06	$22,601.60	$0.05
14	11907	27653.3	15746.50	11.15	39.36	$96.77	$1,313.54	$1,410.31	$35,257.71	$0.05
15	27146	192626	165480.60	117.17	89.74	$1,016.99	$2,994.65	$4,011.64	$100,291.12	$0.02
Total for Watershed									$18,660,634.83[✝]	

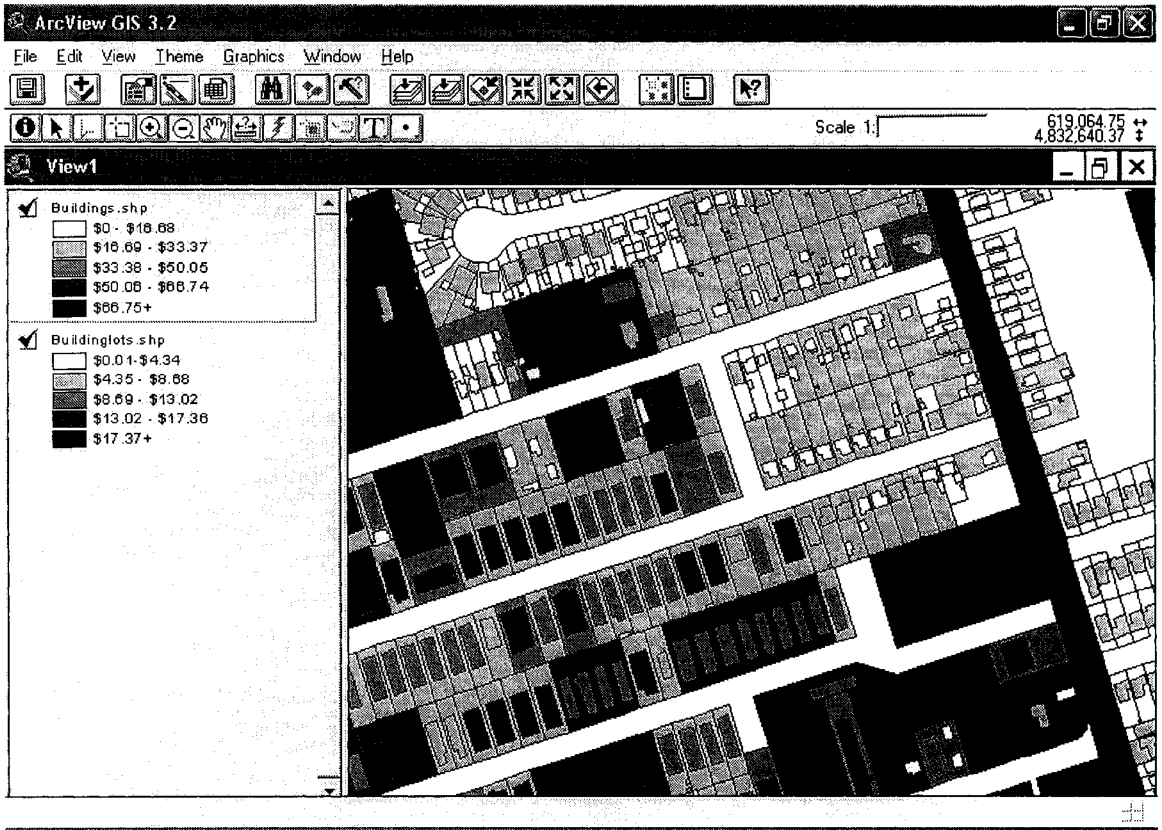
[✝] For information on surplus revenues see Section 9.1.2 on page 101

Table 7.1 *cont.*: Example Runoff Charges For Properties in the Mimico Creek Watershed Using The *Combined Charges* Method

(Table data generated from a random sample of 15 different properties in the Mimico Creek Watershed)

