A CONSERVATION PLAN FOR THREE WATERSHEDS WITHIN THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT (MMSD)

By Mark J. O'Leary, Applied Ecological Service, Inc.
Doug J. Eppich, Applied Ecological Services, Inc.
Peg Kohring, The Conservation Fund
Steve Apfelbaum, Applied Ecological Services, Inc.

Abstract

Previous watercourse studies completed for the Menomonee River, Oak Creek, and Root River have indicated that demographic and community development trends over the next 20 years will exacerbate flooding problems within these watersheds. These studies have provided recommendations for traditional, engineered strategies to combat flooding: and they have acknowledged the importance of maintaining existing open space to prevent future flooding. As a result, the Milwaukee Metropolitan Sewerage District (MMSD) retained a team led by The Conservation Fund to develop a Conservation Plan for the acquisition and protection of important open space at risk of development. The objectives of the plan were as follows: 1) Identify undeveloped private properties potentially at risk for development that could provide future flood-reduction benefits; 2) Assess opportunities for MMSD to partner with public, private, or non-profit entities that would assist with the acquisition, management, and maintenance of identified properties; 3) Assess mechanisms and strategies to leverage MMSD funding for this effort; 4) Provide recommendations for the acquisition of parcels (or easements on these parcels) at risk for development; and 5) Consider how the ecological restoration of identified parcels could reduce future flooding. The Project Team used GIS-based remote sensing techniques (aerial photography, soils maps, wetland maps, etc.) and field visits to identify more than 28,000 acres of undeveloped land containing hydric soils that provide future flood reduction benefits. A subset of 199 sites that were 25 acres or larger in size (a total of 17,146 acres) was identified for further investigation. Thirty-four sites totaling 2,417 acres (representing 4,835 potential acre-feet of storage) were eliminated during field visits because they had been developed. Other sites were eliminated or ranked as low priority for acquisition if they contained a high number of parcels, were aligned in an impractical configuration, or were known to contain environmental hazards. Forty-two sites were identified as high priorities for acquisition. These were ranked based on several factors including: 1) surface area; 2) potential storage capacity of the site relative to runoff produced by the sub-watershed tributary to the site; 3) Potential storage to reduce flooding along the main stem of the watercourse; and 4) importance of the site in reducing future flood risks. This study provides the scientific and practical rationale for protecting these parcels from development in perpetuity, and for using public, private and non-profit entities to manage these properties to maximize flood control benefits. Furthermore, this study identifies funding mechanisms and strategies to leverage monies earmarked for land acquisition.

Introduction and Background

Watershed Changes

> "While much attention of late has focused on the construction of engineering works as a means of meeting water deficiencies . . . comparatively little consideration has been given to the regulatory influence of the soil and rocks of the watersheds, or of the part played by herbaceous range plants in maintaining the efficiency of these natural reservoirs." (Pearse and Wooley, 1937).

Flooding is a natural process in which a stream or river spills over its banks and into the adjacent floodplain. Flooding usually occurs because the volume of water running off of the contributing tributary area is greater than the capacity of the receiving waterway, and the rate of water running off of the landscape is too great for the receiving waterway to convey within its channel. Flooding also occurs when obstructions within the channel or floodplain create bottlenecks that elevate water levels upstream.

Flooding has many positive effects in a healthy watershed including dissipating the energy of water and thereby minimizing in-channel erosion; depositing nutrient-rich silt and sediment into the receiving floodplain; temporarily storing water in the floodplain and then slowly releasing it into the primary channel as water levels drop; and providing a plethora of habitat benefits, especially for wildlife that depend on floodplain habitat during important times of their life cycle such as breeding and migration. Flooding can result in devastating damage to property, water quality, wildlife habitat, and channel stability when the ability of the floodplain to slow down and store water is impaired.

The frequency and degree of impact of floods is based on a number of watershed factors including precipitation, topography, soil type, vegetation type and cover, and in developed watersheds, the type and extent of land use.

Precipitation drives the storm water runoff of the watershed. Precipitation, while varying with event, is relatively constant over time.

Topography influences the rate and volume of water running off of the landscape. All things being equal, steeper landscapes convey more water at a higher rate than flatter landscapes. Flatter landscapes, or landscapes with depressed areas, provide more opportunities for water to infiltrate, evaporate, and slowly release into the waterway.

Soil type affects the infiltration of water into the ground. Highly pervious soils such as sand infiltrate water more quickly into the ground than tight soils such as clay. Hydric soils, or soils created under anaerobic conditions, often occur in depressed areas of the landscape.

Vegetation cover and type can dramatically affect the rate and volume of runoff. Living vegetation and organic debris (duff) retard runoff. Roots provide channels for water to infiltrate into the ground and build organic matter that has a higher water holding capacity than mineral soil. Vegetation type has a dramatic influence as well. In general, native vegetation such as prairie plants have a much greater ability to capture and infiltrate runoff than introduced species such as turf grass (Weaver and Clements, 1938; Weaver, 1954).

Changing land uses have the most dramatic effect on the frequency and impact of flooding. But before listing the most important reasons, it is useful to consider how the historic Midwest landscape functioned to manage storm water runoff before it was plowed, plumbed and peopled.

Today's Midwest landscape was shaped and formed over the last 10,000 years following the last glacial period. The major land forms – plains, hills, valleys, wetlands, rivers and lakes – are artifacts of the glaciers carving during encroachment, depositing debris during glacial retreats, and creating drainage ways for melting ice to the Gulf of Mexico.

Plants colonized the raw earth left by the retreating glaciers and evolved and adapted to climatic and edaphic conditions that persist today. By the time the first Europeans established a firm foothold 150 years ago, the ecosystems of the tall grass prairies, savannas, woodlands and wetlands were firmly established.

From a storm water management perspective, it is important to note that the capacity and morphology of today's streams and rivers were formed (some might say "sized") when the contributing watershed was vegetated in native prairie, savanna, woodland and wetland. Impervious surfaces only existed in localized areas where bedrock was exposed. All other areas were vegetated or inundated. Storm water runoff was minimal due to the great water holding capacity and natural infiltration of native vegetation and localized natural depressions. In the prairie lands, many of the major rivers of today were little more than large vegetated swales.

