

THE ROUGE RIVER PROJECT
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BRINGING OUR RIVER BACK TO LIFE

Rouge River National Wet Weather Demonstration Project

Wayne County, Michigan

TECHNICAL MEMORANDUM Conceptual Design of Wetland Management Systems

RPO-NPS-TM37.00

March 1995

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Rouge River National Wet Weather Demonstration Project

MISSION STATEMENT

The mission of the Rouge River National Wet Weather Demonstration Project is to restore the water quality in the Rouge River as necessary to:

- provide a safe and healthy environment for ourselves and future generations,
- protect downriver water resources such as the Detroit River and Lake Erie, and
- re-establish a healthy and diverse ecosystem within the Rouge River Watershed.

This will be accomplished through the development, implementation, and financial integration of a technical, social, and institutional framework leading to cost efficient, and innovative, watershed based solutions to control the wet weather problems in the Rouge River Watershed.

PREFACE

The Rouge River has historically suffered and continues to suffer from the combined stress of pollutant loadings from various sources. The vast majority of continuous point sources have been eliminated through the issuance and enforcement of National Pollutant Discharge Elimination System (NPDES) permits for municipal and industrial dischargers. Yet, as established in the Rouge River Remedial Action Plan (RAP), the river remains polluted primarily because of sources associated with wet weather flow.

The Rouge River National Wet Weather Demonstration Project (Rouge Project) is intended to evaluate each of the various sources of wet weather pollution; implement alternative remedial measures; investigate wet weather waste load allocations; establish associated pollutant load reductions; examine the financial and institutional impediments to wet weather pollution control; and recommend a plan and procedure for watershed-wide pollution control which is "implementable" in the Rouge and can be readily transferred to similar urban watersheds throughout the country.

The effort is not being conducted in isolation. The Rouge RAP provides a baseline from which Rouge Project efforts have begun. In fact, the Rouge Project can be viewed as the key component of the initial implementation of the RAP. In addition, ongoing regulatory efforts aimed at controlling Combined Sewer Overflow (CSO) discharge have also been integrated into the Rouge Project and all construction facilities will be in accordance to NPDES permits.

It is widely recognized, and reinforced by RAP recommendations, that CSO control by itself will not be sufficient to restore water quality to acceptable levels in the Rouge River and other similar urban rivers. The project has established a watershed-wide concept as its focus. Within the Rouge River Watershed, a range of pollution sources have been identified. They include: traditional urban runoff, illicit connections to drainage facilities, abandoned dumps within the river flood plain, wet fall and dry fall air deposition, and contaminated sediments within the river channel and impounded lakes.

The Rouge Project has incorporated efforts to develop analysis tools, organize existing and future data, conduct field surveys, collect and analyze water quality samples, develop and implement water quality models, design and test structural and nonstructural best management practices (BMPs), and establish loadings from nontraditional wet weather sources. Additionally, it includes components that will involve watershed residents in pollution control planning, and will study the institutional structure and financial capabilities of those entities responsible for long-term implementation of the recommended watershed plan.

To efficiently manage an effort with diverse objectives, the project has been divided into ten program elements. Each of these has a specifically defined technical or operational purpose. Within each of these elements, work plans are developed to define specific activities to be performed as part of the project. These work plans define the Tasks and level of effort.

The program elements that have been established are as follows:

- Geographic Information System (GIS) and Mapping
- Data Collection and Management
- Sampling and Analytical Program
- Modeling and Decision Support System (DSS)
- Nonpoint Source Best Management Practices (BMPs)
- Combined Sewer Overflow (CSO) Design, Build and Test Facilities
- Value Engineering
- Public Information and Involvement
- Financial and Institutional
- Project Management, Coordination and Reporting

This document has been generated under the Nonpoint Source Best Management Practices (BMPs) Program Element and is a product of Work Plan No. 7 Task 5. This document provides a summary of wetland design criteria and conceptual approaches for the wetland wet weather management demonstration system.

ABSTRACT

The Rouge River National Wet Weather Demonstration Project is a federally funded initiative with the objective of developing demonstration projects to evaluate a variety of urban nonpoint source pollution reduction best management practices (BMPs) for the Rouge River Watershed. These demonstrations will in sum improve the quality of stormwater runoff to the Rouge River. The function of wetland filtration for water quality improvement has been recognized as one potential BMP.