Property #	*Impervious Area*	*Gross Property Area*	*Total Pervious Area per Lot*	*Total PDU's*	*Total ERU's*	*Charge per Property PDU's (Scenario 2)*	*Charge per Property ERU's (Scenario 2)*	*Total Annual Charge Per Property (Scenario 2)*	*Total Charge Per Property Over 25 Years (Scenario 2)*	*Charge per Square Meter*
1	286.27	3215.86	2929.59	2.07	0.95	$101.43	$177.99	$279.42	$1,239.63	$0.09
2	11135	535295	524160.18	371.12	36.81	$18,147.82	$6,923.11	$25,070.92	$111,243.11	$0.05
3	72.22	652.91	580.69	0.41	0.24	$20.11	$44.90	$65.01	$288.40	$0.10
4	3048.9	44507.9	41458.94	29.35	10.08	$1,435.42	$1,895.65	$3,331.07	$14,778.65	$0.07
5	0	2505.32	2505.32	1.77	0.00	$86.74	$0.00	$86.74	$384.92	$0.03
6	6370.4	13532.8	7162.36	5.07	21.06	$247.98	$3,960.74	$4,208.72	$18,669.69	$0.31
7	12221	22958.9	10737.88	7.60	40.40	$371.77	$7,598.27	$7,970.05	$35,354.58	$0.35
8	3509	11574.7	8065.68	5.71	11.60	$279.26	$2,181.67	$2,460.93	$10,916.80	$0.21
9	913.14	6096.05	5182.91	3.67	3.02	$179.45	$567.74	$747.18	$3,314.70	$0.12
10	251.29	51602.8	51351.52	36.36	0.83	$1,777.93	$156.24	$1,934.16	$8,582.82	$0.04
11	2188.3	9938.53	7750.19	5.49	7.23	$268.33	$1,360.58	$1,628.91	$7,226.07	$0.16
12	10374	45845	35470.94	25.11	34.30	$1,228.10	$6,449.94	$7,678.04	$34,060.82	$0.17
13	7694.9	16672.9	8977.95	6.36	25.44	$310.84	$4,784.25	$5,095.09	$22,601.60	$0.31
14	11907	27653.3	15746.50	11.15	39.36	$545.19	$7,402.95	$7,948.14	$35,257.71	$0.29
15	27146	192626	165480.60	117.17	89.74	$5,729.38	$16,877.56	$22,606.93	$100,291.12	$0.12
Total for Watershed									*$105,159,544.15*	

Figure 7-2: User Fees per property based on a Combined Charge ***(ERU charges derived from Buildings.shp dataset, PDU charges derived from Buildinglot.shp dataset)***



It should be kept in mind that any monies awarded as credits or reductions will have to be raised through increased charges to other properties or taken out of any surplus revenues that the utility may generate.

7.12 Conclusions:

The impervious area and gross area incorporating undeveloped properties method may be the best method for urban areas with lands waiting for development, because of the treatment of undeveloped parcels and the reliance on actual measurements of impervious area. This method also allows for expansion in the future (water quality issues). However, the measurement of impervious area is a labor-intensive task, but significant savings could result from the development of flat rates to be used for single-family residences.

Chapter 8: Other Issues in Stormwater Charges

This chapter looks at some of the other considerations that should be taken into account by utility managers from a rate setting and revenue generation point of view. Many of the methods described in previous chapters described opportunities for credits; these will be elaborated on in this portion. Also in previous chapters the issue of 'Flat-Fees' has been brought up as an alternative to some of the more complicated calculation methods described, this is examined here. As well, the issues of new developments in an existing watershed or stormwater utility jurisdiction are addressed.

8.1 Credits

By establishing credits in its rate structure, a stormwater utility can involve property owners in protecting water quality – and help lower the total cost of stormwater management for the community. Credits are designed to give property owners incentives to implement peak runoff controls and water quality best management practices (BMPs) and properly maintain onsite stormwater facilities. Credits could also reward those users who go beyond minimum requirements in the local stormwater management code. Some stormwater utilities offer credits for onsite stormwater detention-retention facilities in new developments. Others provide credits to property owners that retrofit older dry detention basins.

In addition to rewarding utility customers, credit programs can save municipalities money in the long run on stormwater management costs. They increase the equity of the fee structure and are also good for community relations since customers are being given the option for lowering their utility bills.

Despite these advantages, incentive programs and credits are not yet widely used. A 1996 survey (Doll and Lindsey, 1999) conducted found only 26% of utilities studied nationwide (United States) using credits to promote runoff quantity reductions – and only 11% had fee structures that addressed runoff quality. This may be due to the administrative work involved in the implementation of incentive programs. Most utilities surveyed expressed interest in exploring these features. As well, in many municipalities in the United States, credits usually are available only to nonresidential property owners (Doll and Lindsey, 1999).

8.1.1 Mitigation or Management Credits

Fee systems where charges are tightly correlated with runoff quantity provide an incentive to property owners to manage stormwater on site. Some utilities increase this incentive by offering credits that lower the fees charged to property owners using stormwater runoff "best management practices" (BMPs). Credits can be given for structural BMPs, such as a runoff retention pond on a campus-style industrial park, or non-structural practices, such as disconnecting a residential roof gutter to keep the runoff out of the municipal sewer. Landowners can also be rewarded either for reducing the quantity of stormwater runoff on a parcel or for improving its quality (Doll and Lindsey, 1999).

Mitigation credits apply to parcels that have provided on-site, man-made stormwater management facilities. Argument can be made that credits should be given only to such facilities that are privately maintained, and meet design standards in terms of performance. This argument is based on the fact that the municipality will otherwise incur the full cost of maintenance of those facilities dedicated to the jurisdiction, just as if it were a publicly built facility. Where capital charges are separated from operations charges, credit could be separated depending upon whether the facilities were privately maintained.