The character of our historic watersheds and receiving waterways began to change shortly after the arrival of Europeans. In 1859, Henry F. French records the effects of agricultural practices on stream flows in his *Farm Drainage* monograph:

> "The effect of drainage upon streams and rivers, has, perhaps, little to interest merely practical men, in this country, at present; but the time will soon arrive, when mill-owners and land-owners will be compelled to investigate the subject… If now, this surplus of water, this part which cannot be evaporated, and must therefore, sooner or later, enter the stream or pond, be, by artificial channels, carried directly to its destination, without the delay of filtration through swamps and clay-banks; the effect of immediate agricultural drains furnish those artificial channels. The flat and mossy swamp, which before retained the water until the Midsummer drought, and then slowly parted with it, by evaporation or gradual filtration, now, by thorough-drainage, in two or three days at most, sends all its surplus water onward to the natural stream. The stagnant clay-beds, which formerly, by slow degrees, allowed the water to filter through them to the wayside ditch, and then to the river, now, by drainage, contribute their proportion, in a few hours, to swell the stream. Thus, evaporation is lessened, and the amount of water which enters the natural channels largely increased; and, what is of more importance, the water which flows from the land is sent at once, after its fall from the heavens, into the streams. This produces upon the mill-streams a two-fold effect; first, to raise sudden freshets to overflow the dams, and sweep away the mills; and, secondly, to dry up their supply in dry seasons, and to diminish their waterpower."

Engineering News printed in 1892 a story with a similar message, titled "The Drainage of the Kankakee Marsh," and excerpted as follows:

> "But when the whole swamp is drained and under cultivation the rainfall will drain off from it as rapidly as from any other tract of cultivated land of similar slope and character of soil. The swamp will no longer be a great shallow storage reservoir to hold the floods which pour down from other parts of the watershed. It is certain, then, that when the drainage enterprise is carried out, a considerable increase in the flood volume of the Kankakee will result. The exact amount of the increase it will be the duty of the engineers of Chicago drainage canal accurately to determine, for in future years, when the compensation for flood damages in the Illinois valley arises the increased flow from the Kankakee must be considered as well as that from the Chicago River".

These early investigators write of draining the land and changing the plant communities from native prairie, savanna, woodland and wetland, to agricultural land. It wasn't long before we started removing the vegetation all together and began constructing impervious roofs, roads and parking lots.

The sequence of events beginning with a healthy undeveloped watershed with minimal to no flooding to an urbanized watershed with severe flooding are summarized as follows (Coffman, 2002):

- In a healthy, undeveloped landscape, water falling on the ground is intercepted by vegetation, retained in depressed areas such as wetlands, and is evaporated and infiltrated. Essentially, water falling on the land stays on the land, or is slowly released into receiving streams.
- Urbanization results in compressed soils, an increase in impervious surfaces, and improved conveyance systems such as streams straightened to ditches, agricultural drain tiles, and storm sewers. Rather than remaining on the land as in a natural setting, water is piped off of the land as quickly as it falls on to the ground.
- Streams and rivers, "sized" over the millennia to receive water from the native landscape, respond to increased runoff by becoming wider and deeper. Flooding occurs as the effects of urbanization outpace the ability of the waterways to receive and convey water; water quality drops as the channel erodes, and water is conveyed through pipes rather than through native vegetation that filters water; wildlife habitat is lost.

It wasn't long before the historic prairie streams – moving marshes with a current, really – were well beyond their capacity to convey the volume and rate of water racing off of the urbanizing landscape. And flooding began in earnest.

The MMSD Model

Studies completed for the Menomonee River, Oak Creek, and Root River watersheds in southeast Wisconsin indicate that demographic and community development trends over the next 20 years will exacerbate flood problems. These studies provide recommendations for conventional, engineered strategies to combat flooding, as well as acknowledging the importance of maintaining existing open space to prevent future flooding (SWRPC, 1990; CDM, 2000, a,b,c).

Conventional engineered strategies include constructing massive storm water detention facilities where storm water runoff is temporarily stored and released downstream at a controlled rate, or improved conveyance to move water more quickly from one point in the watershed to another point downstream.

While detention and improved conveyance has been proven to reduce flooding within a localized region, in many cases, these strategies have failed to adequately protect downstream communities from flooding, degraded water quality and wildlife habitat, and eroding waterways for a number of reasons:

- New developments are still mass graded and sewered to drain water from the site as quickly as possible. Conveyance is maximized while infiltration and evaporation are minimized.
- Proactive communities require detention ponds designed to release water from new developments at the same rate water was released before the site was developed. However, release rates for detention ponds are usually calculated based on the land cover type immediately prior to development rather than the historic vegetation cover that likely had a much slower release rate. As a result, release rates are often over estimated.

- Detention facilities do not account for the increased volume of runoff from developed areas due to the reality that much less water infiltrates into the ground than under historic conditions (Ferguson, 2002).
- Most storm water regulations address individual development projects but do not take into account the cumulative affect of multiple detention facilities constructed along the same waterway.
- Some communities continue to allow development of naturally depressed storage areas such as wetlands and floodplains. Even if existing regulations do protect these depressed storage areas, regulations can change. Isolated wetlands, for example, are no longer protected from filling under Section 404 of the U.S. Clean Water Act.
- Runoff characteristics of a watershed are very complex and storm water runoff models often underestimate the actual rate and volume of runoff (Apfelbaum, 2001).

The construction of detention facilities over the last 30 years has provided tremendous flood protection benefits and will continue to do so in the future. However, the persistence of flooding in areas where detention facilities and other conventional storm water management strategies are in place, and the failure of conventional techniques to adequately address water quality and habitat goals, makes the objective observer question whether there aren't alternatives to at least supplement conventional strategies.