Wetlands increase stormwater detention capacity, increase stormwater attenuation, moderate low flows, and improve water quality by removing nutrients, sediments and metals. The goal of the wetland demonstration project is to evaluate the effectiveness of wetlands in the treatment of stormwater. The wetland demonstration project utilizes existing, enhanced, and created wetlands to demonstrate the value and effectiveness of wetlands in treating stormwater runoff. This evaluation will identify pollutants removed by the demonstration wetlands, the efficiency of the removal processes and the effects of sediments on this removal efficiency.

This document addresses conceptual wetland designs required to implement the Rouge wetlands wet weather management demonstration system. Design criteria for each of the wetland study areas were developed with similar design elements to provide comparable experimental data that can be related to known design parameters. These elements include: the incorporation of a sediment forebay; treatment of "first flush" for all storm events less than a 2 year, 24 hour storm; designed discharge outlets with monitoring capabilities; and, intermediate monitoring points where applicable. The contributing storm sewer area for each study area has been defined and modeled so that the effect of a given wetland area on water quality and quantity can be determined.

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1.0 INTRODUCTION

1.1 DESCRIPTION OF PROPOSED PROJECT. The Rouge River National Wet Weather Demonstration Project (Rouge Project) is a federally funded initiative with the objective of developing a wet weather management plan for the Rouge River Watershed. The project includes a variety of demonstration projects which, in sum, will improve the quality of stormwater runoff to the Rouge River. The demonstration projects include a variety of urban nonpoint source pollution reduction best management practices (BMPs) including structural controls, source controls, treatment of impoundment sediments, detention basins, public participation and wetland treatment. This document addresses conceptual wetland designs which will be required to implement the Rouge River wetlands wet weather management demonstration system.

The Rouge River wetland wet weather management system will utilize existing, enhanced, and created wetlands to demonstrate the value and effectiveness of wetlands in treating stormwater runoff. Supplementing the two wetland areas investigated purely for water pollution abatement potential, three created wetlands will be developed under grant moneys designated for wetland creation within the Rouge River Watershed. These moneys have been designated under an Michigan Department of Natural Resource (MDNR) and United States Environmental Protection Agency (EPA) permit which required Waste Management of Michigan, Inc. (WMI) to provide Wayne County a grant of money to create wetlands within the Rouge River Watershed for the purpose of providing water quality improvement to the Rouge River. These created wetlands will be designed to function in perpetuity and will be monitored as required by MDNR/EPA. In addition to monitoring the success of the wetland creation, two of the created wetlands will be monitored for water quality improvement by the Rouge Project.

1.2 PURPOSE OF PROPOSED PROJECT. The purpose of the wetlands wet weather management system is to increase stormwater detention capacity in the Rouge River Watershed which will increase stormwater attenuation, moderate low flows, and improve water quality by removing nutrients, sediments and metals. The goal of the wetlands demonstration project is to evaluate the effectiveness of the demonstration wetlands in the treatment of stormwater. This evaluation will include identification of pollutants removed by the demonstration wetlands, the efficiency of the removal processes and the effects of sediments on this removal efficiency. The demonstration project will compare the pollutant removal effectiveness of different types of wetlands:

- An existing forested wetland;
- An enhanced mixed forested, open water and scrub wetland system;
- A created emergent wetland; and
- A created emergent/shrub/scrub wetland system.