Where the jurisdiction incurs the cost of maintenance of the on-site facilities, the parcel owner is often not entitled to a credit. However, where the responsibility for maintenance and upkeep falls on the owner, the burden incurred by the jurisdiction is substantially reduced, a credit is in order.

The mechanics of calculating a precise credit for each eligible parcel lies within the expertise of professional stormwater engineering or management. A credit process must be based on sound principles and must be codified or standardized in order to be consistently applied across time and by various qualified individuals. As a result, this could be a time consuming and expensive process.

Typically, so as to assign credits to eligible parcels in an inexpensive manner when setting up the utility database, a single credit value is calculated for each stormwater design code (this could be a runoff coefficient or intensity of development factor) that is in effect in the jurisdiction. All parcels developed under that code are assigned the same credit value. Often, a jurisdiction will only have adopted two or three substantially different design codes over the "life" of the jurisdiction (Florida Association of Stormwater Utilities, 1998).

In the United States, some local governments have incorporated credits against charges for onsite controls of volumes of runoff (i.e. quantity of runoff) through the use of BMPs. Some US public works officials have been cautious to approve credits because of the potential reduction in revenues and because of uncertainties associated with the effective operation and maintenance of BMPs. For instance, additional costs can be incurred by municipalities through periodic inspections to establish that BMPs do exist on individual properties, and remain operating effectively over time. The issue of whether to adopt credits is one that typically is debated whenever charges are considered (Cameron et al., 1999).

In the fairest or most equitable stormwater fee structures, the owners of those properties contributing the most runoff would be charged the highest fees. By extension, reducing runoff would lead to reduced fees. Utility customers would therefore have an incentive to reduce the amount of runoff produced on their property by either reducing impervious surface or implementing stormwater best management practices (BMPs) to contain and process stormwater on site – before it "runs off" and contributes to pollution problems. Equitable systems offer property owners a degree of control over how much they pay in stormwater management fees to the extent that they can control stormwater flow on their land.

8.1.2 Low Income Credits:

Some stormwater utilities offer fee reductions or exemptions to property owners who can show financial hardship. In practice, this only applies to residential properties, not businesses (Pioneer Valley Planning Commission, 1998).

The City of Bellingham WA allows credits based on income work out as follows (City of Bellingham, Date Unknown): Senior citizens and disabled people who own single-family residences, and who have been granted a senior citizen or disabled exemption by the City due to low income, are entitled to a rate reduction that is scaled to their household income. Other property owners may also obtain the reduction if they rent the property to a qualified senior or disabled citizen and pass the savings to the tenant. Qualifying household income levels are established by the City Finance Director each year.

The reductions applicable at each income level are:

- Up to 50 percent of qualifying household income: 75 percent fee reduction
- 51 to 75 percent of qualifying household income: 50 percent fee reduction
- 76 to 100 percent of qualifying household income: 25 percent fee reduction (City of Bellingham, Date Unknown)

8.2 Flat Fees

A flat fee is a stormwater utility charge that is the same for all property owners within a particular land use classification. It is most commonly used for residential customers, although there are instances where a flat fee has been used as the sole billing mechanism covering all property classes. Flat fees are the simplest of all stormwater utility assessment methods to utilize, as they do not require individual property measurements or involve complicated assessment formulas. However, they offer the lowest degree of correlation between utility payments and runoff contribution from the property – and consequently rank low on the issue of fairness and ability to provide incentives for property owners to minimize runoff (Pioneer Valley Planning Commission, 1998).

Utilities could use flat fees during the start-up period, moving over to more individually-based billing systems as data for making property area and impervious surface calculations became more and more available.

8.4 Development Charges

Development charges are the fees levied against residential and non-residential development that are directed toward the cost of infrastructure services that are necessitated by the new growth. In some municipalities in the United States and Canada, for example, developers will not receive final approval for construction until a construction plan for needed stormwater improvements has been prepared and approved by the local government. If the stormwater improvements to be constructed will handle a greater capacity than the development requires, the developer may be reimbursed for the additional costs through a cash repayment from other developers or a stormwater fee credit after the completion of the stormwater facilities. A developer reimbursement program would allow the municipality to develop more rapidly since developers would not have to wait for the municipality to install needed stormwater improvements before construction can commence.

Some services to which development charges currently relate:

- Roads related to the development;
- Transit facilities in or around the development;
- Storm water management for the properties within the development;
- Parks and libraries in the development;
- Public works/Parks Shared Facilities; and,
- Major indoor Recreation Facilities.