MMSD took the judicious approach of adopting a conventional storm water management plan per the recommendations of Watercourse Reports prepared by Camp Dresser McKee. But in addition, they launched an aggressive land acquisition program targeting land at threat to development that provided important, natural storm water management functions.

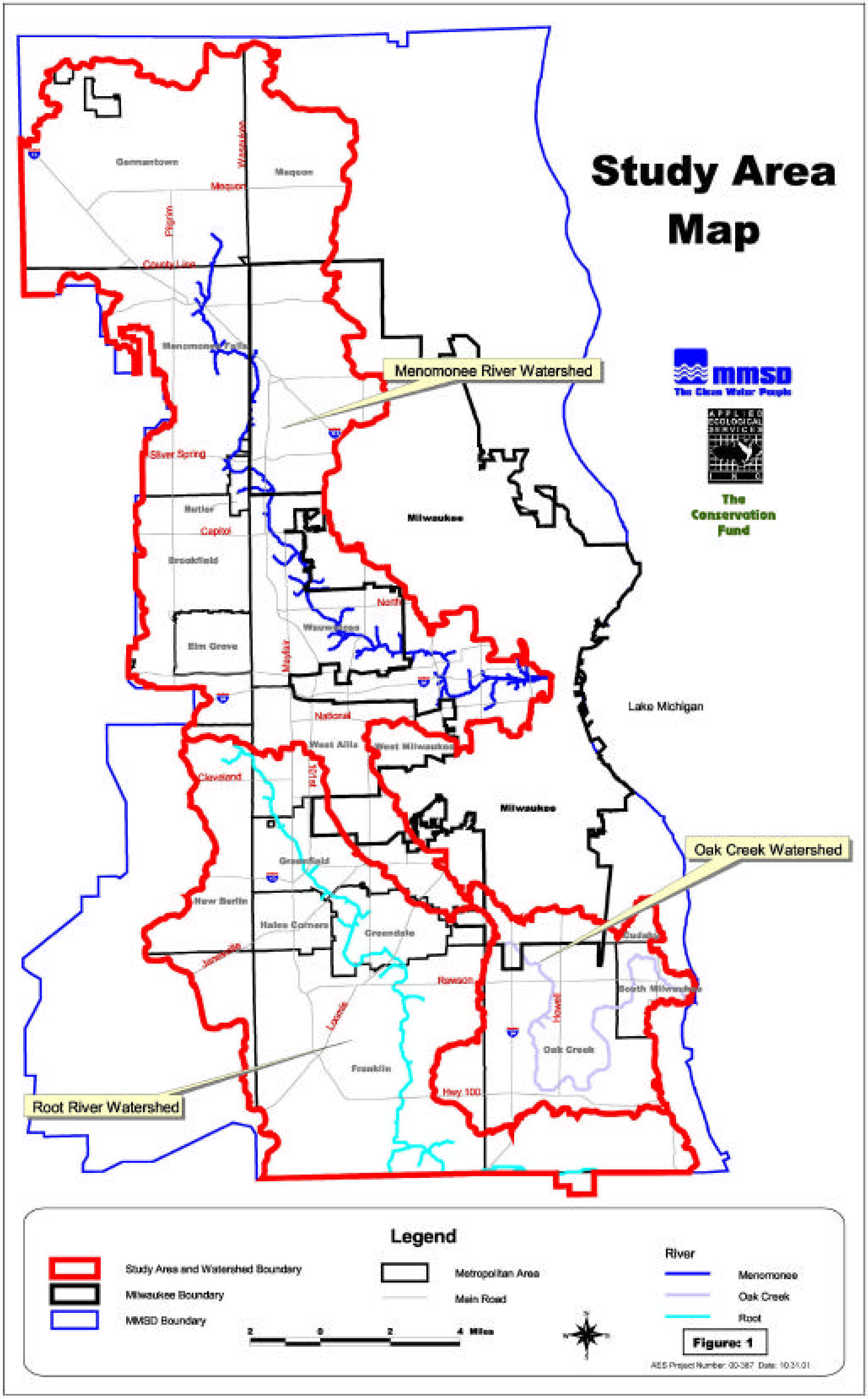
MMSD retained a team led by The Conservation Fund to develop a Conservation Plan with the following key components: 1) Identify undeveloped private properties potentially at risk for development that could provide future flood-reduction benefits; 2) Assess opportunities for MMSD to partner with public, private, or non-profit entities that would assist with the acquisition, management, and maintenance of identified properties; 3) Assess mechanisms and strategies and leverage MMSD funding for this effort; 4) Provide recommendations for the acquisition of specific parcels (or easements on those parcels) at risk for development; and 5) Consider how the ecological restoration of identified parcels could reduce future flooding.

The Conservation Plan was completed during 2001 and provides a technical basis and justification for identifying undeveloped properties to purchase that have the greatest potential to protect against future flooding. The plan also describes a land acquisition strategy, partnership opportunities, additional funding sources, and how the plan can be expanded to target additional objectives such as water quality and wildlife habitat with the implementation of an ecological restoration strategy. MMSD allocated $15 million dollars over five years to develop the Conservation Plan and purchase property.

Project Area

The project area consisted of the watersheds of the Menomonee River, Root River and Oak Creek that are within the MMSD Planning Area (Figure 1). The MMSD planning area is in southeast Wisconsin and includes portions of Washington, Waukesha, Milwaukee, and Ozaukee counties. The Menomonee River drains an approximately 135 square mile area including at least portions of the cities of Brookfield, Milwaukee and Germantown. The Root River drains an approximately 197 square mile area including at least portions of the cities of Franklin and New Berlin. Oak Creek drains an approximately 27 square mile area including the city of Oak Creek, Milwaukee, and South Milwaukee.

Figure No. 1: The study area consists of the Menomonee River, Root River and Oak Creek watersheds.



