Utilization of Information Management Systems for Sustainable Infrastructure Planning

by

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Abstract

In an effort to improve the accounting, management, and reporting of infrastructure assets by smaller U.S. towns and cities, the Government Accounting Standards Board (GASB) has created a set of asset management standards entitled Statement 34. The aim of GASB 34 is to extend the considerations and planning horizon of local infrastructure managers, such that efficient and effective means of infrastructure development and maintenance can be utilized to extend the lifecycle of these assets. The lifecycle value considerations and system-based approach to planning inherent in GASB 34 compliance are also highly applicable to another critical issue facing local governments today: the practical implementation of the economic, environmental, and social factors comprising the concept of "sustainable development".

This thesis will evaluate a web-based capital asset management system, *Barchan*, created to address the requirements of GASB 34. Field testing of the system will take place in Winchester, Massachusetts, and will involve an analysis of the infrastructure configuration and condition input processes, followed by a scenario analysis of system performance relative to maintenance quality and resource optimization. The methodology of information management tools like *Barchan* will be extended to address the requirements of sustainable development. The concept and various definitions for and governmental approaches to sustainable development will be discussed in an attempt to show that Federal and state regulations stipulating rigid policies for sustainability do not adequately account for the variable and highly specific applications and obligations of sustainable development. As an alternative, policy decisions made at the local government level are proposed as a more effective approach to long-term sustainability. The use of the GASB 34 compliance methodology and information management tools, such as *Barchan*, discussed in the early chapters of this thesis are then analyzed as an enabling mechanism to promote sustainable development at the community level.

Thesis Supervisor: Fred Moavenzadeh
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Chapter 1 Introduction

1.1 Why Asset Management and Accounting for Local Infrastructure?

Over the past two centuries, municipal governments have become very accustomed to addressing local infrastructure issues in a relatively ad hoc, reactionary manner. Why should local governments invest time and resources to implement strategies and tools for better infrastructure planning, cost accounting, and maintenance? The answer is twofold: First, the Governmental Accounting Standards Board has enacted an infrastructure management regulation entitled Statement 34, which requires local governments to better account for their infrastructure assets and maintenance operations, providing better transparency and accountability to the public for tax-dollar usage. The second, and less straightforward, reason is that changing social and environmental responsibilities will require local governments to take a closer look at their infrastructure networks, how they are put in place, and how they interact with other social and natural systems both now and in the future. The buzzword associated with these considerations is "sustainable development". Increasing public recognition of the impacts of short-term, poorly planned, unsustainable development puts a great deal of pressure on local governments to take action in the common, "everyday" activities of socio-economic development, such as zoning and infrastructure. In the context of one small town these issues may seem minor, but in aggregate with all the small towns in the United States and the world, planning and development at the local level has the potential to impact the global social, environmental, and economic condition in a very significant way.

This thesis will discuss the use of information management tools to serve local government interests through more informed infrastructure management. Chapter 1 will discuss the applications and obligations of GASB Statement 34 and introduce *Barchan,* a web-based capital asset management tool developed to address the challenges of Statement 34 implementation. Chapters 2, 3, and 4 will analyze and evaluate the use of *Barchan* through beta-site testing in Winchester, Massachusetts. Chapter 5 will introduce the concept of sustainable development, as well as the challenges of achieving sustainability. Chapter 6 will present historical case analyses of sustainable development, focusing on one facet of sustainability, urban sprawl, which correlates well with the considerations and characteristics of infrastructure management.

Chapter 7 will analyze the role of local governments in achieving sustainable development, and the use of information management tools such as *Barchan* to enable local governments to make informed decisions with regard to sustainability. Finally, Chapter 8 will present key conclusions from this analysis, and outline desired improvements to *Barchan* with respect to sustainable development, as well as identify valuable areas of future research on this subject.

1.2 Governmental Accounting Standards Board

The standards by which state and local governments in the United States account for and report their financial activities are developed and issued by the Governmental Accounting Standards Board (GASB). The GASB is a private, nonprofit organization established in 1984 and overseen by the Financial Accounting Foundation, which also oversees GASB's sister-organization in the private sector, the Financial Accounting Standards Board.

The primary function of GASB is to induce transparency in the allocation and expenditure of public funds through external financial reporting. Such reporting is a critical element of fair and informed investment disclosure, such as municipal bond offerings, and is of great importance to decision-makers in both the public and private sectors.

The mission of the Governmental Accounting Standards Board[1] is to establish and improve standards of state and local governmental accounting and financial reporting that will:

- Result in useful information for users of financial reports
- Guide and educate the public, including issuers, auditors, and users of those financial reports

1.2.1 GASB Statement 34

The GASB released Statement 34 in June 1999 to address increasing demand by citizens and private sector industry for better transparency and reporting by local governments relative to infrastructure assets. For example, the Governmental Research Association, a national organization of citizen research and taxpayer groups, drafted a letter to the GASB which stated, "As intensive users of financial information, we believe that infrastructure reporting is an

essential element in improving the accountability of governments to their citizens...[P]ossessing information about capital asset costs or condition is important in helping policymakers and citizens make better informed choices about the expenditures of public funds and appropriate levels of taxation." Also, the National Federation of Municipal Analysts (NFMA), composed of thousands of brokers, fund managers, insurers, and rating agencies, cites the importance of infrastructure information to municipal credit analysis, saying, "By their nature, most municipal bonds finance 'capital assets' and as such, the relevance of this information to public finance professionals is paramount."

Government spending for infrastructure-related programs is in no way insignificant. In the United States, local governments spend approximately $150 billion per year on the construction and maintenance of infrastructure assets, with nearly that entire amount financed through the sale of municipal bonds. Infrastructure-related spending represents more than 10% of total expenditures by local governments.[2]

The fact that current and future generations will be required to fund the construction and maintenance of infrastructure projects dictates that accurate and transparent financial reports be produced by local governments detailing capital and recurring costs for infrastructure assets. Of primary importance is documentation that current infrastructure assets are being maintained such that their useful life is maximized, reducing the financial burden on taxpayers in replacing these assets.

1.2.2 Requirements of GASB Statement 34

Despite the significance of infrastructure asset costs in the long-term financial responsibilities of local governments, current governmental accounting methods and financial statements omit the costs of infrastructure-related services. Instead, government reporting is limited to short-term considerations for capital investment. Statement 34 seeks to remedy this problem.

The long asset lives associated with infrastructure often make depreciating these assets meaningless, since the annual depreciation amount would be negligible in many cases. The guidelines of Statement 34 allow governments to report their expenses for maintaining and preserving infrastructure assets instead of depreciating them, provided that the government can

demonstrate that infrastructure assets are maintained at some consistent level. In this case, termed the "Modified Approach", local governments are required to disclose the following information:

- The assessed physical condition of infrastructure assets
- Methodology used to assess and report asset condition
- The condition level at which the government intends to maintain the assets
- A 5-year comparison of the estimated annual dollar amount to maintain and preserve the assets at the condition level established by the government and the actual expenditures required to maintain the assets over that same 5-year period

If governments elect to use this approach, these disclosures will give financial statement users (and citizens in general) information that most have never had. The new information should help the public better assess the job their governments have done building and maintaining infrastructure. The users of this new information should then be able to communicate more clearly to government officials the level of infrastructure investment, maintenance and condition they prefer.

1.3 Introduction to Barchan

Barchan is a remote-hosted, web-based capital asset management tool developed to assist public works officials and town and city managers in meeting the requirements of GASB Statement 34. Though the research contained within this thesis is focused on beta-site testing for road and highway management only, future production versions of *Barchan* will have the capability to manage multiple "layers" of infrastructure systems, such as water, sewer, and stormwater networks. *Barchan* accesses local Geographic Information System (GIS) mapping networks to display the most current infrastructure system layout available within the client's specific planning area. Using the GIS network, meta segments of infrastructure assets are constructed. Individual roadway segments can be grouped into meta segments based on a number of criteria, including spatial layout, traffic flow/type, maintenance schedules, etc. After meta segments are built, administrative classifications, functional groupings, and geometric cross-sections are

assigned. Initial infrastructure quality assessments are then conducted for each meta segment, reflecting the initial date the roadway was put in service, the current condition of the roadway, and any repair/maintenance requirements and action items observed by DPW staff, other city or town officials, or citizens in general. *Barchan* links to the R.S. Means Construction Costs database to assign an initial asset value relative to the put-in-service date and a present value based on current roadway conditions, in accordance with the accounting requirements of Statement 34. Finally, scenarios of maintenance and action items are generated by specifying a total infrastructure budget and a desired average quality target. Scenario options are explored by prioritizing any of a number of different criteria, such as repairing and improving the roads with the lowest current value, the busiest roads, or roads in a certain geographic area first.

As a remote hosted tool, *Barchan* allows local governments to satisfy the requirements of GASB Statement 34 without expending large amounts of resources or time to implement an in-house accounting and management system. This is particularly advantageous, given that Statement 34 has been openly criticized as a good intention with serious feasibility and cost-related implementation hurdles.[3]

1.4 Hypothesis

As this paper will demonstrate, information management systems such as *Barchan* also provide planning and management advantages to local governments in the implementation of sustainable development strategies. For example, the costing abilities of systems like Barchan allow local governments to explore more environmentally sustainable infrastructure programs through scenario analysis, and to justify larger initial capital expenditures by accurately determining the future recurring economic, social, and environmental benefits of sustainable development through the system's information management and costing capabilities. In short, the planning horizons of local infrastructure managers are both broadened and lengthened, such that better decisions, and justifications for those decisions, can be made through a more comprehensive cost-benefit analysis.

The following three chapters discuss the deployment and configuration of beta-site testing for *Barchan* in the town of Winchester, Massachusetts. The primary focus of this effort is to

evaluate two of the primary considerations of any infrastructure asset management system: usability and operability.

Chapter 2 Configuring Winchester's Infrastructure Inventory

On March 12, 2003 researchers for this project met with Winchester DPW officials to discuss expectations and requirements for Winchester's participation in beta-site testing for Barchan. DPW officials confirmed that Winchester meta segments were to be classified as one of five options: public (local) roads, improved private roads, unimproved private roads, state roads, or Metropolitan District Commission roads. Researchers for this project also decided at this time to name meta segments according to street name, corresponding house number, and state-assigned Road Inventory Number (RIN). This strategy promotes efficiency and simplicity in system management, as local street names and numbers are familiar to DPW staff, while also satisfying state and GASB accounting standards by incorporating RINs into meta segment descriptions.

Researchers for this project also collected several documents at this meeting to be used in the Barchan configuration and input stages for Winchester's infrastructure assets. These documents have proven to be most helpful in configuring Winchester's infrastructure profile, and are noted here in an attempt to foster similar efficiency in meeting future client needs. These documents include:

- Massachusetts Highway Department, Bureau of Transportation Planning and Development, Road Inventory Printout, January 30, 1997, Town of Winchester
- Massachusetts Highway Department, Bureau of Transportation Planning and Development, Description of Road Inventory Printout, September 1996
- Massachusetts Highway Department, Bureau of Transportation Planning and Development, Alphabetical Street Listing, January 30, 1997, Town of Winchester
- Massachusetts Highway Department, Bureau of Transportation Planning and Development, Fully or Partially Unaccepted Street Listing, January 30, 1997, Town of Winchester
- RIN Checkplot (Plan-view drawing) for Winchester, Massachusetts, February 13, 1997, Executive Office of Transportation & Construction, Massachusetts Highway Department, Bureau of Transportation Planning and Development

- Plan-view utility map of Winchester, Massachusetts (utilized as named roadway map)

2.1 Meta Segment Configuration Process

Barchan configuration and input procedures began on March 12, 2003. Researchers, unfamiliar with Barchan commands and utilities, first practiced configuring the system and generating maintenance scenarios until a general comfort level was achieved. It should be noted that the system's user interface is quite straightforward and user-friendly.

System configuration and input for Winchester's infrastructure assets began March 13, 2003. The configuration process involves: selecting an area within the GIS mapping window in which meta segments are to be built, scanning the roadway segments of the selected area in the data columns below the mapping window, selecting those roadway segments to be grouped as meta segments (which are highlighted in the GIS window when selected), and selecting the "group as new meta segment" command from the right-click command list. Researchers utilized the documents listed above to configure meta segments from the road inventory list. Meta segments were decided upon by Barchan administrators and Winchester DPW officials, and marked on a town roadway map. Researchers for this project utilized this map and town road inventories to configure meta segments within Barchan, naming segments according to the nomenclature discussed earlier. It was discovered that combined use of a roadway map listing street names, the Mass Highway BTPD RIN checkplot drawing, and the roadway inventory list resulted in the most efficient and effective configuration process. The GIS mapping window within *Barchan* is not full-screen, and the GIS mapping network does not contain Road Inventory Numbers. As such, caution must be exercised in selecting roadway segments to be grouped and transferring RIN's into *Barchan* when configuring meta segments. Problems and issues of note relative to the configuration process are further discussed below. An example screenshot displaying the GIS window on the left and a corresponding list of configured meta segments on the right follows. The light blue dotted square denotes the area of the town under investigation. The dark blue streets are those that are already grouped into meta segments and listed on the right of the screen. The red street illustrates the meta segment that has been selected from the list on the right side of the screen. The data listed below the GIS window consists of segments that have not yet been grouped into meta segments.

