ENHANCING SUSTAINABILITY AT LOWER HURON METROPARK

A project submitted in partial fulfillment of the requirements for the degree of
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Jose Miguel Friz
Jordan Garfinkle
Naomi Hamermesh
Khawar Khan
Jason Levine
Lindsay Nelson

Faculty Advisors:
Assistant Professor Josh Newell
Associate Professor Stan Jones

University of Michigan
School of Natural Resources and Environment

METROPARKS

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Abstract

Urban parks throughout the nation are recognizing the need to become more sustainable environments, moving beyond their traditional roles. The Huron-Clinton Metropolitan Authority, which oversees 13 parks spanning 24,000 acres across five counties in Southeast Michigan, recognizes that its operations currently lack a detailed sustainability plan. While the Metroparks are a valuable environmental resource for the surrounding area, current practices are impacting human and natural systems. With the HCMA's mission in mind, a sustainability plan for Lower Huron Metropark was developed, detailing sustainability initiatives that can be integrated with the park's natural and built environments. The hope is that this plan can serve as a model for enhancing sustainability at the other Metroparks. This sustainability plan outlines recommendations for enhancing the environmental, economic, and social benefits provided by the Huron-Clinton Metroparks.

After selecting Lower Huron as the study park, five issue areas (energy, water, waste management, stormwater management, and education) were chosen as the focus of the report. Lower Huron's baseline was analyzed in each of these areas, followed by the research of precedent studies. The Metroparks of the Toledo Area and Portland Department of Parks and Recreation are two organizations highlighted which have embraced sustainability measures throughout their operations. Finally, potential options for implementation were evaluated against specific criteria and recommendations of the most beneficial options were made. The criteria used to evaluate each option included project cost, site appropriateness, economic benefits, social benefits, and environmental benefits.

The recommendations made include a system for increased data tracking, the installation of a solar awning, the expansion of sustainability educational programs for children, the development of a waste reduction policy, the capture and treatment of stormwater on site, and the installation of water and energy efficiency measures at park facilities.

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Lastly, we are very grateful to the staff at both the Metroparks of the Toledo Area and Portland Parks and Recreation for meeting with us and providing us with key information about the sustainability initiatives undertaken at their respective parks. These impressive initiatives gave us inspiration for our project.

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Acronyms

BAS	Building automation system
BMP	Best management practices
BTU	British thermal unit
CCF	100 cubic feet
CFL	Compact fluorescent bulbs
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP	Coefficient of performance
CRI	Color-rendering index
DOE	United States Department of Energy
DTE	Detroit Edison
EB: O&M	Existing Buildings: Operations & Maintenance
EPA	United States Environmental Protection Agency
GBCI	Green Building Certification Institute
GPF	Gallons per flush
GPM	Gallons per minute
HCMA	Huron-Clinton Metropolitan Authority
HVAC	Heating, ventilation, and air conditioning
IDEP	Illicit Discharge Elimination Plan
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
MBTU	Million BTU
MEP	Maximum Extent Possible
MLC	Mobile Learning Center
MRF	Materials Recovery Facility
MS4s	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
OSDS	On-site disposal systems
PV	Photovoltaic
RCRA	Resource Conservation and Recovery Act
REPI	Renewable Energy Production Incentive
RRR	Reduce-Reuse-Recycle
SHGC	Solar Heat Gain Coefficient
USGBC	U.S. Green Building Council
VMT	Vehicle miles traveled


Photo Source: HCMA

Executive Summary

In recent years, the importance of sustainability in parks has gained newfound recognition. In many ways, sustainable parks deliver the socially beneficial services of traditional parks while also serving to enhance the surrounding ecology. The Huron-Clinton Metropolitan Authority (HCMA) has expressed interest in enhancing sustainability at their parks, and recognizes that their operations currently lack a detailed sustainability plan. While the Metroparks are a valuable environmental resource for Southeast Michigan, current practices are impacting human and natural systems. When considering sustainability initiatives, it is critical to also maintain the cultural and historical significance of the parks.

We have developed a sustainability plan for Lower Huron Metropark, detailing specific initiatives that can be integrated with the natural and built environments within the park. In addition to providing direction to efforts to reduce environmental impacts at Lower Huron, this plan can also serve as a model for enhancing sustainability at the other Huron-Clinton Metroparks. This plan outlines recommendations for improving the environmental, economic, and social impacts of Lower Huron Metropark, many of which can be adopted at a number of other Metroparks, as well as by other park systems.

Issue Areas

Sustainability is an inherently broad concept that encompasses a wide range of factors related to the way parks operate. This sustainability plan focuses on five specific areas: energy, water, waste, stormwater, and education. At Lower Huron, energy is used primarily for lighting, space heating and cooling, and for operations at Turtle Cove Family Aquatic Center. Water use includes potable water, irrigation, and operations at Turtle Cove. Waste issues are concerned with waste generated by park operations and by visitors, as well as purchasing policies that dictate what materials energy the park. Stormwater management issues arise from polluted runoff entering the Huron River. Finally, education offers the opportunity to connect the community to the various sustainability initiatives taking place at the parks, initiate behavior changes, and raise awareness about environmental issues. These five areas encompass a significant portion of environmental impact at Lower Huron.

Before evaluating any potential recommendations, it was critical to establish a baseline for each of these five areas. Once the baseline was determined, we established goals for each area. These goals provided guidance in determining the final recommendations for Lower Huron.

Energy Goals

- Determine strategies to reduce energy usage in buildings and park operations.
- Evaluate feasibility of alternative energy systems including solar photovoltaic and small-scale wind turbines.
- Reduce reliance on utility grid and dirty fossil fuel sources of electricity.
- Promote future policies for energy efficiency measures.

Water Goals

- Decrease the need for potable water from the various water utility providers.
- Determine strategies to reduce water usage in park buildings and operations.
- Reduce need for wastewater treatment due to decrease in water usage.

Waste Goals

- Establish systems that gradually reduce waste sent to landfills by 25 percent over ten years.
- Incorporate environmental considerations into the park's purchasing policies.
- Become a model of more sustainable waste management and promote good practices among visitors and communities.

Stormwater Goals

- Implement Structural Best Management Practices (BMPs) to capture and treat stormwater on site.
- Improve upon existing BMPs to enhance performance and ecological benefits.
- Design BMPs as an educational and cultural tool.
- Improve habitat and ecological value of areas affected by stormwater.

Education Goals

- Spread knowledge of specific actions individuals can take towards sustainability throughout the region, starting with park visitors.
- Instill in park visitors a deeper understanding of why sustainability is importantd.
- Work towards changing cultural perceptions of sustainability, specifically emphasizing the interdisciplinary nature of sustainability.
- Ensure that employees of the park understand and work towards sustainability in their everyday tasks.

After considering the baseline and developing the project goals, we determined numerous options that might help Lower Huron to meet their sustainability goals. Each of these options was evaluated to determine if they were appropriate for Lower Huron. The following criteria were used to evaluate each option:

Cost – the dollar value of complete implementation of the option, based on the most likely scale of the option as evaluated

Site Appropriateness – the feasibility of implementing the option, based on the location and context of Lower Huron Metropark

Economic Benefits – the direct economic gain realized over time by HCMA

Social Benefits – human health, well-being, and cultural benefits provided to the greater community

Environmental Benefits – the improvements to the health and quality of the natural environment

Recommendations

After considering each option's potential with respect to each criterion, those that offer the greatest overall benefit are presented as recommendations. To facilitate consideration and implementation of these recommendations, they are organized by intended audience. For each recommendation, we determined which staff at HCMA and Lower Huron would have the largest role in implementation. The four audiences to whom the recommendations are directed are: administration, interpretive services, maintenance and operations, and planning.

Administration

Establish Employee Roundtable

Involving employees in developing and implementing sustainability initiatives is critical for maintaining more environmentally friendly operations. Establishing a framework for employees to contribute ideas and raise issues is an important strategy for embedding sustainability within the organization. Ideally, employees at all the parks should get together regularly (perhaps monthly) to generate ideas, set goals, and discuss progress.

Join DTE GreenCurrents

DTE's GreenCurrents program offers customers the opportunity to support Michigan-based renewable energy projects. Customers can choose one of two enrollment options. HCMA can either match 100 percent of their consumption with a pledge of 2 cents per kWh purchased, or "blocks" of 1,000 kWh for $20 per month. Both options support renewable energy in the region. While the GreenCurrents program does not offer any financial benefits to HCMA, it does provide an opportunity to help increase local renewable energy generation.

Develop Waste Reduction Policy

In order to address waste issues throughout the park, HCMA should develop a waste reduction policy for Lower Huron. Doing so requires establishing a recycling policy and modifying purchasing policies.

Implement Recycling at Events

The initiation of a recycling system at special events in the park has the potential to impact the community's behavior and awareness of sustainability. Although the absolute and direct environmental benefits are low compared with other measures, the main benefits are found in instituting behavioral shifts towards sustainability.

Increase Data Tracking

One of the largest inhibitors to developing options and making recommendations was the availability of relevant data. Specifically, data were sparse or difficult to obtain regarding some aspects of energy use habits and consumption, water use habits, and waste patterns. While some of these data are difficult to track, others—such as monthly energy and water use—are readily available in monthly utility bills. Compiling these data and maintaining a database is a helpful way to learn about and monitor use patterns, as well as to identify possible anomalies. While establishing such a system may be a daunting task, maintaining it is quite simple once it has been developed.

Interpretive Services

Install Signage that Highlights Sustainability Measures

Many of the recommended sustainability measures will be visible to park visitors. This exposure presents an opportunity to educate visitors about the benefits of the various measures, and provides the potential for visitors to adopt certain practices in their own lives. To help realize this potential, it is important to highlight the sustainability initiatives where possible. Signage providing an overview of the measure and its benefits can help educate visitors about the importance of sustainable practices and some of the options available.

Expand Educational Programs for Children

Engaging elementary school-aged children in active learning about ways that they can incorporate sustainable practices into their own lives will have a broader impact on the environmental impact of the community at large. The particular program that should be used is a program called "Your Living World" that is currently in use at the Toledo Metroparks. "Your Living World" encourages children to discover ways to lead a more sustainable lifestyle with a focus on protecting the natural environment.

Expand Mobile Learning Center

The mobile learning center that Lower Huron currently operates offers an excellent platform for increasing awareness of sustainability issues among local children. Expanding the program, which currently focuses on natural and cultural history, would give more children access to this wonderful resource. Given the increased emphasis on sustainability at the park, the mobile learning center should provide basic information about many of the related issues.

Maintenance and Operations

Install Water Efficiency Measures

Many of the most cost-effective ways to reduce water consumption are through various efficiency measures, primarily in the restrooms. These include:

- Faucet Aerators
- Automatic Faucets
- Waterless Urinals and Low-Flow Urinals and Toilets

Install Energy Efficiency Measures

Similarly to water, many of the most cost-effective ways to reduce energy consumption are through reducing demand by installing a range of efficiency measures. These include:

- High efficiency Indoor Lighting
- Lighting Controls
- Energy Efficient Office Appliances

Develop Recycling System

A single stream recycling system should be implemented in the park. Recycling bins should be located next to regular bins to maximize usage. Visitors' education has to be emphasized, as their behavior is essential for the program to be effective. Even though a system like this does not pay for itself, it has a series of environmental and social benefits. It may be advisable to start with a pilot at Turtle Cove, an area with a high density of visitors.

Implement Composting Program

A large proportion of the waste generated at Lower Huron is organic waste. A composting program would eliminate the need to haul this waste to a landfill while potentially providing useful fertilizer generated on-site. The cost of establishing and maintaining such a program is highly variable; nevertheless, the potential of a composting program at Lower Huron is promising.

Install Pool Covers

Pool covers should be purchased for Turtle Cove to prevent unnecessary heat and water loss when the pools are not in use. Fitting a cover to the rectangular pool will be straightforward, inexpensive, and therefore cost-effective; doing so for the lazy river and other areas of irregular shape, however, will be more costly. Depending on the cost of having these specialized covers made, covering this portion may or may not be cost-effective.

Incorporate Centrally Controlled Irrigation

A centrally controlled irrigation system allows for substantial water savings by allowing for optimal irrigation controlled from a central computer. This system easily accounts for time of day, weather and other factors, and has resulted in enormous savings when properly implemented. If the golf course at Lower Huron does not remain open, however, irrigation will decrease dramatically, and this type of system may no longer be needed.

Explore Further Water Conservation Measures at Turtle Cove

Due to the majority of utility water being used by Turtle Cove, further water conservation measures should be closely examined. While no specific recommendations were made in this report, examples of best practices are included. Implementation of various conservation measures can significantly reduce water usage and water costs.

Planning

Implement Bioretention BMPs

Bioretention is appropriate for the site because there is so much open space to work to implement rain gardens at a variety of scales. Signage should be incorporated into the design to educate visitors on the ecological importance of rain gardens .

Install Rain Barrels and Cisterns

Although the detention pond near Turtle Cove collects runoff, additional runoff from roofs could be collected in rain barrels and cisterns. Although additional irrigation water may not be needed, these could both serve as low-cost educational tools that visitors could implement at their homes.

Expand Use of Native Vegetation
Many of the previously-mown areas of Lower Huron have been transformed into no-mow areas. This initiative should be further expanded to include additional areas within the park and involve actual planting of native woodland and prairie species in order to support healthy habitat and ecological function throughout the landscape. Native vegetation should also be incorporated into best management practices.

Enhance Existing Vegetated Swales
Many of the parking lots at Lower Huron have turf swales to move runoff from impervious surfaces. Theses wales can be more effective at treating polluted runoff and slowing flow before entering the Huron River if they are vegetated with natural plants. Bridges across these swales will improve pedestrian access to different areas of the park.

Install Vegetated Roofs
Green roofs are a more expensive option in terms of structural BMPs, and are not entirely necessary at Lower Huron because runoff can be collected within the landscape due to the large amount of natural area. However, the educational component that is associated with green roofs make them a viable option for Lower Huron and will bolster the park's image as a leader in sustainability.

Install Solar Awning
Given the large electricity needs of Turtle Cove, the favorable solar conditions at Lower Huron during the summer, and complaints from visitors about standing in line in uncomfortable heat, a solar awning at Turtle Cove is financially viable and desirable.

I***nvestigate Potential for Geothermal System***
The potential exists for geothermal heating and cooling at Lower Huron. While these systems are expensive to install, they can have very short payback periods depending on the specific geothermal conditions at the site. Given regional projects under way or currently operating, Lower Huron is good candidate for further investigation. Engineering professionals in the field should be consulted to determine the specific payback time at the park.

Summary

This report analyzes options and makes specific recommendations for improving the sustainability at Lower Huron Metropark. Impacts from energy and water consumption can be reduced through a combination of efficiency measures and renewable energy sources (such as solar and geothermal). Similarly, waste can be managed both by reducing waste and incorporating a viable recycling system. Stormwater would be best managed by collecting rainwater and minimizing impermeable surface cover. Education can be a powerful tool, publicizing measures such as those in this report as well as increasing the efficacy of these measures by encouraging participation in activities such as recycling both within the park and in the community at large.

Our hope is that components of this sustainability plan will be implemented in Lower Huron as funds become available. We also hope that the plan will serve as a model for other parks within the HCMA, across the region, and beyond. All parks present unique challenges to sustainability and these recommendations will not be universally feasible or effective; however, recommendations can serve as a starting point for many parks hoping to achieve higher standards of sustainability.


Photo Source: HCMA

Introduction

This report begins with a brief background of sustainability, the Huron-Clinton Metropolitan Authority, and Lower Huron Metropark. We discuss the five areas of sustainability that were investigated (energy, water, waste management, stormwater management, and education) as well as the reasoning behind selecting these five areas. Additionally, we describe the criteria used to evaluate potential options within each area of sustainability. Next two precedent studies are investigated to examine sustainability initiatives at parks similar to Lower Huron Metropark: Metroparks of the Toledo Area and Portland Department of Parks and Recreation.

Following the precedent studies, we explore the five areas of sustainability. First, the baseline conditions of each area at Lower Huron Metropark are assessed. Next, we describe and analyze potential options for enhancing sustainability in each area. After analyzing the options, we present recommendations based on which options offer the greatest overall benefit to the Huron-Clinton Metropolitan Authority. These recommendations are structured based on their intended audience, which are administrative subdivisions of the park staff that will play the largest role in implementing each of the recommendations. The four audiences addressed are: administration, interpretive services, maintenance and operations, and planning.

After presenting the recommendations, we conclude by discussing the overall findings as well as the impact that we hope this report will have on Lower Huron Metropark, the Huron-Clinton Metropolitan Authority, and Southeast Michigan. Finally, we provide additional resources that may be helpful for investigating these areas further or for implementing the recommendations.

The Huron-Clinton Metropolitan Authority recognizes that its operations currently lack a detailed sustainability plan. While the Metroparks are a valuable environmental resource for the surrounding area, current practices are impacting human and natural systems. With the HCMA's mission in mind, we have developed a sustainability plan for Lower Huron Metropark, detailing sustainability initiatives that can be integrated with the park's natural and built environments. The hope is that this plan can serve as a model for enhancing sustainability at the other Metroparks. This sustainability plan outlines recommendations for enhancing the environmental, economic, and social benefits provided by the Huron-Clinton Metroparks.

What is Sustainability?

Human and natural systems are fundamentally inextricable, and the ways in which they interact impact both society and the environment. Indeed, maintaining the integrity of the natural world is paramount for ensuring the stability of human systems. The concept of environmental sustainability, therefore, is concerned with shaping human interactions with the environment in such a way that does not threaten the future of either. Amid increasing awareness about environmental degradation, efforts to enhance sustainability have taken on urgency in recent years.

Sustainability is an inherently integrated concept that encompasses a range of factors with respect to the ways organizations operate. In the context of this report, sustainability is defined as a durable balance of environmental, social, and economic impacts over the long term. Negative impacts include environmental degradation, economic losses, and impacts on the broader community. Positive impacts include improved environmental quality, human health and well-being, cultural benefits, and economic gain. In order to be truly sustainable, initiatives that work towards these benefits while minimizing negative impacts must be implemented in a way that ensures their endurance for future generations.

Sustainability and Parks

While parks may seem like a natural fit for sustainability measures, implementing sustainability at parks has only emerged in recent decades. In an article in *Landscape Journal*, authors Cranz and Boland identify four distinct stages of the evolution of urban parks to serve the ever-changing needs of local residents: pleasure grounds, reform parks, recreation facilities, and open space systems [1]. The authors also envision a fifth type of urban park, which may have already begun to emerge. The sustainable park, as they call it, is designed to promote human and ecological health and help meet societal goals of sustainability. More broadly, sustainable parks emphasize ecological value while incorporating social value in harmony with, rather than in opposition to, natural aspects.

In many ways, sustainable parks deliver the socially beneficial services of traditional parks while also serving to enhance the surrounding ecology. Various urban parks around the country and throughout the world have been transformed to incorporate diverse best management practices (BMPs), including landscape standards, design, visitor information, and maintenance. Some parks at the forefront of implementing these BMPs are Central Park in New York City, Golden Gate Park in San Francisco, the Royal Parks in London, and Millennium Park in Chicago, among others [2]. While each of these parks may have different practices based on location, size, and function, they emphasize sustainability. The underlying goal of sustainability has been emphasized via reduced water, energy, and materials consumption, cost savings, improved operating efficiency, and enhanced quality of life for park visitors as well as the surrounding communities.

HCMA Background

The Huron-Clinton Metroparks, managed by the Huron-Clinton Metropolitan Authority (HCMA), is a regional parks system encompassing parks in Wayne, Oakland, Macomb, Washtenaw, and Livingston Counties in Southeast Michigan [3]. The Metroparks are located on the Huron and Clinton Rivers, forming a greenbelt around the Metropolitan Detroit region. Thirteen parks span 24,000 total acres, serving nine million visitors annually. The parks average around 1,000 acres each, while Stony Creek and Kensington are larger than 4,000 acres. The parks are staffed by 224 full-time employees and up to 800 part-time employees.

The inspiration to create the Metroparks dates back to the darkest days of the Great Depression. Early visionaries believed recreation and open space preservation would dramatically enhance the quality of life for the residents of Southeast Michigan. Dr. Henry S. Curtis, a nationally known advocate of outdoor leisure activity, and Dr. Harlow O. Whittemore, chairman of the Landscape Architecture Department at the University of Michigan, pioneered the idea of a massive interconnected park system for Southeast Michigan. After years of advocating their ideas for a park system and garnering support, in February 1939 the State approved Senate Bill 115, authorizing the establishment of the Huron-Clinton Metropolitan Authority. Governor Lauren D. Dickenson signed the bill, Public Act 147, three months later. The first park, now Kensington Metropark, opened in 1948 [4].

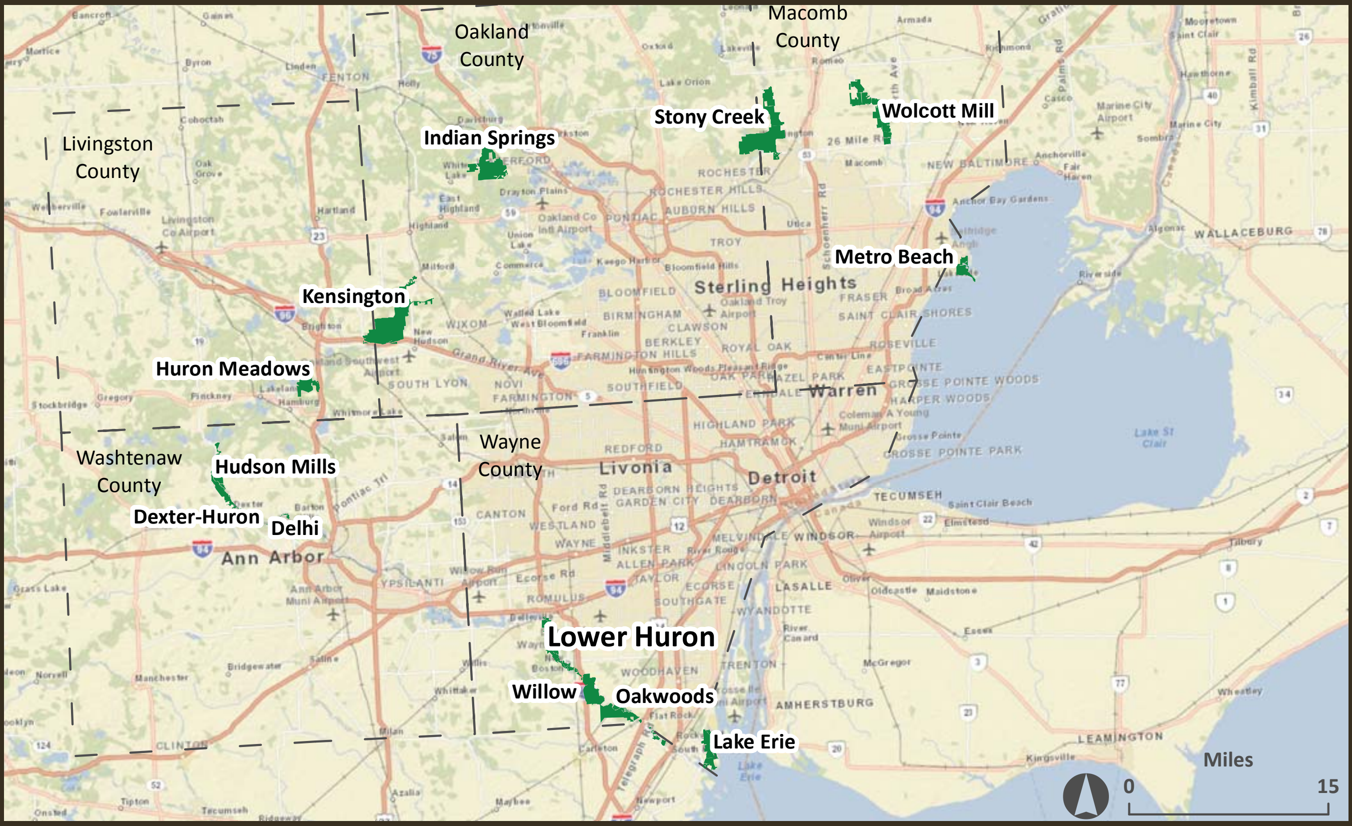


Figure 1: Regional Map of the Huron-Clinton Metroparks Source: ESRI and HCMA

The main administrative building for the HCMA is located in Kensington Metropark in the City of Brighton. Kensington Metropark spans Livingston and Oakland Counties. Huron Meadows Metropark is also located in Livingston County, 10 miles southwest of Kensington. Hudson Mills, Dexter-Hudson, and Delhi Metroparks are located in northern Washtenaw County. Lower Huron, Willow, Oakwoods and Lake Erie Metroparks are located in Wayne County, reaching up to 30 miles outside of Detroit. Indian Springs, Stony Creek, Wolcott Mill, and Lake Saint Clair Metroparks are located in Oakland and Macomb Counties, distributed among the northern suburbs of Detroit. See Figure 1 for a map of the Huron-Clinton Metroparks.

HCMA's 2011 budget totaled $73.5 million, which is determined by the HCMA Board of Commissioners [3]. The board consists of seven members, one representing each of the five counties containing Metroparks, and two appointed by the Governor of Michigan. Revenue from total park operations for fiscal year 2009 was $13.8 million. Capital improvement expenditures under the general fund for fiscal year 2009 were $8.6 million. Total capital expenditures were $12.8 million and total operating expenditures were $32.1 million. The main funding sources for the HCMA are a property tax levy and revenue from vehicle entry fees, as well as other user fees for various facilities such as the Turtle Cove Family Aquatic Center at Lower Huron Metropark.

The Huron-Clinton Metroparks serve as a source of outdoor recreation and enjoyment for the greater Metropolitan Detroit community and provide access to natural spaces for millions of residents. They offer a variety of outdoor activities, including picnicking, fishing, swimming, boating, hiking, biking, golf, disc golf, winter sports and various outdoor educational programs. The

Figure 2: Environmental Discovery Center at Indian Springs Metropark

Figure 3: Turtle Cove Family Aquatic Center at Lower Huron Metropark

Metroparks include 10 golf courses, two of which are par-three courses. The system operates nine full service interpretive centers that provide a variety of interpretive programs for almost 1.8 million visitors each year.

The Huron-Clinton Metropolitan Authority has received national recognition as a leader in recreation and land use. As Cynthia Reynolds states in her book Metroparks for the People, "The HCMA has created a regional legacy, and it has served as a model agency for park systems around the nation" [4]. Former Director Frank Sudek once said about HCMA, "We're certainly unique. We're a classroom example of how to do things right…We have enhanced the quality of life of people even if they never visit a Metropark, because the Authority has encouraged balanced growth and open space in the area" [4].

Although the Metroparks largely function as recreational parks, they were created in order to preserve open space and to ensure the provision of a healthy future for the residents of Southeast Michigan. As the parks were being planned in the mid-1930s, loss of open space, pollution of the Huron and Clinton Rivers, and disappearing fish and wildlife were growing concerns, particularly given the public's need for clean and safe recreation [4]. As the parks were established and the benefits of conservation began to take effect, riverbanks and water quality were restored and native plants and animals began returning to the land. As the Metroparks evolved through the decades, environmental sustainability became a key priority for the parks system.

The Huron-Clinton Metroparks "preserves and protects the benefits offered by open space, land preservation, and recreational facilities - not merely for the present generation, but for future generations" [4]. The mission statement of HCMA states, "The Huron-Clinton Metropolitan Authority, a regional park system created in 1940 by the citizens of Southeast Michigan, provides excellent recreational and educational opportunities while serving as stewards of its natural resources. Our efforts are guided by the belief that the use of parks and exposure to natural environments enhance society's health and quality of life."

Lower Huron Metropark

Lower Huron Metropark, which opened in 1948, comprises 1,258 acres [4]. Lower Huron is located in western Wayne County, 25 miles from Detroit. It is adjacent to Willow and Oakwoods Metroparks, which are located downstream of Lower Huron. The park spans both sides of the Huron River.