Methods and Results

Base GIS Information

An extensive Geographical Information Systems (GIS) database was developed using ArcView ™ to assemble, store, manipulate and display geographically referenced information. Digital data was obtained from Southeast Wisconsin Regional Planning Commission (SEWRPC), MMSD, participating counties, townships and municipalities, and the World Wide Web. Data layers developed included watershed boundaries, sub-watershed boundaries, digital elevation models, aerial topography, 2' topography (where available), planned and existing environmental corridors, governmental boundaries, parcel boundaries and other layers.

Digital ortho-rectified aerial photography (1995 were the most current images available during the study period), hydric soils, floodplain, private/public land, and land use/land cover data were obtained from SEWRPC. Watershed boundaries and characteristics were obtained from Wisconsin DNR, Geographic Services Section (April 1997). USGS 7.5" Digital Elevation Model (DEM) data were used to create an elevation model.

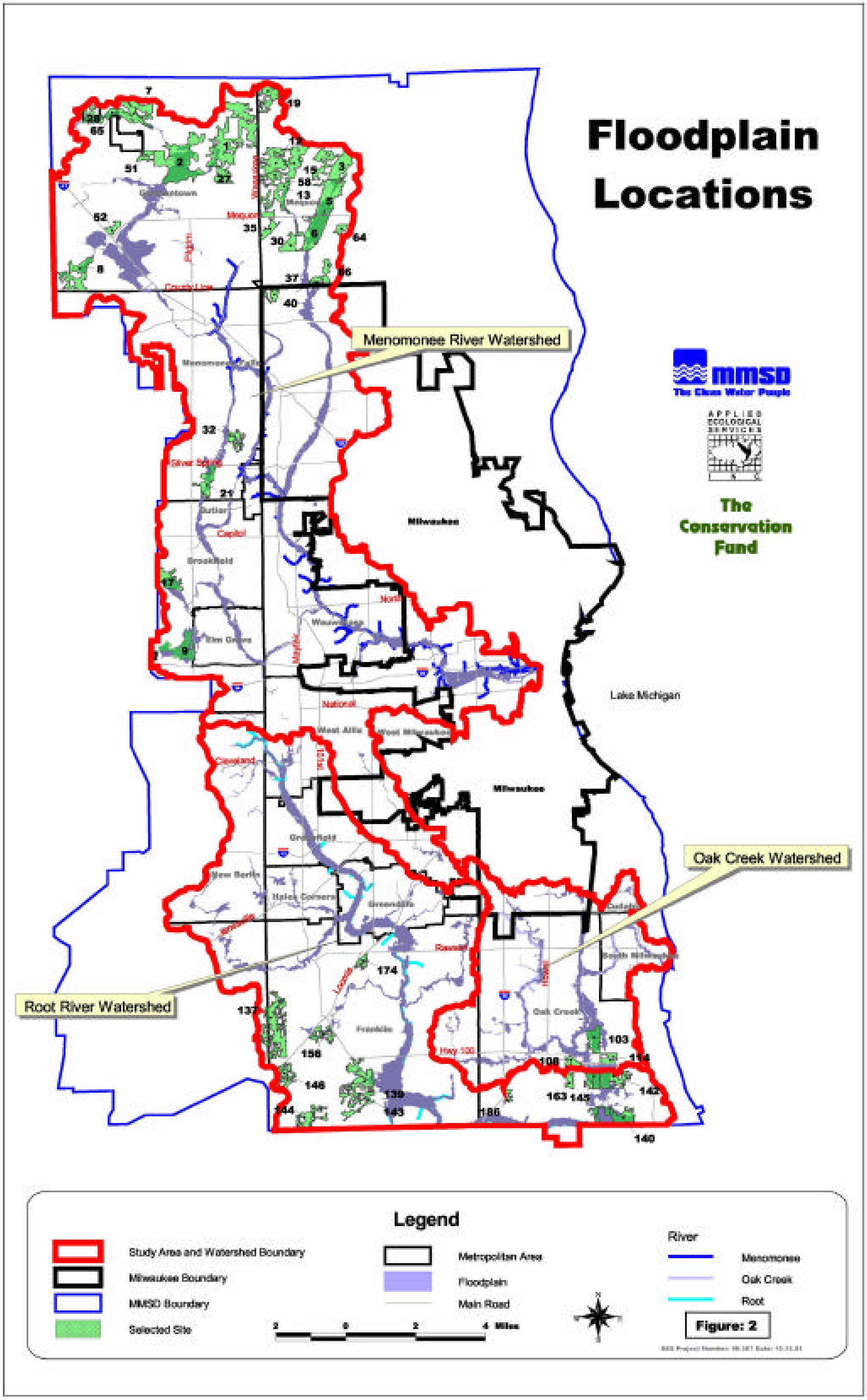
Hydrologic Impact Site Analysis

The primary objective of the Hydrologic Impact Site Analysis was to identify undeveloped, privately held parcels and evaluate their potential ability to store runoff and reduce flood risks.

An undeveloped site can reduce flooding in two ways. One, reduce the rate and volume of water running off of the site; and two, reduce the rate and volume of water running off of lands tributary to the site. Several criteria were used to evaluate and rank potential sites for restoration for floodwater runoff reduction including: area; the potential floodwater storage capacity of the site relative to runoff tributary to the site; the effectiveness of a site to store water; and the importance of a site to reducing flooding downstream along the mainstem.

Site Selection – We began our initial investigations for potential sites by intersecting privately held, undeveloped lands with hydric soils and floodplain. More than 28,000 acres of land were identified in the initial query. Sites less than 25 contiguous acres were dropped leaving a subset of 199 (Figure 2) sites totaling 17,146 acres. The smaller sites were dropped to create a more manageable data set to work with, and because smaller sites would likely have less potential to affect floodwater runoff.

Figure No. 2: Each floodplain was mapped to assist in the hydrologic analysis.



Each of the 199 sites was field-verified with mapped data. Sites already developed or in the process of being developed were removed. Thirty-four sites totaling 2,417 acres were eliminated during field visits because they had been developed between 1995 and 2001.

Capacity Relative to Runoff – Each of the 199 sites were evaluated and ranked as to their potential to efficiently handle runoff from their tributary watershed during a 100-year, 24 hour duration, storm event.