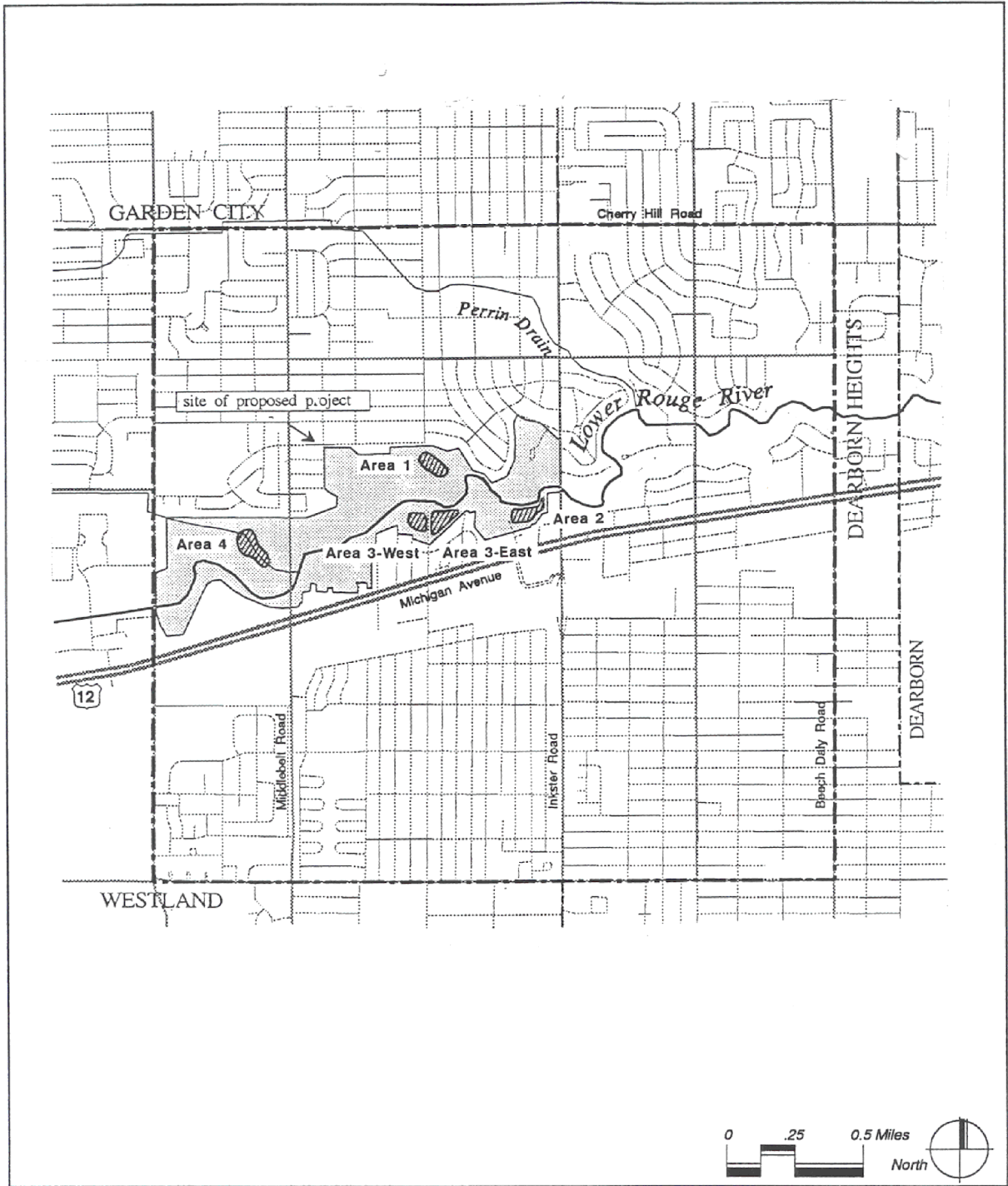
2.0 SITE DESCRIPTION AND EXISTING CONDITIONS. The proposed project is located within the City of Inkster, north of Michigan Avenue between Inkster and Henry Ruff Roads (*Figure 2-1*). The study wetlands will be located in four areas situated adjacent to the Rouge River. The following paragraphs characterize the existing conditions at the selected wetland study areas.

2.1 WETLAND STUDY AREA 1. Area 1, funded by the WMI grant, is located on the north side of the Rouge River on Wayne County Parks Division land between Inkster and Middlebelt Roads. The location for the proposed wetland creation is within an existing 12-acre upland field with grasses and herbaceous vegetation centrally located on the site. The site is bordered by steep slopes to the north and east, which is predominantly single family residential, and by the Rouge River floodplain to the south and a berm to the west. Currently, stormwater from a 48-acre residential watershed discharges via a 48-inch pipe to a 0.35-acre emergent wetland in the north portion of the site. A portion of the stormwater discharge flows through an 1,100-foot long ditch along the east edge of the site and discharges to the Rouge River. This ditch is approximately two feet wide and supports occasional wetland species such as willow along its banks.