2.1.1 Meta Segment Configuration Discussion:

Several streets within the GIS mapping network, MapCiti, were labeled as "unnamed streets". It was assumed that these streets were private driveways, commercial entrances, or recently constructed roadway extensions. To verify this assumption and ensure accuracy in constructing meta segments, these unnamed streets were driven by *Barchan* administrator to assess their layout, geometry, quality, and assign names to these meta segments.

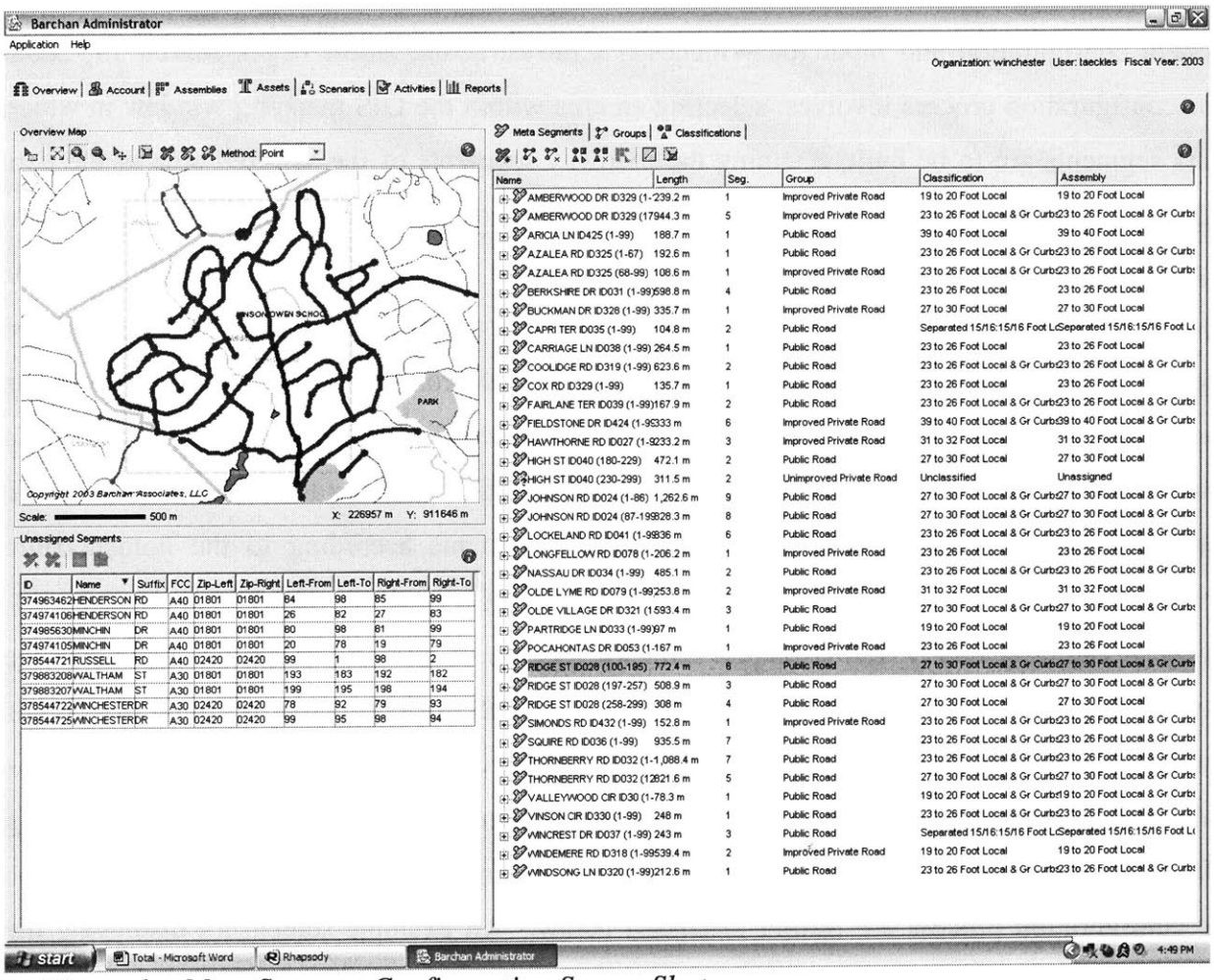

Figure 1. Meta Segment Configuration Screen Shot

In addition to several unnamed streets within the GIS network, researchers for this project also discovered some erroneous roadway data in the MapCiti database. These errors include incorrectly named streets, incorrect roadway layouts, and several streets not shown at all. A MapCiti database update was carried out from March 21 through March 24, 2003. While it is assumed that this update will solve the mapping anomalies experienced during Winchester beta-

site testing, *Barchan* administrators and clients should monitor mapping accuracy on a regular basis. As in the case of Winchester configuration, *Barchan* administrators and Winchester DPW officials were able to quickly detect many of these mapping errors and correct them. Clearly, client input and coordination at the configuration phase, as well as all other critical stages, is an efficient and effective way to accurately configure and productively run the system to generate maintenance scenarios.

Many times while trying to use the zoom command in the GIS map screen, the researchers were kicked off of the system. This resulted in frustration for the researchers, and increased the time needed to configure the meta segments. In response, the researchers sent tickets to the software developer. This problem was eventually corrected when the software developer switched from Oracle 8 to Oracle 9.

2.1.2 Meta Segment Configuration Recommendations

Researchers for this project would like to make two recommendations for *Barchan* system improvement relative to the meta segment configuration process:

Incorporate an option to view the GIS map in full-screen rather than just a zoom-in command. As discussed earlier, the small map window makes it difficult to configure meta segments from streets that are broken by many intermittent intersections, as these streets contain many individual segments. A detailed view is necessary to ensure that segments are accurately selected and incorporated into meta segments. The zoom-window provides this detailed view. However, many major arterials extend through several neighboring townships, and these neighboring segments are selectable in the GIS mapping window. Thus, a large view of the mapping area is necessary to ensure that these remote segments are not selected by mistake. The combined requirements of a large view and level of detail suggest that a full-screen window would be more appropriate and efficient than just a zoom-in command.

The street data columns under the GIS mapping window are too wide to fit in one view. Users must use the right scroll command to view street numbers, which are necessary to name meta segments according to the process described above. Researchers discovered that failure to shrink the columns manually before selecting segments to be incorporated into a meta segment requires

that the process be repeated, since all selections are lost. While a higher monitor screen resolution can alleviate this problem, shrinking the columns such that all data can be seen without scrolling or modifying the software such that columns can be manipulated without deselecting segments would be a helpful modification, and eliminate headaches while users are overcoming the learning curve in configuring the system.

2.2 Meta Segment Classification Process

Data input for constructed meta segments began on March 17, 2003. Researchers for this project utilized the Town of Winchester Road Inventory Printout and accompanying Description to assign classifications and geometries to Winchester meta segments. The process used by the project researchers for assigning properties to meta segments is detailed below:

Under the "Assets" tab, a view is selected in the GIS window, thus listing the meta segments located in that view in the list located on the right-hand side of the screen.

Each meta segment is selected with a right-hand mouse click, displaying a menu for further inputs entitled "Meta Segment Properties." In this menu, researchers are required to make two entries based upon information located in the document entitled "Massachusetts Highway Department Bureau of Transportation Planning and Development Road Inventory Printout, January 30, 1997."

First, the road must be placed in one of the following designated groups: Improved Private Road, Unimproved Private Road, Public Road, MDC Parkway, Public Driveway, Public Unimproved Road, or State Road.

Second, the road receives a classification. The researchers choose this classification from a list of typical cross-section assemblies developed by a *Barchan* administrator. This list of assemblies is found under the "Assemblies" tab.

Barchan automatically completes the Cross-Section data input under the "Meta Segment Properties" menu based upon the previous classification entry.

A sample screenshot illustrating the "Meta Segment Properties" dialogue box follows:

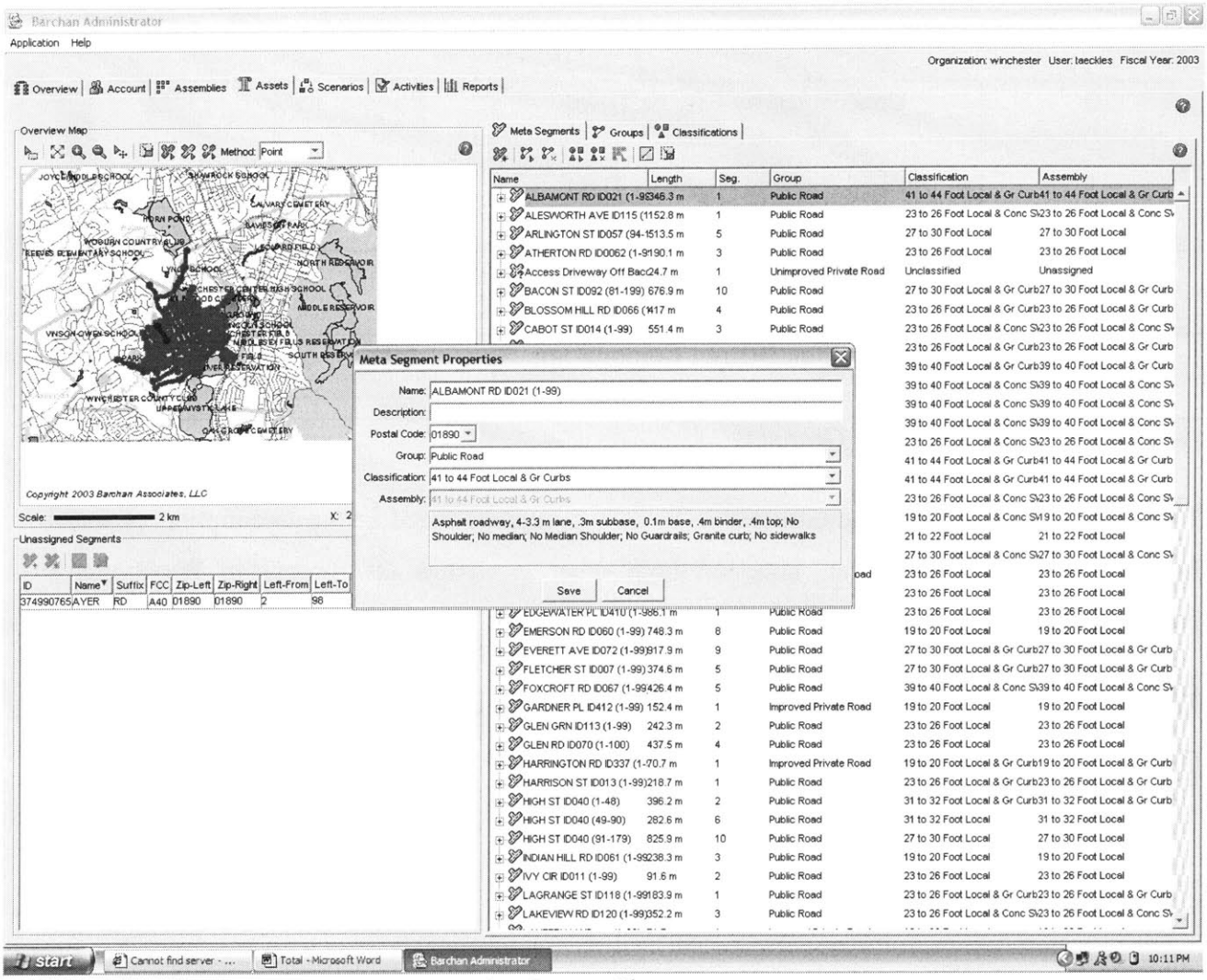

Figure 2. Meta Segment Properties Screen Shot

The Administrative System (Ad Sy) column in the Road Inventory list was used to group meta segments. The Description of Road Inventory Printout details this Administrative System heading. Meta segments were grouped as follows:

Administrative System	Description	Barchan Classification	Miles
0	Unaccepted by City or Town	Private	13.22
1	Massachusetts Highway Dept.	State	2.07
2	City/Town Accepted Road	Public	72.52
3	Metropolitan District Commission	MDC	4.17

Table 1. Meta Segment Grouping

There are numerous other Administrative System groupings listed in the Description of Road Inventory Printout. However, none of these other groupings are present in Winchester's infrastructure system.

The Surface Type (Sf Ty) heading in the Road Inventory List was used to determine whether private roads were improved or unimproved according to the following chart:

Surface Type	Description	Barchan Classification
0	No Data	**Specific determination required**
2	Unimproved road	Unimproved
5	Gravel or stone road	Unimproved
6	Bituminous surface-treated road	Improved
8	Mixed bituminous road (high type)	Improved
9	Bituminous penetration road (high type)	Improved
11	Bituminous concrete sheet or rock asphalt road (high type)	Improved

Table 2. Improved/Unimproved Grouping

As with the Administrative System groupings, there are numerous Surface Types listed in the Inventory list, but only those listed above are applicable to Winchester roadways.

Meta segments were also classified according to information contained in the Road Inventory Printout. Classification involves the following determinations:

- Determine paved surface width. This is the sum of the Surface Width (Sf Wd) and the corresponding Left and Right Side Shoulder Width and Type (Lsh W&T, Rsh W&T) data from the printout according to the following designation:

Shoulder Type	Description	Barchan Paved Width
H	Hardened bituminous mix or penetration	(Sf Wd)+(Lsh W&T)+(Rsh W&T)
S	Stable-unruttable compacted subgrade	Sf Wd
U	Unstable shoulder	Sf Wd
-	No shoulder	Sf Wd

Table 3. Paved Surface Width Determination

- Determine status of curbs and sidewalks. The Curb (Cb), Left Sidewalk (Lt SW), and Right Sidewalk (Rt SW) headings in the Inventory Printout are self-explanatory. However, project researchers and Barchan administrators encountered problems associated with meta segments with varying sidewalk and curb characteristics. A description of this issue and resulting solution is included in the Classification Discussion section of this report.

