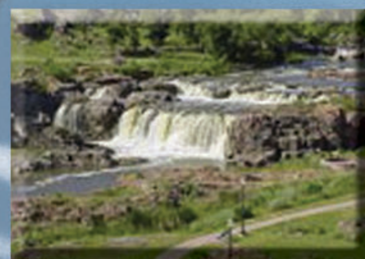
Stormwater BMP Master Plan



Final Report
Volume 1

for

The City of Sioux Falls, South Dakota

Submitted by

CH2MHILL

in association with

Howard R. Green Company

July 2003

Final Report

Stormwater BMP Master Plan
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Executive Summary

Project Vision and Goals

The City of Sioux Falls chose to develop a Stormwater Best Management Practices (BMP) Master Plan to address growth areas in the city. The priority of the Master Plan focused on new development areas based on 2015 land use and the 2002 Sanitary Sewer Collection Systems Facility Plan. The extent of the study area was developed based upon 2015 land use.

The vision statement for the master plan is to develop a stormwater plan that meets regulatory requirements, enhances quality of life, and is implemented through a regional BMP approach. The goals for the stormwater BMP master plan are to:

- Establish Sioux Falls as a leader in South Dakota
- Provide a template of how to manage stormwater discharges
- Be endorsed by the development community
- Be understood by the general public
- Facilitate planned growth
- Support water quality
- Enhance natural resources
- Be affordable

To deal with growth and to ensure that stormwater BMPs are in place before development occurs, a Master Plan is needed to pinpoint the regional stormwater needs. The regional stormwater basins need to include both flood control and water quality elements as based on the *Sioux Falls Engineering Design Standards,* Chapter 11, "Drainage Improvements." The water quality requirements were developed to be in compliance with the Surface Water Discharge System Permit (SDS-000001) for stormwater that the city received in 1999 from the South Dakota Department of Environment and Natural Resources (DENR).

Master Planning Process

This report documents the master planning process and results so that Sioux Falls can implement a regional stormwater BMP approach based upon anticipated new development and future planning.

As Sioux Falls continues to grow, natural resources in new development areas must be considered in the development process. Identifying such resources in new development areas provides the twofold benefit of having both the city and development community aware of impacts on regulated natural resources. Consequently, the Master Plan has identified the regulated resources and the permitting process required by regulatory agencies. The U.S. Army Corps of Engineers and the South Dakota DENR regulate construction in wetlands and streams. The regional stormwater BMPs have the potential to affect both natural resources.

The CH2M HILL team's approach to the Stormwater BMP Master Plan was developed to identify regional BMP locations based upon environmental constraints, public input, anticipated development, and siting constraints. That approach provides guidelines for implementing the regional BMP approach to address both water quality and flood control. Hydrologic modeling was conducted to determine the required pond volumes and outlet structure dimensions to detain the water quality capture volume, and the 5- and 100-year detention volumes needed to meet Chapter 11 requirements. Preliminary designs and an implementation plan provide examples and concepts to bring the information contained within the Master Plan to implementation.

To implement the findings of the Master Plan, a prioritization schedule and cost opinion for the improvements have been developed. The prioritization schedule will allow the city to incorporate stormwater BMP construction into capital improvement budgets. Identifying funding needs will allow the city to schedule BMP construction with available funding.

This report documents the major activities and findings of the BMP Master Plan with supporting documentation found in the appendixes. The major sections of this report are:

- Natural Resource Inventory
- BMP Siting Considerations
- BMP Locations
- Public Outreach
- Hydrologic Modeling
- Preliminary Design
- Implementation Plan

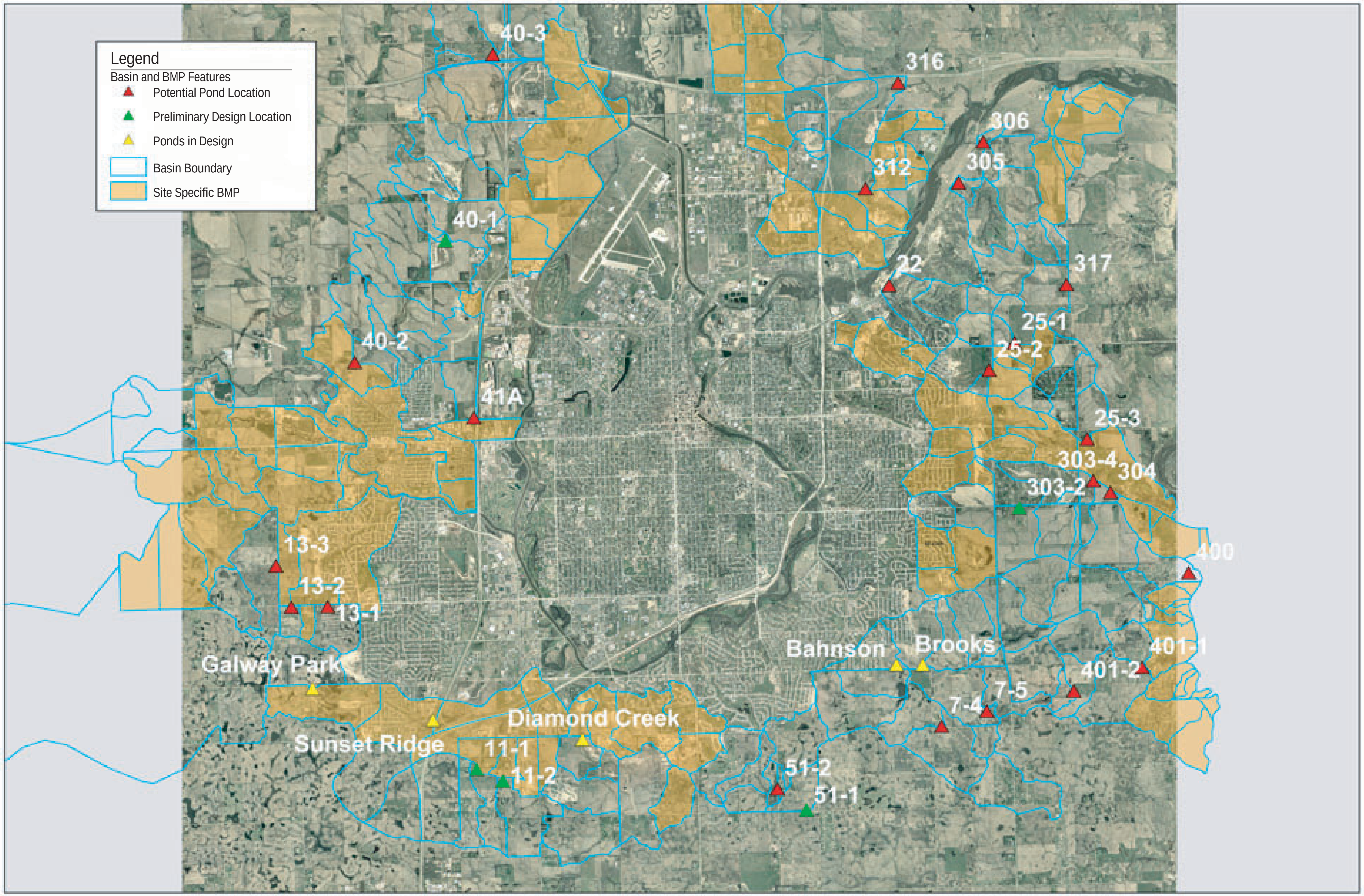
Master Plan Summary

Locations

Figure 1 shows the locations of proposed regional stormwater BMPs, including those being designed by others and those for which preliminary designs have been prepared on this project. It also shows areas assumed to be served by site-specific BMPs, using the criteria presented in Section 3.

Cost

Table 1 summarizes the locations, 100-year storage volumes and estimated land cost, construction cost, and total capital cost for the proposed regional BMPs. The total capital costs for the program are estimated to be $63.7 million, with the cost of individual BMPs ranging from $640,000 to $6.5 million. This cost estimate is an order-of-magnitude estimate appropriate for a master planning analysis. This cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time that the estimate was developed. The final costs for the project will depend on final project scope, implementation schedule, actual labor and material costs, competitive market conditions, and other variable conditions. As a result, the final project cost will vary from the estimate presented herein.



NOTE: Areas within developed portions of the City are also site specific as shown in Figures 3-1 through 3-4.

FIGURE 1
Location of BMPs and Basin Boundaries

Stormwater BMP Master Plan
Sioux Falls, South Dakota

TABLE 8-1
Proposed Detention Pond Volumes and Costs

BMP Site	Year	Location Description	Water Quality Capture Volume[a] (ac-ft)	100-yr Vol. (ac-ft)	Land Cost	Construction Cost[b]	Capital Costs[b]
13-1	2003	2,100 ft west of 41st St. and Sertoma Ave. intersection, on south side of 41st	4	31	$258,000	$597,000	$1,568,000
13-2	2003	850 ft east of Tea Ellis Rd. and 41st intersection, on north side of 41st	1	6	$135,000	$447,000	$644,000
13-3	2003	2,700 ft north of Tea Ellis Rd. and 41st St. intersection, on west side of Tea Ellis Rd.	11	86	$676,000	$1,353,000	$2,217,000
11-1	2005	East of Tallgrass Ave. and south of 69th Street, Pond 17C of Prairieview Study	14	95	$938,000	$2,229,000	$3,512,000
11-2	2005	750 ft west of Crane St. and 77th St. intersection, Pond 17B of Prairieview Study	5	44	$313,000	$642,000	$1,087,000
40-1	2005	1,200 ft east and 700 ft north of Marion Rd. and W 34th St. N intersection	55	348	$1,791,000	$2,461,000	$4,836,000
51-2	2005	1,500 ft north of Cliff Ave. and 85th Street intersection, on west side of Cliff Ave.	9	86	$676,000	$1,353,000	$2,775,000
7-4	2006	600 ft east of intersection of Sycamore and 69th St., on north side of 69th St.	16	151	$1,103,000	$1,880,000	$3,569,000
51-1	2006	1,850 ft east of Cliff Ave. and 85th St. intersection, on north side of 85th St.	9	48	$188,000	$528,000	$1,026,000
7-5	2007	1,600 ft west and 1,000 ft north of Rushmore and 69th St. intersection, extends upstream and downstream of future East Side Corridor	13	140	$1,045,000	$1,809,000	$3,364,000
25-3	2007	Southeast corner of Six Mile Rd. and 10th St.	9	34	$273,000	$615,000	$1,016,000
303-2	2007	1,600 ft east of Powderhouse and 26th, on south side of 26th Street	11	93	$397,000	$1,209,000	$1,785,000
25-1	2008	1,600 ft east of Madison St. and Powder House intersection, on north side of Madison St.	7	86	$676,000	$1,353,000	$2,253,000
25-2	2008	1,600 ft south of Madison St. and Powder House intersection, on west side of Powder House	5	60	$403,000	$1,016,000	$1,740,000
41-A	2008	1,500 ft north of I-29 and 12th St. intersection, on west side of I-29	14	116	$903,000	$1,633,000	$2,763,000
401-1	2010	4,000 ft east of Six Mile Rd., on south side of 57th St.	15	94	$744,000	$1,437,000	$2,591,000
401-2	2010	1,800 ft south of Six Mile Rd. and 57th St. intersection, west side of Six Mile Rd. (Tisdale).	23	114	$890,000	$1,617,000	$2,798,000
40-2	2010	Northeast corner of Madison St. and LaMesa Dr. intersection	30	502	$2,013,000	$3,004,000	$6,467,000
304	2010	2,600 ft southeast of intersection of Six Mile Road and STH 42 (Minnehaha Rd.), on south side of STH 42	6	46	$332,000	$768,000	$1,207,000
312	2010	2,750 ft east of I-229, on north side of Benson Rd.	13	48	$342,000	$808,000	$1,262,000
400	2010	7,200 ft east of Six Mile Rd., on north side of 41st St.	11	78	$602,000	$1,262,000	$2,040,000

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Proposed Detention Pond Volumes and Costs

BMP Site	Year	Location Description	Water Quality Capture Volume[a] (ac-ft)	100-yr Vol. (ac-ft)	Land Cost	Construction Cost[b]	Capital Costs[b]
303-4	2010	1,300 ft southeast of Six Mile Rd. and STH 42 (Minnehaha Road) intersection, on south side of STH 42	11	52	$362,000	$882,000	$1,367,000
22	2012	2,600 ft east of Bahnson Rd., between Rice St. and the railroad tracks	7	64	$452,000	$1,077,000	$1,679,000
317	2012	1,300 ft south of Maple Rd. and Six Mile Rd. intersection, on west side of Six Mile Rd.	11	87	$685,000	$1,364,000	$2,275,000
40-3	2015	Northwest corner of I-90 and I-229 interchange	6	61	$416,000	$1,032,000	$2,258,000
305	2015	East side of Rice St., 400 ft northeast of Lawrence Pl, north of Great Bear.	5	61	$416,000	$1,032,000	$1,592,000
306	2015	Northeast of intersection of Rice St. and Timberline, upstream of East Side Corridor	8	49	$347,000	$827,000	$1,289,000
316	2015	4,700 ft east of I-90 and I-229 interchange, on south side of I-90	21	112	$876,000	$1,600,000	$2,699,000
Total Cost			**—**	**—**	**$18,252,000**	**$35,835,000**	**$63,679,000**

[a]Water Quality Capture Volume is the storage volume designed to be detained for frequent storms for water quality purposes.

[b]Master Plan order-of-magnitude cost estimate.

Table 2 lists a breakdown of cost for each BMP between items related to both water quality control and water quantity control. Costs associated with water quality include the water quality orifice plate, water quality trash rack, and part of the excavation. The portion of the excavation costs due to water quality was assumed to be equal to the ratio of the WQCV to the 100-year storage volume of a BMP. Water quality and quantity costs were calculated for the five preliminary design sites, and then the average ratio of quality cost to quantity cost was used to estimate the water quality and water quantity costs for the remaining BMPs. Also listed in Table 2 are 2015 land use near each BMP, WQCV tributary acres, and the projected 100-year storm impoundment area.

Table 3 presents cost estimates for the inspection and maintenance of the 28 regional BMPs included in the master plan. These estimates are based on the number and types of BMP facilities, the identified maintenance actions (e.g., debris removal, sediment removal, etc.) for each type of BMP facility, the identified staff costs and expenses, frequency of maintenance, and desired level of service. As such, it is not the intent of the maintenance cost analysis to provide a single number for overall maintenance. Instead, the analysis separates costs into routine (preventive) maintenance and nonroutine (long-term) maintenance.

TABLE 2
Water Quality versus Water Quantity Cost Breakdown, 2015 Land Use, WQCV Tributary Area, and Pond Area

BMP Site	Cost for Water Quality	Cost for Water Quantity	2015 Land Use	WQCV Tributary Area (acres)	Pond Area (acres)
13-1	$51,000	$1,517,000	Residential single family	210	10
13-2	$21,000	$623,000	Residential single family	65	5
13-3	$72,000	$2,145,000	Residential single family	596	27
11-1	$148,000	$3,364,000	Residential single family	698	38
11-2	$36,000	$1,051,000	Residential single family	309	13
40-1	$143,000	$4,693,000	Residential single family/open space	2,691	72
51-2	$90,000	$2,685,000	Residential single family	540	27
7-4	$110,000	$3,453,000	Residential single family	917	44
51-1	$17,000	$1,009,000	Residential single family	457	8
7-5	$116,000	$3,254,000	Residential single family	741	42
25-3	$33,000	$983,000	Residential single family/residential multiple family	547	11
303-2	$74,000	$1,711,000	Residential single family	582	16
25-1	$73,000	$2,180,000	Residential single family	369	27
25-2	$57,000	$1,683,000	Residential single family	252	16
41-A	$90,000	$2,673,000	Manufacturing	636	36
401-1	$84,000	$2,507,000	Residential single family	834	30
401-2	$91,000	$2,707,000	Residential single family	1,351	36
40-2	$211,000	$6,256,000	Open space	1,793	81
304	$39,000	$1,168,000	Residential multiple family	339	13
312	$41,000	$1,221,000	Manufacturing	410	14
400	$66,000	$1,974,000	Residential single family	669	24
303-4	$45,000	$1,322,000	Residential multiple family	531	14
22	$55,000	$1,624,000	Residential single family	424	18
317	$74,000	$2,201,000	Residential single family	612	27
40-3	$74,000	$2,184,000	General commercial	291	17
305	$52,000	$1,540,000	Residential multiple family	298	17
306	$42,000	$1,247,000	Manufacturing	427	14
316	$88,000	$2,611,000	Manufacturing	699	35
Total	**$2,093,000**	**$61,586,000**			

TABLE 3
Inspection and Maintenance Cost Estimate for 28 Wet Ponds

Year	Number of Facilities[a]	Total Routine Maintenance	Total Nonroutine Maintenance	Inspection	Total
2004	3	$5,600	$19,600	$400	$25,600
2005	3	$5,600	$19,600	$400	$25,600
2006	7	$13,100	$45,700	$800	$59,700
2007	9	$16,900	$58,800	$1,100	$76,700
2008	12	$22,500	$78,400	$1,400	$102,300
2009	15	$28,200	$97,900	$1,800	$127,900
2010	15	$28,200	$97,900	$1,800	$127,900
2011	22	$41,300	$143,600	$2,600	$187,600
2012	22	$41,300	$143,600	$2,600	$187,600
2013	24	$45,000	$156,700	$2,900	$204,600
2014	24	$45,000	$156,700	$2,900	$204,600
2015	24	$45,000	$156,700	$2,900	$204,600
2016	28	$52,500	$182,800	$3,400	$238,700
10-year Average		*$30,000*	*$104,500*	*$1,900*	*$136,400*
10-year Net Present Value[b]		*$277,400*	*$965,300*	*$17,700*	*$1,260,400*

[a]Based on construction schedule.
[b]Assumes 4 percent discount factor.

Natural Resources

Preliminary estimates of potential wetland and stream impacts were developed for the recommended BMP sites. Initially, 50 proposed BMP locations were compared to resulting wetland locations from both the NWI (National Wetlands Inventory) and available data on locations of hydric soils to determine potential wetland impacts as a result of BMP construction. Estimated pond footprints for these 50 sites were developed based upon rule-of-thumb BMP footprint areas. After the initial screening and a fatal flaw analysis, 28 final BMP locations were selected. The wetland and stream length impact analysis for the final BMP locations is summarized in Table 4, which shows the significant reduction in wetland and stream length impacts from the initial locations to the final locations.

Designing BMPs

To help educate the Sioux Falls engineering and development community on BMP design process, a half-day BMP design training seminar was held on June 19, 2003. The seminar reviewed the BMP design procedures contained in the Sioux Falls Engineering Design Standards Chapter 11 *Drainage Improvements*, and provided BMP implementation case study examples. Over 30 people from the Sioux Falls engineering and architectural community took advantage of this seminar.

TABLE 4
Analysis of Potential Impacts to Wetlands and Streams

	Initial 50 Sites	Final 28 Sites
NWI Wetland Potential Impact	27.8 acres	13.7 acres
Hydric Soils Potential Impact	97.6 acres	65.3 acres
Stream Potential Impact	89,464 LF	57,348 LF

Note: Wetland areas are based on available NWI and hydric soils data and have not been field verified. Stream potential impact is based upon flow-line information developed during basin delineation and is not an indication of stream type (intermittent, perennial, etc.).

Five BMPs underwent preliminary design as part of the Master Plan process. Descriptions of the five preliminary design sites are included in Section 7 and associated appendixes. Implementation of those BMPs will give the City the opportunity to develop the BMPs into local amenities. Studies have shown that properly designed water features increase property value, become recreational destinations, and provide habitat benefits. Opportunities exist to use BMP sites as amenities to facilitate planned growth.

BMPs can be developed to provide other uses in addition to stormwater management. For example, BMPs have been developed into parks, green space, ball fields, bike paths, nature trails, and urban nature centers. For example, a BMP developed near a school could include a bike/walking path, provide open space, or serve as an outdoor science educational center.

Implementation Schedule and Steps

The planning period for the master plan regional BMP construction costs is 2004 through 2015. A detailed construction implementation schedule is provided for the 28 regional BMPs in Section 8. Inevitably, the phasing of construction will change to reflect actual economic conditions and priorities in the City. The key to successful implementation of the Stormwater BMP Master Plan is to adopt the plan and set in place an overall implementation strategy. The phasing and implementation strategy for the Stormwater BMP Master Plan includes the following key components:

- **Stakeholder Involvement**: To ensure successful implementation, City staff and the CH2M HILL team conducted a proactive stakeholder involvement campaign during the preparation of the Stormwater BMP Master Plan. The stakeholders included the public, community associations, the Infrastructure Review and Advisory Board, resource and regulatory agencies, City staff, elected officials, developers, and engineers. Coordination with these and other stakeholders should continue during the implementation of the Stormwater BMP Master Plan.
- **Phasing and Implementation Steps:** The overall implementation of the Stormwater BMP Master Plan should be conducted in accordance with the following concurrent steps:
  - Step 1—Procedural Approvals
  - Step 2—Funding Mechanisms
  - Step 3—BMP Design, Construction, and Maintenance
  - Step 4—Program Enhancements

Figure 2 shows the proposed 18-month Implementation Schedule. The procedural approvals in Step 1 result in adoption of the Master Plan. In Step 2, the funding mechanisms for the BMPs are evaluated and finalized. Step 3 consists of refining the BMP designs and proceeding with permitting, construction, and establishing a maintenance program. Step 4 addresses related stormwater program administration and outreach. Details of these steps are provided in Section 8.

It is recommended that the construction of regional (watershed-level) BMPs be funded with developer-based support through the adoption of a pro-rata share ordinance, or extension of the existing Drainage System Cost Recovery program. It is further recommended that other implementation activities (see phasing and implementation steps below), including operations and management of existing and proposed regional BMPs, be supported through the existing stormwater utility.

FIGURE 2

Proposed Implementation Plan Schedule

Regional Stormwater BMP Master Plan

City of Sioux Falls, South Dakota

	2003						2004											
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Step 1 - Procedural Approvals																		
1. Prepare and submit ACOE permit application for initial 5 BMPs			■	■	■	■	■	■										
2. Identify policies and procedures to be created/amended			■	■														
3. Obtain state and federal permits												■	■					
4. Define ordinance update needs and design guidelines					■													
5. Develop draft ordinances						■	■	■	■	■	■	■						
6. Conduct public meetings/hearings						■	■	■	■	■	■							
7. Adopt ordinances													■	■	■	■		
Step 2 - Funding Mechanisms																		
1. Adopt and proceed with funding strategy					■	■	■											
2. Finalize rate structure for stormwater utility (SWU)							■	■	■	■	■	■	■					
3. Finalize pro-rata share rates and policies							■	■	■	■	■	■	■					
4. Identify and evaluate administrative policies						■	■	■	■	■	■	■	■					
5. Evaluate rates for the existing SWU										■	■							
6. Develop and implement a public information plan				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7. Provide staff training																	■	■
8. Revise SWU and pro-rata share ordinances																	■	■
9. Implement any administrative policy changes																		■
Step 3- BMP Design, Construction, and Maintenance																		
1. Define procedures for design and construction				■	■													
2. Define wetland mitigation alternatives		■	■	■	■	■												
3. Incorporate existing BMPs into the maintenance program			■															
4. Identify BMPs/SW facilities not maintained by the City			■															
5. Evaluate facility/system condition and upgrade costs				■	■	■	■											
6. Develop process to inspect and accept new BMPs						■	■	■										
7. Refine estimate of maintenance costs								■	■									
8. Develop maintenance policy and maintenance agreement									■	■	■							
9. Define process to obtain and track easements									■	■								
10. Identify procedure for development BMP credits				■	■													
11. Develop Master Plan BMP modification policy				■	■	■												
12. Develop policy to approve BMPs before Master Plan adoption				■	■	■												
13. Develop mechanism to track rezonings/land use changes					■	■	■											
14. Develop incentives for use of source controls								■	■									
15. Develop incentives for maintaining riparian buffer integrity								■	■									

FIGURE 2

Proposed Implementation Plan Schedule

Regional Stormwater BMP Master Plan

City of Sioux Falls, South Dakota

	2003						2004											
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Step 4 - Program Enhancements																		
1. Define the level of service to be provided								■	■	■								
2. Train staff to maintain watershed models				■														
3. Develop procedures to maintain Master Plan GIS layers					■													
4. Continue public information program (see Step 2, item 6)			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5. Develop web site to communicate Master Plan activities									■	■								
6. Develop procedures to track Master Plan implementation					■	■	■											
7. Identify monitoring opportunities							■											
8. Develop MOUs with related agencies							■	■	■									
9. Incorporate the Regional BMP Master Plan in Comprehensive Plan														■	■	■		
10. Define staff needs									■	■								

Contents

Appendixes

Tables

Figures

Acronyms and Abbreviations

ACOE	U.S. Army Corps of Engineers
AIRFA	American Indian Religious Freedom Act
ARPA	Archaeological Resources Protection Act
BMP	Best Management Practices
DENR	Department of Environment and Natural Resources
DSCR	Drainage System Cost Recovery
ERU	equivalent residential unit
FEMA	Federal Emergency Management Agency
ft/sec	feet per second
HSA	Historic Sites Act of 1935
IRAB	Infrastructure Review Advisory Board
MS4	municipal separate storm sewer system
NAGPRA	Native American Graves Protection and Repatriation Act
NHPA	National Historic Preservation Act of 1966
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
O&M	operation and maintenance
PMF	probable maximum flood
SHPO	State Historic Preservation Office
SSURGO	Soil Survey Geographic
Tc	time of concentration
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WQCV	water quality capture volume
WRIR	Water-Resources Investigations Report

SECTION 1

Project Approach

The CH2M HILL team's approach to the Sioux Falls Master Plan for Stormwater Best Management Practices (BMPs) was developed to identify regional BMP locations based upon environmental constraints, public input, anticipated development, and siting constraints. That approach, documented in this report, provides guidelines for implementing the regional BMP approach to address both water quality and flood control. Preliminary designs and an implementation plan provide examples and concepts to bring the information contained within the Master Plan to implementation.

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- BMP Locations
- Public Outreach
- Hydrologic Modeling
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- Implementation Plan

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As Sioux Falls continues to grow, natural resources in new development areas must be considered in the development process. Identifying such resources in new development areas provides the twofold benefit of having both the city and development community aware of impacts on regulated natural resources. Consequently, the Master Plan process focused upon identifying these natural resources in determining the regional stormwater BMP locations.

In constructing regional BMPs, the city will need to know what regulatory permits will be required. Consequently, the Master Plan has identified the regulated resources and the permitting process required by regulatory agencies. The U.S. Army Corps of Engineers (ACOE) regulates construction in wetlands and streams. The regional stormwater BMPs have the potential to affect both natural resources.

To implement the findings of the Master Plan, a prioritization schedule and cost opinion for the improvements have been developed. The prioritization schedule will allow the city to incorporate stormwater BMP construction into capital improvement budgets. Identifying funding needs will allow the city to schedule BMP construction with available funding.

This report documents the master planning process and results so that Sioux Falls can implement a regional stormwater BMP approach based upon anticipated new development and future planning.

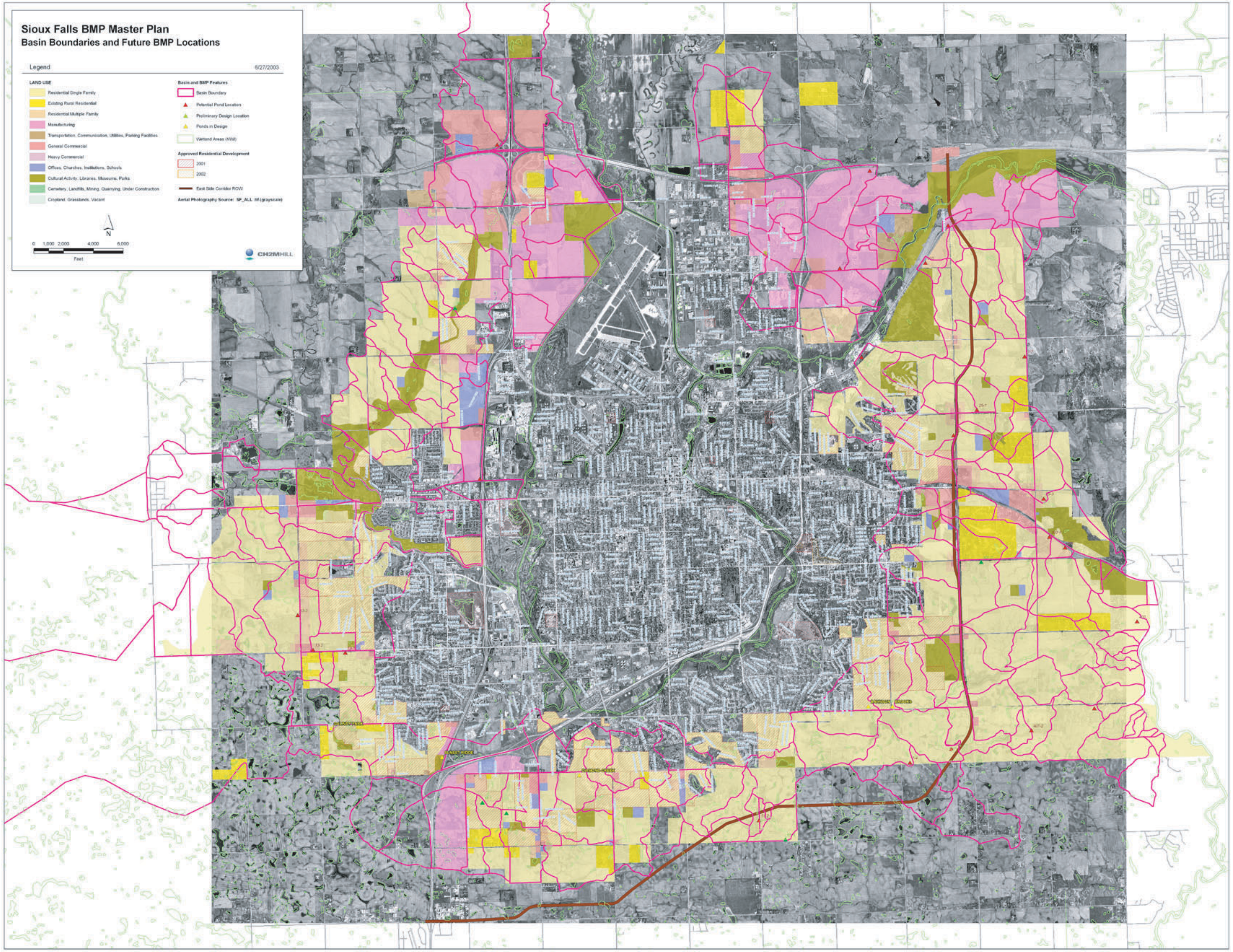


FIGURE 1-1
2015 Land Use
Stormwater BMP Master Plan
Sioux Falls, South Dakota

CH2MHILL

SECTION 2

Natural Resource Inventory

The Master Plan process identified natural resources in the new development areas of the city through a desktop analysis effort. Natural resources that were examined include:

- Wetlands
- Threatened and endangered species
- Cultural resources

A memorandum was written to document the findings of the natural resource inventory and resulting permitting issues (see Appendix A, "Wetland Permitting for Stormwater Management Facilities"). The memorandum also discusses such permitting considerations as dam safety, Federal Emergency Management Agency (FEMA) floodplain, and construction erosion control permits.

The natural resource inventory was conducted to identify potential permitting issues and to develop strategies to address issues that were identified. The potential for natural resource impacts to delay project construction increases when ACOE permitting is not addressed early on during the planning and design process. Consequently, the City should use a planning horizon of no less than 2 to 3 years to select and schedule wetland and other appropriate resource surveys. This period is recommended to allow adequate time to conduct surveys but to minimize the amount of time during which the circumstances in the project area can change (i.e., newly listed species). Project locations and rough estimates of the extent of their impacts (footprint) should be known before initiating surveys. The City should coordinate with the ACOE to ensure that the appropriate surveys are being planned and conducted.

For example, if a project location is identified in an area known to be sensitive for archaeological resources, then the City should coordinate with the ACOE on the type of survey that appears to be required, survey methodology, the professional qualifications of the firm selected, and the expected results of the survey. This up front coordination will help to ensure that the ACOE will be able to accept the survey results when they become available. The City should coordinate the survey results directly with the ACOE. Typically, the ACOE reviews the findings and forwards the survey information and the ACOE's review findings to the State Historic Preservation Office (SHPO) for SHPO review and comment. If the survey is being conducted in support of a Section 404 permit, then the survey results must be forwarded to the ACOE and not directly to other supporting agencies.

Each major natural resource area is summarized below.

2.1 Wetlands

Given the large size of the City's future urbanizing area, the Master Plan team conducted a two-tiered desktop approach for wetland identification. In the first tier, National Wetland Inventory (NWI) mapping was used and in the second tier, hydric soils information was considered. Figure 2-1 provides soils and wetlands information for the Sioux Falls area.