Lower Huron provides opportunities for a variety of outdoor activities. A 4.1-mile paved trail follows the Huron River and continues 11 miles through the adjacent Willow and Oakwoods Metroparks. Overnight and day camping are available at the park for organized youth groups. The park's rustic Walnut Grove Campground provides camping for families in tents, campers, and motor homes. Lower Huron provides recreational space at various picnic areas, including basketball hoops, softball diamonds, tennis courts, and volleyball nets. Tables, grills, and picnic shelters are provided throughout the park, and fishing decks are located at the north and south ends of the park. Turtle Cove Family Aquatic Center features two waterslides, a lazy river, and a zero-depth entry pool with lap lanes.

Issue Areas

Within the context of parks in general and Lower Huron in particular, many different aspects of management and operations relate to sustainability. This sustainability plan focuses on five issue areas: energy, water, waste, stormwater, and education. Numerous other areas are intimately connected to the short- and long-term sustainability of Lower Huron, and many are related to several aspects of the areas of focus. These five were chosen because of their prominence at Lower Huron, available information about each issue area's status at the park and potential options, the group's expertise, and constraints on time and resources.

Energy

Energy systems can play an important role in parks' environmental impacts. While parks are generally thought of as green space for recreation and, increasingly, conservation, they often have substantial energy needs. Indeed, several of the Metroparks offer large water parks, golf courses, and buildings such as nature centers and administrative offices. Current energy use practices have significant environmental impacts – one of the largest concerns has to do with the greenhouse gas emissions associated with fossil fuels, the dominant energy sources today. Renewable energy such as wind and solar can be implemented to help reduce the environmental impacts of energy use within the parks. These systems come in various sizes and with a range of capacities to potentially meet the specific needs of a variety of parks and provide another valuable educational resource. Reducing energy consumption in buildings and park operations is a prominent issue and can be achieved through a variety of technological and educational strategies.

Water

Water consumption is a critical issue as public water withdrawals have increased in recent years. Water conservation measures can help reduce the extraction of freshwater resources and also reduce costs of purchasing and pumping water into the park facilities. This category includes potable water entering the park, faucets and fixtures, operations at Turtle Cove, and irrigation. As with energy, conservation measures offer enormous potential for reducing consumption.

Waste

High amounts of waste are generated at Lower Huron. As a result, it seems natural to implement strategies that divert waste from going to landfills. Though intuitive, this approach is complicated by the fact that most visitors only visit the park sporadically, and are more difficult to educate about an altered waste management system. Designing a recycling system, evaluating the potential for composting, and implementing a waste reduction policy become of paramount relevance.

Stormwater

Managing stormwater has become a growing concern in urban areas, as traditional approaches to stormwater management have had serious

Table 1: Project Goals

Energy	▪ Determine strategies to reduce energy usage in buildings and park operations . ▪ Evaluate feasibility of alternative energy systems including solar photovoltaic and small-scale wind turbines. ▪ Reduce reliance on the utility grid and dirty fossil fuel sources of electricity. ▪ Promote future policies for energy efficiency measures.
Water	▪ Decrease the need for potable water from the various water utility providers at Lower Huron. ▪ Determine strategies to reduce water usage in park buildings and operations. ▪ Reduce the need for wastewater treatment due to decrease in water usage.
Waste	▪ Establish systems that gradually reduce waste sent to landfills by 25 percent over ten years. ▪ Incorporate environmental considerations into the park's purchasing policies. ▪ Become a model of more sustainable waste management and promote good practices among visitors and communities.
Stormwater	▪ Implement Structural Best Management Practices (BMPs) to capture and treat stormwater on site. ▪ Improve upon existing BMPs to enhance performance. ▪ Design BMPs as an educational and cultural tool and provide interpretive signage and other materials to education on their importance. ▪ Improve habitat and ecological value of areas affected by stormwater by establishing native vegetation in the design of proposed BMPs.
Education	▪ Spread knowledge of sustainable actions individuals can make throughout the region, starting with park visitors. ▪ Instill in park visitors a deeper understanding of why sustainability is important. ▪ Work towards changing cultural perceptions of sustainability, specifically emphasizing the interdisciplinary nature of sustainability. ▪ Ensure that employees of the park understand and work towards sustainability in their everyday tasks.

ecological impacts, particularly on downstream riparian zones. Urban development has dramatically impacted natural hydrologic systems by reducing the landscape's ability to absorb stormwater and by introducing pollutants [5]. The impervious surfaces of urbanized landscapes prevent water from infiltrating at its source, and sediments and pollutants from impervious surfaces are carried into pipes and water bodies by runoff. Although Lower Huron Metropark contains large areas of open space, popular picnic areas and Turtle Cove have extensive areas of impervious surfaces that drain untreated runoff into the Huron River.

There are many opportunities to properly manage stormwater within Lower Huron, from retrofitting parking lots, playing fields, golf courses, and rooftops, to providing a strong educational component that stresses the importance of proper stormwater management. Stormwater management at Lower Huron provides opportunities for responsibly handling large flows of polluted runoff from impervious surfaces and as an educational tool.

Education

Education ties these four areas together and promotes environmental awareness among park visitors. Education initiatives create the potential for sustainability measures within the park to have a greater impact on the community at large, initiating behavior changes and raising awareness of these sustainability issues throughout the Detroit metropolitan area. The HCMA strives to include opportunities for environmental education in their parks, and considers it a top priority for the future [4].

Methods

Research and Precedent Studies

The group met with representatives of the Huron-Clinton Metropolitan Authority at Kensington Metropark. We discussed our interest in HCMA with respect to sustainability and familiarized ourselves with the Metroparks system. For most of the group members, this was their first visit to a Metropark.

The group determined that an important way to study potential sustainability options for the Metroparks was to investigate precedents around the country. In addition to researching these issues in isolation, we decided to meet with several park systems to learn what they have done to promote sustainability. We chose to visit the Metroparks of the Toledo Area based on the geographic and cultural similarities to the Huron-Clinton Metroparks and its close proximity to Ann Arbor. The group met with representatives from Toledo Metroparks on September 30, 2011.

The group also met with park management employees from the Portland Department of Parks and Recreation on October 17, 2011 in Portland, Oregon. Portland Parks and Recreation was chosen because of its reputation as a national leader in sustainability. In addition, we visited the City of West Linn, Oregon and met with Ken Worcester of West Linn Parks and Recreation. Sustainability initiatives from West Linn are highlighted throughout the report, though in less detail than Toledo and Portland. Smaller case studies based on research beyond these interviews are also incorporated into the report in order to highlight important sustainability projects that support our options and recommendations for sustainability initiatives. The Portland Parks and Recreation and the Metroparks of the Toledo Area case studies are discussed in the next chapter.

Options and Recommendations

The *Options* sections in each of the five issue areas highlight sustainability initiatives that were considered for Lower Huron and give a brief explanation of each option. Options were extensively researched and evaluated for implementation at Lower Huron. Although not all options are explicitly recommended, some may be worthy of further investigation.

We evaluated the options based on three main factors: economic, environmental, and social benefits. Focusing on these three components allows organizations to achieve long-term success while making significant strides towards sustainability. Following this framework, we developed specific definitions and criteria for each. Keeping in mind our definition of sustainability as well as the practicality of implementation, we based our recommendations for sustainability initiatives on the following factors:

Cost – the dollar value of complete implementation of the option, based on the most likely scale of the option as evaluated

Site Appropriateness – the feasibility of implementing the option, based on the location and context of Lower Huron Metropark

Economic Benefits – the direct economic gain realized over time by HCMA

Social Benefits – human health, well being, and cultural benefits provided to the greater community

Environmental Benefits – the improvements to the health and quality of the natural environment

Limitations

It is important to acknowledge that many issues affecting sustainability are not specifically evaluated in this report. For example, transportation is an important sector that we did not consider. Transportation has significant impacts such as greenhouse gas emissions and resource depletion. Though beyond the scope of this project, this and other issues should be evaluated as HCMA works towards a more comprehensive view of sustainability.

It will be necessary to consult organizations with specific expertise to evaluate or implement several of the larger-scale initiatives recommended in this report. While this sustainability plan suggests a wide range of potential options, implementation is always a challenging step. Thus, this report seeks to establish a framework for considering options and evaluating alternatives rather than to dictate a concrete path going forward.

Summary

While the implementation of these recommendations will depend on several factors, one critical finding is the need for an institutional commitment to sustainability on an organizational level. Every action taken by the HCMA has downstream impacts, whether environmental, economic, or social. Incorporating these factors into decision-making will offer critical insights into the implications for sustainability. Evaluating projects partially on this basis and employing effective metrics such as life cycle costing[1] and net present value[2] will help to better understand and internalize the true costs. Embedding sustainability within the organization will also be an important step toward the HCMA's mission, which emphasizes natural resource stewardship and enhancing the surrounding communities' health and quality of life.

Urban parks throughout the nation are recognizing the need to become more sustainable environments, moving beyond their traditional roles [1]. The Metroparks have provided a tremendous variety of recreational and educational opportunities for the past sixty years. Although primarily used for recreation, the Metroparks have made it a

1 Life cycle costing involves taking the entire cost of a product or project into account including purchase, installation, operations, transportation, and disposal.

2 Net present value involves adding the total revenue expected to be made over a project's lifetime and subtracting initial costs involved, while discounting both the future costs and revenues at a specified rate.

priority to enhance sustainability throughout the parks. With this report we hope to provide the HCMA with recommendations for taking steps to transform Lower Huron Metropark into a model of sustainability. It is our hope that this sustainability plan can serve as a model for similar work at the other twelve Metroparks as well as contribute to the growing discussion surrounding parks and sustainability across the country.

Precedent Studies

When considering sustainability at Lower Huron Metropark, it was important to consider how other park systems across the country are addressing similar issues. Two park systems in particular stand out for what they can offer to inform idea-building and decision-making at HCMA and Lower Huron. The Metroparks of the Toledo Area (hereafter, Toledo Metroparks), Toledo, Ohio's regional parks agency, is situated within the upper Midwest region and is affected by similar climatic, geographic and demographic circumstances as Lower Huron. Toledo Metroparks has taken a number of steps to enhance sustainability at their parks, many of which are directly applicable to Lower Huron.

Though geographically and demographically distinct from Southeast Michigan, Portland Department of Parks and Recreation, the agency responsible for managing Portland, Oregon's parks, can also offer important insights for sustainability at Lower Huron. Considered one of the national leaders in environmental protection, the City of Portland's general emphasis on sustainability is reflected in many aspects of park management. While some initiatives are specific to regions with similar geographic and weather conditions, many can be adapted for Lower Huron.

Metroparks of the Toledo Area

The group visited the Toledo Metroparks on September 30, 2011 to discuss sustainability initiatives within their parks system. We met with Joe Fausnaugh, Park Services Manager, and Beckie Finch, Programs Director, at Wildwood Preserve in Sylvania, Ohio. The group chose Toledo Metroparks due to its record on sustainability issues. Additionally, Toledo's proximity to Lower Huron and the geographic similarities across the region offer relevant comparisons of the challenges faced by both park systems.

Toledo Metroparks provides citizens of Lucas County, Ohio with over 10,500 acres of natural space and recreational areas. The parks system is funded primarily by a countywide $1.4 million property tax levy and comprises twelve parks, each offering picnic areas, playfields, hiking and cross-country skiing trials, and educational opportunities for visitors [6].

Toledo Metroparks started their sustainability plan by measuring their baseline carbon footprint in 2005. Initially, they made a list of all the potential areas for sustainability through employee participation and preliminary studies to identify where efficiency improvements could be made. The items were prioritized according to their environmental and economic benefits, and the order in which they were implemented reflected these analyses.

Energy

Toledo Metroparks has focused on improving energy efficiency and energy management in many of their parks. Electricity consumption has been reduced by 12 percent in Wildwood Preserve. Despite certain technological improvements, the largest reduction in electricity consumption was achieved through employee behavioral changes. A checklist for effective and efficient use of electricity was distributed among employees and garnered a strong response. The checklist is included as Appendix 1.

T12 light bulbs have been replaced by T8 and T5 bulbs in most of the indoor areas. T8 and T5 bulbs are newer, thinner and more efficient lighting options than the old T12 light bulbs. T8 and T5 light bulbs can produce the same amount of light for less power consumption. These are discussed in more detail in the energy section. Generally T8s and T5s reduce energy consumption by 41 percent and 51 percent respectively over T12s [7]. Recently, more efficient LED lighting has also become a popular option for limited indoor applications.

Motion sensors were installed on vending machines to reduce electricity consumption during inactivity. The annual electricity bill for one vending machine was estimated to be approximately $2,000. These motion sensors enhance energy efficiency, and save electricity and money by keeping the machines minimally operational when no one is in the vicinity. Motion sensors were also installed on many indoor lights at the parks to reduce unnecessary electricity consumption.

A central computerized Heating Ventilation and Cooling (HVAC) monitoring system was recently installed at the parks. This system ensures that the proper temperature is maintained at numerous park facilities by displaying the local temperatures of all facilities in one central location. Some systems are also equipped with a function to override local thermostat settings, enabling strict monitoring and management of temperature settings. The system has been effective at decreasing heating costs and reducing the associated emissions at the parks.

Vehicle Fleet

Toledo Metroparks has focused on improving the efficiency and management of their vehicle fleet for both financial and environmental reasons. Over the past five years, they have reduced the size of their fleet from 83 vehicles to 52, and have reduced vehicle miles traveled (VMT) from 500,000 miles in 2007 to 380,000 miles in 2010. This 24 percent reduction in VMT saved 10,000 gallons of gasoline.

Toledo Metroparks is also using alternative vehicle technologies to reduce their carbon footprint. Since 2008, they have replaced 11 trucks with electric utility carts. Their revised vehicle purchasing policy dictates that they purchase the smallest vehicle available that meets the particular job requirement for which the vehicle is being acquired. The use of smaller vehicles has improved overall fleet mileage by three miles per gallon. They have also taken a proactive approach by integrating alternative fuel vehicles into their fleet. Since 2007, they have purchased seven E-85 vehicles, which use a gasoline blend containing 85 percent ethanol. In 2008 and 2009 they purchased four propane-fueled mowers for maintaining the turf grass in several parks.

The benefits of these fleet initiatives extend beyond carbon mitigation and economic benefits. Due to the use of electric cars, traffic noise pollution has been reduced in the parks and surrounding community. An increase in visitor traffic has coincided with these initiatives, making a strong case for their enhancement of the ambience in the parks as well as the potential for greater public education through exposure.

Waste

Toledo Metroparks has found waste management to be a unique challenge, mainly because tracking the amount of waste generated is difficult. They have recently negotiated a new contract with Allied Waste for a waste audit measuring the volume of waste removed when each dumpster is collected. In the offices, employees are encouraged to recycle recyclable material and recycling bins are provided in every office at the parks. They have also revised material purchasing policies to encourage buying less wasteful material. For instance, they are switching to purchasing concentrated cleaners and

Figure 4: Solar Panels on a restroom at Swan Creek Preserve, part of the Metroparks of the Toledo Area

Figure 5: Tanner Springs, a constructed wetland and city park is located in downtown Portland

roll-free toilet paper. In terms of localized toxicity concerns, hazardous waste is separated from other waste and is either recycled or sent to a specialized disposal facility.

Education and Community Involvement

Toledo Metroparks strongly believes active participation by all staff and community members is crucial for sustainability at their parks. The "Employee Idea Metropark" is an active program in which employees are encouraged to submit their ideas about how the parks can improve upon various aspects of sustainability. To help realize some of these suggestions, they established an internal grant program that allocates specific funds for implementing these ideas each year. At the implementation stage, they actively seek volunteer help; they believe that involving community members has substantial positive impacts both within and beyond the parks.

Portland Department of Parks and Recreation

The group met with park management employees from the Portland Department of Parks and Recreation on October 17, 2011. The department shared a great deal of information about its sustainability initiatives in addition to suggestions for Lower Huron Metropark.

Portland Parks and Recreation is a large agency with 441 full time employees and a $100 million annual budget [8, 9]. While this organization is comparable to the HCMA (which has 223 full time employees and a $75 million budget) [10], some of their initiatives are not directly applicable to Lower Huron. Nevertheless, many of Portland's successes can potentially be replicated on a smaller scale.

The agency has established policies from a top-down approach to achieve its comprehensive sustainability goals. Empowered by a progressive city government and environmentally minded residents, the parks operate under a citywide Climate Action Plan and a Carbon Footprint Reduction Strategy. New buildings and major retrofits must meet LEED Silver standards and LEED standards are followed to guide best management practices when certification is not feasible. In addition, "green teams" made up of department employees are active in many sustainability initiatives. Parks and Recreation has stressed the importance of achieving employee support and participation in these programs by encouraging employees to adopt some of their sustainability initiatives in their own lives [11].

Energy

Portland Parks and Recreation has also implemented many initiatives to reduce electricity and natural gas usage in the parks. The department has installed high efficiency LED lighting, occupancy sensors (shuts off light when space is not occupied), photocells for lighting control (dim light bulbs to maximize daylighting), and late automatic lockout systems on lights for stadiums and outdoor courts. In addition, high efficiency appliances have been installed to replace older models when needed. The department has recently received several federal grants for significant additional lighting retrofits, window replacements, and the installation of a 51kW photovoltaic system at a community center to offset some of the facility's energy consumption.

The parks have centrally controlled HVAC systems to monitor performance, consumption, and costs more efficiently. Portland Parks and Recreation is currently investigating setting temperatures one or two degrees cooler than current settings to further reduce energy consumption from heating. While Southeast Michigan's climate is more extreme than Portland's, this step may be feasible if approached properly (i.e. ensuring people are comfortable and are not opening or closing windows to alter the temperature). In addition, pool covers are used in indoor pools to minimize heat loss overnight. This action has reduced heating consumption by 15 to 20 percent.

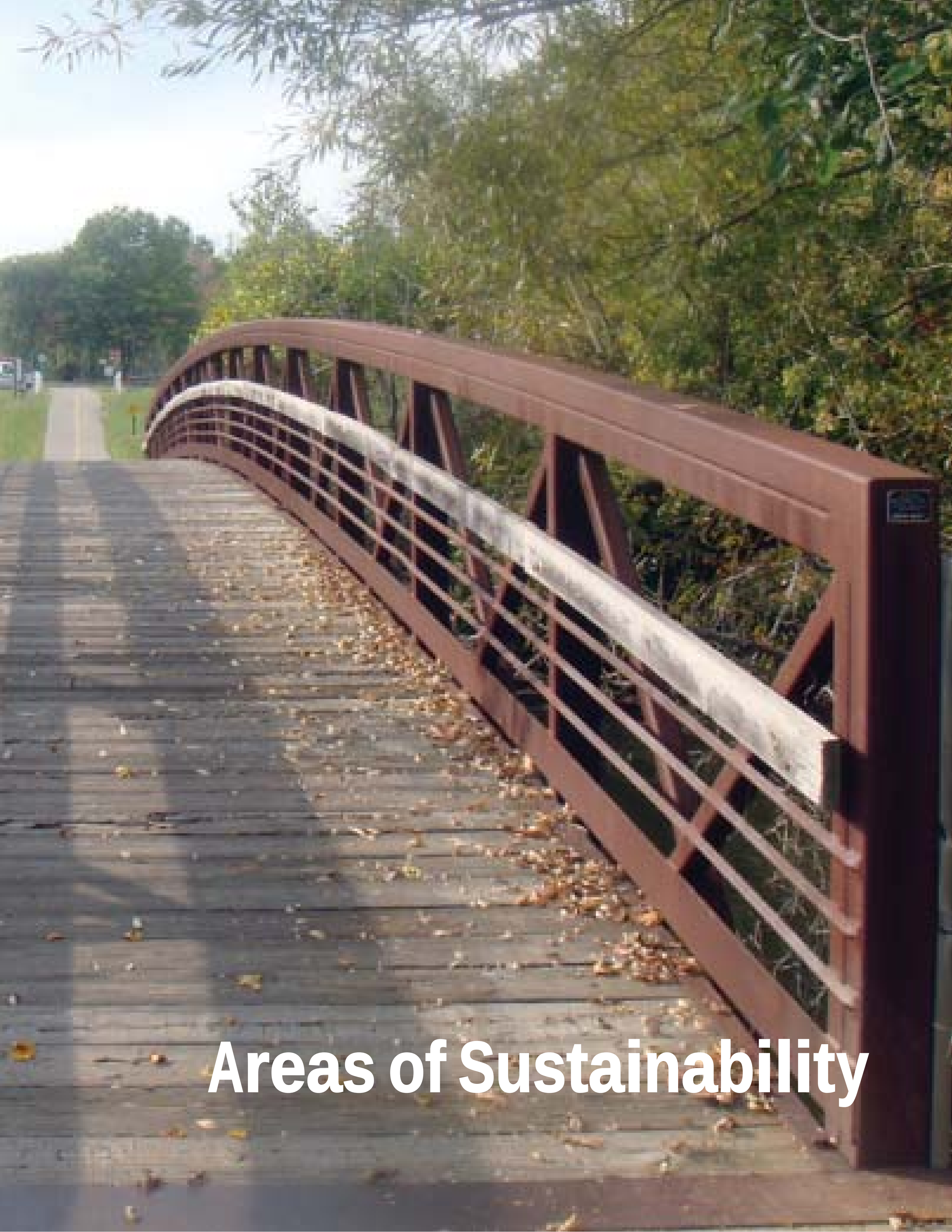
Water

Portland Parks and Recreation has achieved significant accomplishments in water sustainability. First, they have reduced demand on municipal water through the installation of wells at a dozen sites. In addition, a centrally controlled irrigation system manages water use at all of the largest parks and some of the smaller parks. This system allows for the grounds to be watered at night or in the early morning to reduce evaporation and allow greater water infiltration into the soil. Low-flow toilets and water fountains have also been installed to reduce water usage. Finally, field staff have been trained in basic maintenance for sprinkler heads to ensure optimal performance of water efficiency and cost savings measures.

Waste

Portland Parks and Recreation has pursued a number of initiatives targeting waste. For example, organic materials are recycled and used as mulch, reducing the need for fertilizers and diverting material from the waste stream. In terms of waste produced at their headquarters and other offices, recycling is available for paper, plastic, aluminum, cardboard, and glass. Other park facilities such as community centers and pools also accommodate bottle recycling. Parks and Recreation has a contract with their waste hauler requiring the hauler to collect and provide dumpsters for recycling these items if requested. In addition, all hauled waste is weighed and tracked for reporting purposes.

An industrial waste recycling program is currently being formalized, which will include items not currently being tracked such as paint, wood, oil and grease, metals, batteries, and light bulbs. During special events in major parks, vendors are required to have recycling containers available. The department's goal is to divert 25 percent of industrial waste from the waste stream by 2020. Its annual diversion rate for 2010 was 17 percent, up from 15 percent in 2009. One persistent challenge has been finding effective solutions to dispose of dog waste. Parks and Recreation has investigated a number of options such as providing biodegradable bags, but the sheer volume of waste has made it difficult to overcome.



Areas of Sustainability

Energy

Energy sources can be categorized as either renewable or non-renewable. Renewable sources of energy can be easily replenished, while non-renewables are finite resources that cannot be replenished on a human time scale [12]. Both of these are used to produce secondary energy sources including electricity. Non-renewable resources include petroleum, natural gas, coal, and nuclear power. Renewable resources include solar, wind, geothermal (heat from inside the earth's crust), biomass (organic material from plants), and hydropower from dams. Over 90 percent of the country's energy usage is generated from non-renewable sources [12]. Only a small percentage of energy is produced from renewable sources, with hydropower and biomass being the largest sources. While non-renewable fossil fuels are often less expensive and more convenient sources than technologies that utilize renewable sources, they cause environmental impacts and are becoming scarcer. Fossil fuels — most significantly coal — contribute to local and regional environmental pollution, including air pollution and destruction of land from mining and extraction, and global climate change as they emit large quantities of greenhouse gases, primarily carbon dioxide [13]. Greenhouse gases are a significant concern because they trap heat near the surface of the Earth, contributing to climate change.

The State of Michigan generates the majority of its electricity from coal-fired power plants. Specifically, 57 percent of the state's electricity is generated from coal, 27 percent from nuclear, 11 percent from natural gas and only 3 percent from renewable sources [14]. Michigan has significant biomass and wind energy resources and ranks 14th among states for wind energy potential [14]. Natural gas is the primary source for space heating in buildings [15].

The state's reliance on coal brings about many environmental problems. Burning coal emits more carbon dioxide than any other source. The DTE grid carbon intensity is around 264 kg Carbon/GJ of energy produced, due to the company's reliance on coal (comprising approximately 67 percent of their fuel mix) [16]. Thus, a shift away from coal to renewable energy sources will help to mitigate greenhouse gas emissions.

Baseline

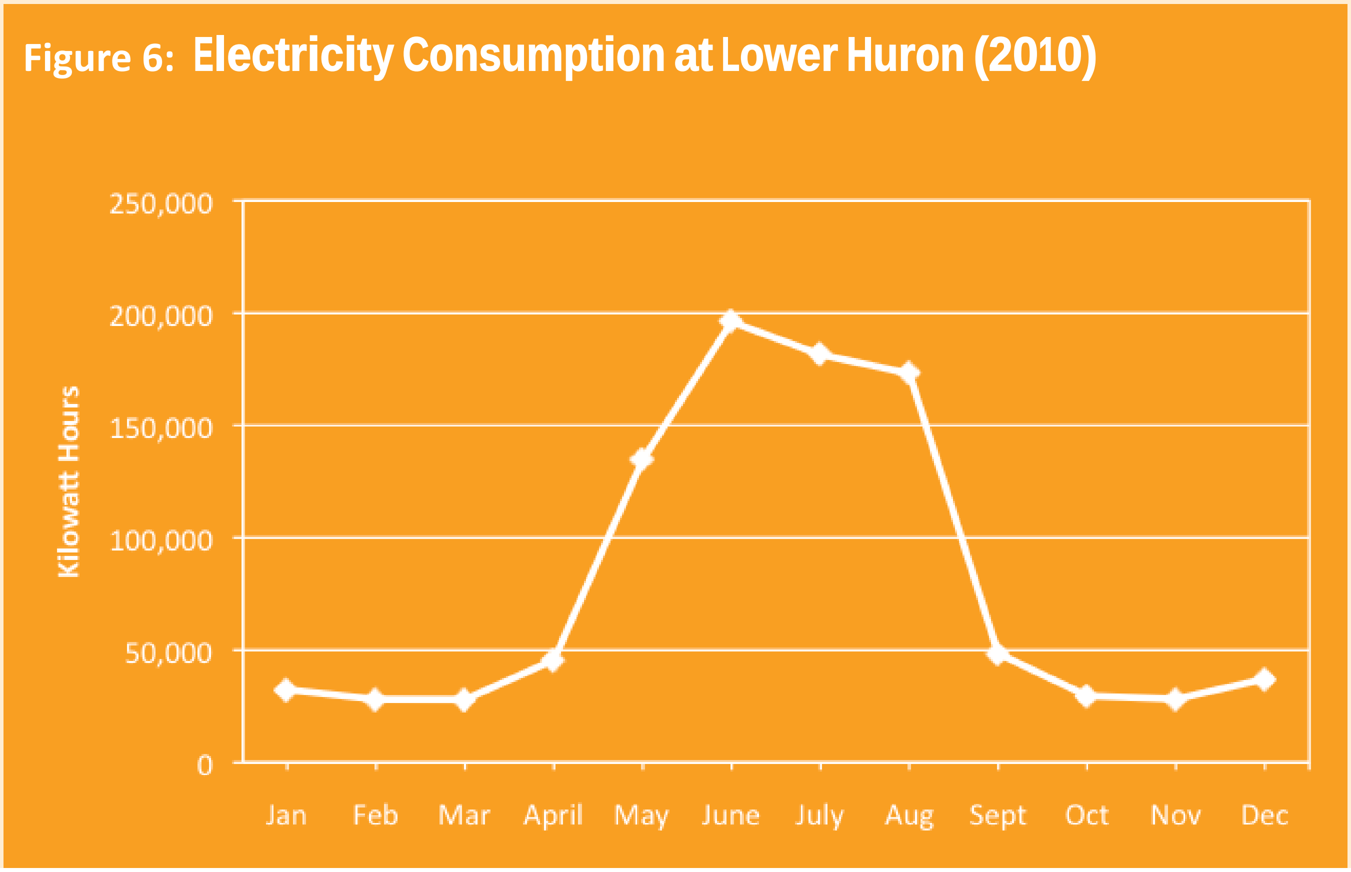
Utility bills from 2010 were used to determine the baseline electricity and natural gas consumption at Lower Huron Metropark. Energy use at Lower Huron Metropark comprises a significant portion of the park's environmental footprint. It also offers substantial potential for improvement through a variety of measures. Electricity and natural gas consumption are largely seasonal, fluctuating by orders of magnitude throughout the year. The current state of energy consumption was determined through a top-down approach based on the park's energy bills for 2010. Where the data were incomplete, consumption numbers were estimated by interpolating between the existing data, based on assumptions outlined in Appendix 2.