2.2.1 Meta Segment Classification Discussion

The researchers were required to make several assumptions while assigning properties to the meta segments in order to alleviate some inconsistencies in the provided documents. For example, several times the documents stated that portions of the same meta segment were private roads while others were public roads. In these situations, the Barchan administrator field checked this erroneous data, and separated these segments into multiple meta segments to better reflect their assembly and improve accuracy of the system. Also, there were several roads that contained sidewalks and/or curbs on only one side of the street while there is no such classification available in Barchan. Rather than create a new cross section for each of these anomalies, the Barchan administrator recommended that the researchers use a "best fit" classification for such meta segments. Often times, when portions of a meta segment varied in

width or in sidewalk or curb presence, the researchers assigned a classifications that represented the majority of the meta segment's properties. The researchers were again kicked off of the system while assigning properties to the meta segments. This problem was corrected with the switch from Oracle 8 to 9.

2.2.2 Meta Segment Classification Recommendations

During the classification of the meta segments, the researchers noted one recommendation for the *Barchan* administrator relative to meta segment classification.

The researcher is unable to view all of the meta segments formatted for the town at one time without generating a full report for the system. Instead, he must select a portion of the town, and then work only with the meta segments in that area. The availability of an alphabetical listing of all meta segments for a town would greatly reduce the time needed to assign classifications to meta segments, and would also allow the client to pick a meta segment from the list and immediately access the location and characteristics of that meta segment.

Chapter 3 Assessing Winchester's Infrastructure Assets

3.1 Meta Data Configuration Process

Upon completion of configuring various independent street segments into meta segments and assigning the resulting meta segments cross sectional properties and functional classification, the researchers then assigned each meta segment an individual initial service date and the number of sewer manholes and potable water valves located in the pavement of the respective meta segment. The Barchan administrator assigned the meta segments the appropriate number of storm drains. The process for entering this data into Barchan is as follows:

- Under the Assets heading, select an area of the map, thereby displaying the list of meta segments contained in that region in a list on the right-hand side of the screen.
- Right-click on a selected meta segment and choose "Metadata" from the pop-up menu.
- Enter the initial service date and the number of manholes, gate valves, and storm drains into the appropriate spaces.

An example screen shot showing a selected meta segment, Albamont Road, and its corresponding meta data configuration dialogue box follows:

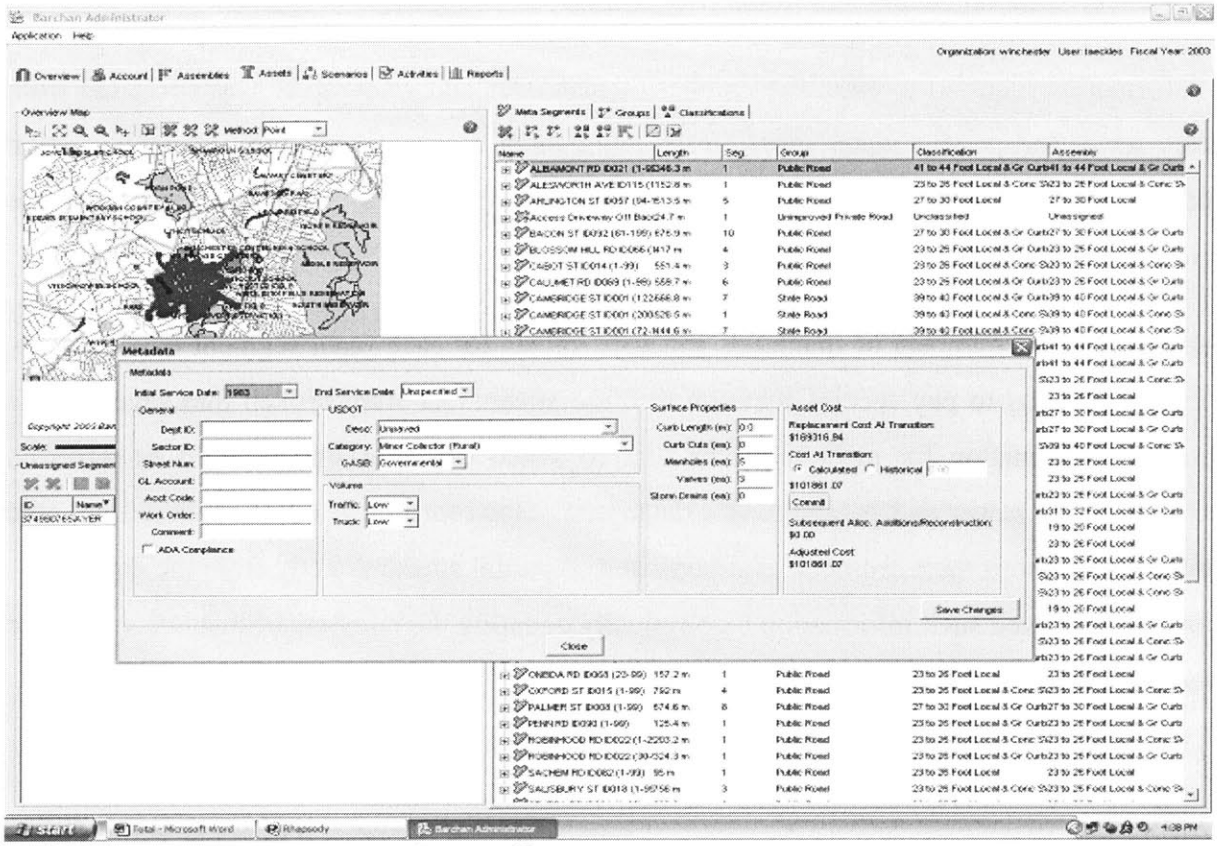

Figure 3. Meta Data Input Screen Shot

3.1.1 Initial Service Date

The information required for the initial service date assignments was compiled from two separate documents provided to the researchers by the Town of Winchester:

- A spreadsheet containing a log of initial service dates reflecting when the road was originally accepted by the city. This document is included in the appendix for this chapter, and is entitled "WinStreetsInServiceDates."|

- A spreadsheet reflecting the most recent complete resurfacing date of each street in Winchester's street inventory. This document is also included in the appendix for this chapter, and is entitled "Town of Winchester DPW Street Resurfacing Alphabetical Street Inventory."

3.1.2 Number of Sewer Manhole, Potable Water Gate Valves, and Storm Drains

The information required to enter the number of manholes and gate valves was compiled from sanitary sewer and potable water supply maps and lists of sewer and potable water information exported from a database created by previous GASB 34 researchers. A Barchan administrator provided this information to the researchers.

When entering the numbers of manholes and gate valves for each meta segment into Barchan, the researchers had to pay special attention to those streets that were broken into several meta segments. Information for meta segments that consisted of entire streets could be retrieved directly from the sewer and potable water databases. However, the researchers could not take information for those meta segments that consisted of partial streets directly from the data bases, and instead retrieved such information by physically counting the numbers of manholes and gate valves on the respective maps.

3.1.3 Meta Data Configuration Discussion

The researchers used the document entitled "Town of Winchester DPW Street Resurfacing Alphabetical Street Inventory" as their primary reference for determining the initial service date for the meta segments because it contains the date that the streets were last completely resurfaced and brought to a "like new" standard. If the particular street under investigation was not found on this list, the document entitled "WinStreetsInServiceDates" was utilized. Because this reference only lists the date that the street was first officially accepted by the town, the dates range from the 19th century to the late 20th. The researchers were advised that 1960 was to be used as the earliest possible initial service date because any road constructed before then and not completely resurfaced would have depreciated to a negligible present value regardless of its true initial service date.

The researchers relied on the Barchan administrator to provide the number of storm drains located in each meta segment. Judgment calls were often required when counting the number of manholes and gate valves that were to be assigned to a particular meta segment. Specifically, when two streets intersect, and a manhole and/or gate valve is located in the middle of the intersection, the researchers used their best judgment as to what street that item would be

assigned. The researchers gleaned much of the manhole and gate valve quantity information from databases created by others. A comparison of the numbers of manhole and gate valve numbers assigned to each street by the previous researchers and the numbers shown on the respective maps led the current researchers to trust their predecessors' judgment. Following the apparent precedent set by the previous researchers, items located in intersections were generally assigned to the longer road to avoid accounting for the item twice and to provide continuity to the assignment process.

3.1.4 Meta Data Configuration Recommendations

Recommendations to Barchan Developer

The researchers noted several recommendations that should be taken into account by the Barchan administrator to ease the meta data configuration process. These recommendations are listed below:

As mentioned before as a recommendation to ease meta segment classification, it would be extremely helpful if Barchan users were able to view all of the meta segments located in the research area in one alphabetical listing. Because Barchan requires the user to first "zoom in" on a window of limited maximum size and then work with the meta segments located within the boundaries of that window, it is difficult to complete the meta data configuration of a street that consists of multiple meta segments without choosing several different views.

The meta data configuration dialogue box should be updated to include a distinction between sanitary sewerage and storm water drainage manholes. Manholes are required for both systems whenever a change in grade or direction is necessary. Because both systems generally follow road right-of-ways, manholes for both are prevalent in street pavement. Therefore, an input box for both items should be available in Barchan. The researchers only accounted for sewer manholes during the meta data configuration process to avoid confusion between the two systems.

The meta data dialogue box does not allow the client to simply type the initial service date into the appropriate input window. Instead, he must scroll through a listing of years from 2003 to 1800. While this may seem minor, when considering the time it takes to scroll through the list

and the fact that a town such as Winchester contains over 300 meta segments, rectifying this situation will save the client undo frustration.

Recommendations to Future Barchan Clients

The researchers approached this portion of the project with a trial and error mentality. As always, hindsight is 20-20, and the researchers have developed the following list of helpful ideas for maximizing the efficiency of meta data configuration:

Data entry works best with a team of two people: one person looking up and calling out the information to the second person who then handles the inputs into the dialogue box.

Clients should verify all information (numbers of gate valves, manholes, etc) presented to them as a database compiled by others by first comparing it to the appropriate map and then driving around the town and inspecting several streets to ensure accuracy.

3.2 Meta Segment Maintenance

The next stage of data input provides Barchan with the schedule of maintenance activities performed by the town. Such activities can include street sweeping, centerline repainting, litter control, maintaining ground cover, tree and brush trimming, grass mowing with a tractor, and catch basin cleaning. Winchester DPW provided the researchers with four lists of roads included in special plow routes. These roads are the main roads of the town, and therefore DPW sweeps them three times a year, repaints the centerlines twice a year, and cleans the catch basins located along them once a year. These lists were consolidated into one document by the researchers, and included in the appendix. Those roads not included on this list are only swept once a year, do not have centerlines, and have catch basins cleaned once every other year.

The before-mentioned maintenance activities, in general, do not increase the service life of infrastructure. However, the municipality must account for these activities when developing an accurate representation of their expenses.

3.3 Meta Segment Maintenance Data Input Process

The process required to input the maintenance data into Barchan is as follows:

- Under the Assets heading, select an area of the map, thereby displaying the list of meta segments contained in that region in a list on the right-hand side of the screen.

- Right-click on a selected meta segment and choose "Maintenance" from the pop-up menu.

- In the maintenance dialogue box, check the boxes beside the appropriate maintenance tasks that the town provides. Then enter the number of times per year that those items are done into the appropriate spaces. For catch basin cleaning, the number of catch basins located in that meta segment must be entered as well.