The NWI was prepared by the U.S. Fish & Wildlife Service (USFWS) through aerial photography interpretation. The USFWS used color infrared aerial photographs interpreted by a trained professional. The South Dakota ACOE Regulatory Office considers the NWI to be a reliable indicator of overall wetland presence. However, the NWI usually is generated through the use of 1 year of aerial photographic coverage. It also is heavily dependent upon the skill and experience of the aerial photograph interpreter and is, therefore, subject to an unquantified amount of error. Finally, NWI photointerpreted wetlands are not field-verified.

A hydric soil is one that is saturated, flooded, or ponded with water long enough during the growing season to develop anaerobic conditions in the upper horizons. The Natural Resource Conservation Service (NRCS) has developed local lists of hydric soils for each county or parish in the U.S. These local lists are preferred for use in making preliminary wetland determinations. However, distinct soil areas of less than 3 acres often are not reported in the county soil surveys. Therefore, the absence of hydric soils data for a specific site does not necessarily mean that hydric soils are not present.

The NWI provides a strong indication as to the presence or absence of protected wetlands. When used together, the NWI and hydric soils information provides an even stronger predictor of the presence of wetland in a project area. The NWI and soils data provide a useful planning tool for identifying and avoiding large wetland areas or for minimizing impacts to wetlands. The use of such a planning tool allows for the avoidance or minimization of impacts to wetlands during project planning. If NWI information indicates a wetland is present, a delineation survey using accepted ACOE methodology is required during the permitting and design phase.

The project team obtained these data and considered them in conducting a first cut of regional BMP locations as a way of avoiding and minimizing wetland impacts. Criteria used in the siting evaluation were included in the memorandum, "Criteria for Siting and Design of Regional BMP Facilities" (Appendix B).

Wetland impacts were estimated at each BMP location based upon a BMP sizing rule of thumb. Initial BMP sizes were extrapolated to other locations around the City. The results of this analysis are contained in Section 4, "BMP Locations."

2.2 Threatened and Endangered Species

When issuing permits, the ACOE is required to examine potential impacts to threatened and endangered species. Endangered species information was obtained through discussions with the ACOE and the USFWS. A number of species are recognized by the federal government as threatened or endangered within South Dakota (Table 2-1).

TABLE 2-1
Federally Listed Species in South Dakota

Status	Species Name		Notes
T	Bald eagle	*Haliaeetus leucocephalus*	Bird. Known occurrence in Lincoln and Minnehaha counties. Habitat: Wintering, breeding habitat in tall trees near lakes, reservoirs, or large rivers. Nest tree reported on northeast side of City, near Big Sioux River, location reported by USFWS to be T 102 N, R 48 W, Section 30, unable to field verify because the property was posted and access was not possible.
E	Topeka shiner	*Notropis topeka*	Fish. Known occurrence in Lincoln and Minnehaha counties. Habitat: Small, low order, prairie streams with high water quality and cool temperatures. Reported in tributaries of Big Sioux River in Minnehaha County (Beaver Creek, Four-Mile Creek, Slip-up Creek, Split Rock Creek, Spring Water Creek, W. Pipestone Creek, and Willow Creek) and Vermillion River in Lincoln County (Blind Creek, Long Creek, and Saddle Creek).
T	Western prairie fringed orchid	*Plantanthera praeclara*	Plant. Possible occurrence in Lincoln and Minnehaha counties. Habitat: Wet grassland habitat, wet prairie remnants.

Source: http://ecos.fws.gov/servlet/TESSWebpageUsaLists?state=SD, January 2003

ACOE permit applicants are required to notify the ACOE District Engineer if any listed species or designated critical habitat might be affected by or is in the vicinity of a proposed project. This means that surveys for listed species may be required prior to submittal of a permit to alter regulated waters and wetlands in certain cases. It is important to plan ahead if biological surveys are required because some species are seasonal, and fieldwork may be required during specific times of the year.

2.2.1 Bald Eagle

The threatened bald eagle is known to occur in Minnehaha and Lincoln counties. Figure 2-2 shows the general vicinity of a known bald eagle nesting site. No critical habitat is designated for the species.

Recommended management strategy: Bald eagles may not be harassed, harmed, or disturbed when present, nor may nest trees be cleared. Close coordination between the City and the USFWS is recommended whenever a project is proposed to take place within 1 mile of the existing nest tree in the northeastern part of the City.

2.2.2 Topeka Shiner

Topeka shiners were reported to occur within the City of Sioux Falls in Willow Creek, but they are not known to exist there today. They are reported to occur near Sioux Falls in Slip-up Creek, West Pipestone Creek, Split Rock Creek and one of its unnamed tributaries, Beaver Creek, and Four-Mile Creek. These creeks are all tributaries of Big Sioux River and occur north and east of the City in Minnehaha County. They also are reported to occur in Blind Creek, Long Creek, and Saddle Creek, which are tributaries of the Vermillion River in Lincoln County (USFWS 2003).

A recent study titled *Topeka Shiner* (Notropis topeka) *Population Status and Habitat Conditions in South Dakota Streams* was completed in 2001 (Wall et al. 2001). The study included information on the known distribution of Topeka shiners and identified streams that had the potential to contain them based on the results of a model that used data on their distribution and habitat preferences. Copies of the study report have been provided to the City of Sioux Falls. The report indicates that there are many streams that have the potential for Topeka shiner presence and that they are more widely found than was previously known. One potential location is the Skunk Creek drainage on the west side of the City.

In January 2003, the USFWS proposed critical habitat for the Topeka shiner. The general locations of proposed critical habitat within the Lower Big Sioux Watershed in the Sioux Falls vicinity include Slip-up Creek, Split Rock Creek, West Pipestone Creek, Beaver Creek, and Four-Mile Creek. General locations of proposed critical habitat on the Vermillion River Watershed in the vicinity of Sioux Falls include Camp Creek and Long Creek. Appendix A contains maps depicting the proposed critical habitat areas.

Recommended management strategy: Surveys for Topeka shiners should be conducted by a qualified wildlife biologist for proposed work in or adjacent to any streams where the species is reported to be found, or streams that are proposed critical habitat. Plans should be made to incorporate riparian buffers that include trees, shrubs, and native grasses along streams that may be Topeka shiner habitat.

2.2.3 Western Prairie Fringed Orchid

The western prairie fringed orchid is listed as threatened and is considered to potentially occur based on historical records and habitat distribution. It occupies wet grassland habitats. No critical habitat is designated for the species.

Recommended management strategy: The western prairie fringed orchid should be searched for by a wildlife biologist or other qualified person whenever wet prairie remnants are encountered. Typically, wet prairie remnants are found in undisturbed areas inhabiting the transition zone between upland prairie and low-land wetlands.

2.3 Cultural Resources

The ACOE will not approve any activity that may affect historic properties listed or eligible for listing in the National Register of Historic Places (NRHP) until the District Engineer has complied with the ACOE's cultural resource procedures (found at 33 CFR part 325, Appendix C). There are many federal laws that address various aspects of our shared cultural heritage. Some of the more commonly encountered are:

- American Indian Religious Freedom Act (AIRFA)
- Antiquities Act of 1906
- Archaeological Data Preservation Act of 1974
- Archaeological Resources Protection Act (ARPA)
- Historic Sites Act (HSA) of 1935
- National Historic Preservation Act (NHPA) of 1966
- Native American Graves Protection and Repatriation Act (NAGPRA)
- South Dakota State Law SDCL 1-19A-11.1

Of these, the NHPA is the law most likely to be triggered by a stormwater BMP project. The NHPA requires the federal government to consider the effects that proposed actions would have on historic property[1] important to the nation's history. All cultural resource work must be performed under the supervision of a professional who meets the Secretary of the Interior's Professional Qualifications Standards. Due to the sensitive nature of archaeological site information, site-specific information typically is treated as confidential if the security of the information cannot be assured.

An ACOE permit applicant must notify the ACOE District Engineer if the proposed activity may affect any historic properties listed, determined to be eligible, or which may be eligible for listing on the NRHP. The applicant is not allowed to begin the activity until notified by the District Engineer that the requirements of the NHPA have been satisfied. For activities

[1] Historic property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria. The term *eligible for inclusion in the National Register* includes both properties formally determined as such in accordance with regulations of the Secretary of the Interior and all other properties that meet the National Register criteria [36 CFR 800.16.l].

that may affect historic properties, the notification must state which historic property may be affected by the proposed work or include a vicinity map indicating the location of the historic property.

During the Master Plan development process, the Archaeology Laboratory at Augustana College was retained to conduct a sensitivity analysis of the City's future urbanizing area. This analysis was based on the results of previously conducted surveys, known archaeological sites, previously mapped mound groups, the relationships between land forms (i.e., bluffs or perennial water) with known archaeological surveys, and the experience of the professional archaeologists who have worked in the area for 2 decades. The results of this sensitivity analysis are contained in an attachment to Appendix A, "Draft Archaeological Sensitivity Analysis, Stormwater Best Management Practices (BMP) Project, Sioux Falls, South Dakota," and in a Geographic Information System (GIS) layer that provides detailed spatial information on sensitive areas.

Figure 2-2 shows areas of potentially high sensitivity for archaeological resources. One of the most sensitive archaeological resources near Sioux Falls is the Blood Run National Historic Landmark, located southeast of the City along the South Dakota/Iowa border on the Big Sioux River. Blood Run appears to be outside the future urbanizing area.

Table 2-2 summarizes the BMPs located in areas with potentially high sensitivity for archaeological resources. It is recommended that the BMP sites that fall within such areas undergo a phase 1 archaeological reconnaissance survey encompassing both desktop research and a field walkthrough with selective exploration. Coordination with the ACOE on archaeological survey requirements at BMP sites located outside the high sensitivity designation should be initiated as early as possible. Characteristics of these sites are described in Section 4, BMP Locations.

TABLE 2-2
Cultural Resources Screening Table

BMP	Located in Potentially High Sensitivity Cultural Resources Area	BMP	Located in Potentially High Sensitivity Cultural Resources Area
13-1	No	41-A	No
13-2	No	401-1	No
13-3	No	401-2	Yes
11-1	Yes	40-2	Yes
11-2	Yes	304	No
40-1	Yes	312	No
51-2	Yes	400	Yes
7-4	No	303-4	No
51-1	Yes	22	Yes
7-5	Yes	317	No
25-3	No	40-3	No
303-2	No	305	No
25-1	No	306	Yes
25-2	No	316	Yes

If human remains are uncovered during construction, work must stop immediately and appropriate City personnel notified. Although accidental disturbance of human remains is acceptable, intentional disturbance can result in criminal prosecution of the offending party. All construction personnel and all involved parties must be informed of and understand the process and the difference between accidental discovery and intentional disturbance.

Recommended management strategy: If an area has not been surveyed for archaeological resources and such a survey is required, the first step typically is a Phase I Archaeological Reconnaissance Survey. The goal of the survey is to identify archaeological resources. Reconnaissance surveys typically seek to identify all archaeological sites (both precontact and historic) in the project area of potential effect, especially those that may meet the criteria of significance regarding eligibility for listing on the NRHP.

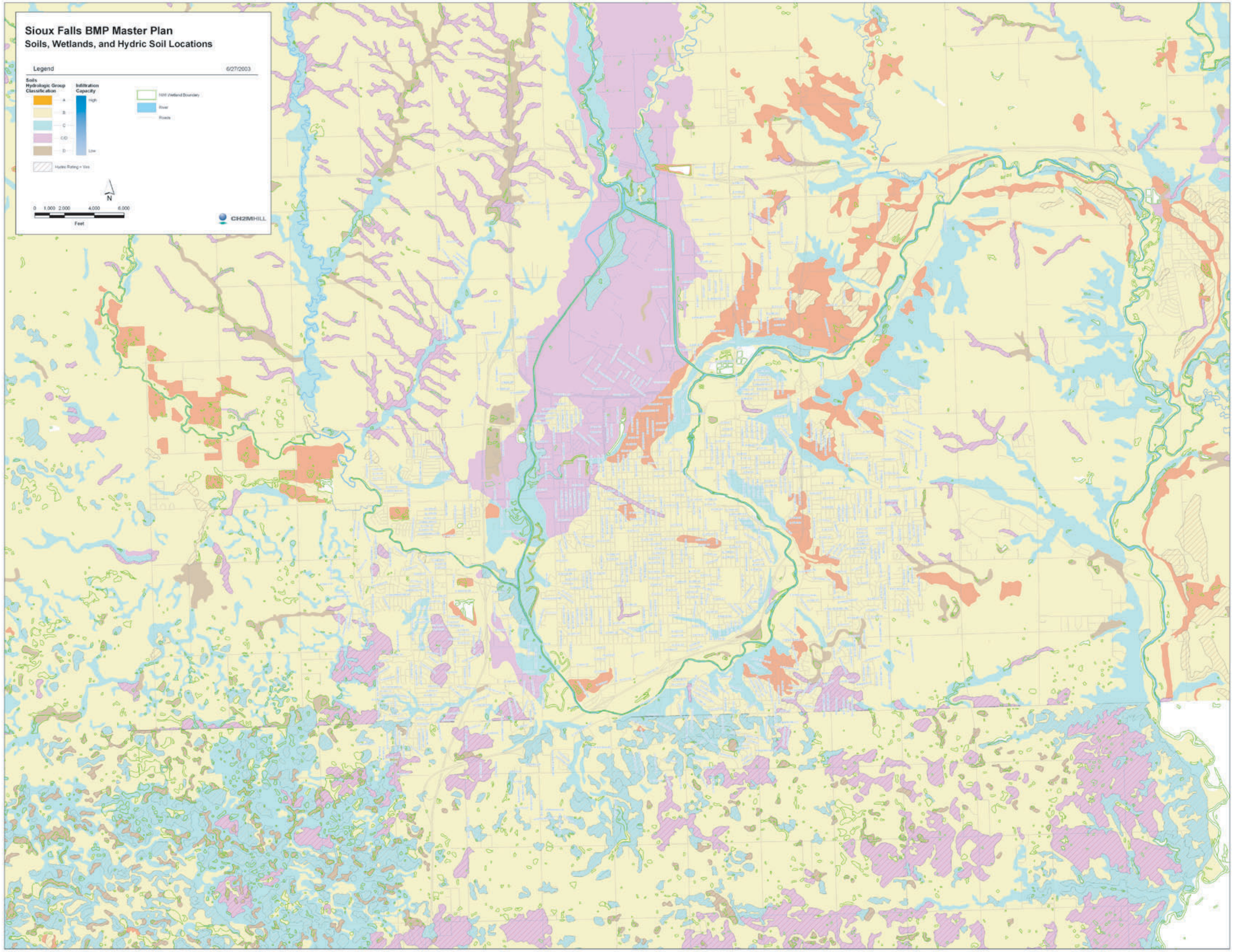


FIGURE 2-1
Soils and Wetland Information
Stormwater BMP Master Plan
Sioux Falls, South Dakota

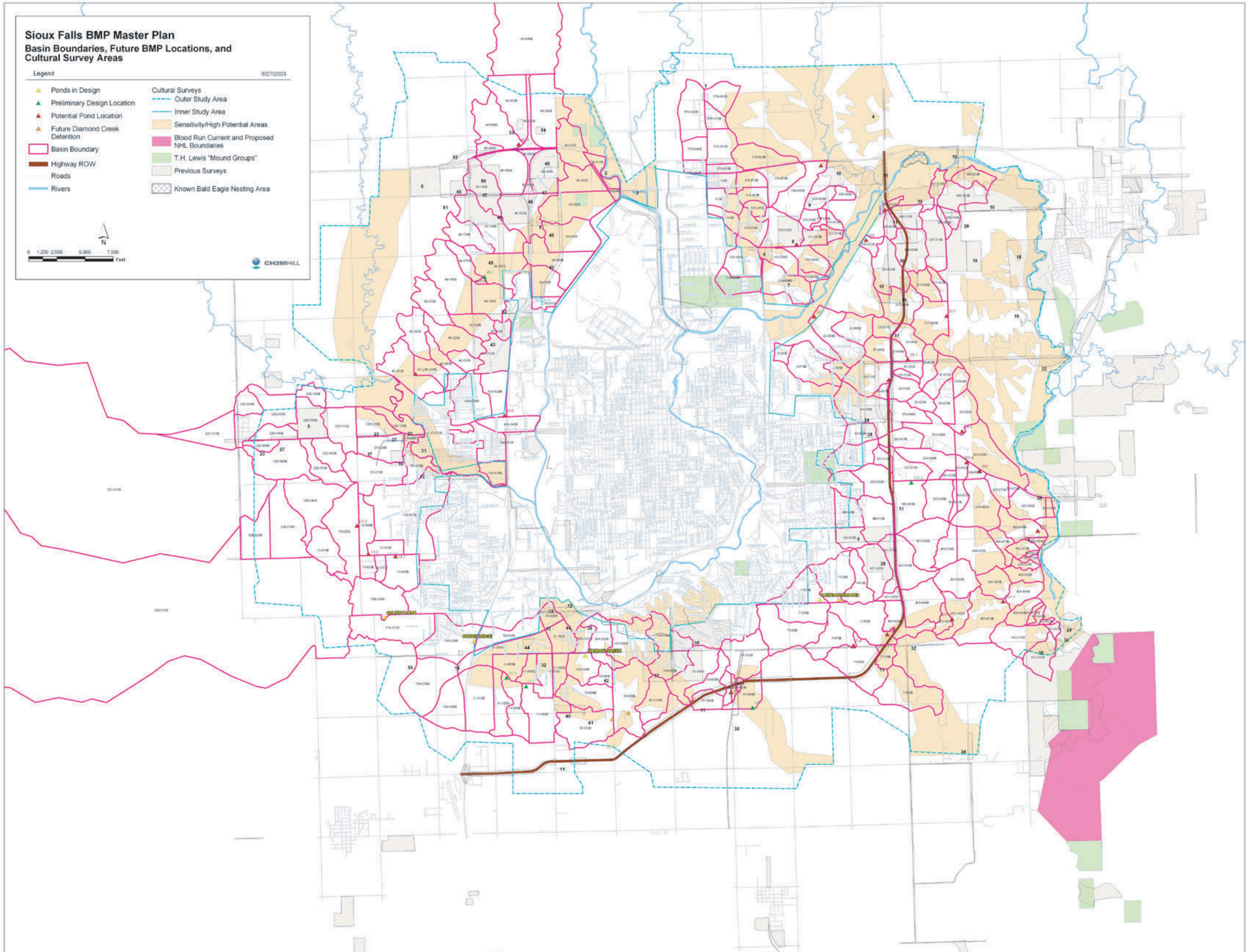


FIGURE 2-2

Cultural Resource Information

Stormwater BMP Master Plan
Sioux Falls, South Dakota

SECTION 3

BMP Siting and Design Considerations

Determining the locations of regional BMPs is based upon natural resource information, the local topography, design standards, and other considerations. In some instances, it will be more effective to not provide regional BMPs and instead have individual developments address BMPs on a site-specific basis. The elements considered in the Master Plan study are summarized in this Section under:

- Siting and Sizing Criteria
- Stormwater Controls
- Site-Specific Areas

Information on each of these considerations is summarized below.

3.1 Siting and Sizing Criteria

To define technically sound, implementable and consistent siting and sizing criteria, the memorandum "Criteria for Siting and Design of Regional BMP Facilities" (Appendix B) was developed to document the design standards used as part of the master planning process. Siting and sizing criteria from the memorandum are summarized below.

3.1.1 BMP Type Selection Approach

Chapter 11 water quality capture volume (WQCV) BMPs formed the basis for BMPs selected as part of the Master Plan. Where there was an observed or expected baseflow in the stream, the pond and stream channel upstream intersect the groundwater level, and so wet ponds (retention basin) are more appropriate and recommended. In some instances, alternative BMPs within a permanently inundated area, such as a constructed wetlands basin are appropriate and recommended. A dry pond at such a location would definitely have a persistent wet area, in the "low-flow" channel and likely in areas near the sediment forebay or the outlet. In instances where a baseflow is not expected, a "dry-pond" (extended detention basin) is appropriate and recommended.

3.1.2 BMP Siting and Layout Criteria

For the master planning process, criteria were developed to help guide the BMP site selection process. The siting criteria are presented in the Table 3-1. The siting process consisted of the following steps:

1. The end of each subbasin was examined as a potential BMP location. A qualitative decision was made by viewing the wetlands at the end of the basin to determine if it would have a relatively high wetland impact or low wetland impact. If a high wetland impact was anticipated, a different location was chosen for the BMP and the qualitative screening process was documented.

2. Once subbasin and BMP sites were selected, estimates of the BMP footprint were made and the associated wetland impacts quantified.
3. If known threatened and endangered species are present at a BMP site location during site screening, consideration would be given to an alternative BMP location. A change in sites would be documented.
4. If known cultural resources are present, consideration would be given to an alternative BMP location.
5. For instances where additional information becomes available for threatened and endangered species or cultural resources after site selections have been made, at a minimum, permitting considerations would be documented.

Other factors listed in Table 3-1 were considered in the siting process.

TABLE 3-1
Siting Criteria for Watershed-Level BMP Facilities

Criterion	BMP Applicability
Take advantage of existing topography and maintain natural vegetation	All
Use the known wetlands and threatened and endangered species information to screen sites	All
Minimize impacts to known cultural resources	All
Maximize use of man-made infrastructure (road-crossings)	Ponds
Maximize use of existing ponds (including BMPs and farm ponds)	Ponds
Consider small subbasin confluences for BMP sites.	Ponds
Keep drainage area for ponds within 100 to 300 acres. Evaluate larger drainage areas on main streams to maximize BMP coverage. Balance critical habitat with drainage area size.	Ponds
Land-use appropriateness and watershed shape	All
Minimize interference with utility easements.	All
Balance water quality benefits, permitting requirements, and costs	All

3.1.3 BMP Sizing Criteria

The regional BMPs included a three level sizing criteria. In order of increasing magnitude, the design size is determined by:

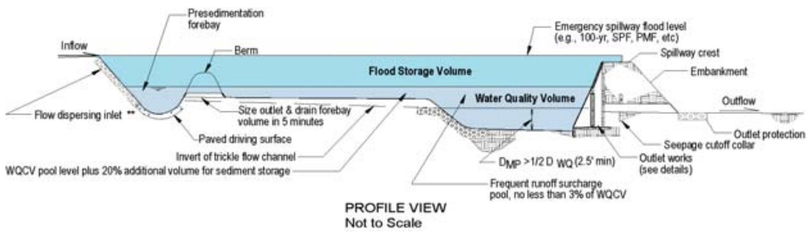
1. WQCV
2. Runoff peak attenuation design storm: match predevelopment peak flows for developed peak flows for the 5-year storm
3. Runoff peak attention design storm: match predevelopment peak flows for developed peak flows for the 100-year storm

Where BMPs were sited adjacent to principle arterial roadways, no road overtopping during the 100-year storm was an additional design criteria. In such instances, a 20-foot maximum pond outlet pipe width was used in most circumstances. In some cases, this had the effect of holding postdevelopment peak flows to a level below predevelopment peak flows.

Peak attenuation can be done through either a structure or a spillway. The standard approach assumed for the Master Plan is to have both the 5- and 100-year storms entirely contained within the same structure while the berm spillway or roadway will be an "emergency spillway" which is only activated for events larger than the 100-year storm.

Sample Design Criteria

- Water quality volume from Engineering Design Standards
- 5- and 100-year peak flow control (match predevelopment land use)
- Maintenance access
- Wet or dry ponds



It is necessary to obtain a permit from the DENR for BMPs which have a 25-foot or higher dam or which contain 50 acre-feet or more of water at the top of the berm. Spillway design requirements vary depending upon the dam classification, but it is expected that the typical design criteria will be for the 100-year design flood or one half of the probable maximum flood (PMF). Additional information on dam safety considerations is found in Section 8.

3.2 Stormwater Controls

Certain nonstructural BMPs can help to promote water quality. In some instances, nonstructural BMPs may be required as part of the ACOE's permitting approval of the regional BMP facilities. As a result, the master planning process evaluated and identified nonstructural and vegetative management measures based on current planning and engineering practice, including buffer zones, open space preservation, river greenways in-line with 2015 land use, and vegetative BMPs. The evaluation provided information on the feasibility of implementing nonstructural management measures in development projects, with emphasis on the 2015 growth area. The evaluation was documented in the memorandum "Nonstructural and Vegetative BMP Controls" (Appendix C).

BMPs evaluated as part of the process include:

- Riparian buffers
- Grass swales
- Modified grass swales
- Filter strips
- Bioretention
- Grass shoulders
- Transportation—grass swales

3.3 Multi-use Design Considerations

BMPs can be developed to provide other uses besides stormwater management. For example, BMPs have been developed into parks, green space, ball fields, bike paths, nature trails, and urban nature centers. Where suitable conditions exist, multi-use concepts should be incorporated into the regional BMP designs.

Not all BMPs will be suitable for multi-use facilities, depending upon local topography, land use, and other constraints. However, where opportunities exist to tie into other recreational plans and facilities, the regional BMPs may provide an added benefit to the citizens of Sioux Falls. The preliminary design discussion in Section 7 contains additional information on multi-use opportunities and examples.

3.4 Site-Specific Areas

The BMP siting process revealed that there are several areas in the City where individual developments will have to meet the Chapter 11 water quality standards on a development-by-development basis. These areas have been defined as "site-specific areas." Several practical factors influenced the designation of these areas, including the following:

- Locations that are part of a watershed that is predominately developed such that a regional BMP would likely be an individual development anyway
- Areas of 2015 land use that are remote, not directly connected to growth areas, and that are best served by site-specific BMPs
- Areas where much of the watershed already has received development approval prior to the December 28, 2002, implementation date, after which development must meet the stormwater quality standards contained in Chapter 11 Drainage Improvements.
- Areas where the sanitary sewer basin overlaps a small portion of a watershed where most development will not occur in that watershed until beyond the 2015 planning horizon
- Areas where existing development and local topography limit the types of BMPs appropriate to the watershed
- Smaller watersheds where it is less strategic to provide regional facilities
- Small subbasins that flow directly into the Big Sioux River
- New and redevelopment areas within the already urbanized City core

To visually show the regional BMP coverage, the City was divided into four quadrants. The areas designated as site-specific are shown in Figures 3-1 through 3-4. These figures also show the areas served by regional BMP facilities.

For the purpose of the Master Plan study, only the new development areas with 2015 land use were evaluated for regional facilities. No evaluation was made to locate facilities within the existing urbanized area. Consequently, those areas are labeled as site-specific.

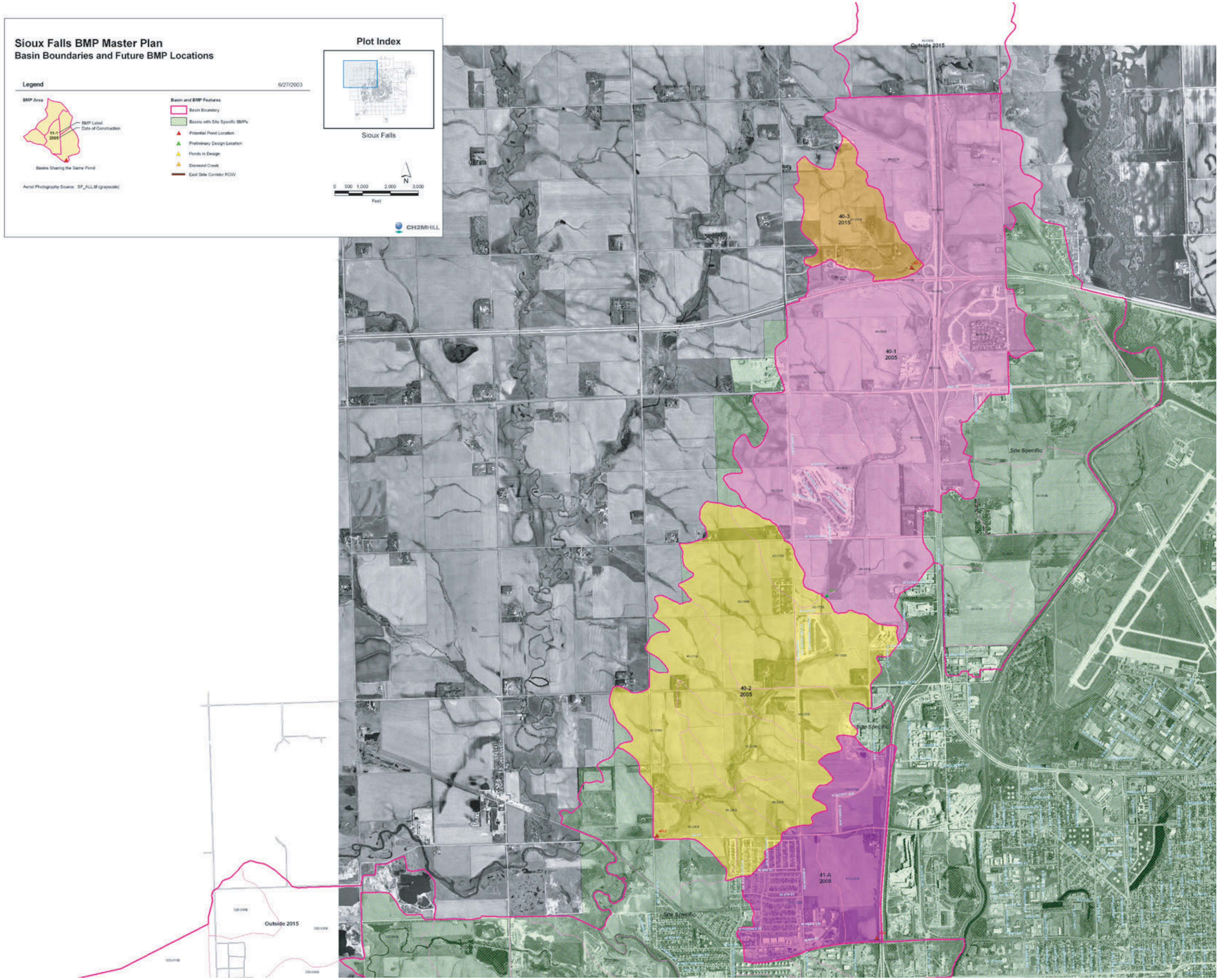


FIGURE 3-1
NW Quadrant
Regional BMP Coverage
Stormwater BMP Master Plan
Sioux Falls, South Dakota

CH2MHILL

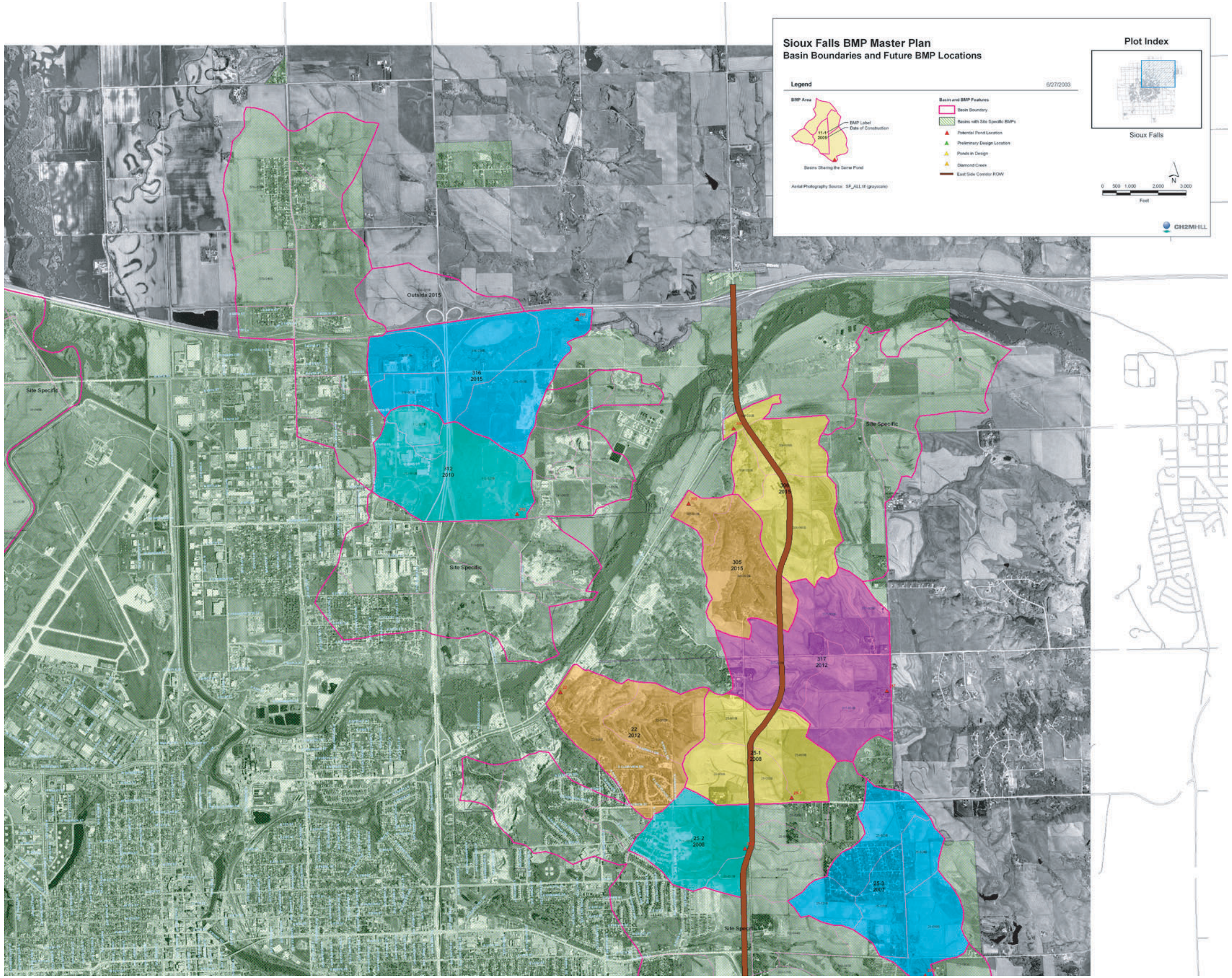


FIGURE 3-2
NE Quadrant
Regional BMP Coverage
Stormwater BMP Master Plan
Sioux Falls, South Dakota
CH2MHILL