Development charges can vary from municipality to municipality. As well, it is not only the local municipality that can levy a development charge on a newly developed property. Development charges may be levied by municipalities, school boards, or regional governments (see Table 8.1 on page 98 on for an example of Development Charges)

An example of development charges related to stormwater management is in the City of Fort Collins in the United States. The Fort Collins stormwater program charges development fees to all newly developed parcels or additions in the service area that result in an impervious area greater than 350 square feet. The one-time fee helps to cover the costs of the design and construction of needed stormwater facilities and helps the city obtain needed rights-of-way for the storm drain system. Development fees are assessed based on the basin the parcel is located in, the gross area of the parcel, the percent of the parcel that is covered by impervious surfaces, and the amount of on-site detention or reduction that is provided by the development. The per acre development fees for the

Table 8.1 - Sample Development Charges - Town of Ajax Ontario

(Adapted from: Town of Ajax Ontario Website, 2002)

Town of Ajax Summary of Development Charges Revised July 1, 2002				
RESIDENTIAL				
Type (residential)	*Town of Ajax*	*Board of Education*	*Region of Durham*	*Total*
Single Detached Dwelling	$5,754	$2,084	$10,335	$18,173
Semi-Detached Dwelling	$5,754	$2,084	$9,194	$17,032
Apartment Dwelling, Two or More Bedrooms	$3,453	$2,084	$6,508	$12,045
Apartment Dwelling, Less than Two Bedrooms	$2,630	$2,084	$3,824	$8,538
Other Dwellings (townhouses, links)	$4,930	$2,084	$9,194 (Low density multiples)	$16,208
COMMERCIAL				
Per Square Metre	$13.17	$1.94	$18.62	$33.73
Per square foot	$1.22	$0.18	$1.73	$3.13
OTHER NON-RESIDENTIAL				
Per Square Metre	$13.17	$1.94	---	$15.11
Per square foot	$1.22	$0.18	---	$1.40

twelve drainage basins in the stormwater program's service area range from $2,175 to $10,000 depending on the construction needs of each basin. Two of the Fort Collins drainage basins do not charge development fees at this time (Center for Urban Policy and the Environment, date of publication Unknown).

Chapter 9: Deciding and Adopting a Rate Structure and Conclusions

After a stormwater utility has reviewed all of the options available for calculating user fees for stormwater runoff, a decision must be made about which one is most appropriate. This decision may be largely political in nature, however there are some basic questions that should be answered:

- Is the rate structure able to raise sufficient revenue for the operation of the utility?
- Is the rate structure fair to all properties in the municipality?
- Does the rate structure represent an optimal distribution of charges?

When answering these questions, the decision makers must keep in mind some simple facts about stormwater treatment:

- The first is that regardless of who pays, and how much they pay, everyone in the watershed receives the same benefit, improved quality in the receiving waters;
- The second is that one square meter of impervious surface on a large property will generate roughly the same amount of runoff as one square meter of impervious surface on a smaller property. As well, one square meter of pervious surface on an large lot will represent roughly the same reduction in runoff as one square meter on a smaller lot;
- If land use is to be an issue, decision makers must also take into account the differences in tax rate for residential, industrial, and commercial properties. Often commercial and industrial properties pay much more tax than do residential properties.

With this in mind, decision makers can then review the options for a user fee system.

9.1 Will Sufficient Revenues be Generated?

For the Mimico Creek Study, the following data were found:

Table 9.1 - Revenue Comparisons Across Fee Calculation Methods

Equivalent Residential Units		*Rate Factor Method*		*Combined Charges Method*	
Scenario 1	*Scenario 2*	*Scenario 1*	*Scenario 2*	*Scenario 1*	*Scenario 2*
$18,295,265.60	$103,097,140.60	$19,256,720.46	$105,911,962.55	$18,660,634.83	$105,159,544.15
- $18,295,265.60	- $103,097,140.60	- $18,295,265.60	- $103,097,140.60	- $18,295,265.60	- $103,097,140.60
+/- 0	*+/- 0*	*+ $961,454.86*	*+ $2,814,821.95*	*+ $365,369.23*	*+ $2,062,403.55*

9.1.1 – Revenues Generated

The % imperviousness method is excluded from the table above due to the fact that it was run for one scenario only, and could be easily adapted to raise whatever revenue the stormwater utility deemed necessary.

The Equivalent Residential Units Method will raise exactly as much revenue as is required for both scenarios. This is due to the nature of the calculation. The total revenues required are simply divided by the total number of billable units or ERUs in this case, (it should be mentioned again that properties with no development or impervious area were excluded from this calculation). The utility would always be able to increase the charge per ERU. Much like the % imperviousness method, the rates could be adapted to raise whatever amount of revenue is deemed necessary.

The Rate Factor Method and Combined Charges Method generate a surplus under both scenarios. This could be considered a desirable outcome, as there is always the possibility of fee amounts being contested, bills not being paid, or credits being awarded. Also, there is always the possibility of an error in cost estimates and extra revenues being needed to make up for any short falls. These surpluses however, must be treated with care. There is always the possibility that property owners may start to question what is being done with the extra money, or simply demand lower stormwater rates.