An example screen shot showing a selected meta segment, Albamont Road, and its corresponding meta data configuration dialogue box follows:

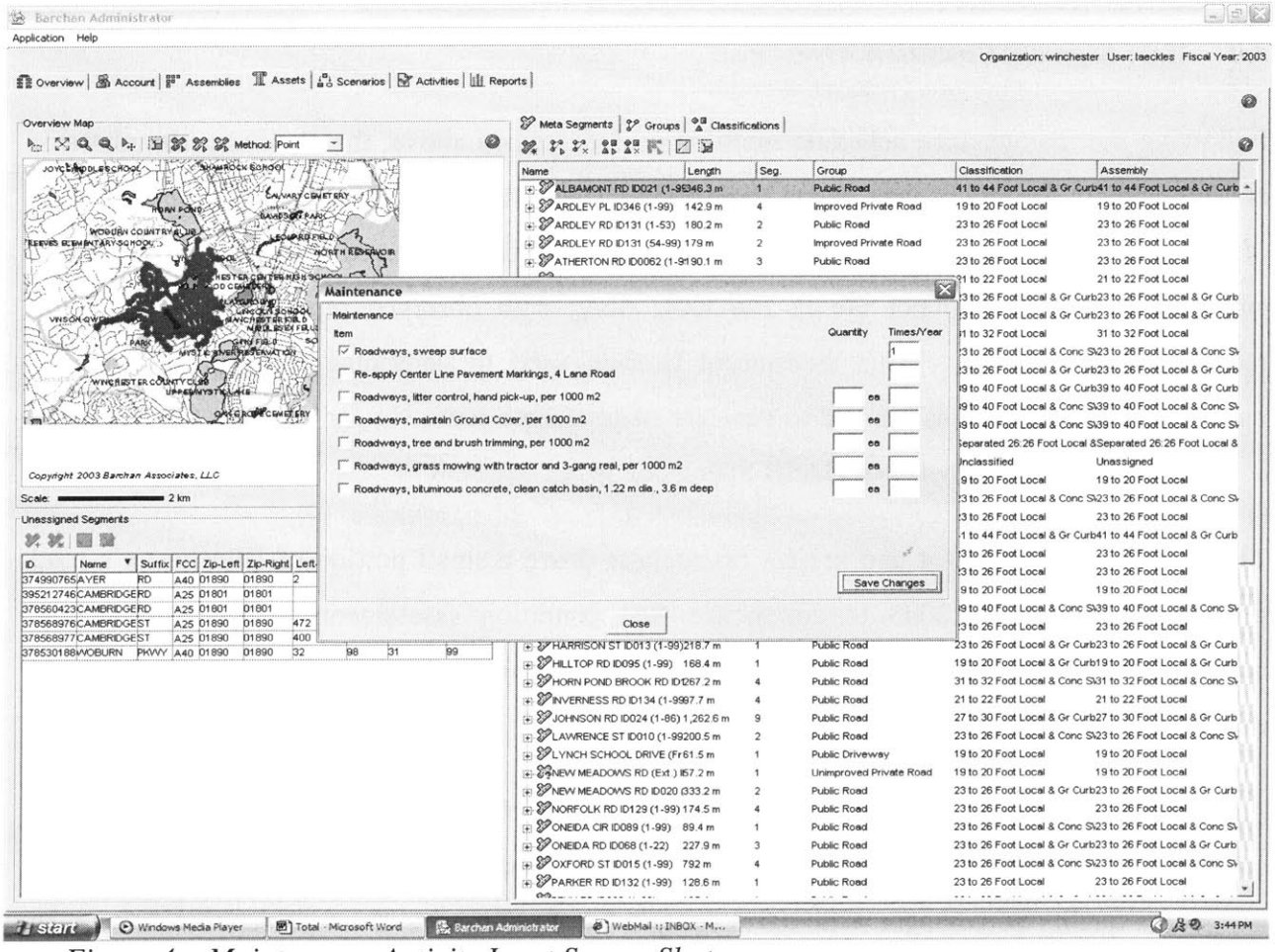

Figure 4. Maintenance Activity Input Screen Shot

3.3.1 Meta Segment Maintenance Recommendations

The researchers offer two suggestions to the Barchan developer:

The client is required to enter the number of gate valves located in a meta segment twice: first during the meta data input process, and again during the maintenance data input process. If possible, the developer should incorporate a link between the two dialogue boxes so that the client only needs to provide Barchan with the information once.

Barchan will not accept a fraction as the number of times per year that a maintenance activity as performed (the fraction is automatically rounded when the client chooses to save changes). Therefore, the client cannot accurately account for activities such as catch basin cleaning that may only occur once every other year. If possible, the developer should incorporate the ability to enter fractional inputs into dialogue boxes.

3.4 Meta Segment Condition Assessment

Following the maintenance schedule input process described above, the *Barchan* administrator and researchers for this project began to develop a methodology for first condition assessments of Winchester's streets. These condition assessments will be transferred to a quality degradation curve under the Assessment tab in *Barchan*, along with observed repair requirements and recommended activities. This assessment is then used to determine the current value of individual infrastructure assets and to generate maintenance scenarios for resource optimization, according to the requirements of GASB Statement 34.

The *Barchan* administrator and project researchers drove a small portion of Winchester's road network on April 28, 2003 to commence first condition assessments. This allowed the researchers to understand this process. The balance of condition assessment was conducted and entered by the *Barchan* administrator.

Assessment logs were used to record observed conditions, repair items, and recommended activities. A sample of this log is contained in the appendix of this report. Assessments were assigned a quality percentage, with 100% being a "perfect" road with no perceptible defects. In general, the goal of *Barchan*'s infrastructure management capabilities is to allow local managers

to maintain a 70% condition rating across their infrastructure portfolio. This condition level allows for sufficient roadway conditions to be maintained while still enabling a broad and efficient allocation of maintenance resources. Assessments are grouped into the following categories:

Maintenance – Condition rating of 70% to 85%. Roads in this category are free from major defects, and therefore no activity recommendations are made. Repair and maintenance items observed include isolated crack sealing, isolated patching, isolated pot hole repair, isolated full depth repair, as well as regularly scheduled activities such as street sweeping.

Light Preservation – Condition rating of 50% to 70%. Whereas roads in the Maintenance category are in a general state of good repair with isolated anomalies, roads in the Light Preservation category are in a general state of declining quality. This is characterized by rutted, uneven pavement surfaces requiring widespread crack sealing, patching, and shoulder leveling. Recommended activities for this category include sand sealing, fog sealing, or rubberized asphalt sealing. Performance of these recommended activities results in a quality assessment adjustment to 75% in Barchan's inventory condition.

Heavy Preservation – Condition rating of 25% to 50%. The quality of roads in this category is severely diminished, such that patching repairs would offer little to no solution. In this case, recommendations must be made for segment-wide change activities. These activities include cold milling and leveling overlay, chip sealing, and open graded friction coursing. Performance of these recommended activities results in progressive adjustments to Barchan's condition assessment, as displayed in the appendix of this report.

Addition Reconstruction – Condition rating of 0% to 25%. Roads in this category are virtually un-driveable. Recommendations for this category involve construction of additional lanes and reconstruction of the street altogether. Performance of these recommendations will result in an adjustment in condition assessment to 100%, as these will be "new" streets.

3.5 Meta Segment Condition Assessment Process

The process for transferring condition assessment data from field assessment logs to Barchan was as follows:

- Under the Assets heading, select an area of the map, thereby displaying the list of meta segments contained in that region in a list on the right-hand side of the screen.

- Right-click on a selected meta segment and choose "Assessment" from the pop-up menu.

- On the condition graph located on the left-hand side of the dialogue box, click on the appropriate condition assessment percentage. This will become the "Initial Condition," and will be noted at the top right corner of the dialogue box.

- If any repairs were noted on the field assessment log, enter the quantity of each and the respective condition percentage deduction in the appropriate input boxes. The initial condition will be automatically adjusted according to the deductions, and an "Adjusted Condition" will be displayed directly below the "repairs" section of the dialogue box.

- If any recommended change activities were noted on the field assessment log, choose the appropriate one from the scroll down menu located below the repair input boxes. When actually completed, these activities will improve the condition assessment of the meta segment. Therefore, in Barchan, when a change activity is noted in the "Assessment" dialogue box, the adjusted condition is automatically increased, and becomes the "Resulting Condition," displayed directly below the Recommended Change Activity portion of the dialogue box.

- After all inputs are complete, the client must click on the "Create" button. This causes another pop-up box to appear, asking the client, " The assessment will become permanent and unchangeable, create segment?" If the client chooses the continue option, the condition is saved.

An example screen shot showing a selected meta segment, Albamont Road, and its corresponding assessment dialogue box with accompanying create pop-up follows:

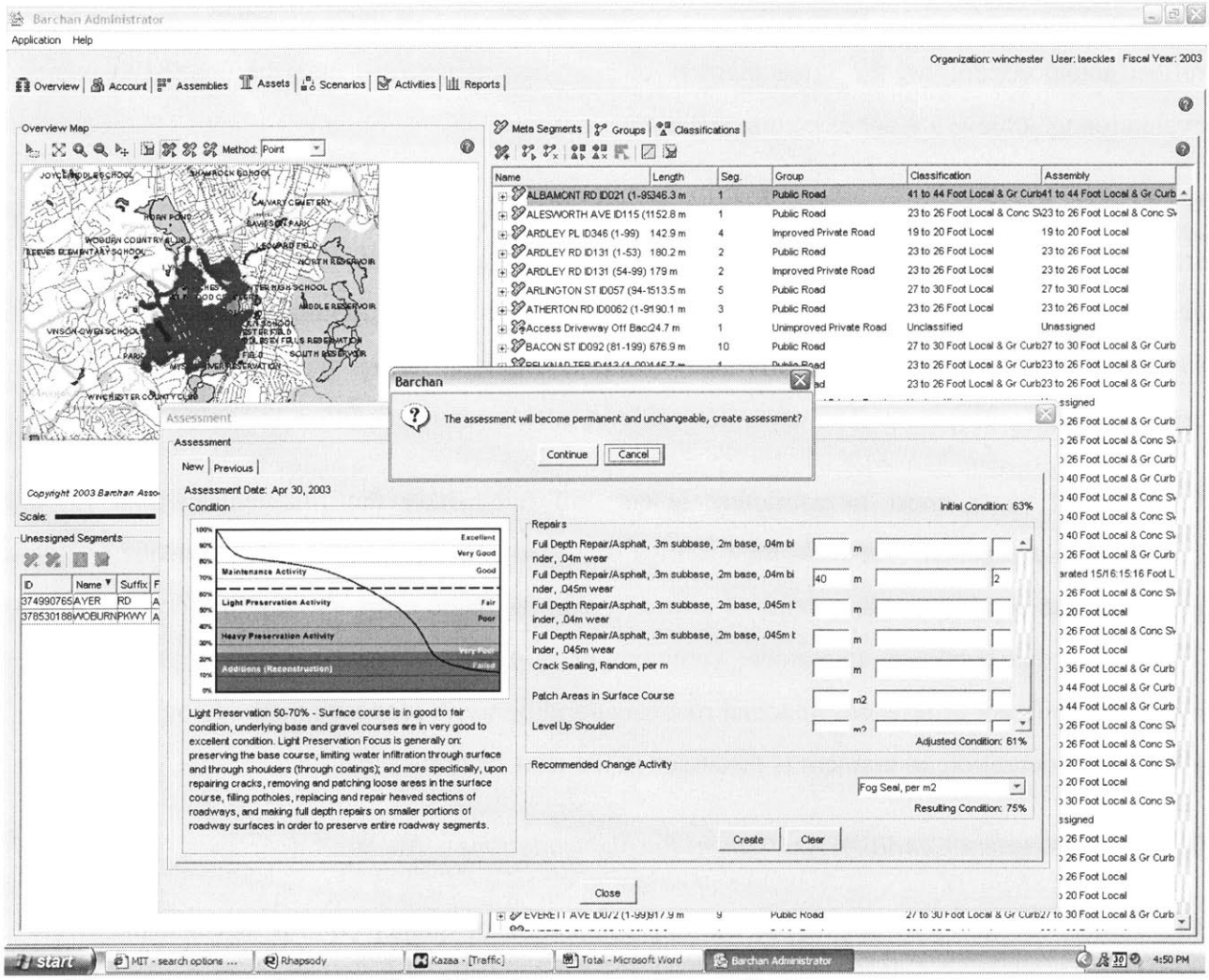

Figure 5. Meta Segment Condition Assessment Screen Shot

This screen shot shows that Albmont Road was given an initial condition assessment of 63%. In addition, it was noted that the meta segment required 40 m of full depth asphalt repair, a problem that decreased the initial condition by two percentage points, creating an adjusted condition of 61%. Furthermore, it was recommended that the metasegment receive a fog seal. Upon completion of this, the assessment of the road would increase to the resulting condition of 75%.

3.5.1 Meta Segment Condition Assessment Discussion

The development of and adherence to a standard condition assessment methodology is critical to the accuracy and usefulness of maintenance scenarios and resource allocation schedules generated through *Barchan*. For example, *Barchan* allows local governments to explore maintenance scenarios based on the distribution of condition and distribution of value of

infrastructure assets across their respective towns. To ensure that these distributions accurately reflect actual conditions, the same markers of condition assessment must be applied to every evaluation to achieve a level of precision among assessors.

While this directive is very straightforward, the process of developing and implementing a standard condition assessment methodology is in no way a simple task. The condition categories described above are very broad, and it is relatively easy to assign individual streets to one of the four categories. However, condition assessments and quality ratings within the categories are critical to the development of an accurate profile of infrastructure condition and value.

In a typical town, most infrastructure assets will fall within the Maintenance and Light Preservation categories. As such, their ratings will likely be within 10 to 20 percentage points. However, the condition assessments of streets within the same category can vary dramatically. This means that condition assessment variations of as much as 2 or 3 percentage points could indicate significant differences in actual roadway conditions. A proposed methodology to ensure precision in condition assessment is discussed in the next section.

3.5.2 Meta Segment Condition Assessment Recommendations

Researchers for this project propose the implementation of quality control mechanisms in the condition assessment process to achieve a level of precision among different assessors for a given infrastructure inventory.

First, all assessors should perform an initial assessment as a group, discussing individual observations and resulting condition assessments for a given street. This allows identification of a common set of markers to be used in an agreed upon rating system. Individual assessments can then be carried out independently using the common rating system. After all streets have been assessed, a sampling of these streets should be evaluated by a different assessor, and the results compared with the original assessment. Discrepancies can then be discussed and resolved cooperatively. This quality control procedure will help ensure that assessments accurately reflect even the smallest differences between street conditions in the client's infrastructure portfolio.

Chapter 4 Winchester Scenario Analysis

After all configuration of a town's inventory within *Barchan* is complete, a researcher can then use the Scenarios function to develop a maintenance, repair, and action item log. By providing *Barchan* with a proposed budget and the desired overall inventory condition, the researcher is provided with a summary of suggested activities that will achieve the desired condition. Before developing a scenario in *Barchan*, the client should determine a proposed budget and the desired overall condition of the town's assets. After this decision is made, *Barchan* can be used as a tool to map out what improvements should be made to the infrastructure inventory to achieve the desired overall condition within the budget constraints. These improvements relate directly to the initial condition assessment entered earlier in the configuration process. The improvement activities prescribed during the scenario analysis are based on the initial condition, the needed repairs, and the recommended change activities input by the client.