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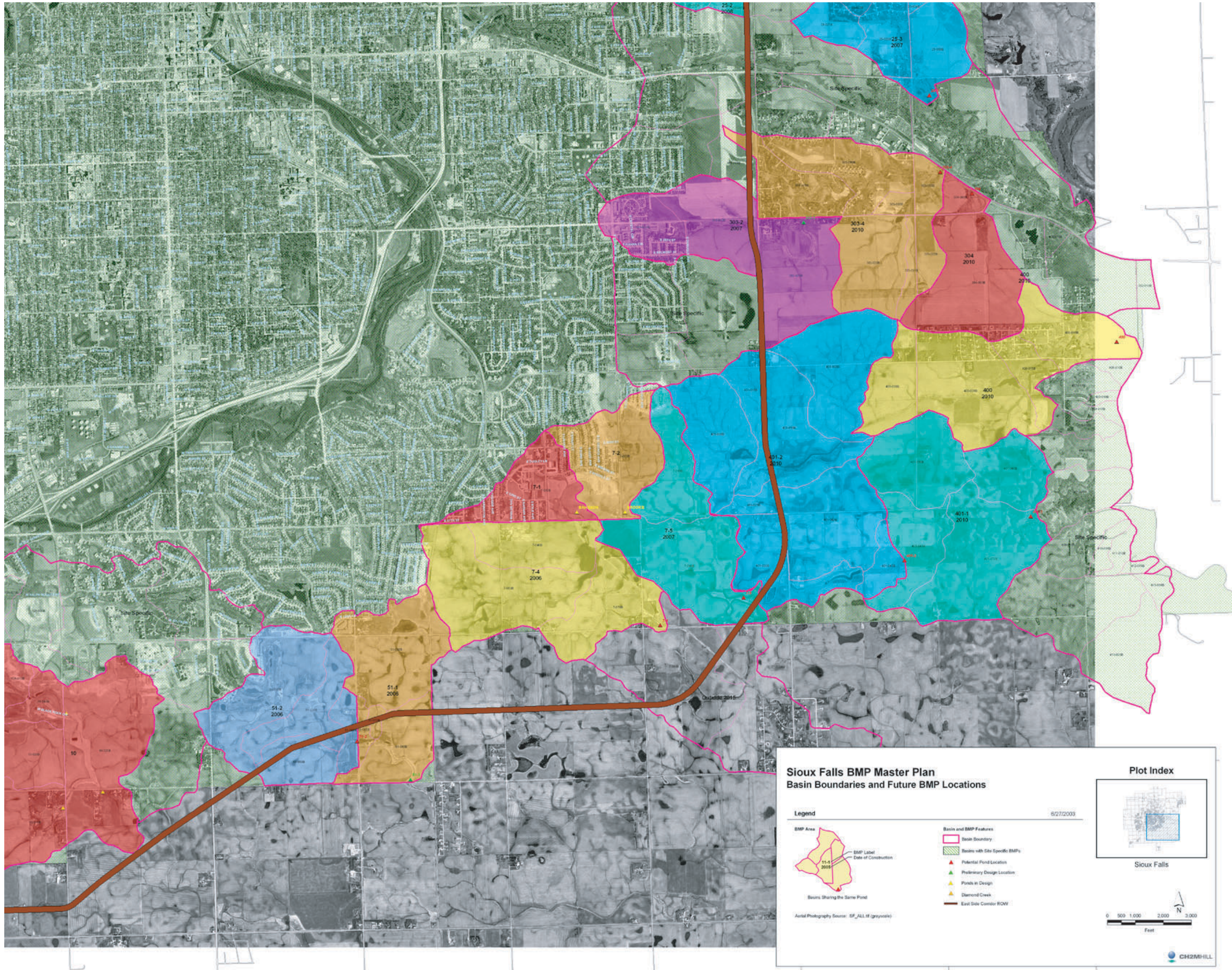


FIGURE 3-3
SE Quadrant
Regional BMP Coverage
Stormwater BMP Master Plan
Sioux Falls, South Dakota
CH2MHILL

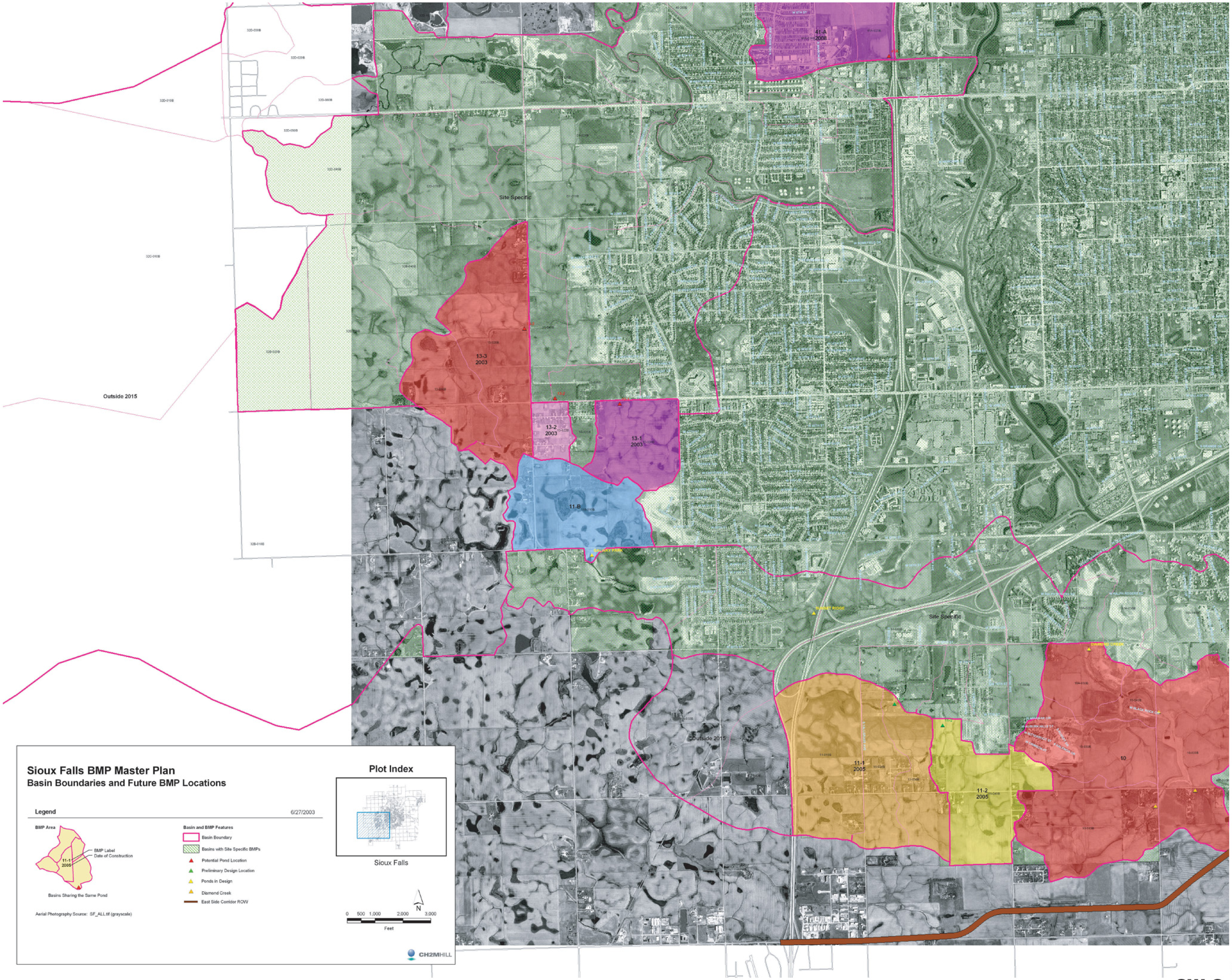


FIGURE 3-4
SW Quadrant
Regional BMP Coverage
Stormwater BMP Master Plan
Sioux Falls, South Dakota

SECTION 4

BMP Locations

BMP locations are shown in Figure 4-1 in an overall view for the City and in Figures 3-1 through 3-4 in more detail for each quadrant of the study area. Yellow, green, and red triangles on the figures represent BMP locations. The yellow triangles indicate BMP locations for which design is under way; the green triangles locations for which preliminary designs were developed under the Master Plan project; and the red triangles additional BMP sites identified through the Master Plan. Additional BMP sites were considered but eliminated because of siting constraints and limitations on the realistic number of regional facilities that can effectively be managed by the City.

4.1 Field Verification

Each proposed BMP site location was investigated to assure that selected sites could accommodate detention pond construction. City staff performed field investigations in April 2003 at each proposed BMP location. In general, the field investigations assessed potential environmental impacts, grading and construction issues, temporary and permanent access/maintenance considerations, and potential land ownership/value issues. Field investigators completed the standard "Sioux Falls BMP Site Field Data Sheet" for each location. The information collected includes:

- Location description
- Current land use
- Type of land ownership
- Topography and hydrology characteristics
- Potential storage capacity
- Construction considerations
- Bank erosion observations
- Longitudinal slope analysis
- Photos

Individual data field sheets, a map of the wetland impacts resulting from each BMP, and a summary sheet for each BMP can be found in Appendix D, "BMP Information," under the corresponding tab for each BMP. Table 4-1 summarizes the information compiled during the field investigations.

4.2 Property Parcels

Geographic coordinates for each proposed BMP location were determined and used to query the Sioux Falls, Minnehaha County, and Lincoln County GIS parcel information to obtain information regarding the property parcels potentially affected by the BMP. Some information for Lincoln County is unavailable as it is not yet all in a GIS system.

The parcel boundary information will facilitate future coordination for informational outreach, site access, and property acquisition. For planning purposes, a concentric circle radiating 500 feet from the approximate BMP location was used to query parcel information. Table 4-2 lists the identification numbers of potentially affected parcels. Depending upon final BMP design configuration, some properties could be dropped from the list and others added.

TABLE 4-1
Sioux Falls BMP Site Field Data Sheet

BMP ID	Location Description	Current Land Use	2015 Land Use	Land Owner-ship	Baseflow Present	Vegetation Type	Access Feasible for Construction
13-1	2,100 ft west of 41st Street and Sertoma Avenue intersection, on south side of 41st Street	Agricultural/slough	Residential single family	Private	N	Long grasses	Yes
13-2	850 ft east of Tea Ellis Road and 41st intersection, on north side of 41st Street	Vacant lot	Residential single family	Private	NA	Long grasses	Yes
13-3	2,700 ft north of Tea Ellis Road and 41st Street intersection, on west side of Tea Ellis Road	Agricultural/slough	Residential single family	Private	NA	Long grasses	Yes
11-1	East of Tallgrass Avenue and south of 69th Street, Pond 17C of Prairieview Study	Agricultural/slough	Residential single family	Private	Y	Cattails, pasture	Moderate, in the middle of agricultural operation
11-2	750 ft west of Crane Street and 77th Street intersection, Pond 17B of Prairieview Study	Agricultural/slough	Residential single family	Private	Y	Cattails, long grass	Yes
40-1	1,200 ft east and 700 ft north of Marion Road and W 34th Street N intersection	Agricultural/slough	Residential single family/open space	Private	Y	Cattails, long grasses	Yes
51-2	1,500 ft north of Cliff Avenue and 85th Street intersection, on west side of Cliff Avenue	Agricultural/slough	Residential single family	Private	Y	Tall grasses and cattails	Good
7-4	600 ft east of intersection of Sycamore and 69th Street, on north side of 69th Street	Agricultural/slough	Residential single family	Private	Y	Tall grasses and cattails	Good
51-1	1,850 ft east of Cliff Avenue and 85th Street intersection, on north side of 85th Street	Agricultural/slough	Residential single family	Private	Y	Tall grasses and cattails	Good

TABLE 4-1
Sioux Falls BMP Site Field Data Sheet

BMP ID	Location Description	Current Land Use	2015 Land Use	Land Owner-ship	Baseflow Present	Vegetation Type	Access Feasible for Construction
7-5	1,600 ft west and 1,000 ft north of Rushmore and 69th Street intersection, extends upstream and downstream of future East Side Corridor	Agricultural/slough	Residential single family	Private	Y	Tall grasses and cattails	Below average
25-3	Southeast corner of Six Mile Road and 10th Street	Slough	Residential single family/residential multiple family	Private	Y	Low grass in wet conditions	Adequate
303-2	1,600 ft east of Powderhouse and 26th Street, on south side of 26th Street	Agricultural/slough	Residential single family	Private	Y (very little)	Low grass in wet conditions	Adequate
25-1	1,600 ft east of Madison Street and Powder House intersection, on north side of Madison Street	Farmstead	Residential single family	Private	NA	Agriculture, grasses, timber	Acceptable
25-2	1,600 ft south of Madison Street and Powder House intersection, on west side of Powder House	Agriculture	Residential single family	Private	NA	Grassland	Acceptable
41A	1,500 ft north of I-29 and 12th Street intersection, on west side of I-29	Agricultural/slough	Manufacturing	Private	N	Agriculture	Moderate
401-1	4,000 ft east of Six Mile Road, on south side of 57th Street	Agricultural/slough	Residential single family	Private	Y	Tall grasses and cattails	Below average
401-2	1,800 ft south of Six Mile Road and 57th Street intersection, west side of Six Mile Road (Tisdale)	Agriculture	Residential single family	Private	Y	Tall grasses	Below average
40-2	Northeast corner of Madison Street and La Mesa Dr. intersection	Agricultural/slough	Open space	Private	Y	Cattail, long grasses	Yes
304	2,600 ft southeast of intersection of Six Mile Road and STH 42 (Minnehaha Road), on south side of STH 42	Agricultural	Residential multiple family	Private	Y	Low grass in wet conditions	Adequate

TABLE 4-1
Sioux Falls BMP Site Field Data Sheet

BMP ID	Location Description	Current Land Use	2015 Land Use	Land Owner-ship	Baseflow Present	Vegetation Type	Access Feasible for Construction
312	2,750 ft east of I-229, on north side of Benson Road	Agriculture, slough	Manufacturing	Private	NA	Grasses	Acceptable
400	7,200 ft east of Six Mile Road, on north side of 41st Street	Agriculture	Residential single family	Private	Y	NA	Inadequate, private access
303-4	1,300 ft southeast of Six Mile Road and STH 42 (Minnehaha Road) intersection, on south side of STH 42	Agricultural	Residential multiple family	Private	Y	Low grass in wet conditions	Adequate
22	2,600 ft east of Bahnson Road, between Rice Street and the railroad tracks	Agricultural/timber	Residential single family	Private	NA	Timber	Moderate
317	1,300 ft south of Maple Road and Six Mile Road intersection, on west side of Six Mile Road	Farmstead	Residential single family	Private	NA	Grasses	Acceptable
40-3	Northwest corner of I-90 and I-229 interchange	Agricultural/slough	General commercial	Private	Y	Long Grass	Yes
305	East side of Rice Street, 400 ft northeast of Lawrence Pl, north of Great Bear	Agriculture	Residential multiple family	Private	NA	Grasses	Difficult due to RR
306	Northeast of intersection of Rice Street and Timberline, upstream of East Side Corridor	Vacant	Manufacturing	Private	NA	Timber	Acceptable
316	4,700 ft east of I-90 and I-229 interchange, on south side of I-90	Farmstead	Manufacturing	Private	NA	Timber, grasses	Access substandard, easement required

TABLE 4-2
Property Ownership Information

BMP Location	Parcel Source	Parcel ID Number	BMP Location	Parcel Source	Parcel ID Number
40-3	M	011524400001000	40-2	M	012110400004000
40-3	M	011524400002000	40-2	M	012111300001000
40-3	SF	011525100007000	40-2	M	012111300002000
40-3	M	011525200002000	40-2	M	012111300003000
40-3	M	011525200004000	41-A	SF	012113100006000
316	M	011625100003000	41-A	SF	012113201001000
316	M	011625300002000	41-A	SF	012113376001000
316	M	011626400009000	41-A	SF	012113377001000
316	M	011626400011000	40-2	M	012114100006000
312	SF	011635300003000	40-2	M	012115200006000
312	SF	011635400008000	40-2	M	012115200007000
306	M	011636200004000	13-3	SF	012127100004000
305	SF	011636300004000	13-2	M	012127300002000
306	SF	011636400002000	13-2	M	012127300003000
306	M	011636400002000	13-1	M	012127300003000
305	SF	011636400002000	13-1	M	012127400003000
306	M	011731100002000	13-1	SF	012127486002000
306	M	011731100004000	13-1	SF	012127486003000
306	M	011731300001000	13-3	M	012128200014000
306	M	011731503002000	13-1	M	012134100004000
40-1	SF	012101100006000	13-1	M	012134100005000
40-1	SF	012101100008000	13-2	M	012134101001000
40-1	SF	012101125001000	13-2	M	012134101002000
40-1	SF	012101170001000	13-2	M	012134101003000
40-1	SF	012101300002000	13-2	M	012134101004000
40-1	SF	012101300006000	13-2	M	012134101005000
40-1	SF	012101300011000	13-2	M	012134101006000
40-1	SF	012101301006000	13-2	M	012134101007000
40-1	SF	012101302014000	13-2	M	012134101008000
40-1	SF	012101302015000	13-2	M	012134101009000
40-1	SF	012101303034000	13-2	M	012134101010000
40-1	SF	012101303035000	13-2	M	012134101011000
40-1	SF	012101304010000	13-2	M	012134101012000
40-1	SF	012101304011000	13-2	M	012134101013000
40-1	SF	012101304012000	13-2	M	012134101014000
40-2	M	012110400003000	13-2	M	012134101015000

TABLE 4-2
Property Ownership Information

BMP Location	Parcel Source	Parcel ID Number	BMP Location	Parcel Source	Parcel ID Number
13-2	M	012134101016000	13-1	M	012134127012000
13-2	M	012134101017000	13-1	M	012134200001000
13-2	M	012134101018000	305	SF	012201100005000
13-2	M	012134101019000	312	SF	012202100001000
13-2	M	012134102005000	312	SF	012202200006000
13-2	M	012134102006000	22	SF	012211202008000
13-2	M	012134102007000	22	SF	012211227001000
13-2	M	012134102008000	22	SF	012211252005000
13-2	M	012134102009000	22	SF	012211503002000
13-2	M	012134102010000	22	SF	012212101001000
13-2	M	012134102011000	25-2	M	012213200002000
13-2	M	012134102012000	25-2	M	012213200003000
13-2	M	012134126001000	25-2	M	012213200004000
13-2	M	012134126002000	25-2	M	012213200005000
13-2	M	012134126003000	25-2	M	012213200006000
13-2	M	012134126004000	25-2	M	012213200017000
13-1	M	012134126008000	317	M	012307100001000
13-1	M	012134126009000	317	M	012307200002000
13-1	M	012134126010000	25-1	M	012307300003000
13-1	M	012134126011000	317	M	012308100001000
13-1	M	012134126012000	317	M	012308100002000
13-2	M	012134126013000	303-3	M	012317300014000
13-2	M	012134126014000	303-3	M	012317300019000
13-2	M	012134126015000	303-3	M	012317300020000
13-2	M	012134126016000	25-2	M	012318100001000
13-2	M	012134126017000	25-1	M	012318100002000
13-1	M	012134126021000	25-1	M	012318100003000
13-1	M	012134126022000	25-1	M	012318100004000
13-1	M	012134126023000	25-1	M	012318100005000
13-1	M	012134126024000	25-1	M	012318100006000
13-1	M	012134126025000	25-1	M	012318100007000
13-2	M	012134127001000	25-1	M	012318100009000
13-2	M	012134127002000	303-3	M	012318400004000
13-1	M	012134127009000	303-3	M	012318400006000
13-1	M	012134127010000	303-3	M	012319200001000
13-1	M	012134127011000	303-3	M	012319200002000

TABLE 4-2
Property Ownership Information

BMP Location	Parcel Source	Parcel ID Number	BMP Location	Parcel Source	Parcel ID Number
303-2	M	012319352012000	303-2	M	012330100011000
303-2	M	012319352015000	303-2	M	012330100019000
303-2	M	012319352016000	303-2	M	012330100020000
303-2	M	012319376009000	401-1	M	012332300002000
303-2	M	012319376010000	401-1	M	012332400003000
303-2	M	012319376011000	401-1	M	012332400004000
303-4	M	012319400009000	400	M	012333100008000
303-4	M	012319400013000	11-1	SF	022817150001000
303-3	M	012320100001000	11-2	SF	022817150001000
303-3	M	012320100002000	11-2	SF	022817244013000
303-4	M	012320151010000	11-2	SF	022817251001000
303-4	M	012320151011000	11-2	SF	022817434013000
303-4	M	012320151012000	11-2	SF	022817434026000
303-5	M	012320300003000	11-2	SF	022817435003000
303-4	M	012320300003000	11-2	SF	022817435004000
303-5	M	012320300008000	11-2	SF	022817435005000
303-4	M	012320300008000	11-2	SF	022817435006000
303-5	M	012320300009000	11-2	SF	022817435007000
303-4	M	012320300009000	11-2	SF	022817435008000
303-3	M	012320300009000	11-2	SF	022817436002000
303-5	M	012320300015000	11-2	SF	022817436003000
303-4	M	012320300015000	11-2	SF	022817436004000
303-5	M	012320451001000	11-2	SF	022817436005000
303-5	M	012320451002000	11-2	SF	022817436006000
303-5	M	012320451014000	11-2	SF	022817436007000
303-4	M	012320504003000	11-2	SF	022817436008000
400	M	012328300015000	11-2	SF	022817436009000
400	M	012328300016000	11-2	SF	022817436010000
400	M	012328300018000	7-5	no parcels	
400	M	012328300019000	7-4	no parcels	
303-2	M	012330100004000	51-1	no parcels	
303-2	M	012330100005000	51-2	no parcels	
303-2	M	012330100006000	401-2	no parcels	

This is a partial list due to the 500-foot radius estimate because not all tax parcel information was available in GIS.
SF = Sioux Falls, M=Minnehaha County

4.3 Wetland Impacts

Various BMP locations were analyzed for wetland impacts. A screening process was developed to identify BMP sites as discussed in the Section 2.

4.3.1 Initial Screening Results

Initially, 50 proposed BMP locations were compared to resulting wetland locations from both the NWI and available data on locations of hydric soils to determine potential wetland impacts as a result of BMP construction. Estimated pond footprints for these 50 sites were developed based upon rule-of-thumb BMP footprint areas. After the initial screening and a fatal flaw analysis, 28 final BMP locations were selected. The wetland impact analysis for the final BMP locations is described below in Section 4.3.2.

The stream length affected by both the initial and final BMPs was also determined. Stream length influence was estimated by digitizing flow paths using the City's 2-foot contour interval mapping. Table 4-3 compares the results of the wetland and stream impact analyses and shows the significant reduction in wetland and stream length impacts from the initial locations to the final locations.

TABLE 4-3
Analysis of Potential Impacts to Wetlands and Streams

	Initial 50 Sites	Final 28 Sites
NWI Wetland Potential Impact	27.8 acres	13.7 acres
Hydric Soils Potential Impact	97.6 acres	65.3 acres
Stream Potential Impact	89,464 LF	57,348 LF

Note: Wetland areas are based on currently available NWI and hydric soils data and have not been field verified. Stream potential impact is based upon flow-line information developed during basin delineation and is not an indication of stream type (intermittent, perennial, etc.).

TABLE 4-4
Wetland Impacts at Five BMP Locations with Preliminary Designs

BMP	Total Potential Wetlands Impact
11-1	0.6 acre
11-2	0.7 acre
40-1	4.0 acres
51-1	4.0 acres
303-2	0.2 acre

4.3.2 Recommended Master Plan Location Results

For the recommended BMP locations shown in Figures 3-1 through 3-4 (those denoted by red and green triangles), a more detailed wetland and stream impact analysis was conducted. Each BMP site was analyzed using the City's 2-foot contour mapping in combination with detention volumes, berm heights, and estimated 100-year storm detention elevation identified during the modeling task. (One foot of freeboard was included below the berm heights.)

The wetland impact analysis estimated impacts upon both NWI wetlands and hydric soils. The analytical results should be treated as preliminary because wetland locations have not been field verified for this Master Plan, and pond designs are either preliminary or conceptual. Table 4-4 shows the preliminary potential wetland impacts for the five preliminary design sites presented in Section 7.

Stream impacts also were estimated for the recommended BMP sites because stream impacts are also regulated under the ACOE permitting process. The influence of perennial versus intermittent streams on permitting requirements is detailed further in Appendix A. Table 4-5 lists the results of the wetland impact and stream impact analyses.

TABLE 4-5
Wetland Impacts at Recommended BMP Locations

BMP	Pond Area (Ac)	Pond Area with 100' Buffer (Ac)	NWI Only (Ac)	Hydric Soils Only (Ac)	Both NWI and Hydric Soils (Ac)	Total Potential Wetlands Impact (Ac)	Stream Length Impact (ft)	Perennial/ Intermittent Stream
13-1	16.2	28.1	0.0	10.5	0.0	10.5	1,069	intermittent
13-2	1.2	5.3	0.0	0.0	0.0	0.0	156	intermittent
13-3	18.3	35.1	0.0	0.0	0.0	0.0	3,494	intermittent
11-1	1.3	4.8	0.0	0.0	0.0	0.0	556	intermittent
11-2	3.1	9.2	0.5	0.0	0.0	0.5	491	intermittent
40-1	142.4	186.5	2.5	5.0	0.0	7.6	10,884	intermittent
51-2	46.5	64.3	0.0	7.2	2.1	9.3	4,763	intermittent
7-4	24.8	41.4	1.1	4.2	0.0	5.4	938	intermittent
51-1	14.5	25.7	4.1	2.6	0.0	6.7	2,455	intermittent
7-5	30.7	45.3	3.1	1.2	0.0	4.3	2,034	intermittent
25-3	13.4	21.8	0.7	0.0	0.0	0.7	1,439	intermittent
303-2	7.4	17.2	0.2	0.0	0.0	0.2	1,448	intermittent
25-1	2.3	7.5	0.0	0.6	0.0	0.6	668	intermittent
25-2	5.5	12.5	0.0	3.0	0.0	3.0	1,147	intermittent
41-A	34.8	52.9	0.0	0.0	0.0	0.0	3,670	intermittent
401-1	4.1	14.2	0.0	3.5	0.0	3.5	1,706	intermittent
401-2	3.9	12.9	0.0	1.1	0.0	1.1	1,090	intermittent
40-2	59.2	90.2	0.9	15.3	1.0	17.2	7,528	intermittent
304	1.8	6.9	0.0	0.0	0.0	0.0	230	intermittent
312	4.6	13.1	0.0	0.0	0.0	0.0	1,930	intermittent
400	2.9	8.4	0.0	0.0	0.0	0.0	711	intermittent
303-4	4.6	10.4	0.0	0.0	0.0	0.0	992	intermittent
22	10.5	20.2	0.0	0.0	0.0	0.0	1,094	intermittent
317	12.4	24.5	0.6	0.0	0.0	0.6	2,761	intermittent
40-3	16.1	27.6	0.0	11.1	0.0	11.1	1,783	intermittent
305	0.3	3.0	0.0	0.0	0.0	0.0	910	intermittent
306	1.3	4.8	0.0	0.0	0.0	0.0	528	intermittent
316	6.8	15.4	0.0	0.0	0.0	0.0	1,027	both

Note: Wetland areas are based on available NWI and hydric soils data and have not been field verified. Stream potential impact is based upon flow-line information developed during basin delineation and is not an indication of stream type (intermittent, perennial, etc.).

There are some differences between the numbers for wetland impacts when comparing the five preliminary design locations in Table 4-4 and the information in Table 4-5 because the analysis is more refined at the preliminary design level than at the Master Plan estimation level. Appendix D contains figures that illustrate the estimated pond footprint and wetland impact at each BMP location. Actual footprints and wetland impacts will vary depending upon final design considerations. A refinement was made to the BMP footprint area estimate as provided in Section 8, Implementation Plan based upon preliminary design information.

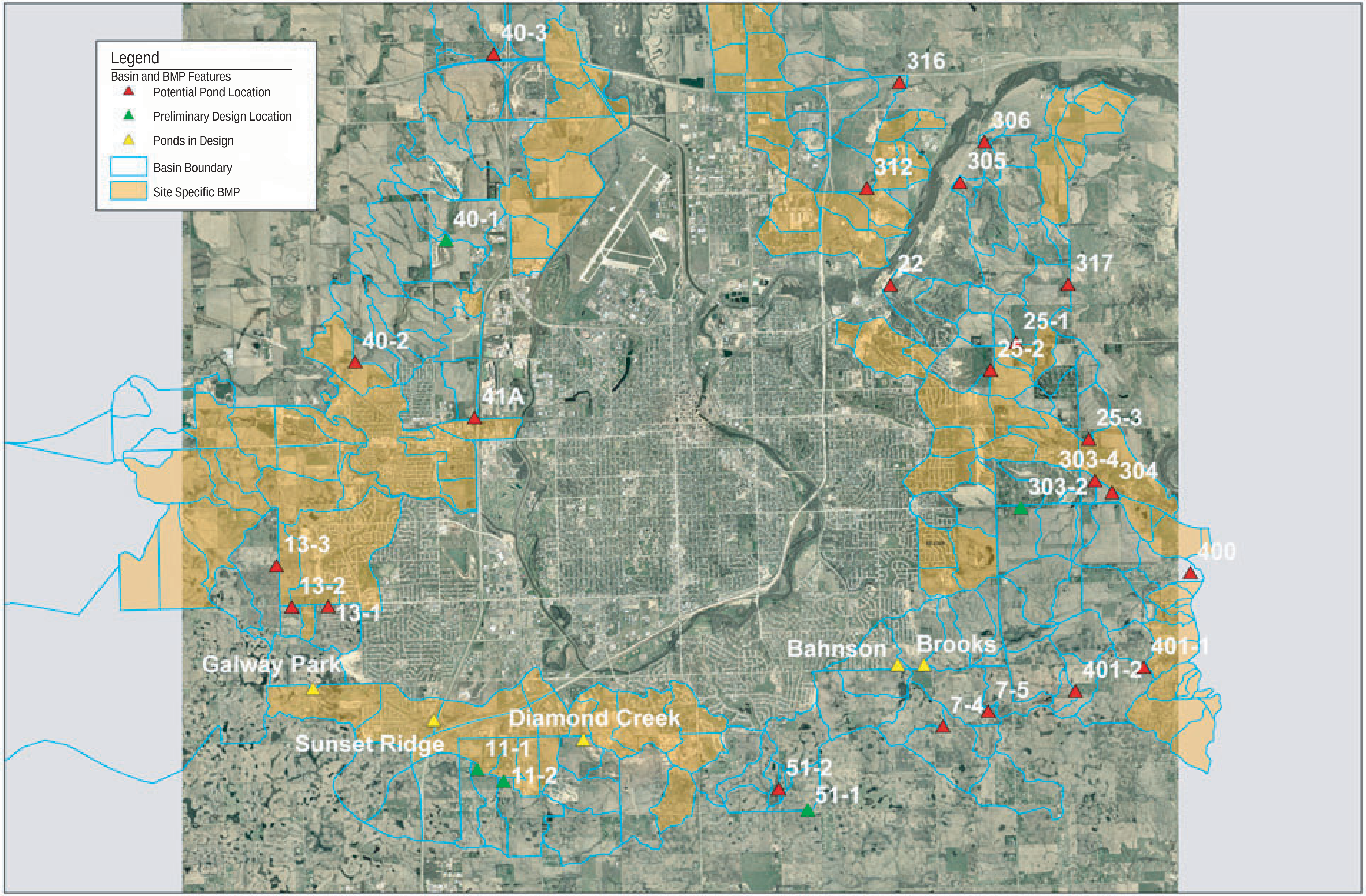
4.4 Ponds under Design

Figures 3-1 through 3-4 show five yellow triangles in BMP locations for which design is currently under way. These ponds are being designed to provide water quality and flood control. Because these ponds are currently under design, they were not included in the HEC-HMS modeling undertaken as part of this project. The detention ponds currently under design are:

- Galway Park
- Diamond Creek
- Bahnson
- Brooks
- Sunset Ridge

4.5 Site-Specific Subbasins

Certain subbasins within the Sioux Falls 2015 planning area were identified as site-specific basins. The location of these subbasins are shown on Figures 3-1 through 3-4. These subbasins will have water quality, 5-year detention, and 100-year detention provided by a site-specific pond not included in this study. The site-specific ponds likely will be the responsibility of the developer or private landowner to build, operate, and maintain. Several criteria determined whether a basin should be called site-specific, as explained in Section 3.