The entire site is within the 100-year floodplain of the Rouge River. A 6.2-acre forested wetland is located along the south edge of the site, 1,800 feet south of the storm sewer outlet, and extending to the banks of the Rouge River. The forested wetland contains boxelder, green ash, cottonwood and American elm.

2.2 WETLAND STUDY AREA 2. Area 2, funded by the Rouge Project, is located south of the Rouge River between Inkster and Middlebelt Roads. The site contains an existing 3.0-acre, forested wetland dominated by cottonwood, American elm, boxelder and willow. The existing topography slopes to the east, and the wetland naturally discharges to the Rouge River at the eastern most end of the wetland. The wetland is bounded by steep slopes on the south and a low berm to the north and west. The western berm was created and maintained to provide access to an above ground electric transmission line. This wetland does not receive storm sewer discharge. Surface runoff from the surrounding area, groundwater, and flood water from the river contribute to maintain this area's wetland hydrology. The land between the existing storm sewer line and the berm defining the site's western edge contains similar forested wetland areas scattered across an upland shrub/scrub meadow area.

The entire site is within the 100-year floodplain of the Rouge River. Water marks on the trees indicate standing water does occur in low areas of the wetland. This wetland currently does not receive water from the surrounding 165-acre, primarily residential, watershed. This urban runoff is discharged directly to the Rouge River via an underground 60-inch storm sewer located approximately 500 feet west of Area 2.



Study Area Map
Conceptual Design of Wetland Management Systems
Rouge River National Wet Weather Demonstration Project

Figure 1.0

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2.3 WETLAND STUDY AREA 3. Area 3, funded by the WMI grant and the Rouge Project, is also located south of the Rouge River between Inkster and Middlebelt Roads, approximately 1,800 feet west of Area 2. The entire site is within the 100-year floodplain of the Rouge River. The site is bisected by an 80-foot long channel which currently conveys storm water runoff directly to the Rouge River from a 183-acre, residential and commercial watershed. The ditch has partially filled with sediments resulting in some stormwater flow being diverted to the wetlands on the east and west sides of the ditch. The 4.7-acre wetland on the east side of the ditch contains forested/scrub/shrub/emergent and open water communities. Existing vegetation includes willow, cattail, water plantain, elm, cottonwood, sedges, rushes and snags. Water discharges from this wetland to the river via surface flow from a shallow swale along the site's eastern river bank.

Approximately 2.4 acres of emergent/scrub/shrub wetland are located along the west side of the ditch. It appears that this wetland also receives stormwater from the existing storm sewer line due to the clogged ditch. This wetland contains primarily willow, dogwood and cattail. While no detailed hydrogeological data has been collected, moderate base flow in the ditch indicates groundwater may also contribute to the wetland hydrology. It does not appear that the water from this wetland discharges directly into the Rouge River.

2.4 WETLAND STUDY AREA 4. Area 4, funded by the WMI grant, is located west of Middlebelt Road north of the Rouge River. An intermittent drain traverses the site flowing easterly to a culvert at Middlebelt Road and discharging to the Rouge River. The site contains a mixture of wetland and upland communities. Approximately 18 acres of emergent and scrub/shrub wetlands follow the drain corridor. These wetlands contain cattail, dogwood, willow and American elm. Approximately 12 acres of forested wetland are located adjacent to the river. The forested wetlands are dominated by American elm, cottonwood and willow. The wetland hydrology is expected to be maintained by precipitation, runoff from adjacent land and groundwater. The entire site is within the 100-year floodplain of the Rouge River.

3.0 WETLAND DESIGN CRITERIA. The proposed wetlands projects, funded by the WMI grant and the Rouge Project, will create new wetland and enhance existing wetlands for the purpose of treating urban stormwater runoff. The following paragraphs describe the activities proposed to meet the objectives of this study.

Design criteria for each of the wetland study areas were developed from modeled hydrological data in combination with characteristics of the available treatment area. The proposed wetland creation and enhancement areas contain similar design elements to provide comparable experimental data which can be related to known design parameters. These elements include the incorporation of a sediment forebay to filter large particles before the stormwater enters the wetland system; treatment of "first flush" for most storm events; designed discharge outlets to the Rouge River with monitoring capabilities; and, intermediate monitoring points where applicable. The contributing storm sewer area for each study area

has been defined and modeled so that the effect of a given wetland area on water quality and quantity can be determined. The influence of directly adjacent land is assumed to be negligible.