9.1.2 – The Issue of Surplus Revenues

The Ontario Municipal Act Regulation 244/02 states that:

"The amount of fees or charges for the use of a waste management system, for the use of a sewage system or the consumption of water shall not exceed the cost of providing the waste management system, the sewage system or the water system, as the case may be".

The Ontario Municipal Act effectively prohibits user charges in excess of revenues needed to be collected. Therefore, two of the calculation methods would need modification in order to be considered for use in the Mimico Creek Watershed.

In this case, the Rate Factor Method would have to reduce charges by 5.25% and the Combined Charges Method would have to reduce fees by 2% in order to be legally accepted. The Equivalent Residential Units method would yield no surplus revenues, and the % Imperviousness Method could be easily modified to yield no surplus revenues. Conversely, the storm sewer improvement programs could be modified in order to accommodate these surplus revenues. While the Equivalent Residential Unit and % Imperviousness Method could be accommodated to meet virtually any revenue requirements without a surplus, the Rate Factor Method and the Combined Charges Method would need some attention.

For instance, the surplus revenues could be used for a public outreach and education program *(not accounted for in the revenue requirements)*. This would represent a simple, flexible, and necessary means to eliminate any surplus revenues. There may also be opportunities for program expansions. For instance, the surplus $961,000 from the rate factor method could be used to expand the plan to disconnect 3200 extra downspouts in the area, if feasible.

As well, it should also be noted that the original cost analysis does not take into account a credit system for the utility. The 5% extra revenues could be devoted to paying credits to those properties that are able to reduce the amount of runoff they may be generating, or pay out credits for socio-economic factors such as those on fixed incomes, or those property owners that may not be working.

9.2 Does the Rate Structure represent a Fair Structure?

For the purposes of deciding whether or not the rate structure selected is fair and efficient, the measure of cost per property per square meter was examined. To repeat what was said in the introduction, it must be remembered that one square meter of impervious surface on a large property will generate roughly the same amount of runoff as one square meter of impervious surface on a smaller property. As well, one square meter of pervious surface on an large lot will represent roughly the same reduction in runoff as one square meter on a smaller lot.

Economic theory tells us that the marginal costs of providing a service should equal the marginal revenues generated for that services. In the example here, the cost per square meter (over the 15 selected properties) will be the marginal cost of reducing the stormwater runoff. In Scenario 1, (only 1 scenario will be reviewed here) the marginal cost is equal to $0.02/meter^2 (on an annual basis).

Figure 9.2 below is a table containing a sample of properties from the Mimico Creek Watershed, and the respective costs per square meter for each of the fee structures.

As can be seen from the table, the costs per square meter vary dramatically between fee structures. However, within the fee structures, there are no extreme variations.

It can be seen that both the ERU method and the rate factor method both yield an average cost per square meter of $0.02, exactly equal to the marginal cost of the stormwater management plan.

The combined charges method yields an amount slightly higher than the marginal cost at $0.03 per square meter. The % imperviousness method yields a cost per square meter value of $0.20 per square meter, 10 times that of the marginal cost for the stormwater management plan.

It is presumed that due to the more scientific nature of the ERU, rate factor, and combined charges fee structures; they would yield a marginal revenue value closer to the marginal cost value. The % Imperviousness uses a method to classify properties into different groups, however the charges per square meter that the method assigns are arbitrary, and therefore result in less desirable outcomes.

Aside from economic issues, the fee per square meter is also a measure of how fair the rate structure is. The cost to treat the water running off a square meter of property is the same throughout the entire watershed. Therefore, the fee structure with the least amount of variation between properties would be the most fair for all properties in the watershed.

Table 9.2 Comparisons of various rates per square meter

(This table contains those rates calculated for Scenario 1 over the 15 sampled properties)

Property #	*Equivalent Residential Unit Method*	*Runoff Coefficient/Rate Factor Method*	*Percentage Impervious Method*	*Combined Charges Method*
1	$0.01	$0.03	$0.05	$0.02
2	$0.00	$0.02	$0.01	$0.01
3	$0.01	$0.01	$0.07	$0.02
4	$0.01	$0.01	$0.04	$0.01
5	$0.00	$0.00	$0.00	$0.01
6	$0.05	$0.02	$0.51	$0.06
7	$0.06	$0.04	$0.57	$0.06
8	$0.03	$0.03	$0.24	$0.04
9	$0.02	$0.02	$0.10	$0.02
10	$0.00	$0.02	$0.00	$0.01
11	$0.02	$0.01	$0.18	$0.03
12	$0.03	$0.03	$0.18	$0.03
13	$0.05	$0.02	$0.50	$0.05
14	$0.05	$0.02	$0.46	$0.05
15	$0.02	$0.02	$0.09	$0.02
Average Charge Per Square Meter	***$0.02***	***$0.02***	***$0.20***	***$0.03***

In this case, the fee structure that is the most fair is the Rate Factor Method. The cost per square meter in the fifteen properties sampled varies from $0.04 to less than $0.01, a variance of 4 cents per square meter at the most. The combined charges method has a range of 5 cents per square meter. The ERU method has a slightly greater range of 6 cents per square meter. The % Imperviousness method has a large range of over 50 cents per square meter.