We assumed that the land cover of the tributary watershed was a typical, residential urban development (Cn=75). This resulted in approximately 3.5" of runoff during a 100-year event (duration 24 hours, Huff 3rd quartile precipitation distribution, precipitation 6.24") for the watershed.

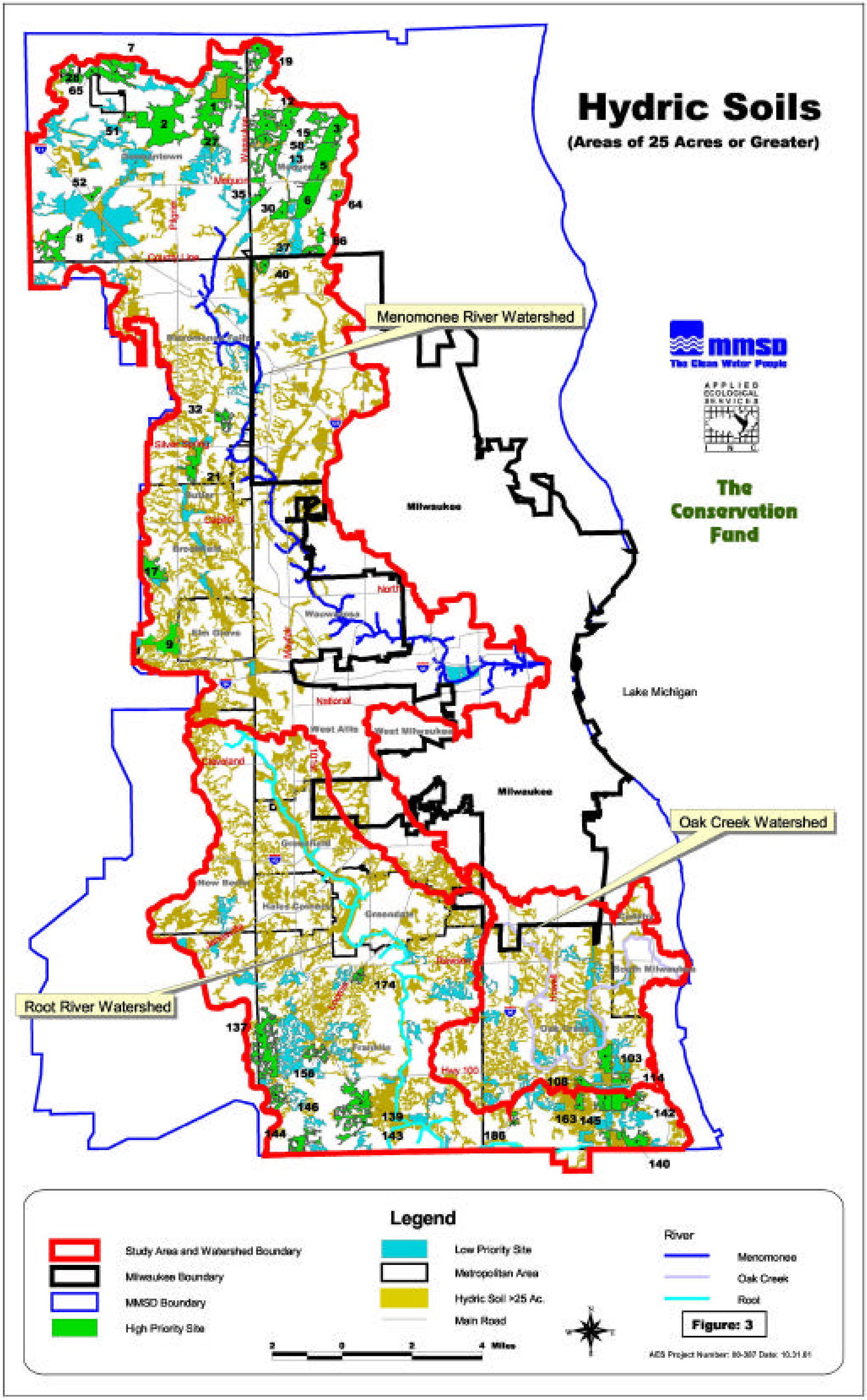
We also assumed that 2 feet of storage was available within the open space site, so a site with a watershed seven times the size of the site (7:1 watershed to site ratio) would most efficiently handle 3.5" of runoff (watershed area x 3.5 inches/12/foot = storage area x 2 feet). Table 1 describes the ranking system created to develop the Watershed/Site Area Ratio Score.

Table No. 1: Watershed/Site Area Ratio. A weight of 0 is assigned to sites with negligible on-site storage capacity for runoff relative to the size of the contributing watershed. A weight of 10 is assigned to sites with optimum on-site storage capacity for runoff relative to the size of the contributing watershed. Note each weight is assigned to a range of ratios.

Watershed area: site area ratio	Weight
0:1 to 2:1	3
2:1 to 4:1	6
4:1 to 6:1	8
6:1 to 8:1	10
8:1 to 10:1	9
10:1 to 12:1	8
12:1 to 14:1	7
14:1 to 16:1	4
16:1 to 18:1	2
18:1 to 20:1	1
> 20:1	0

Storage Effectiveness – The storage effectiveness of each site was calculated as a function of the area of the site, and the ratio between the area of the site and the area of the contributing watershed. Larger sites that efficiently store water are ranked higher than smaller sites that do not efficiently store water. The storage effectiveness score was used to identify the 42 highest priority sites (7,065 acres) for protection (Figure 3).

Figure No. 3: Soil analysis contributed to site assessment and prioritization.



Site Importance to Flood Risk Reduction – Each of the 42 high priority sites were assessed as to their importance for reducing flooding risks along the main stems of the primary channels of their watersheds. The importance of the site was based on the proximity of the site to areas along the main stem projected to have flood increases between the 1995 design year and 2020.