NOTE: Areas within developed portions of the City are also site specific as shown in Figures 3-1 through 3-4.

FIGURE 4-1
Location of BMPs and Basin Boundaries

Stormwater BMP Master Plan
Sioux Falls, South Dakota

CH2MHILL

SECTION 5

Public Outreach

As part of the Master Planning process, public outreach began early and continued over the course of the project to obtain informed consent based on broad-based stakeholder support of the decisionmaking process.

5.1 Master Plan Public Outreach Approach

Master Plan public outreach focused upon a proven approach. The three key steps in public involvement are:

Communicate ⟶ Listen ⟶ Respond

Display of findings:

Complex Technical Analysis ⟶ Simple Format

The public outreach meetings were advertised through targeted mailings of potentially interested stakeholders using a postcard developed for the Master Plan. Public outreach meetings were also advertised on news releases to the *Argus Leader*, Channel 16, and the BigSioux.com website. In all, three public outreach meetings were held. Information was disseminated and feedback was obtained from interested stakeholders.

Table 5-1 lists the dates and purpose of each meeting.

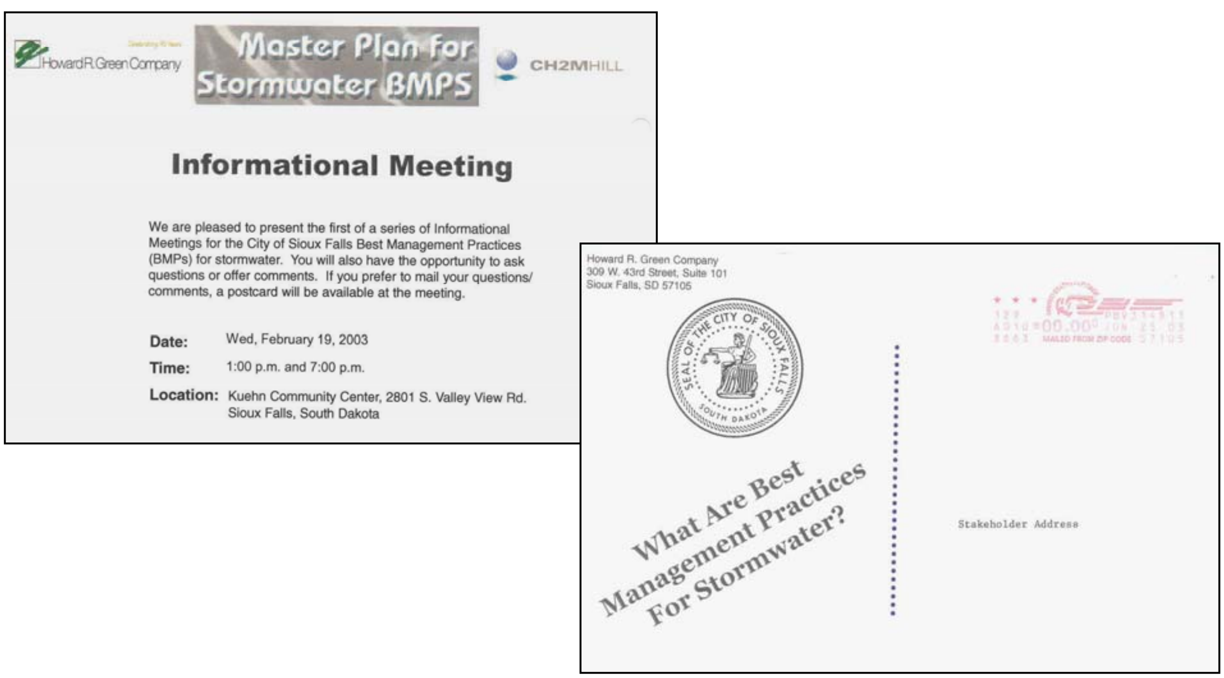


TABLE 5-1
Public Outreach Meeting Summary

Meeting	Date
What is a BMP? An introduction to the Master Planning process.	February 19, 2003
BMP Master Plan Progress Update. A description of initial modeling findings and natural resources inventory.	April 10, 2003
Draft BMP Master Plan. A discussion of the draft Master Plan results.	June 18, 2003

The public involvement plan invited representatives from the City of Sioux Falls staff, state and federal regulatory agencies, Infrastructure Review and Advisor Board (IRAB), development community, engineering community, South Dakota Department of Transportation, the general public, and representatives from surrounding towns, counties, and townships.

5.1.1 IRAB Outreach

Input from IRAB was very valuable and beneficial for the Master Plan. The IRAB board advises the mayor regarding fees and regulations relating to engineering design standards, infrastructure construction requirements, excavation and grading, and subdivisions with the intent of recommending the elimination of unnecessary regulations and the adoption of only those regulations necessary for the health, safety, and welfare of the citizens of Sioux Falls. The IRAB members are made up of representatives from the City of Sioux Falls, engineering community, development community, contractors, private utility companies, and local business owners.

5.1.2 General Public Outreach

All three public outreach meetings were conducted at the Kuehn Community Center. The first series of public meetings were held on February 19, 2003. The project team gave the IRAB members a presentation during their regularly scheduled meeting at 8:30 A.M. Additional meetings at 1:00 P.M. and 7:00 P.M. targeted City Staff, SDDOT, other agencies, developers and the general public. The project team explained what a BMP is and the characteristics and features of a BMP. The presentation also addressed priority areas of the City 2015 land use plan where development is expected to occur and where regional BMPs might be targeted. There were roughly 25 attendees for the afternoon and evening meetings combined.

The second series of public information meetings on April 10, 2003, presented preliminary findings of the Master Plan. The project team presented the preliminary findings at the 8:30 A.M. IRAB meeting and at the 7:00 P.M. evening meeting. The four quad maps of the City, similar to Figures 3-1 through 3-4, identified preliminary locations for regional BMPs and areas that would be served by site-specific BMPs. IRAB members were given colored dots and asked to place their dots where they felt a regional BMP should be located. The project team reviewed this information with City staff and was helpful in prioritizing regional BMP locations, including the five preliminary design locations in the Master Plan. This series of meetings had 32 attendees.

The third series of public information meetings on June 18, 2003, presented the draft Master Plan findings. The project team presented the findings at the 8:30 A.M. IRAB meeting and at the 7:00 P.M. evening meeting. The four quad maps of the City, similar to Figures 3-1 through 3-4, and two of the preliminary designs for 40-1 and 51-1 were presented. Many of the comments from the third series of meetings were geared toward funding of the project. There were also questions on retrofitting existing ponds and how areas are classified for site-specific BMPs. This series of meetings had 38 attendees.

Presentation materials and handouts distributed during the public meetings are found in Appendix E. The appendix materials have been organized by meeting. Information contained in Appendix E includes meeting mailing and attendees list, meeting minutes (which include meeting date, location, format, and questions/concerns expressed by the attendees), public outreach postcards, comment cards, meeting agendas, PowerPoint presentation materials, and other handouts for each meeting.

5.2 Recommended Future Outreach

Future public outreach is recommended as these facilities are brought forward to final design and construction. A continuing plan to communicate the regional BMP approach to the community is recommended. The City uses many resources (e.g., updates with water and sewer bills, Channel 16, neighborhood link on Sioux Falls website, bigsioux.com, *Argus Leader,* etc.) to reach the citizens of Sioux Falls and surrounding communities. These resources will continue to provide opportunities for continuous communication.

The public outreach approach for regional BMPs can be a twofold process of targeting both Citywide and watershed-specific communication. General information about stormwater management can be disseminated Citywide to inform residents and stakeholders about key stormwater management goals, priorities, and how they can prevent stormwater pollution. Project-specific education regarding BMP construction can target residents within the watershed, neighboring watersheds, and property owners adjacent to a BMP site.

Two City programs currently target stormwater related education. The Health Department has an educational campaign for the West Nile virus, and Public Works has a stormwater pollution prevention educational program. These two educational efforts can be used to disseminate practical information to the general public regarding issues of concern and practical steps that can taken to prevent stormwater pollution. Both Citywide and project-specific educational efforts are compatible with the educational efforts of these programs. Such an outreach approach should continue to provide the City with valuable input and an informed public as the Master Plan moves into implementation.

5.3 Chapter 11 BMP Training

CH2M HILL and Howard R. Green Company presented a BMP design training session on the *Engineering Design Standards* Chapter 11, Section 8, Best Management Practices. The session took place on June 19, 2003, and was geared toward informing both City staff and the engineering and architectural community about design procedures contained in Chapter 11, Section 8. During the session, an overview of BMP types was provided. Example BMP design procedures were reviewed with a focus upon commonly implemented BMPs and the use of spreadsheet design tools that will soon be made available by the City to the engineering and architectural community. The training session included a summary of the regulatory drivers behind the City's stormwater program and brief discussions on the stormwater BMP Master Plan.

Appendix E contains information on the Chapter 11 BMP training.

SECTION 6

Hydrologic Modeling

6.1 Data Collection

6.1.1 GIS Data

GIS data were available from several sources. GIS data from the City were provided in the Universal Transverse Mercator Coordinate System Zone 14, NAD 1983 in feet. Data obtained on different coordinate systems from other sources were projected to match the City's coordinate system and datum. Table 6-1 summarizes GIS data used in the master plan development.

TABLE 6-1
GIS Data

GIS Layer Name	Description	Source
Existing Conditions Land Use	2002 Land Use located within the 2002 Sanitary Sewer Facilities Plan basin boundary	City of Sioux Falls
2015 Land Use	Projected Land Use for 2015 in Sioux Falls and areas planned for annexation	City of Sioux Falls
Major Streets	Major street locations current as of 2000	City of Sioux Falls
Sanitary Sewer Basins	Sanitary sewer basin boundaries from the *2002 Sanitary Sewer Facilities Plan*	City of Sioux Falls
2-foot topographic contours	Topography within the *2002 Sanitary Sewer Facilities Plan* area boundary (1998/2001)	City of Sioux Falls
Aerial photography	5-foot pixel resolution (11/01/2001)	City of Sioux Falls
Soils information	SSURGO database, January 2002	USDA-NRCS website
Wetland Inventory	Information gathered from previous city studies	City of Sioux Falls
Wetland Inventory	National Wetland Inventory	NWI website
Eastside Corridor Alignment	Location of the planned Eastside Corridor	City of Sioux Falls
City Streets	Streets within the City	City of Sioux Falls
Floodplain mapping	FEMA floodplain location	City of Sioux Falls
Cultural Resources Information	Blood Run, mound groups, prior surveys, etc.	Peter Winham, Augustana College
Parcel Locations	Tax ID parcel information	City of Sioux Falls

6.1.2 Previous Study Review

Existing stormwater studies were reviewed for applicability to the regional stormwater management approach. CH2M HILL staff reviewed stormwater documents maintained by the city on January 29, 2003. The review focused on the stormwater basins entirely or partially within the 2015 planning area. The document review familiarized the project team with work previously performed for the City and determined what information would be useful in developing the master plan. Useful information in the studies included subbasin delineations, hydrology data, rating curves for detention ponds, sizes of existing culverts, and general findings and recommendations. The memorandum "BMP Master Plan Stormwater Document Review" (February 10, 2003) contains a detailed description of the document review (see Appendix F, "BMP Master Plan Stormwater Document Review").

6.2 Modeling Software

The hydrologic modeling software used was HEC-HMS Version 2.2.1 (Hydrologic Engineering Center-Hydrologic Modeling System), developed by the U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California. Components included in the HEC-HMS model include runoff segments (subbasins), channel routing segments (reaches), reservoir routing segments (reservoirs), and hydrograph combination segments (junctions). The HEC-HMS software and user documentation is available free from the Hydrologic Engineering Center's website: http://www.hec.usace.army.mil/default.html.

6.3 Modeling Parameters

Many of the modeling parameters were calculated for predevelopment and postdevelopment conditions. The following subsections describe the procedures used to calculate the parameters and how they were used in HEC-HMS.

6.3.1 Watershed and Basin Delineation

Watershed boundaries initially were identified using boundaries delineated in the drainage studies that fell within the 2015 planning area. Additional delineation was performed for areas not covered by previous studies, and redelineation was performed for areas that did not topographically agree with previous studies. Delineation was based on watershed boundaries. Watersheds were labeled with the existing drainage study number used by the city (e.g., "22") if an existing study was available. If the watershed was not associated with any existing drainage studies, the project team assigned it a name.

Watersheds were then subdelineated into smaller subbasins. The 2-foot contour mapping was used to delineate the subbasins. Subbasins were delineated to a target basin size of 250 acres or to a specific hydrologic feature at the downstream end of the subbasin, such as a confluence of streams, proposed detention site, existing pond, or restrictive culvert. Basin sizes ranged from 10 to 10,900 acres, with an average basin size of 275 acres. Where a large contributing drainage area discharged into the 2015 planning area, the entire basin upstream of the planning area was delineated as a basin. Two hundred thirty-one basins were delineated in an area of 66,000 acres (103 square miles). All watersheds and subbasins were digitized as a layer in the GIS. Figures 3-1 through 3-4 show the subarea delineation. Table 6-2 summarizes the subbasin areas calculated using the digitized GIS layer.

TABLE 6-2
Hydrologic Parameters

Subbasin ID	Area (ac)	Drains to Regional BMP # or Site-Specific BMP	Predevelopment Total Tc (min)	Predevelopment Total Lag (min)	Postdevelopment Tc (min)	Postdevelopment Total Lag (min)	Predevelopment CN	Postdevelopment CN
2-005B	52.4	Site-specific BMP	41.6	25.0	12.6	7.6	73.4	86.1
2-010B	265.5	Site-specific BMP	45.3	27.2	20.5	12.3	71.8	83.6
2-020B	49.3	Site-specific BMP	18.0	10.8	7.3	4.4	70.8	82.6
22-005B	160.3	22	29.1	17.4	12.7	7.6	79.0	84.8
22-008B	263.3	22	47.5	28.5	16.6	9.9	75.7	85.8
25-001B	77.6	25-1	27.9	16.7	9.4	5.7	74.0	85.4
25-005B	131.3	25-1	28.6	17.2	13.8	8.3	74.1	84.0
25-009B	108.1	25-1	30.1	18.1	13.6	8.1	74.0	85.7
25-010B	52.2	25-1	23.3	14.0	11.3	6.8	74.2	85.4
25-015B	230.0	25-2	48.3	29.0	26.4	15.9	74.5	85.7
25-017B	30.4	25-2	27.3	16.4	7.9	4.7	75.4	86.0
25-018B	32.6	Site-specific BMP	31.0	18.6	31.0	18.6	74.2	74.2
25-019B	112.8	Site-specific BMP	27.1	16.2	27.1	16.2	76.1	76.1
25-020B	62.5	Site-specific BMP	29.3	17.6	29.3	17.6	76.7	76.7
25-021B	69.4	25-3	30.5	18.3	11.6	6.9	74.0	81.2
25-022B	95.4	Site-specific BMP	29.3	17.6	29.3	17.6	76.2	76.2
25-023B	138.5	25-3	44.7	26.8	26.1	15.7	75.3	78.3
25-024B	67.2	25-3	22.7	13.6	9.7	5.8	74.0	85.2
25-025B	122.7	25-3	28.8	17.3	12.3	7.4	75.7	79.3
303-001B	129.2	25-3	45.5	27.3	22.2	13.3	75.2	88.0
303-002B	193.1	25-3	50.5	30.3	26.0	15.6	73.8	85.8
302-005B	165.9	Site-specific BMP	NA	NA	NA	NA	75.8	78.3
302-010B	25.4	Site-specific BMP	NA	NA	NA	NA	74.0	96.6
303-005B	259.3	303-2	53.9	32.3	32.0	19.2	73.6	85.6
303-010B	55.7	Site-specific BMP	31.5	18.9	31.5	18.9	75.2	75.2
303-015B	153.6	303-4	39.6	23.8	18.7	11.2	74.8	74.8
303-020B	126.6	Site-specific BMP	21.6	13.0	9.1	5.5	74.0	78.9
303-025B	49.9	303-4	23.2	13.9	9.2	5.5	74.0	85.5
303-030B	195.2	303-4	31.9	19.2	14.8	8.9	72.2	82.5
303-031B	31.9	303-4	23.6	14.1	10.9	6.6	74.1	86.6
303-035B	23.2	303-4	22.3	13.4	6.2	3.7	75.5	86.7
303-040B	183.8	303-4	34.6	20.8	15.1	9.0	75.0	74.4
303-044B	138.9	Site-specific BMP	32.5	19.5	18.1	10.9	75.9	88.0
303-045B	207.4	Site-specific BMP	38.2	22.9	NA	NA	75.7	90.7
25-050B	149.1	25-3	34.1	20.5	16.9	10.2	74.8	86.0
303-055B	47.0	303-4	18.0	10.8	5.3	3.2	77.7	88.5
304-060B	300.1	304	42.6	25.6	28.1	16.9	74.2	83.8
304-065B	39.3	304	29.0	17.4	9.3	5.6	74.1	87.3
303-070B	88.5	Site-specific BMP	27.9	16.7	NA	NA	75.5	81.7

TABLE 6-2
Hydrologic Parameters

Subbasin ID	Area (ac)	Drains to Regional BMP # or Site-Specific BMP	Predevelopment Total Tc (min)	Predevelopment Total Lag (min)	Postdevelopment Tc (min)	Postdevelopment Total Lag (min)	Predevelopment CN	Postdevelopment CN
303-075B	17.3	Site-specific BMP	18.6	11.2	NA	NA	76.1	73.3
303-080B	398.3	Site-specific BMP	46.9	28.1	NA	NA	78.1	85.2
305-005B	247.7	305	27.2	16.3	14.0	8.4	77.4	87.7
305-010B	49.8	305	16.9	10.2	8.9	5.3	78.6	87.4
306-005B	226.0	306	35.6	21.3	18.6	11.2	74.2	85.1
306-010B	123.3	306	28.9	17.3	9.3	5.6	74.2	86.1
306-020B	48.6	306	16.3	9.8	7.5	4.5	80.8	90.2
306-030B	29.2	306	50.8	30.5	16.0	9.6	77.1	89.8
307-005B	33.5	Site-specific BMP	28.4	17.0	NA	NA	73.3	91.5
307-010B	212.1	Site-specific BMP	35.7	21.4	NA	NA	74.9	85.9
307-020B	64.1	Site-specific BMP	45.4	27.2	NA	NA	71.4	84.2
308-005B	46.5	Site-specific BMP	19.5	11.7	NA	NA	75.3	96.5
308-010B	178.5	Site-specific BMP	70.8	42.5	NA	NA	73.8	90.4
308-020B	108.0	Site-specific BMP	31.0	18.6	NA	NA	72.2	91.7
309-005B	81.3	Site-specific BMP	23.8	14.3	NA	NA	72.8	87.1
309-030B	42.8	Site-specific BMP	20.9	12.5	NA	NA	68.0	83.8
310-010B	54.9	Site-specific BMP	17.2	10.3	NA	NA	69.1	84.4
310-015B	27.6	Site-specific BMP	19.9	11.9	NA	NA	64.9	81.6
310-020B	37.8	Site-specific BMP	22.8	13.7	NA	NA	70.4	95.6
311-005B	74.2	Site-specific BMP	39.4	23.6	NA	NA	70.4	85.8
311-010B	38.1	Site-specific BMP	16.7	10.0	NA	NA	70.2	94.3
312-005B	48.7	312	24.7	14.8	11.6	6.9	74.1	88.1
312-010B	132.4	312	48.2	28.9	31.2	NA	74.1	88.7
312-025B	229.2	312	32.0	19.2	17.5	10.5	74.7	90.5
312-040B	139.8	Site-specific BMP	33.2	19.9	NA	NA	73.8	86.5
313-005B	122.5	Site-specific BMP	41.6	25.0	NA	NA	67.6	89.3
313-020B	37.0	Site-specific BMP	45.6	27.4	NA	NA	71.0	75.5
314-005B	203.1	Site-specific BMP	56.4	33.8	NA	NA	72.0	87.7
314-020B	148.8	Site-specific BMP	57.8	34.7	NA	NA	68.5	83.6
314-030B	240.4	Site-specific BMP	36.0	21.6	NA	NA	66.9	80.8
316-005B	78.4	316	42.4	25.4	25.1	15.1	73.4	88.4
316-010B	88.5	316	27.7	16.6	12.9	7.8	72.2	88.0
316-020B	200.1	Outside 2015 Land Use	45.9	27.6	45.9	27.5	74.2	74.2
316-030B	193.2	316	44.2	26.5	19.4	11.6	76.1	91.9
316-050B	238.6	316	39.0	23.4	19.7	11.8	72.6	87.2
317-005B	54.3	317	30.9	18.5	13.3	8.0	74.4	85.8
317-006B	113.5	317	27.2	16.3	14.9	9.0	74.2	84.6
317-008B	214.2	317	37.7	22.6	14.2	8.5	74.8	85.7
317-010B	229.6	317	24.4	14.6	11.1	6.7	75.3	85.0

TABLE 6-2
Hydrologic Parameters

Subbasin ID	Area (ac)	Drains to Regional BMP # or Site-Specific BMP	Predevelopment Total Tc (min)	Predevelopment Total Lag (min)	Postdevelopment Tc (min)	Postdevelopment Total Lag (min)	Predevelopment CN	Postdevelopment CN
4	209.8	Site-specific BMP	57.0	34.2	32.4	19.4	74.5	87.2
4A-005B	109.4	Site-specific BMP	27.9	16.7	12.8	7.7	75.0	88.3
4A-010B	319.7	Site-specific BMP	41.7	25.0	21.7	13.0	74.7	88.7
10-010B	329.6	Diamond Creek	87.4	52.4	37.0	22.2	75.4	84.3
10-020B	394.8	Diamond Creek	58.9	35.4	42.6	25.5	77.0	85.8
10-030B	240.6	Diamond Creek	44.0	26.4	21.0	12.6	76.5	84.3
10-040B	64.4	Diamond Creek	18.9	11.4	7.1	4.3	77.5	86.7
10A-010B	143.9	Diamond Creek	23.5	14.1	11.2	6.7	77.7	87.6
10A-020B	76.3	City Pond 47	23.3	14.0	10.5	6.3	77.6	88.1
10A-030B	185.6	City Pond 47	42.7	25.6	25.3	15.2	76.0	85.9
10A-040B	324.7	City Pond 47	28.9	17.3	13.7	8.2	77.6	87.7
10A-050B	181.8	City Pond 47	47.6	28.6	22.8	13.7	77.5	85.5
10A-060B	156.0	City Pond 47	71.3	42.8	39.2	23.5	76.2	85.6
400-010B	167.4	400	35.4	21.2	18.1	10.8	77.9	84.9
400-015B	77.4	400	32.8	19.7	15.6	9.4	75.6	81.1
400-020B	297.4	400	47.2	28.3	23.4	14.0	74.5	82.0
400-030B	126.4	400	42.4	25.4	19.1	11.5	75.1	86.2
401-005B	272.3	401	47.0	28.2	24.5	14.7	74.2	85.4
401-010B	209.9	401	45.4	27.2	23.5	14.1	75.4	87.2
401-015B	100.6	401	65.4	39.2	38.2	22.9	75.4	82.3
401-020B	212.9	401	51.5	30.9	32.1	19.3	74.2	77.0
401-025B	34.5	401	76.8	46.1	63.0	37.8	78.4	89.3
401-030B	173.0	401	63.9	38.4	37.7	22.6	76.7	86.8
401-040B	271.0	401	62.8	37.7	43.5	26.1	76.1	86.8
401-043B	54.6	401	25.0	15.0	25.0	15.0	75.5	75.5
401-045B	149.8	401	51.0	30.6	51.0	30.6	75.5	86.1
401-050B	215.7	401	65.6	39.4	36.2	21.7	74.3	85.2
401-060B	138.4	401	38.8	23.3	20.0	12.0	75.2	86.0
401-070B	330.5	401	28.1	16.8	11.6	6.9	76.5	86.8
401-080B	122.1	Site-specific BMP	25.1	15.1	8.6	5.2	78.9	89.1
402-010B	66.6	Site-specific BMP	27.2	16.3	16.3	9.8	NA	NA
403-010B	10.2	Site-specific BMP	47.0	28.2	5.4	3.3	NA	NA
404-010B	21.6	Site-specific BMP	40.4	24.3	5.3	3.2	NA	NA
405-010B	38.3	Site-specific BMP	26.8	16.1	9.9	5.9	NA	NA
406-010B	91.6	Site-specific BMP	34.5	20.7	12.9	7.8	NA	NA
407-010B	178.2	Site-specific BMP	63.6	38.2	38.9	23.4	NA	NA
408-010B	21.5	Site-specific BMP	36.8	22.1	7.9	4.8	NA	NA
409-010B	96.5	Site-specific BMP	45.9	27.5	21.6	13.0	NA	NA
410-010B	23.9	Site-specific BMP	47.9	28.7	11.1	6.6	NA	NA

TABLE 6-2
Hydrologic Parameters

Subbasin ID	Area (ac)	Drains to Regional BMP # or Site-Specific BMP	Predevelopment Total Tc (min)	Predevelopment Total Lag (min)	Postdevelopment Tc (min)	Postdevelopment Total Lag (min)	Predevelopment CN	Postdevelopment CN
411-010B	26.1	Site-specific BMP	125.0	75.0	12.6	7.6	NA	NA
412-010B	12.3	Site-specific BMP	70.2	42.1	6.1	3.6	NA	NA
413-010B	236.5	Site-specific BMP	46.9	28.2	30.6	18.3	NA	NA
413-020B	164.2	Site-specific BMP	52.2	31.3	52.2	31.3	NA	NA
413-030B	25.4	Site-specific BMP	78.1	46.9	6.5	3.9	NA	NA
51-010B	262.3	51-2	52.7	31.6	29.7	17.8	77.5	84.0
51-020B	133.9	51-2	61.4	36.9	38.3	23.0	76.5	86.7
51-030B	276.5	51-1	217.8	130.7	157.0	94.2	76.6	85.7
51-050B	98.1	51-2	42.7	25.6	23.0	13.8	76.2	86.5
51-060B	46.1	51-2	33.0	19.8	19.8	11.9	75.3	85.8
51-065B	20.7	51-1	37.0	22.2	18.0	10.8	75.3	85.8
51-070B	13.2	51-1	20.2	12.1	4.8	2.9	74.7	85.4
51-080B	145.7	51-1	52.7	31.6	39.0	23.4	75.1	85.8
6B-010B	238.9	Site-specific BMP	63.7	38.2	39.1	23.5	74.9	86.2
6B-020B	147.7	City Pond 28	74.9	44.9	42.2	25.3	74.0	87.4
6B-030B	102.5	Site-specific BMP	18.0	10.8	16.9	10.1	74.0	85.1
11-010B	356.2	11-1	102.0	61.2	47.1	28.2	75.1	90.5
11-020B	161.9	11-1	56.9	34.2	19.9	12.0	75.7	82.5
11-030B	179.9	11-1	55.3	33.2	25.6	15.3	74.4	81.8
11-040B	309.1	11-2	89.4	53.6	49.8	29.9	74.3	83.5
11A-040B	249.6	City Pond 52	89.6	53.7	86.7	52.0	78.1	78.1
7-010B	157.3	7-5	54.0	32.4	27.8	16.7	75.0	85.9
7-020B	260.2	Brooks	68.8	41.3	34.8	20.9	74.6	85.7
7-030B	195.6	Bahnson	44.9	27.0	18.5	11.1	79.3	89.9
7-040B	172.2	7-4	87.1	52.3	50.9	30.6	77.4	87.6
7-050B	340.4	7-4	60.1	36.1	27.6	16.5	76.1	86.5
7-070B	207.5	7-4	106.5	63.9	65.2	39.1	75.9	86.3
7-090B	323.5	7-5	138.8	83.3	88.8	53.3	76.1	86.4
11-050B	118.5	City Pond 52	33.4	20.0	11.6	7.0	76.4	87.1
11-060B	75.8	City Pond 52	52.2	31.3	24.4	14.7	75.2	86.0
11-070B	129.4	City Pond 54	61.6	36.9	32.2	19.3	74.8	87.4
11-080B	270.5	City Pond 52	81.2	48.7	36.8	22.1	76.9	93.5
11-090B	88.7	City Pond 54	52.1	31.3	22.2	13.3	74.0	86.8
11-100B	133.4	Site-specific BMP	62.0	37.2	20.5	12.3	NA	NA
11A-010B	390.5	Site-specific BMP	115.7	69.4	79.2	47.5	NA	NA
11A-020B	347.6	Site-specific BMP	78.1	46.8	46.3	27.8	NA	NA
11A-030B	375.6	City Pond 52	142.8	85.7	138.5	83.1	NA	NA
11B-010B	314.1	Site-specific BMP	168.7	101.2	145.4	87.3	NA	NA
56-010B	196.5	Site-specific BMP	79.9	47.9	76.5	45.9	NA	NA

TABLE 6-2
Hydrologic Parameters

Subbasin ID	Area (ac)	Drains to Regional BMP # or Site-Specific BMP	Predevelopment Total Tc (min)	Predevelopment Total Lag (min)	Postdevelopment Tc (min)	Postdevelopment Total Lag (min)	Predevelopment CN	Postdevelopment CN
56-020B	69.8	Site-specific BMP	14.1	8.4	13.1	7.9	NA	NA
13-022B	65.3	13-2	51.0	30.6	22.0	13.2	74.0	75.3
13-025B	47.3	Site-specific BMP	68.0	40.8	27.0	16.2	75.1	80.5
13-030B	210.3	13-1	72.0	43.2	47.0	28.2	80.6	89.0
13-035B	93.9	Site-specific BMP	27.0	16.2	27.0	16.2	76.2	86.2
13-040B	136.2	Site-specific BMP	44.0	26.4	22.0	13.2	75.6	87.2
13-010B	195.2	13-3	80.0	48.0	38.0	22.8	75.8	86.6
13-020B	400.7	13-3	100.0	60.0	66.0	39.6	75.2	86.4
14A-020B	92.0	Inside 2015 Area	NA	NA	NA	NA	74.0	86.0
14A-010B	221.3	Inside 2015 Area	NA	NA	NA	NA	73.9	88.8
15-010B	49.0	Site-specific BMP	NA	NA	NA	NA	74.0	88.6
16-010B	51.1	Site-specific BMP	NA	NA	NA	NA	79.1	91.1
D1-010B	307.2	Site-specific BMP	NA	NA	NA	NA	75.2	86.9
D1-020B	198.3	Site-specific BMP	NA	NA	NA	NA	74.6	83.8
D1-030B	127.7	Skunk Creek	NA	NA	NA	NA	74.2	84.1
D1-040B	30.3	Skunk Creek	NA	NA	NA	NA	74.0	79.1
32A-010B	3663.5	Beyond 2015 Area	NA	NA	NA	NA	77.4	77.4
32B-010B	10868.2	Beyond 2015 Area	NA	NA	NA	NA	76.6	76.7
32B-020B	245.9	Site-specific BMP	NA	NA	NA	NA	76.2	96.6
32B-040B	370.5	Site-specific BMP	NA	NA	NA	NA	75.2	85.9
32B-030B	386.0	Site-specific BMP	NA	NA	NA	NA	77.2	89.5
32C-010B	7053.0	Beyond 2015 Area	NA	NA	NA	NA	75.4	75.4
32D-080B	138.8	Site-specific BMP	NA	NA	NA	NA	75.2	85.0
32D-120B	274.4	Site-specific BMP	NA	NA	NA	NA	72.7	69.2
32D-010B	237.4	Beyond 2015 Area	NA	NA	NA	NA	74.8	74.8
32D-020B	342.1	Beyond 2015 Area	NA	NA	NA	NA	72.9	72.9
32D-030B	97.6	Beyond 2015 Area	NA	NA	NA	NA	73.8	73.8
32D-100B	79.3	Beyond 2015 Area	NA	NA	NA	NA	67.3	67.3
32D-060B	103.3	Beyond 2015 Area	NA	NA	NA	NA	74.7	74.7
32D-110B	224.5	Site-specific BMP	NA	NA	NA	NA	73.2	93.5
32D-090B	194.9	Site-specific BMP	NA	NA	NA	NA	74.9	75.7
32D-070B	154.6	Site-specific BMP	NA	NA	NA	NA	75.8	86.6
32D-050B	54.5	Beyond 2015 Area	NA	NA	NA	NA	74.0	74.0
32D-040B	348.6	Site-specific BMP	NA	NA	NA	NA	75.0	94.5
37-010B	749.3	Inside 2015 Area	NA	NA	NA	NA	73.7	84.1
38-030B	178.2	Site-specific BMP	NA	NA	NA	NA	76.4	88.3
38-040B	324.0	Site-specific BMP	NA	NA	NA	NA	77.1	84.0
38-050B	283.7	Site-specific BMP	NA	NA	NA	NA	77.7	87.1
38-060B	294.9	Site-specific BMP	NA	NA	NA	NA	77.7	88.9

TABLE 6-2
Hydrologic Parameters

Subbasin ID	Area (ac)	Drains to Regional BMP # or Site-Specific BMP	Predevelopment Total Tc (min)	Predevelopment Total Lag (min)	Postdevelopment Tc (min)	Postdevelopment Total Lag (min)	Predevelopment CN	Postdevelopment CN
38-070B	152.9	Site-specific BMP	NA	NA	NA	NA	75.4	88.5
38-020B	27.7	Site-specific BMP	NA	NA	NA	NA	82.7	91.2
38-015B	70.4	Site-specific BMP	NA	NA	NA	NA	81.2	98.0
38-010B	199.8	Site-specific BMP	NA	NA	NA	NA	75.1	91.8
40-040B	386.3	40-1	59.0	35.4	20.0	12.0	76.5	93.1
40-050B	291.3	40-3	62.0	37.2	20.0	12.0	76.0	92.5
40-070B	15.6	40-1	52.0	31.2	52.0	31.2	76.0	97.3
40-060B	40.6	40-1	64.0	38.4	15.0	9.0	75.0	91.1
40-030B	65.4	40-1	19.0	11.4	19.0	11.4	82.4	98.0
40-020B	307.0	40-1	85.0	51.0	31.0	18.6	76.4	93.1
40-110B	22.0	40-1	46.0	27.6	46.0	27.6	83.2	98.0
40-080B	27.3	40-1	45.0	27.0	45.0	27.0	82.3	98.0
40-090B	281.8	40-1	130.0	78.0	93.0	55.8	77.3	90.9
40-130B	226.2	40-1	58.0	34.8	37.0	22.2	75.7	90.4
40-120B	302.7	40-1	149.0	89.4	94.0	56.4	76.5	89.1
40-140B	346.2	40-1	70.0	42.0	51.0	30.6	75.0	85.2
40-150B	173.1	40-1	51.0	30.6	33.0	19.8	74.8	85.8
40-170B	93.4	40-2	48.0	28.8	30.0	18.0	75.6	85.6
40-175B	9.6	40-2	22.0	13.2	6.0	3.6	75.8	86.8
40-180B	212.9	40-2	35.0	21.0	31.0	18.6	75.8	86.8
40-160B	282.7	40-1	87.0	52.2	57.0	34.2	75.1	86.3
40-210B	188.0	40-2	51.0	30.6	33.0	19.8	75.8	86.1
40-200B	145.4	40-2	24.0	14.4	22.0	13.2	77.3	87.0
40-250B	192.7	40-2	64.0	38.4	43.0	25.8	76.4	86.0
40-230B	85.9	40-2	32.0	19.2	14.0	8.4	76.2	85.6
40-220B	233.6	40-2	63.0	37.8	45.0	27.0	76.9	83.4
40-240B	133.3	40-2	50.0	30.0	31.0	18.6	77.2	84.3
40-245B	108.5	40-2	74.0	44.4	48.0	28.8	77.7	83.6
40-100B	236.5	40-1	58.0	34.8	37.0	22.2	75.9	88.3
40-190B	383.7	40-2	87.0	52.2	66.0	39.6	76.2	85.0
40-010B	4873.6	40-1	282.0	169.2	282.0	169.2	76.5	76.5
41A-040B	147.2	Inside 2015 Area	82.0	49.2	45.0	27.0	79.6	93.8
41A-010B	178.3	41-A	53.0	31.8	24.0	14.4	74.3	88.6
41A-020B	167.8	41-A	58.0	34.8	34.0	20.4	76.4	90.5
41A-030B	290.0	Site-specific BMP	57.0	34.2	28.0	16.8	75.9	88.5

6.3.2 Curve Number

The Basin Model Loss Rate used the SCS Curve Number Method to determine rainfall losses in each subarea. A weighted curve number was developed for each subbasin using GIS based on Sioux Falls land use information for predevelopment and postdevelopment conditions and hydrologic soil group information obtained from the U.S. Department of Agriculture (USDA) NRCS Soil Survey Geographic (SSURGO) Database.

