Executive Summary

A properly sized and functioning stormwater system is essential to the protection of public, property, and infrastructure of any metropolitan area. This is especially true in the City of New Orleans where the local topography presents a unique challenge for stormwater drainage. Of the three places in the United States at elevations below sea level, the City of New Orleans is the only one with significant population and industry.

The storm water drainage and conveyance system in New Orleans falls under the auspices of three different entities: the City of New Orleans, Department of Public Works (NO DPW), the Sewage &Water Board of New Orleans (S&WB), and the U.S. Army Corps of Engineers (USACE). The NO DPW is responsible for the construction and maintenance of roadside ditches and the underground stormwater structures associated with lines smaller than 36-inches in diameter. It is these City facilities which are the main focus of the Stormwater Management Capital Improvement Plan, and this report, although some S&WB systems were included in the model for connectivity.

Purpose

In order to address stormwater challenges, the City of New Orleans, acting through the Department of Public Works, commissioned the Stormwater Management Capital Improvements Plan (CIP) for the following purposes:

1. Develop an understanding of the existing drainage system level of service (LOS),
2. Identify opportunities to improve the LOS and functionality of the system,
3. Recommend a capital improvements program (CIP) to meet the desired level of service, and
4. Provide database, models, and tools to support implementation of the system improvements.

Study Area Characteristics

The entire City of New Orleans is addressed in the Stormwater Management CIP. The City has incorporated all of the Parish land acreage of which 91% is on the east bank and 9% is on the west bank of the Mississippi River. Historically, development of the City has gradually migrated northward and eastward from the ridges along the Mississippi River into the lower areas toward the Lake. New Orleans is currently almost completely developed.

The city's land uses can be separated into seven categories. A breakdown of each type, including total acreage is listed in ***Table ES-1.***

Table ES-1: Land Use Area Distribution

Land Use Type	Total Acreage	Percent of Total
Residential – Low Density	30,220	24.8 %
Residential – Medium Density	12,804	10.4 %
Residential – High Density	6,058	4.9 %
Commercial	22,055	17.7 %
Industrial	8,421	6.8 %
Parks	2,525	2.0 %
Wetlands	41,107	33.4 %
Total	**123,190**	**100.0%**

System Inventory

The NO DPW system encompasses approximately 1,287 miles of drainage lines that range in size from eight inches to 36 inches. ***Table ES-2*** categorizes the system by pipe diameter. Nearly one third of the system is less than 15 inches in diameter, which is the current minimum pipe size required for new projects involving drainage infrastructure. Over half of the system is less than 18 inches in diameter. In addition to the pipe described in ***Table ES-2***, the NO DPW is also responsible for approximately 117,770 drainage manholes, catch basins, and inlets.

Table ES-2: NO DPW Drainage Pipe

Nominal Diameter (In)	Length (Feet)	Length (Miles)	Percent of Total
8	31,698	6	0.5%
10	1,538,510	291	22.6%
12	673,132	127	9.9%
15	1,373,963	260	20.2%
18	1,114,430	211	16.4%
21	841,223	159	12.4%
24	739,675	140	10.9%
27	223,245	42	3.3%
30	245,716	47	3.6%
Elliptical	20,829	4	0.3%
Total	**6,802,421**	**1,287**	**100.0%**

Model Development and Results

A main component of achieving the goals set for the Stormwater Management CIP was the creation of a hydrologic and hydraulic model to represent the City's stormwater system. The City was split into 15 project areas based on the S&WB's pump station service areas and modeled using the Storm Water Management Model (SWMM) created by the U.S. Environmental Protection Agency.

The desired level of service was chosen to be no more than six inches of flooding above the road for the 10-year, 24-hour storm as determined by CDM Smith to be 8.5 inches. This level was chosen to allow safe passage of vehicles and limit damage of property. After development, the model was calibrated against high water marks in the DPS 01 drainage area for a 12.6 inch storm in May 1995 and against flow monitoring data capturing two 7 inch storms in December of 2009.

The results from the existing condition model runs indicate that most of the city does not currently meet the proposed level of service and that both the NO DPW and S&WB system need to be improved to meet the intended LOS goals. Over the city's modeled system, 42% of nodes showed flooding over six inches during the 10-year design storm, which equated to just under 600 miles of streets experiencing flooding greater than the desired levels (see ***Tables ES-2*** and ***ES-3***). These results assume the drainage system is in a well-maintained condition, with smooth pipes and no obstructions. Actual flooding may be worse than modeled in areas that have damaged pipes, clogged catch basins, and/or significant siltation.

Table ES-2: Summary of Flooded Nodes

Area	Model	Number of Flooded Nodes*			
		2-Yr Event	5-Yr Event	10-Yr Event	100-Yr Event
East Bank	DPS 01	685	1,262	1,769	2,651
	DPS 02	124	231	336	697
	DPS 03	246	478	566	967
	DPS 04	299	708	868	1,687
	DPS 06	114	311	480	948
	DPS 07	350	596	735	1,108
	DPS 12	90	194	275	520
	DPS 17	17	39	64	144
	DPS 19	199	361	485	732
NO East	DPS 05	96	264	719	698
	DPS 10	137	287	340	599
	DPS 14	26	48	63	191
	DPS 16	100	230	288	568
	DPS 18	33	60	68	121
West Bank	DPS 13	361	710	992	1,922
	Total	**2,877**	**5,779**	**8,048**	**13,553**

* A node is considered flooded if the peak stage in the model simulation exceeds the rim elevation by 0.5 ft.