9.3 Other Factors

Aside from cost recovery, fairness, and efficiency, there are other factors that should be compared when looking at the scenarios. The two factors investigated here are: the data requirements, and the public understanding of each scenario.

9.3.1 – Data Requirements

The data requirements for each of the fee structures are likely to represent the single largest cost, both time and money, for the stormwater utility. For the purposes of this analysis, only the number of data points will be looked at. The type of data required for each of the fee structures is important, but will not be included in this evaluation. This is due to the fact that the type of data available can vary drastically from municipality to municipality. As well the costs of data, although important, will not be examined as the amounts can also vary dramatically from place to place and may be largely based on availability.

Table 9.3 - Comparison of Data Requirements Between Fee Structures

Data Requirements	*Equivalent Residential Unit Method*	*Runoff Coefficient/Rate Factor Method*	*Percentage Impervious Method*	*Combined Charges Method*
Data Required	1) A Measurement of Impervious Area for each property; or, 2) Arial Photographs; 3) Current and projected land use (optional, not used in this example); and, 4) Service addresses and property boundaries	1) Property records to determine the total area of each property 2) Runoff coefficients, if already available 3) Service address, and approximate property boundary.	1) Property records to determine the total number of parcels in each existing land use 2) Gross area of each parcel 3) Aerial photography 4) Impervious area of each parcel 5) Land use map for each property 6) Service address, and approximate property boundary	1) Property records to determine the total number of parcels in each existing land use 2) Gross area of each parcel 3) Aerial photography 4) Impervious area of each developed parcel 5) Service address, and approximate property boundary.
# Of pieces of Data	*4 pieces*	*3 Pieces*	*6 Pieces*	*5 Pieces*

As can be seen from Table 9.3, the ERU method requires only 4 pieces of data. This is perhaps why it is such a widely adopted rate structure in the United States. The combined charges method requires only one item more than the ERU method. Due to the increased revenues that can be generated using the combined charges method, it is likely that gathering the extra data would be well worth the costs associated. The % imperviousness method requires 6 data points, and the rate factor method requires only 3 data points, assuming that runoff coefficients are readily available.

It should be mentioned that several of the fee structures require data that can be extracted out of other data sources. For example, as was done in the Mimico Creek Study, aerial photographs (which are required data for 3 of 4 methods listed above) can be used to extract the amount of impervious area for the properties in the watershed. Although a time consuming and labour intensive procedure, also due to the fact that it ultimately relies on human judgement, (and may be subject to error), it may be worth the resources if data on impervious area are available or are prohibitively expensive.

There may also be instances where more data than is listed above is required. An example of this may be the runoff coefficients required by the rate factor method. If these are not readily available, the utility would have to take the time to gather all of the runoff coefficients or the necessary data in order to calculate the runoff coefficients for each property in the study area. In a large study area or municipality, this could take a lot of time and resources to accomplish, and may make the Rate Factor Method less attractive or impossible to adopt.

9.3.2 – Public Understanding of Fee Structures

The level of public understanding of a fee structure is ultimately what could make a stormwater utility, or any utility, a success or failure. It is the public that must pay the bills, and make any improvements to their properties based on the fee or credit structure.

Also, it is likely that elected officials would want the public to have a good understanding of the rate structure, as the property owners are also voters.

Of all the rate structures, the Equivalent Residential Units method is likely to be the easiest understood by the general public. The contribution to stormwater runoff, and therefore the charge levied, is directly proportional to the impervious area of each lot. The impact of paving or developing land is very easy to explain and could be easily understood by the landowners and ratepayers.

The public may have some difficulty understanding the Rate Factor/Runoff Co-efficient Method and the % Imperviousness Method. It may be difficult for a non-engineer to fully grasp the relationship between the rate factors or range groupings and their contribution to runoff.

The public will generally have a good understanding of the Combined Charges Method. It may be difficult however, for the general public to understand the purpose of the dual rate concept, as well as how rainwater can run off and not be absorbed by lawns, gardens and other pervious surfaces around their property.