Electricity

In 2010, the total electricity consumption at Lower Huron was 962,869 kWh and cost $109,755. Overall, the park's electricity consumption peaked in the summer months. Total electricity use was just under 200,000 kWh in June, overwhelmingly due to air conditioning and other end-uses at Turtle Cove Family Aquatic Center. In addition to Turtle Cove, electricity demand at several other facilities – such as the office, comfort stations, and buildings on the golf course – peaks during the summer as well. Figures 6 and 7 show electricity demand and expenditures at Turtle Cove throughout the year, highlighting the seasonality of its electricity consumption.

While aggregate consumption is relatively constant throughout the fall and winter, specific facilities experience individual fluctuations during this period. Although consumption at the comfort stations peaks in the summer, it is highly variable throughout the rest of the year. This is very likely due their sporadic use and the substantial impact a few uses can have on a particular month's total consumption. Electricity at the comfort stations is primarily used for lighting, which is likely to be used more heavily when the comfort stations are occupied. A few comfort stations are equipped with motion-detecting lighting and ventilation equipment, virtually ensuring summer peaks in consumption. The exterior lighting at the ice skating ponds behind Fox Woods Comfort Station (#6), on the other hand, peaks in the winter. This is expected as a result of two factors – first, ice rinks are used in the winter, and second, there are more hours of darkness in the winter. Detroit Edison, the local utility, currently has an on-going program to replace existing light fixtures with energy efficient alternatives, which should reduce overall consumption but have no effect on seasonality.

Some end-uses of electricity are nearly constant regardless of season. Consumption at the tollbooths, for example, was relatively unchanged month-to-month. The tollbooths are equipped with fans, which initially led to the assumption that demand would be higher in the summer. It is possible, however, that the majority of consumption at the tollbooths is due to the exterior lights, which are illuminated on the same schedule year-round.



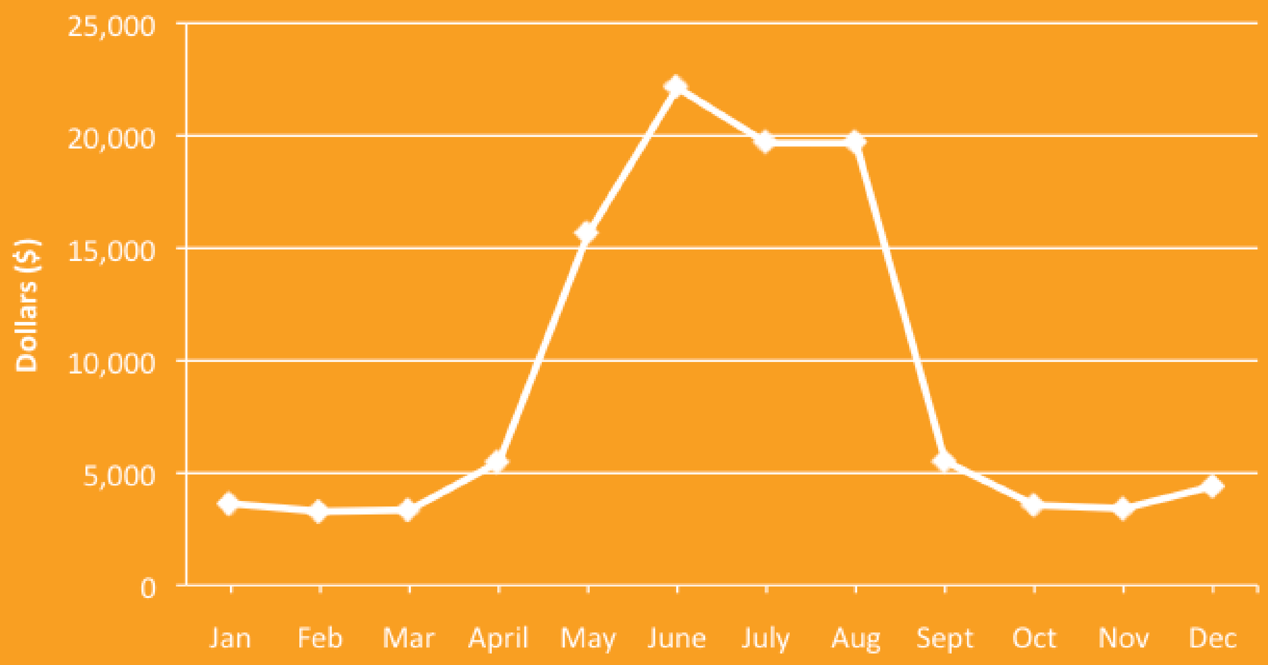
Electricity expenditures mirror consumption nearly perfectly. The rate per kWh across all meters throughout the entire year varied by less than $0.03, with the vast majority of meters billed at a constant rate of $0.11 per kWh. In addition to this negligible fluctuation, all meters were charged a flat service fee regardless of consumption. As a result, meters that recorded no consumption in a given month still incurred a small fee, slightly skewing the relationship between consumption and cost. Still, the peaks in cost reflect the peaks in consumption at each facility and throughout the year. Based on Lower Huron's annual electricity consumption and DTE's grid mix, electricity use at Lower Huron contributes 915 metric tons of CO_2-e emissions annually. Fortunately, numerous opportunities exist for substantially reducing these emissions.

Natural Gas

There are five meters for natural gas in Lower Huron. They are: Turtle Cove's main meter; separate meters at both the Turtle Cove bathhouse and food bar; in the garage; and at the administrative office. Natural gas is used for water and space heating and for cooking at Turtle Cove's food bar. Similar to electricity use, natural gas consumption at Lower Huron also fluctuated heavily throughout calendar year 2010.

Total natural gas consumption for 2010 at Lower Huron was 42,628 CCF (100 cubic feet) at a cost of $41,874. Winter and summer months were associated with high gas consumption, while spring months had the lowest consumption. The largest amount was consumed in March with 5,147 CCF, followed by June with 4,293 CCF. The total cost of gas for March was $5,351.15, while the cost for June was $4,281.73. The month with the lowest consumption was May, with only 269 CCF and a cost of $354.68. Some end-uses of natural gas were

Figure 7: Cost of Electricity at Lower Huron (2010)



fairly constant throughout the year. Figures 8 and 9 provide an overview of annual gas consumption and expenditures at Lower Huron.

The price of gas also varied monthly in terms of dollars per 100 cubic feet. It ranged from $0.94 per CCF in September to $1.25 per CCF in April. This is typical of fluctuating supply and demand in the market. Finally, a flat rate service charge of $21.00 to $25.00 is applied by the utility, even if no gas is consumed in a given month.

Goals

- Determine strategies to reduce energy usage in buildings and park operations.
- Evaluate feasibility of alternative energy systems including solar photovoltaic and small-scale wind.
- Reduce reliance on utility grid and dirty fossil fuel sources of electricity.
- Promote future policies for energy efficiency measures.

Potential Options

While many options were researched, there are still a number of options that were not investigated due to time and resource constraints. Further options such as smart meters may be chosen for exploration as decided by the HCMA.

Electricity

In this section, a number of options on how to approach sustainability with respect to electricity are presented and analyzed.

One potential strategy for addressing energy consumption that will lower utility bills and reduce the associated emissions is on-site renewable electricity generation. Two popular options are to

Figure 8: Gas Consumption at Lower Huron (2010)

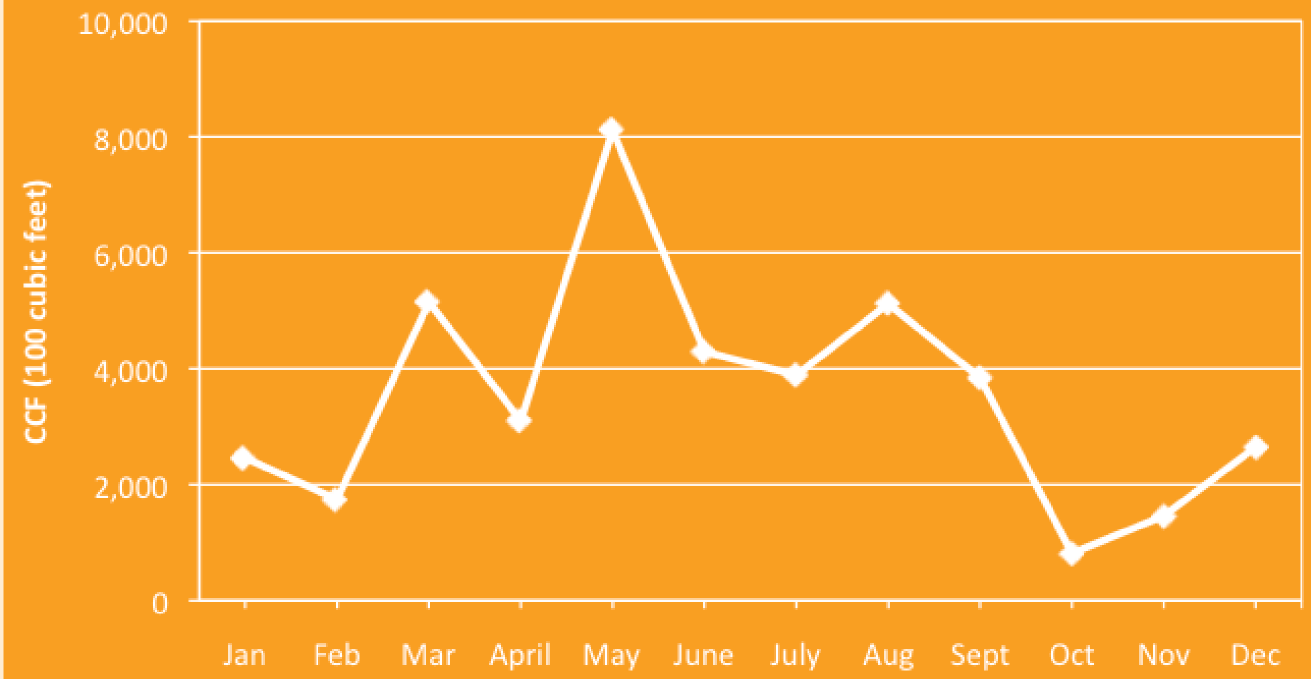
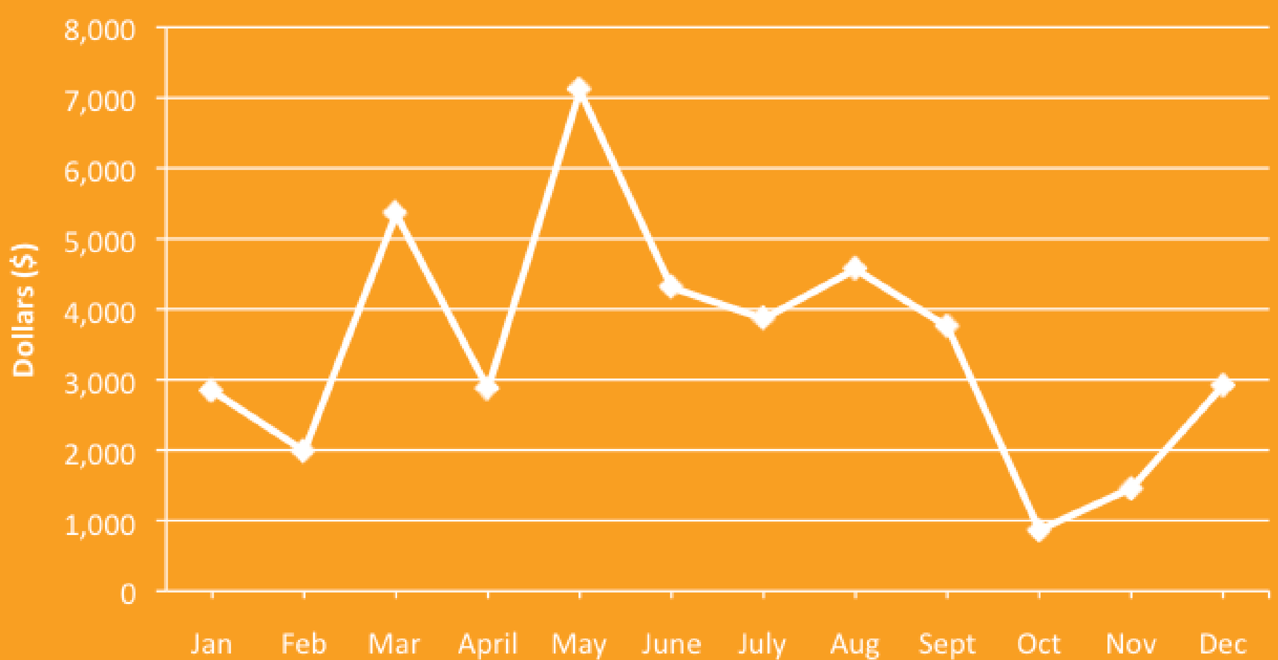


Figure 9: Cost of Gas at Lower Huron (2010)



harness wind energy and solar energy.

Wind Energy Production

In general, conditions for on-shore wind energy systems in Southeast Michigan are not ideal. Moreover, the specific conditions can change considerably over different topography and a span of only a few hundred yards. Thus, it is critical to take extensive measurements at several sites within the park to determine the true potential of wind energy. For the purpose of this study, rough calculations based on the best-available regional wind speed data provide some insight into the likely feasibility of wind energy at Lower Huron.

For a commercially available 35 kW wind turbine produced by Endurance Wind Power - a small system intended for large residential or small commercial applications [17] - and using 30-meter wind speed data by AWS Truewind [18], it would be possible to generate approximately 3500 kWh/month (42 MWh/year). At the current rate of $0.11 per kWh, this would save $384/month – about $4,600/year – and would account for up to 15 percent of electricity consumption at Lower Huron during the winter. While costs vary considerably on a project-to-project basis, total cost for purchasing and installing a 35 kW turbine is likely to be approximately $200,000, not including regular maintenance costs [19]. At the current savings of $4,600/year and assuming a discount rate of 5 percent, this project would theoretically never provide a positive return on investment. Given the high upfront cost and the relatively low amount of energy it would generate, a small wind energy system is most likely not a cost-effective option for Lower Huron. The projected energy generation would reduce CO_2-e emissions by 40 metric tons/year.

The wind speed data indicated average speeds of 4.75 meters/second at a height of 30 meters over much of Southeast Michigan. If, however, on-the-ground measurements indicate true speeds of around 6 meters/second or higher, this type of energy system may be worthy of consideration. The detailed calculations can be found in Appendix 3.

Solar Energy Production

Another option for on-site renewable energy generation is solar photovoltaic (PV). At Lower Huron, this may make particular sense as peak electricity demand is during the summer months. During the summer the solar radiation flux is at its highest, around 5 kWh/m^2/day in southeast Michigan [20]. According to the Department of Energy, the average annual solar radiation flux for southeast Michigan is 4.1 kWh/m^2/day, taking into account the considerably lower radiation in the winter [21]. Given its seasonal use, high summer electricity demand and large swaths of pavement, Turtle Cove Family Aquatic Center is an appealing candidate for solar PV. In light of recent complaints about waiting in line in uncomfortable heat to enter Turtle Cove, installing a solar PV awning over the area directly in front of the park entrance was considered. The relevant area for the solar awning is approximately 195m^2. Solar panels can be installed over this entire area or over a portion of it, depending on specific cost and energy factors. The calculations below reflect the energy and cost potential for the entire area, which can be used as a baseline when considering solar PV.

The conversion efficiency of most common solar panels ranges from 10-16 percent [22]. Considering 13 percent efficiency, a 195m^2 solar PV array would generate about 117 kWh of electricity daily at Lower Huron. The annual energy production would be 38 MWh. At the current rate of $0.11/KWh, total electricity savings would amount to $4,200/year. The cost of installing this type of solar awning is estimated to be approximately $50,000 [22]. At a discount rate of 5 percent, the payback time for the solar panels is 18.5 years if financed entirely by HCMA. Some additional savings may be achieved by federal tax rebates, but the future and scope of these rebates is currently uncertain. The greenhouse gas savings from this solar panel installation would be 35 metric tons CO_2-equivalent per year.

Case Study: Solar Canopy at Cincinnati Zoo & Botanical Garden, Ohio

The Cincinnati Zoo & Botanical Garden recently installed the largest publicly accessible urban solar canopy in the U.S.—a 1.56 MW PV system located on a canopy structure over one of the zoo's parking lots. The 6,400 panel array—equal to four football fields—cost an estimated $11 million and was supported by a mix of private investors, federal tax credits, and Ohio's alternative energy incentives. The project was developed under a leasing mechanism where the zoo pays a locked-in rate of 10 cents per kilowatt hour to the solar panels, roughly the same that it would have paid to the local utility. Over time, the zoo may save millions of dollars as electricity prices rise. The structure provides shade to 800 of the 1,000 parking spots available and provides approximately 20 percent of the zoo's annual energy needs . On many sunny days, the zoo will be completely off the electricity grid and will send power back to the utility. Additionally, in continuing to educate the zoo's patrons on sustainability, a kiosk located near the zoo's Go Green Garden allows visitors to learn about the performance of the array and benefits of solar energy in general.

Sources:
Marcacci, Silvio. "Solar Leasing Provides Power for Pennies." Cleantechnica.com. September 27, 2011. Accessed March 20, 2012. < http://cleantechnica.com/2011/09/27/solar-leasing-provides-power-for-pennies/>

"Cincinnati Zoo and Melink Celebrate the Largest Publicly Accessible Urban Solar Array in the Country." Cinncinatti Zoo & Botanical Garden. May 9, 2011. Accessed March 20, 2011.

Figure 10: Aerial photograph of solar canopy of parking lot

Figure 11: Cars are shaded by solar awnings while visitors spend time at the zoo.

In addition to tax rebates, federal and state grants may be available to help fund renewable energy projects, such as the Department of Treasury's Renewable Energy Grants and the Department of Energy's Renewable Energy Production Incentive (REPI), which pays $0.022/kWh for the first ten years of a renewable energy project. At the estimated level of electricity generation, REPI would pay just under $1,000/year for wind and $836/year for solar. These and other incentives offer opportunities to offset some of the investment required by HCMA, and help reframe the calculations about the quantity of wind or solar resource needed in order for the project to be cost-effective. Few technical limitations should impact the installation of a solar awning at Turtle Cove. There are many companies in the region that are equipped to perform the assessment, design, and installation.

Energy-Efficient Office Appliances

While office appliances make up a tiny portion of the electricity consumption at Lower Huron, aggregate potential savings of the entire park's office equipment are not negligible. The EPA estimates that configuring an existing computer for energy efficiency, such as entering sleep mode when not in use, will save approximately 600 kWh/year [23]. Replacing existing computers with Energy Star-certified computers will save an additional 200 kWh/year per computer, for total potential savings of around 800 kWh and $90 per computer per year. EPA's publicly available tool for calculating potential energy savings from office computer use can be found on the CD included in this report. According to the EPA, similar savings are available for printers and copiers, as well.

Although the savings will generally be very small on a per-unit basis, energy efficiency in general and the Energy Star label in particular should be taken into account when purchasing new appliances or replacing existing machines, as the combined impact can be quite substantial. Some organizations, such West Linn, Oregon's Department of Parks and Recreation, have fashioned purchasing policies that encourage such decisions. This type of consideration embedded within an organization-wide purchasing policy can have a significant impact on Lower Huron and the Metroparks as a whole. Additionally, embedding these practices at work may encourage people to begin considering wasteful electronics and appliances at home, broadening the impact of such a policy.

High Efficiency Indoor Lighting (CFLs, LEDs, and incandescent bulbs)

Lighting is one of the largest end uses of electricity in commercial buildings, typically requiring 20 to 30 percent of their total energy consumption [24]. Fortunately, numerous opportunities exist to either improve the energy efficiency of the lighting system or to reduce the amount of time the lights are used. One strategy is to lower the wattage of the existing system (a process known as relamping) or to replace entire fixtures. Another method is to improve lighting controls and educate users to turn off unneeded lights. Optimizing use of daylight in order to replace electric lights with natural lighting is also an effective strategy; however, this is usually incorporated at the design stage of a facility, and is more difficult to introduce as a retrofit.

Many energy efficient options exist for both interior and exterior lighting. Lower Huron utilizes external lighting in the various comfort stations, the skating rink, outside restrooms, and for exterior lighting at the office. Interior lighting is found primarily in the administrative offices, as well as the restrooms and other facilities. Retrofitting consists mainly of replacing existing fixtures or lamps with more efficient models. In the absence of a comprehensive energy audit, it is impossible to determine the exact impact each lighting alternative will have at Lower Huron. Instead, we have assessed numerous options for relative savings compared to traditional systems and outlined some scenarios in which specific options may be optimal. An overview of these options and their merits is given below. A per unit life cycle cost comparison of selected light options is included in Appendix 4. Additionally,

Case Study: Funding Structure for Solar Arrays on Municipal Facilities in Evansville, Indiana

The City of Evansville recently signed a 15-year guaranteed savings performance contract with Energy Solutions Group, LLC for energy savings and renewable energy projects at three municipal facilities. Half of the project will be funded through energy savings with the remainder being funded through city funds. The total cost of this 25.2 kW system will be $1,096,403 with $535,000 to be paid with city funds and the remainder to be funded with guaranteed energy savings. Energy savings are guaranteed to be $590,340, with operational and renewable energy savings guaranteed to be $84,750, for a total savings of $675,090 over the life of the contract.

Sources:
"City of Evansville Parks Board Awards Energy Savings Performance Contract to ESG." Energy Systems Group. September 7, 2011. Accessed March 20, 2012. <http://www.energysystemsgroup.com/news.asp?catch=&num=137>

more information about lighting principles that have been considered in this analysis is included in Appendix 5. Appendix 6 gives a more detailed overview about the characteristics and applications of each type of lighting.

In addition to the significant energy cost reductions, switching to more efficient lighting can lead to environmental and social benefits, as well. Since Michigan's primary electricity source is coal, any reductions in electricity consumption will decrease emissions associated with air and water pollution. Some studies also suggest that better lighting can increase worker productivity [25]. Due to the fact that the cost of employing employees is the most significant expense in many organizations, a slight increase in office productivity can be equivalent to the entire energy budget.

The main challenge to implementation is the initial cost of installation. LEDs currently have the highest initial cost, followed by CFLs. In addition, due to their slight mercury content, CFLs are required to be disposed of with electronic or hazardous waste. On a more practical note, some individuals tend to be resistant to change and may not initially be in favor of new lighting schemes that alter the ambience of the workplace.

According to Mike Arens, the Chief Engineer of HCMA, some comfort stations are currently equipped with motion-detecting lighting, however the precise number was not known. In addition, the HCMA has an on-going program of replacing existing light fixtures with energy efficient fixtures. Again, the location and amount was not known [26].

Compact fluorescent bulbs (CFLs) combine the energy efficiency of fluorescent lighting with the convenience and popularity of incandescent bulbs. CFLs can replace incandescents that are roughly three to four times their wattage while emitting the same amount of light as a traditional bulb. Thus, replacing a standard incandescent bulb with a CFL will achieve energy savings of up to 75 percent [27].

In addition, CFLs produce 90 percent less heat, while producing more light per watt. Therefore, the HVAC system will not need to operate as much to compensate for the reduction of waste heat. For example, a standard 18-watt CFL is considered an equivalent light source to a 75-watt incandescent at a fraction of the energy demand and without emitting excess heat. While CFLs cost three to ten times more than incandescent bulbs, they last about ten times longer (approximately 10,000 hours). CFLs are most cost-effective in areas where lights are on for long periods of time, and therefore may be a viable option for the office buildings at Lower Huron. CFL costs can range from as little as $1.50 to $4.00 a unit for screw-in bulbs, and around $4.50 for a two-pin base bulb. According to our analysis, which is found in Appendix 4, the replacement of a 75W incandescent bulb with a comparable 18W CFL will result in annual cost savings of $14.32, annual energy savings of 119kWh, and a payback time of only 0.14 years on a per unit basis. Similarly, the replacement of a 100W incandescent bulb with a comparable 27W CFL will result in annual cost savings of $16.04, annual energy savings of 152kWh, and a payback time of about 6 months. Thus, the slightly higher initial cost should not be a major limitation.

CFLs are available in a variety of shapes and sizes, each of which is dependent on the fixture. CFLs can either be screw-base with the ballast attached to the tube, or pin-base with the ballast separate from the tube. Screw-base CFLs are typically found in residential applications and smaller fixtures, whereas pin-base CFLs are more common in commercial buildings [28]. Pin-base CFLs allow for the changing of the bulb without changing the electronic ballast. The tubes typically will last about 10,000 hours and the ballast will last about 50,000 hours [27]. These types of fixtures are more expensive to install due to the initial price of the ballast. Lower Huron will likely utilize a combination of the two due to its wide range of buildings from administrative to service areas.

Case Study: Lighting and Productivity, San Diego Federal Building and Courthouse, California

The San Diego Federal Building and Courthouse undertook a $1.3 million upgrade that involved the conversion of T12 fluorescent lamps and magnetic ballasts to T8 fluorescent lamps powered by electronic ballasts. In addition to achieving annual energy cost savings of over $275,000, employee productivity improved by 3 percent in office areas and by 15 percent in the courthouse, correctional, and post office spaces, a benefit which was estimated to be $1.3 million per year.

Sources:
"City of Evansville Parks Board Awards Energy Savings Performance Contract to ESG." Energy Systems Group. September 7, 2011. Accessed March 20, 2012. <http://www.energysystemsgroup.com/news.asp?catch=&num=137>

"Lighting Upgrades Boost Workplace Productivity." Philips Lighting Electronics. 2008. Accessed March 20, 2012. <http://www.advance.philips.com/documents/uploads/general/SS-2008-AJ-R01_Lighting_Upgrade_Workplace_WP.pdf>

Light-emitting Diodes (LEDs)
The light-emitting diode (LED) is a fairly new, highly energy efficient technology. LEDs use 75 percent less electricity and last 25,000 hours. This is 25 times longer than incandescent bulbs, a similar energy savings as CFLs with over twice their lifespan [29]. LEDs are currently significantly more expensive than CFLs and incandescents, however, and are not appropriate for all applications. These bulbs may cost $30.00 or more depending on the model. LEDs are directional (like a flashlight), which makes them ideal for task lighting but generally suboptimal for space lighting, where floodlights are generally used. They are most applicable in residential settings and outdoor settings such as streetlights, but do have relevant commercial applications. In offices, LEDs are most suitable as desk lamps due to their small size and directionality [29]. Thus, the optimal use of LED lights in Lower Huron would be for hallways lighting and desk lamps. However, due to the relatively small amount of hallway lights and lack of necessity for many desk lamps, LEDs would likely not be cost-effective options.