Flood projections were taken from Hydrologic Simulation Program-Fortran (HSPF) models prepared Camp Dresser and McKee (2000 a,b,c). Sites were assigned a **high priority** location rank if they were located in sub-watersheds that discharged into reaches of the main stem projected to have significant increases in the 100-year design flood substantially greater than projected increases on the main stem immediately upstream of the site.

Sites were assigned a **medium priority** location rank if they were located in sub-watersheds that discharged into reaches of the main stem projected to have increases in the 100-year design flood that were similar to projected increases on the main stem immediately upstream of the site.

Sites were assigned a **low priority** location rank if they were located in sub-watersheds that discharged into reaches of the main stem that were not projected to have increases in the 100-year design flood.

Final Ranking of Each Site – Each of the 42 high priority sites were ranked in order of 1-42 using weighted variables described above. The rank of each site is described within each of the three watersheds as well as within the entire project area. Table 2 indicates the final rank of each of the 42 high priority sites.

Table No. 2: Final ranking of high priority sites by watershed as well as within the entire study area.

Restoration Site	Watershed	Site Area (Acres)	Storage Effectiveness Score	Location Rank	Watershed Rank	Study Area Rank
8	Menomonee River	250.2	85	H	1	1
2	Menomonee River	667.2	80	H	2	2
7	Menomonee River	265.3	76	H	3	3
27	Menomonee River	105.4	63	H	4	5
28	Menomonee River	104.3	62	H	5	6
35	Menomonee River	71.7	60	H	6	7
5	Menomonee River	312.7	87	M	7	8
15	Menomonee River	188.5	81	M	8	9
13	Menomonee River	208.9	74	M	9	11
52	Menomonee River	51.4	42	H	10	13
21	Menomonee River	145.5	69	M	11	14
40	Menomonee River	64.3	36	H	12	15
3	Menomonee River	354.7	58	M	13	17
12	Menomonee River	226.1	55	M	14	18
37	Menomonee River	68.7	51	M	15	21
30	Menomonee River	95	45	M	16	22
58	Menomonee River	47.4	27	H	17	23
51	Menomonee River	55.2	43	M	18	25
32	Menomonee River	84.4	21	H	19	27
1	Menomonee River	673.7	80	L	20	28
9	Menomonee River	230.6	75	L	21	29
65	Menomonee River	43.1	15	H	22	30
17	Menomonee River	155.8	71	L	23	32
64	Menomonee River	44.1	23	M	24	33
66	Menomonee River	42.6	22	M	25	34
6	Menomonee River	292.8	19	M	26	35
19	Menomonee River	152.6	26	L	27	40
103	Oak Creek	138.9	68	H	1	4
114	Oak Creek	65.3	43	H	2	12
108	Oak Creek	73.8	55	M	3	19
144	Root River	135.3	76	M	1	10
137	Root River	420.3	59	M	2	16
174	Root River	44.8	31	H	3	20
156	Root River	88.3	44	M	4	24
139	Root River	239.7	38	M	5	26
146	Root River	119.4	25	M	6	31
142	Root River	188.6	54	-	7	36
145	Root River	120	50	-	8	37
140	Root River	195.3	36	-	9	38
143	Root River	148.9	9	M	10	39
163	Root River	54.9	16	-	11	41
186	Root River	29.9	14	-	12	42

Parcel Prioritization

Each parcel within each of 42 high priority sites was evaluated and prioritized for acquisition based on the potential storm water runoff storage each parcels would provide. The parcel evaluation methodology consisted of a two-step process:

- Identification of parcels, boundaries and ownership within each of the high priority sites;
- Evaluation of the storage potential of each of the individual parcels.

Parcel Identification – Parcel boundaries and ownership was defined according to available land parcel ownership records.

Parcel Storage Evaluation – The storage potential for each parcel within each of the 42 high priority sites were determined as follows:

1. A site digital elevation model (SDEM) using ArcView ™ software was developed for each site.
2. The minimum elevation value (site runoff evaluation) along the perimeter of the site was extracted from the SDEM.
3. A reservoir surface model was generated based on the minimum elevation value along the perimeter of the site.
4. Ownership parcel boundaries were defined and put into the SDEM.
5. The potential volume of each parcel was calculated by using the SDEM elevation grid as the product of the difference between the grid elevation and the minimum elevation along the site perimeter for each SDEM grid and the area of the grid cell. Iterations were calculated based on existing conditions, and the construction of 2-foot, 4-foot, and 6-foot berms.
6. Parcels were ranked and prioritized based on their potential storage at various berm heights.

While the parcel storage evaluation method provided an effective way to compare the potential storage capacity of one parcel to another, the topographic drawings available to us were at too coarse of a scale to permit an accurate representation of actual storage per parcel.

Site Action Plan – A site action plan was developed for each of the high priority sites. The site action plan included an aerial base map indicating site limits and parcel boundaries within the site. Parcels were color coated to indicate parcels with the most potential for storing water. Parcels were linked to a Microsoft 2000 ACCESS database that provided additional information useful to land negotiators, including ownership, size, potential storage, and other information.

Partnership Opportunities and Potential Funding Mechanisms

Concurrently with the preparation of the Base GIS Information and Hydrologic Impact Site Analysis, staff from The Conservation Fund investigated opportunities for partnering with land trusts, local units of government and private landowners to own, hold easements, or manage Conservation Plan Sites. Staff from Heart Lake Conservation Associates investigated methods to leverage the $15 million MMSD had allocated to this effort to obtain additional monies through grants or gifts.

Partnership Opportunities – Partnership opportunities with local units of government were evaluated by identifying the overlap between each of the 13 local government's park and open space plans with Conservation Plan sites. Eleven local units of government were surveyed. Eight of the 11 governments were interested in working with MMSD to manage Conservation Plan sites long term.

Partnership opportunities with non-profit land trusts were evaluated by developing a list of land trusts operating in the project area, and by determining whether the land trust met the minimum requirements for a profile The Conservation Fund developed. Sixteen organizations were identified and 10 were interviewed to determine interest and whether or not the organization met the profile. Two organizations expressed interest and have the capability to own and manage 23 of the 42 Conservation Plan sites.