4.1 Scenario Analysis Process:

The following steps are required to develop a scenario in *Barchan*:

- Click on the Scenario tab at the top of the *Barchan* screen and create a new scenario by choosing the appropriate command button with a mouse click.
- A "New Scenario" dialogue box will appear. Enter a scenario name, a proposed budget, and a target condition in the respectively named input boxes. Choose the create command to proceed.
- *Barchan* will produce a log showing all meta segments located in the town, the costs to complete the normal maintenance and needed repairs noted during the condition assessment, recommended change activities, the cost to complete those change activities, the total cost to improve the meta segment, and the condition that will result when those changes are completed.
- The total funds required for maintenance, repairs, and major changes are noted at the top of the screen. If the budget exceeds the funds required to increase the

condition to the target, the remaining dollar amount is shown. This number will be negative if the budget was insufficient.

- The original (current), target, and new conditions are also displayed. The new condition will be realized once all of the recommended repairs and change activities are completed.

- The client can either increase or decrease the remaining funds, and therefore the new condition, by adding, altering, or removing change activities for the various meta segments.

4.1.1 Scenario Analysis Discussion:

To demonstrate the various scenarios that a *Barchan* client may develop to determine an appropriate budget request and allocation program, the researchers conducted two scenario development sequences.

Chapter 5 Defining Sustainable Development

5.1 Introduction

One of the more prominent buzzwords floating around university campuses, city planning commissions, and architectural firms today is "*sustainable development*", the term used to describe an integrated approach to planning and development where economic, environmental, and social considerations are integrated into the decision-making process. But, after two decades of research, international conferences, and head butting regarding the definition and practical implementation of sustainable development, much ambiguity remains. It is often local governments who face increased pressure and challenges from this ambiguity in fostering sustainable methods of development. This is especially true in the case of infrastructure planning. Infrastructure networks within the U.S. are widely distributed and interconnected. For example, there are nearly 4,000,000 miles of public state and local streets[4] and over 170,000 public water supply systems[5] in the United States. This structure makes infrastructure planning and management increasingly difficult. The interrelationships among infrastructure networks require a "system" approach, since a decision regarding one system will also affect other systems. An example of this interconnectedness is the consideration of stormwater management when planning for roadway expansions. But the distributed nature of infrastructure networks makes the establishment of this "system" viewpoint quite challenging. The first four chapters of this thesis discussed the use of a web-based asset management tool to overcome these challenges relative to the financial accounting, planning, and maintenance of infrastructure networks. This same approach can and should be applied to the challenges of incorporating sustainable methods of development into infrastructure planning for local governments.

This chapter will highlight some of the numerous, often conflicting statements and initiatives regarding the applications and obligations of sustainability. As this analysis will show, it is unreasonable to expect that a single, rigid view of sustainable development can be "standardized" to satisfy the multitude of challenges faced by local governments. Chapter Six will discuss practical applications of sustainable development to illustrate the counter-productivity that results from attempting to ascribe a single, holistic definition of sustainable development to the drastically varied agencies and organizations within the United States social,

political, and economic systems. The role of local governments in realizing sustainable development will be explored in Chapter Seven, as will the use of information management tools such as *Barchan* to allow local governments to make more informed, effective decisions regarding the implementation of sustainable methods of development.

Before proceeding further, it is important to recognize that sustainable infrastructure, and infrastructure planning in general, is in no way the responsibility of the public sector alone. In fact, nearly two-thirds of capital stock in the United States is privately held.

Capital Stock	US$ (trillions)	% Total
Total	**6.8**	**100**
Private	4.3	64
Public	2.5	36
State & Local	1.7	25

Table 4. Nonresidential Net Capital Stocks, 1988 (From Munnell, 1990)[6]

Because *Barchan* was developed specifically to aid state and local governments in satisfying the requirements of GASB Statement 34, this thesis will limit its discussion of sustainable development through information management to the role of state and local governments. However, it should be pointed out that information management tools such as this could be the impetus for greater public/private sector coordination to achieve more sustainable "system" approaches to infrastructure management. Further research could and should be carried out to analyze this hypothesis.

5.2 The Need for Sustainable Infrastructure Management

Local governments should be concerned with sustainable development for a number of reasons. The primary considerations for local governments in pursuing sustainable development are very

similar to those responsible for GASB 34. For example, increased public awareness and transparency are prompting the Federal government to issue mandates for sustainable methods of development within its agencies. For example, Executive Order 13123[7] sets forth a commitment by the Federal Government to make its facilities more efficient and sustainable. The preamble of Executive Order 13123 states:

The Federal Government, as the Nation's largest energy consumer, shall significantly improve its energy management in order to save taxpayer dollars and reduce emissions that contribute to air pollution and global climate change. With more than 500,000 buildings, the Federal Government can lead the Nation in energy efficient building design, construction, and operation. As a major consumer that spends $200 billion annually on products and services, the Federal Government can promote energy efficiency, water conservation, and the use of renewable energy products, and help foster markets for emerging technologies. In encouraging effective energy management in the Federal Government, this order builds on work begun under EPACT and previous Executive orders.

The Order directs agencies to "optimize life-cycle costs, pollution, and other environmental and energy costs associated with the construction, life-cycle operation, and decommissioning of facilities."

It is likely that the sustainability initiatives adopted by the Federal Government will soon begin to trickle down to the local government level. However, as this and the next chapter will illustrate, "command-and-control" policies and regulations imposed on local governments by Federal and state legislatures are often more of a deterrent to effective implementation of sustainable development. Local governments should then begin to develop their own methodology to achieve sustainability. Furthermore, given the similarities of GASB 34 and sustainable infrastructure planning, such as a desire for improved use of taxpayer dollars and the consideration of life-cycle costs and benefits, the consideration of sustainable development during GASB 34 planning and implementation could prove cost-effective, and encourage the development of creative and innovative strategies relative to sustainability and infrastructure management in general.

A second incentive for sustainable infrastructure management can be found in the private sector. Many citizens and corporations have noticed that sustainable development makes good business sense. For example, over $2.3 trillion was invested in socially and environmentally screened equity funds last year, and Dow Jones has created a Sustainability Index with more than 300 listed companies.[8] Further, economists have noted that a commitment to sustainable development is an indicator of good management and strategic focus. As a result, organizations with sustainability initiatives are considered less risky by lenders and thus typically have lower costs of capital[9]. The rationale for GASB 34 identifies transparency in infrastructure management as a key element of public finance, such as municipal bond offerings. Similarly, the evidence above suggests that sustainable development could provide a mechanism for improved investment in and lending to local governments, such that taxpayer burdens can be eased and tax dollar usage optimized.

While local governments should consider sustainable development as a valuable tool for long-term infrastructure planning, the actual implementation of sustainability has proven very difficult. Ambiguity and conflict in ascribing a definition, and therefore a set of obligations, to sustainable development are at the heart of the problem.

5.3 Conflicting Views of Sustainable Development

The primary driver behind sustainable development is the co-optimization of a "triple bottom line" comprised of economic, environmental, and social benefits of projects and operations.[10] The pursuit of this "triple bottom line" reflects the advantages and optimism of sustainable development at the surface-level. Digging deeper, however, reveals that achieving this end result is no simple task. As MIT Professor and Nobel Laureate Robert Solow notes, "It is very hard to be against sustainability. In fact, the less you know about it, the better it sounds".[11]

Two "camps" have traditionally occupied the sustainable development community: those that apply a neo-classical economic perspective to sustainability, and those that assert the ecological obligations of sustainable development.[12] In between and outside of the economic and ecological views, though, are numerous other permutations of sustainable development.

5.3.1 Brundtland Report[13]

Increasing awareness of the adversarial interests of economic development and environmental protection prompted the United Nations World Commission on Environment and Development (UNWCED), in 1983, to appoint an international commission to assess the impact of conventional development methods on the natural environment. Norwegian Prime-Minister Gro Harlem Brundtland chaired the Commission, whose findings and recommendations were published in a 1987 report entitled "*Our Common Future*". The report became widely known as "The Brundtland Report", and was a landmark statement on the critical need for institutional and organizational change to more sustainable methods of development. The Brundtland Report "helped trigger a wide range of actions, including the UN 'Earth Summits' in 1992 and 2002, the International Climate Change Convention and worldwide 'Agenda 21' programs" (www.brundltandnet.com). The definition resulting from the Brundtland report epitomizes the ecological view of sustainable development:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs....The loss (of biodiversity) can greatly limit the options of future generations; so sustainable development requires the conservation of plant and animal species.

This definition recognizes that the concept of *development* has very different meanings to different groups. In developing nations, for example, development may be viewed as purely economic (quantitative) growth, whereas in industrialized nations where higher GDP ensures that basic human needs are met, the concept of development begins to encompass more qualitative issues, such as environmental protection and cultural equality. At the root of sustainable development is the balance of welfare of present and future generations. The *needs* of future generations, however, are largely unknown at the present. Furthermore, with few exceptions of significantly limited accuracy, the present generation cannot assess specific capabilities of future generations in meeting their needs. The Brundtland report recognizes, however, that ecology could play a key role in meeting the needs of future generations. For this reason, Brundtland argues that sustainable development requires both the investment of capital wealth *and* natural wealth for future generations.

5.3.2 Robert M. Solow: An Economist's Perspective[14]

MIT Professor and Nobel Laureate Robert Solow, in a lecture to the Marine Policy Center at the Woods Hole Oceanographic Institute in 1991, defined sustainable development as the "obligation to conduct ourselves so that we leave to the future the option or the capacity to be as well off as we are". Professor Solow stresses that sustainability is ultimately imprecise, saying "we realize that the tastes, the preferences, of future generations are something that we don't know about. Nor do we know anything very much about the technology that will be available to people 100 years from now". However, Solow differs from Brundtland in his view of the present generation's obligation to preserve natural resources and biodiversity. Solow says, "Resources are, to use a favorite word of economists, fungible in a certain sense. They can take the place of each other. That is extremely important because it suggests that we do not owe to the future any particular thing. There is no specific object that the goal of sustainability, the obligation of sustainability, requires us to leave untouched." Solow's view represents the neo-classical economist's position on the obligations of sustainability. The present generation, in the name of intragenerational equity, should utilize natural resources as they are needed. So long as this utilization is accompanied by the substitution of resources of similar value, such as technology, capital, or interchangeable man-made resources, and investment of capital gained through the utilization of these resources for future generations, then Solow argues that the pure obligations of sustainability are met.

5.3.3 William McDonough and Michael Braungart: "Eco-Effectiveness"[15]

McDonough, an architect, and Braungart, a chemist, the co-founders of McDonough Braungart Design Chemistry, LLC., published a ground-breaking paper in 1998 entitled "The Next Industrial Revolution". McDonough and Braungart view conventional environmental and sustainable strategies as "eco-efficient" in concept. As the authors say in "The Next Industrial Revolution", "many participants (at the 1992 Earth Summit in Rio de Janeiro) touted a particular strategy: eco-efficiency. The machines of industry would be refitted with cleaner, faster, quieter engines.....The hope was that eco-efficiency would transform human industry from a system that takes, makes, and wastes into one that integrates economic, environmental, and ethical concerns." But, according to the authors, "eco-efficiency – doing more with less – is an

outwardly admirable and certainly well-intended concept, but, unfortunately, it is not a strategy for success over the long term, because it does not reach deep enough. It works within the same system that caused the problem in the first place, slowing it down with moral proscriptions and punitive demands. It presents little more than an illusion of change. Relying on eco-efficiency to save the environment will in fact achieve the opposite – it will let industry finish off everything quietly, persistently, and completely...Plainly put, eco-efficiency aspires to make the old, destructive system less so. But its goals, however admirable, are fatally flawed." These flaws include the imposition of limits to growth and the scaling back of production in the name of efficiency. Instead, McDonough and Braungart propose that sustainability requires an "Eco-effective" approach based on nature's systems. "Nature", as McDonough and Braungart note, "(is) highly industrious, astonishingly productive and creative, even 'wasteful'...(nature) is not efficient, but *effective.*" Nature's excess, or "waste", is cycled back into the system as nutrients for subsequent generations. The first principle of the Next Industrial Revolution then is "waste equals food". The Next Industrial Revolution also stresses the value of "regional, cultural, and material uniqueness of a place". Eco-effective designs will emit "regenerative" wastes, designs will be "flexible, to allow for changes in the needs of people and communities". Thus, the second principle of the Next Industrial Revolution is "respect diversity". Finally, eco-effectiveness stresses the progression beyond our reliance on fossil fuels, petrochemicals, and incineration for energy production. McDonough and Braungart propose development that acts "as a kind of tree...It would purify air, accrue solar income, produce more energy than it consumes, create shade and habitat, enrich soil, and change with the seasons." The third principle of the Next Industrial Revolution is then "use solar energy". McDonough and Braungart have had great success in converting many industry leaders, such as Ford Motor Company, Nike, and Gap, to their "eco-effective" mindset. Adding fuel to the fire of ambiguity, Eco-effectiveness is in direct opposition to the traditional governmental approach to sustainability: regulatory limits and environmental controls.

While all of these definitions share some commonalities, such as the need for longer project cost/benefit horizons and the recognition that the environment is not an infinite asset and should be valued appropriately through some form of economic accounting, they each represent fundamentally different views of what sustainable development really means and, as the next

section of this chapter shows, how governmental agencies should foster the implementation of sustainable development.