The common 1.5-inch diameter T12 cool-white fluorescent lamp and magnetic ballast were the dominant commercial light source for many years. The newer, high-efficiency 1-inch diameter T8 lamp powered by an electronic ballast is quickly emerging as the new standard for lower power consumption, lower life-cycle cost, and illumination that more closely resembles natural light [30]. T8 lamps are rated at 32 watts and produce similar levels of light as the 40-watt T12 bulb, and are typically available in 4-foot and 8-foot tubes. T8 lamps also have a higher color-rendering index (CRI) than T12s, emitting a more natural looking light than the traditional lighting typically associated with fluorescent bulbs [31]. When compared to T12 bulbs, T8 bulbs lead to energy savings of up to 40 percent, provide more desirable light, generate less heat and noise, and are lightweight for easy storage and installation. T5 fluorescent bulbs are even more energy efficient that T8 bulbs, but come at a higher cost premium. The implementation of this model will likely not be cost-effective for Lower Huron.

According to our analysis, found in Appendix 4, replacing a T12 bulb with a T8 will result in net annual savings of $2.02, annual energy savings of 17kWh, and a payback period of approximately 19 months on a per unit basis. A similar analysis of the replacement of a T12 bulb with a T5 bulb found lower cost and energy savings and a longer payback period, primarily due to the high cost of T5 units. However, since bulb prices played a large role in this analysis, other models may result in different results (i.e. reduced cost due to bulk purchasing).

Electronic versus Magnetic Ballasts
Ballasts are the parts of the light fixture that secure and power the fluorescent bulbs and provide circuit protection. New electronic high-frequency ballasts are more efficient than the traditional magnetic ballasts in providing power to the bulbs. They increase lamp-ballast efficacy, which results in increased energy efficiency and lower operating costs. These are more efficient than magnetic ballasts in converting input power to the proper lamp power. Thus, operating fluorescent lamps at higher frequencies reduces end losses, resulting in an overall lamp-ballast system efficacy increase of 15 to 20 percent [32]. Electronic ballasts provide more light for each watt, run cooler and last longer. In addition, these ballasts nearly eliminate both the flicker and humming noise that is associated with common fluorescent lights, and are less than half the weight of magnetic ballasts. A retrofit of electronic ballasts could eliminate nearly six pounds from a standard four-lamp fixture [30].

Improved Lighting Controls
Advanced lighting controls that can aid in energy efficiency include photocells, timers, occupancy sensors, and dimmers. Lighting controls can reduce the energy used for lighting in an existing commercial building by 50 percent, while reducing peak demand charges [33]. A recent survey of commercial office buildings found that the average lighting energy savings was 30 percent for occupancy

sensors, 28 percent for day lighting controls, and 23 percent for scheduling controls [34]. One option in particular is a system of intelligent relay panels, a low-voltage control system that turns off lights at a preset time, resulting in 5 to 15 percent energy savings [33]. In these systems, a clock sends a low-voltage signal to relays, which break power to the load. These relays can connect to other controls such as a photosensor or building automation system (BAS). Intelligent panels provide the foundation for energy saving lighting control systems. Among these supplemental components include manual flip switches, occupancy sensors, and photosensors. Ideal applications of intelligent panels are large areas with many people working on a defined schedule. Based on this, these controls seem directly applicable to the park offices at Lower Huron.

Mechanical or electronic time clocks are available for both indoor and outdoor lighting. These controls automatically turn on and shut off lights for security and safety needs, and for tasks such as janitorial work. Photocells activate switches or dim lights depending on natural light levels. For example, photocells can switch outdoor park lights on at dusk and off at dawn. In addition, occupancy sensors activate lights when someone enters the space, and shut off lights after detecting no presence for a set amount of time [24]. Occupancy sensors are ideal in private offices, copy rooms, storage areas, and restrooms, where localized control of lighting is desired. Special features such as dual-technology and self-calibration for maximum reliability, manual-on for maximum savings, integral dimmers, and integral photosensors that keep lights off when there is sufficient daylight should be considered when selecting occupancy sensors. To maximize cost savings, occupancy sensors can also be installed for task lighting. One popular model is the Lutron Maestro Switch with either an occupancy sensor or vacancy sensor (120 Volt, 5 Amp), which currently costs $52.00 [35].

Various limitations and challenges exist for the implementation of this type of program. Depending on the type of lighting control chosen, rewiring of the electrical circuits may be needed. Therefore, installation costs may be a factor in the overall cost of the initiative. In addition, some potential problems associated with these controls include lights being switched on or off prematurely.

DTE GreenCurrents Program

The GreenCurrents program is a renewable energy program operated by Detroit Edision (DTE) that allows customers to support the generation of electricity from Michigan-based, renewable energy sources [36]. The program has two options, a 100 percent match option and a kilowatt-back block enrollment option. The 100 percent match option allows the customer to match 100 percent of the monthly electric consumption for two cents per kilowatt-hour. This monthly cost is based on the amount of kilowatt-hours used each month, which is in addition to the normal monthly electric charges. For 2010, the total electricity consumption for Lower Huron was 962,869 kWh for a cost of $109,755. For this option, the additional two-cent charge would make the new cost $0.13 per kWh. Therefore, the new cost with the first option would be $125,173, a $15,418 premium.

The second option, the kilowatt-hour block enrollment, allows for more flexible participation. Renewable energy can be purchased in single block increments, which represent 1,000 kilowatt-hours of renewable energy per block. Each block costs $20.00 per month, and there is no limit on the amount of blocks purchased. This monthly cost is in addition to the normal monthly electric charges. For example, a 25 percent offset would equate to 240 blocks and a premium of $4,800. A 100 percent offset under this option would cost around $19,240.

While this program doesn't offer any direct cost benefits for Lower Huron, it does provide environmental benefits including reductions in air pollution and protection of natural resources, and stimulates the local Michigan economy. This program will help to encourage growth of renewable energy sources such as wind farms and biomass plants, which provide jobs to the local economy. Thus, while this program costs a premium, it can help Lower Huron and the HCMA shape their image as a strong performer in sustainability. A possible limitation is the difficulty of educating the employees, visitors, and community about the value of this program, as this is not an observable benefit in Lower Huron.

HVAC

At Lower Huron one of the most common uses of natural gas is for air and space heating. Opportunities to reduce the energy demands for heating and cooling can significantly reduce natural gas consumption. Several options exist for replacing natural gas use with other energy sources or utilizing natural gas-based systems more efficiently. The associated energy, cost, and emissions savings are often substantial.

Geothermal

Unlike conventional furnace heating systems, which generate heat by burning fossil fuels, geothermal heating systems depend on energy inside the earth for heating and cooling. Geothermal systems extract heat from the ground in winter and use the ground as a heat sink in summers. They generally work well throughout the United States, as the temperature inside the earth remains constant [37] [38]. There are three main components of a geothermal system: 1) heat exchange coils/pipes buried in the earth or under water; 2) geothermal heat pump(s); and 3) heat distribution ducts or pipes inside the building.

There are two types of loop systems for the geothermal coils: a pipe system with closed ends and an open-end pipe system. In a closed loop system the water is circulated continuously through the ground while in an open loop system water is extracted from the ground source and returned back after the heat exchange.

The average monthly gas consumption at Turtle Cove during the winter was 747 CCF (76 MBTU). This gas consumption is equivalent to an average heat load of 0.10 MBTU/hr and an annual gas consumption of 305 MBTU (this gas consumption is for peak winter duration i.e. from November to February). Although the peak heat load of the building can be much higher than the average heat load depending on the ambient temperature variation, it is almost impossible to correctly estimate the peak heat load from the available data (manufacturers usually design geothermal heat pumps on peak heat load of the building). Thus, all calculations have been performed based on average heat load. Consulting geothermal system professionals will provide a complete audit to determine the specific potential at Lower Huron.

CO_2 emissions reductions from a geothermal system depend on a number of variables, including the emissions intensity of the electricity grid, the building's heating and cooling loads, coefficient of performance (COP) of the geothermal heat pump, and fuel used in existing heating system (i.e. oil, natural gas or electricity) [38] [39]. Heating and cooling load of building is the energy consumed by building usually measured in BTU/hr and COP is a measure of how efficient heat pump. Geothermal systems use electricity for water circulation between ground and building, tying this portion of the system directly to the carbon intensity of the grid.

At Turtle Cove, if a conventional natural gas furnace with an efficiency of 78 percent is replaced with a geothermal system with a COP of five, CO_2 emissions will be reduced by about four tons per year. This estimate is only for heating during winter, but additional reductions can be achieved if such a system is used to meet both cooling and heating needs. During the summer, energy and emissions savings are achieved by the geothermal system substituting for the electricity that is traditionally used to run air conditioning systems. In addition, as the annual heat load increases, so do the energy savings from geothermal systems.

It is important to note that these carbon reductions are achieved for a specific set of parameters. As they change, it becomes necessary to reevaluate emissions savings. For instance, if a geothermal system with a COP of four is installed only for heating purpose, the actual carbon emission will increase by one metric ton annually. Appendix 7 provides a detailed account of all related calculations. In the office at Lower Huron, the average gas consumption is 369 CCF/month, which corresponds to an average heat load of 0.052 MBTU/hr and an annual gas consumption of 158 GJ/year. The CO_2 savings by replacing a 78 percent efficient natural gas furnace with geothermal systems with a COP of five would be 2 MTons per year.

The payback time of a geothermal system depends on a number of variables, including the cost of natural gas, the heating and cooling requirement of the building, the cost of electricity, and the type of geothermal system installed. A typical geothermal system can reduce heating and cooling costs by up to 60 percent [38]. According to Michigan Energy Services, the average utility bill for a 2000 ft^2 home in Ypsilanti, MI was reduced from $390 per month to $80 per month after a geothermal system was installed [40]. Commercial scale projects tend to have higher savings, but a higher upfront cost.

Geothermal systems incur high upfront cost, but can reduce utility bills significantly. One study by [41] examining a geothermal system in Washington, D.C. schools suggested a payback period of 13 to 16 years. Durkin and Cecil, 2007 calculated that "it costs approximately $500,000 to install a geothermal system in a 100,000 ft^2 school to save $32,000 to $38,000 per year" (p. 47). Problems associated with the geothermal system installation are its high upfront cost and lot of construction activities in retrofitting the existing HVAC system. A geothermal systems expert should carry out the site analysis for exact estimate of upfront cost, energy savings and system retrofit.

Radiant Heating System

Radiant heating systems work by circulating hot fluid, usually water, in the ceiling, floor or walls. Usually, radiant heating systems are embedded in floors, otherwise known as heated floors. In modern radiant heating systems, only the areas nearby human activity are heated, so it makes the space more comfortable at lower temperatures than conventional systems because the surfaces close to human activity are at higher temperature. They are more efficient than conventional forced air systems because no heat is lost through ducts [42]. Several studies by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) conclude that in some cases these systems can reduce heating cost by 25-35 percent [43].

There are three different types of radiant heating systems that depend on different heating media: air radiant systems, electric radiant systems, and hydronic radiant systems [42]. The most cost effective and energy efficient systems are hydronic radiant systems, which have the capacity to handle huge heating loads in cold conditions. Hydronic radiant systems typically heat water in a boiler and circulate it. The boiler can be fired by either natural gas or oil, based on the local availability of fuel. The cost of such a system is around $3 per ft^2, and varies depending on the size of the space [44] [45]. Hydronic radiant heating system is the most efficient of radiant systems and could be a cost effective solution for Lower Huron but for a real estimate, a complete assessment of the system by the vendor is highly recommended due to complexities of the system. The disadvantage of the radiant heating system is its retrofitting in an existing building as the installation of heating ducts under the floor and walls, and reflooring can be very expensive.

Energy Efficient Windows

Windows are a significant source of heat loss in cold climates and unwanted heat gain in warm climates. The primary challenge is limiting heat loss while also preserving functionality, such as providing natural light and outdoor views. Thermal transmittance (U-factor) and solar heat gain are the most important energy considerations [24]. Thermal transmittance or U-factor includes heat flow by conduction, convection, and radiation through the window. One solar heat gain measure is the solar heat gain coefficient (SHGC). This the ratio of solar heat passing through the glass to solar heat falling on the glass at a 90 degree angle. These and other related terms are defined in detail in Appendix 8. In addition, air leakage, frame material, optical characteristics, and type of glass are also important factors to consider.

Many window conservation measures can be expensive. Retrofitting an existing building by replacing windows can cost from $5 to $50 per square foot of window area [24]. Window replacements need to be designed to significantly reduce thermal transmittance, solar transmittance, or both. Air leakage reduction associated with the replacement typically results in small energy savings.

Energy efficient windows use three main strategies to improve the thermal resistance (R-value) of glass: multiple panes, gas filings, and special coatings [24]. Multiple panes provide better insulation for the building. In addition, gas fills between the panes and special coatings on the glass each prevent excess radiation from entering. Combining at least two of these will lead to more efficient windows. There are many types of window glazing layers. For example low-e coatings are specifically designed for either heating-dominated or cooling-dominated climates, and tend to have a short return on investment. Those in cold weather are designed to minimize the U-factor, while those in warm weather minimize SHGC.

In addition, various window treatments are available to improve the winter and summer thermal performance of windows. Cold weather treatments such as storm windows and window insulation reduce the U-factor [24]. Warm weather treatments such as sunscreens, window films, and interior shades and blinds reduce solar heat gain. For Lower Huron, the most cost-effective options are likely to be a variety of these window treatments for colder climates such as window insulation.

In terms of selecting the appropriate windows, climate will be the most important factor. Since Michigan is generally a heating-dominated climate, U-factor will be the most important criterion. A U-factor under 0.40 is most effective to minimize heat transmission and window condensation [24]. According to the Efficient Windows Collaborative, the recommended U-factor for a building in the Northern Zone should be lower than 0.32. The SHGC should be between 0.30 and 0.60 if air conditioning is not an importance, and under 0.40 if cooling is important [46].

Window replacement typically has a longer payback period than other investments in reducing energy consumption for climate control [24]. However, after building insulation and improved efficiency of the HVAC system, windows may be the logical next step to make the building more energy efficient. To determine Lower Huron's range of options for HVAC efficiency, an energy specialist should be consulted for a comprehensive audit.

Retrofitting to Meet LEED Standards

Leadership in Energy and Environmental Design (LEED) is an internationally-recognized green building certification system that was developed by the U.S. Green Building Council (USGBC) in 2000. LEED provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions [47].

To date, there are a number of rating systems for design and construction including Homes, Neighborhood Development, Commercial Interiors, Core & Shell, New Construction, and School, Healthcare, and Retail. In addition, LEED for Existing Buildings: Operations & Maintenance (EB: O&M) exists for the operations phase. The LEED rating system provides a whole-building approach to sustainability by measuring performance in five key areas: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, and Indoor Environmental Quality [48].

LEED certification provides independent, third-party verification to ensure that the building was designed and built using strategies aimed at achieving high performance in these five areas. Certification occurs through the Green Building Certification Institute (GBCI), an independent non-profit that was created in 2008 with the support of the USGBC. LEED certified buildings are designed to lower operating costs and increase asset value, reduce waste sent to landfills, conserve energy and water, be healthier for occupants, reduce greenhouse gas emissions, and qualify for incentives such as tax rebates [49].

The LEED process, unlike the conventional linear non-iterative development process, is very holistic and emphasizes that all stakeholders work together from the initial pre-design stage. This includes building owners, architects, engineers, contractors, consultants, project managers, and users. While LEED certification is usually expensive, it is possible to meet various LEED standards without obtaining certification.

For Lower Huron, as well as other parks in the system, the LEED 2009 EB: O&M rating system is most appropriate as a reference for implementing sustainable operational policies and procedures in the various existing buildings. Many of the potential initiatives discussed in this report are found in various LEED credits in the reference guide. For example, water usage reductions of indoor fixtures, efficient lighting and lighting controls, stormwater management strategies, onsite and offsite renewable energy, and solid waste management policies and audits are all specific credits.

Case Study: Energy Savings at the City of West Linn Parks and Recreation, Oregon

While in Oregon, the group also met with Ken Worcester from the West Linn Parks and Recreation office. West Linn is located about 20 miles south of Portland, and has over 600 acres of park land [50]. West Linn's parks contain spaces for both active and passive recreation. Similar to the Huron-Clinton Metroparks, West Linn parks are located between two rivers, the Willamette and Tualatin [51]. West Linn Parks and Recreation have pursued a variety of sustainability initiatives that are relevant for sustainability at Lower Huron. Many of these commitments to sustainability are reflected in their policy that all new construction be built to LEED silver certification standards at a minimum, while several of their facilities meet even more rigorous standards.

West Linn Parks and Recreation has installed solar panels on many of their picnic shelters. The electricity they generate is used for the restroom as well as the water pump for the spray pad at their aquatics center [51].

West Linn Parks and Recreation has developed a purchasing policy that allows staff to spend up to a 15 percent premium for energy efficiency appliances and other sustainable products, directly addressing the issue that environmentally friendly products are typically more expensive than their traditional alternatives.

Water

In many parts of the country and the world, freshwater resources are becoming increasingly scarce. While over 70 percent of the water consumed in the U.S. is used for agriculture, a significant percentage is also used for industrial processes and by municipal water agencies [13]. Buildings account for 12 percent of freshwater consumption [52]. In many areas, fresh water is being extracted faster than it can be replenished. In addition to increasing demand for freshwater, the quality of water can be significantly impacted by contaminants and pollutants entering the water streams. Thus, strong water quality regulations and prevention of harmful runoff pollutants is also an important issue. Many steps in other areas such as energy efficiency will help to combat this growing issue.

Although concerns about water scarcity are not as pressing in Michigan as energy issues, it is nevertheless an important topic to address. The Great Lakes Basin ranks fourth among the 21 major watersheds in the country in public water withdrawals. Michigan has the eighth largest public water supply withdrawals in the United States [53]. Around 77 percent of the state's water withdrawn for public water supply systems comes from the Great Lakes and connecting waters and 21 percent comes from groundwater sources [53]. Thus, Michigan has abundant water resources but should nevertheless be effective in employing sustainable water measures. Many water conservation and efficiency measures can be taken to reduce the demand for water.

Baseline

Water bills from 2010 were used to determine the baseline water consumption at Lower Huron Metropark. Due to a metering malfunction that resulted in an excess reading, and some missing data, the baseline may not be entirely accurate. The water used by Lower Huron is supplied by three local municipalities: the City of Romulus, Van Buren Township, and Charter Township of Huron. There are three primary meters for the Lower Huron Metropark, the main meter at Turtle Cove, the Hannan Road Pit meter, and the group campsite meter. The main water meter is located in the center of the park close to the Turtle Cove Aquatic Center. This meter controls the water intake for the main office buildings, golf course, service buildings, and all comfort stations (with the exception of East Bend Comfort Station). The Hannan Road Pit meter brings water to the East Bend Comfort Station and nearby restroom facilities. The group campsite meter distributes water to the group campsite. The restroom facilities located at the campsite do not have running water and utilize a basic composting system.

Water usage at the Lower Huron Metropark fluctuates significantly throughout the year, with the peak usage period occurring in the summer months from June to the beginning of September. The Turtle Cove Aquatic Center is one of the largest consumers of water, primarily during the summer. In August, the meter measured about 373,700 cubic feet of water at a cost of nearly $14,000, over 99 percent of Lower Huron's total water consumption for the month. The group campsite is the least costly and least consistent throughout the year. A flat service fee is applied regardless of whether water is used or not. In 2010, the group campsite used no more than three cubic feet during any given month at a price no higher than $30.26 per month. The Hannan Road Pit site is also not very costly, and is billed in three-month cycles. From July to October, 4,278 cubic feet of water were used at a cost of $165.72.

Goals

- Decrease the need for potable water from the various water utility providers.
- Determine strategies to reduce water usage in park buildings and operations.
- Reduce need for wastewater treatment due to decrease in water usage.

Potential Options

While this report includes many options, there are still a number of options that were not investigated due to time and resource constraints. Many may still be worthy of investigation as determined by HCMA.

Irrigation

Next to use to run Turtle Cove, irrigation is responsible for the largest amount of consumption at Lower Huron. A centrally controlled irrigation system can help regulate and ultimately reduce overall water use.

Maxicom Central Irrigation Water System, by Rain Bird Corporation, is once such system [54]. The Maxicom system saves water primarily by taking into account weather conditions and avoiding unnecessary irrigation. The software takes the rain and temperature information from different weather channels and controls the irrigation water based on these data. The software also takes into account the water loss by plants through evapotranspiration. During warmer conditions this water loss increases, so the Maxicom system increases the output of irrigation water. This system will result in lowering operating costs and a reduction in water bills. An additional benefit of this centrally controlled irrigation system is that multiple geographically dispersed sites can be controlled from one central desktop, increasing the ease of operation and reduces the need for labor. Finally, this system can greatly reduce fertilizer use.

The Portland Department of Parks and Recreation currently utilizes an irrigation control system. By installing a new centrally controlled Maxicom irrigation system and conducting audits to optimize water use, Portland Parks and Recreation has reduced their water use by 25 percent [55]. In some cases, the water savings from this system are as high as 45 percent [54]. The Maxicom irrigation system has been installed by many other park systems besides Portland Parks and Recreation, such as the Washington D.C. Department of Parks and Recreation, Tierra Verde Resources, Inc. in San Diego, and others. If proven effective at Lower Huron, this type of system can be incorporated across the entire HCMP system while still being controlled from one central location.

It is important to note that according to Mike Arens, the Chief Engineer of HCMA, the Lower Huron golf course is being reviewed for potential closure [26]. The course's closure would eliminate the use of city water for irrigation. This would significantly decrease Lower Huron's need for irrigation and could change the analysis for a central irrigation system.

Pool Covers

The single largest source of energy and water consumption at Lower Huron is Turtle Cove Aquatic Center. Turtle Cove in particular represents the inextricable nature of numerous sustainability issues and emphasizes the importance of taking a holistic perspective when assessing alternatives. While pools are inherently large consumers of both water and energy, there are steps that can be taken to reduce the intensity of their demand for both. Pool covers, for example, offer a relatively simply way to contain heat at night and stem water waste through evaporation. For an average outdoor pool of 200 square feet in the same climate and with similar use patterns to Turtle Cove's, for example, a pool cover used for eleven hours each night would save about $500 per year on energy costs by reducing natural gas consumption by over 55,000 cubic feet. This would offset 3 metric tons of CO_2 annually. Additionally, a cover would prevent losses of approximately 700 gallons per week. Of course, these calculations are based on generic data for a commonly sized pool in similar conditions to those at Lower Huron. The calculations were performed using an online tool via the Washington State University Extension Energy Program [56]. This tool can perform fairly detailed calculations for expected energy, water, and cost savings through a number of factors in addition to pool covers, such as heater type and use, hours of operation, and others.

Plumbing Fixtures

Water usage in restrooms and kitchen facilities at Lower Huron can be reduced significantly through retrofits in faucets, urinals, and toilets. Each of these can have different savings but will definitely reduce water usage significantly. The EPA sponsors a program called WaterSense, which helps select water efficient fixtures for usage in either residential or commercial buildings. WaterSense products are independently tested and certified to use at least 20 percent less water than standard models, while performing as well or better [57]. The most cost-effective measures are the installation of faucet aerators where needed followed by the replacement of older urinals and toilets with low-flow models. While the exact number of fixtures was not known for the analysis of these options, the main benefits are still relevant. Further analysis will need to be conducted for exact costs and savings of each desired option.

Low-Flow Urinals

Current federal building standards allow a maximum of 1.0 gallons per flush (gpf) for commercial urinals. However, many older urinals use many times that amount. Replacing inefficient fixtures with WaterSense labeled fixtures can save from 1 to 4.5 gallons per flush [57]. WaterSense labeled products use no more than 0.5 gpf. Replacing a single 1.5 gpf urinal with a WaterSense labeled model can save a facility approximately 4,600 gallons of water per year. Assuming an average water rate of $3.00 per 1000 gallons and average sewage rate of $3.00 per 1000 gallons, this would amount to $27.60 in annual savings per unit at Lower Huron.

It is important to note that these numbers are averages and may need to be adjusted accordingly. In terms of cost, a 0.5 gpf Sloan flushometer urinal costs around $500 per unit. A 0.25 gpf Sloan flushometer urinal costs from $570.00 to $940.00 per unit depending on the model [58]. Flushometer models use pressure from the water supply system rather than gravity to discharge water into the bowl, using less water than conventional models.

If current toilets installed at Lower Huron are all 1.0 gpf, then it is not necessarily recommended to replace these fixtures with 0.5 gpf or waterless models. This action would not be cost-effective, as 1.0 gpf urinals still save a significant amount of water. However, older models above 1.0 gpf should be retrofitted to 1.0 gpf or lower models to realize significant water and cost savings over time. The exact cost-savings will depend on the amount of urinals that require replacement and the exact model chosen.

Waterless Urinals

Waterless urinals do not flush and therefore require no water to operate. While they are connected to a standard drain like conventional urinals, they do not use the conventional water-filled trap. Instead, waterless urinals utilize

Case Study: Efficient Irrigation System at the University of Michigan, Ann Arbor

In 2006, Maxicom irrigation system was adopted by the University of Michigan to manage its irrigation water; the switch resulted in a 68 percent reduction in water consumption for irrigation. The system has generated an estimated savings of twenty-two million gallons of water each year and a monetary savings of $141,000 for the University. The total cost of the project was $350,000, so the system will pay for itself in less than three years.

Case Study: Portland Building, City of Portland, Oregon

In 2003, conventional urinals on the 12th floor men's restroom of the Portland Building were replaced with waterless urinals. Each waterless urinal saved about 40 to 50 gallons of water per day, totaling 80 to 100 gallons per day in this restroom. Total costs for these urinals were found to be lower than conventional urinals. Other than an initial maintenance routine shift, the facility staff found these urinals to be performing well and to be easier to clean.

Sources:

"Improved Irrigation System Provides Water and Cost Savings." University of Michigan. July 27, 2011. Accessed March 21, 2012. <http://ns.umich.edu/new/releases/8373-Improved%20irrigation%20system%20provides%20water%20and%20cost%20savings>

"Waterless Urinals: A Cleaner, Greener Option." City of Portland Procurement Services. September 2011. Accessed March 21, 2012. <http://www.portlandonline.com/omf/index cfm?a=368276&c=44701>

a vapor trap consisting of sealant liquids [59]. Installation is similar to conventional urinals, but no water hookup is necessary.

There are many benefits of installing waterless urinals. The most obvious is the fact that these fixtures do not use any water during use, resulting in significant water savings. An average waterless urinal will save around 40,000 gallons per year [52]. Assuming an average water rate of $3.00 per 1000 gallons and average sewage rate of $3.00 per 1000 gallons, this would amount to $240.00 in annual savings per unit at Lower Huron. It is important to note that these numbers are averages and may need to be adjusted accordingly. Other benefits include low maintenance, improved hygiene, odor control and environmental benefits from water reduction and the elimination of wastewater treatment [59]. Additionally, energy usage is reduced due to the lack of need to treat and pump water for usage. The most apparent disadvantages are associated with retrofitting. The removal of flush valves and capping of water supply lines will be necessary [59]. In addition, while maintenance is reduced, facility staff may need to be trained how to perform proper maintenance on these urinals with attention to the cartridges. The cartridge must be replaced anywhere from one to six times a year depending on the usage. Based on usage at Lower Huron, this will likely fall on the lower side, as compared to a large commercial building.

Waterless urinals are less expensive to purchase, install, and maintain than conventional urinals since they have no flush valves, sensors, or mechanical parts. They reduce sewer costs, eliminate all water costs associated with flushing, and lower energy costs associated with transporting water to and from urinals [60]. For retrofits, alterations to the piping may increase installation costs. Replacement cartridges cost an average of $40 and the replenishment of the sealant liquid costs $1.50 to $2.00 per application [59]. Typically, the payback time ranges from one to four years. While the costs of replacement cartridges can outweigh the maintenance labor savings, the reduction in water costs should still cause the overall annual costs to be less. Exact costs will depend on the number of fixtures and the intensity of use. For these reasons waterless urinals may be an appropriate option for replacing older urinals inside the facilities at Lower Huron. However, as reported by Portland Parks and Recreation, waterless urinals are not recommended for outdoor restrooms due to upkeep issues.