The hydrology of the wetland study areas is also designed to be as similar as possible. As mentioned above, the wetland study areas will treat "first flush" runoff in the sediment forebay for most storm events. Wetland Area 1 will receive runoff from all storm events based on the size of the storm sewer area and wetland acreage. Wetland Areas 2, 3-East, and 3-West will receive runoff from all storms less than a 2-year, 24-hour event; excess runoff will be diverted through the existing channels or drainageways directly to the Rouge River. This direct runoff will not be treated by the sediment forebay.

The volume of water to be directed to the study area wetlands will be variable, depending on experimental design; however, the treated volume of water will generally be proportional both to the size of the storm event and the size of the contributing storm sewer area. The sediment forebays have been designed to retain stormwater from designated storm events for approximately one hour to allow larger than 40 micron particles to settle.

Material excavated from any of the wetlands within this project will be used as top dressing in created wetlands or as fill for the construction of berms to contain stormwater within the study treatment area. Remaining material will be disposed of in upland locations within the site boundaries and will not impede floodwaters within the 100-year floodplain. The impacts to existing wetlands within each of the different wetland study areas are described below.

3.1 WETLAND STUDY AREA 1. A sediment forebay, designed to capture the stormwater flowing from the existing 42-inch storm sewer, will be constructed in an existing emergent wetland area. All of the stormwater from each rain event will be directed to the proposed wetland system via the sediment forebay and vegetated swale. The existing ditch and associated wetland vegetation will only receive water from its watershed and possibly from overflow of the sediment forebay that may result during extreme storm events. This change of the area's hydrology may result in increased acreage of the existing wetland system over time.

This study area will be developed in conjunction with WMI and will function as an emergent wetland after completion of the demonstration project. Soil boring information was acquired to document and test wetland creation designs with varying soil types. Area 1 will test the need for a clay liner in sandy soils, soil fertility, soils in direct contact with ground water, etc. An outlet structure has been designed for this wetland and is to include a manhole for the installation of water quality and flow monitoring equipment. The outlet will discharge to the Rouge River, 1,100 feet from the current outlet of the stormwater discharge pipe. Access to the outlet manhole will be provided for monitoring activities. Manipulation of flow rates and retention periods may be discontinued at the end of the demonstration period. The wetland area however has been designed to be sustained by the contributions from the existing storm sewer area.

3.2 WETLAND STUDY AREA 2. Wetland Study Area 2 is proposed to demonstrate the efficiency of stormwater treatment by an existing forested wetland. Approximately 3.0 acres of forested wetland will be enclosed by berms designed to retain a specified amount of stormwater from the storm sewer area. Stormwater from the storm sewer area is currently discharged directly to the Rouge River via a 60-inch pipe.

The proposed wetland study area will utilize a specified portion of the stormwater from the storm sewer, depending on the storm event. Stormwater will be pumped to the wetland study area from the storm sewer via an underground pipe into a catch basin designed to function as a sediment forebay. Both the pipe and catch basin will be constructed in an upland area. The water will be piped under the existing bermed powerline easement and discharged directly to the wetland study area. The wetland study area will be enclosed by an 18-inch berm along the northern boundary of the site to isolate the study area to a known and measurable area. This berm will be parallel to the Rouge River and set at an elevation that will be crested by 100-year flood waters from the Rouge River.

This wetland study area currently discharges water to the Rouge River at one location situated at the far eastern point of the site. Overflow from wetland study area 2 will continue to discharge from this location; however, the outlet will require modification to control the outflow rate and allow monitoring activities. Minor grade modifications will be necessary for the installation of a control structure. The lowpoint of the weir will be set to retain water within the wetland and slowly release it to the Rouge River.