The Conservation Fund also explored potential partnership opportunities with the private sector including private landowners, residential developers and commercial developers. Private landowners would be more inclined to explore easement arrangements such as the Wetland Reserve Program, Crop Reserve Enhancement Program and the Wisconsin Stewardship program. Commercial and residential developers would more likely be interested in incentive for conservation developments.

Potential Funding Mechanisms – Heart Lake Conservation Associates identified and researched 30 grants that MMSD might pursue to purchase and/or manage Conservation Plan sites and interviewed 18 agencies and organizations. Public and private entities exhibited a high level of interest in supporting a Conservation Plan they viewed as an innovative and exciting approach to deal with multiple objectives (flooding, water retention, wildlife habitat, water quality, open space protection, etc.). Heart Lake estimated that MMSD had the potential to double its $15 million investment through leveraging.

Heart Lake identified two broad categories of funding that might be leveraged. The first, existing grant programs, is available to grant applicants that meet the criteria of the grant program. The second, that Heart Lake termed "money to be found," has even greater potential for leveraging funding than grants. "Money to be found" refers to MMSD developing successful partnerships and relationships with organizations that can provide funds. It is not uncommon for agency staff to direct discretionary funds to a project because the project is attractive, a priority for the agency, or will help an organization achieve its goals.

One nearly universal rule when soliciting funds from outside sources is that funding agencies tend to look more favorably on projects that meet multiple objectives. A project that provides flooding, water quality, wildlife habitat and recreational benefits and opportunities would be looked on more favorably than a project with just flood reduction benefits.

Discussion

A Case for Protection

State and federal statues and regulations govern much of the activities that are permitted in floodplains, floodways, wetlands and shore land zones. However, most of these resources are not given outright protection by these statues or regulations, but are merely regulate as required by the statutes.

For example, floodplains and wetlands are frequently impacted by agricultural operations and development. These impacts often result in filling, and reduced size and capacity to function. Many of these impacts are permissible by state and federal regulations with a permit. Whether or not these permits compensate for lost resources is subject to debate.

Studies of wetland mitigation areas across the country have suggested that most wetland mitigation projects designed to compensate for wetland fills fail to meet design standards. Isolated wetlands, which have been regulated by the Corps of Engineers for more than 15 years, have lost their protection since February 2001 due to changing regulations.

Protection through acquisition or easement offers the very best way to ensure that areas currently used for floodwater storage will be allowed to function in this way in the future. Where protection has not been granted, the range of impacts and alterations to these important areas have contributed greatly to the current flooding problems now experienced in our communities.

Flood Benefits of Protected Sites

An undeveloped open site provides two opportunities for floodwater runoff reduction. 1) Reduce the rate and volume of runoff from the site itself; and 2) Reduce the rate and volume of runoff from the site through on site management of floodwater runoff from a watershed tributary to the site.

Volume reduction is accomplished through retention (surface water is prevented from leaving the site). Rate reduction is accomplished both by retention and by detention (surface water is temporarily stored on the site and then slowly discharged at a controlled rate).

The type of land cover and vegetation on the landscape has a substantial effect on the amount of surface water running off of the land. A typical urban development will result in surface runoff of approximately 3.5 inches from a 100-year recurrence interval design storm (duration 24 hours, Huff 3rd quartile precipitation distribution, precipitation of 6.24”). An undeveloped fallow field with deep-rooted vegetation (i.e. prairie plants) decreases surface runoff of a fallow field from 2.9 inches to 1.1 inches, providing retention of 1.8” of floodwater runoff.

The construction of low berms provides an additional (and greater) volume of floodwater storage. Perimeter berms can reduce floodwater runoff to zero inches. The installation of additional berms at strategic locations throughout the site can retain storm water runoff to a depth of two feet that in turn provides two feet of retention on a site. Such a strategy has the potential to reduce runoff to zero inches for an off-site tributary area up to 6.5 times larger than the site itself.

Cost Effectiveness of Preservation

It is difficult to accurately measure the cost effectiveness of preserving and restoring open space to the extent that flood benefits are realized. While the Conservation Plan provides a technically defensible method for identifying and prioritizing land to protect, budget and data limitations prevented us from precisely quantifying how much runoff each site or parcel could store.

The budget for preparing the Conservation Plan was less than $200,000. In the absence of funds to prepare a 1’ or 2’ topographic survey, we were forced to use U.S.G.S. 7.5” topographical data to quantify the potential storage in sites and parcels. Storage numbers cited in the plan are most useful for comparisons between sites and parcels rather than as a precise representation of actual storage provided.

However, common sense and the use of reasonable assumptions indicate that preserving open space can be very economical when compared to the costs of flood damages, conventional flood damage studies, the costs of implementing conventional flood damage strategies, and costs associated with the loss of water quality, habitat, and other open space opportunities when conventional strategies are exclusively used.

For example. MMSD has a goal of purchasing 5,000 to 7,000 acres of land over the next 5 years using the $15 million budgeted for the project. If we assume that each acre of land would provide an average of two acre-feet of storage (Eppich et al. 1998), the acquisition of 7,000 acres of land could provide approximately 14,000 acre feet of storage (7,000 acres x two feet of storage per acre = 14,000 acre feet of storage). That translates into $1,071 per acre-foot of storage for land costs.

Cost per acre-foot of storage would increase once you add construction costs associated with restoring a site to maximize its capacity to store floodwater. Costs for restoration can range from $1,000 to $5,000 per acre which raises total cost per acre-foot of storage to $2,071 to $6,071 per acre-foot of storage.

It is useful to consider how these costs compare with traditional storm water detention facilities. The Village of Arlington Heights, Illinois provides one such comparison. The Village allows some developers to purchase storm water storage from a regional storm water detention facility in lieu of providing storm water detention on site at a cost $1/cubic foot of storage, or $43,560 per acre-foot of storage.