Table ES-3: Summary of Flooded Streets

Area	Model	Miles of Flooded Streets*			
		2-Yr Event	5-Yr Event	10-Yr Event	100-Yr Event
East Bank	DPS 01	55.8	100.8	146.5	247.3
	DPS 02	11.3	21.0	32.2	70.3
	DPS 03	9.2	24.2	30.8	51.4
	DPS 04	22.9	52.0	63.5	115.9
	DPS 06	8.9	22.4	34.9	83.2
	DPS 07	62.7	78.8	86.3	101.8
	DPS 12	15.3	23.4	26.8	35.2
	DPS 17	1.2	2.7	4.5	10.0
	DPS 19	18.3	27.3	34.9	140.6
NO East	DPS 05	18.7	35.9	46.6	60.8
	DPS 10	3.8	9.3	15.0	27.3
	DPS 14	2.3	7.7	9.0	25.0
	DPS 16	0.8	0.8	0.8	3.0
	DPS 18	1.7	3.2	4.9	3.9
West Bank	DPS 13	22.7	45.6	61.3	96.4
	Total	**256**	**455**	**598**	**1,072**

* A street is considered flooded if the peak stage in the model simulation exceeds the street elevation by at least 0.5 ft over 50 linear feet of street.

The streets with predicted peak stages in excess of the LOS are identified in a GIS Shapefile so that mapping and public communication can be performed.

Required upgrades were determined to bring the system up to the desired LOS. These upgrades consisted primarily of pipe size increases and additional pipe networks. ***Table ES-4*** contains a listing of major improvements per service area. Construction costs for all upgrades and including an additional 15% for professional services and 25% for contingencies was estimated at $3.1 billion for the NO DPW system and $1.7 billion for the S&WB system. These figures should be considered a baseline against which other stormwater management alternatives can be measured. Additional storage or low impact development such as reducing impervious areas or adding biofiltration areas can be compared to the cost and efficiency of the outlined pipe size upgrades.

Table ES-4: Capital Improvements Summary

Service Area	Summary of Significant Improvements and Findings	Cost of Improvements*	
		NO DPW	S&WB
DPS 01	• Significant size increases were needed in the Marlyville-Fontainbleau and Gert Town neighborhoods. • Broadmoor neighborhood has the worst flooding under existing conditions • A total of 17 new pipes were suggested to be added.	$445,698,000	$177,708,000
DPS 02	• Significant size increases were needed in the Tulane-Gravier neighborhood • A total of 5 new pipes were suggested to be added.	$166,060,000	$60,370,000
DPS 03	• Nearly all of the NO DPW system in this service area needs to be upgraded to meet the proposed LOS. • Significant size increases were needed in the Bayou Saint John neighborhood. • A total of 38 new pipes were suggested to be added.	$261,483,000	$133,525,000
DPS 04	• Significant size increases were needed in the Fillmore, Milneburg and Desire Area neighborhoods. • The Milneburg area has some of the worst predicted flooding i. • A total of 48 new pipes were suggested to be added.	$454,459,000	$184,930,000
DPS 05	• Significant size increases were needed in the Lower Ninth Ward and Holy Cross neighborhoods. • A total of 9 new pipes were suggested to be added.	$158,453,000	$61,748,000
DPS 06	• Significant size increases were needed in the Audubon and Leonidas neighborhood. • A total of 34 new pipes were suggested to be added. • In a few areas the LOS could not be met due to boundary conditions/issues.	$239,738,000	$86,552,000
DPS 07	• Significant size increases were needed in the Mid-City and Lakeview neighborhoods. • A number of new pipes were suggested to be added. • In a few areas the LOS could not be met due to boundary conditions/issues.	$250,490,000	$137,585,000
DPS 10	• Model simulations indicate that about three quarters of the pipe networks require upgrades to meet the proposed LOS. This is less than most other service areas. • Significant size increases were needed in the Read Boulevard East neighborhood and along Crowder Boulevard between Lake Forest Boulevard and the Dwyer Canal. • A total of 16 new pipes were suggested to be added.	$161,369,000	$69,958,000
DPS 12	• Compared to neighboring service areas there are relatively few major improvements needed. • Some significant size increases were needed in the Lake Vista neighborhood and West End between 32nd and 38th Streets.	$83,339,000	$53,158,000
DPS 13	• Significant size increases were needed in the McDonogh, Whitney and Old Aurora neighborhoods. • Two existing pipes were removed to disconnect two neighborhoods and upgrade the system separately. • A total of 31 new pipes were suggested to be added.	$489,959,000	$279,379,000
DPS 14	• Model simulations indicate that less than 40% of the pipe networks require upgrades to meet the proposed LOS. Making this the service area one of the best performing systems. • Significant size increases were needed in the Read Boulevard East neighborhood. • A total of 11 new pipes were suggested to be added.	$92,772,000	$96,069,000
DPS 16	• Significant size increases were needed along Crowder Boulevard, Chantilly Drive, Pines Boulevard and Townsend Place. • A total of 8 new pipes were suggested to be added.	$193,429,000	$111,197,000
DPS 17	• Significant size increases were needed along Elysian Fields Avenue, Pleasure Street and Arts Street. • Only one new pipe was suggested to be added.	$21,892,000	$20,799,000
DPS 18	• Significant size increases were needed along Michoud Boulevard, Chateau Court, Alsace Street, Nemours Street, Lemans Street and Biscay Street.	$66,772,000	$53,606,000
DPS 19	• Significant size increases were needed along France Avenue, Montegut Drive and Alvar Street. • A total of 13 new pipes were suggested to be added.	$51,437,000	$117,526,000