Implementation of this project will involve alterations of the area's hydrologic regime as follows. The forested wetland is currently maintained by both surface drainage and groundwater contributions. The volume of surface runoff entering the system will increase from the current levels during the proposed study period. In addition, the installation of an outlet control structure to manipulate flow and water depths may result in increased retention time. It is anticipated that this may result in minor alteration of the vegetation community; a herbaceous understory may develop to a greater degree than is currently present and some woody species may be stressed due to increased frequency flooding. However, the site's hydrology will be returned to its current condition upon completion of the study period. If it is decided to discontinue the demonstration project after two years. It is unlikely that substantial changes to the existing forested wetland system will occur in this limited amount of time.

3.3 WETLAND STUDY AREA 3. Wetland study area 3 contains two separate treatment areas, 3-East and 3-West. A sediment forebay will be located at the inflow of each wetland area. Three outlets will be constructed in this basin to direct first flush and small storm event flow to wetland study area 3-East and 3-West, and overflow from larger storms directly to the Rouge River.

The existing ditch, presumably originally built to transport the storm sewer outflow directly to the Rouge River, has degraded and must be rebuilt. Reconstructing the ditch will require excavating the channel to provide positive flow and construction of banks along the edge of the channel.

3.3.1 Wetland Study Area 3-East. Wetland study area 3-East is an existing mixed wetland system which will be enhanced to provide additional stormwater treatment. The designated study area will be enclosed by eighteen inch berms. In addition, short berm segments will be constructed within the wetland to direct flow through various wetland types and lengthen the flow path. This proposed design will require the following activities and wetland alterations.

Stormwater flow from the sediment forebay will be discharged into the existing wetland. A containment berm will be constructed along the northern portion of the wetland area. The berm will not impede the 100-year flood flow from the Rouge River flood conditions.

Two additional berms will be constructed within the wetland area to direct flow through various wetland systems. These berms may also serve as stations which may be used to assess the efficiency of the different treatment areas or of different flow path lengths. The first berm will be located between an existing upland area and the steep slope at the southern site boundary to minimize the amount of fill required. The second berm will be placed within an emergent wetland area and in a narrow swale separating two upland areas to minimize the amount of fill required. Both of these berms will be set at an elevation that will not impede 100-year flood waters from the Rouge River.

Wetland study area 3-East currently drains to the Rouge River at a low point located along the eastern boundary. Overflow from this study area will continue to discharge from this location; however, the outlet will require modification to control the outflow rate and allow monitoring activities. A controlled outlet structure will be placed at this point.

The hydrology of this study area will be modified during this study. It is not anticipated that the altered hydrology will greatly affect the functions or structure of this wetland area because it is expected that the volume of water flowing through the system may not be significantly different. The system currently receives flow from the storm sewer outlet as a result of the disintegration of the drainage channel transporting water directly to the Rouge River.

3.3.2 Wetland Study Area 3-West. Wetland study area 3-West will contain emergent and scrub/shrub wetlands created within an existing upland area. The created wetland will be apportioned into two areas, one and two acre wetland cells. Flow will be directed through both cells; however, the effect of wetland size on storm water treatment will be able to be demonstrated. These wetlands are created in conjunction with WMI; therefore, these wetlands are designed to function as wetlands with minor modifications, if any, after the demonstration is completed.

Two connected emergent/wet meadow wetlands from an upland area. The first wetland in the series will be approximately one acre in size. Flow from the sediment forebay will be released directly into this one-acre wetland. The succeeding wetland will be approximately two acres in size. This sizing allows for an assessment of water quality treatment from specified areas of created wetland. Across the demonstration project, the treatment efficiencies of created emergent wetlands of one, three, and four and one half acres can be compared and assessed.

Transporting the water from the sediment forebay to the emergent one-acre wetland will require minor modifications of an existing emergent wetland system. The proposed water flow path passes from the one acre wetland into the two-acre system at a narrow point where monitoring can occur. The water then flows through this two-acre system to an outlet to the Rouge River. This outlet is located at a naturally occurring low point within the forested wetland along the River's banks. A controlled outlet structure will be constructed at the outlet point to control retention time and water depth and allow monitoring activities.

The construction of Area 3-West and the improvement to the existing ditch may have secondary impacts to an existing one-acre emergent wetland located directly at the base of the steep slope at the southern site boundary. This slope also defines the 100-year floodplain. A portion of this wetland area will be disturbed by the improvements to the drainage ditch. This wetland currently receives contributions from the storm sewer overflow and possibly ground water. After improvement of the existing ditch, construction of the sediment forebay, and diversion of the flow to the created one acre wetland area, this wetland may only receive water from surface runoff sources and ground water. The level and type of impact that may result cannot be determined.