9.4 A Fee Structure for the Mimico Creek Watershed

In reviewing the fee structures examined in this work, the best method for the Mimico Creek Watershed is likely to be the *Rate Factor Method.* This is due to the following

1. It is an efficient and Fair Method;
2. It is a tested method in many municipalities in the United States;
3. It includes undeveloped or open space parcels in the fee structure;
4. The datasets needed already exist and are available;

5. It would raise enough revenue for the Stormwater Program proposed by Li and Banting (1999);
6. The revenues generated would leave enough of a surplus that a credit program could be easily established;
7. The factors involved in the calculation are all rational and scientifically based;
8. Although the public may not immediately understand the runoff coefficients, the surplus revenues could be invested in a public outreach program.

The ERU, % Imperviousness and Combined Charges Methods were not selected for the following reasons:

The Equivalent Residential Unit method was not selected for the simple reason that it does not include charges for open space. Over 25% of the Mimico Creek Watershed consists of open space or undeveloped properties; this would represent far too many lost revenues for the Stormwater Utility. Also, the method leaves little in the way of surplus revenues in the event of a shortfall or the desire to implement a credit program.

The % Impervious Method simply leaves too much up to human and possibly political decision making. It does not (at this point) distribute the charges in a fair or efficient a way. As well, the rates are likely to be seen as arbitrary to the public.

The Combined Charges Method does not distribute charges in as fairly or efficiently as the Rate Factor Method. Also, the extra steps involved in the calculation could lead to increased resources devoted simply to data maintenance and calculation. Also, it is likely that the public would not fully understand the need for two separate charges to be levied on each property. Finally, the combined charges method has not been tested and remains an experimental method.

Although the three methods that were not selected could be easily changed to better suit the Mimico creek Watershed, it is difficult to say exactly who would be the ones to change them. It could be engineers who understand only the scientific aspects; it could be managers who understand only the financial aspects; or, it could be elected officials who may only be interested in what the public may think.

Regardless, the Rate Factor Method is still the most scientific, the most efficient, fair, and tested method available, it can raise the money, it has been accepted in many other municipalities, and it can be implemented *as is* in the Mimico Creek Watershed.

9.5 A Direction for Future Work

The analysis done in this work should be regarded only as a beginning. The intention of this work was to examine rate structures that may be appropriate for the Mimico Creek Watershed, and determine if one in particular was best suited for implementation in that area. Although the analysis completed in this paper did arrive at one method being better suited for the Mimico Creek Watershed, the analysis did not look at the surrounding City of Toronto.

The City of Toronto is the municipal government that would be implementing a user charge for stormwater if one were to be implemented. It is unlikely that the City would implement a user fee for the Mimico Creek Watershed only, but would implement a user fee for the entire city of Toronto.

The next stage in this work would be to take the fee calculation methods discussed here, and apply them to the entire City of Toronto. It is likely that the Mimico Creek

Watershed does not represent the built areas and open spaces of the rest of the city, and it is possible that different conclusions could be drawn as to what is best, or most efficient for the City.

The City of Toronto as a whole may also require completely different technologies for stormwater treatment and management than those looked at in the Mimico Creek study. It is possible that there are economies of scale that could be taken advantage of if a stormwater treatment plan and user fee system was created for the whole city.

There is also a need for more detailed socio-economic analysis of the issue. Certainly if the municipal government were to implement a user fee for stormwater management, it would become a political issue very quickly. As well, if a user fee for stormwater management were adopted for the City of Toronto, could the residents expect a reduction in their property taxes?

Another possible route for future work to take would be to establish that perhaps for the purposes of stormwater and other environmental issues, the watershed should be the planning unit and not the entire city. This suggestion is certainly not new, particularly in the city of Toronto. Toronto contains several different watersheds, all with very unique features, and, with active interest groups working for watershed improvements, how would these groups feel about the uniqueness of these environmental features being homogenized into one large plan?

With regards to the technologies available, particularly GIS, how can these be better suited for the analysis of user fees and stormwater management? For this project, a GIS was invaluable for data management and extraction. However, GIS has even greater potential. Would it be possible to fully combine the management and engineering factors together, and make them useable?

Throughout the course of this project, there were many instances were hours, days and even weeks, were spent trying to get datasets to work together. This is due to the fact that the engineering and socio-economic datasets were likely created by totally different people, for totally different purposes. How can this issue best be resolved?

While examining the issue of GIS, despite the fact that it is still a relatively new, and rapidly changing technology, it is quickly becoming a very powerful resource. The fact that GIS allows managers, scientists, and engineers to look at data in a new way, and with greater precision than before is certainly an exciting prospect for future work. From the point of view of stormwater management, an issue that is as much a science as it is an art, GIS offers a way to combine all of the disciplines involved.

A next logical step would be to create a fully integrated stormwater management plan using GIS software. There are methods in GIS for modeling stormwater flows; there are methods for completing socio-economic analysis using a GIS; Li and Banting (1999) contributed a GIS method for determining stormwater controls (the basis for this work); and, this work examined a method for taking GIS data and calculating user fees for a stormwater management plan. The problem is that these were done as three separate exercises, when they could potentially be done as one. Further research should be undertaken to try and do so more effectively.