Toilets

WaterSense toilets can save over 4,000 gallons of water per year compared to older, inefficient models [61]. Assuming an average water rate of $3.00 per 1000 gallons and average sewage rate of $3.00 per 1000 gallons, this would amount to $24.00 in annual savings per unit at Lower Huron. It is important to note that these numbers are averages and may need to be adjusted accordingly. One specific model 1.26 gpf Sloan flushometer toilet costs $360.00, while one specific model1.6 gpf Sloan flushometer toilet costs $340.00 [58]. If current toilets installed at Lower Huron are all 1.6 gpf, then it is not recommended to replace these fixtures with 1.26 gpf models. This action would not be cost-effective, as 1.6 gpf toilets still save a significant amount of water. However, older models above 1.6 gpf should be retrofitted to 1.26 gpf models to realize significant water and cost savings over time. The exact cost-savings will depend on the number of toilets replaced and the exact model chosen.

Automatic Faucets

Current plumbing codes have reduced the maximum commercial faucet flow to 0.5 gallons per minute (gpm) for non-residential applications [62]. Automated controls for faucets can significantly lower water consumption and potentially minimize bacteria transmission through contact with faucet handles [52]. Electronic controls can either be installed with new plumbing fixtures or retrofitted onto many types of existing fixtures. While savings depend on the size and type of facility, some facilities have reported up to 70 percent water savings. In addition, savings can also be achieved in water heating and sewage treatment [52]. Battery-powered sensor faucets range from $400.00 to $1000.00 per unit as shown on Sloan's price sheet [63].

In some cases, automatic faucet retrofits may not necessarily be the most cost-effective or environmentally friendly option. The main issues that have arisen include the incorrect timer setting of the automatic sensors. A 2009 study by Veritec Consulting and Koeller and Company found that the replacement of manually operated commercial lavatory faucets with sensor-activated faucets resulted in a 30 percent increase in water consumption. In addition, the replacement of manual toilet flush valves with sensor-activated units resulted in a 54 percent increase in water usage. For urinals, water use dropped by a small amount [64]. Although these results are not conclusive, they do present an important consideration. Thus, it is vital for automatic faucets be set to a correct timer setting for ideal usage.

Faucet Aerators

Faucet aerators limit the stream of water by spreading it into many small droplets. They determine the maximum flow of the faucet. New restroom faucets restrict flow rates from 0.5 to 1.5 gallons per minute (gpm), reducing water usage by 30 percent, while new kitchen faucets restrict flow rates to 2.2 gpm [65]. Aerators are very inexpensive to replace, typically around $4 per unit, making them one of the most cost-effective measures for water conservation. To maximize water efficiency in the restroom faucets, aerators with flow rates of no more than 1.0 gpm should be installed.

Turtle Cove Operations

Efficient water recycling strategies can be utilized at Turtle Cove to decrease its usage of potable metered water. These strategies will be more costly, but may very well have appealing payback periods. Due to the majority of water usage being attributed to Turtle Cove, conservation strategies may be worth researching further. However, due to various constraints, this was not a focus of this project.

Various facilities across the country have implemented water saving measures. The electricity generated from the solar array at West Linn Parks and Recreation is used to operate the water pump for the spray pad at their aquatics center [51]. Some other best practices of water parks in the U.S. employing conservation measures include SeaWorld San Antonio using excess ice chips for its cooling system to help it run more efficiently and gathering air conditioning condensate for use to water potted plants [66]. Schlitterbahn, also in Texas, chlorinates water and uses a UV system to clean the water, which runs through a closed system at the park. Water World in Denver, Colorado uses drought tolerant plants and artificial turf, bans midday watering, and irrigates with recycled water [67]. Splash water is returned to the attractions. These measures have saved the park an estimated 15 million gallons of water a year.

Waste

Waste management is a critical component of sustainability in any facility. Each American generates an average of 4.3 pounds of solid waste per day [68]. Parks are not isolated from this pattern of waste generation, so finding ways to manage waste is an important step towards environmentally sound park management. The EPA proposes the RRR framework [69], which states that the first step is to reduce the amount and toxicity of waste. The second step is to reuse containers and products. When these are not feasible, the third step, recycling, should be employed as much as possible. Traditional disposal should be a last resort after all three options have been considered.

An efficient waste management system at the Huron-Clinton Metroparks would involve a well-run recycling system, both for employees and for visitors, as well as paper and packaging waste control strategies, policies regarding purchasing material, and an education system to encourage participation in the recycling program.

Baseline

Lower Huron Metropark has an electric waste compactor with 40 cubic yards of capacity. This compactor processes the waste from Lower Huron as well as nearby Oakwoods and Willow

Metroparks. During the peak season it has a filling period of about one week, and during the low season, it fills approximately once a month. Each pickup yields about 5 to 10 tons of waste. Because all three parks use the same compactor, it is difficult to determine how much waste each individual park produces. A good way to estimate this might be to use the number of visitors to each park per year. According to this approximation, 58 percent of the waste from the three parks is generated in Lower Huron (see Appendix 9 for details). Under these estimates, and considering June, July, and August as the peak season with a pickup every week, October through April as the low season with pickups once a month, and May and September as intermediate with pickups every two weeks, we estimated waste generation in the park (see Table 2).

Table 2: Monthly Waste Generation at Lower Huron

	Low (tons)	High (tons)
January	2.9	5.8
February	2.9	5.8
March	2.9	5.8
April	2.9	5.8
May	6.4	12.8
June	12.4	24.9
July	12.8	25.7
August	12.8	25.7
September	6.2	12.4
October	2.9	5.8
November	2.9	5.8
December	2.9	5.8
Total	71.1	142.1

Because a full waste assessment has not been done, there is no way to characterize the waste beyond this approximation of volume. Currently, there is a paper recycling program for employees at Lower Huron. The same company that collects regular waste also collects the paper. In addition, the company provides a service for safely disposing of batteries and light bulbs. In terms of a purchasing policy at the park, environmental factors are not considered.

The park system is an RCRA Conditionally-Exempt Small Quantity Hazardous Waste Generator. RCRA is the Resource Conservation and Recovery Act enacted by Congress to ensure the proper disposal of waste and to mitigate the potential impacts on the environment. This exemption means very little hazardous waste is produced. Typical hazardous waste that is generated at the park consists of unusable or empty aerosol cans (often with minimal pressure or with potentially flammable vapors still inside), oil-based paint material and paint brush solvents, batteries (all except wet lead-acid), florescent bulbs, and consumer electronics.

Other typical non-hazardous regulated waste includes items such as oil filters and used oil, water-based paints and related materials, contaminated fuel removed per "Recoverable Petroleum Product" regulations, empty propane cylinders, refrigerant-containing products (e.g. old water coolers or window air conditioners), and lead-acid vehicle batteries.

Goals

- Establish systems that gradually reduce waste sent to landfills up to 25 percent over a period of ten years.
- Incorporate environmental considerations into the park's purchasing policies.
- Become a societal model of sustainability with respect to waste and spread good practices among visitors and communities.

Potential Options

In this section, different options on how to approach sustainability from a waste management perspective are presented and analyzed.

-Recycling System

An optimal recycling system would include capacity for a broader range of materials such as metal cans, packaging waste, plastic tubs, cardboard, etc. A waste assessment would determine if any material has sufficient volume to implement an efficient recycling program. The experiences of the other parks studied for this report indicate that implementing a recycling program involving visitors is difficult due to the challenges of changing their behavior, given that many visitors do not properly utilize existing recycling systems.

Creating a recycling program that incorporates the waste generated by visitors poses a specific set of challenges. Toledo Metroparks, which has adopted several sustainability initiatives, has been unable to design a comprehensive system. Nevertheless, there are some examples of successful cases, some of which are highlighted as case studies in this section.

> The EPA has an initiative called "Recycle on the Go", which presents guidelines for setting up recycling programs in public places such as parks, stadiums, convention centers, transportation hubs, shopping centers, and at special events [70].

The initiative shows eight steps that guide the effective implementation of a program:

Step 1: Select a Recycling Coordinator
Step 2: Determine the Waste Stream
Step 3: Practice Waste Prevention
Step 4: Include Concessionaires, Staff, and Volunteers
Step 5: Select a Contractor/Hauler
Step 6: Set Up the Collection Program
Step 7: Facilitate Outreach and Education
Step 8: Monitor and Evaluate the Program

It also highlights some target areas specific to parks:

- Location of Recycling Bins
- Education
- Concessionaires

Another aspect of establishing a recycling program for visitors is the program's educational value. Parks are places where people can enjoy outdoor recreational activities, which has been found to be positively correlated with adopting more environmentally-conscious behavior [71]. Thus, a recycling system could serve to raise awareness and promote environmental stewardship.

Nevertheless, one of the biggest problems reported in the case studies of Toledo and Portland corresponds to visitors' behavior. Visitors to these parks tend not to utilize the proper bins. As a result, trash and recyclables often end up in the wrong bins. Contaminating a recycling system with non-recyclables can lead to large inefficiencies in the entire system. This happens in part because people are in an unfamiliar environment that demands that they perform an action (dispose of waste in different bins) in a manner that requires more effort than many are used to. Essentially, since new or infrequent visitors are not familiar with recycling systems at a particular location, ignoring the program altogether is the easiest option. Because of this, single stream recycling, which is much simpler from the visitors' standpoint, offers the potential for higher compliance rates.

Another way this problem has been addressed is through education about recycling and waste management. Fort Flagler State Park in the state of Washington developed a strategy to educate people by building a recycling center in their environmental learning facility. Details about this program can be found in the case study box. HCMA has already begun educating park visitors through effective signboards and education stations at the various nature centers like those at Kensington and Metro Beach Metroparks. These learning centers can be effective at educating people about both recycling and waste management systems. The two approaches for addressing this issue can be performed simultaneously.

The true volume of recyclable material could be determined by a waste assessment. Nevertheless, using the information in Table 2 and that from a waste audit of Toronto parks (which states that recyclables range from 24.5 percent to 28.5 percent of their waste [72]), we can estimate that the amount of recyclable material in the park ranges between 17.4 and 40.5 tons per year. If these quantities are not large enough to engage recycling companies, actions as the one made in Yellowstone might make sense (see case study).

Table 3. Recyclable Potential at Lower Huron

	Recyclable Low (tons)	Recyclable High (tons)
January	0.7	1.7
February	0.7	1.7
March	0.7	1.7
April	0.7	1.7
May	1.6	3.7
June	3.0	7.1
July	3.1	7.3
August	3.1	7.3
September	1.5	3.5
October	0.7	1.7
November	0.7	1.7
December	0.7	1.7
Total	17.4	40.5

In terms of costs, it is important to note that a recycling system does not offer direct financial benefits, but the environmental and social benefits must be considered. With respect to infrastructure, a recycling program is somewhat capital intensive. The main costs are the bins (signage costs are lower). A 50-gallon recycle bin can be purchased for approximately $100. Considering that recycling should be single stream and that Lower Huron has 300 bins, one recycle bin per trash bin would mean an initial cost of $30,000. In order to test how the system works, a smaller pilot could be carried out. Turtle Cove would be a good setting as it has a high number of bins in a small area. In terms of operations, the only significant increase in costs would be extra bin pickups.

All the material would need to be transported to a recycling plant. One potential option would be Ann Arbor's municipal Materials Recovery Facility (MRF), which receives recyclable materials. In this plant, the material is received mixed and is separated by a mechanical process. MRF officials negotiate directly with customers for rates charged for incoming recyclables. As a reference, the city of Ann Arbor, which has large negotiating power, pays approximately $15 per ton for using MRF in contrast to the $24 they pay for landfilling their traditional waste. This number includes a fee for a transfer station where waste is compacted and hauled to the landfill, as well as a landfill tip fee.

Recycling at Events

In terms of the educational or behavior change potential that recycling at parks can have, an opportunity to spread this impact is to extend recycling to events that take place at the park. Doing so may have a significant impact on the community.

West Linn Parks and Recreation requires recycling at all events held within the parks. People who work in these events are all volunteers from the community. In each event there are Master Recyclers, volunteers who have experience in these topics, who coordinate with less experienced groups (scouts or other youth groups) to carry out all the necessary tasks. Last year they diverted close to two tons of recyclable material from events, which corresponds to 41 percent of the generated waste. Moreover, West Linn has taken recycling

Case Study: Yellowstone National Park

Yellowstone National Park has made sustainability a critical issue and has taken many steps to reduce its environmental impacts. For a park which averages more than 3 million visitors per year, whose average stay is 1.9 days and in 2007 generated more than 3,500 tons of solid waste, reducing waste streams was not an easy task. Nevertheless, in 2007 75 percent of the waste was diverted from landfills and the park's goal is to divert 100 percent by 2010. The EPA's Recycle on the Go program and the park's composting program are two examples of initiatives that have been undertaken.

The EPA's Recycle on the Go program highlights Yellowstone National Park as a success story. Presently, recycling is widely available throughout the park. Waste is separated into five types of recyclables: aluminum and steel, mixed paper, cardboard, glass, and plastic. Over the years, the program has cut waste disposal costs by 50 percent. However, this program has had some challenges. Initially, the program struggled with the quantities generated, as the amount was not large enough to be attractive to recycling companies. To solve this problem, the park allied with neighboring communities to combine collected recyclables and generate larger quantities .

Due to the fact that a great portion of waste is organic, composting also fits into Yellowstone's waste diversion intentions. In 2003, the West Yellowstone Compost Facility opened with the capacity for processing 50 tons of waste per day. In 2005, after two years of operation, the facility had produced more than 3,500 yards of compost of acceptable quality. The compost has been used in Yellowstone's landscape projects as well as sold to local gardeners in the surrounding area .

Sources:
NPS. NPS Reports. National Park Service Public Use Statistics Office. [Online] [Cited: February 7, 2012.] http://www.nature.nps.gov/stats/.
EPA. Yellowstone National Park Recycling Program. s.l. : EPA, 2006.
Yellowstone Park Foundation. Yellowstone Environmental Stewardship - Waste Reduction: Yellowstone Park Foundation. Yellowstone Park Foundation. [Online] [Cited: February 8, 2012.] http://www.ypf.org/site/PageServer?pagename=WHAT_greenest_YES_Waste.
EPA. Yellowstone National Park Recycling Program. s.l. : EPA, 2006.
Composting Finds its Niche in Yellowstone National Park. O'Hern, Kathleen and O'Neill, Tim. 7, s.l. : ByoCycle, 2005, Vol. 46.

Case study: Fort Flagler State Parks, Washington

Educating people about recycling is one of the biggest problems that many parks face while starting to implement their recycling program. Fort Flagler State Parks in the state of Washington adopted an innovative strategy for educating park visitors about the recycling system in their parks. They built a recycling education center in their environmental learning center to educate visitors about recycling and reducing litter. At this learning center, they have different recycling bins, properly labeled and displayed with recyclable material in them. Park visitors come to this educational center and learn about recycling. Fort Flagler is the first park system in the state of Washington to implement the recycling program. They mention that this recycling center has proven to be very helpful in educating people about recycling and reducing waste at their site. Waste reduction has resulted in improving all three pillars of sustainability; social, environmental and economic .

Source:
Fort Flagler State Park (2001). State Park Litter and Waste Reduction Program. Retrieved from www.litter.wa.gov/Presentations/Fort_Flager_Case_Study.pps

Figure 12: Recycling at a park event in West Linn, Oregon

Figure 13: Marathon RJ-250SC Solar Compactor

at events one step further: for a major event they hold each year, they have decided that the staff will wear clothing made from bottles recycled at last year's event. This initiative is purely a cost, and they estimate that the material recollected is not enough to make all the clothing, but they consider the primary objective to be educating their community. The main limitation of this option is that the scope of people directly affected is quite low.

Composting

A similar study on reducing urban solid waste by solid waste handling techniques such as recycling, organic waste composting, and trash compaction was conducted in Mexico. The study showed that through these waste reduction methods waste sent to the landfill could be reduced by up to 70 percent. One interesting fact about this study is that the biggest area of improvement highlighted was the handling of organic waste. Organic waste included tree leaves, branches, leftovers from concessionaries, and grass from mowing. They handled all this organic waste by composting that resulted in significant amount of compost [73]. Some benefits of composting according to EPA are:

- Enriches soil by increasing the production of beneficial microorganisms that reduce the organic matter.
- Helps in remediation (clean up) of contaminated soil.
- Prevents excess pollution by keeping trash from the landfill
- Reduces the need for fertilizer, water, and pesticides [74].

This study can be applied to Huron Clinton Metroparks since the parks tend to generate a lot of organic waste from cafeterias, mowing and visitors' food waste. For exact economic and environmental benefits in Lower Huron Metropark an assessment or a pilot study should be carried out. According to a study done by a group member, the composting cost to a municipality in Chile is $3/ton [75]. For Huron-Clinton Metroparks this number is most likely substantially higher as the wages are much higher in the US compared to Chile. For instance, the minimum wage specified in Chile is about $2.0/hour [76] while this rate is $7.40/hour in Michigan [77].

Solar Compactor

Lower Huron relies on a trash compacter to reduce the volume on waste for pickup. One option is to introduce a solar powered compactor. These compactors are available on the market and work both with solar energy and grid electricity.

Table 4: Potential Cost Savings of a Solar Compactor

Month	Current Consumption (kWh)	Cost (US $)	Potential Solar Generation (kWh)	Cost Avoided (US $)
January	1,040	114	35	4
February	1,120	123	51	6
March	1,120	123	77	8
April	1,200	132	102	11
May	2,720	299	132	14
June	4,160	458	140	15
July	4,240	466	136	15
August	4,160	458	121	13
September	1,840	202	99	11
October	1,600	176	66	7
November	1,280	141	36	4
December	1,160	128	28	3
Total	25,640	2,820	1,021	112

Table 4. Electricity consumption and approximate cost due to waste compactor shows the electricity consumption and cost of the compactor for 2010. Assuming that the solar area of the panel of the compactor is 6 m^2, it has an efficiency of 13 percent, and the solar potential of Detroit, we estimated that potential savings would be $112 and 1,021 kWh per year (see Table 4).

According to Marathon Equipment, which sells solar compactors, an appropriate model would be the RJ-250RC, which costs approximately $31,500. Considering a discount rate of 5 percent, changing the compactor while having the current one operating will never pay back.

In term of environmental benefits, this measure would avoid 1,021 kWh per year, which is equivalent to 1 ton of CO_2e per year. It also has educational value when showcased as a sustainability initiative made by the park. For enhancing the educational and behavior change potential, refer to the education section of this report.

An important challenge for this option is that in order to have educational value, the compactor has to be visible and accessible. Waste compactors, however, are not commonly in plain sight to visitors. Moreover, this particular option raises concerns with sanitation.

Waste Reduction Policy

It is important to have a policy that focus on various areas of waste reduction. Such policies focus on embedding strategies for reducing waste. A few successful examples offer insight into how to craft and implement waste reduction policies. The University of North Caroline, Charlotte has a comprehensive waste reduction policy that is focused on three key elements [78]. The first portion is the policy that is focused on the University's commitment and stewardship of waste. The second element is the most important part, and focuses on four ways to achieve targeted waste reduction. They are:

- Source reduction
- Reuse of products
- Recycling
- Purchase of recycled/sustainable material

The third element of the waste reduction policy is the formation of the implementation team. UNC Charlotte has designated staff in each department to implement the waste reduction policy. Allegheny County, Pennsylvania, has a similar waste policy that focuses on the same aspects. There, emphasis is placed on purchasing recycled materials when possible. An additional step is to allocate an increased price margin for recycled/green products as they typically cost more than traditional products [79].

A study on solid waste management for the National Park Service [80] provides a step-by-step guide for solid waste management. According to the report, the two most important elements for Huron-Clinton Metroparks are waste tracking and waste analysis. The analysis can determine what type of waste is produced, and then mitigation steps are designed according to the existing waste reduction policy. Liebl 1998 from University of Wisconsin did an extensive analysis for waste reduction options in parks, and recommended prioritizing the steps in this way:

- Reduce waste at the source
- Recycling
- Treatment
- Disposal

Source reduction means reducing the material consumption either by using less or by using lighter products. The second focus that is most effective is recycling [81]. A study at the University of Toronto compared both upstream and downstream handling options for aluminum. The study analyzed different options for reducing drinking bottles such as deposit refund programs, packaging fee and taxes, recycling and other options. They did both social and economic analyses of the outputs. The social benefits from reduced pollution are conservation of landfill area, conservation of resources (both material and energy) and littering. They concluded two important factors for waste reduction: source reduction and an efficient recycling program. They noted that the packaging waste weight of soft drinks was reduced by 91 percent in Ontario between 1972 and 1992 due to material use in packaging. In addition, they found that recycling results in both economic and energy benefits. For instance, aluminum recycling can save approximately $ 900/ton and 14000 KWh of electricity per ton [82].

Source reduction is the most effective, economical, and sustainable way to handle waste. Instead of handling the waste downstream through different methods like recycling and composting, a more sustainable strategy is to simply reduce the material consumption. Some of the general tips provided by Liebl 1998 for waste reduction are:

- "Buy only the amount and type of product needed for the job"
- "Packaging reduction"
- "Reuse of products or materials"
- "Durable goods"
- "Good housekeeping practices"
- "Employee training and involvement"

It is important to remember that other ways of reducing waste should also be considered beyond the proposed purchasing policy improvements. These include but are not limited to the reuse of products, recycling, and promoting waste-conscious behavior among employees.

Stormwater Management

For much of the last century, drainage systems have been engineered to quickly move water runoff into underground pipes, treating rainfall as waste [5]. Urban development has dramatically impacted natural hydrologic systems by reducing the landscape's ability to absorb stormwater and by introducing pollutants [5]. The impervious surfaces of urbanized landscapes prevent water from infiltrating at its source. Sediment and pollutants from impervious surfaces are carried by runoff into pipes and water bodies [5].

The major impacts of high volume and velocity of stormwater runoff emptying into riparian corridors and lakes are as follows:

Increased Flooding: Increased amounts of impervious surfaces decrease the amount of rainwater that can infiltrate into the soil, increasing the amount of runoff. This leads to more frequent and severe flooding and potential property damage.

Degraded Riparian Corridors: Water moving at higher velocities through stream channels due to increased rates of runoff creates "flashy flows." As a result, the stream bank and streambed become eroded, resulting in the widening and deepening of the stream channel, decline in stream quality, and degradation of habitat.

Decreased Groundwater Recharge: Infiltration of stormwater to groundwater sources is diminished as impervious surfaces increase. Groundwater is an important source of drinking water supply. Groundwater is also an important source of recharge to rivers and lakes during dry weather, ensuring a steady flow of water.

Impaired Water Quality: Pollutants accumulate on impervious surfaces and are carried away by stormwater, entering directly into lakes and stream. According to the EPA, pollutants in runoff include:

- Sediment
- Oil, grease, and toxic chemicals from automobiles
- Pesticides and nutrients from fertilizers used on lawns and gardens
- Viruses, bacteria, and nutrients from pet waste and failed septic systems
- Road salt
- Heavy metals from rooftops and motor vehicles
- Heated water running of dark impervious surfaces, such as asphalt and rooftops [83].

Loss of Habitat: Erosive flows, contaminants, and increased water temperature of runoff degrades habitat, negatively affecting aquatic biodiversity.

Loss of Recreational and Cultural Value: The negative effects of stormwater runoff result in diminished recreational and economic opportunities for communities that depend on the ecosystem services of nearby water bodies [84].

Huron River Watershed

The Huron River Watershed covers more than 900 square miles of southeast Michigan, draining water to the Huron River by means of hundreds of tributaries. The drainage area includes seven Michigan counties (Oakland, Livingston, Ingham, Jackson, Washtenaw, Wayne, and Monroe) and 63 municipalities. Over half a million residents inhabit the Huron River Watershed. The watershed is comprises a variety of land uses including: natural preserves, cultivated farmland, urban and industrial land, suburban residential, and a variety of lakes, ponds, wetlands, and streams [85]. The watershed supports numerous threatened and endangered species and habitats, wetlands, and remnant prairies of statewide significance [86].

At 74 square miles, the Lower Huron River Watershed comprises approximately 8 percent of the entire Huron River Watershed [86]. The Watershed includes portions of Belleville, Brownstown, Huron Township, Flat Rock, Rockwood, Van Buren Township, Sumpter Township, Romulus, Ash Township, Woodhaven, Gibraltar, Berlin Township, and South Rockwood [86]. Nearly 11,000 acres of wetlands remain in the Lower Huron River Watershed as of 2000 [86]. Four Metroparks exist within the watershed: Lower Huron, Willow, Oakwoods, and Lake Erie [86].

The Huron River flows more than 125 miles from its headwaters at Big Lake, near Pontiac, to its mouth at Lake Erie. Nearly one hundred dams segment the Huron River system, 17 of which are located on the main stem of the River [86]. The Huron River is a valuable resource to southeast Michigan, providing drinking water to approximately 150,000 people [86]. The river is Southeast Michigan's only state-designated Scenic River [86].

Impacts to the Huron River have long been felt due to human development within the watershed. In recent decades, the entire watershed has undergone large amounts of development. The Lower Huron Watershed has experienced a 23 percent increase in total population from 1990 to 2004. Projections for the year 2030 estimate the population to increase an additional 26.2 percent from 2004 levels with an average increase of 42 percent in the total number of households [84]. The health of the river is already at risk due to development within the watershed. The projected level of development within the watershed will continue to adversely affect the River and communities within the watershed, if certain sustainability issues are not considered. Climate change also poses a threat to the river, and although its direct impacts are somewhat unpredictable, Michigan will experience warmer temperatures and more intense storms in the future that will alter the health of the river and its watershed [86]. Addressing the issues of stormwater management today will extend the health and wellbeing of southeast Michigan's most valuable river.

Baseline

Nearly 80 percent of the total land cover in the Metroparks, or 20,000 acres, is left in a natural state. Of this total, 3,500 acres are developed for recreational purposes, and the remaining land is leased to municipalities [87]. Although Lower Huron provides extensive open space along the Huron River, about 5 percent of the land area is developed with impervious surfaces (see Figure 14). Runoff from impervious surfaces at Lower Huron drains into ditches, which ultimately drain into the Huron River.

There are currently limited stormwater mitigation efforts at Lower Huron, with the exception of Turtle Cove. Turtle Cove comprises the largest portion of impervious surfaces at Lower Huron. Most of the runoff from the site drains into a nearby retention pond. The water from the pond is used to irrigate the lawn and landscaping at Turtle Cove and the remainder drains into the Huron River. A bioswale along the south side of the parking lot collects runoff from half the surface area of the lot. All other runoff from Lower Huron drains into the Huron River.

Wood's Creek is an area of concern, as it provides valuable habitat to trout and other wildlife. Runoff entering the river from outside sources and from Lower Huron's parking lots is carrying pollutants into this valuable resource. An impoundment upstream increases the temperature of the creek, degrading the value of its habitat. The area near the creek at Wood's Creek Picnic area has been transformed to a no-mow zone and planted with native vegetation, creating a riparian buffer for stormwater and habitat for wildlife and plants.

In 2010, HCMA implemented a Storm Water Management Plan (SWMP) in order to reduce the amount of pollutants discharged to the Waters of the State within its jurisdiction. The management plan was developed in order to fulfill the requirements for Part I. Section B of the State of Michigan's National Pollutant Discharge Elimination System (NPDES) General Permit (MIS049000) for Storm Water Discharges from Separate Storm Water Drainage Systems.