3.4 WETLAND STUDY AREA 4. The wetland creation site in Area 4, which is located west of Middlebelt Road and north of the Rouge River, is an upland area of approximately seven acres that is interspersed with scrub-shrub and emergent wetland types. The created wetland will utilize an intermittent drain that traverses the site flowing easterly to a culvert at Middlebelt Road and discharging to the Rouge River. The site is surrounded by a mixture of wetland and upland communities. Approximately 18 acres of emergent and scrub-shrub wetlands follow the drainage corridor. These wetlands contain cattail, dogwood, willow and American elm. Approximately 12 acres of forested wetland are located adjacent to the river. The forested wetlands are dominated by American elm, cottonwood and willow. The wetland hydrology is expected to be maintained by precipitation, runoff from adjacent land and groundwater. The entire site is within the 100-year floodplain of the Rouge River.

4.0 MONITORING ACTIVITIES. The wetlands monitoring results will be used to evaluate the effectiveness of different wetland types in the removal of sediments, nutrients and metals thereby improving water quality. In addition to the water quality sampling program, a biological monitoring program will be completed to assess the success of vegetative establishment for newly created wetlands, biological changes of community diversity and/or

abundance, and the impact of stormwater runoff on the biological community. The Biological Monitoring Program is intended to measure the impacts of stormwater runoff on the biological communities of the demonstration wetlands.

4.1 WATER QUALITY MONITORING. Water quality monitoring will be performed at select wetland sites with various configurations to assess NPS storm event pollutant loading reductions that can be achieved at wetlands. The objectives of the water quality monitoring program are to collect dry and wet weather samples from the demonstration wetlands, analyze water quality, establish loadings and assess the loading reduction achieved by various wetland designs. The water quality monitoring program of the wetland sites has been documented in the “Field Sampling for NPS Storm Event Monitoring Program”, RPO-SAM-FSP11.