5.4 Governmental Approaches to Encourage Sustainable Development

In addition to the significant differences among the many opinions and definitions of sustainable development, there is also a great deal of conflict concerning the appropriate way to force or incent sustainable methods of development. At the governmental level, two primary, and opposing, methodologies have been used to encourage sustainable development. These methodologies are "command-and-control" regulations and market-based incentives.

5.4.1 Regulations

The traditional approach of the public sector to meeting environmental initiatives has been through "command-and-control" regulations that set standards, limits, and minimum levels of compliance. The delineation of "command-and-control" as a mechanism to achieve *environmental*, as opposed to *sustainable*, initiatives is intentional. Critics have pointed out that compliance with these regulations in many, but certainly not all, cases results in less-than-optimal allocation of resources, and, as a result, greater total costs to society.[16] In these cases, environmental policy is weighted more than economic and social considerations, and, according to the basic premise of the concept, regulations are not a consistent strategy for sustainable development. Nevertheless, "command-and-control" regulations are often the primary mechanism in public-sector initiatives for sustainability.

Examples of this kind of regulation include:

- Emissions standards for chemical and manufacturing facilities
- Zoning legislation based on environmental impact assessments (EIA's)
- Procurement mandates stipulating that products or materials contain a minimum amount of recycled content

5.4.2 Market Incentives

At the other end of the policy spectrum are market-based incentives to encourage sustainable development. The rationale behind market-based incentives asserts that the full costs of non-sustainable activities should be borne by those committing, and benefiting from, the act.[17] Unfortunately, economic markets do not inherently assign these costs appropriately. For example, long term, far-reaching environmental impacts, such as acid rain produced by coal consumption, impose costs on the whole of society. But these indirect costs, often referred to as "externalities"[18], do not accrue directly to their production source.

Market incentives, then, seek to "internalize" these externalities, through a number of mechanisms, including[19]:

- Pollution taxes that assign a fee for each unit of pollution generated
- Per-can consumer pricing for garbage collection and disposal
- Tradable pollution permits
- Deposit/refund systems to encourage recycling

5.5 Choosing a Path

Sustainable development calls for the co-optimization of economic, environmental, and social benefits of development for both the present and future generations in developed and developing countries. Such a holistic, variable task requires the application of science, technology, economics, political science, law, sociology, and psychology. Given the considerable scope of the applications and obligations of sustainable development, it is no surprise that each of the numerous definitions and policies for sustainable development discussed above can represent such fundamentally different, but still very valid, viewpoints. This suggests that there is no single definition or mechanism suitable for the numerous applications and considerations of sustainable development. The following chapter will discuss the ineffectiveness that results from a rigid, unilateral approach to sustainable development.

Chapter 6 Urban Sprawl & Smart Growth

In analyzing the ineffectiveness of rigid, standardized approaches to the unique, non-standard challenges of sustainable development, it is necessary to consider the characteristics and results of current trends in sustainability, particularly those applicable to the planning and management of local infrastructure. For example, urban sprawl, characterized by increased consumption of land and resources by expanding populations and economic growth, has been cited as a primary cause for many social, environmental, and economic overloads. However, a uniform, standardized approach to combat the effects of sprawl has been shown in several instances not to remedy the problems of urban sprawl, but rather to produce new adverse effects.

6.1 Urban Sprawl

The Environmental Protection Agency defines urban sprawl as "low density, automobile dependent development beyond the edge of service and employment areas. It is ubiquitous and its effects are impacting the quality of life in every region of America, in our large cities and small towns".[20] Other characteristics include an abundance of roads, parking lots, and buildings, in addition to "architectural, economic and racial homogeneity, the absence of regional planning, and a shift of development from the inner city to the periphery".[21] Durning[22] identifies three distinguishing characteristics of urban sprawl: Densities of less than 12 people per acre, segmented development where homes are separated from commercial and industrial areas, and urban spatial layouts, such as branching street patterns and cul-de-sacs.

Urban sprawl is quantified using a formula known as the Human Use Index, or U-Index, which measures the amount of total watershed area covered by either urban or agricultural lands. The land use patterns identified through the U-Index range from simple to quite complex. The transition from simple to complex patterns might be a measure of the degree to which humans have structured their own environment, or conversely, an indicator of geographic or natural constraints on human activity. Local and regional patterns of the U-index identify those areas that have experienced the greatest land cover conversion from the natural landscape intrinsic to the region.[23]

6.1.1 Causes of urban sprawl

A number of factors have been shown to contribute to urban sprawl. Those cited most often are discussed below.[24]

- Population growth: Rapid population growth in and around an urban area is one of the most commonly identified causes of urban sprawl. Logically, if population increases are not accompanied by urban capacity increases, such as housing and public service provisions, the natural response is further expansion of development beyond the current urban footprint.

- Economic growth and stability: Increasing household incomes, especially in the context of the "American Dream" of (bigger and better) home ownership, is a major driver of increased suburban development. The benefits of urban sprawl, such as more affordable housing and the personal satisfaction of independent living, are very real, yet often overlooked. Economic stability also provides less expensive, less volatile fuel prices, such that the increased automobile commuting costs of urban sprawl are no longer an effective deterrent.

- Fragmented municipal governments: Today's metro areas typically span across several towns or municipalities. The absence of a coordinated, integrated approach to development between these local governments often results in unplanned, sprawling urban development.

- Patterns of infrastructure investments: Public subsidization of infrastructure programs often provides an incentive for the expansion of urban development. For instance, funding for major arterial highways in and around metro areas, as opposed to funding for better local streets within the existing metro footprint, can encourage broader urban development through commute-supporting infrastructure.

- Lack of topographic barriers and other physical constraints upon development: The natural landscape of urban areas can have a significant effect on development patterns.

For example, Atlanta's relatively flat, unobstructed topographic landscape makes sprawl a timely, inexpensive development option.

6.1.2 Forms of Urban Sprawl

There are three primary forms of urban sprawl: low-density sprawl, ribbon sprawl, and leapfrog development. Each is explained below.

Low-density sprawl is defined as the "consumptive use of land for urban purposes along the margins of existing metropolitan areas", and driven by "piecemeal extensions of basic urban infrastructures such as water, sewer, power, and roads."[25]

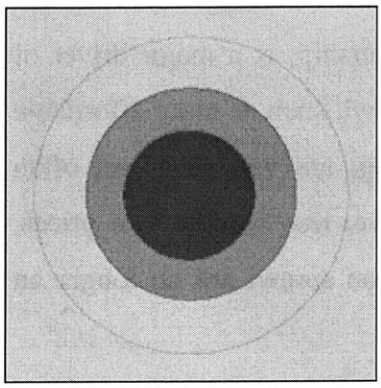

Figure 6. Low-Density Sprawl

Ribbon Sprawl is characterized by "development that follows major transportation corridors outward from urban cores. Lands adjacent to corridors are developed, but those without direct access remain in rural uses/covers."[26]

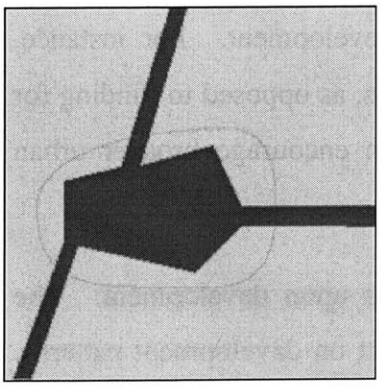

Figure 7. Ribbon Sprawl

Leapfrog development is represented by "a discontinuous pattern of urbanization, with patches of developed lands that are widely separated from each other and from the boundaries, albeit blurred in cases, of recognized urbanized areas." Leapfrog development has the disadvantage of incurring the greatest costs for public services, such as water distribution and sewage collection.[27]

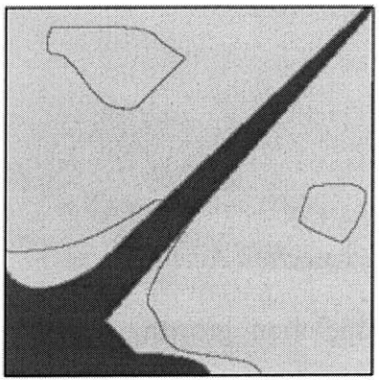

Figure 8. Leapfrog Development

6.1.3 Impacts of Urban Sprawl

Numerous environmental, social, and economic impacts have been attributed to urban sprawl. These include increased traffic congestion, fossil fuel consumption, air pollution, car accidents, and pedestrian injuries as a result of increased commuter travel[28], displaced farmland and other green space, racial and economic homogeneity and inequity, and a general decline in the feeling of community among residents.[29]

A very problematic environmental impact resulting from increased development and reduction in tree-cover is the phenomenon knows as the "urban heat island effect". Heat islands are characterized by higher ambient air temperatures over urban areas relative to the surrounding, less developed areas. This temperature increase is typically between 1 to 10 degrees F.[30]

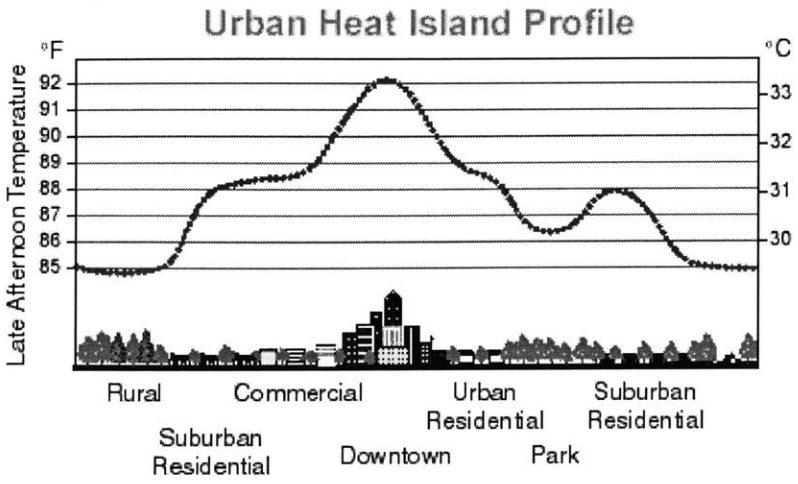

Figure 9. Urban Heat Island Profile (From U.S. Environmental Protection Agency)

Urban heat islands result when elements of development and population growth, such as buildings, streets, and parking lots, replace trees and vegetation in the natural environment. These facilities have low-albedo surfaces, meaning they absorb solar heat. As a result, the ambient temperatures over these areas rise significantly relative to the surrounding environment. In the natural environment, ambient temperatures are cooled by vegetation in two ways: shading from trees and evapotranspiration.[31] Urban sprawl displaces large amounts of vegetation, thus eliminating the cooling effect of evapotranspiration.

Urban heat islands produce a number of environmental, economic, and social hazards, including:

- Increased smog in cities caused by ozone production at the surface level, rather than in the earth's stratosphere. Ozone results from the reaction of volatile organic compounds and Nitrogen with heat as a catalyst. Ozone is particularly harmful to those with less robust immune systems, such as children and senior citizens.

- Increased energy use resulting from decreased livability and human comfort. The primary energy consumption mechanisms are indoor and automotive air conditioning. Increased consumer energy demand results in the use of more fossil fuels to produce electricity, which then increases air pollution and the formation of greenhouse gases.

6.1.4 Evidence of Urban Sprawl

Numerous studies have been conducted to quantify the economic, environmental, and social impacts of urban sprawl.

According to the American Farmland Trust (AFT), 70 percent of "prime or unique" U.S. farmland is now threatened by urban development.[32] Further, the AFT estimates that 50 acres of farmland are lost each hour to sprawling development.[33]

Metro Atlanta, having achieved distinction as the fastest growing metro area in world history[34], now inhabits 20 Georgia counties. Atlanta has nearly doubled its size in the past 10 years and now stretches 110 miles north to south.[35] Further, the Surface Transportation Policy Project recently named metro Atlanta as the second-deadliest city for pedestrians in the nation. In 1999 the Centers for Disease Control and Prevention found that Atlanta's pedestrian fatality rate increased 13% from 1994 to 1998, while the national rate declined by 9.6%.[36]

Nearly 20 states have enacted state-run growth-management regulations, or have formed task forces to implement farmland and open space protection programs.[37]

In a collaborative research effort aimed at analyzing the health effects of urbanization and sprawl, doctors and researchers for the Centers for Disease Control and Prevention (CDC) found several fundamental correlations between suburban sprawl and public health[38]. Their findings include:

- Increases in vehicle miles traveled (VMT's) have resulted in an increase in air pollution and in the incidence of respiratory diseases. Results of a study by the Centers for Disease Control and Prevention during the 1996 Olympic Games in Atlanta, at which time vehicular traffic was kept at artificially low levels by city authorities, showed that the Peak daily ozone concentrations decreased 27.9 percent and peak weekday morning traffic counts dropped 22.5 percent; at the same time the number of asthma emergency medical events dropped 41.6 percent.

- Sedentary living habits contribute to poor health outcomes because they are a significant factor in the incidence of overweight and obesity. Researchers have estimated that as many as 300,000 premature chronic disease deaths each year are due to obesity.

- Lack of pedestrian friendly features in a community was linked to illness and even death. In 1997 and 1998, 13 percent of all traffic fatalities - 10, 696 people - were pedestrians.