As outlined on HCMA's website, the SWMP aims to develop a program to implement six measures required by the General Permit which include:

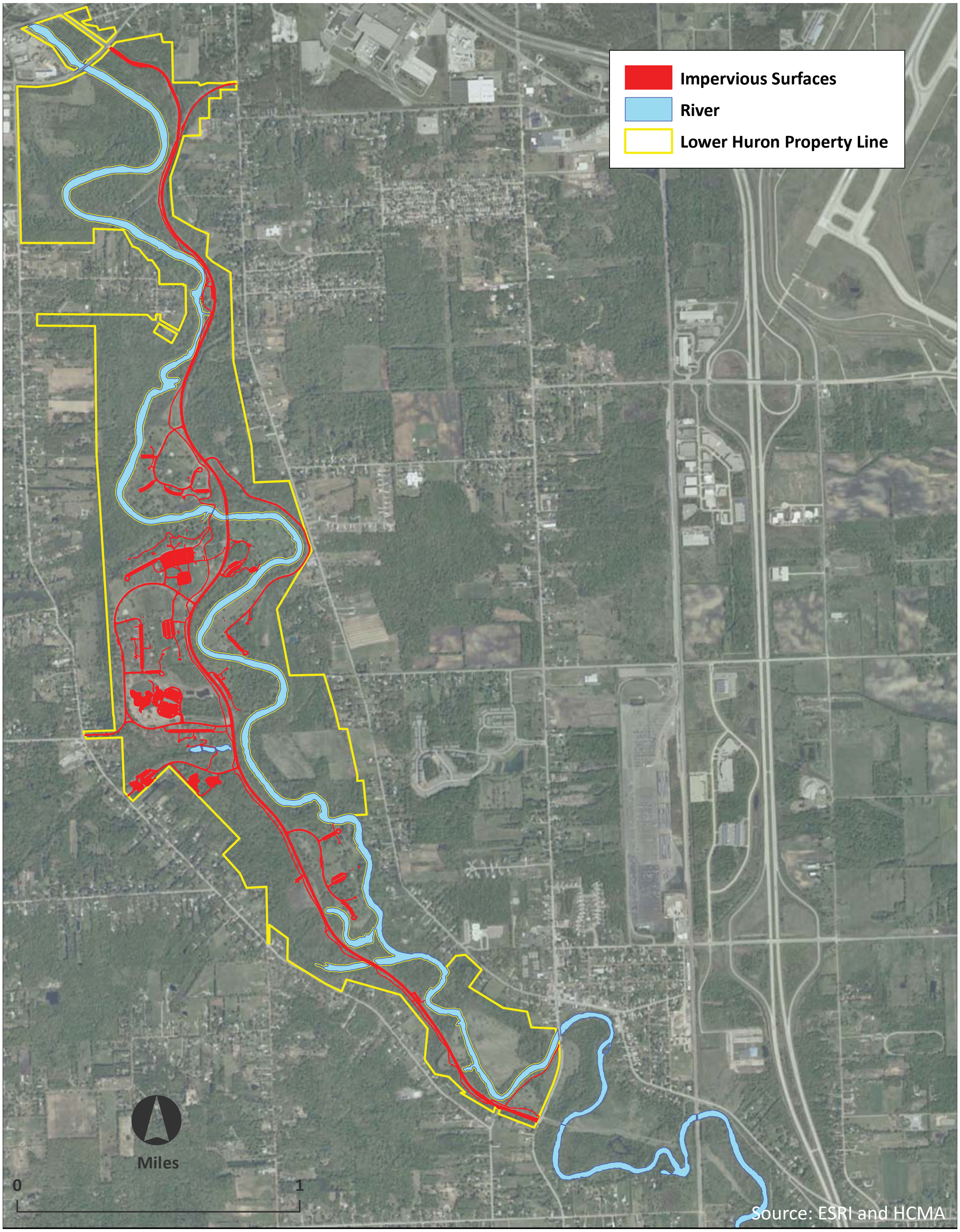
- Public Education Plan
- Public Involvement and Participation Plan
- Illicit Discharge Elimination Plan
- Post Construction Storm Water Management Program for New Development and Redevelopment Projects
- Construction Storm Water Runoff Control
- Pollution Prevention / Good Housekeeping for Municipal Operations

These measures are intended to reduce the negative impacts or reduce discharge of pollutants within the stormwater conveyances of the Metroparks to the Maximum Extent Possible (MEP) [87]. phenomenon.

Goals

- Implement Structural Best Management Practices (BMPs) to capture and treat stormwater on site.
- Improve upon existing BMPs to enhance performance.
- Design BMPs as an educational and cultural tool and provide interpretive signage and

Figure 14: Impervious Surfaces at Lower Huron



other materials to education on their importance.

- Improve habitat and ecological value of areas affected by stormwater by establishing native vegetation in the design of proposed BMPs.

Potential Options

Effectively managing stormwater by mimicking the natural hydrological function of healthy ecosystems can dramatically improve water quality by reducing pollution, runoff volume, and runoff temperature, and protecting aquatic habitats, and aesthetically improve sites [5]. Sustainable stormwater design seeks to manage stormwater at its source, and should filter and remove excess sediments and other pollutants from runoff, slow the velocity of runoff through detention, and reduce the volume of stormwater by allowing it to infiltrate at its source [5].

Low Impact Development (LID) is a development or redevelopment approach that seeks to manage stormwater as close to its source as possible [88]. By implementing LID practices, water can be managed in a way that reduces negative effects of developed areas on natural waterways and ecosystems. LID can be applied to new development, redevelopment, or as retrofits to existing development [88]. Applied on a large scale, LID can maintain or restore the hydrologic and ecological functions of a watershed.

Best management practices (BMPs) are the primary way to control stormwater runoff. BMPs can be either structural or non-structural. Non-structural BMPs approach stormwater management at a broad scale and typically are implemented in the site design stage of development [84]. Many structural BMPs actually rely upon vegetation and soil mechanisms in order to perform similar stormwater functions to a natural hydrologic system, such as rain gardens or vegetated swales.

Introducing BMPs to urban areas will bring about strong economic, environmental, and social benefits. Stormwater management strategies do not always bring about direct economic benefits, as they mainly occur in the background and are overlooked in cost accounting [89]. However, properly managing stormwater runoff can reintroduce many ecosystem services – the benefits ecosystems provide to people – provided by a natural hydrologic system that are associated with economic, environmental, and social benefits, including:

Climate Regulation: Best management practices that involve vegetated controls balance atmospheric gases, creating clean air and sequestering greenhouse gases.

Air and Water Cleansing: The main function of many BMPs is to remove pollutants carried by stormwater runoff, maintaining water quality in lakes and rivers. Vegetated BMPs offer air-cleansing benefits beyond those associated with climate regulation.

Water Supply and Regulation: BMPs reduce the amount and velocity of stormwater flow to water bodies, which can be otherwise harmful to natural systems if not managed correctly. Infiltration BMPs allow water to seep through the surface and infiltrate groundwater, regulating water supply to lakes and rivers during dry weather. BMPs also provide flood protection by regulating hazardous flashy flows.

Erosion and Sediment Control: By reducing the amount and velocity of stormwater running over the ground, BMPs prevent the effects of erosion, retaining soil within ecosystems. They also prevent sediment loading in lakes and streams that is a result of erosion.

Pollination: Vegetated controls provide pollinator plants for the reproduction of important native plant species.

Habitat: By regulating the flow and quality of stormwater that enter lakes and streams, best management practices protect aquatic habitats. Vegetated BMPs also provide terrestrial habitat for plants and animals, contributing to the biodiversity of watershed ecosystems.

Human Health and Well-Being: The healthy natural systems that result from responsible stormwater management enhance the physical, mental, and social well-being of people who interact with them.

Cultural Benefits: Improving natural systems through BMPs enhances cultural, educational, and aesthetic experiences as people in the watershed interact with nature.

Non-Structural BMPs

Non-structural BMPs are typically implemented early in the site design process and primarily function to prevent stormwater from running off the site [84]. They typically take an entire site design approach and are not fixed or specific to one location [84]. Since they are used for future site design, they are not as applicable to existing conditions at Lower Huron as structural BMPs. For this reason only a brief discussion of non-structural BMPS is included below:

Utilize Natural Flow Pathways: Identifying, protecting, and utilizing the site's natural drainage pattern can be an effect BMP and minimize or eliminate the need for traditional infrastructure. Natural, vegetated drainage features slow runoff and improve water quality through filtration, infiltration, and evapotranspiration [90].

Reduce Impervious Cover: By reducing the amount of impervious surface, the amount of stormwater runoff is reduced on site and opportunities for infiltration are increased. Reducing impervious surfaces also reduces development costs and enhances the aesthetics and environmental integrity of the site [84].

Disconnect Impervious Cover: The amount of stormwater generated on site can be reduced by disconnecting roof downspouts and impervious surfaces from conventional stormwater systems, allowing the runoff to be stored and treated on site.

Cluster Development: Cluster development concentrates development over a smaller area on a portion of a larger site. Benefits of cluster development include a reduction in the amount of infrastructure required, increased open space, and protection of environmentally sensitive areas [84].

Minimize Soil Compaction: Protecting and minimizing impact on existing soil due to compaction in the development process increases infiltration of stormwater on site and maintains a healthy habitat for plant species [84].

Minimize Disturbed Area: Containing disturbed area during site development, and reducing the amount of land impacted by grading, removal of vegetation, and soil disturbance, has environmental benefits, as the site is able to maintain runoff volume and flow rates, infiltration capacity, and healthy vegetated environments [84].

Protect Sensitive Areas: Sensitive areas typically include riparian buffers, wetlands, and areas of valuable habitat, which are important to protect in order to maintain hydrological and other environmental benefits [84].

Protect Riparian Buffers: Riparian buffers are critical to the health of waterways, as they stabilize stream banks, reduce flow rates of runoff, and provide pollution and sediment control. Protecting riparian buffers during site development improves water quality, reduces shoreline and bank erosion, maintains habitat, and provides flood control, preserving the overall integrity of nearby water bodies [84].

Structural BMPs

Implementation of structural BMPs is a viable option for managing stormwater runoff from the existing development at Lower Huron. Types of structural BMPs are described below, and are categorized by their primary functions. Although the specific BMPs are organized in separate groups, they are not necessarily limited solely to one category, as many perform multiple functions.

Rain Gardens

Rain gardens are shallow depressions planted with appropriate native plant species to capture and treat stormwater from impervious surfaces. The bioretention process allows water to pool and infiltrate within the planting area and filters suspended solids and pollutants from stormwater runoff [84]. Plants within rain gardens absorb pollutants associated with runoff while soil microbes break them down. The soil filters pollutants and provides a medium for runoff storage and infiltration. In addition to reducing runoff volume and filtering pollutants, bioretention can provide habitat for local species, recharge groundwater, reduce impacts of stormwater temperature, and enhance the aesthetics of the site [84].

Simple rain gardens can be relatively very low cost to install, averaging $5 - $7 per cubic foot of storage area [84]. Rain gardens are often located in underutilized space along parking lots and streets, in large parking lot islands, and in residential areas [5]. Rain gardens can be used in a variety of applications, as they are flexible in size and configuration, and can be incorporated nicely with other structural BMPs on site, such as permeable pavement and vegetated swales [91]. Rain gardens are a very feasible option for Lower Huron due to the flexibility in design, ease of installation, and low cost.

Detention Basins

Detention basins are surface or underground structures that temporarily store stormwater to prevent downstream flooding. Types of detention basins include dry ponds, wet ponds, underground detention, constructed wetlands, and bioretention [84]. Detention basins are designed to provide high levels of channel protection and flood control [91].

Green Roof

Green roofs consist of a vegetated layer covering a roof. The system is composed of multiple layers, including waterproofing, a drainage layer, engineered planting media, and vegetation [91]. Green roofs are effective at reducing the velocity and volume of stormwater from roofs [91]. Performance of the green roof depends upon the depth of the growing medium, soil, slope, and vegetation; most studies show extensive green roofs reporting runoff reductions between 50 and 70 percent [92]. In addition to stormwater benefits, green roofs serve as a heat sink to reduce heating and cooling costs, improve air quality by filtering dust particles, and can potentially extend roof life by two to three times [91]. Green roofs vary widely in cost depending on the type of vegetation.

Planter Boxes

Planters are narrow, flat-bottomed landscaped areas used to treat runoff [5]. Planters are similar to vegetated swales, with the distinction that side slopes of swales are replaced with vertical concrete walls in planters, allowing for greater storage volume in less space [5]. Stormwater planters are appropriate for use along streets and parking lots where space is constricted, and provide volume and water quality benefits [5]. Planter boxes are more expensive than vegetated swales and are typically only appropriate in high-density urban settings, but may be suitable for retrofitting parking lots without eliminating many parking spaces [5].

Rain barrels

Rain barrels are often connected to rooftop downspouts to collect and store runoff until the water is needed for its intended use [84]. Rain barrels are suitable for use on residential homes and commercial and industrial buildings with

Photo Source: USDA Natural Resource Conservation Service - Iowa

Figure 15: Green roof on a park building in Coralville, Iowa

Photo Source: Alabama Cooperative Extension System

Figure 16: Rain water harvesting system at Little River Canyon Center in Alabama

landscaped areas [84]. Rain barrels typically cost between $3 and $9 per gallon of capacity; a typical rain barrel holds 50 gallons [92]. Additional costs include hoses, special connectors, labor, site preparation, and the construction of a concrete pad [92]. Reuse of runoff is limited to irrigation for on-site landscaped areas [92].

Cisterns
Cisterns are above- or below-ground storage structures that have greater capacities than rain barrels, typically holding between 200 and 10,000 gallons of runoff [84]. Cisterns are frequently used for irrigation or to supplement graywater needs (toilet flushing, other uses) [84]. Cisterns cost from $.50 per gallon to $2 per gallon, depending on the material [92]. Additional costs include labor, site preparation, and plumbing retrofits [5]. Cisterns are best suited for use next to buildings adjacent to open space, or any property with adequate space for installation [92].

Constructed Filter
Filters are structures or excavated areas that contain a layer of sand, compost, organic material, or other filter material [91]. They filter pollutants from runoff and can potentially provide detention, depending on the design [91]. Filters are appropriate on sites where vegetated systems are not practical, in urbanized areas with limited space for other BMPs, or as pretreatment for other BMPs, such as wet ponds or infiltration systems [91, 90]. A wide variety of filters exist, including surface and subsurface filters, vegetated filters, and filters with or without infiltration [84]. A typical filter consists of five or six components: pretreatment, inlet, surface storage, filter media, underdrain (if necessary), and positive overflow [84].

Parking lots and roadways at Lower Huron may benefit from the use of a constructed filter, especially if used in conjunction with other BMPs, extending the life and enhancing the performance of the stormwater management system. Costs of filters vary depending on the filter media, amount of land to be cleared, excavated, and graded, inlet and outlet structures, perforated pipes, encasing structure, and maintenance [84]. In general, constructed filters are costly BMPs that require extensive maintenance compared to other BMPs [84].

Vegetated Filter Strip
Filter strips are vegetated areas that treat sheet flow from adjacent areas that serve as pretreatment for other BMPs [91]. Filter strips are effective for reducing the velocity of runoff, removing pollutants, and promoting infiltration [91]. The use of a filter strip extends the life of the associated BMPs, which can include bioretention, detention

basins, and porous pavement [91].

Level Spreaders

Level spreaders evenly distribute stormwater flows over a stabilized, vegetated surface, allowing for infiltration and treatment of runoff [84]. Examples of level spreaders include: concrete sills, earthen berms, and level perforated pipes [84]. Level spreaders should be used with other structural BMPs in order to maximize stormwater benefits and prevent erosion that can be associated with other BMPs [84]. By dispersing stormwater flows, level spreaders assist vegetated BMPs by reducing erosion, a source of sediment pollution to water bodies [84].

There are two types of level spreaders: inflow and outflow. They may be used as inflows to structural BMPs, such as a filter strip or infiltration basin, or as outlets from structural BMPs not discharging directly to a receiving stream [90]. Materials and equipment cost for level spreaders will vary between $5 and $20 per foot, depending of the design [84]. Careful construction and design of level spreaders is essential for proper functioning [84]. Level spreaders are a relatively low cost structural BMP, applicable to many different sites, making them a viable option for stormwater treatment at Lower Huron.

Vegetated Swale

Vegetated swales are long, narrow depressions in the landscape, with a slight longitudinal slope [5]. They are used to convey runoff and also provide water quality control. Water moving through a swale is slowed by the interaction with plants and soil, allowing sediments and pollutants to be filtered [5]. Parking lots and streets that have long, continuous amounts of space are excellent sites for vegetated swales. The longer a vegetated swale, the more effective it is at slowing the movement of water and filtering runoff [5].

Swales planted with turf grass are common, but are not as effective as deeper-rooted vegetation at decreasing peak flow, promoting infiltration, and decreasing erosion [91]. Cost depends on the design but is relatively low, making swales a widely accepted BMP [5]. In addition to environmental and aesthetic benefits, vegetated swale installation and maintenance costs are far less than those of traditional conveyance elements, making swales an attractive strategy for managing stormwater [84].

Native Revegetation

Revegetation could take the form of prairie, no-mow lawn, woodland, constructed wetlands, buffer areas, or replacement lawn areas [84]. Native vegetation, generally described as species that existed over an area prior to European settlement, reduces stormwater runoff volume, improves water quality, and reduces long-term mowing and irrigation maintenance needs [84]. Over time, native vegetation does not require chemical maintenance by fertilizers and pesticides and are typically more resistant to pests, drought, and other local conditions. Native species result in a greater volume of water uptake (evapotranspiration), improved soils due to organic material and macropore formation, carbon sequestration, and increased infiltration [84].

Cost estimates for native revegetation vary significantly, depending on the type. Prairie or woodland understory installations typically range from $1000 - $2500 per acre. Tree installation and potted perennials add to this cost depending on the size, type, and spacing of trees and native perennials. Costs for prairie establishment are much lower than woodland projects, as there is no need for tree installations. Elimination of mowing can significantly reduce annual maintenance costs, ranging from $2000 - $3000 per acre per year. Establishment of native areas may take an extended period of time and extensive management, but the environmental, aesthetic, and cost benefits of native revegetation make this a viable option for Lower Huron.

Pervious Pavement

Pervious paving systems consist of a porous surface course underlain by a storage reservoir on uncompacted subgrade, allowing stormwater to pass through the surface and infiltrate into the ground below [5]. The storage reservoir may consist of course aggregate with a void space of approximately 40 percent or structural storage units [84]. There are four types of pervious pavement: porous asphalt, pervious concrete, permeable pavers, and reinforced turf or gravel. Pervious concrete and asphalt are formulated with pore spaces within the material itself. Permeable pavers allow water to pass through evenly spaced gaps between pavers' edges [5].

Pervious pavement is appropriate for low-volume streets, parking stalls, alleys, residential driveways, and sidewalks [5, 88, 83]. Permeable pavement systems typically range from $10-$15 per square foot, depending on the type of pavement and type and depth of porous medium underneath [92]. The performance of permeable pavement depends on the depth of subsurface storage media, typically ranging from 18 to 24 inches. If properly designed and maintained, a permeable pavement system may produce virtually no runoff from most storms and function successfully for more than 20 years [92, 84].

Importance of Stormwater Management

Proper management of stormwater at Lower Huron has the potential to have further-reaching effects than simply reducing runoff into the Huron River. The educational component of stormwater management can not only educate the public on the importance of properly managing stormwater, but can also contribute to making structural BMPs a cultural norm. Urban stream remediation presents challenges within urban communities with respect to engaging people to achieve a shared understanding of what

Case Study:
OMSI Parking Lot, Portland, Oregon

The bioswales at the parking lots of Oregon Museum of Science and Industry (OMSI) are Portland's first efforts toward large-scale stormwater treatment and infiltration. The goal of the project, which started in 1990, was to filter pollutants in stormwater runoff and to reduce the volume of runoff entering the Willamette River. Ten bioswales collect runoff from over 174,000 square feet, preventing nearly 4 million gallons of runoff from entering the storm sewer system annually. The elimination of the need for stormwater pipes, sedimentation manholes, and catch basins saved $78,000 in construction costs for the parking lot.

Source:
Portland Bureau of Environmental Services, City of Portland, Oregon. 2012. http://www.portlandonline.com/bes/index.cfm?a=68741&c=36848

Figure 17: OMSI parking lot swale

is achievable and desirable for their local streams. Implementation of BMPs, such as rain gardens, can change people's perception of riparian land, shifting the ideal from mowed grass in riparian areas to natural conditions. Lower Huron can play a role in educating communities on how natural riparian areas might be more desirable for their local streams, thereby having far greater impacts on the Huron River.

New stormwater management techniques can use stormwater to create amenities that enhance the attractiveness or value of a site [93]. Echols and Pennypacker (2008) term this concept "artful rainwater design." Artful rainwater design employs BMPs that call attention to stormwater management in order to educate and enhance the value of site design, serving as site amenities [93]. According to Echols and Pennypacker, stormwater treatment systems may fulfill one of five goals in order to serve as amenities to sites:

Education: provides favorable conditions for learning about stormwater and related issues;

Recreation: provides conditions that encourage interaction with the BMP;

Safety: mitigates danger associated with stormwater;

Public Relations: provides a semiotic statement about the values of those who designed, created, or own the site;

Aesthetic Richness: creates an experience of beauty or pleasure centered on stormwater design [93].

Artful rainwater design has the potential to increase public exposure to ecological stormwater design and serve as an educational resource, thereby increasing the cultural value of Best Management Practices.

Remediation of urban stream degradation due to stormwater flows is likely to be addressed through widespread application of innovative approaches to drainage design. Walsh et al. (2005) stress that end-point restoration of streams is a short-term solution, and that a catchment-wide solution is needed to restore the health of urban streams [94]. Applicable management solutions lie in experimental catchment-scale alternatives. Small amounts of stormwater runoff that land throughout a watershed accumulate into large volumes of water downstream. Small changes in the landscape, such as the options outlined in this section, have the potential to capture these small amounts of stormwater, resulting in vast improvements to overall watershed health [5]. For this reason, site-scale stormwater management approaches for Lower Huron are central to the stormwater recommendations.

Case Study: Tanner Springs Park, Portland, Oregon

Tanner Springs Park is a 0.91-acre park in the Pearl District of downtown Portland at Northwest 10th Avenue and Marshall Street. The Pearl District once existed as Lake Couch and surrounding wetlands that were fed by streams flowing from the hills in southwest Portland. The springs of Tanner Creek flowed into the shallow basin of Couch Lake. In the late 19th century as the city developed, Tanner Creek was rerouted through a series of underground pipes that drain to the Willamette River. Lake Couch and the surrounding wetlands were subsequently filled to make way for rail yards and warehouses, which have since been replaced by the dense mixed-use urban fabric characteristic of the area today.

Construction of Tanner Springs began in June 2004, with a budget of $7.8 million. The park is maintained by the Friends of Tanner Springs. The design of the park attempts to highlight the site's history with native wetlands and flowing runnels. The site represents different native ecosystems. Trees in the northwest corner represent an oak-savannah prairie. A spring emerges among native grasslands and wetlands, which flow into a pond. Tanner Springs reveals the presence of the creek - the actual creek is twenty feet lower than the constructed wetland. The park attracts wildlife, as it creates a pocket of habitat in the dense urban surroundings, and osprey and heron are frequent visitors as a result. Native grasses are mowed annually.

Tanner Springs was intended to stand as a beacon of sustainability. Tanner Springs receives stormwater that falls within the curb line for the park and drains into the central pond. The pond is resupplied with city water to keep water at the desired level. Reclaimed railroad ties from nearby 19th century rail yards form the east wall of the park. Basalt Belgian blocks, which originally served as ballast on ships along the Columbia River and later cobbled the city's streets, form walkways throughout the park. A local glass art company supplied 99 translucent blue pieces of glass. They were painted by Herbert Dreiseitl with scenes of indigenous animals and are interspersed in the rails. Signage throughout the park educates visitors about sustainability efforts at the site. Calling attention to native ecosystems, reclaimed materials, and stormwater management, Tanner Springs serves as an experiment in sustainable park design and management that might likely guide park design in Portland and beyond.

Sources:
Portland Department of Parks and Recreation. Tanner Springs Park. 2011. http://www.portlandonline.com/parks/finder/index.cfm?PropertyID=1273&action=ViewPark (accessed November 8, 2011).
Strand, Tim, interview by Lindsay Nelson. Associate Landscape Designer Portland , Oregon, (October 19, 2011).

Figure 18: Tanner Springs, a constructed wetland in Downtown Portland

Education

More than 40 years ago, education was described as the greatest resource for achieving a just and ecological society [95]. Two decades later, the Brundtland Commission affirmed that educators had a crucial role to play in helping to bring about the extensive social changes necessary for sustainable development [95]. Consequently, if a park system is planning to develop a sustainability plan with real impact in its community, it has to consider ways to educate visitors in order to create or reinforce sustainability notions.

In this report, we view education to be a tool to produce behavior change towards sustainability. Throughout history, several models have tried to explain the major drivers of behavior change. The Reasonable Person Model (RPM) is a framework developed to understand contexts which "brings out the best in people," helping them to meet their needs [96]. These contexts are the basis for promoting positive behavior change, as people should feel that the changes they are making are ultimately beneficial for themselves.

RPM organizes human informational needs into three major categories. Each of these categories, which are highly interdependent, relates to different areas, which help people make reasonable decisions. The three categories are building models, being effective, and meaningful action:

Building models deals with the need to understand what happens around us. Models should match preconceived notions about the way the world works, so that people are not confused or overwhelmed by them.

Being effective is the need to feel that one is utilizing his or her knowledge and skills. People like to feel that they are competent and that the knowledge they possess and skills they have developed are useful in that precise context.

Meaningful action deals with the human desire to be needed and to make a difference. People want to feel that what they are doing is important, not only to themselves, but to those around them.

A context that enhances these three categories is more likely to bring out the best in people. Because of this, if options seeking to produce behavior change towards sustainability are planned, all three categories must be considered. For instance, any measure should consider the people for whom it is being developed and try to build on previous knowledge of this audience (which would fulfill building models and being effective) and interests (addressing meaningful action).

Baseline

Educational programs at the Metroparks are largely focused on conservation and communing with nature. The Metroparks offer programs in both natural and cultural history at a variety of levels to every age group. Educational programs come in a variety of forms, such as guided nature walks, hands on activities (e.g. gardening, prescribed burning, chemical analyses of water, and removing invasive species), lectures, and team building (e.g. canoeing, ropes courses, etc.). While they offer programs for all age groups (elementary school, family oriented programs, adult education, and programs for senior citizens), field trips for students in grades three to six are the main focus of their educational programs [97].

At Lower Huron, educational programs are passive, as there are no classrooms or dedicated buildings in which to host substantial educational events. There are labeled nature trails where visitors can use self-interpretation to individually learn about the ecosystems on the Huron River. Occasionally, however, interpreters from the nature center at nearby Oakwoods Metropark will give guided hikes at Lower Huron [97].

Lower Huron also hosts organized groups such as boy scouts and girl scouts overnight camping experiences. Lower Huron officials are also considering starting family camping at the park in the summer of 2012 [97]. This program will also include educational programming.

The Mobile Learning Center (MLC) is a valuable educational resource shared between Lower Huron and Oakwoods Metropark. Interpreters at the Oakwoods Nature Center bring the MLC to Turtle Cove during the summer months [97]. The MLC—a 48-foot trailer filled with natural and cultural history exhibits—offers children and adult visitors the opportunity to learn about nature before returning to the water slides [97]. In addition to visiting Turtle Cove, the MLC makes appearances throughout local communities and schools to educate children who may not have the opportunity to visit the Metroparks [98].

The Nature Center at Oakwoods Metropark consists of a 400-acre Nature Study Area featuring backwater trails for canoeists, five nature trails, a butterfly garden, a three-acre pond [98] and a 700-gallon turtle tank [99]. Interpreters are available to assist visitors and interpretive leaflets offer visitors the opportunity for self-guided walks along the nature trails.

The Huron-Clinton Metroparks' web page (www. metroparks.com) has informative materials about the settings of the region and environmental stewardship. This information is divided into Land, Water and Stewardship. Land is divided into Ecosystems, Plants and Wildlife. Each section has information about the topics in the area and links to places where visitors can go to investigate their interests further. Water has a similar structure, but is divided into Lakes and Rivers. It also has a Stormwater Management section explaining the parks' stormwater management programs and provides guidelines to visitors on how to protect waterways. Finally, Stewardship is divided into Ecosystem Management, where visitors can learn about different ecosystem management techniques and current restoration projects taking part at the Metroparks, and Wildlife Management and Sustainability, both of which are currently under construction [98].

Goals

- Disseminate knowledge of specific actions individuals can take towards sustainability throughout the metro Detroit region, starting with park visitors.
- Instill in park visitors a deeper understanding of why sustainability is important and its relationship to a range of areas.
- Work towards changing cultural perceptions of sustainability, specifically emphasizing the interdisciplinary nature of sustainability.
- Ensure that employees of the park understand and work towards sustainability in their everyday tasks.