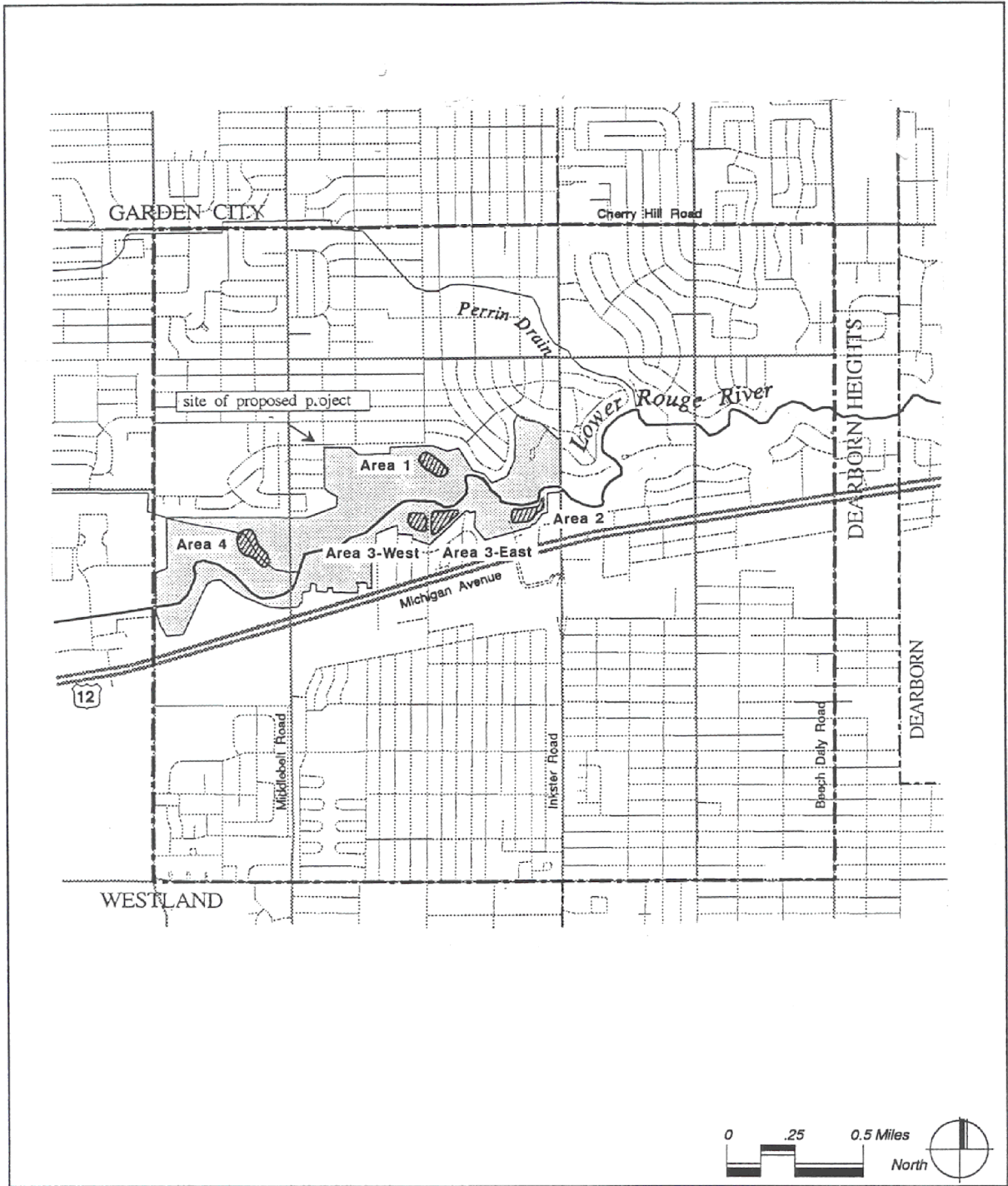
4.2 BIOLOGICAL MONITORING. The Biological Monitoring Program is intended to measure the impacts of stormwater runoff on the biological communities of wetland wet weather management systems that have been selected to meet the objectives of the Nonpoint Source Pollution Control Work Plan No. 7. The biological monitoring program will be completed to assess the success of vegetative establishment for newly created wetlands, biological changes of community diversity and/or abundance, the impact of stormwater runoff on the biological community.

- Vegetation - Wetland creation and enhancement has been designed to establish open water, shallow water, emergent and wet meadow wetland habitat types using planting and natural succession revegetation techniques. Wetland ecologists will evaluate plant communities that are representative of various wetland types. Evaluations will be made of the percent vegetation cover, relative frequency of each plant species, and the wetland frequency indicator value.
- Wildlife - Wetland creation and restoration has focused on providing diverse habitat for a variety of wildlife. Feeding, nesting and brood-rearing habitat for waterfowl, wading birds, shorebirds, passerine birds as well as mammals, reptiles and amphibians have been targeted in the wetland design. Wildlife biologists will visit the site when many bird species are either nesting or migrating. Bird species sighted or heard will be recorded. Although no trapping of mammals or herptofauna is proposed, observations by biologists during the course of field surveys will be documented including tracks, nests, scats and any wildlife use of plants or animals as food. Wildlife monitoring will include both sight and sound documented observations made by a field biologist during the course of site visits.

Aquatic biologists will conduct qualitative macroinvertebrate studies. Organisms will be identified to family (genus for order Insecta) and classified as to level of tolerance to environmental stress. Additionally, a quantitative macroinvertebrate survey will be completed including standardized sampling by eliminating subjectivity in sample collection techniques, minimizing habitat differences and sampling variability by providing a standardized

microhabitat for colonization, and isolation of water quality effects (from sediment quality/type effects) on benthos populations.

The proposed wetland systems will not provide sustainable fishery habitat. They will be shallow (less than three feet), subject to wide fluctuations in dissolved oxygen and temperature, and subject to winter freeze and flooding. Fish surveys are proposed in shallow water and open water zones within wetland systems utilizing a backpack electroshocker and minnow seines. Fish collected within wetland systems will be identified to species, measured and documented. Details of the sampling protocols established for the biological monitoring program are presented in Field Sampling Plan RPO-NPS-FSP12.



Study Area Map
Conceptual Design of Wetland Management Systems
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Figure 1.0

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