6.2 "Smart Growth": An Intended Solution to Urban Sprawl

In response to the environmental, economic, and social hazards resulting from increasing urban sprawl, many scientific researchers, NGO's, and public policy analysts have initiated pressures on Federal and state governments to adopt a land management policy known as "smart growth".

Smart growth is characterized as a regional development management strategy that stresses high-density urban development centered around existing infrastructure, increased pedestrian-friendliness, mass transit, the incorporation of green space within urban development, and social and economic heterogeneity within the urban environment.[39]

The Department of Energy has identified two main features of traditional land use practice over the latter half of the 20th century that have "converged to generate haphazard, inefficient, and unsustainable urban sprawl" [40]:

- Zoning practices that segment and segregate employment locations, shopping and services, and housing locations from each other

- Low-density growth planning that creates incentives and need for increased automobile dependence and access to increasing expanses of land.

Smart growth seeks to reverse these practices through top-down incentives and regulations that limit the expansion of urban development, and the supporting infrastructure and ancillary services that accompany such expansion. Specifically, smart growth utilizes:

- Development of "urban growth boundaries" outside of which urban expansion is discouraged or prohibited,

- Tax incentives and zoning strategies to support containment within the boundary, and
- Refusal to supply public services, such as water and sewer service, outside of the boundary.

Proponents of smart growth summarize the goals and methodology of this top-down approach as "a simple but profound principle: that taxpayers' dollars should not be spent on programs that either promote sprawl or damage the environment. (Smart growth) encourage(s) development and economic expansion, but only in locations where it makes the most sense and where the infrastructure is in place (or planned) to support it".[41]

6.2.1 Smart Growth Shortcomings and Misconceptions

Critics of smart growth have certainly not been hard to find. Criticism of top-down growth management policy has targeted many aspects of smart growth, including methodology, actual effects, and the need to discern perception from reality.

Land Use Statistics

The National Center for Policy Analysis[42] cites several statistics that indicate urban sprawl is not a pervasive, widespread problem, as it has often been described.

- The most rapid rate urban expansion occurred between 1920 and 1950. By the 1970s and 1980s, this expansion was topping off, according to a study of more than 300 fast-growth rural counties. Urban land constitutes only a small percentage of overall land use, and does not pose a foreseeable threat the nation's food production and supply capacity.
- Less than 5% of U.S. land stock is developed. Further, 75% of the population lives on less than 4% of the land. Figure 10 below illustrates the distribution of land development in the United States.

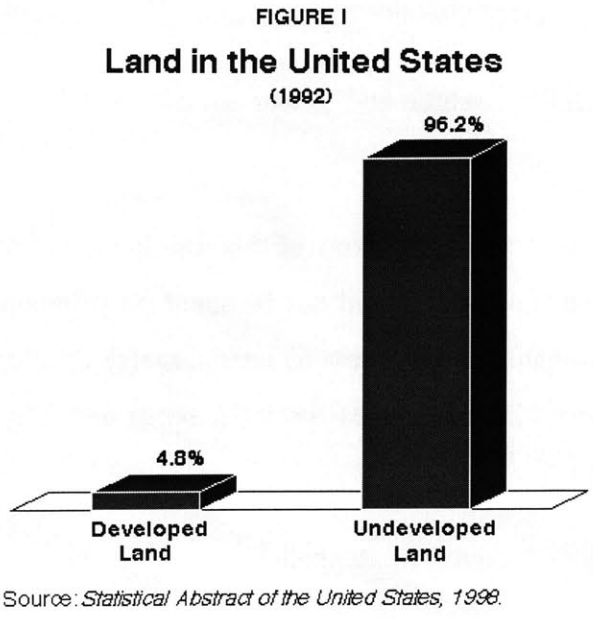

Figure 10. Land Use in the United States, 1992 (National Center for Policy Analysis)

- Urbanization is responsible for only one-quarter of the farmland displaced since 1945.
- Predictions of future farmland loss based on past trends are misleading because farmland loss has been moderating since the 1960s, falling from a 6.2 percent decline in farmland per decade in the 1960s to a 2.7 percent decline in the 1990s.
- In addition, with dramatic increases in agricultural output, American farmers are producing almost 50 percent more food than in 1970, using less land.
- Rural parks and wildlife areas have increased as dramatically as urbanized land.
- More than three-quarters of the states have more than 90 percent of their land in rural uses, including forests, cropland, pasture, wildlife reserves and parks.
- Acreage in protected wildlife areas and rural parks exceeds urbanized areas by 50 percent.

U.S. Transit Statistics

A central tenet of smart growth is the proliferation of mass transit as a more sustainable mode of transportation. However, historical data tracing the usage of mass transit indicates strategies that ascribe principal modal transportation responsibilities to mass transit are likely to fail.

Wendell Cox, urban development consultant, notes the following trends in mass transit use[43]:

- Federal, state, and local governments have invested nearly $400 billion in transit systems since 1960, yet public transit usage has actually declined, falling from a 7.1% share of urban travel in 1960 to a 1.8% share in 1998.

- Nearly 70% of mass transit use occurs in seven metropolitan areas. Half of this use occurs in New York City alone.

Economist Randal O'Toole notes that time is a significant deterrent to public transportation use, saying, "The average public transit commuter travels a shorter distance yet spends more time commuting than the average driver." Also, the opportunity costs of mass transit are high. Taxpayer revenue used to fund inefficient mass transit could have been used to finance additions or upgrades to roads or to build parks[44].

Perception versus Reality

Steven Hayward, during testimony to the Senate Environment and Public Works Committee[45], stated, "aggregate national statistics are almost irrelevant to the politics of the issue (of urban sprawl)." Mr. Hayward argues that "smart growth" is a reaction not to real environmental, economic, or social dilemmas, but rather to the perception that development has run amuck, saying, "nearly every piece of open space that yields to the bulldozer occurs in the line of sight of a populated area where people live now, and the change and disruption it brings locally trumps the fact that the land area in question represents a statistically minuscule portion of the whole...The aversion to rapid change is the dominant social fact behind the controversy over sprawl, and it is enhanced by a second powerful social fact: the increasing latitude for choice that people have today."

Mr. Hayward refutes the claim that smart growth is the proper tool for long-term sustainable development, saying, "Most of the ideas that make up the conventional wisdom on the subject at the moment, such as urban growth boundaries and, to a lesser extent, the bundle of ideas that go under the banner of 'smart growth', are misguided, because they misperceive much of what is happening in urban areas (especially the increase in traffic congestion), and as remedies they would be ineffective in solving the main problems associated with growth."

6.2.2 Adverse Effects of Smart Growth

Both proponents and critics point to Portland, Oregon as a model for smart growth. Growth management policies in Portland include growth boundaries to limit suburban development, a focus on high-density urban development, and increased funding for mass transit systems and other methods, such as the Bureau of Transportation System Management's Traffic Calming Program, to encourage alternatives to automobile travel. Like many cities enacting growth management policies, Portland's use of smart growth is mandated by regulation at the state level. The Oregon legislature passed its landmark urban growth boundary law in 1973. Today, each of Oregon's 241 cities is surrounded by an urban growth boundary. Portland's growth boundary was established in 1979.[46]

Despite good intentions, Portland's attempts to avert what it considered an impending disaster from Los Angeles-like sprawl[47] have resulted in some unexpected and very significant adverse effects.

Limits on new development, combined with record population increases in the Portland metro area since 1990, have caused housing prices in the area, in the words of one resident economist, to "skyrocket". Portland ranked as the 55th most affordable city in America in 1991. With no development outside the urban growth boundary to meet the population increase over the decade, Portland ranked 174th in housing affordability in 2000, making it the second least affordable city in the nation.[48] In one inner-city Portland neighborhood, home prices doubled between 1990 and 1995 from $41,300 to $83,800, "seriously undercutting the chance of moderate- and low-income families to own homes".[49]

Further, despite Portland's capital investment in mass transit, such as a US $1 billion light rail line, automobile alternatives represent only 12% of total transportation.[50] The combined effect of continued automobile use and high-density development has been to significantly increase congestion within the growth boundary. As a result, smog and other air quality issues have actually worsened since the advent of Portland's smart growth initiative.[51]

While Oregon's growth management policies in Portland may be the current poster child for smart growth, other states are beginning to follow suit. The following excerpt from an article by Dr. Jefferson Edgens entitled "Sprawl and Traffic: Is GRTA the Solution?" summarizes nicely the intent of this chapter: More sustainable methods of development are needed to alleviate very real financial, social, and natural system overloads, such as urban sprawl. But "command-and-control" regulations issued by Federal and state legislatures are often too rigid, narrow and shortsighted to be effective mechanisms for real community sustainability.

Georgia's recent effort to address sprawl via the creation of the Georgia Regional Transportation Authority (GRTA) again applies another big government solution to a situation best managed via local governments and the land and real estate markets. GRTA, a 15-member board responsible for steering dollars toward transportation needs, will operate under the assumption that sprawl is minimized by encouraging higher density developments coupled with public transportation. Public transportation, especially light rail, is mentioned as a means of reducing traffic congestion; however, the data indicates otherwise. Since 1982, traffic has increased from 18 to 55 percent in metropolitan areas that have built or expanded rail systems. Research also indicates that in no case have rail systems had a noticeable impact on traffic congestion or air quality. Rather than seriously exploring the causes of its perceived 'sprawl' problems, Georgia's political leaders have instead opted for another layer of bureaucracy.[52]

Chapter 7 Local Decision-Making for Sustainable Development

Chapter six illustrated the ineffectiveness of rigid, top-down regulations that attempt to mandate sustainability. A better alternative appears to be policies and decision-making at the local government level to encourage sustainable development within the unique economic, environmental, and social structures of the community in which development is envisioned. According to the International Council for Local Environmental Initiatives (ICLEI), "Making a community sustainable means integrating economic development, community development and environmental protection. This cannot be achieved without the direct involvement of local government. Building sustainable communities requires a proactive, localized and highly participatory approach that depends upon the unique role and capabilities of local government."[53] Similarly, Agenda 21, a global, regional, and local action plan for sustainability resulting from the U.N. Conference on Environment and Development in Rio de Janeiro in 1992, highlights the role of local governments, and individual citizens, in sustainable development. Chapter 28 states, "Local authorities construct, operate and maintain economic, social and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, and as the level of government closest to the people, they play a vital role in educating, mobilizing and responding to the public to promote sustainable development." Further, Chapter 40 of Agenda 21 recognizes that every individual is a potential user and provider of information, experience and knowledge[54].

7.1 Mechanisms for Local Sustainable Development

Just as there are numerous considerations and applications of sustainable development within the economic, environmental, and social structures of all communities, local governments have many mechanisms available to apply sustainability principles to their operations. While these mechanisms are often classified as "market-oriented", the term "community-oriented" seems more appropriate, because it emphasizes that local sustainability encompasses many intangible considerations beyond the traditional economic metrics.

Many day-to-day municipal activities have long-term impacts. This means almost every local government department or agency could be involved in sustainability efforts. The following considerations from the ICLEI[55] represent a sample of these efforts:

- Tailored adjustments to the planning process for more sustainable zoning and development
- Flexible procurement policies to minimize waste and increase energy efficiency
- Modified maintenance scheduling and infrastructure planning
- Community-specific land practices to evaluate and establish parks and green spaces as protected habitats or other alternative developments
- Stimulating sustainability-appropriate business in the private sector
- Legislature at the municipal level to encourage sustainable development

According to Fiscelli, the following concepts illustrate how sustainable initiatives "can be perceived by the general public as market-oriented without restrictive government controls that don't respect personal freedoms."[56]

- "Focus on the neighborhood level, not the region. Regional redistribution attempts are almost always exposed as social engineering of which we need less."
- "Emphasize (local sustainability) as an innovation that can occur in suburbs, urban villages, central cities, and exurbs. Kentlands, MD and Seaside, FL, two of the most popular new urbanist communities are hardly central city areas. This is precisely why they work so well - urban-like and suburban-like amenities."
- "Understand that while walkable and transit accessible may be nice, most people will drive most of the time. Consumers may love the quaint village atmosphere, walkable main streets, and picturesque streetscapes, but they will also want the convenience of the suburbs. Traffic congestion will not be alleviated by the occasional walk to the store or bus trip downtown."
- "Realize that the concept (of local sustainability) can succeed only if it is perceived as an improved development innovation from the average suburb, not a mandated government design. New designs can be marketed, but some people may still choose a homes-only

subdivision on a cul-de sac and regulation should not force them into a government pre-agreed upon design."

- "Understand that (there is no) policy cure for all growth ills, but rather (many) alternative neighborhood designs that may improve the attractiveness, functioning, and aesthetics of a neighborhood."

7.2 Enabling Local Sustainability Through Information Management

While sustainability planning at the local level allows for a more informed, effective approach to sustainable development, it poses a significant challenge to local governments through the need for greater information management and integration. This represents a significant departure from the typical lack of information accumulation and utilization inherent in most local governments.[57] It is therefore very appropriate for local governments to incorporate at least an incremental step toward sustainability planning in developing an infrastructure information management and accounting system to satisfy the requirements of GASB Statement 34.

According to the International Council for Local Environmental Initiatives[58], key elements of local sustainability are:

- Full community participation
- Assessment of current conditions
- Target setting for achieving specific goals
- Monitoring
- Reporting

These elements are virtually identical to those of GASB 34 compliance, and underscore not only the role of local governments in sustainable development, but also the role of information management systems, like *Barchan*, to enable local sustainability. Specifically, the GASB 34 compliance methodology of *Barchan* and similar information management tools discussed in

Chapters two, three, and four is also a methodology applicable to local sustainability. This methodology is discussed below.