Soil types within the Sioux Falls study area were obtained from SSURGO in January 2002. Infiltration rates for soils vary widely and are affected by subsurface permeability and surface intake rates. The SCS has classified soil types as hydrologic soil groups A, B, C, and D according to minimum infiltration rate. Group A soils have the greatest infiltration capacity and the lowest runoff rates; Group D soils have very slow infiltration rates and greater runoff rates.

The City of Sioux Falls maintains GIS map layers of existing and future (2015) land use, based on development plans. The data were used to develop the postdevelopment land use coverage for the hydrologic model. If a small part of a subbasin extended beyond the 2015 planning area, the curve number was calculated assuming the entire subarea was within that area. Predevelopment condition curve numbers were developed using an undeveloped land use condition in all areas. Table 6-3 shows the curve numbers used for land uses specific to the City of Sioux Falls. Listed curve numbers reflect an antecedent moisture condition of 2. Figure 1-1 illustrates the postdevelopment land use.

TABLE 6-3
Land Uses and General Curve Numbers for Hydrologic Soil Groups

Land Use	Hydrologic Soil Group			
	A	B	C	D
Residential Single Family	77	85	90	92
Rural Residential	51	68	79	84
Residential Multiple Family	77	85	90	92
Manufacturing	81	88	91	93
Transportation, Communication, Utilities, Parking Facilities	98	98	98	98
General Commercial	89	92	94	95
Heavy Commercial	89	92	94	95
Offices, Churches, Institutions, Schools	81	88	91	93
Cultural Activity; Libraries, Museums, Parks	49	69	79	84
Cemetery, Landfills, Mining, Quarrying, Under Construction	68	79	86	89
Undeveloped*	64	74	81	85

*Assumes contoured row crops in good hydrologic condition

Predevelopment weighted curve numbers ranged from 64.9 to 83.2 with an average of 75.3. Postdevelopment weighted curve numbers ranged from 67.3 to 98.0 with an average of 85.6. Percent impervious area also was calculated for each subarea and used to calculate WQCV.

Postdevelopment percent impervious ranged from 20 to 98 percent impervious with an average of 58.8 percent.

As noted, predeveloped and developed conditions were modeled. The curve numbers and lag times used in the modeling were based on the two development conditions. However, certain subbasins are identified as site-specific subbasins. Those subbasins will have water quality, 5-year detention, and 100-year detention provided by one or more site-specific ponds or other BMPs not included in this study. The site-specific ponds will likely be the responsibility of the developer or private land owner to build, operate, and maintain.

Where site-specific subbasins are located downstream of the 2015 planning area or downstream of modeled areas, the site-specific subbasins are not included in the models. Where site-specific subbasins are located within an area being modeled, the site-specific subbasin is included in the model. To accurately model the discharges from site-specific ponds that will flow downstream and enter the ponds included in this study, the postdevelopment model used the predevelopment curve number and time of concentration. This allows the City's peak discharge matching requirement (developed condition discharges must be less than predevelopment discharges) to be accounted for in the study's developed condition models.

6.3.3 Time of Concentration

Hydrographs of the subbasin outlets are constructed using unit hydrograph techniques. The HEC-HMS Transform Model used the SCS Unit Hydrograph method, which requires only lag time as an input parameter. Lag time is defined as 0.6 times the time of concentration (Tc). Tc is the time required for runoff to travel from the hydraulically most distant point of the watershed to the point of interest. Calculation procedures for Tc outlined in the *Sioux Falls Engineering Design Standards* were incorporated into a spreadsheet tool to calculate time of concentration and lag time for this study.

The *Sioux Falls Engineering Design Standards* differentiate surface runoff into three general types of flow: sheet or overland flow, shallow concentrated flow, and channelized flow. Travel times were calculated for each flow mode and summed to determine the total time of concentration for the basin. Predevelopment sheet flow lengths were calculated using a maximum flow length of 300 feet, whereas postdevelopment sheet flow calculations used maximum lengths of 100 feet in areas of paved commercial and industrial land uses and 200 feet in areas of residential and open space land uses. The sheet flow lengths were selected based on the modeling team's experience in determining typical sheet flow lengths for developed areas. Shallow concentrated flow lengths were categorized as unpaved for predevelopment conditions and as paved for postdevelopment conditions. Channel flow segments remained identical for predevelopment and postdevelopment conditions.

The *City of Sioux Falls, Engineering Design Standards* specify a minimum time of concentration of 15 minutes for a single subbasin. However, many subbasins in this study have Tc values of less than 15 minutes. The actual Tc values were used for the study when they were less than 15 minutes, to a minimum of 5 minutes. This was done so that the HEC-HMS modeling would better represent actual watershed conditions.

Time of concentration used in the predevelopment models ranged from 14 to 282 minutes, with an average of 51 minutes, while time of concentration used in the postdevelopment models ranged from 5 to 282 minutes, with an average of 32 minutes. Table 6-2 summarizes the various hydrology parameters.

6.3.4 Rainfall Data

Synthetic storms were used to compute basin runoff, with a 24-hour duration and return periods of 1, 2, 5, 10, and 100 years. Rainfall intensities and depths for the various durations were based on the data provided in the *Sioux Falls Engineering Design Standards,* Appendix A. Table 6-4 lists rainfall depths for specified durations and frequencies.

TABLE 6-4
Rainfall Depths (in.) for Specified Durations and Frequencies

Frequency	5 Minutes	15 Minutes	1 Hour	2 Hours	3 Hours	6 Hours	12 Hours	24 Hours
1 Year	0.340	0.710	1.200	1.360	1.440	1.700	1.970	2.210
2 Years	0.417	0.825	1.450	1.660	1.800	2.100	2.328	2.688
5 Years	0.517	1.050	1.910	2.280	2.340	2.640	3.060	3.600
10 Years	0.575	1.175	2.300	2.740	2.760	3.180	3.540	4.200
100 Years	0.841	1.775	3.400	3.720	4.350	4.560	5.160	6.000

The Meteorologic Model used the Frequency Storm method to model the rainfall for this synthetic storm. The peak was placed at 50 percent of the storm duration.

6.3.5 Reaches

A reach is a continuous stretch or segment of a stream channel. Where indications of open channel flow were observed, reaches were modeled using the Muskingum-Cunge 8-point cross section method. Cross sections were generated using the 2-foot interval contours with a GIS 8-point cross-section generation tool. Cross sections were selected to represent typical dimensions over the length of the routing reach. Manning's "n" values and low-flow channel geometry for the reaches were taken from a field reconnaissance performed on February 27, 2003, that documented typical channel characteristics in the different geographic regions of the 2015 planning area. Cross sections, lengths, and "n" values used for each routing reach are contained in the actual HEC-HMS models.

The Reach Model used the Muskingum-Cunge 8-Point Cross Section method to simulate the attenuation of hydrographs in open channel reaches. This method uses an 8-point cross section to represent the channel and floodplain overbank areas. Additional input parameters include the reach length, energy (channel) slope, and the Manning's roughness values for the channel and overbanks. The cross sections were taken from the City's GIS topography layer and represent typical dimensions over the length of the routing reach.

6.3.6 Detention Ponds

Hydrograph routing routines were used in HEC-HMS to simulate the translation and attenuation of hydrographs as they travel through storage areas. Modified-Puls (level pool reservoir) Routing was performed for select reservoirs such as major lakes, existing and proposed detention areas, and at select restrictive road crossings where flows are detained in a surface depression and released through a culvert or outfall structure. For Modified-Puls Routing, HEC-HMS requires the development of a stage-storage-discharge relationship for the pond or detention area in question. In HEC-HMS, an upstream hydrograph is used to define the inflow into the pond. HEC-HMS then uses the stage-storage-discharge relationship to determine the outflow from the detention area as the water levels in the pond rise and fall.

6.3.7 Detention Areas

Potential ponding areas were screened by visual inspection and rule-of-thumb comparison for inclusion in the models. If the available information were insufficient on a culvert or pond with potential for causing significant attenuation, a field investigation was performed before incorporating the culvert or pond in the hydrologic model. Farm ponds with berms and no formal outlet structure generally were not included in the hydrologic models but were conservatively assumed to overtop the berms immediately. Stage-storage-discharge curves for culvert and pond reservoir routing can be found in the HEC-HMS models. Detailed stage-storage-discharge curves and other information on the conceptual design for proposed detention sites can be found in Appendix D, "BMP Information," in the pond modeling output summary sheets for each BMP.

6.3.7.1 Existing Detention Areas

A stage-storage relationship for existing ponds or detention areas was developed from the City's GIS topography layer or from information provided in previous studies. For facilities where this relationship had not already been determined, the stage-discharge function was computed using HY8 or CulvertMaster software. These programs analyze the hydraulics of flow through numerous types of pipes, given various upstream headwater, downstream tailwater conditions, and loss conditions. Flowline elevations were determined from existing studies, topographic maps, and field investigation. In some cases, the volume of flow exceeds the capacity of the detention area and the downstream dam or roadway embankment is overtopped. In those cases, HY8 software was used to compute weir flow.

The stage-discharge output from the software was merged together (based on elevation) with a spreadsheet containing stage-storage information. The completed spreadsheet defined the overall stage-storage-discharge relationship for the detention area, and the data were input into the appropriate reservoir in the HEC-HMS model.

6.3.7.2 Proposed Detention Areas

The stage-storage relationship for a proposed pond was developed using a pond "footprint" consisting of a 3:1 length-to-width ratio and 4:1 side slopes. The 3:1 length-to-width ratio was adjusted as needed to fit the specific space available for each BMP site. In some cases, due to topographic or other constraints, the length-to-width ratio ended up being less than 3:1. The 4:1 side slopes were selected to maximize the space available for future development by maximizing storage provided with the smallest pond footprint.

The pond storage volume for proposed detention areas was sized so that the 5- and 100-year outflow discharges under postdevelopment watershed conditions (2015 land use) did not exceed the predevelopment 5- and 100-year peak flows. To determine the volume of storage required in a proposed pond, HEC-HMS models of the predevelopment and fully developed conditions (without proposed detention) were constructed. At the proposed detention location, the outflow hydrographs from the HEC-HMS models for existing and fully developed conditions were copied to a “pond sizing” spreadsheet. The spreadsheet computed the volumes of runoff at the proposed detention location under each watershed condition. The additional volume of flow for the fully developed condition served as the initial estimate for the volume to be detained in a proposed detention facility.

The pond sizing spreadsheet automatically developed a stage-storage relationship for the proposed detention location based on the top length, top width, and maximum depth physically available to accommodate a detention pond. The spreadsheet contained tools to enable the designer to determine quickly if the pond size could actually accommodate the required detention volume. Stage-discharge relationships were developed in CulvertMaster for various outfall pipe and box sizes and incorporated in the pond sizing spreadsheet. Modelers then selected an appropriate outfall structure configuration to release the pond volume at a rate not to exceed predevelopment peak flows. Outfall pipes generally were limited to pipes 6 feet in diameter or smaller and boxes no wider than 20 feet. This was done to keep the structure sizes constructable and feasible. One foot of freeboard for the 100-year storm event without road overtopping was provided for each pond. Where necessary and deemed feasible, it was assumed the road would be raised to provide the storage and freeboard requirements.

The completed spreadsheet defined the overall stage-storage-discharge relationship for the proposed detention area. The data were then input into the appropriate reservoir in the HEC-HMS model. Adjustments were made to the pond size or outfall structure for a proposed detention site until the desired storage and discharges were achieved. Due to the flat topography or high flow rates from larger tributary areas, the outfall structure size needed to pass the outflow sometimes was very wide. In such instances, a general rule of thumb limiting the culvert to a 20-foot width was used. In these circumstances, additional storage was provided in the detention pond to allow for a lower 100-year peak release rate associated with the smaller, more feasibly constructed outlet structure.

The final berm height and 100-year water surface elevation were then compared to the surrounding topography and physical site conditions to ensure that the embankment could be feasibly constructed, the flooding limits did not encroach on any structures, and wetland impacts were minimized. A site review of each BMP location was performed to look for potential “fatal flaws” with each of the BMP locations.

6.3.7.3 Water Quality Capture Volume

For proposed detention ponds, a volume for water quality control was incorporated into the model and pond geometry. The additional volume is known as WQCV. For this study, WQCV is based on the 80th percentile runoff event as specified in Chapter 11 of the *Sioux Falls Engineering Design Standards.* WQCV is the volume of rainfall that must be detained and then drained slowly over time to provide water quality benefit. The WQCV benefit is achieved by allowing suspended sediments, solids, and other pollutants to settle to the bottom of the pond where they can be absorbed through biological uptake processes or removed through routine maintenance.

6.4 Predevelopment Modeling Results

Predevelopment conditions were modeled using the predevelopment hydrologic parameters summarized in the preceding section. No existing culverts or detention ponds were modeled as part of the predevelopment condition modeling. Predevelopment conditions were analyzed for the 1-, 2-, 5-, 10-, and 100-year design storm events in watersheds containing a planned regional detention pond facility. Watersheds categorized as having site-specific BMP management were not modeled in HEC-HMS unless they were tributary to areas with regional BMPs. Table 6-5 summarizes the predevelopment peak flows at each proposed BMP site.

6.5 Postdevelopment Modeling Results

Postdevelopment conditions were modeled using the postdevelopment hydrologic parameters summarized in the preceding section. Select existing culverts and existing detention ponds were modeled as part of the postdevelopment condition modeling. Postdevelopment conditions were analyzed for the 1-, 2-, 5-, 10-, and 100-year design storm events in watersheds containing a planned regional detention pond facility. Watersheds categorized as having site-specific BMP management were not modeled in HEC-HMS unless they were directly tributary to a regional BMP further downstream. Postdevelopment peak outflows discharged from the pond outlet for each proposed BMP site are summarized in Table 6-6. The five preliminary design sites (11-1, 11-2, 303-2, 40-1, and 51-1) were analyzed further as a part of that process (see Section 7). The values listed in the tables for those BMPs were obtained for the sites through the master plan process. The updated preliminary design values appear in Section 7.

6.6 Model Verification

The modeling results were verified to ensure they were representative of measured storm events. No recorded stream gauge data were available for any of the modeled watersheds. Of the modeled streams, only Skunk Creek watershed (Basin 40) has a Flood Insurance Study performed by FEMA. That study was requested from FEMA but was out of stock and not available for verification of model flows developed for the master plan project. Existing drainage studies were available for some watersheds, but were not used to verify the new models. This is because the studies looked at small parts of watersheds, did not use the same GIS land use information available for the study, or were performed by various consultants using different methodologies. While the drainage studies provided valuable information for other components of the master plan effort, they are unsuitable for comprehensive comparison of all watersheds.

TABLE 6-5
Predevelopment Peak Flow Summary

BMP Location	1-Year Peak Flow (cfs)	2-Year Peak Flow (cfs)	5-Year Peak Flow (cfs)	10-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
13-1	80	120	204	268	467
13-2	17	29	56	77	148
13-3	113	183	345	473	865
11-1	356	479	712	916	1,550
11-2	119	163	254	327	551
40-1	530	830	1,460	1,980	3,824
51-2	166	264	455	663	1,212
7-4	440	594	906	1,160	1,940
51-1	197	326	569	835	1,565
7-5	250	346	549	683	1,075
25-3	403	720	1,418	1,940	3,627
303-2	144	240	448	624	1,221
25-1	121	212	402	551	1,087
25-2	76	127	239	326	620
41-A	178	293	552	752	1,415
401-1	277	467	803	1,255	2,439
401-2	144	264	501	819	1,708
40-2	510	815	1,466	1,970	3,682
304	101	171	323	442	853
312	122	208	402	544	1,040
400	161	273	484	750	1,574
303-4	219	394	788	1,098	2,264
22	183	284	472	674	1,245
317	195	338	650	896	1,744
40-3	83	135	248	335	624
305	156	242	418	548	1,003
306	144	242	421	626	1,156
316	225	380	737	1,015	1,963

TABLE 6-6
Postdevelopment Peak Flow Summary

BMP Location	1-Year Peak Flow (cfs)	2-Year Peak Flow (cfs)	5-Year Peak Flow (cfs)	10-Year Peak Flow (cfs)	100-Year Peak Flow with BMP (cfs)
13-1	81	112	184	270	407
13-2	1	2	39	58	144
13-3	98	149	261	491	848
11-1	79	120	343	878	1,312
11-2	25	44	200	251	450
40-1	550	815	1,333	1,680	2,628
51-2	114	168	282	421	910
7-4	42	82	164	556	1,302
51-1	201	294	421	648	1,170
7-5	7	44	100	146	482
25-3	261	329	511	684	1,465
303-2	165	241	377	626	930
25-1	12	24	47	61	177
25-2	8	20	39	86	150
41-A	189	278	476	632	1,092
401-1	314	456	659	1,411	1,884
401-2	101	149	383	593	1,569
40-2	500	740	1,264	1,620	2,614
304	92	141	255	391	703
312	83	193	260	450	618
400	195	254	361	558	1,524
303-4	300	395	623	886	1,373
22	133	201	333	581	1,030
317	174	267	473	893	1,561
40-3	90	123	199	330	500
305	9	15	134	290	505
306	246	302	376	904	1,132
316	286	404	676	895	1,587

Note: The five preliminary design sites (11-1, 11-2, 303-2, 40-1, and 51-1) were analyzed further as a part of the preliminary design process described in Section 7. The values listed above for those BMPs were obtained for the sites through the master plan process. The updated preliminary design values appear in Section 7.

Thus, the U.S. Geological Survey (USGS) regression equations were used for model verification. An analysis of the flood-frequency data for stream gauge records for rural unregulated watersheds in South Dakota is presented in Water-Resources Investigations Report (WRIR) 98-4055, *Techniques for Estimating Peak-Flow Magnitude and Frequency Relations for South Dakota Streams.* The study divided South Dakota into seven hydrologic subregions. Sioux Falls is part of Region "A," which contains the physiographic areas of Minnesota-Red-River Lowland, Coteau des Prairies, and eastern part of the Southern Plateaus physical divisions of Flint. The regional regression equations relate peak flow magnitude for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals to selected basin and climatic characteristics. The equations for Region A include the contributing drainage area and precipitation intensity index, which was equal to 1.15 inches for Sioux Falls. They apply to streams located in rural watersheds and should not be applied to watersheds substantially affected by urbanization, which makes them appropriate to use to approximate predevelopment flows. The equations were developed for drainage areas ranging from 0.14 square mile to 983 square miles. They are appropriate to use for watersheds with drainage areas less than 1,000 square miles.

This report superceded two previous sets of regression equations produced for South Dakota by the USGS, including WRIR 35-74 (August 1974) and WRIR 80-80 (September 1980). A report on watershed 40, *Master Plan for Drainage, Northwest Drainage Basin, Sioux Falls, South Dakota* by DeWild, Grant, Reckert, and Associates (March 1998) contained an interesting comparison of the three sets of regression equations. The study found that results from the 1974 and 1998 equations are quite similar, whereas the 1980 equations produce estimates ranging from 20 to 37 percent of the estimates from the 1974 and 1998 equations.

Because of the variation in range between the three sets of equations available for South Dakota, peak flow estimates from the Iowa regression equations also were used for comparison purposes. The extreme northwest corner of Iowa also drains to the Big Sioux River and has hydrologic characteristics similar to those of the areas modeled for the master plan.

An analysis of the flood-frequency data for stream gauge records for rural unregulated watersheds in Iowa was presented in WRIR 00-4233, *Techniques for Estimating Flood-Frequency Discharges for Streams in Iowa.* This study divided Iowa into three hydrologic subregions, with the northwestern corner of Iowa in Region 2. The regional regression equations relate peak flow magnitude for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence intervals to selected basin and climatic characteristics. The equations used for comparison to the master plan modeling results for Region 2 include the contributing drainage area. The study also used a three-variable regression equation. The equations apply to streams located in rural watersheds and should not be applied to watersheds substantially affected by urbanization, which makes them appropriate to use to approximate predevelopment flows. The equations were developed for drainage areas ranging from 1.3 to 5,146 square miles.

The 2000 Iowa regression equations produce flow estimates generally 2 to 3 times the estimates produced by the 1998 South Dakota regression equations. Modeling results for this master plan generally fell between the two sets of regression equations and were considered to be within the accuracy range of the available regression equations.

6.7 Detention Pond and Outlet Structure Results

Conceptual designs for proposed detention ponds were completed in accordance with the procedure described in Section 7. A detailed summary sheet for each proposed pond is included in Appendix D. The detailed summaries include peak flow information, 5- and 100-year hydrographs at the pond outfall, pond geometry information, and the pond rating curve. Table 6-7 summarizes the pond outlet structure configurations, Table 6-8 the pond geometries, and Table 6-9 the pond volumes. The five preliminary design sites (11-1, 11-2, 303-2, 40-1, and 51-1) were analyzed further as a part of the preliminary design process described in Section 7. The values listed in Section 6 for these BMPs were obtained for the sites through the master plan process. The updated preliminary design values appear in Section 7.

6.8 Culvert Analysis

Planned future road crossings, as identified in the City's Long Range Transportation Plan, were evaluated using the FlowMaster and CulvertMaster software programs (Haestad Methods). FlowMaster was used to obtain the normal depth rating for each culvert site. CulvertMaster was used to determine culvert size requirements to meet the City's Chapter 11 culvert design standards for the 10- and 100-year design storms. Twenty culvert analyses were performed in the study area, with culverts selected in coordination with the city. A memorandum titled "Major Street Drainage Analysis" and a map showing the culvert locations are included in Appendix G, "Major Street Drainage Structure Analysis." Invert and pipe slopes were estimated using the 2-foot interval contours in lieu of surveying. Appendix G also contains the results of the major street drainage analysis.

6.9 Channel Velocity Calculations

The adequacy of the channel downstream of each proposed BMP was evaluated. The erosion potential for each downstream reach was evaluated by estimating channel slopes and cross sections to determine design storm velocities at normal depth from Manning's equation. Typical channel cross section and slope information were obtained from the City's 2-foot interval contour maps and input in FlowMaster to compute channel velocity. Channel velocity was calculated for high-frequency storms (2-year) because such storms generally control erosion processes. Channel stability recommendations were made based upon calculated channel velocities. For velocities less than 5 feet per second (ft/sec), grass lining was assumed; for velocities between 5 and 8 ft/sec, geosynthetic or bioengineering lining; for velocities greater than 8 ft/sec, riprap. Table 6-10 summarizes channel conditions downstream of proposed BMPs and recommendations for channel stability under developed conditions.

The physical conditions for each downstream reach (roughly 1,000 feet) were field investigated and photographed to record the existing level of bank erosivity, bank length needing stabilization, erosion protection required, and other conditions noted at the site. The actual length which will need to be stabilized should be determined during final design. The field sheets documenting this information are found in Appendix D.

TABLE 6-7
Proposed Detention Pond Outfall Structures for Conceptual Design

BMP Location	5-yr Pipe or Box Size (ft or ft × ft)	5-yr Number of Pipes / Boxes	100-yr Pipe or Box Size (ft or ft × ft)	100-yr Number of Pipes/Boxes
13-1	4 × 10	1	4 × 12	1
13-2	3	2	3	3
13-3	4 × 12	1	6 × 20	1
11-1	4 × 6	1	8 × 12	2
11-2	4	1	6 × 10	1
40-1	8 × 12	3	8 × 12	3
51-2	4 × 16	1	6 × 20	1
7-4	6	1	8 × 12	2
51-1	6 × 12	1	4 × 10	3
7-5	6	1	8 × 10	1
25-3	4 × 20	1	8 × 12	2
303-2	6	1	8	1
303-2alt*	6	1	8	1
25-1	3	1	4.5	1
25-2	3	1	3	2
41-A	4 × 10	2	6 × 10	2
401-1	5.5	2	6 × 20	1
401-2	5.5	1	8 × 12	1
40-2	8 × 12	3	8 × 12	3
304	4 × 10	1	8 × 12	1
312	4 × 8	1	6 × 10	1
400	4 × 8	1	10 × 12	1
303-4	6 × 10	1	10 × 10	1
303-4alt*	6 x 10	1	8 x 10	2
22	4 × 16	1	6 × 20	1
317	4 × 16	1	8 × 12	2
40-3	4 × 6	2	4 × 8	2
305	2	1	5 × 20	1
306	4 × 6	1	6 × 10	1
316	8 × 10	2	10 × 10	2

*303-2alt and 303-4alt were analyzed with existing upstream storage at specific culvert locations.

Note: Box sizes are listed rise × span.

TABLE 6-8
Proposed Detention Pond Geometries for Conceptual Design

BMP Location	Existing Berm Elevation Sufficient?	Required Berm Elevation (ft)	Pond Invert Elevation (ft)	Pond Side Slope (xH:1V)	Length-to-Width Ratio
13-1[a]	Raise road	1,512	1,504.5	4	2.2
13-2[b]	Y	1,509	1,504.5	4	1.66
13-3	Raise road	1,492	1,484.5	4	1.67
11-1	N	1,480	1,472	4	1.64
11-2	N	1,505	1,498	4	1.76
40-1[c]	Build new road or berm	1,458	1,448	4	3.21
51-2	Raise road	1,464	1,456	4	1.7
7-4	N	1,434	1,426	4	1.3
51-1[d]	Raise road	1,454	1,446	Natural topo	Natural topo
7-5	N	1,428	1,420	4	1.3
25-3[e]	Build new berm	1,362	1,352	4	3.01
303-2[f]	Y	1,457	1,440	4	3
303-2alt[g]	Y	1,457	1,440	4	3
25-1[h]	Y	1,441	1,432	4	2.4
25-2[i]	Raise road	1,453	1,446	4	3
41-A[j]	Build new berm	1,424	1,415	4	1.2
401-1	No existing berm/road	1,329	1,312	4	4
401-2	No existing berm/road	1,401	1,382	4	3.7
40-2	Raise road	1,442	1,431	4	3
304[k]	Y	1,382	1,372	4	1.75
312	Y	1,381	1,370	4	3
400	No existing berm/road	1,310	1,294	4	3.33
303-4[l]	Y	1,358	1,340	4	3
303-4alt[m]	Y	1,358	1,340	4	2.8
22[n]	Raise road	1,326	1,317	4	4.67
317[o]	Raise road	1,420	1,410	4	3
40-3[p]	Yes; hwy ramp	1,489.5	1,482	4	2
305[q]	Y	1,334	1,328	4	2.4
306[r]	No existing berm/road	1,339	1,318	4	1.83
316	Build new berm	1,332	1,320	4	1.82

[a]Water main on north side of street

[b]Pond on north side of road. Potential rural water utility conflicts: water main on north side of street.

[c]Pond location upstream of future 34th Street.

TABLE 6-8
Proposed Detention Pond Geometries for Conceptual Design

[d]Pond constructed for water quality purposes only; outlet sized to convey 100-yr flow. Quantity controlled by BMP 51-2. Pond to be built with minimal excavation and uses existing natural topography to minimize wetland impacts. Raise road 5.5 feet.

[e]Berm location is an existing farm pond. Farm pond berm needs evaluation for use with new BMP. Potential rural water utility conflicts: water line nearby.

[f]Outlet size was held at existing pipe size to protect downstream development. Analysis was performed to not increase flows over existing downstream of BMP. Houses on 26th Street must be carefully avoided during preliminary design, and two residential wells must be relocated. Potential rural water utility conflicts: water main on north side of street.

[g]Alternative ponds for 303-2 and 303-4 were designed including additional existing storage at the following culvert locations: under the farm access road at 26th Street at a location 430 ft W of Six Mile Road, under 26th Street at a location 75 ft W of Six Mile Road, under Rushmore Drive (Hwy. 11) at a location 560 ft S of 26th Street, under Six Mile Road at a location 540 ft N of 26th Street, and under Six Mile Road at a location 1,200 ft N of 26th Street. If existing storage at these culverts is preserved, the smaller volumes listed under the alternatives could be used at those pond locations.

[h]Outlet size was held at existing to protect downstream development. Analysis was performed to ensure that head and flows do not increase over existing downstream of BMP. A structure probably associated with agricultural activity is impacted. This BMP also involves combining flow from Basins 25-005 and 25-010 upstream of Madison Street. Streams from the two basins presently converge just downstream of Madison St, therefore a length of stream relocation is required. Houses are located near the drainage way that will accept the combined flow. Potential rural water utility conflicts: water main present to east and south.

[i]Raise road 5 feet. Outlet size was held at existing to protect downstream development. Analysis was performed to ensure that head and flows do not increase flows over existing downstream of BMP. Potential rural water utility conflicts: water main present to east.