Costs associated with a Phase II Corps of Engineers flood damage reduction project on the Des Plaines River in Illinois provide another useful comparison. The maximum flood of record in 1986 caused $35 million in damage. The cost of just the study to determine what can be done is $9.8 million.

Logic suggests that costs associated with flood damages, preparing engineering studies to deal with flood damages in conventional means, and constructing conventional flood damage reduction projects are far greater than costs associated with protecting open space important in storing floodwaters.

Restoration ecologists and storm water management experts will argue without cease as to the virtues and pitfalls of their respective approaches. If approached objectively, and with humility, such arguments are healthy. Ecologists must have the numbers to back up assertions for alternative approaches; engineers must recognize that models can turn into black boxes with simplistic answers to complex questions. However, no alternatives to conventional practices will exist without the land on which to work.

Water Quality Benefits

Water quality benefits associated with storing storm water runoff in the natural landscape when compared with no storm water management, or even conventional storm water management strategies where water is piped to detention ponds, are substantial.

Coffman (2002) prepared a table summarizing research completed by the Center for Watershed Protection that cites 16 papers published between 1979 and 1994 examining the relationship between urbanization and stream water quality. These papers indicate significant reductions in the diversity of aquatic fauna once total impervious cover in the contributing watershed approaches 10%.

Liptan and Thomas (2002) cite a Portland Bureau of Environmental Service experiment in which a swale planted in turf grass is compared with an identically configured swale planted in native prairie grasses and forbs. The investigators found that runoff attenuation in the native swale was 41% compared with the turf grass swale that was 27%. 68% of the total suspended solids (TSS) in the runoff were retained within the native swale compared with 59% in the turf grass swale. It is important to note that if sewers were used for conveyance rather than swales, attenuation of runoff and TSS would not be significant.

The Storm water Treatment Train™ concept uses constructed landscape features of upland prairies, swales vegetated in native plants, wetlands and lakes to retain and treat runoff. Apfelbaum et al (1995) used HSPF modeling to predict the effectiveness of this system in treating runoff from the Prairie Crossing conservation development in Grayslake, Illinois, with the following results: Surface runoff would be reduced by 65%; TSS would be reduced by 98%; total nitrogen would be reduced by 85%; and total phosphorus would be reduced by 95%.

Lessons Learned and Additional Research

- This paper provides an original approach for quantifying the potential efficiency of open space to provide storage for storm water runoff. While the topographic information at our disposal was too coarse to provide a precise quantification of potential storage, the technique used permitted us to make objective comparisons between sites and parcels. Higher resolution topographic data would have allowed us to make precise quantification of potential storage using the techniques we developed.
- Costs associated with flood damages, preparing studies to reduce flood damages, and implementing conventional storm water management strategies to combat flooding, are enormous. This study justifies allocating more resources toward studying alternative strategies that rely on preservation and restoration as a cost effective means to combat flooding, as well as address other objectives such as water quality, habitat, and open space benefits.
- The investigators were restricted to considering only privately held open space. We recommend expanding the study to include publicly held open space for additional passive floodwater storage opportunities.
- The ranking system did not include restoration measures on each site that could maximize the potential for each site to store floodwater. We recommend expanding the study to consider how restoration could maximize the potential for each site.
- This study concentrated on floodwater benefits of open space. We recommend additional work to demonstrate how preserved open space will provide multiple benefits including water quality, habitat, and other open space benefits.
- The investigators learned that it is absolutely essential to be sensitive and humble when proposing alternative methods for combating flooding. Communities may wait years for flooding relief that may or not be consistent with alternative strategies described in this paper. The investigators acknowledge the value conventional storm water strategies have had in the past and will continue to have today and into the future.

Conclusion and Summary

- This Conservation Plan identified 199 sites total 17,146 acres for further investigation. Thirty-four sites totaling 2,417 acres were eliminated during field visits because they were already developed.

Forty-two sites totaling 7,065 acres were identified as high priority sites. Remaining sites were identified as low to medium priority for acquisition due to limited flooding benefits, an impractical configuration for acquisition, or an excessive number of parcels.

- Interviews with potential partners (local governments, land trusts, others) indicate that 61% of the high priority sites have entities that are "definitely" interested with MMSD.
- Thirty-four high priority sites containing up to 4,835 acre-feet of potential storage have been lost or altered since 1995.
- Approximately $15 million is earmarked for the implementation of the Conservation Plan. While variable land costs prohibit an accurate estimate of the amount of land that might be purchased with available funds, this study indicates that costs associated with preserving and restoring important open space is less than the cost of constructing traditional detention facilities to deal with existing or future flood problems.
- This study provides an original approach for quantifying the potential efficiency of open space to provide storage for storm water runoff. While the topographic information at our disposal was too coarse to provide a precise quantification of potential storage, the technique used permitted us to make objective comparisons between sites and parcels. Higher resolution topographic data would have allowed us to make precise quantification of potential storage using the techniques we developed.
- Conceptual cost estimates indicate that securing undeveloped sites and maximizing their natural flood storage potential is cost effective compared with conventional flood control alternatives.

Acknowledgements

Portions of this paper first appeared in the MMSD's Conservation Plan (2001). Steve McCarthy was the MMSD's project manager. Peg Kohring of The Conservation Fund led the consulting team. Mark O'Leary of Applied Ecological Services, Inc. was the project manager for the technical team and writing the Conservation Plan. Doug Eppich of Applied Ecological Services, Inc. assisted with the development of the ranking system. Neal Thomas of Research Data, Inc., and Jason Carlson of Applied Ecological Services, Inc. completed the GIS analysis. Steve Apfelbaum of Applied Ecological Services, Inc. provided leadership and vision. Peter McKeever of Heart Lake Conservation Associates contributed to the funding portion of the study. Megan Kelly, David Johannesen and Pam Sullivan provided additional assistance on the Conservation Plan. Karen Sands and Kevin Shafer provided important reviews of the Conservation Plan. Iva McRoberts edited and formatted this paper. The Project Team gratefully acknowledges their support and assistance.

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