First, the *Barchan* methodology configures a portfolio of all the assets within the local community. In the context of sustainability, this "asset portfolio" would obviously extend beyond infrastructure assets to include the natural and social assets of the community as well. Nevertheless, the basic tenet is the same: to establish the extent of the community's economic, environmental, and social elements, and to recognize the interdependence and interaction among these elements. The utilization of geographic information systems (GIS) can facilitate this "system" view, and is a critical component of information management tools like *Barchan* to enable better informed, more sustainable planning at the local level. For instance, "layers" of assets can be configured, such as infrastructure, zoning and land use, green space and natural resources, etc.

The next step is to determine the current value of these assets. The valuation of infrastructure assets is purely economic. While valuations of elements for the purpose of local sustainability must also assess the intangible environmental and social values, the assessment of economic value is a logical first step. While environmental and social valuations are critical, the purely economic metrics are tangible and relatable, and tend to be easier for citizens and legislators to comprehend. Economic considerations, then, when applied to the costs and benefits of sustainable development can act as an impetus for sustainability-driven coordination and greater participation in the planning and development process by stakeholders.

When the asset networks within a community have been configured, and current values determined, *Barchan's* historical costing capabilities incorporate the long-term recurring maintenance and repair costs of assets, such that a tangible comparison can be made between the true lifecycle costs of various development options to determine the benefits of more sustainable practices. This ability to analyze different development scenarios based on real, historical data, giving equal weight to local economic, environmental, and social assets, to determine the best course of action within the unique characteristics of a particular community is inherently more sustainable than Federal or state mandates because it recognizes and respects the diverse attributes of local communities.

As in the use of information management systems for GASB 34 compliance, development decisions arrived at through this methodology are supported by tangible data, which provides accountability to citizens and the private sector for their tax dollar usage. This transparency provides two key catalysts for local sustainability. First, an information management system provides a baseline for further development considerations and acts as a forum to facilitate stakeholder participation in future decisions, which is a primary tenet of local sustainability. Second, this transparency is a precursor to effective, long-term investments from Federal and state governments, corporate stakeholders, and citizens in general. Similarly, the availability of true asset values and recurring costs allow local governments to explore alternative finance strategies, such as private sector Design/Build/Operate/Maintain (DBOM) or Build/Operate/Transfer (BOT), to optimize the planning and management process at the local level. This allows local governments to achieve desired results within the existing financial constraints or capabilities of local governments.

The presence of a system view of economic, environmental, and social assets within a community, the current condition of those assets, and cost/benefit analyses and scenario planning to determine the available options allows local communities to develop targets for sustainability that are both appropriate and feasible given the unique attributes, constraints, and vision of that community. Subsequent iterations of and reporting from this methodology allow the effectiveness of previous strategies to be evaluated, and foster, if needed, the development or exploration of new strategies to achieve target goals. Development of functional targets can then be adjusted, such that local communities begin to approach system optimization with regard to their economic, environmental, and social conditions and considerations.

Finally, while the concept of a perfectly sustainable world is indeed noble and democratic, the likelihood that such a goal can be attained, at least in the near future, is slim. Perhaps the best that we can achieve is a "portfolio effect" of sustainable development within a given community. In effect, this is the same rationale as the use of *Barchan* to achieve an overall quality level for the infrastructure portfolio of local government planners and managers. When viewed as an integrated system, our political, economic, and environmental structures can work in relative unity, which leads to a sustainable, though inherently imperfect, community.

7.3 A Step to More Sustainable Decision Making

The applicability of GASB 34-inspired information management systems such as *Barchan* to local sustainable development is limited to drivers, methodology, and desired outcome. The specific capabilities of such systems, as purely economic instruments for the purpose of financial accounting, are not sufficient to serve as a planning and management tool for local sustainability. However, the recognition that the capabilities of more and better information management relative to GASB 34 can also be applied as a mechanism for local sustainable development is a valuable first step toward the creation of focused strategies and processes for system-wide sustainability across the economic, environmental, and social community attributes. This concept is embodied in the Change Matrix[59] shown below.

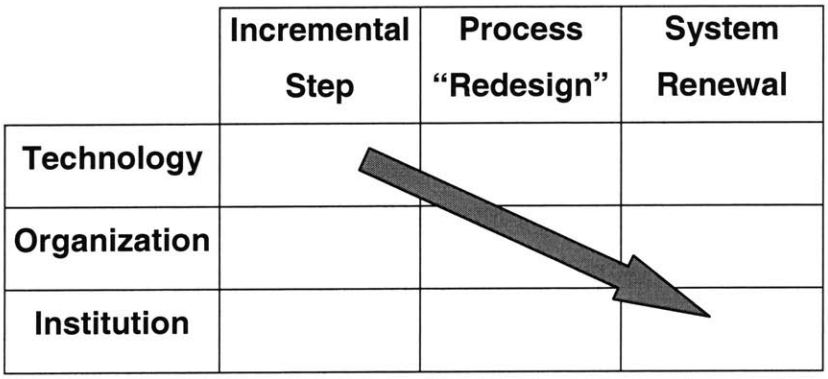

Figure 11. Organizational Change Matrix

The Change Matrix describes the way in which incremental steps lead to system-wide innovation through a process of double-loop learning. The process starts in the upper left of the matrix, where the application of a newly applied technology or methodology to an existing challenge within an organization results in an observed improvement in results over previous operations. This observation leads to a re-examination of the drivers of this task, and to a redesign of the process by which it is undertaken. The first loop of learning in the Change Matrix is then that the re-thinking and redesign of this particular process results in more desirable results. The realization that process renewal is both beneficial and possible should then lead organizations to re-examine other processes at the institution level to determine if further redesign is needed. So the second loop of learning is essentially the process of "learning to learn". In other words, to look at processes and systems in a new way, applying newly learned lessons and methodologies to achieve better results and a better functioning system as a whole.

The Change Matrix applied to information management tools like *Barchan* and the pursuit of local sustainability is represented by the following figure.

	Incremental Step	Process "Redesign"	System Renewal
Technology	*Barchan* Method.		
Organization		Planning/Mgmt.	
Institution			Local SD

Figure 12. Information Management/Local Sustainability Change Matrix

The strategic utilization of the *Barchan* methodology, comprised of asset configuration, assessment of value and condition, target setting, scenario analysis, and results reporting, relative to GASB 34 is an incremental step toward local sustainability. Specifically, this methodology allows local governments to establish a system-wide inventory of its assets such that interactions and interdependencies among assets can be evaluated and considered in the planning process. This methodology also focuses planning and management considerations on optimizing the lifecycle benefits of these assets, as opposed to the short-term capital considerations that have typically plagued local government decision-making.

The recognition of the benefits of this methodology, and the use of information management tools such as *Barchan* as an enabling mechanism, should then encourage local governments to apply this methodology to the challenges of local sustainable development. Given the similarities among the requirements for GASB 34 compliance and local sustainability, such as community participation, condition inventory and assessment, target setting for system- and lifecycle optimization, and tracking and reporting of results, local governments should analyze their planning and management practices, above and beyond GASB 34 infrastructure considerations, and redesign, if necessary, their decision-making processes to utilize this methodology as a tool for local sustainable development.

As tangible results of this new decision-making model are evaluated and further utilized to redesign the planning and management strategies of local governments to achieve more

sustainable methods of development, system renewal at the institutional level will begin to occur. Rather than the continuation of efforts at the Federal and state legislative levels to adopt and apply rigid, top-down policies for sustainable development to local government agencies, system renewal should take the form of a shift to decision-making and policy analysis by and between local governments, where sustainability initiatives can be driven by and tailored to the interests, capabilities, and vision of local stakeholders and the unique economic, environmental, and social assets of the community in which sustainable development is envisioned. The responsibility of Federal and state governments relative to sustainability then becomes one of support, information and resource provision, and guidance, as opposed to the traditional regulatory role typically assumed by top-level legislators today. The combined effect is one of greater efficiency, through better allocation of Federal and state funds, and effectiveness, in that local issues and considerations are now being addressed by local decision-makers, experts, and stakeholders representing the community in which these decisions will have the greatest impact and potential benefit.

Chapter 8 Conclusions and Recommendations

The testing and evaluation of *Barchan*, a web-based capital asset management tool developed to assist local governments in meeting the requirements of GASB Statement 34, was shown in Chapters two, three, and four to be an effective and usable tool for local infrastructure management. The premise behind *Barchan*, and similar information management systems, is that the availability of accurate cost/benefit data, combined with the ability to view this data in the context of a system of interactive and interdependent components, allows local governments to make more informed decisions regarding infrastructure planning, maintenance, and management. The description of this tool as "effective and usable" is intentional and important. *Barchan* accumulates and configures significant amounts of data within a given planning area, such that real results and benefits can be observed, resulting in an *effective* tool for infrastructure management. At the same time, the system is not overly academic or theoretical, and is grounded in the knowledge that local governments are constrained, sometimes severely, by financial restrictions, personnel capabilities, and implementation timetables. Thus, the system is flexible enough to be integrated into the client-specific operating environment of local government planners and managers, providing a *usable* tool for these agencies.

In applying the use of an effective, usable tool such as *Barchan* to the achievement of sustainable development, several conclusions can be drawn. Those conclusions are discussed below.

8.1 Conclusions

- Significant initiatives toward sustainable development are currently occurring both at the Federal and state legislative levels, and at the public level through citizen groups and private sector industries. This suggests that local governments will face increasing challenges from top-down and bottom-up pressures for sustainable development at the community level.

- It is a simple process for local governments to announce their commitment to sustainable development. Actually achieving local sustainability is a very different, and challenging, task. A primary reason for this difficulty is the ambiguity and conflict inherent in the numerous theoretical and academic definitions and macro-level approaches to sustainable

development. Though these specific views of the applications and obligations of sustainable development differ, there are some general commonalities that form the basic tenets of sustainability. These tenets include the recognition that economic, environmental, and social factors are symmetrical considerations for effective development planning, and that a system dynamics approach is required to evaluate each of these considerations in the context of the others. The numerous views of sustainable development also suggest that there are numerous valid approaches to achieving sustainability, with the appropriate methodology being determined by the unique economic, environmental, and social drivers within the community being considered. This indicates that much of the decision-making for sustainable development should occur at the local level.

- The use of state-mandated "Smart Growth" regulations to combat urban sprawl in Portland, Oregon was used as an example of the inability of rigid, sustainability-based legislation to recognize and utilize the unique financial, social, and natural assets present at the community level in order to achieve real sustainable development. This legislation often fails to recognize many local stakeholder positions relative to development decisions, and as such, these approaches are not sustainable because they produce adverse economic, environmental, and/or social consequences for one or many community stakeholder groups.

- Local sustainable development requires community participation, inventory and assessment of current economic, environmental, and social conditions, target setting, and reporting of observations and results. The methodology for GASB Statement 34 is nearly identical. As such, information management tools such as *Barchan* developed to aid local government in compliance with Statement 34 are also highly appropriate as planning and management mechanisms for local sustainability.

- Given the similarities among the drivers, requirements, and methodology for Statement 34 and community sustainability, the use of information systems such as *Barchan* to satisfy Statement 34 is also an incremental step toward local sustainable development. Hafkamp's Change Matrix provides a visual representation of the process through which

incremental steps such as this can lead to system-wide innovation and renewal. The recognition of the benefits of information management to local decision-making should prompt an analysis and re-design of planning and management strategies at the community level to address and enable sustainable methods of development within the organizational structure of local governments. System renewal and innovation then follows, as the public sector approach to sustainable development shifts from Federal and state legislative policies to a strategy of decision-making at the local level.

8.2 Recommendations

The methodology employed by *Barchan* and similar information management tools is highly appropriate as a mechanism for local sustainable development. But as a financial accounting tool, the specific capabilities of these information systems are not sufficient to account for and manage the social and environmental assets within a community. Thus, the next step in this research is to develop similar information management tools for natural and social asset inventory, configuration, valuation, condition assessment, scenario analysis, and reporting to be utilized along with financial tools such as *Barchan* to facilitate integrated, comprehensive decision-making for sustainable development.

As in any strategy for sustainable development, however, stating a commitment to the development of these tools and actually constructing and utilizing them are two very different propositions. To accomplish this, local governments may be best served through coordination with the private sector. Much research has been done to quantify the environmental and social benefits of sustainable methods of development, such as increased employee productivity in "Green" buildings as opposed to conventional office space.[60] The goal of these private sector initiatives is typically to increase revenues or profitability. While the public sector is not in the "business" of turning a profit, the methodology is still valid. Here again we see an opportunity for local governments to analyze and adopt an established, effective external methodology for sustainable development and to adapt that methodology to reflect the role and responsibility of municipal governments in local sustainability. The public/private coordination regarding this methodology could also provide the impetus for greater corporate community participation in local sustainability in general.

The implementation schedule for GASB Statement 34 dictates that even the smallest local governments should have compliance strategies in place by June 2003. This means that all municipal governments are instituting policies and procedures to account for and optimize the lifecycles of their infrastructure assets. This commitment could and should serve as the starting point for collaboration and coordination between neighboring and regional local governments to develop, analyze, and implement innovative, effective, and tailored mechanisms for informed planning and management decisions across their operations and agencies. The utilization of information management tools such as *Barchan* has the potential to serve as the platform for this collaborative approach to informed, sustainable decision making.

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