[j]New berm to be built along north side of railroad. Outfall channel downstream may be needed.

[k]Potential rural water utility conflicts: water main on west side of street.

[l]Potential rural water utility conflicts: water main on west side of street.

[m]Alternative ponds for 303-2 and 303-4 were designed including additional existing storage at the following culvert locations: under the farm access road at 26th Street at a location 430 ft W of Six Mile Road, under 26th Street at a location 75 ft W of Six Mile Road, under Rushmore Drive (Hwy. 11) at a location 560 ft S of 26th Street, under Six Mile Road at a location 540 ft N of 26th Street, and under Six Mile Road at a location 1,200 ft N of 26th Street. If existing storage at these culverts is preserved, the smaller volumes listed under the alternatives could be used at those pond locations.

[n]Raise the road on the western side of the pond. Regrade ditch downstream of pond to allow an outflow at an elevation of 1,317 feet if necessary. Big Sioux River nearby.

[o]Six Mile Road must be raised 4 feet. Excavation approaches 15 feet at extreme upstream end of pond. There is a structure, possibly a barn or house 280 feet south of pond 2 to 4 feet higher than proposed 100-year water surface. Potential rural water utility conflicts: water main present

[p]Existing structure upstream of pond could potentially be influenced. Structure should be evaluated during final design. Future zoning shows industrial and commercial in this area.

[q]Pond site is immediately upstream of railroad that could serve as berm. If this is not possible, a berm could be constructed parallel to the railroad tracks. The pond should follow up the channel and probably will narrow as it goes upstream. Some significant excavation in the 15- to 18-foot range may be required in the upstream extreme of the pond.

[r]Outfall structure to be built adjacent to the railroad trellis. Upstream end of pond intersects proposed location of Eastside Corridor. However, it is likely the new roadway will be elevated over the pond location because of nearby floodplain and railroad tracks. Potential Rural Water Utility Conflicts: Near water main, Big Sioux River across road.

Note: See Figure J-1 in Appendix J for a map that shows both BMP locations and major roads.

TABLE 6-9
Proposed Detention Pond Volumes for Conceptual Design

BMP Location	WQCV (acre-feet)	5-yr Volume (acre-feet)	100-yr Volume (acre-feet)
13-1	4	18	31
13-2	1	3	6
13-3	11	54	86
11-1[a]	14	91	124
11-2[a]	5	25	45
40-1[a, b]	49	252	407
51-2	9	44	86
7-4	16	101	151
51-1[a]	8	15	25
7-5	13	75	140
25-3[c]	9	18	34
303-2[a, d]	11	37	69
303-2alt[e]	11	31	51
25-1	7	43	86
25-2	5	31	60
41-A	14	63	116
401-1[f]	15	52	94
401-2[f]	23	63	114
40-2[b]	30	302	502
304	6	25	46
312[g]	13	29	48
400[h]	11	39	78
303-4[d]	11	25	52
303-4alt[e]	11	19	29
22	7	33	64
317	11	50	87
40-3	6	37	61
305	5	37	61
306	8	28	49
316	21	60	112

[a]Preliminary design ponds. Pond volumes were determined during the master plan process. Volumes may differ, as they may be adjusted during preliminary design. See Section 7 for preliminary design volumes for the ponds.

[b]Model for BMP 40-1 and BMP 40-2 included existing detention storage northwest of the intersection of I-29 and 60th Street N., immediately west of the highway offramp.

[c]Model for BMP 25-3 included existing detention storage located at Pine Lake and upstream of a culvert that crosses Six Mile Road at a location 610 feet north of 10th Street.

[d]Model for BMP 303-2 and BMP 303-4 included existing detention storage at Split Rock pond between Split Rock Road and Grey Goose Circle and Golden Valley pond southeast of 26th Street and Alpine Avenue

TABLE 6-9
Proposed Detention Pond Volumes for Conceptual Design

[e]Alternative ponds for 303-2 and 303-4 were designed including additional existing storage at the following culvert locations: under the farm access road at 26th Street at a location 430 ft W of Six Mile Road, under 26th Street at a location 75 ft W of Six Mile Road, under Rushmore Drive (Hwy. 11) at a location 560 ft S of 26th Street, under Six Mile Road at a location 540 ft N of 26th Street, and under Six Mile Road at a location 1,200 ft N of 26th Street. If existing storage at these culverts is preserved, the smaller volumes listed under the alternatives could be used at those pond locations.

[f]Model for BMP 401-1 and BMP 401-2 included existing detention storage upstream of a culvert located at the corner of 57th Street and Highway 11 and a culvert located under Highway 11, ¼ mile north of 57th Street.

[g]Model for BMP 312 included existing detention storage at a detention pond located north of Hainje Avenue and 54th Street N. and upstream of a culvert crossing the southbound I-229 off-ramp to Benson Road.

[h]Model for BMP 400 included existing detention storage at an area upstream of a culvert that crosses 41st Street at a location 900 feet east of Daniel Avenue.

TABLE 6-10
Channel Velocity Summary

BMP Location	2-yr Storm Discharge (cfs)	Channel Velocity (ft/s)	Required Protection
13-1	112	3.1	Grass lining
13-2	2	1.0	Grass lining
13-3	149	3.3	Grass lining
11-1	120	2.6	Grass lining
11-2	44	1.4	Grass lining
40-1	815	2.3	Grass lining
51-2	168	2.3	Grass lining
7-4	82	2.0	Grass lining
51-1	294	4.6	Grass lining
7-5	44	1.5	Grass lining
25-3	329	4.1	Grass lining
303-2	241	5.0	Geosynthetic or bioengineering lining
25-1	24	2.1	Grass lining
25-2	20	1.6	Grass lining
41-A	278	6.2	Geosynthetic or bioengineering lining
401-1	456	5.2	Geosynthetic or bioengineering lining
401-2	149	4.0	Grass lining
40-2	740	1.8	Grass lining
304	141	4.0	Grass lining
312	193	4.3	Grass lining
400	254	5.0	Geosynthetic or bioengineering lining
303-4	395	6.6	Geosynthetic or bioengineering lining
22	201	6.8	Geosynthetic or bioengineering lining
317	267	3.1	Grass lining
40-3	123	3.4	Grass lining
305	15	3.0	Grass lining
306	302	6.8	Geosynthetic or bioengineering lining
316	404	5.3	Geosynthetic or bioengineering lining

Note: Grass lining assumed for velocities under 5 ft/sec. Geosynthetic or bioengineering lining assumed for velocities between 5 and 8 ft/sec. Riprap lining assumed for velocities over 8 ft/sec.

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SECTION 7

Preliminary Design

7.1 Design Considerations

Each preliminary designs incorporated the design criteria from Section 3, BMP Siting and Design Considerations. As the regional BMP plan is implemented in Sioux Falls, opportunities to develop the BMPs into local amenities should be investigated. Studies have shown that properly designed water features increase property value, become recreational destinations, and provide habitat benefits. Within Sioux Falls, coordination between Planning and Building Services, Parks and Recreation, and Public Works will provide the best opportunity to identify BMPs sites which can serve multiple uses to be amenities to facilitate planned growth.

BMPs can be developed to provide other uses in addition to stormwater management. For example, BMPs have been developed into parks, used as green space, ball fields, bike paths, nature trails, and urban nature centers. As an illustrative example, a BMP could be developed near a school to provide open space, be an outdoor science educational center, and include a bike/walking path (see example.

Not all BMPs will be suitable for multi-use facilities depending upon local topography, land use, and other constraints. However, where opportunities exist to tie into other recreational plans and facilities, the regional BMPs may provide an added benefit to the citizens of Sioux Falls.

7.2 Site Descriptions and Summary

Five regional BMP locations were selected for preliminary design: BMP 11-1, BMP 11-2, BMP 40-1, BMP 51-1, and BMP 303-2. The five sites were selected from discussions with City staff and were presented at the Public Outreach meetings on April 10, 2003. Site selection was based upon obtaining a diversity of locations throughout the City and targeting quickly developing areas that must be taken to the next design level in the near future.

They are indicated by the green triangles on Figures 3-1 through 3-4 and summarized in Figure 7-1. See Appendix H, "Preliminary Designs," for designs for these five locations.

The City's 2-foot topographic mapping was used to determine the grading for each location. Each site was visited to obtain pipe invert and road overtopping information, if applicable, and to observe and locate visible aboveground utilities or structures. Several sites were observed to have recent development adjacent to the BMP locations. Because of the quick development pace at some locations, it is recommended that a detailed utility survey be conducted before final design. Land use and wetland impact assumptions must be field verified during final design.

Safety shelves (the area labeled on the preliminary design plans as the "littoral zone") have been incorporated into the design of the wet-bottom retention ponds. Signage at the BMP locations combined with educational materials as part of existing city stormwater education efforts are recommended to inform the public of potential hazards associated with the BMPs.

Due to the additional detailed analysis conducted during preliminary design, parameters presented for the BMPs such as the postdevelopment flows, outlet structure sizes, elevations, length-to-width ratios, and storage volumes may change from the master plan to preliminary design phases. Updated information for the five preliminary design sites appear in the following tables. Table 7-1 lists predevelopment flows (these values did not change during preliminary design, but are included here for reference purposes). Table 7-2 lists postdevelopment flows discharged from the pond outfall structures. Table 7-3 lists proposed detention pond outfall structures. Table 7-4 lists proposed detention pond geometries. Table 7-5 lists proposed detention pond volumes.

Each site is summarized briefly below. Included in each site's description is a section that addresses Final Design Considerations. The five ponds have been investigated to a preliminary design level of detail, but additional effort is needed to refine the designs. Final design should consider optimizing the grading plan to decrease excavation, optimizing final modeling and structure sizes, ensure there are not additional site constraints, consider recent development impacts, include changes in design criteria (if applicable), consider construction feasibility and phasing, and reduce costs where ever feasible. For each site, some specific items to be addressed during final design are indicated.

TABLE 7-1
Predevelopment Peak Flow Summary for Preliminary Design Sites

BMP Location	1-Year Peak Flow (cfs)	2-Year Peak Flow (cfs)	5-Year Peak Flow (cfs)	10-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
11-1	356	479	712	916	1,550
11-2	119	163	254	327	551
40-1	525	824	1,454	1,978	3,790
51-1	193	322	551	821	1,515
303-2	144	240	448	624	1,221

TABLE 7-2
Postdevelopment Peak Flow Summary for Preliminary Design

BMP Location	1-Year Peak Flow (cfs)	2-Year Peak Flow (cfs)	5-Year Peak Flow (cfs)	10-Year Peak Flow (cfs)	100-Year Peak Flow with BMP (cfs)
11-1	297	478	704	825	1,433
11-2	25	75	194	254	438
40-1	575	901	1,376	1,707	2,610
51-1	147	268	423	605	1,188
303-2	65	134	247	370	681

TABLE 7-3
Proposed Detention Pond Outfall Structures for Preliminary Design

BMP Location	5-yr Pipe or Box Size (ft or ft × ft)	5-yr Number of Pipes / Boxes	100-yr Pipe or Box Size (ft or ft × ft)	100-yr Number of Pipes / Boxes
11-1	4 × 12	2	6 × 16	2
11-2	4 × 10	1	6 × 10	1
40-1	None	None	6 × 16	3
51-1	None	None	6 × 16	2
303-2	6	1	8	1

Note: Box sizes are listed rise × span.

TABLE 7-4
Proposed Detention Pond Geometries for Preliminary Design

BMP Location	Existing Berm Elevation Sufficient?	Required Berm Elevation (ft)	Pond Invert Elevation (ft)	Pond Side Slope (xH:1V)	Length-to-Width Ratio
11-1	N	1,481.6	1,473	4	1
11-2	N	1,505.8	1,498	4	1.25
40-1[a]	N	1,456.1	1,448	4	2
51-1[b]	Raise road	1,452.9	1,444	4	2
303-2[c]	Y	1,452.3	1,440	4	3

[a]Pond location upstream of new berm approximately 550 feet north of 34th Street North.

[b]Pond constructed for water quality purposes only, outlet sized to convey 100-year flow. Quantity controlled by BMP 51-2. Pond to be built with minimal excavation as shown on Preliminary Design Plan in Appendix H.

[c]Outlet size was held at existing pipe size to protect downstream development. Two residential wells must be relocated. Rural water main is located on north side of 26th Street.

TABLE 7-5
Proposed Detention Pond Volumes for Preliminary Design

BMP Location	WQCV (acre-feet)	5-yr Volume (acre-feet)	100-yr Volume (acre-feet)
11-1	14	46	95
11-2	5	22	44
40-1	55	204	348
51-1	9	26	48
303-2	11	49	93

7.2.1 BMP 11-1

7.2.1.1 Preliminary Design Considerations

BMP 11-1 is located on the southwest side of the City, roughly 2,000 feet south of 69th Street on the east side of Tallgrass Avenue. The location is within a high sensitivity cultural resources area. The 2015 land use at the site is residential single family. Within the upstream watershed, the 2015 land use is split between residential single family and manufacturing. The design is intended to minimize the pond footprint while providing water quality treatment and matching the 5- and 100-year predevelopment flow rates. It is designed as a retention basin (wet pond) with a dual-use component. A recreation area was added on the south side of the BMP to provide open space that remains dry for frequently occurring storms and is inundated and provides flood control for less frequent large storms. The sizing for BMP 11-1 assumes that the area tributary to BMP 11-1 on the west side of Interstate 29 would have its own water quality and flood control features for postdevelopment land use. The flow from the area west of Interstate 29 was included based on predevelopment conditions because it is outside the city's 2015 land use and the west side of the interstate is a promising location for a regional facility in the future.

The berm for BMP 11-1 is near an existing barn. The elevation of the barn foundation was surveyed, and the berm height was designed to be lower than the foundation with 3 feet of freeboard. The barn grading does not show on the City's topographic mapping because it was constructed following the 2-foot contour interval topographic mapping. The channel slopes upstream of the BMP are at a relatively high slope. Thus, the major influent flow channel will require a series of rock weir drop structures and grading to stabilize the channel.

The design is intended to minimize the pond footprint and to match predevelopment flow rates while maintaining a reasonably sized outlet structure. The pond would limit peak flow from the 5- and 100-year storms to the predevelopment conditions. A forebay and maintenance access road have been added along Tallgrass Avenue. The estimated wetland impact based upon NWI and hydric soils information is 0.6 acre. With grading, the 100-year water surface elevation is estimated to be 1,480.6 feet.

7.2.1.2 Final Design Considerations

Designing the BMP without affecting the barn increased the required excavation. The cost of the BMP may reduce if the area to the north were included and the barn and several nearby buildings were removed or relocated. An analysis would have to be conducted to see if building acquisition costs would effectively reduce the excavation costs. Excavation costs could be further reduced by extending part of the BMP across Tallgrass Avenue and raising the elevation of Tallgrass Avenue roughly 5 feet. This would allow the 100-year water surface elevation to be raised and reduce the pond footprint in the southern area of the pond where excavation is significant. A second berm or hydraulic control at Tallgrass Avenue may be required to pond water upstream of Tallgrass Avenue. Another option for consideration during final design would be to remove the permanent pool and use the extended detention basin design criteria (see discussion for BMP 303-2). Under this scenario, a much smaller permanent pool likely would remain due to baseflow in the stream from the west.

Another option to decrease cost would be to separate the outlet structures for the 100-year storm from the 5-year and water quality capture volume (see discussion for BMP 51-1). This option is available here because the embankment creating the pond does not carry a road. The embankment could be designed to provide a spillway that allows embankment overtopping to control the 100-year storm, instead of carrying the flow through the large concrete box outlets. Dam permit requirements for flood conveyance capacity of either the 100-year return period or 0.5 PMF need to be determined through a combination of ordinance development and DENR coordination as described further in Section 8.

7.2.2 BMP 11-2

7.2.2.1 Preliminary Design Considerations

BMP Site 11-2 is located on the southwest side of the city, about 750 feet west of the Crane Street and 77th Street intersection. The location is just to the south of a high sensitivity cultural resources area. The 2015 land use in the immediate area of the BMP is residential single family. The upstream watershed contains a mix of 2015 land use that includes residential single family, residential multiple family, institutional, general commercial and open space.

BMP 11-2 is designed as a retention basin (wet pond). The design is intended to minimize the pond footprint while providing water quality treatment and matching the 5- and 100-year predeveloped flow rates. The pond will limit peak flow from the 5- and 100-year storms to predevelopment conditions. A forebay and maintenance access road have been added by means of an easement to a future road as development occurs in the area. The estimated wetland impact based upon NWI information is 0.7 acre. With grading, the 100-year water surface elevation is estimated to be 1,504.8 feet.

7.2.2.2 Final Design Considerations

One option to consider during final design is removal of the permanent pool and using the extended detention basin design criteria, resulting is less excavation (see discussion for BMP 303-2). Dam permit requirements for flood conveyance capacity of either the 100-year return period or 0.5 PMF need to be determined through a combination of ordinance development and DENR coordination as described further in Section 8.

Comments were received subsequent to completing the preliminary design that the BMP should be moved further south to a location already planned for city ownership as a school and park. Evaluation of this alternative location should be included prior to final design.

7.2.3 BMP 40-1

7.2.3.1 Preliminary Design Considerations

BMP 40-1 is located on the west side of the city, near where the future 34th Street extension will cross the Skunk Creek tributary. The location is within a high sensitivity cultural resources area. The 2015 land use at the site is mostly open space, but the site extends into adjacent 2015 land use areas of residential single family and residential multiple family. A proposed school site is located on the west side of the facility. The upstream watershed is an extensive area that contains a variety of 2015 land uses including residential single family, residential multiple family, manufacturing, general commercial, institutional, and open space.

The BMP is designed as a constructed wetlands basin. BMP 40-1 was designed with multiple uses in mind. A sanitary sewer trunk line passes through the area, and the route is designed as a nature walking path through the wetlands. At the north end of the facility, an open space green area adjacent to the school is designed to be dry during frequent storms but to serve as a detention facility during larger storms. Because of the proximity to the school, signs, handrails, or fencing should be considered for protection and safety. Recent development is present near the southwestern corner of the site. Elevations of fill and roads were surveyed to estimate the elevations of future structures. The berm for the detention facility was placed across the stream just upstream of where the channel passes the development. The low points of backyards of houses located in the development adjacent to the west of the channel downstream of the berm for the detention facility have elevations of about 1,456 feet. No information was available for house elevations at the time of the survey. The estimated required 100-year water level is 1,456.1 feet and the berm 1,457.1 feet.

The concept behind the design is to minimize the pond footprint while providing water quality treatment and matching the 5- and 100-year predevelopment flow rates. In addition, the facility can be used for teaching and observation of wetland functions and habitat. The multi-use facility would be a valued amenity for the school and future residential neighborhoods. A forebay and maintenance access road have been added along Benson Road. The estimated wetland impact based upon NWI information is 4.0 acres. With grading, the 100-year water surface elevation is estimated to be 1,456.1 feet.

7.2.3.2 Final Design Considerations

Options for reducing excavation for the pond are limited. A spillway section could carry the 100-year flows over the berm. This option would allow the volume, footprint, and excavation required for the pond to be reduced. The costs for the spillway would have to be weighed against the resulting pond construction cost savings. The sanitary sewer manholes should be sealed to reduce infiltration and inflow into the sanitary sewer collection system. If the manhole are sealed, an analysis should be conducted to determine if the sewer should be ventilated at select locations. Dam permit requirements for flood conveyance capacity of either the 100-year return period or 0.5 PMF need to be determined through a combination of ordinance development and DENR coordination as described further in Section 8.

Comments were received subsequent to completing the preliminary design that at least some of the BMP land requirements should be moved further north of Benson Road to a location already planned for city ownership as a park. Due to the BMP size, the site may have to straddle Benson Road with the facility split north and south of Benson Road. Evaluation of this alternative location should be included prior to final design.

7.2.4 BMP 51-1

7.2.4.1 Preliminary Design Considerations

BMP 51-1 is located on the south side of the city about 1,850 feet east of Cliff Avenue on the north side of 85th Street. The plan is to minimize the pond footprint while providing water quality treatment and matching the 5-year and 100-year predevelopment flow rates. It is designed as a constructed wetlands basin. The site is the second in a series of two BMPs that control and treat stormwater within Basin 51 upstream of 85th Street.

The upstream BMP site functions to reduce postdevelopment flows to predevelopment levels such that BMP 51-1 needs only to provide water quality treatment by capturing the WQCV. Because of the flat topography in the basin, additional flow attenuation will occur at BMP 51-1, but it is not a design requirement since the upstream BMP discharges flows meeting the predevelopment flow matching requirement.

BMP 51-1 is located within a high sensitivity cultural resources area. The 2015 land use at the location of BMP 51-1 and within its upstream watershed is residential single family. The concept behind the design is to provide WQCV with 85th Street acting as a berm across the channel. A forebay and maintenance access road have been added via 85th Street. The road will be overtopped for storms over the 100-year level and flows less than the 100-year event will be conveyed through the outlet structure which crosses underneath 85th Street.

7.2.4.2 Final Design Considerations

It is estimated that the road at 85th Street will have to be raised 5.5 feet to prevent overtopping during the 100-year return period storm. Given the topography upstream of 85th Street and two 6- by 16-foot outlet pipes crossing at 85th Street, the 100-year water surface elevation is estimated to be at an elevation of roughly 1,451.9 feet. The estimated wetland impact based upon NWI and hydric soils information is about 4.0 acres. BMP 51-1 requires very little excavation because the existing topography provides storage that is nearly sufficient to contain the WQCV and prevent the 100-year event from overtopping the road.

The outlet structure at this BMP was sized to meet the hydraulic requirements to convey the flow through the road embankment for the design storms. However, the structure does not meet the City's trash rack requirement of 4 times the outlet pipe open area. If this criterion had been met, the structure would have been about 40 feet wider. The trash rack criterion is intended for smaller outlet pipes and can result in impractical structure sizes when large outlet pipes are required. When large outlets are used, the risk of pipe blockage by debris is much less than with smaller pipes. In final design, a custom trash rack should be considered to minimize the area blocked by the trash rack bars while providing as much open area as possible.

Another alternative to consider is separating the outlet structure, so that the outlet structure for the water quality capture volume and 5-year storm is smaller, and the outlet for the 100-year storm is provided by allowing overtopping of the berm. Since the berm in the preliminary design is provided by 85th Street (see Appendix H), the option of allowing berm overtopping at the road is infeasible. This could be accomplished, however, by building a new berm just upstream of the road, sizing the concrete outlet structure for just the WQCV and the 5-year storm, and designing the berm to serve as a spillway for the 100-year storm. Culverts under the road at 85th Street would still need to be sized to pass the 100-year storm. Dam permit requirements for flood conveyance capacity of either the 100-year return period or 0.5 PMF need to be determined through a combination of ordinance development and DENR coordination as described further in Section 8.

7.2.5 BMP 303-2

7.2.5.1 Preliminary Design Considerations

BMP 303-2 is located on the east side of the city, roughly 1,600 feet east of Highway 11 (Powderhouse Road) on the south side of 26th Street. The location is not within a high sensitivity cultural resources area. The 2015 land use in the area is residential single family. In the upstream watershed, the 2015 land use is primarily residential single family, with a small amount of general commercial and institutional land use.

The concept behind the design is to minimize the pond footprint while providing water quality treatment and matching the 5- and 100-year predevelopment flow rates. It is designed as a retention basin (wet pond). The BMP discharges to a channel that flows into a rural residential neighborhood with a detention pond near Split Rock Avenue. The outlet for BMP 303-2 was sized to keep the same 8-foot diameter outlet pipe as the existing culvert. Two residential wells would have to be relocated as part of pond construction. The pond would limit peak flow from the 5- and 100-year storms to predevelopment conditions. A forebay and maintenance access road have been added off 26th Street. The estimated wetland impact based upon NWI and hydric soils information is 0.2 acre. With grading, the 100-year water surface elevation is estimated to be 1,351.3 feet.

7.2.5.2 Final Design Considerations

Options that could minimize excavation during final design include removing the permanent pool feature and using the extended detention basin design criteria. By using the extended detention design criteria, the water quality drain time would increase, but there would not be the requirement to excavate a permanent pool equal in size to the WQCV. This could be beneficial because the excavation for the permanent pool is significant. In this case, a much smaller permanent water pool could be constructed that would be maintained by natural baseflow in the stream running through this BMP. The 100-year water surface elevation could be raised during final design to 1,357 feet. This would decrease excavation but greatly increase the footprint of the pond. Dam permit requirements for flood conveyance capacity of either the 100-year return period or 0.5 PMF need to be determined through a combination of ordinance development and DENR coordination as described further in Section 8.

7.3 Review of Soil Survey Information

The available soil survey information for Lincoln and Minnehaha counties was reviewed to assess the surficial soil types at proposed dam locations 11-1, 11-2, 51-1, 40-1 and 303-2. The purpose of the review was to make a preliminary assessment of any obviously unsuitable soil conditions that could influence the siting of the dams. Soil survey reports provide information on only the top 5 feet of soil, which can be appropriate for a Master Plan level screening analysis, but which is inadequate for final determination of the suitability of a site for dam construction. A geotechnical investigation must be conducted before designing the dams.

Detention areas 11-1, 11-2, and 51-1 are within Lincoln County and areas 40-1 and 303-2 within Minnehaha County. Detention areas will be created by constructing earthen dams across existing drainageways, consisting of native material excavated on site. The surficial soils at the proposed dam sites have similar engineering properties. Based on the soil survey report for Lincoln County[1] and soil survey information for Minnehaha County,[2] the top 5 feet of soil at the proposed dam locations consists of silt loam, silty clay loam, and silty clay with Unified Soil Classification System designations of CL, CL-ML, and CH. The plasticity index of the material is expected to range between 5 and 40 percent, and the shrink/swell potential is moderate to high. Some soil layers were reported to have high lime content.

The information summarized above does not indicate soil conditions unsuitable for dam construction at the proposed sites. However, soft soils may be encountered and need to be overexcavated before fill is placed during dam construction. Before designing the dams, a comprehensive geotechnical investigation program must be conducted to evaluate foundation soil conditions, borrow materials for dam construction, and soil parameters for dam design. The geotechnical investigation should include soil borings, sampling, laboratory testing for strength, composition, and consolidation characteristics, evaluation of groundwater conditions, and geotechnical analyses for stability and settlement of the dams.

7.4 Cost Opinion

7.4.1 Methodology to Develop Costs

Capital costs for the BMP program were developed in two steps. First, five BMPs were selected for which preliminary design plans could be prepared as part of the Master Plan. Cost estimates were developed for those BMPs and then projected to estimate costs for the remaining BMPs. The projected costs were based on typical costs of the different types of BMPs to be used in the Master Plan.

This cost estimate is an order-of-magnitude cost estimate appropriate for a master planning analysis. This cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time that the estimate was developed. The final costs for the project will depend on final project scope, implementation schedule, actual labor and material costs, competitive market conditions, and other variable conditions. As a result, the final project costs will vary from the estimate presented herein.

7.4.2 Preliminary Design Cost Estimates

The BMP cost estimates were based on quantity takeoffs from the preliminary plans, and construction cost experience from the Sioux Falls region. The estimates for the five designs are based on the following assumptions:

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[1] *Soil Survey of Lincoln County, South Dakota*, USDA, Soil Conservation Service, Washington DC, June 1976.

[2] Soil survey information for Minnehaha County, obtained from the U.S. Department of Agriculture, Natural Resource Conservation Service, Huron, South Dakota.

- The plans are based on Sioux Falls GIS 2-foot contour topography. It was assumed that the earthwork calculations based on existing and proposed grades are a close approximation to the actual earthwork quantities.
- The mobilization/construction access cost is assumed to be 5 percent of the BMP construction cost. Actual costs will vary depending upon proximity to roadways.
- Land acquisition costs were estimated through a standard unit cost of $25,000 per acre provided by Public Works. Any area that would be necessary for a spoil pile was not included in the cost estimate. Depending upon construction phasing, a spoil pile may be required, in which case a permanent or temporary easement should be considered for the spoil pile location.
- The cost associated with field topographic survey, engineering, environmental permitting, and construction staking and construction management was assumed to be 16 percent of the cost of each BMP without contingency, wetland mitigation, and land acquisition costs.
- An assumed contingency of 15 percent of the construction cost of each BMP was included in the estimate.
- The wetland mitigation costs were assumed to be $40,000 per acre of mitigation, with a mitigation ratio of 1.5:1, resulting in a net unit cost per acre of wetland impacts of $60,000. The estimated cost includes monitoring costs associated with the wetland mitigation construction. Desktop evaluations were used to estimate the wetland impacts for the five BMPs. (No field survey has yet been conducted to confirmed the wetland limits.) The wetland mitigation costs do not include mitigation for stream impacts.
- The costs for the constructed wetland basin do not include planting following construction. Such planting should be accounted for in the maintenance budget.
- Where infrastructure relocation or alternation was known, the associated costs were added to the overall BMP cost.
- The costs associated with raising roads were not included in the overall BMP cost.

Table 7-6 summarizes the cost estimating assumptions. Appendix H contains the detailed cost estimates for each of the five preliminary design sites. Table 7-7 summarizes the estimated construction and total capital cost.

TABLE 7-6
Cost Estimate Assumptions for Stormwater BMPs

Clearing and Grubbing	Estimated footprint size in acres × $3,500
Earthwork	## × estimated 100-year storage volume in cubic yards × $2.10/yd^3
Fill for Embankment	## × estimated 100-year storage volume in cubic yards × $5/yd^3
Erosion and Sediment Control	Estimated footprint size in acres × $5,500/acre
Outlet Structures	Based on costs for excavation and fill, and concrete quantities.
Wetland Mitigation	Estimated NWI wetland and hydric soils impact in acres × 1.5 × $40,000
Land Acquisition	Estimated footprint size in acres × 1.25 × $25,000
Plantings: Grass Seeding	Estimated footprint size above permanent pool area in acres × $1,000/acre
Plantings: Aquatic Bench	Estimated wetland planting for the littoral zone in acres × $5,000/acre
Mobilization and Construction Access	5% of the construction cost before contingency.
Survey, Engineering, Permitting, and Construction Administration	16% of construction cost before contingency. It is assumed that the City will perform the geotechnical work, with at least 3 soil borings per site.

TABLE 7-7
Estimated Total Construction and Capital Cost at Five BMP Locations with Preliminary Designs

BMP	Total Construction Cost	Total Capital Cost
11-1	$2,229,000	$3,512,000
11-2	$642,000	$1,087,000
40-1	$2,461,000	$4,836,000
51-1	$528,000	$1,026,000
303-2	$1,209,000	$1,785,000

SECTION 8

Implementation Plan

8.1 Introduction

This section summarizes the schedule, costs, and permitting considerations of the regional BMPs and associated programs, potential funding mechanisms and strategies, and necessary steps to implement the potential programs. The scope of the study did not include detailed evaluation of funding mechanisms and implementation steps, so the discussion herein provides only a framework for more detailed evaluation as needed. This section has four subsections:

- **Costs—**Development of capital and operation and maintenance (O&M) costs associated with the Regional BMP Master Plan.
- **Funding Mechanisms and Recommendations—**Evaluation of strategies to fund the estimated costs of the program.
- **Regulatory Considerations—**Outlines issues and strategies likely to influence obtaining permits and the associated implementation schedule, as well as considerations related to stormwater permit compliance.
- **Schedule Phasing and Implementation Strategy—**A phasing timeline for implementation of the Regional BMP Master Plan, and implementation steps necessary for the successful and timely implementation of a selected strategy.

8.2 Costs

8.2.1 Planning Period and Construction Schedule

The planning period for the Master Plan regional BMP construction costs is from 2004 through 2015. Figure 8-1 shows the anticipated BMP construction cost schedule through 2015. O&M costs will build over that period as BMPs are constructed and will continue past 2015. The construction costs can be spread over time depending upon the type of funding mechanism. No funding mechanisms to spread costs over time were evaluated as part of the Master Plan; however, funding issues for the City to consider are discussed later in this section.

8.2.2 Capital Costs

8.2.2.1 Methodology to Develop Costs

Capital costs for the BMP program were developed in two steps. First, five BMPs were selected for which preliminary design plans could be prepared as part of the Master Plan. Cost estimates were developed for those BMPs and then projected to estimate costs for the remaining BMPs. The projected costs were based on typical costs of the different types of BMPs to be used in the Master Plan. The methodology and results for developing the construction cost estimates for the five preliminary BMP sites are presented in Section 7.