Potential Options

In this section, different options on how to approach sustainability from an educational and behavior change perspective are presented and analyzed.
Signage near Sustainability Measures

This measure involves providing signage or posters near every implemented sustainability initiative explaining its impact. Commonly, this sort of signage provides information on why the measure is important and its effects. Parks are places where people can perform outdoor recreational activities; these activities are positively related to having a more pro-environmental behavior [71]. The very nature of parks presents an opportunity to take advantage of this fact and promote change to more sustainable behavior.

Behavior change theory indicates that knowledge of an issue is just one component driving change, and that information alone is very unlikely to produce behavioral change [100]. Other necessary aspects that should be considered are competence (knowing what to do to perform the behavior) and locus of control (belief that you have the ability to change a situation). These factors influence whether or not a person will engage in a specific behavior, so all of them should be considered.

Research is unclear about the impact of providing large amounts of information in behavioral change. Moreover, the effects of prompts are highly variable, from negligible to significant. Effective prompts share these characteristics: they are explicit in their message; they are delivered close to the desired behavior; the behavior is convenient to perform; they have non-demanding messages; they are salient and clearly discriminable [101].

In the context of the Metroparks, there are cases where the desired behavior is directly related to the sustainability measure (for instance, a bin for recycled material). In this case, the behavior (recycling) is supported by the measure (having recycling bins) and enhanced with proper signage. Nevertheless, there are other cases in which behaviors are not directly linked to the sustainability initiative (as in the case of solar powered devices). In these circumstances, the signage provides information.

Information alone, however, is not enough to produce behavioral change. Asking people to internalize the information can often achieve a more

Photo Source: HCMA

Figure 19: Mobile Learning Center at Lower Huron

Photo Source: Metroparks of the Toledo Area

Figure 20: Outdoor educational program at one of the Toledo Metroparks

personal result. For instance, signs near energy initiatives might ask people how they could save energy in their homes. A take-away of some kind, such as stickers reminding people to turn off the lights, can be provided alongside these initiatives.

The costs associated with this option are not negligible due to the material that has to be developed, printed, and installed. Costs can range from $100 to $1000 per sign [102]. Similar to most of the education measures proposed, evaluating the impact of this type of educational measure is difficult.

Mobile Learning Center (MLC) Lessons Expanded

Currently, Lower Huron makes an effort to casually educate local children about the natural world and conservation with its Mobile Learning Center, a mobile version of the nature center at nearby Oakwoods Metropark [97]. This format can be very effective since it is interactive and makes education and knowledge more enjoyable to children. Because the park already has the capability to operate the MLC and the means to bring this sort of informal education to children in the neighboring communities, there is a great opportunity to incorporate new lessons that teach about actions individuals can take to work towards sustainability. These lessons can include, but certainly should not be limited to, energy and water conservation, sustainable landscaping, and the importance of recycling (including what is and is not recyclable in whichever community the MLC is visiting).

The energy and water conservation lessons would teach children about 21st century energy concerns such as 'ghost power,' the electricity wasted by keeping electronics plugged in when they are not in use. Children would also learn about simple tasks such as being sure to turn the water all the way off and taking shorter showers. Although the children themselves most likely are not involved in the landscaping of their homes, it is important to include lessons on sustainable landscaping to foster appreciation for natural landscapes.

Expanding the lessons included in the MLC is a very flexible option for Lower Huron to consider. The costs would be negligible because the MLC is already in existence; the only costs associated with the project would be salary for interpreters for additional training sessions necessary to expand their lesson plans, as well as the cost of any supplies needed to demonstrate these concepts. Supplies could include diorama-style displays of natural landscapes, interactive displays showing the increased energy and water consumption associated with certain activities, or pledges for children

Figure 21: Interpretive signage at Indian Springs Metropark

Figure 22: Exploring nature at Oakwoods Metroparks

to sign indicating a change they plan to make in their lives. While some of these supplies could be expensive, they are mostly one-time purchases that can be reused. They are also optional and can be incorporated into the lessons gradually as funds become available.

Some limitations of this program include the difficulty in measuring the environmental impact of the program as well as the expertise needed to develop the curricula in the first place. It is very difficult to determine the extent of the behavioral changes made by participants in this program and even more difficult to measure the environmental impact of those changes. Because there will be some energy consumption associated with the lessons, it will be hard to tell if the net impact of the lessons will actually reduce energy consumption. Also, developing the lessons will require expertise in interactive exhibit design that HCMA may or may not have. This could be a large upfront cost that will not directly be paid back. However, because this program has the potential to reach so many children in the region, the societal benefits of the program may outweigh these upfront costs.

Educational Programs for Children

Different factors have been recognized as influencing children's attitudes towards the environment. Children who have more ecologically focused attitudes have proven to be those who periodically talk and read about the environment [103]. To be effective, an educational program should allow the children to talk, read, discuss, and learn about the environment and their relationship with it.

This measure involves creating programs for elementary school children that teach them about the importance of sustainability and steps that they can take to develop a more sustainable lifestyle. Toledo Metroparks has a program designed for cub scouts in which they deal with these issues. The program, called "Your Living World," encourages children to discover ways to lead a more sustainable lifestyle that protects the natural environment. For more details, see Appendix 10. The program is aimed at 2nd grade boys, but it can easily be modified for other groups. For Lower Huron, the programs could strongly rely on the sustainability initiatives carried out in the park and the material developed for them. For instance, if solar awnings are installed at Turtle Cove, the program should visit and teach about them. They could also visit any structural stormwater management Best Management Practices to learn about the importance of managing stormwater runoff.

One way to expand the impact of a sustainability education program would be to include parents.

Ideally, parents and children should share concepts of behavior change, which could then be applied more effectively in their households. The main cost of this option would be the salaries of those implementing the program.

Employee Roundtable

A few years ago, Toledo Metroparks carried out an employee roundtable to stimulate a discussion regarding sustainability initiatives at their parks [104]. This event was an important starting point and involved a series of meetings with different stakeholders (mainly employees) to determine which sustainability issues were most relevant to their day-to-day job functions. Having a sustainability plan with a strong foundation based on local knowledge and early employee involvement is essential.

In 2010 Huron-Clinton Metroparks carried out a similar event. During that year two meetings were held among approximately 20 employees representing the different parks, where they discussed sustainability issues for each location. In between these meetings these representatives were instructed to inform the other employees in their park or department about what was going on and ask for other ideas. All ideas were posted on a shared drive on their internal internet site, so people could add content or review content at any time. As information was accrued and organized, it was also placed on the shared site, so that anyone who was interested was able to review the new information [105].

Last year, no meetings we held. Reviving this program in a more institutionalized way could go a long way toward fostering sustainability among employees. Considering that it might be impractical to hold meetings with large numbers of employees from the 13 parks, comprehensive standardized meetings should be held in each park. After this, representatives of all the parks could compile the best initiatives raised in each park meeting. It is very important to periodically communicate with employees about the status of initiatives and to carry out a follow-up meeting at least once a year.

One potential limitation is that employees are generally not inclined to take on additional tasks that have not traditionally been part of their jobs. To minimize rejection from participants, sessions should be carried out during work time and have planned breaks. After the roundtable takes place, participants should be asked for feedback to keep them engaged. There is no major cost associated with this initiative, making it an extremely viable option that could have a great impact on sustainability in the Metroparks.

Case Study: Vondelpark Amsterdam, Netherlands

Chiesura (2004) outlines the results of a study about Vondelpark in Amsterdam. She collected survey data from visitors to the park with the purpose of answering a number of questions regarding use of the park. Chiesura (2004) determined that most park visitors utilize the park with the purpose of relaxation, but that there were significant differences in motivation for park visits between age groups. The most common emotion experienced in the park was freedom when compared with 'unity with myself,' 'unity with nature,' 'luck,' 'adventure,' and 'happiness.' After analyzing the results of the survey data, the following things were deemed beneficial strategies for developing parks that are more in line with the vision of a sustainable city: public involvement, citizens' participation, and a qualitative appraisal of needs and interests.

Source:
Chiesura, A. "The role of urban parks for the sustainable city." Landscape and Urban Planning. 68(2004): 129-138.

Table 5: Assessment Criteria

Area	Option	Cost[1]	Site Appropriateness[2]	Economic Benefits[3]	Social Benefits[4]	Environmental Benefits[5]	Limitations/Challenges
		$ (low cost) to $$$ (high cost)	+ (low) to +++ (high)	0, + (low) to +++ (high)	0, + (low) to +++ (high)	0, + (low) to +++ (high)	Notes
Education	Signage or posters near sustainability measures	$$	+++	0	++	+	Difficult to measure impact (very releavant in this case, where outcomes vary widely).
Education	Teach children about sustainability	$	+++	0	++	++	Difficult to measure impact.
Education	Employee roundtable	$	+++	+ (indirect)	+++	+++ (indirect)	Employees schedules are hard to work with.
Education	Nature cart lessons expanded	$	+++	0	+++	+	Difficult to measure impact; expertise needed to develop demonstrations.
Energy	Wind turbine	$$$	+	0	++	++	Low and variable wind speeds.
Energy	Solar awning at Turtle Cove	$$$	++	++	+++	+++	High upfront cost.
Energy	Energy efficient office appliances	$-$$	+++	+	+	++	Requires behavior change to optimize outcome.
Energy	High efficiency indoor lighting	$-$$	+++	++	+	+++	Modest capital cost.
Energy	Lighting controls	$	+++	+++	+	+++	Requires technical expertise to properly position and install.
Energy	Join DTE GreenCurrents program	$-$$	+++	0	++	++	Solely a cost - will never pay back for HCMA.
Energy	Geothermal heating/cooling system	$$$	+	MBD	++	MBD	Requires advanced technical analysis; determination of feasibility.
Energy	Radiant heating	$$	MBD	++	+	++	Requires advanced technical analysis; determination of feasibility.
Energy	Install energy efficient windows	$$	++	+	+	++	Very expensive and difficult to install in existing facilities.
Stormwater	Bioretention	$	+++	++	++	+++	High maintenance until vegetation is established.
Stormwater	Detention basin	$$	++	+	++	+++	Good peak rate performance, but depending on type might have low water quality benefits; relatively high maintenance required.
Stormwater	Vegetated roof	$$	++	+	+++	+++	High maintenance until vegetation is established; careful design and construction required.
Stormwater	Planter boxes	$	++	0	+	+	Limited stormwater benefits; relatively high cost compared to other BMPs; relatively high maintenance.
Stormwater	Cisterns	$	+++	++	+	++	Manages only small storm events; requires use for stored water.
Stormwater	Rain barrels	$	+++	++	+	++	Manages only small storm events; requires use for stored water.
Stormwater	Constructed filter	$$	++	+	0	+++	Low stormwater benefits, unless designed for infiltration; relatively high cost and high level of maintenance.
Stormwater	Vegetated filter strip	$	+++	++	+	+++	Should be used in conjunction with other BMPs for maximum stormwater benefits.
Stormwater	Riparian buffer restoration	$	+++	++	++	+++	
Stormwater	Native revegetation	$	+++	++	++	+++	
Stormwater	Vegetated swale	$	+++	++	++	++	Limited volume control, unless designed for infiltration.
Stormwater	Level spreader	$	+++	++	+	+	Low stormwater benefits unless used with other BMPs.
Stormwater	Pervious pavement	$$$	++	0	++	+++	Not suited for all uses; requires extensive maintenance.
Waste	Composting	$-$$	+++	+	++	+++	
Waste	Waste reduction policy	$	+++	++	++	+++	
Waste	Recycling system	$$	++	0	+++	++	Hard to educate one-time visitors; difficult to create a behavior change, has to be easy to participate.
Waste	Recycling at events	$	+++	0	++	+	Does not affect a lot of people.
Waste	Solar compactor	$$	++	0	+	+	Cleanness of the site is a challenge; it is not an attraction for educational purposes.
Water	Waterless urinals	$$	+++	+++	++	+++	Initial retrofit installation costs may be higher and maintenance staff will need to be trained to properly care for them.
Water	Low-flow urinals and toilets	$$	+++	+++	++	++	May not make sense if toilets are already up to newest plumbing code.
Water	Pool covers	$$	++	+++	+	++	May be difficult to create pool cover based on odd shape of pool.
Water	Automatic faucets	$$	+++	++	++	++	May actually increase water usage due to timer mismanagment.
Water	Faucet aerators	$	+++	+++	+	+++	No major limitations or challenges; most cost-effective measure.
Water	Centrally controlled irrigation system	$$$	+++	+++	++	+++	High investment but high payback too; should consult manufacturer.
Water	Water conservation measures at Turtle Cove	$$	+++	++	+	+++	

Recommendations

The options laid out in the previous section provide a range of potential strategies for addressing sustainability issues. The energy options tend to focus on improving energy efficiency and the potential for renewable energy. Similarly, the water-related options focus primarily on reducing water consumption through efficiency measures. For stormwater management, the options offer a number of structural best management practices to capture and treat polluted stormwater, reducing harmful discharge to the Huron River. In terms of waste, the options target overall waste reduction and augmenting recycling at Lower Huron. The education options offer initiatives for involving park employees in sustainability as well as broader outreach efforts to educate visitors about what HCMP is doing to address sustainability and how they can incorporate certain practices into their own lives. Together, the recommendations drawn from these options offer a multi-faceted approach to enhancing sustainability in a number of ways.

When considering these recommendations, it is important to evaluate their potential at Lower Huron in several ways. The options matrix in the previous section provides an overview of the relative merits and drawbacks of each option. Beyond their individual potential, however, it is also critical to consider the connections and interdependence between options and areas of sustainability. Options that appear to address certain issues (such as water pollution) within a specific area (such as stormwater) often have implications for other areas that have not been determined or explicitly addressed. Conversely, options that may only be moderately beneficial for addressing a specific area may have ancillary benefits in another area. While the discussions of each option attempt to capture some of these connections, they do not pretend to be comprehensive. Rather, the goal is to provide a framework for thinking about these and future efforts to enhance sustainability.

Just as it is important to consider how the recommendations connect to the other areas discussed throughout the report, it is also essential to consider their relationship to areas that were not mentioned. Sustainability is a broad, wide-ranging concept that encapsulates the entire realm in which organizations operate. Truly enhancing sustainability means incorporating an equally broad perspective when critically assessing options. This report provides in-depth discussions of energy, water, stormwater management, waste, and education at Lower Huron in terms of current status and potential improvements. These areas represent a small subset of the vast issues affecting sustainability at the park, however, and do not specifically aim to address issues surrounding a number of other areas such as wildlife, habitat, biodiversity, air quality, and many others. A number of recommendations may have implications for these areas that should not be overlooked. For example, vegetated filter strips, which capitalize on plants' natural ability to remove toxins from runoff, have positive impacts on the aquatic ecosystems into which the water flows.

Some options are in fact quite limited in their purview, and only directly influence one issue or area. Installing faucet aerators, for example, will not necessarily have profound, direct impacts on areas other than water. Similarly, the impacts of incorporating lighting controls into the buildings' lighting systems will almost exclusively be on energy consumption. A lack of clear connections to other areas does not necessarily reduce the validity or importance of a particular option, and the identified benefits can certainly still be realized. The importance lies in identifying and understanding the connections, not only in the number and reach of the connections themselves. Options that are limited in the range of their impact may in fact still be quite effective and appealing. Similarly, options that appear to touch on a broad range of areas may be impractical for other reasons, such as cost or site appropriateness. Thus, considering the connections between options and areas provides another tool for assessing options and should not in itself be the ultimate determinant.

Finally, viewing sustainability as an end goal is not the most appropriate approach for HCMA to take when tackling these issues. The title of this report, "Enhancing Sustainability at Lower Huron Metropark," more accurately reflects the direction in which HCMA strives to take its parks. Improving the overall sustainability at the parks by moving towards more environmentally and socially conscious practices and perspectives is entirely attainable, and HCMA has in fact already demonstrated substantial progress in this direction. Indeed, enhancing sustainability is an iterative process that must not be based on an end goal but rather on an institutional desire for the parks to continue to operate more in harmony with society and the environment. If viewed in this light, the following list of recommendations can simultaneously serve as a framework for moving forward while directly enhancing the sustainability of Lower Huron Metropark.

Based on a holistic approach and the considerations outlined in the options section, a number of recommendations have been identified. Each option was evaluated based on the economic, social and environmental benefits it offered, as well as the appropriateness of pursuing it in the context of LH and the magnitude of the challenges to implementation. Those that offered substantial benefits and whose challenges were deemed to be manageable were recommended. Most of the recommendations have short- to medium-term economic benefits for HCMA. The recommendation with the longest payback period is the proposal for a solar awning at Turtle Cove, which is estimated to pay back in approximately 18 years if fully financed by HCMA. Some of the recommendations, however, do not offer financial benefits and therefore will only be a cost to HCMA. The recommendations that will not pay back were still chosen because of the relatively low cost and high social and environmental benefits they offered. Enrolling in DTE's GreenCurrents program, for instance, will not provide economic gains, but the small investment will help finance renewable energy projects in the region, and is a highly visible initiative.

The following sections list the recommendations by the organizational branch to which they are most applicable (administration; interpretive services; maintenance and operations; and planning). Where necessary, more information about particular options can be found in the preceding Options sections as well as appendices.

Administration

Establish Employee Roundtable

Involving employees in developing and implementing sustainability initiatives is critical for maintaining more environmentally friendly operations. Establishing a framework for employees to contribute ideas and raise issues is an important strategy for embedding sustainability within the organization. Ideally, employees at all the parks should get together regularly (perhaps monthly) to generate ideas, set goals, and discuss progress.

Given the large area over which the Metroparks are dispersed, holding this type of large meeting on a regular basis may be impractical. Instead, it would still be beneficial to hold regular meetings among each park's employees to discuss similar goals and targets. Annually or semi-annually, representatives from each park should then meet at the central location to compile their work and inform HCMA-wide policies and objectives.

Join DTE GreenCurrents

DTE's GreenCurrents program offers customers the opportunity to support Michigan-based renewable energy projects. Customers can choose one of two enrollment options. HCMA can either match 100 percent of their consumption with a pledge of 2 cents per kWh purchased, or "blocks" of 1,000 kWh for $20 per month. Both options support renewable energy in the region. While the GreenCurrents program does not offer any financial benefits to HCMA, it does provide an opportunity to help increase local renewable energy generation.

Develop Waste Reduction Policy

In order to address waste issues throughout the park, HCMA should develop a waste reduction policy for Lower Huron. Doing so requires establishing a recycling policy and modifying purchasing policies.

Implement Recycling at Events

The initiation of a recycling system at special events in the park has the potential to impact the community's behavior and awareness of sustainability. Although the absolute and direct environmental benefits are low compared with other measures, the main benefits are found in instituting behavioral shifts towards sustainability.

Increase Data Tracking

One of the largest inhibitors to developing options and making recommendations was the availability of relevant data. Specifically, data were sparse or difficult to obtain regarding some aspects of energy use habits and consumption, water use habits, and waste patterns. While some of these data are difficult to track, others – such as monthly energy and water use – are readily available in monthly utility bills. Compiling these data and maintaining a database is a helpful way to learn about and monitor use patterns, as well as to identify possible anomalies. While establishing such a system may be a daunting task, maintaining it is quite simple once it has been developed. Data are a critical component of developing options and making recommendations, and should be tracked and collected where feasible. Toledo Metroparks started collecting their energy consumption data using a very simple and effective Excel spreadsheet and it has helped them save a significant amount water and energy by noticing and treating various usage trends [104].

Interpretive Services

Install Signage Highlighting Sustainability Measures

Many of the recommended sustainability measures will be visible to park visitors. This exposure presents an opportunity to educate visitors about the benefits of the various measures, and provides the potential for some visitors to adopt certain practices in their own lives. To help realize this potential, it is important to highlight the sustainability initiatives where possible. Signage providing an overview of the measure and its benefits can help educate visitors about the importance of sustainable practices and some of the options available.

Expand Educational Programs for Children

Engaging elementary school-aged children in active learning about ways that they can incorporate sustainable practices into their own lives will have a broader impact on the environmental impact of the community at large. The particular program that should be used is a program called "Your Living World" that is currently in use at the Toledo Metroparks. The program targets 2nd grade boys, but can be adapted to other age groups and applied to girls and co-ed groups as well. "Your Living World" encourages children to discover ways to lead a more sustainable lifestyle with a focus on protecting the natural environment. For more information, see Appendix 10.

Expand Mobile Learning Center

The mobile learning center that Lower Huron currently operates offers an excellent platform for increasing awareness of sustainability issues among local children. Expanding the program, which currently focuses on natural and cultural history, would give more children access to this wonderful resource. Given the increased emphasis on sustainability at the park, the mobile learning center should provide basic information about many of the related issues such as energy and water conservation, sustainable landscape design and stormwater management, and the importance of recycling.

Maintenance and Operations

Install Water Efficiency Measures

Many of the most cost-effective ways to reduce water consumption are through various efficiency measures, primarily in the restrooms. These include:

Faucet Aerators

By installing aerators on restroom faucets, LH can reduce faucet water use by 30 percent at very little cost (typical units, designed to reduce flow to 1 gallon per minute, cost approximately $4.00 each).

Automatic Faucets

Automated controls for faucets can significantly lower water consumption and potentially eliminate bacteria transmission from surfaces. Automatic controls can be installed in either new construction or retrofitted on many types of existing fixtures. While initial costs may be expensive, some facilities have seen significant water savings, which make up for these costs.

Waterless Urinals and Low-Flow Urinals & Toilets

Where feasible, replacing indoor urinals with waterless urinals will offer the largest cost and water savings. Outdoor urinals should be replaced with low-flow units to reduce water consumption while avoiding additional maintenance costs. Additionally, all toilets should be replaced with low-flow units depending on the consumption specifications of the existing units.

Install Energy Efficiency Measures

Similarly to water, many of the most cost-effective ways to reduce energy consumption are through reducing demand by installing a range of efficiency measures. These include:

High efficiency Indoor Lighting

One way to achieve substantial energy savings is through more efficient lighting. Most incandescent bulbs can be profitably replaced by compact fluorescent lamps (CFLs), and more energy efficient T8 fluorescent tube lamps can replace T12 lamps. Although T5 lamps are significantly more expensive, they may become financially viable as costs decrease.

Lighting Controls

Advanced lighting controls are essential for achieving the greatest savings from high efficiency lighting. The controls include light sensors, occupancy sensors, timers, and dimmers. In general, timers and dimmers can be installed relatively easily and at low cost. Depending on the type of system and the lighting system it is being applied to, light and occupancy sensors may require rewiring, which substantially increases cost. At minimum, the low cost options are recommended. HCMA's engineers should be consulted to determine the cost of installing more advanced options in specific facilities.

Energy Efficient Office Appliances

While office appliances are only responsible for a tiny portion of electricity consumption at Lower Huron, they present a low cost opportunity to save money and energy. One easy step is to amend the purchasing policy for office equipment to require all new appliances purchased to be Energy Star-certified. Existing appliances should be replaced at end of life, and not discarded prematurely. Additionally, all office computers should be configured for maximum energy efficiency.

Develop a Recycling System

A single stream recycling system should be implemented in the park. Recycling bins should be located next to regular bins to maximize usage. Visitors' education has to be emphasized, as their behavior is essential for the program to be effective. Even though a system like this does not pay for itself, it has a series of environmental and social benefits. It may be advisable to start with a pilot at Turtle Cove, an area with a high density of visitors.

Implement Composting Program

A large proportion of the waste generated at Lower Huron is organic waste. A composting program would eliminate the need to haul this waste to a landfill while potentially providing useful fertilizer generated on-site. The cost of establishing and maintaining such a program is highly variable; nevertheless, the potential of a composting program at Lower Huron is promising.

Install Pool Covers

Pool covers should be purchased for Turtle Cove to prevent unnecessary heat and water loss when the pools are not in use. Fitting a cover to the rectangular pool will be straightforward, inexpensive, and therefore cost-effective; doing so for the lazy river and other areas of irregular shape, however, will be more costly. Depending on the cost of having these specialized covers made, covering this portion may or may not be cost-effective.

Incorporate Centrally Controlled Irrigation

A centrally controlled irrigation system allows for substantial water savings by allowing for optimal irrigation controlled from a central computer. These systems easily account for time of day, weather and other factors, and have resulted in enormous savings when properly implemented. If the golf course at Lower Huron does not remain open, however, irrigation will decrease dramatically, and this type of system may no longer be needed.

Explore Further Water Conservation Measures at Turtle Cove

Due to the majority of utility water being used by Turtle Cove, further water conservation measures should be closely examined. While no specific recommendations were made in this report, examples of best practices are included. Implementation of various conservation measures can significantly reduce water usage and water costs.

Planning

Implement Bioretention BMPs

Bioretention is appropriate for the site because there is so much open space to work to implement rain gardens at a variety of scales. Signage should be incorporated into the design to educate visitors on the ecological importance of rain gardens and how they can be incorporated into their own landscapes at home.

Install Rain Barrels and Cisterns

Although the detention pond near Turtle Cove collects runoff, additional runoff from roofs could be collected in rain barrels and cisterns. Although additional irrigation water may not be needed, these could both serve as low-cost educational tools that visitors could implement at their homes.

Expand Use of Native Revegetation

Many of the previously-mown areas of Lower Huron have been transformed into no-mow areas. This initiative should be further expanded to include additional areas within the park and involve actual planting of native woodland and prairie species in order to support healthy habitat and ecological function throughout the landscape.

Enhance Existing Vegetated Swales

Many of the parking lots at Lower Huron have turf swales in place to move runoff from impervious surfaces. These existing swales can be more effective at treating polluted runoff and slowing flow before entering the Huron River if they are vegetated with natural plants. Bridges across these swales will improve pedestrian access to different parts of the park.

Install Vegetated Roofs

Green roofs are a more expensive option in terms of structural BMPs, and are not entirely necessary at Lower Huron because runoff can be collected within the landscape due to the large amount of natural area. However, the educational component that is associated with green roofs make them a viable option for Lower Huron and will bolster the park's image as a leader in sustainability.

Install Solar Awning

Given the large electricity needs of Turtle Cove in the summer, the favorable solar conditions at Lower Huron during the summer, and complaints from visitors about standing in line in uncomfortable heat, a solar awning at Turtle Cove is financially viable and desirable.

Investigate Potential for Geothermal System

The potential exists for geothermal heating and cooling at Lower Huron. While these systems are expensive to install, they can have very short payback periods depending on the specific geothermal conditions at the site. Given regional projects under way or currently operating, Lower Huron is good candidate for further investigation. Engineering professionals in the field should be consulted to determine the specific payback time at the park.

Conclusion

Addressing sustainability issues at parks is becoming a growing trend with increasing urgency. Major park systems in the United States are changing their traditional operations in favor of best management practices to reduce environmental impact. Some parks systems highlighted in this report are Portland Parks and Recreation, Yellowstone National Park, and Toledo Metroparks. In addition to providing social services to their communities, these parks systems have reduced their environmental footprints by implementing sustainability initiatives. This report addresses why sustainability is important for HCMA and presents a plan for enhancing sustainability at Lower Huron Metropark. This sustainability plan is intended to serve as a model for enhancing sustainability at other parks, as well – Lower Huron was selected because of the high number of visitors and the broad and varied opportunities it offered for enhancing sustainability. Many of the initiatives recommended for Lower Huron will also be applicable at other parks.

Energy consumption at Lower Huron is a major cause of environmental impact, and one that can be significantly reduced through a number of cost-effective measures. The park currently lacks a comprehensive waste management plan that incorporates recycling, resulting in significant waste of recyclable materials. Numerous opportunities exist to reduce water consumption, and polluted stormwater runoff currently flows into the Huron River unmitigated. Finally, implementing some of the recommended initiatives offers new opportunities to enhance the educational experience at Lower Huron,

Figure 21: Proposed green roof and recycling

Figure 22 (above): Proposed solar awning at Turtle Cove
Figure 23 (below): Proposed vegetated swale and bridge

particularly with respect to sustainability. While important, implementing technological solutions is only a portion of developing more sustainable operations. In this light, special attention has been paid to the importance of education and fostering environmentally conscious behavior.