One thing that can be said in the present is that stormwater management is going to become a larger and larger issue in the very near future, particularly in the City of Toronto. Development is not going to stop, it may change form, but not cease. As a result of this stormwater managers, and other environmental managers, must keep their options open.

"The Best Decisions, are the ones that leave us with the most option in the end"

Source: Unknown

Appendix 1: Regulations

ONTARIO REGULATION 244/02
made under the
MUNICIPAL ACT, 2001

Made: August 19, 2002
Filed: August 20, 2002

FEES AND CHARGES

Conditions re: waste, water

12. (1) This section applies only to the power of a municipality or a local board under Part XII of the Act to impose fees or charges for the use of a waste management system, the use of a sewage system or the consumption of water.

(2) The amount of fees or charges for the use of a waste management system, for the use of a sewage system or the consumption of water shall not exceed the cost of providing the waste management system, the sewage system or the water system, as the case may be.

(3) A by-law, if not repealed earlier, expires on December 31 of the year following the year in which the by-law was passed.

(4) Despite subsection (3), in the case of a by-law, which was in force on the day this Regulation comes into force, the by-law expires on December 31 of the year following the year in which this Regulation comes into force.

(5) Amendments to a by-law under Part XII of the Act do not affect the term of the by-law under subsection (3) or (4).

(6) Before passing a by-law imposing a fee or charge, the municipality or local board, as the case may be, shall,

(a) hold at least one public meeting at which any person who attends has an opportunity to make representation with respect to the matter;

(b) ensure that a minimum of 21 days notice of the public meeting is given, including giving 21 days notice to every person and organization that has, within five years before the day of the public meeting, given the clerk of the municipality or secretary of the local board, as the case may be, a written request for notice of the passing of the by-law containing a return address;

(c) ensure that notice under this section,

(i) sets out the intention of the municipality or local board to pass the by-law and whether the by-law would impose any fee or charge which was not in effect on the day the notice is given or change any fee or charge which was in force on the day the notice is given, and

(ii) sets out the information described in clause (d) or states that the information will be made available at no cost to any member of the public upon request; and

(d) shall make available to the public information setting out,

(i) a description of the service or activity or other matter for which the fee or charge is being imposed,

(ii) an estimate of the costs of providing the waste management system, the sewage system or the water system, in respect of which the fee or charge is being imposed,

(iii) the amount of the fee or charge, and

(iv) the rationale for imposing the fee or charge.

Appendix 2: Metadata

The geographic co-ordinates of all features in these map series had already been standardised, in units of the three-degree Universal Transverse Mercator projection (3? UTM), based on the 1927 North American Datum (NAD27). Attribute records describing the features found on the maps were not extensive, except for roads, which had been stored as standard database (dbf) files. However, these had not been linked to digital geographic representations of their locations. Some additional records were only available as hard copy (paper maps of land use, parks, soils and 13 key maps of sewer sheds) at different scales, to different standards and for diverse purposes. That the municipal records were aggregated as maps was also incompatible with the study's layer-based evaluations, which would rely on separate database entries for individual features. The initial tasks therefore involved isolation of the available Microstation (.dgn) records from municipal files and supplementing these with data digitised specifically for this project (also using Etobicokes Microstation software, and Etobicokes standard projection and datum). These map-based files were all clipped to the limits of the Mimico Creek Watershed then exported and converted to feature-based and topologically-structured, point, arc, and polygon layers (Arc/Info coverages and ArcView .shp files).

Specific data sources:

Layer	Sources (EPW Etobicoke Public Works; TRCA - Toronto Region Conservation Authority)
1. Storm Sewer Sub catchments & outfalls	Digitising of EPW Sewer Design Sheets (Storm Key Plans), with runoff coefficients for each subcatchment (sewershed)
2. Roads	EPW PIX 11 double-sided streets, converted to centre-lines
3. Watercourses	EPW Series 1 & hard copy paper records, TRCA Fish Habitats
4. Lots	EPW PIX 1
5. Parks/Open Spaces	EPW / Parks/Planning, - parks, cemeteries & golf courses
6. Utilities Easements	EPW Series 1 & 2
7. Buildings	EPW Series 1
8. Geology/Soils	Scanned EPW hard copy paper records
9. Elevation points	EPW Series 3 & hard copy paper records (roads) ~50,000 spot elevations
10. Floodlines	Toronto Region Conservation Authority
11. Areas with Downspouts Directly Connected to Storm Sewers	EPW hard copy
12. Spill prone areas	Etobicoke Works Department kept record of spill location in the last two years.
13. Sensitive Aquatic Habitat	Toronto and Region Conservation Authority's paper map."

From Li and Banting, 1999, pp6-7.

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