FIGURE 8-1
Proposed BMP Construction Schedule
Regional Stormwater BMP Master Plan
City of Sioux Falls, South Dakota

BMP Name	Preliminary Design	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
13-1														
13-2														
13-3														
11-1	X													
11-2	X													
40-1	X													
51-2														
7-4														
51-1	X													
7-5														
25-3														
303-2	X													
25-1														
25-2														
41-A														
401-1														
401-2														
40-2														
304														
312														
400														
303-4														
22														
317														
40-3														
305														
306														
316														
Total		3	0	4	2	3	3	0	7	0	2	0	0	4

8.2.2.2 Cost Projections for Remaining BMPs

Preliminary designs have not been prepared for most of the proposed BMPs. Costs for those facilities are based on such information as approximate location, type, drainage area, footprint, and volume. The cost projections were estimated by developing a regression relationship between 100-year pond storage volume requirement and total capital cost for the five preliminary design sites. A linear relationship was used for small BMPs before a transition at a volume of about 40 acre-feet to a logarithmic relationship for larger BMPs. The 100-year storage volume was used as the primary cost indicator because earthwork is the primary component of the cost estimates and is most closely related to storage requirements. Figure 8-2 summarizes the resulting cost estimating relationship based on the data in Tables 7-5 and 7-7.

8.2.2.3 Resulting Capital Costs

The methodology described above was used to estimate capital costs for the Master Plan BMPs. The total capital cost of the BMP program is estimated to be $63.7 million. Table 8-1 summarizes the total land, construction, and capital cost for each of the 28 proposed BMPs. Table 8-2 lists the costs of water quality and water quantity components, and also lists 2015 area land use, WQCV tributary area, and projected area for the BMP. Costs associated with water quality include the water quality orifice plate, water quality trash rack, and part of the excavation. The portion of the excavation costs due to water quality was assumed to be equal to the ratio of the WQCV to the 100-year storage volume of a BMP. Water quality and quantity costs were calculated for the five preliminary design sites. Then the average ratio of quality cost to quantity cost was used to estimate the water quality and water quantity costs for the remaining BMPs.

FIGURE 8-2
Construction Cost Relationship for Five Preliminary Design Sites

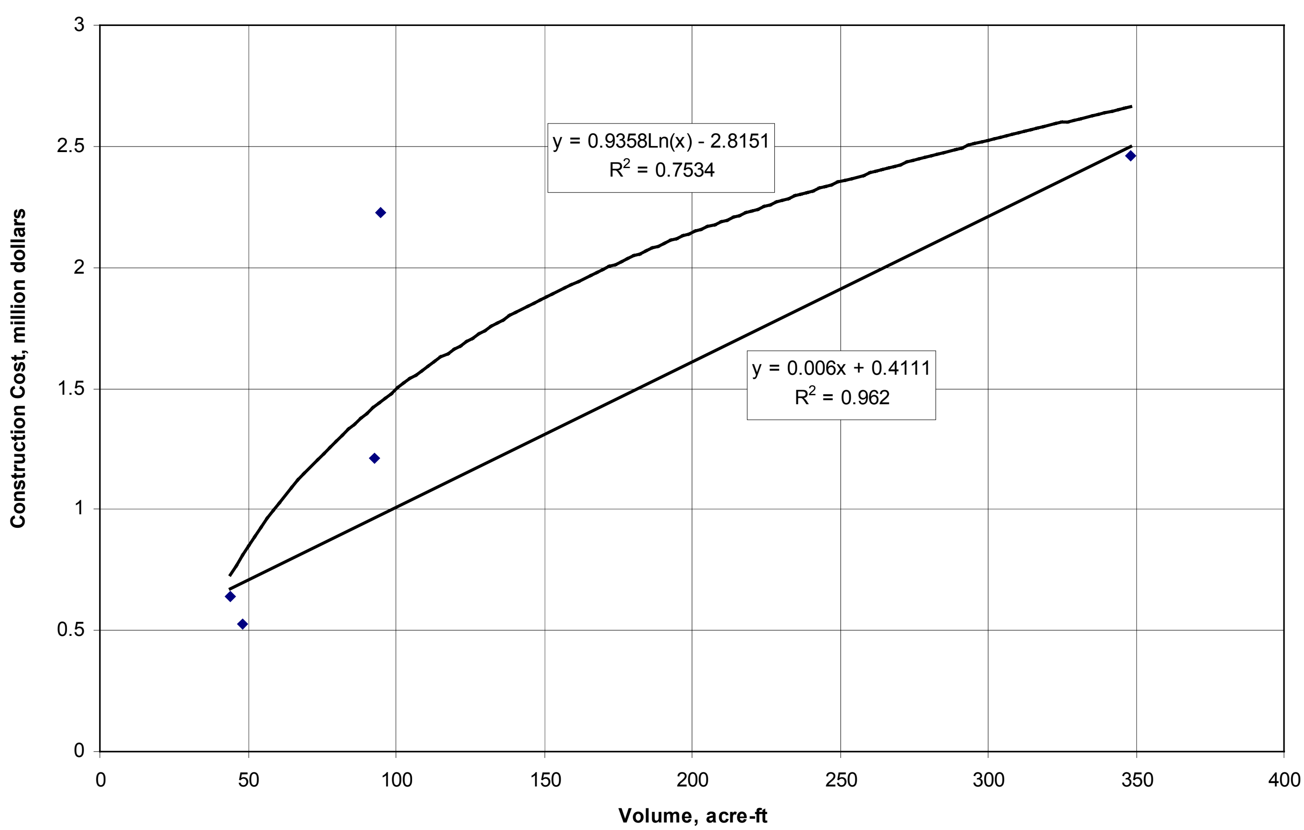


TABLE 8-1
Proposed Detention Pond Volumes and Costs

BMP Site	Year	Location Description	Water Quality Capture Volume[a] (ac-ft)	100-yr Vol. (ac-ft)	Land Cost	Construction Cost[b]	Capital Costs[b]
13-1	2003	2,100 ft west of 41st St. and Sertoma Ave. intersection, on south side of 41st	4	31	$258,000	$597,000	$1,568,000
13-2	2003	850 ft east of Tea Ellis Rd. and 41st intersection, on north side of 41st	1	6	$135,000	$447,000	$644,000
13-3	2003	2,700 ft north of Tea Ellis Rd. and 41st St. intersection, on west side of Tea Ellis Rd.	11	86	$676,000	$1,353,000	$2,217,000
11-1	2005	East of Tallgrass Ave. and south of 69th Street, Pond 17C of Prairieview Study	14	95	$938,000	$2,229,000	$3,512,000
11-2	2005	750 ft west of Crane St. and 77th St. intersection, Pond 17B of Prairieview Study	5	44	$313,000	$642,000	$1,087,000
40-1	2005	1,200 ft east and 700 ft north of Marion Rd. and W 34th St. N intersection	55	348	$1,791,000	$2,461,000	$4,836,000
51-2	2005	1,500 ft north of Cliff Ave. and 85th Street intersection, on west side of Cliff Ave.	9	86	$676,000	$1,353,000	$2,775,000
7-4	2006	600 ft east of intersection of Sycamore and 69th St., on north side of 69th St.	16	151	$1,103,000	$1,880,000	$3,569,000
51-1	2006	1,850 ft east of Cliff Ave. and 85th St. intersection, on north side of 85th St.	9	48	$188,000	$528,000	$1,026,000
7-5	2007	1,600 ft west and 1,000 ft north of Rushmore and 69th St. intersection, extends upstream and downstream of future East Side Corridor	13	140	$1,045,000	$1,809,000	$3,364,000
25-3	2007	Southeast corner of Six Mile Rd. and 10th St.	9	34	$273,000	$615,000	$1,016,000
303-2	2007	1,600 ft east of Powderhouse and 26th, on south side of 26th Street	11	93	$397,000	$1,209,000	$1,785,000
25-1	2008	1,600 ft east of Madison St. and Powder House intersection, on north side of Madison St.	7	86	$676,000	$1,353,000	$2,253,000
25-2	2008	1,600 ft south of Madison St. and Powder House intersection, on west side of Powder House	5	60	$403,000	$1,016,000	$1,740,000
41-A	2008	1,500 ft north of I-29 and 12th St. intersection, on west side of I-29	14	116	$903,000	$1,633,000	$2,763,000
401-1	2010	4,000 ft east of Six Mile Rd., on south side of 57th St.	15	94	$744,000	$1,437,000	$2,591,000
401-2	2010	1,800 ft south of Six Mile Rd. and 57th St. intersection, west side of Six Mile Rd. (Tisdale).	23	114	$890,000	$1,617,000	$2,798,000
40-2	2010	Northeast corner of Madison St. and LaMesa Dr. intersection	30	502	$2,013,000	$3,004,000	$6,467,000
304	2010	2,600 ft southeast of intersection of Six Mile Road and STH 42 (Minnehaha Rd.), on south side of STH 42	6	46	$332,000	$768,000	$1,207,000
312	2010	2,750 ft east of I-229, on north side of Benson Rd.	13	48	$342,000	$808,000	$1,262,000
400	2010	7,200 ft east of Six Mile Rd., on north side of 41st St.	11	78	$602,000	$1,262,000	$2,040,000

TABLE 8-1
Proposed Detention Pond Volumes and Costs

BMP Site	Year	Location Description	Water Quality Capture Volume[a] (ac-ft)	100-yr Vol. (ac-ft)	Land Cost	Construction Cost[b]	Capital Costs[b]
303-4	2010	1,300 ft southeast of Six Mile Rd. and STH 42 (Minnehaha Road) intersection, on south side of STH 42	11	52	$362,000	$882,000	$1,367,000
22	2012	2,600 ft east of Bahnson Rd., between Rice St. and the railroad tracks	7	64	$452,000	$1,077,000	$1,679,000
317	2012	1,300 ft south of Maple Rd. and Six Mile Rd. intersection, on west side of Six Mile Rd.	11	87	$685,000	$1,364,000	$2,275,000
40-3	2015	Northwest corner of I-90 and I-229 interchange	6	61	$416,000	$1,032,000	$2,258,000
305	2015	East side of Rice St., 400 ft northeast of Lawrence Pl, north of Great Bear.	5	61	$416,000	$1,032,000	$1,592,000
306	2015	Northeast of intersection of Rice St. and Timberline, upstream of East Side Corridor	8	49	$347,000	$827,000	$1,289,000
316	2015	4,700 ft east of I-90 and I-229 interchange, on south side of I-90	21	112	$876,000	$1,600,000	$2,699,000
Total Cost			**—**	**—**	**$18,252,000**	**$35,835,000**	**$63,679,000**

[a]Water Quality Capture Volume is the storage volume designed to be detained for frequent storms for water quality purposes.

[b]Master Plan order-of-magnitude cost estimate.

This cost estimate is an order-of-magnitude cost estimate appropriate for a master planning analysis. This cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time that the estimate was developed. The final costs for the project will depend on final project scope, implementation schedule, actual labor and material costs, competitive market conditions, and other variable factors. As a result, the final project costs will vary from the estimate presented herein.

These costs have not been adjusted for inflation. It is assumed that the funding mechanism the City chooses will be adjusted annually to reflect the percentage changes in *Engineering News-Record's* Construction Cost Index.

8.2.3 Operations and Maintenance Costs

The cost for inspecting and maintaining stormwater management facilities depends on the level of service for which a jurisdiction is willing and able to allocate financial resources. While certain maintenance actions can be delayed, some may be required by a jurisdiction's National Pollutant Discharge Elimination System (NPDES) permit (i.e., inspection of aboveground and underground facilities).

This section presents cost estimates for the inspection and maintenance of stormwater management facilities (i.e., 28 wet ponds). The estimates are based on a BMP inspection and maintenance cost estimating model that uses maintenance frequencies and other assumptions from literature and information specific to the City. Table 8-3 provides a summary of costs and Table 8-4 the underlying assumptions for them.

TABLE 8-2
Water Quality versus Water Quantity Cost Breakdown, 2015 Land Use, WQCV Tributary Area, and Pond Area

BMP Site	Cost for Water Quality	Cost for Water Quantity	2015 Land Use	WQCV Tributary Area (acres)	Pond Area (acres)
13-1	$51,000	$1,517,000	Residential single family	210	10
13-2	$21,000	$623,000	Residential single family	65	5
13-3	$72,000	$2,145,000	Residential single family	596	27
11-1	$148,000	$3,364,000	Residential single family	698	38
11-2	$36,000	$1,051,000	Residential single family	309	13
40-1	$143,000	$4,693,000	Residential single family/open space	2,691	72
51-2	$90,000	$2,685,000	Residential single family	540	27
7-4	$110,000	$3,453,000	Residential single family	917	44
51-1	$17,000	$1,009,000	Residential single family	457	8
7-5	$116,000	$3,254,000	Residential single family	741	42
25-3	$33,000	$983,000	Residential single/multiple family	547	11
303-2	$74,000	$1,711,000	Residential single family	582	16
25-1	$73,000	$2,180,000	Residential single family	369	27
25-2	$57,000	$1,683,000	Residential single family	252	16
41-A	$90,000	$2,673,000	Manufacturing	636	36
401-1	$84,000	$2,507,000	Residential single family	834	30
401-2	$91,000	$2,707,000	Residential single family	1,351	36
40-2	$211,000	$6,256,000	Open space	1,793	81
304	$39,000	$1,168,000	Residential multiple family	339	13
312	$41,000	$1,221,000	Manufacturing	410	14
400	$66,000	$1,974,000	Residential single family	669	24
303-4	$45,000	$1,322,000	Residential multiple family	531	14
22	$55,000	$1,624,000	Residential single family	424	18
317	$74,000	$2,201,000	Residential single family	612	27
40-3	$74,000	$2,184,000	General commercial	291	17
305	$52,000	$1,540,000	Residential multiple family	298	17
306	$42,000	$1,247,000	Manufacturing	427	14
316	$88,000	$2,611,000	Manufacturing	699	35
Total	**$2,093,000**	**$61,586,000**			

TABLE 8-3
Inspection and Maintenance Cost Estimate for 28 Wet Ponds

Year	Facilities[a]	Total Routine Maintenance	Total Nonroutine Maintenance	Inspection	Total
2004	3	$5,600	$19,600	$400	$25,600
2005	3	$5,600	$19,600	$400	$25,600
2006	7	$13,100	$45,700	$800	$59,700
2007	9	$16,900	$58,800	$1,100	$76,700
2008	12	$22,500	$78,400	$1,400	$102,300
2009	15	$28,200	$97,900	$1,800	$127,900
2010	15	$28,200	$97,900	$1,800	$127,900
2011	22	$41,300	$143,600	$2,600	$187,600
2012	22	$41,300	$143,600	$2,600	$187,600
2013	24	$45,000	$156,700	$2,900	$204,600
2014	24	$45,000	$156,700	$2,900	$204,600
2015	24	$45,000	$156,700	$2,900	$204,600
2016	28	$52,500	$182,800	$3,400	$238,700
10-year Average		*$30,000*	*$104,500*	*$1,900*	*$136,400*
10-year Net Present Value[b]		*$277,400*	*$965,300*	*$17,700*	*$1,260,400*

[a]Based on construction schedule.
[b]Assumes 4 percent discount factor.

TABLE 8-4
Underlying Assumptions for the Inspection and Maintenance Cost Estimates

	Maintenance Assumptions for Wet Pond BMPs	Frequency (Years between Maintenance Events)	Staff Cost/ 8-Hour Day	Hours / Event	Materials and Incidentals	% Facilities Maintained per Year Budgeted for Maintenance	% of Facilities Requiring Maintenance Based on Assumed Frequency	Estimated Cost per Facility per Maintenance Event	Estimated Annual Cost per Maintained Facility
Routine / Preventive									
✓	Debris Removal[a]	0.5	$640	4	$50	100	200	$370	$740
✓	Vegetation Management[a]	0.5	$640	4	$50	100	200	$370	$740
✓	Minor Maintenance[a]	1.0	$640	4	$50	100	100	$370	$370
x	Aeration Maintenance[a]	—	$640	—	—	0	0	—	—
✓	Reporting (Inspection / Maintenance)	3.0	$160	3	—	100	33	$60	$20
✓	Information Management	3.0	$160	1	—	100	33	$20	$6
✓	Inspection	3.0	$640	4	—	100	33	$150	$50
Long-Term / Corrective (Estimate Provided Elsewhere)									
✓	Woody Vegetation Removal[b]	3.0	$1,280	16	$100	10	33	$2,660	$886
✓	Sediment Removal[b]	15.0	$1,280	24	$50,000	100	7	$53,840	$3,589
✓	Mechanical Components[b]	5.0	$1,280	8	$250	100	20	$1,530	$306
✓	Structural Repairs[b]	20.0	$1,280	16	$3,000	100	5	$5,560	$278
✓	Dewatering[b]	15.0	$1,280	16	—	100	7	$2,560	$170
✓	Erosion Repairs[b]	5.0	$1,280	8	$300	100	20	$1,580	$316
✓	Fence Repairs[b]	10.0	$1,280	8	$250	100	10	$1,530	$153
✓	Dam Embankment and Slope Repairs[b]	3.0	$1,280	16	$1,000	100	33	$3,560	$1,186
✓	Animal Burrow Removal[b]	1.0	$1,280	8	$250	10	100	$1,530	$1,530
✓	Access[b]	10.0	$1,280	8	$1,000	100	10	$2,280	$228
✓	Information Management	3.0	$160	4	$100	100	33	$180	$60

✓ Assumes maintenance
x Assumes no maintenance

[a]Assumes 2-person crew
[b]Assumes 3-person crew

The methodology used to develop the maintenance cost estimates is based on the number and types of BMP facilities, the identified maintenance actions (e.g., debris removal, sediment removal, etc.) for each type of BMP facilities, the identified staff costs and expenses, frequency of maintenance, and desired level of service. As such, it is not the intent of the model to provide a single number for overall maintenance. Instead, the model separates costs into routine (preventive) maintenance and nonroutine (long-term) maintenance. Actual costs will vary depending upon the level of maintenance activity provided.

8.2.3.1 Maintenance Program Benefits

A regular and systematic stormwater BMP maintenance program provides various benefits to water quality, environmental compliance, and the general public.

- A regular maintenance program is needed in order for BMPs to continue providing the water quality benefits intended. Because BMPs trap pollutants over time, those pollutants, such as sediment, must be removed to restore the BMP to its intended function and to continue to provide water quality benefits.
- A systematic maintenance program provides water quality benefits and clear communication to regulators on pollution prevention steps the City undertakes. The actions attributed to the maintenance program can be documented as specific activities Sioux Falls conducts to prevent stormwater pollution.
- Regular BMP maintenance also benefits the general public through improved aesthetics and mosquito control. For example, regular maintenance functions (i.e., debris removal, litter removal, vegetation control) provide water levels at depths conducive to mosquito predator habitat, minimizes mosquito habitat, and consequently reduces mosquito populations. Insufficient maintenance causes sediment to build up over time and can result in shallow stagnant water and prime mosquito breeding conditions. In addition, removing litter that can create stagnant pools of water also reduces mosquito breeding conditions. Implementing a regular maintenance program will help control mosquito habitat. Coupling regular maintenance with other mosquito initiatives, such as the Health Department's education and control program, can function to reduce mosquito related risks, such as the West Nile virus.

  The city already has an active mosquito abatement program that includes monitoring of mosquito populations and the targeted application of growth inhibitors and/or larvicides. The Health Department is the sole city department with the authority and training to control mosquitoes and other pests. The department has the equipment and trained personnel required for the application of a variety of mosquito control substances in accordance with applicable federal and state law. The department discourages the application of synthetic pesticides unless absolutely necessary as these pesticides generally also kill mosquito predators that help control mosquito larvae.

8.2.4 Other City Program Costs

In addition to the capital and O&M costs of the BMP Master Plan, the City has several other programs that may benefit from a dedicated stormwater funding source. The City should consider whether these programs should be included in the funding solutions being developed for the Master Plan. The programs include:

- **NPDES Stormwater Permit.** On November 1, 1999, the City received a permit to operate the municipal separate storm sewer system (MS4) from the South Dakota DENR. The implementation of the permit requirements includes monitoring stormwater discharges, public education, illicit discharge detection, annual report preparation, and implementing stormwater pollution prevention plans at City-owned maintenance and materials management facilities to control pollutants at the source.
- **Existing Public Works and Parks and Recreation programs.** The City maintains drainage ditches, detention ponds, storm sewers, and other stormwater infrastructure primarily through the departments of Public Works and Parks and Recreation.

8.3 Funding Mechanisms and Recommendations

The scope of the study did not include evaluation of funding mechanisms. However, in CH2M HILL's experience, successful implementation cannot be discussed without some consideration of funding mechanisms, roles and responsibilities of key parties, and implementation steps. Consequently, a brief discussion is included to provide a framework for more detailed evaluation of funding mechanisms as the City deems necessary.

8.3.1 Funding Mechanisms Considered

Many funding mechanisms are available to fund different aspects of a stormwater program. Generally these fall into the four categories that offer the best potential to raise the required revenues (Table 8-5). Each option is explained briefly below.

TABLE 8-5
Funding Mechanisms Evaluated for Sioux Falls Regional Stormwater BMP Master Plan

Funding Mechanism	Legislation	Revenue Base
Pro Rata Share	SD Code: 46A-10B Drainage Basin Utility Districts Section 46A-10B-21—Payment of Development Fee as Condition for Development	Developer
Stormwater Utility	SD Code: 46A-10B Drainage Basin Utility Districts Section 46A-10B-22—Imposition of Stormwater Utility Fee	Residents and Property Owners
General Funds		City Tax Base
Grants and Loans		Temporary State and Federal

8.3.1.1 Pro Rata Share (Regional BMP Construction Only)

Brief Description and Most Likely Applicability. A pro rata share program is similar to the Drainage System Cost Recovery (DSCR) Program that the City already has in place and is restructuring. The state enabling legislation refers to this type of charge as a stormwater basin development fee (Section 46A-10B-21).The typical method for implementing a pro rata share program is to develop an ordinance that requires developers to pay the fee as part of their storm drainage and water quality compliance. The fee is based on the pro rata share of the total estimated cost of providing reasonable and necessary BMP facilities. The mechanism for assessing the fees can depend on the ordinance but should assess the developer based on the increased volume of stormwater runoff to be caused by the proposed development.

Potential for Revenues. Moderate to high.

Options. Three options are available within the pro rata share funding strategy. The fee can be assessed based upon several units of measurement. The most appropriate options for the City of Sioux Falls are impervious area, developed acres, developed acres by land use, and equivalent residential units (ERUs):

- **Impervious Area.** This option assesses the developer based on the area of impervious surface that will be created. Because there is a direct relationship between the amount of impervious surface and the contribution to stormwater flows, this option allows the City to assess a greater fee on those creating greater stormwater flows. The impervious surface area often can be determined fairly easily. Consequently, this option usually is relatively easy to implement.

- **Developed Acres.** This option assesses the developer based on the area of land to be developed. Each developer will pay a set fee per acre of developed land, regardless of land use. Although this is the most straightforward approach to the pro rata share option, it does not hold the developer responsible for the amount of stormwater generated on the developed property. Therefore, the fee is not as strongly tied to the equity principle, which assesses charges to properties in relation to cost causation.

- **Developed Acres by Land Use.** This option is similar to the developed acres by land use option, but each developer will pay a set fee per acre of developed land where the fee varies by land use type. The City's DSCR basically is based on this approach: a formula that computes runoff based on runoff coefficient and land use, resulting in a cost per acre for various land uses. This approach is somewhat better than basing a pro rata fee on developed acres alone, because the fee is more directly tied to runoff potential. However, by not differentiating between different densities and patterns of development, the approach still is not as strongly tied to the equity principle that assesses charges to properties in relation to cost causation.

- **Equivalent Residential Units.** This option assesses the developer based on the number of ERUs. An ERU is defined as the impervious area for a typical single residential property within the service area. The value of the ERU would be determined based on an assessment of the City land uses. Residential developers would be assessed based on the number of lots. Commercial/industrial developers would be assessed by applying the ERU to determine the number of residential units equivalent to the commercial property based on the amount of impervious surface. This option allows the City to assess a greater fee on those contributing the largest volumes to the stormwater flows. However, it is more difficult to implement than the impervious area option.

CH2M HILL recommends the impervious area method for consideration within the range of options for collecting pro rata share contributions. The impervious area method is strongly tied to the contribution that various types of development make toward watershed problems and has some advantages over the ERU method with respect to implementation.

In principle, different fees can be set by watershed, based on the cost of regional BMPs that serve the watershed. The enabling legislation implies that the program "shall separately assess each basin within the district for facilities installed to serve each basin" (Section 46A-10B-16). However, this would create incentives and disincentives to growth in different areas of the City that may not support the City's 2015 Growth Plan and coordination with other utilities and transportation facilities. Therefore, CH2M HILL recommends that the City consider a single fee per impervious acre, based on the total citywide cost of regional BMPs and other drainage capital improvement needs. A system of credits could be included to reduce or exempt the charges for properties served by onsite or site-specific BMPs in addition to the system of regional BMPs.

Advantages and Disadvantages.

- **Primary advantages.** This funding source would encourage developers to use regional facilities and consider stormwater issues when planning projects. Construction would be financed up front by the developer.
- **Primary disadvantages.** The method could not be used to fund ongoing O&M or administrative expenses. There would be some uncertainty on the timing of program expenditures. For some of the larger, more expensive regional BMPs that span multiple development projects, it may be difficult to coordinate the cash flow requirements necessary to implement the projects. This may pose an administrative burden on the City's staff, and there may be a need to provide seed money from another source to allow projects to be designed and built when needed.

Statutory References. South Dakota Statutes, Title 46A (Water Management), Chapter 10B Drainage Basin Utility Districts:

- Section 2—Counties or municipalities authorized to establish drainage basin utility districts
- Section 16—Assessment of basins—Governing body to designate installation of facilities and assessment methods
- Section 21—Payment of development fee as condition for development

8.3.1.2 Stormwater Utility (Capital and O&M Costs)

Brief Description and Most Likely Applicability. With stormwater utilities, property owners are charged a fee based on the amount of stormwater originating from their properties, typically based on some measure of the impervious area in each property. The City could adjust the existing stormwater utility fee. Several methods are available to modify the fee structure, ranging from flat fees to a formula tied more specifically to a property's contributions to stormwater problems, such as impervious area.

Potential for Revenues. Moderate to high, depending on how the rate is structured.

Options. Stormwater utility can be established on an ERU basis, or based directly on impervious surface. The ERU option assesses residential properties as equivalent, regardless of lot size. Commercial properties are assessed based on the amount of impervious surface.

Advantages and Disadvantages.

- **Primary advantages.** A stormwater utility fee structure represents a new dedicated funding source that is not in competition with other uses. The fee basis could be tied to contribution to stormwater problems (e.g., impervious area estimate). This mechanism provides the basis for an ongoing, stable source of revenue to support the significant expense represented by the capital projects identified within the City (such as the 28 regional BMPs anticipated in the new development area) and other stormwater activities identified within the City. The utility fee could be used to fund capital projects plus O&M and administrative expenses such as NPDES stormwater permit compliance. Creating dedicated funding for stormwater facility maintenance is often viewed as one of the greatest advantages of stormwater utilities, as proactive maintenance is key to preserving the function and value of stormwater BMPs.

- **Primary disadvantages.** Data required to set up a fee structure are significant and depend on the formula selected. There is a time lag to adjust and implement the fee system and to conduct the public information and involvement programs that would be associated with a fee change. There could be at least a moderate cost change to adjust and maintain databases and billing systems required to implement this option.

Adjusting a stormwater utility fee structure would require several data-gathering, policy, and analysis activities on the part of the City.

Statutory References. South Dakota Statutes, Title 46A (Water Management), Chapter 10B Drainage Basin Utility Districts:

- Section 2—Counties or municipalities authorized to establish drainage basin utility districts

- Section 16—Assessment of Basins—Governing body to designate install of facilities and assessment methods

- Section 22—Imposition of stormwater utility fee.

8.3.1.3 General Fund (Seed Money or Administrative Costs)

Brief Description and Most Likely Applicability. General fund monies could be used to fund elements of a City stormwater program. The monies would be funds available from property tax revenues and interest income from prior years' general fund budgets. Stormwater projects could be earmarked as priority projects in the City's Capital Improvements Program.

Potential for Revenues. The funds available from this source could range from low to high. In general, there probably are not significant funds that could be used without increases in property tax rates or other sources of general fund revenues.

Advantages and Disadvantages.

- **Primary advantages.** The mechanism for administering general fund revenues is in place.

- **Primary disadvantages:** General fund balances and especially allocations made to construct BMPs may fluctuate significantly from year to year and may not match the projected needs for the stormwater program. Also, the sources of these funds, such as property tax surpluses, may not relate well to stormwater contributions.

8.3.1.4 Loan and Grant Programs

Brief Description and Most Likely Applicability.

- **State Revolving Funds.** Funding may be available to support some capital projects through the State Revolving Funds programs.
- **Potential for revenues.** Needs further evaluation. Competition with other types of projects and funding allocation criteria could limit the availability of funds significantly.
- **Other grant programs.** Funding may be available through some other state or federal programs to support watershed improvements or programs. No other major programs have been identified that would provide substantial funding for the regional program.
- **Potential for revenues.** Low.
- **Options.** These funding sources would have to be evaluated further after the program has been finalized.

Advantages/Disadvantages.

- **Primary advantages.** The State Revolving Fund provides access to low interest loans. Reduced financing costs also are achieved by eliminating closing and issuance costs. Repayments and interest costs are deferred until project completion. If available, other grant funding would reduce the tax and fee structure required from Sioux Falls residents or property holders.
- **Primary disadvantages.** Competition with other communities and nonwatershed projects (wastewater for existing program, water supply for new program) for State Revolving Funds may be strong. Applicability in South Dakota for watershed programs needs to be verified. Some programs provide only very small loans and grants that may not be worth the administrative cost of associated application and reporting/auditing requirements.

8.3.2 Funding Recommendations

Based on CH2M HILL's experience with different funding mechanisms throughout the U.S., and the advantages and disadvantages of different mechanisms discussed above, two promising primary funding strategies are available for the regional stormwater BMPs and related stormwater activities in the City:

- Strategy 1: The capital cost for constructing the regional BMPs identified for the 2015 planning area would be borne by new development within the watershed. A 2015 planning area stormwater utility would be developed to fund O&M for both regional and existing BMPs within developing areas of the city. This strategy addresses only stormwater issues within the newly developing areas.
- Strategy 2: The capital cost for constructing the regional BMPs identified for the 2015 planning area would be borne by new development within each BMP drainage area. A Citywide Stormwater Utility would be developed to fund O&M for the BMPs

throughout the City as well as enhanced stormwater management programs that would be undertaken by Public Works and other City Divisions.

The selection from among these strategies depends on such factors as:

- Priority given to expanding existing citywide efforts to minimize flooding and reduce pollutants in all surface waters of the city by generating a dedicated funding source for the enhancement of existing stormwater management programs
- Assessment of the reasonableness of the charges to property holders and developers resulting from the various options evaluated
- Consistency of the funding strategies with the City's direction to share the costs associated with BMPs that have been identified within the 2015 planning area to new development within the outer part of the City
- Fairness and reliability of the cost distribution and recovery mechanisms available

Overall, CH2M HILL believes that the City should select Strategy 2 if it chooses to expand its storm drainage and water quality protection efforts citywide. The City should select Strategy 1 if it chooses to limit its protection efforts to the 2015 planning area. Regardless of the funding strategy adopted, it is recommended that maintenance be funded explicitly with a dedicated funding source, so that the long-term function of stormwater facilities is sustained.

A rate study should be considered to determine if the fees and charges associated with either strategy are within the range of charges by other jurisdictions that have implemented comparable programs.

8.3.3 Funding Decision Process and Schedule

Implementation of a successful stormwater master plan will require the support of stakeholders. In addition, successful implementation of a program will require decisions on such issues as level of service to be provided, the timing of program implementation, and the funding mechanism choices outlined in this section. This section identifies some of the key decisions that need to be made, stakeholders to the decision, and some related issues on mechanics of implementing certain of the funding mechanisms. Key stakeholders include:

- Developers and engineers
- Property owners and citizens in Sioux Falls
- Neighborhood associations and other organizations
- Affected City departments (e.g., Public Works; Planning and Building Services; Parks and Recreation; Community Development; Fiscal Management)

As such, the decision process will need to include a combination of briefings of the City Council and the Mayor, public information meetings and hearings, and other opportunities to comment on the plan as it progresses through the implementation process. The decisions that need to be made include:

- Level of service to be provided by the City for the Stormwater Utility
- Selection of a funding strategy evaluated in this section
- Timing for implementation of the selected funding program

Key milestones anticipated include the following:

- Submit Master Plan (regional BMP plan and maintenance program) for review to the Infrastructure Review Advisory Board (IRAB; Summer 2003)
- Public Information Meetings and Hearings (June 2003)
- Session with IRAB (June 2003)
- Approval of the Master Plan (Fall 2003)

In addition to these specific milestones, it is recommended that a strong public information and outreach effort be undertaken to inform stakeholders of these important decisions, as they will have significant implications for the management of stormwater quality and quantity issues for the future.

8.3.4 Mechanics to Implement Funding Mechanisms

More detailed implementation strategies will need to be developed to support either funding strategy. Examples of the implementation mechanics to be addressed include:

- Identify a source for seed money or other means to make timely implementation of BMPs possible on a cash-flow basis.
- Identify specific policies to be used to implement the pro rata share and utility fee options selected as part of the adopted strategy.
- Identify a specific action plan to develop impervious area data required to implement a utility fee structure on a property-by-property basis within the 2015 planning area (Strategy 1) or the City as a whole (Strategy 2).