It is important to understand that sustainability in the areas discussed is not limited to the proposed recommendations. These recommendations should be taken as a baseline for working toward sustainability at Lower Huron and across the Metroparks. Sustainability projects have several implications for HCMA. This report focused on five key areas of sustainability, but additional impacts should be considered and addressed (e.g. transportation, biodiversity, etc.). By implementing the proposed recommendations, HCMA will not only improve sustainability at their parks but will also serve as a model for other parks systems throughout the region. Research indicates that people and organizations follow and model each other in their practices and policies, especially in conditions of uncertainty [106]. As sustainability is a new and uncertain concept for many organizations, HCMA can be a model for other parks in the region by moving forward on many of these issues.

The Metroparks were founded with a dual mission to preserve a threatened landscape and to provide designated space for recreation and relaxation. For over half a century, they have successfully increased access to the outdoors for millions across Southeast Michigan. As the ability to recognize environmental issues and identify solutions evolves, so, too, can the Huron-Clinton Metroparks evolve in fulfilling its mission. By pursuing new ways to simultaneously reduce environmental impact and enhance visitors' experiences at the parks, the HCMA can remain a national leader in providing high quality outdoor recreation to residents of metropolitan areas across the country. The Metroparks' story is an inspiring one that emerged from the darkest days of the Great Depression; the next chapter can follow suit by ensuring that the land the parks preserve is healthy and vibrant for future generations.

Additional Resources

Energy

Nelson, D. (2010). Energy Efficient Lighting. Retrieved October 4, 2011, from Whole Building Design Guide: http://www.wbdg.org/resources/efficientlighting.php.

This article provides a comprehensive analysis of energy efficient lighting in buildings. It compares different lighting systems such as CFLs, LEDs, HIDs and luminaries. It mentions the environmental impacts, energy savings and the barriers of existing technologies. It also talks about applicability and where to install each system.

U.S. Department of Energy. Energy Savers. Retrieved February 8, 2012, from Energy Savers: http://www.energysavers.gov/

This website provides the basis to understand the underlying aspects of energy issues, which is relevant to push change. The DOE Energy Savers website is a great resource to learn more about all energy issues including appliances and electronics, electricity, heating and cooling, landscaping, insulation, lighting, and water heating.

Lighting Control Energy Savings Calculator
http://www.lightingcontrols.com/Utility/Payback/PaybackAnalysis.htm

Efficient Window Collaborative Window Selection Tool
http://www.efficientwindows.org/selection.cfm

Pool Energy Use Calculator, Washington State University Energy Extension Program
http://energyexperts.org/CalculatorsTools/PoolEnergyUseCalculator.aspx

Energy Star Portfolio Manager
http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

The Portfolio Manager is an interactive energy management tool that allows for tracking and assessing of energy and water consumption across an entire portfolio of buildings.

Water

Faucet and Urinal Savings Calculators
http://www1.eere.energy.gov/femp/technologies/eep_eccalculators.html

Sloan Water Savings Calculator
http://www.sloanvalve.com/Water_Savings_Calculators.aspx

Waste Management

Liebl, D. S. (1998). Waste Reduction for State Parks. Madison, WI: University of Wisconsin

This article discusses waste environmental impacts, waste reduction strategies and benefits of waste reduction for state parks. It talks about the importance of regulatory practices and emphasizes the relevance of controlling upstream waste instead of downstream. State park waste is divided into different categories: office, transportation, packaging and food. The article discusses how to manage and reduce each waste. The importance of different tools such as recycling or sustainable products purchases is also discussed.

EPA. Recycle on the Go. Retrieved October 6, 2011, from EPA: http://www.epa.gov/epawaste/conserve/rrr/rogo/index.htm

This website is a comprehensive guideline prepared by EPA on how to how to set up a recycle program in public locations. It is divided in different steps and has a section especially dedicated to parks.

Inform Inc. (2009). Waste Reduction Tips for the Office. Retrieved from Inform: http://www.informinc.org/fact_office.php

This article provides waste reduction tips for offices. The main strategies discussed here are paper reduction, extending product life and switching from disposable to reusable products.

Stormwater Management

Southeast Michigan Council of Governments. (2008). Low Impact Development Manual for Michigan: A Design Guide for Implementors and Reviewers. Detroit, MI: SEMCOG.

This manual provides communities, agencies, builders, developers, and the public guidelines on how to apply Low Impact Development (LID) to new, existing, and redevelopment sites. The manual provides strategies for structural and nonstructural best management practices (BMPs). The manual provides Michigan case studies and also recommends materials and plants for BMPs.

Echols, S., & Pennypacker, E. (2008). From Stormwater Management to Artful Rainwater Design. Landscape Journal, 27(2), 268-290.
This article addresses the need to not only responsibly manage stormwater, but do so in a way that draws attention to stormwater management in order to educate the public. The authors evaluate 20 case studies that serve as exemplary designs for artful rainwater design. Artful rainwater design is defined as, "effective stormwater management as art form." The authors draw five amenity goals from these case studies: education, recreation, safety, public relations, and aesthetic richness.

EPA Stormwater Program. Office of Wastewater Management. Retrieved from EPA: http://cfpub.epa.gov/npdes/home.cfm?program_id=6

This website provides information about the National Pollution Discharge Elimination System stormwater program. The site provides links to general information on stormwater and links specific to municipal, industrial, and construction activities.

Walsh C.J. et al. (2005). The urban stream syndrome: Current knowledge and the search for a cure. Journal of the North American Benthological Society. 24(3): 706–723.
This article discusses the idea of the 'urban stream syndrome,' which describes the degradation of natural waterways draining urbanized land. The authors review literature to describe the symptoms of the urban stream syndrome, mechanisms driving the syndrome, and identify appropriate goals and methods for ecological restoration of degraded streams.

Education

Kaplan, S. & Kaplan, R. (2008). Bringing Out the Best in People: a Psychological Perspective. Conservation Biology. 22(4): 826–829.

This article presents the Reasonable Person Model (RPM), which is a framework developed to understand contexts which bring out the best of people, which is important to promote positive behavior change. RPM organizes human informational needs into three major categories. Each of these categories is related to different areas which help humans to achieve reasonableness. Despite this, the three categories are highly interdependent. They are building models, being effective and meaningful action.

Hines, J. M., H. R. Hungerford and A. N. Tomera (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. Journal of Environmental Education. 18(2): 1-8.

This article presents a meta-analysis which examines which factors are more influential in motivating individuals in taking responsible environmental action. It establishes that information by itself is not enough to produce behavior change.

Katzev, R. D. & T. R. Johnson (1987). Antecedent communications. Prompts. (Chapter 2). Promoting Energy Conservation. An Analysis of Behavioral Research

This article discusses the potential of prompts in behavior change and provides a set of guidelines on how to make them more effective. Even though the effectiveness of prompts varies widely, those ones that have worked share some characteristics: they are explicit in their message; they are delivered close to the desired behavior; the behavior should be convenient to perform; they have non-demanding messages; they are salient and clearly discriminable.

Sustainability

American Society of Landscape Architects, Lady Bird Johnson Wildflower Center at the University of Texas, Austin, United States Botanic Garden. (2009). Sustainable Sites Initiative Guidelines and

Performance Benchmarks. http://www.sustainablesites.org/

The Sustainable Sites initiative aims to transform land development and management practices and make ecosystem services a priority in land use change. The Sustainable Sites Initiative's central messages is that, "any landscape... holds the potential both to improve and to regenerate the natural benefits and services provided by ecosystems in their undeveloped state." This handbook provides guidelines and performance benchmarks for sustainable land use, from site selection, design, and construction.

U.S. Green Building Council. (2009) LEED 2009 for Existing Buildings: Operations and Maintenance. Retrieved from USGBC: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=221
Taking a holistic, integrated approach to sustainability issues in the built environment is critical. The LEED 2009 Existing Buildings: Operations and Maintenance rating system is a great resource for the HCMA in exploring various initiatives within energy, materials, water efficiency, site planning, and indoor air quality. While Lower Huron will likely not be pursuing any LEED certifications, this guide can be very beneficial to understanding the deeper importance and implementation of many sustainability issues regardless of whether they were discussed in the report.

Cranz, G, and M Boland. "Defining the Sustainable Park: A Fifth Model for Urban Parks." Landscape Journal 23 (2004): 102-20.

Traditionally, urban parks had passed through four distinct stages in their evolution to serve the ever-changing needs of local residents. In this paper, the authors envision a fifth type of urban park, which may have already begun to emerge. The sustainable park, as it is called, is designed to promote human and ecological health and help meet societal goals of sustainability. More broadly, sustainable parks emphasize ecological value while incorporating social value in harmony with, rather than in opposition to, the natural aspects.

Sustainable parks are based largely on three unique principles among parks. First, they strive for resource self-sufficiency, aimed at minimizing the material inputs to the parks. Second, they are often well integrated into the urban fabric of the surrounding area, rather than attempting to be separate from it. This positions them to address urban problems beyond the parks associated with the lack of green and open space. Third, the aesthetic aspects of the parks tend to incorporate and emphasize the existing natural and ecological components rather than altering or replacing them. In many ways, sustainable parks deliver the socially beneficial services of traditional parks while also serving to enhance the surrounding ecology. This paper discusses the characteristics and merits of sustainable parks.

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Recommendations

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Appendix 1: Toledo Metroparks' Energy Savings Checklist

- During the next staff meeting department supervisors should use the following checklist of things to do to achieve the five percent electrical use reductions. Please use the suggestions that are applicable to your department. Please contact other departments if you need help to achieve results.

- Turn off your computer, printer and copier at the end of the day. Switching off your computer extends its lifetime, contrary to some misconceptions. Leaving a computer running the whole year will cost you more than 1,000 kWh/y, or almost as much as the total electricity consumption of a high-efficiency household. Activate your computer's sleep setting and don't use screensavers as they prevent electricity savings.

- Turn off all non-essential equipment and appliances by their power chord during three day holiday weekends. Turn them back on at the end of the weekend.

- Use one large electrical power strip for your computer, scanner, printer, monitor, and speakers. Switch off the power strip when equipment is not in use. This is a practical way to cut 200 kWh/y or more of power standby losses.

- Are there items that could be unplugged when not in use? Unplug your cell phone charger if unused. Consider turning off a clock on your desk if you have one on your computer.

- Minimize printing from your computer unless absolutely necessary. Think before you print/copy and discourage the use of paper copies in meetings unless necessary.

- Turn off fluorescent lights if you are going to be gone for 45 minutes or longer. Turn off incandescent lights regardless of the length of time you will be gone. Example: Turn off lights in offices and conference rooms.

- Provide task lighting over desks, tool benches, etc., so that activities can be carried on without illuminating entire rooms.

- Use cold water instead of hot whenever possible. The district has both electric and gas hot water heaters.

- Ask for a volunteer or assign a person to follow up on electricity issues at each staff meeting.

- Contact other departments or divisions to obtain help to accomplish electrical savings issues.

- If you have unneeded light or excessive lights turn them off. Making use of natural light that is available.

- Turn the building thermostat for your air conditioner up a degree or two or your heater down a degree or two and see if you still can be comfortable. Turn thermostats down in the evening if they are not programmable or if the programming has been over-ridden during the day. Furnaces and air conditioners use electricity to run blowers. Ensure programmable thermostats are programmed to adjust the temperature higher or lower as needed when employees arrive and leave for the day.

- Move furniture placed in front of air vents that reduce air flow for heating and cooling.

- Check to determine appropriate insulation in ceilings, walls, and floors over unconditioned crawl spaces. Proper insulation and ventilation is the first and most important energy saving measure. It can reduce heating needs to one-third (about 50 kWh heat/m2/y) or even one tenth (less than 15 kWh heat/m2/y) of what an average house would need.

- Check some of the major air leakage areas in your buildings, including: air ducts; window sashes and frames; plumbing utilities and wall penetrations; furnace flues; attic entrances; wall outlets; and recessed light fixtures.

- Make repairs to plug the air leaks by caulking, weather stripping, or using plastic covers. Weather strip and caulk around all entrance doors and windows to limit air leaks that could account for 15-30 percent of heating and cooling energy requirements.

- Make sure your buildings' fireplace has tight fitting dampers that can be closed when the fireplace is not in use.

- Reduce your water heating bill by 10 percent by lowering the water heater temperature from 140°F to 120°F.

- Clean your light fixtures regularly to allow more light to be seen.

- Change or clean your air conditioner and furnace filters regularly to maximize the unit's cooling and heating potential.

- Check your air conditioner to determine if it has the correct refrigerant charge, the fan works properly, compressor works properly and the coils are clean.

- If you have a refrigerator turn up the temperature, keep the unit away from the wall, keeping the coils clean. Cleaning the coils may require removing a portion of the lower back of the unit.

- Buy a laptop instead of a desktop, if practical. It consumes five times less electricity. If you buy a desktop, get an LCD screen instead of an outdated CRT.

- Replacing appliances and cooling and heating equipment with EnergyStar-rated appliances and equipment can also lower our electrical bills.

Appendix 2: Assumptions About Incomplete Data

Generalizing Months:

- If the start date of the bill is between the 1st and the 20th of the month, the generalized month will be the start month of the bill. (See one exception to this rule in the electricity spreadsheet)
- If the start date is between the 21st and the 31st of the month, the generalized month will be the end month of the bill.
- If the bill spans more than one month (using the rules outlined above to define months), it is split into sub-bills for each month contained within the bill (rules below about how data for these bills are handled).

Multi-Month Bills:

- Cost and consumption are split evenly between the months associated with the bill.

Service Fee Calculations:

- For the electricity and gas spreadsheets, it is assumed that for bills where consumption is not equal to 0:

Service fees = total fees – (rate*consumption)

- Rates were not available for the water spreadsheet, so this calculation was not done.

Interpolation:

- When data for a given meter are missing for a given month, a cost and consumption value is interpolated by taking the average of the values for neighboring months for the same meter.
- When data for more than one month in a row are missing, the averaged value will be applied to all consecutive months without data.
- When data for months at the beginning or end of the year are missing, a wrap-around will occur (i.e. If January and December are missing, interpolation will be based on values for February and November)
- For electricity data, cost will be determined by the most prevalent rate for that meter, multiplying the interpolated consumption by that rate to determine the cost for that month.
- For gas data, cost will be interpolated just as consumption is using the cost of consumption (not additional fees) for the surrounding two months. Rate will be determined by dividing cost by consumption.
- For water data, cost will be interpolated just as consumption is. Consumption interpolation will be done using the pre-conversion consumption values. Conversion factor will then be applied to interpolated value.
- If consumption is interpolated to 0, service fees equal to that of other months on that meter with 0 consumption will be applied. Otherwise, no service fees will be applied.

Appendix 3: Wind Energy Calculations and Assumptions

Formula: (0.5) x (air density) x (swept area) x (wind velocity^3)			
Constant:	0.5		
Air density:	1.23	kg/cubic meter (at sea level)	
Swept area:	290	m^2	
Wind velocity:	4.75	m/s	
Available energy:	19114	Watts	
Total:		**19**	**kW**
Capacity factor:	0.25		
Hours/Month:	730.5		
Total:		**3491**	**kWh/month**
Current cost:	$0.11	per kWh	
Monthly savings:		**$383.98**	
Total:		**$4,607.74**	**Yearly savings**
Estimated cost of project:		$200,000.00	
Discount rate:	5%		
Payback time:		**1489**	**Years**
Net Present Value:		**$92,154.83**	
REPI (incentive)	$0.022	per kWh	
Total:		**$921.55**	**per year**

Appendix 4: Life Cycle Cost Comparison of Selected Bulbs

Bulb	Watts	Lumens	Cost/ kWh ($)	Energy Cost/Yr ($)	Average Rated Life (hrs)	Bulbs Needed Per Year	Purchase Price ($)	Cost of Bulbs Per Year ($)	Total Cost Per Year ($)	Comparative Savings Per Year ($)	Payback Period (Years)	Annual kWh	Annual Energy Savings (kWh)
Incandescent	75	1500	0.11	17.16	1500	1.39	1.17	1.62	18.78	0.00		156	
CFL	18	1200	0.11	4.12	12000	0.17	1.99	0.34	4.46	14.32	0.14	37.44	118.56
Incandescent	100	1440	0.11	22.88	1500	1.39	1.17	1.62	24.50	0.00		208	
CFL	27	1850	0.11	6.18	8000	0.26	8.79	2.29	8.46	16.04	0.55	56.16	151.84
T12	40	2970	0.11	9.15	20000	0.10	3.99	0.41	9.57	0.00		83.2	
T8	32	2800	0.11	7.32	30000	0.07	3.29	0.23	7.55	2.02	1.63	66.56	16.64
T5	28	2750	0.11	6.41	20000	0.10	16.39	1.70	8.11	1.46	11.26	58.24	8.32

Notes:
Model adapted from West Virginia Department of Environmental Protection - http://www.dep.wv.gov/daq/EnergyEfficiency/Pages/LightbulbComparisonSpreadsheet.aspx
Assume 260 work days per year
Assume light in use 8 hours per day

Assume price of electricity is $0.11/kWh
Assume incandescent is 75 watt, A19 soft white bulb by Philips (SKU: 168799) as shown on bulbs.com
Assume CFL is 18 watt, Philips (SKU: 227850) as shown on bulbs.com
Assume incandescent is 100 watt, A19 soft white bulb by Philips (SKU: 168625) as shown on bulbs.com
Assume CFL is 27 watt, cool white bulb by Philips (SKU: 147884) as shown on bulbs.com
Assume 40 Watt, 48 Inch T12 Cool White Fluorescent Bulb (SKU: 142638) by Philips Lighting Company
Assume 32 Watt, 48 Inch T8 Cool White Fluorescent Bulb (SKU: 272484) by Philips Lighting Company
Assume 28 Watt, 46 Inch T5 Cool White Fluorescent Bulb (SKU: 230862) by Philips Lighting Company

Appendix 5: Bulbs - Paramaters and Relative Cost

Lamp	75 W - Incan	150 W - Incan	40 W - CFL
Power (W)	75	150	50*
Light output (lm)	1190	2850	3150
Initial Cost ($)	0.70	1.00	7.00
Energy cost ($/kWh)	0.075	0.075	0.075
Labor Cost ($)	5.00	5.00	5.00
Life (hr)	750	750	20000
Efficacy (lm/kW)	15900	19000	63000
Initial Cost ($/10^6 lm-h)	0.78	0.47	0.10
Operating Cost ($/10^6 lm-h)	4.70	3.90	1.10
Labor Cost ($/10^6 lm-h)	5.60	2.30	0.08
Total Cost ($/10^6 lm-h)	11.08	6.67	1.28

* Includes ballast

Source: Navvab, Mojtaba. University of Michigan Lecture. November 2011.

Appendix 6: Bulbs - Lighting Comparison

Lighting Type	Efficacy (lumens/ watt)	Lifetime (hours)	Color Rendition Index (CRI)	Color Temperature (K)	Indoors/ Outdoors
Incandescent					
Standard "A" bulb	10–17	750–2500	98–100 (excellent)	2700–2800 (warm)	Indoors/ outdoors
Energy-Saving Incandescent (or Halogen)	12–22	1,000–4,000	98–100 (excellent)	2900–3200 (warm to neutral)	Indoors/ outdoors
Reflector	12–19	2000–3000	98–100 (excellent)	2800 (warm)	Indoors/ outdoors
Fluorescent					
Straight tube	30–110	7000–24,000	50–90 (fair to good)	2700–6500 (warm to cold)	Indoors/ outdoors
Compact fluorescent lamp (CFL)	50–70	10,000	65–88 (good)	2700–6500 (warm to cold)	Indoors/ outdoors
Circline	40–50	12,000			Indoors
High-Intensity Discharge					
Mercury vapor	25–60	16,000–24,000	50 (poor to fair)	3200–7000 (warm to cold)	Outdoors
Metal halide	70–115	5000–20,000	70 (fair)	3700 (cold)	Indoors/ outdoors
High-pressure sodium	50–140	16,000–24,000	25 (poor)	2100 (warm)	Outdoors
Light-Emitting Diodes					
Cool White LEDs	60–92	25,000–50,000	70–90 (fair to good)	5000 (cold)	Indoors/ outdoors
Warm White LEDs	27–54	25,000–50,000	70–90 (fair to good)	3300 (neutral)	Indoors/ outdoors
Low-Pressure Sodium	60–150	12,000–18,000	-44 (very poor)		Outdoors

Source: U.S. Department of Energy

Appendix 7: Geothermal Calculations

Calculation of Geothermal CO2 Reductions When Compared to Natural Gas		
		value in kg/GJ
annual heat load (GJ)	322	
CO2 intensity of natural gas (kg/GJ)	51.0	51.0
efficiency of furnace	0.78	
Conventional Fuel Emissions (metric tons)	21.1	
annual heat load (GJ)	322	
CO2 intensity of electricity (t/GWh)	953.0	264.7
COP	5	
Heat Pump Emissions (metric tons)	17.1	
GHG Savings (metric tons)	4.0	
negative values means an increase an emissions		
electric intensity at which geothermal becomes feasible (t/GWh)	1176.0	326.7

Appendix 8: Insulation Definitions

Conduction, convection, and radiation are all important types of heat flow. Conduction is heat flow through solid objects and objects touching each other. Convection is heat transferred by a moving fluid such as air or water. Radiation is the transfer of heat from the sun to an object through the air.

Thermal transmittance or U-factor, includes heat flow by conduction, convection, and radiation through the window. U-factor is measured in units of BTUs per square foot per hour per degree Fahrenheit. Products with lower U-factors are more energy efficient. For example, single pane glass has a U-factor of 1.1, while low-e glass can have a U-factor as low as 0.12.

Solar heat again is the other primary window energy characteristic. Solar heat gain through windows can account for up to 40 percent of the total heat removed by an air conditioner [24]. There are three factors most commonly used to measure solar heat gain, each of which is a ratio with no unit of measurement. The solar heat gain coefficient (SHGC) is the ratio of solar heat passing through the glass to solar heat falling on the glass at a 90 degree angle. Thus, lower values represent more energy efficient windows. For reference, a single pane glass has a SHGC of 0.87, while a low-e insulated glass can have values as low as 0.35. In addition, the shading coefficient (SC) is also very important for heat gain. It shows the amount of solar energy transmitted through a window compared to clear single glass, which has a SC of 1.0. The third component, visible transmittance (VT), measures the amount of visible light transmitted by the window glass. Some reflective coatings or tints may reduce VT by 30 percent but may not be acceptable in various applications [24].

Appendix 9: Number of Vehicles Entering Lower Huron

Vehicles Per Year Per Park

	Lower Huron	Willow	Oakwoods
2000	334	213	53
2001	333	213	51
2002	336	205	47
2003	291	229	48
2004	293	233	46
2005	279	218	40
2006	301	201	39
2007	319	220	37
2008	337	210	38
2009	346	202	43
2010	355	213	42

Percentage of Vehicles Per Park

	Lower Huron	Willow	Oakwoods
2000	56%	35%	9%
2001	56%	36%	9%
2002	57%	35%	8%
2003	51%	40%	8%
2004	51%	41%	8%
2005	52%	41%	8%
2006	56%	37%	7%
2007	55%	38%	6%
2008	58%	36%	7%
2009	59%	34%	7%
2010	58%	35%	7%

Appendix 10: "Your Living World" Program at Metroparks of the Toledo Area

Points B to F are covered in a one hour hike.

A. Complete the Character Connection for Respect.

Know. Discuss these questions with your family: What things have people done to show a lack of respect to our world? Why is it important to respect our environment and natural resources? How can you show respect for your environment?

Commit. Discuss with your family how you feel when you see places in your neighborhood that have lots of litter. Name one thing you can do to help the environment.

Practice. Practice being respectful while doing the requirements for "Your Living World."

B. Land, air and water can get dirty. Discuss with your family ways this can happen.

C. It takes a lot of energy to make glass, cans, and paper products. You can help save energy by collecting these items for use again. Find out how recycling is done where you live. Find out what items you can recycle.

D. With an adult, pick up litter in your neighborhood. Wear gloves to protect your hands against germs and cuts from sharp objects.

E. With an adult, find three stories that tell how people are protecting our world. Read and discuss them together.

F. Besides recycling, there are other ways to save energy. List three ways you can save energy, and do them.

Appendix 10: Team Member Biographies

José Miguel Friz

José Miguel is a master's student in the Sustainable Systems and Behavior, Education, and Communication tracks. He has a bachelor of science degree in industrial engineering, specializing in information technology from Pontificia Universidad de Católica de Chile (PUC). He worked for eighteen months in the asset management industry in LarraínVial, the biggest financial holding of Chile. After this, he worked for one year on the consulting team of Luis Cifuentes (Associate Professor of the School of Industrial Engineering of PUC and member of the Intergovernmental Panel on Climate Change) in environmental policy topics. During the summer of 2011 he leaded a study about recycling programs with the Public Policy Center of PUC. He co-founded Valor Sustentable, a consulting firm in Chile he plans to develop when finishing the program.

Jordan Garfinkle

Jordan is a master's student in the Sustainable Systems track. He has a Bachelor of Science degree from St. Lawrence University, where he double majored in environmental studies and psychology. At St. Lawrence, he served as the sole student representative on the committee charged with developing the University's climate action plan. He spent a semester in East Africa studying the interaction between environmental and socioeconomic issues. In the summer of 2010, he worked at the Department of the Interior in the Bureau of Ocean Energy Management, Regulation, and Enforcement, in the wake of the largest oil spill in American history. He strives to gain and utilize sound technical understanding to help develop and implement energy and environmental policies.

Naomi Hamermesh

Naomi is a master's student in the Environmental Informatics track. She has a Bachelor of Arts degree in mathematics with a minor in geology from Bryn Mawr College in Bryn Mawr, Pennsylvania and is originally from Wilmington, Delaware. She has interned for the Michigan Tech Research Institute (MTRI) conducting research on a variety of topics such as agricultural fires and mapping invasive Phragmites. She will continue to work at MTRI after graduation as an Assistant Research Analyst.

Khawar Khan

Khan is a Fulbright Scholar and a master's student in the Sustainable Systems and Environmental Planning track. He is also doing a graduate certificate in Industrial Ecology. He has a bachelor degree in chemical engineering from the University of Engineering and Technology, Pakistan. During summer 2011, he worked with the City of Ann Arbor on their green fleet policy and greening municipal buildings by replacing natural gas heating with some renewable HVAC system. He also worked at Engro Fertilizers, Pakistan for more then three years in the water treatment, power generation and environmental engineering sections. His interests and career focus areas include green constructions, alternative energy, and sustainable transportation.

Jason Levine

Jason is a master's student in the Sustainable Systems track. He has a Bachelor of Arts degree from the University of Southern California in environmental studies with a business concentration and a minor in urban policy and planning. He has held a LEED Green Associate accreditation since 2010. Jason has interned for a green building consulting and development firm, as well as the City of Beverly Hills in the Water Division of the Department of Public Works. He is interested in green building, sustainable design, and energy efficiency. Jason is originally from Los Angeles, California, and would like to work on the West Coast after graduation doing LEED or sustainability consulting.

Lindsay Nelson

Lindsay is a third year master of landscape architecture student. Lindsay completed her bachelor of science in the Program in the Environment at the University of Michigan in 2008, specializing in botany. Lindsay has interned with Washtenaw County's Economic and Development Department, focusing on brownfield redevelopment. Last summer, Lindsay worked as a project manager for an urban forestry project in the City of Ypsilanti, Michigan. Lindsay has been a graduate student instructor the last two semesters, teaching two landscape architecture courses: NRE 591 - Materials and Methods and NRE 688 - Site Planning Design Studio with Associate Professor Stan Jones. Lindsay's professional interests include making cities more sustainable and livable, specifically through brownfield redevelopment, stormwater management, ecological restoration, and creation of great public space. Lindsay is originally from Southeast Michigan and hopes to dedicate her career to improving urban environments in the region.