8.4 Regulatory Considerations

8.4.1 Wetlands Permitting

A Section 404 Permit Application is required to obtain a permit to impact jurisdictional waters of the U.S., including wetlands, by the ACOE and the South Dakota DENR under Sections 404 and 401 of the Clean Water Act. There are three types of Section 404 permits:

- Nationwide General Permits
- Regional General Permits
- Individual Permits

The wetland permitting strategy for the Stormwater BMP Master Plan is to obtain nationwide permits for smaller projects on ephemeral streams and a regional general permit to site larger projects either on or off of perennial streams. A regional general permit can take the place of multiple individual permits for a general category of activities when two conditions are met. First, the activities are similar in nature and cause minimal environmental impact (both individually and cumulatively). Second, the regional permit reduces duplication of regulatory control by state and federal agencies. If a regional general permit is not obtained, then individual permits would have to be obtained.

A discussion of the relative advantages and disadvantages of obtaining various types of Section 404 permits is included in Table 8-6.

TABLE 8-6
Permitting Strategy Matrix

Type of Section 404 Permit	Advantages	Disadvantages
Nationwide Permit	No public review, limited agency review results in quicker review cycle Complete application package requires less work than that required for Individual permit	Applicable only to projects that impact minimal amounts of wetland (less than 0.5 acre) or stream bed (less than 300 feet) Nationwide permit #43 (stormwater control features) cannot be used to establish stormwater control features in perennial streams
Individual Permit	Required for large impacts to wetlands (greater than 0.5 acres) or large impacts to stream beds (greater than 300 linear feet) Required if stormwater control feature is in perennial streams Required if not all of the 21 general conditions of a nationwide permit are met	Application package requires substantially more work than for a nationwide permit Mitigation plans and mitigation monitoring reports are typically required Mitigation ratios vary with the type of existing wetland to be impacted; ratios for impacts to wooded wetlands are higher than for emergent or grassland wetlands ACOE, public, and agency review cycle requires additional time to process permit request
Regional General Permit	Can provide substantially shorter review cycles for projects that would otherwise require Individual permits Can greatly streamline entire Section 404 permit process for large projects, especially when several large projects are proposed within a 5-year period Best overall approach if substantial numbers of Individual permit projects are anticipated to take place within a 5-year timeframe because it streamlines the review process and paperwork requirements	Typically requires substantial up-front work prior to gaining ACOE approval May require mitigation bank to be in-place prior to gaining ACOE approval Permit good for 5 years, then must be reauthorized or renewed

An approach of balancing nationwide and regional general permits would likely be the most cost-effective permitting strategy. The more individual permits that would be required within a 5-year period, the more cost-effective a regional general permit approach would be. If two regional BMPs function in tandem (for example 40-1 and 40-2), then multiple facilities may be able to be permitted together. A detailed discussion of permitting issues including planning horizons and actions during the permitting process is presented in Appendix A.

In accordance with Section 404 (b) (1) of the Clean Water Act, adverse impacts to wetlands have been avoided and minimized throughout the Master Plan process. As described in Section 2, a natural resource inventory was conducted to characterize environmental resources in the study area. This information was used as a planning tool to avoid and minimize BMP impacts to wetlands, threatened and endangered species, and cultural resources.

The potential for wetland impacts was also an important BMP siting criteria. Preliminary BMP designs also considered potential wetland impacts and were modified to avoid wetland impacts. For example, BMP 401-2 was relocated downstream to minimize the wetlands impact.

Unavoidable impacts to wetlands will need to be mitigated. A wetland bank may be a useful tool to address the wetland mitigation needs of the BMP Master Plan as well as other mitigation needs within Sioux Falls.

8.4.2 DENR Dam Permit

The South Dakota DENR requires that a permit be obtained for dam construction when a dam is either over 25 feet high or if it impounds 50 acre-feet or more of water. A detailed discussion of the DENR dam permit requirements is found in Appendix A.

Final design of the dam embankments must consider the dam permit requirements. Depending upon the dam classification, the spillway must be able to safely pass either the 100-year return period storm or 0.5 times the PMF. If there is the potential of loss of life with a dam failure, then the 0.5 PMF design criteria must be met. If there is not a potential of loss of life, then the 100-year return period criteria must be met. Final determination of dam classification and design criteria must be made through the DENR's process outlined in South Dakota Chapter 74:02:08.

It may be to the City's advantage and to the benefit of the public to implement a floodplain management ordinance which would restrict development from encroachment into the floodplains and waterways of Sioux Falls. Additional discussion on ordinance development is included in the Implementation Strategy Step 3 discussion below.

Table 8-7 summarizes potential permitting approaches and needs for each BMP site. The analysis was made using the following assumptions. If more than 0.5 acre of wetland or more than 300 feet of stream were affected, a regional general permit is assumed. For BMPs that function in series and as a result can be permitted together, it may be advantageous to permit them together through either an individual permit or through a regional general permitting approach. If the required storage is greater than 50 acre-feet, then a dam permit was assumed. It is important to note that the dam permit is required for impoundments that have more than 50 acre-feet or storage at or below the dam elevation, not the primarily spillway elevation. Consequently, impoundments that have less than 50 acre-feet of storage required for flood control can still fall into the dam permit category once freeboard is considered. Consequently, the dam permit requirement should be verified with the final design.

8.4.3 DENR Stormwater Permit Coordination Recommendations

As documented in the City's Commercial/Residential Management Program, the City has previously clarified the DENR's position on implementing regional stormwater quality BMPs in a letter to the DENR on April 6, 2002 and the DENR's response on May 7, 2002. The DENR agreement indicates the City's stormwater quality management step one requirement of minimizing directly connected impervious area will be implemented on a site by site basis while the City's stormwater quality management step two of providing WQCV can be implemented on a regional basis.

TABLE 8-7
Potential Permitting Approaches

BMP Site	Total Potential Wetlands Impact (Ac)	Stream Length Impact (ft)	Type of Wetland Permit Required	100-yr Volume (acre-feet)	DENR Permit Required?
13-1	10.5	1,069	Regional general permit	31	Evaluate
13-2	0.0	156	Nationwide permit	6	No
13-3	0.0	3,494	Regional general permit	86	Yes
11-1	0.0	556	Regional General permit	95	Yes
11-2	0.5	491	Regional General permit	44	Likely
40-1	7.6	10,884	Regional General Permit or grouped Individual	348	Yes
51-2	9.3	4,763	Regional General Permit or grouped Individual	86	Yes
7-4	5.4	938	Regional General permit	151	Yes
51-1	6.7	2,455	Regional General Permit or grouped Individual	48	Evaluate
7-5	4.3	2,034	Regional General permit	140	Yes
25-3	0.7	1,439	Regional General permit	34	Evaluate
303-2	0.2	1,448	Regional General permit	93	Yes
25-1[a]	0.6	668	Regional General permit	86	Yes
25-2	3.0	1,147	Regional General permit	60	Yes
41-A	0.0	3,670	Regional General permit	116	Yes
401-1	3.5	1706	Regional General Permit or grouped Individual	94	Yes
401-2	1.1	1,090	Regional General Permit or grouped Individual	114	Yes
40-2	17.2	7,528	Regional General Permit or grouped Individual	502	Yes
304	0.0	230	Nationwide permit	46	Likely
312	0.0	1,930	Regional general permit	48	Likely
400	0.0	711	Regional general permit	78	Yes
303-4	0.0	992	Regional general permit	52	Yes
22	0.0	1,094	Regional General permit	64	Yes
317	0.6	2,761	Regional General permit	87	Yes
40-3	11.1	1,783	Regional General Permit or grouped Individual	61	Yes
305	0.0	910	Regional general permit	61	Yes
306	0.0	528	Regional general permit	49	Likely
316	0.0	1,027	Regional general permit	112	Yes

[a]Permitting for BMP 25-1 may involve additional permitting by combining two drainageways into one BMP site upstream of Madison Street. The drainageways downstream of Madison could be effected.

Note: Wetland areas are based on currently available NWI and hydric soils data and have not been field verified. Stream potential impact is based upon flow-line information developed during basin delineation and is not an indication of stream type (intermittent, perennial, etc.). The analytical results should be treated as preliminary because wetland locations have not been field verified for this Master Plan, and pond designs are either preliminary or conceptual.

Implementation of some regional facilities or individual developments may require clarification or dialogue with the regulators to confirm DENR's interpretation of stormwater pollution prevention. Such interaction may be necessary to interpret the level at which the stormwater quality management step one needs to be implemented or if development in the watershed occurs differently from what was anticipated subsequent to constructing a regional BMP facility. In determining the required WQCV, the Master Plan has been conservative and assumed that traditional development practice (Level 0) for minimizing directly connected impervious area is implemented within the City. Consequently, while DENR approval of the Master Plan is not required, it is recommended that the City keep the DENR informed about the implementation plan.

8.5 Managing Risk and Change

Adapting the master plan strategy as changes occur will be an important ingredient as implementation proceeds. Change may occur from a variety of sources, most of which will be outside the City's control. In an effort to provide Sioux Falls with flexibility as the master plan is implemented, this section identifies some of the potential changes the City may face and some management option tools which may be useful in addressing change. The City will need to adapt plans accordingly as issues surface during master plan implementation.

8.5.1 Potential Changes

As the City proceeds with implementation, some of the following scenarios could develop.

8.5.1.1 Property Acquisition

In trying to acquire properties for the regional BMP program, the City may face property owners who are uncooperative in their willingness to sell their property. In this situation, the City may be delayed or prevented from acquiring the property. Consequences that could result include a delay in being able to implement the regional BMP facility or an inability to implement the regional BMP facility. This would in turn influence how development would be implemented within the watershed.

8.5.1.2 Permit Approval

As the City pursues wetland permits to implement the regional BMPs, permitting considerations could influence the process. Approval of the permit hinges on minimizing and avoiding wetlands impacts, threatened and endangered species, cultural resources, and streams. A delay or inability in obtaining the permit would result in a corresponding delay or inability to construct the regional facility which would in turn influence how development would be implemented within the watershed.

8.5.1.3 Funding Constraints

As the City determines funding mechanisms for the Master Plan and other important public services, hard choices may have to be made in funding priorities. The ability to fund the Master Plan program at the level required to implement all program components may not be fully possible. In such a situation, the City may only be able to implement regional BMP facilities in select watersheds.

8.5.2 Management Options

Several management options can be useful to the City as changes occur during Master Plan implementation.

8.5.2.1 Change Regional BMP Location

If a specific BMP location cannot be implemented, the City can consider an alternative location. Depending upon the situation, the City may be able to move the BMP location just slightly upstream or downstream to a site that can be implemented. Moving the site would require some additional analysis to determine the appropriate volumes, flow rates, and impacts of a new location. During the master plan process, additional BMP sites were considered. The hydrologic models were developed in such a manner that they can be easily adjusted to simulate regional BMP facilities at alternate sites. Consider alternative locations at subbasin confluences as an initial alternative location. Adjustments to areas covered by the regional BMP would have to be determined with an alternative site. If the site moves upstream, less area would be covered by the regional BMP. If the site moves downstream, additional area could be covered by the regional BMP.

8.5.2.2 Change BMP Type

Changing the type of BMP may make the regional BMP more implementable or acceptable to concerned stakeholders, depending upon site conditions. For example, different BMP types require different amounts of permanent pool volumes. A higher permanent pool volume requires additional excavation and additional cost. However, it may be more appropriate to have a wet pond BMP in areas where a baseflow occurs. Another example where changing the type of BMP may be advantageous is during the permitting process. Due to habitat or other natural resource concerns, the permitting agency may favor one type of BMP over another.

8.5.2.3 Reclassify Watershed to Site Specific

If a regional facility cannot be implemented, then individual developments will have to meet the requirements for water quality and flood control contained in Chapter 11. A regional facility may not be possible if a landowner is uncooperative in selling land for a regional BMP, due to funding constraints, or due to permitting obstacles. The City may have to prioritize funding to certain areas within the City. In these circumstances, the City could change the watershed classification to require site specific BMPs.

8.5.2.4 Adjust Design Criteria

The sizing criteria for the regional BMPs is driven primarily by the 100-year storage volume requirement. Water quality requirements should be maintained unless alternative BMPs protective of water quality are documented and approved. Peak flow control requirements should be maintained unless a lower design criteria can be shown not to have an adverse effect. However, other design criteria within Chapter 11 such as road overtopping requirements, trash racks, etc. should be allowed to have some flexibility if design constraints limit the ability of the overarching regional BMP goals from being effectively achieved.

8.5.3 Example Process for Evaluating a New BMP Site

Determining a BMP location follows a siting criteria process but also involves case-by-case considerations. If the City should need to evaluate an alternative location, the following example process may prove helpful.

> Determine why a new location is to be evaluated and develop the evaluation process based upon the site constraint. For example, if a property owner is not willing to sell the property, then consider moving the site so that it no longer includes the property owner's property.

Additional steps to consider include:

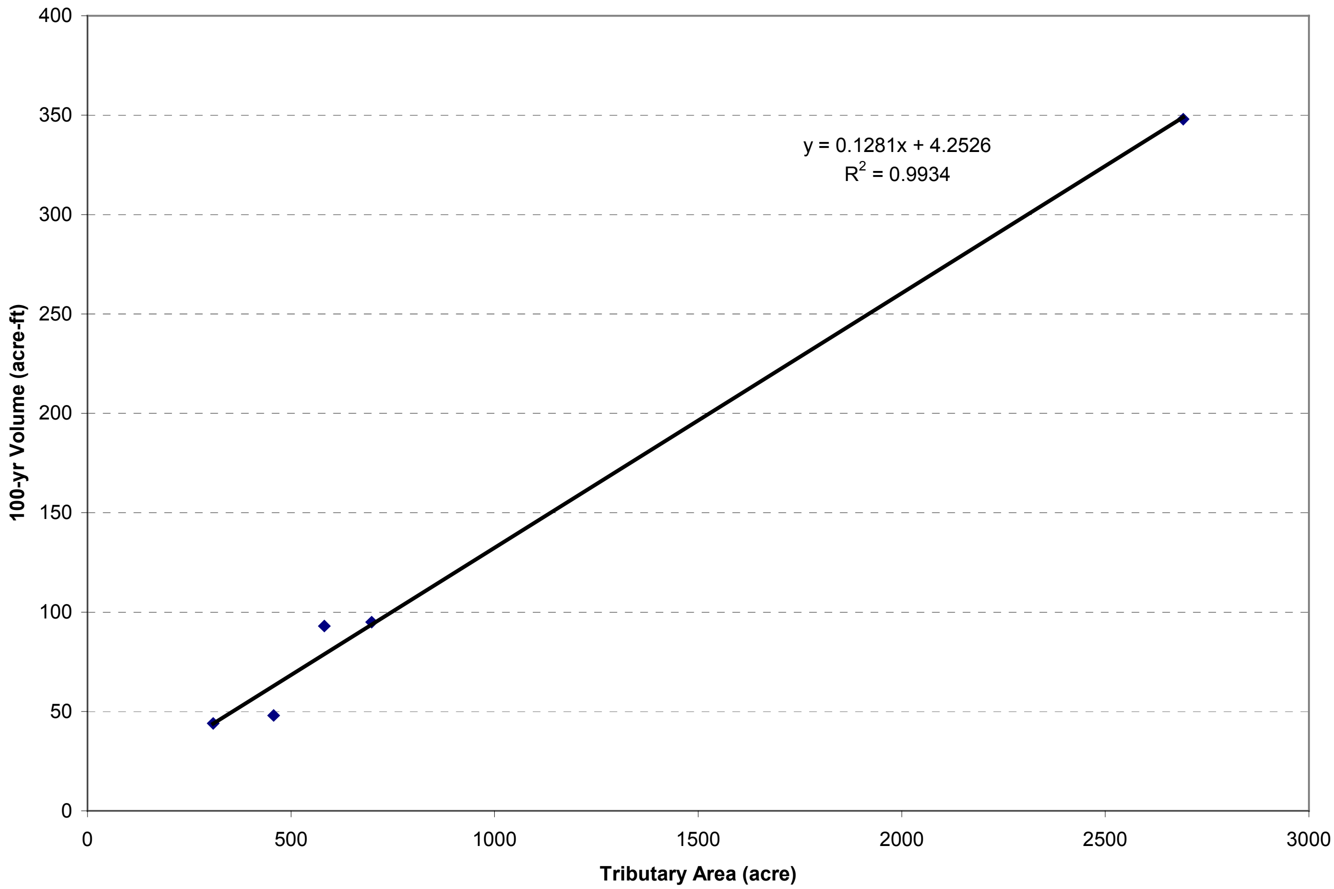
- Evaluate alternative BMP sites previously considered and subbasin boundaries as shown in Appendix I, Figure I-1, for the potential new location. Would one of these locations be able to cover some or all of the facility that needs to be moved?
- Examine the upstream road crossing and downstream road crossing locations. Are these suitable for a BMP site?
- Determine desktop natural resources analysis. What wetlands, habitat, and cultural resources are known to be present at the potential new location? What kind of permitting strategy could be successful for the potential new location?
- If preliminary planning is being conducted, then a rough volume and area estimate of the potential new BMP location can be developed through either scaling the BMP size up or down based upon an increase or decrease in drainage area. The BMP size could also be estimated based upon a statistical analysis of designed or constructed BMPs. If more detailed information is necessary for sizing purposes, then the hydrology model should be updated to reflect the new location, determine predevelopment and postdevelopment flow rates and resulting BMP size.
- GIS analysis of the potential new location can be done to determine tax parcel information, planned land use, and potential conflicts with planned infrastructure. Consider what constraints would be present at the potential new location.

It is recommended that the City use a multidiscipline approach to evaluate potential new locations. If the change in locations is significant enough, a targeted public outreach effort may be appropriate. Involving Public Works, Planning and Building Services, and other interested stakeholders should make decisions on potential new locations more likely to succeed.

8.5.4 Applying Master Plan Findings in Future Planning

Future planning efforts for regional BMPs can take into account the information gleaned from this Master Plan. Planning level estimates of BMP volume, area, and cost can be estimated based upon the findings of the Master Plan. For example, Figure 8-2 can be used to estimate costs based upon expected BMP volume. A similar analysis was conducted to generate the tributary area and pond volume relationship shown in Figure 8-3. These statistical relationships can be used for planning level decision making. Various statistical relationships relating BMP cost, tributary area, pond volume, and pond area are found in Appendix H.

FIGURE 8-3
WQCV Tributary Relationship for Five Preliminary Design Sites



8.6 Schedule Phasing and Implementation Strategy

This section describes the strategy, steps and schedule for the phasing and implementing the Sioux Falls Regional BMP Master Plan.

8.6.1 Phasing and Implementation Strategy

City and CH2M HILL staff developed a phasing and implementation strategy that integrates the environmental resources inventory, watershed models, BMP scenarios, permitting requirements, funding mechanisms, and public involvement activities. The phasing is driven largely by the combination of anticipated development patterns reflected in the 2015 land use and discussions with City staff on priority areas for development. Discussions on the type of activities that need to be included in the strategy were held through out the preparation of the Regional BMP Master Plan. A workshop with City staff was also conducted on June 18, 2003, to discuss the actions to be conducted during implementation.

The proposed strategy is to support community-based efforts to fund the construction of BMPs and the associated programmatic and maintenance activities. Implementation of the Regional BMP Master Plan requires a reliable and equitable funding source. Therefore, the phasing and implementation strategy incorporates the recommended funding strategy

(Strategy 2—Citywide Utility/Pro Rata Share for BMPs) and provides a list of steps that need to take place to implement the master plan successfully.

The implementation of the Regional BMP Master Plan can be considered a utility operation because developed property generates additional runoff that needs to be managed. Runoff management will protect the Big Sioux River and its tributary streams and will allow the City to comply with state and federal regulations. A measurable service (BMPs and programmatic and maintenance activities) is provided. It is recommended that the construction of regional (watershed-level) BMPs be funded with developer-based support through the adoption of a pro-rata share ordinance, or extension of the existing Drainage System Cost Recovery program. It is further recommended that other implementation activities (see phasing and implementation steps below), including O&M of existing and proposed regional BMPs, be supported through the adoption of a stormwater utility.

The phasing and implementation strategy for the Regional BMP Master Plan includes the following key components:

- **Stakeholder Involvement**: To ensure successful implementation, City staff and the CH2M HILL team conducted a proactive stakeholder involvement campaign during the preparation of the Regional BMP Master Plan. The stakeholders included the public, community associations, the IRAB, resource and regulatory agencies (ACOE, South Dakota DENR, South Dakota Game, Fish, and Parks; South Dakota Department of Transportation, the State Historic Preservation Officer, City staff, elected officials, developers, and engineers. Coordination with these and other stakeholders should continue during the implementation of the Regional BMP Master Plan.
- **Phasing and Implementation Steps:** The overall implementation of the Regional BMP Master Plan will be conducted in accordance with the following concurrent steps:
  - Step 1—Procedural Approvals
  - Step 2—Funding Mechanisms
  - Step 3—BMP Design, Construction, and Maintenance
  - Step 4—Program Enhancements

8.6.2 Phasing and Implementation Steps

The implementation activities to be conducted under the four steps are presented below.

8.6.2.1 Step 1—Procedural Approvals

Step 1 consists of activities related to procedural approvals that must be obtained to ensure that the institutional framework of the Master Plan is developed. Several permitting activities also are included to facilitate future construction of BMPs by developers and by the City.

The following activities will be performed under Step 1:

- Prepare and submit 404 and 401 permit applications for initial phase of BMPs (fall 2003).
- Identify policies and procedures that must be created or amended.

- Obtain 404 and 401 Permit (spring 2004). For initial set of BMPs planned for implementation, obtain the ACOE's 404 permit and DENR's 401 certification and minimize the City's wetland mitigation liability.
- Define ordinance update needs (e.g., stormwater, erosion and sedimentation, floodplain management). Ordinances should clearly define the sequence of implementation of regional BMP facilities relative to proposed development in the watershed.
- Develop draft ordinance.
- Conduct public meetings.
- Conduct public hearings (depending upon the type of permit required).
- Adopt ordinances (spring/summer 2004).

8.6.2.2 Step 2—Funding Mechanisms

Step 2 consists of activities related to implementation of funding mechanisms that need to be conducted to ensure that the Master Plan has a reliable and equitable funding source. The following activities will be performed under Step 2:

- Adopt and proceed with implementation of the selected funding strategy (fall 2003).
- Finalize a rate structure for the stormwater utility.
- Finalize pro rata share calculations (DSCR) and implementation policies. It is recommended that the pro rata share be paid at the time the record plat is recorded since the City reviews all plats. Rates should assume that the City will need to implement projects before collecting funds based on complete development in the watershed.
- Identify and evaluate administrative policies. Policies should encourage sequence of pond implementation prior to development.
- Develop and implement a public information plan
- Provide staff training (watershed models, financing mechanisms).
- Revise stormwater utility ordinances (utility and rate structure) and pro rata share ordinance.
- Implement any administrative policy changes.

8.6.2.3 Step 3—BMP Design, Construction, and Maintenance

Step 3 consists of activities related to the design, construction, and maintenance of BMPs that need to be conducted to ensure that the BMPs identified in Section 4 are implemented. These activities include developing incentives to encourage developers and citizens to use source controls (nonstructural and vegetative BMPs, such as riparian buffers), as defined in Section 3, and plan their developments to enhance or complement the functions of the watershed level BMPs.

The following activities will be performed under Step 3:

- Define procedures for conducting design and construction of BMPs. Acceptance and use of the master plan (e.g., models, preliminary design of BMPs, and funding mechanisms) will be enhanced if developers can use the models and tools developed in their development scenarios. The preliminary BMP designs are flexible to adapt to development conditions, while providing clear guidance on design elements to ensure reduction of long-term maintenance needs.
- During land acquisition for regional BMP sites, develop a procedure to increase certainty of land purchase requirements and minimize risk. This can in part by done by developing preliminary designs to more closely determine the extent of land purchase needed and by taking measures, such as a cultural resources Phase 1 survey, to qualify potential permitting constraints. Except for the preliminary design locations, BMP area needs listed in this Master Plan were estimated based upon planning level regression equations. Actual area needs will vary, and a preliminary design level of effort will greatly increase the confidence level of land acquisition needs.
- To minimize costs, designs should include the final design consideration outlined in Section 7.
- Dam safety considerations as outlined under 8.3.5 Permitting Considerations must be taken into account when implementing the BMP dam designs.
- Define wetland mitigation alternatives.
- Incorporate the City's BMPs into the maintenance program and coordinate with retrofit plans. Appendix J is reserved to include the City's retrofit implementation plan as it continues to be developed and implemented.
- Identify the number of private structures not currently maintained by the City.
- Evaluate the condition of the private structures and estimate the cost to upgrade them to acceptable standards.
- Develop process to inspect and accept new BMPs. Establish protocol for accepting such facilities for maintenance by the City.
- Estimate ongoing maintenance costs (once facilities have been upgraded, if necessary).
- Analyze information and develop or adopt a maintenance policy and a standard maintenance agreement.
- Define process to obtain and track easements.
- Identify procedure for giving credits for BMPs constructed as part of development (onsite BMPs).
- Develop policy on BMP modifications and incorporation of BMPs not included in the Master Plan (as discussed in Managing Risk and Change above).
- Develop a policy to approve development projects before the Master Plan is adopted. Work with developers to implement regional (watershed-level) BMPs voluntarily. Request that developers use outfall *controls* (site-specific BMPs) and build temporary

BMPs that can be removed after the regional BMPs are in place. Request the use of *source controls* (nonstructural and vegetative BMPs, such as riparian buffers), as contained in Appendix C of the Master Plan.

- Develop a mechanism for tracking rezoning requests and updating the Master Plan as land use changes deviate from the ultimate land use conditions used in the Master Plan.
- Develop incentives for developers to create open space easements, reduce impervious areas, and use runoff minimization techniques. Potential incentives include reductions in fees tied to reduction in imperviousness, and increased pollutant removal. Wetlands and floodplains should not be included as created open spaces.
- Develop incentives to encourage maintaining the integrity of riparian buffers.
- This stormwater BMP Master Plan focused upon sites for future regional detention facilities. The study did not include a hydraulics analysis of the streams and channels which feed into or flow out from the regional facilities. The channel hydraulics of these channels should be studied to understand how the regional BMPs will influence the hydraulics upstream and downstream of the facilities. Such a study would be similar to a FEMA flood insurance study and would serve the purpose of identifying floodplain areas within the city and providing a basis for areas where development and encroachment should not occur as Sioux Falls continues to develop. A channel hydraulics analysis would identify areas which should be protected by a floodplain ordinance.
- Define mechanisms to discourage and limit development within the floodplain and waterways. It has been observed that encroachment into the floodplain may already be occurring in Sioux Falls. For example, in Basin 40 in the northwest quadrant of the City, development appears to be filling areas which historically functioned as a wide floodplain. This development has the two fold effect of generating additional stormwater runoff and constricting the floodplain, which will result in higher flows downstream and higher flooding elevations in the watershed. Areas downstream are already known to experience flooding problems as evidenced by the current Project Impact in the watershed. A proactive and protective floodplain ordinance can limit additional future flood damages. The ordinance development, buffer protection, and channel hydraulics analysis are all closely tied together.

8.6.2.4 Step 4—Program Enhancements

Step 4 consists of activities related to program enhancements that need to be conducted to ensure that the Master Plan will have staff support and become part of the programs implemented by Public Works. Those activities include several monitoring and program evaluation activities that will provide feedback on the implementation of Master Plan. Several public information and involvement activities are also included that will facilitate stakeholder buy-in and acceptance of the Master Plan.

The following activities will be performed under Step 4:

- Define the level of service to be provided by the City through the stormwater utility. Correlate the level of service with NPDES stormwater permit requirements and BMP maintenance frequencies.

- Train staff to maintain watershed models.
- Develop procedures to conduct ongoing maintenance of land use and watershed GIS layers.
- Continue public information program.
- Develop website to communicate policies and make Master Plan materials available. Schedule meetings with developers to address implementation through status reports, forum for feedback, and interaction to create opportunities.
- Develop plan to track BMP implementation, wetland delineation and mitigation, maintenance activities, and so on.
- Identify monitoring opportunities (streams, reservoir, BMPs) in coordination with other agencies (USGS, DENR). Identify grants and other sources of funding.
- Develop memorandums of understanding with agencies and departments that have functions that will complement the objectives of the Master Plan (e.g., Soil and Water Conservation District, Extension Service, Planning and Building Services, Department of Transportation).

  Include the selected BMP facilities as public facilities in the City's Master Plan. This will facilitate future funding and permitting of the BMPs as public facilities.
- Develop an evaluation and revision process for the Master Plan. This process will integrate the monitoring and public involvement activities and include specific benchmarks to "measure" successful implementation. If the benchmarks are not achieved, the Master Plan needs to be modified as needed. Master Plan evaluations can take place every 3 to 5 years.
- Define staff needs.

Successful implementation of the Regional BMP Master Plan depends on a methodical execution of these steps.

8.6.3 Implementation Schedule

The steps presented in the previous sections represent groups of activities that must be conducted to implement the Regional BMP Master Plan. Because of the complex and developing nature of the Master Plan, implementation of individual steps will occur over different time periods, in parallel rather than linearly.

Figure 8-4 is a schedule for the first 18 months of the implementation of the Regional BMP Master Plan. The schedule must be updated regularly as phasing and implementation steps are completed. Note: the schedule does not show the anticipated phasing of construction of BMPs, rather it shows the administrative planning aspects to develop a solid implementation framework for the regional BMP program. Figure 8-1 is a schedule for BMP construction.

FIGURE 8-4
Proposed Implementation Plan Schedule
Regional Stormwater BMP Master Plan
City of Sioux Falls, South Dakota

	2003												2004																							
	July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
Step 1 - Procedural Approvals																																				
1. Prepare and submit ACOE permit application for initial 5 BMPs					■	■	■	■	■	■	■	■	■	■	■	■																				
2. Identify policies and procedures to be created/amended					■	■	■	■																												
3. Obtain state and federal permits																							■	■	■	■										
4. Define ordinance update needs and design guidelines									■	■																										
5. Develop draft ordinances											■	■	■	■	■	■	■	■	■	■	■	■	■	■												
6. Conduct public meetings/hearings												■	■	■	■	■	■	■	■	■	■	■														
7. Adopt ordinances																									■	■	■	■	■	■	■	■				
Step 2 - Funding Mechanisms																																				
1. Adopt and proceed with funding strategy										■	■	■	■																							
2. Finalize rate structure for stormwater utility (SWU)													■	■	■	■	■	■	■	■	■	■	■	■	■	■										
3. Finalize pro-rata share rates and policies													■	■	■	■	■	■	■	■	■	■	■	■	■	■										
4. Identify and evaluate administrative policies											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
5. Evaluate rates for the existing SWU																			■	■	■	■														
6. Develop and implement a public information plan							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7. Provide staff training																																	■	■	■	
8. Revise SWU and pro-rata share ordinances																																	■	■	■	■
9. Implement any administrative policy changes																																				■
Step 3- BMP Design, Construction, and Maintenance																																				
1. Define procedures for design and construction							■	■	■	■																										
2. Define wetland mitigation alternatives				■	■	■	■	■	■	■	■	■																								
3. Incorporate existing BMPs into the maintenance program					■	■																														
4. Identify BMPs/SW facilities not maintained by the City					■	■																														
5. Evaluate facility/system condition and upgrade costs							■	■	■	■	■	■	■	■																						
6. Develop process to inspect and accept new BMPs											■	■	■	■	■	■																				
7. Refine estimate of maintenance costs															■	■	■	■																		
8. Develop maintenance policy and maintenance agreement																	■	■	■	■	■	■														
9. Define process to obtain and track easements																	■	■	■	■																
10. Identify procedure for development BMP credits							■	■	■	■																										
11. Develop Master Plan BMP modification policy							■	■	■	■	■	■																								
12. Develop policy to approve BMPs before Master Plan adoption							■	■	■	■	■	■																								
13. Develop mechanism to track rezonings/land use changes									■	■	■	■	■	■																						
14. Develop incentives for use of source controls															■	■	■	■																		
15. Develop incentives for maintaining riparian buffer integrity															■	■	■	■																		

FIGURE 8-4
Proposed Implementation Plan Schedule
Regional Stormwater BMP Master Plan
City of Sioux Falls, South Dakota

	2003						2004											
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Step 4 - Program Enhancements																		
1. Define the level of service to be provided								■	■	■								
2. Train staff to maintain watershed models				■														
3. Develop procedures to maintain Master Plan GIS layers					■													
4. Continue public information program (see Step 2, item 6)			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5. Develop web site to communicate Master Plan activities									■	■								
6. Develop procedures to track Master Plan implementation					■	■	■											
7. Identify monitoring opportunities							■											
8. Develop MOUs with related agencies							■	■	■									
9. Incorporate the Regional BMP Master Plan in Comprehensive Plan														■	■	■		
10. Define staff needs									■	■								