*Costs include Road Rehabilitation, Pipe Rehabilitation, Contingency and Fees.

Supporting Material

Beyond the model development and results, additional supporting material was developed including a management and maintenance program, design standards & guidelines, proposed stormwater ordinances, and a potential stormwater utility rate structures.

Management and Maintenance Program

A management and maintenance program is laid out for both the physical stormwater system as well as all of the data collected and generated during the development of the Stormwater Management CIP. Data management and system maintenance work together with one another to improve the function of the stormwater system. Effective data acquisition and management help determine the best maintenance practices and regular maintenance adds more system data which allows for a better determination of needed system improvements. Costs and goals developed include:

- Hardware and software investment to build a strengthened data management infrastructure was phased over four years with a program total cost of $273,500 for infrastructure and $495,000 for contractor support.

- Yearly maintenance goals include cleaning and visually inspecting at least 8% of the stormwater drainage lines and catch basins each year and 100% every 10 years as well as visually inspecting 15% of open ditches each year and 100% every 5 years. This equates to a typical yearly cost of $7.8 million for stormwater system maintenance including line cleaning, catch basin cleaning, CCTV inspection, and visual inspections.

Design Standards & Guidelines

Plan Review Process Recommendations

Suggestions for improving the plan review process were developed and fall into the four categories of internal process standardization, improved communication, process advancements, and fee adoption.

Internal Process Standardization

The NO DPW plan review process could be improved through internal standardization. Currently, process organization relies heavily on a single staff member, which poses a risk if that staff member becomes unavailable. Recommendations for internal standardization include:

1. A formal inventory system which tracks projects throughout the review process. This would allow all staff to know the current status of projects under review.
2. Creation of a simple flow diagram and checklist of standard review procedures so that staff unfamiliar with the process can more easily become engaged when needed.
3. Standardized storage, filing, and disposal procedures for retaining and discarding information.

Improved Communication

As a large portion of development within New Orleans comes in the form of redevelopment, which can occur outside of the subdivision regulations review process, it is important that the needs and requirements of NO DPW are understood by other city agencies. For example, the Office of Safety and Permits handles many redevelopment permit requests and should know when NO DPW input may be required. Having a clear set of guidelines developed can help both developers and other agencies understand NO DPWs requirements.

Process Advancements

With the development of the SWMM models for the Stormwater Management CIP, scenario modeling may be incorporated in the planning review process for large or complex developments to better determine potential effects on the drainage infrastructure. Additionally, a stronger focus on incorporating best management practices (BMPs) into the onsite drainage plan should be developed, specifically for large scale residential and commercial developments.

Fee Adoption

Currently there is no fee to cover NO DPW's portion of the planning review process. A fee should be considered to cover copying and basic administration costs at a minimum.

Permit Guideline Recommendations

Currently, variability in submitted drawings and calculations from different developers decreases the efficiency of NO DPW reviews. Improved guidance for submitting drawings and other documents to review agencies may facilitate increased efficiency.

Updated suggested planning standards and design criteria were developed and are included in ***Volume I, Appendix F*** and should be made available to developers in full and in factsheets containing the most relevant material for particular circumstances.

Review Standard Construction Projects

There is an increased focus nationwide on sustainable urban drainage and the BMPs available to achieve better stormwater management both for reducing peak flows and water quantity concerns, as well as for improving water quality. A list of criteria was developed to assist with determining which stormwater BMPs are currently most relevant for use within New Orleans. The criteria included: flood reduction, retrofit opportunities, pollutant removal, maintenance, and cost. The most relevant BMPs based on the criteria are described in ***Table ES-5***.

Table ES-5: Recommended BMPs

Recommended BMPs	Description	Advantages	Limitations
Pervious Pavement	Paving material which allows for the infiltration of water through the surface and into a gravel reservoir below.	• Blends well into the urban environment • Numerous retrofit locations to replace impervious pavement • Eliminates surface level ponding • Improved moisture access for tree root systems	• Not appropriate for high traffic areas • Care must be taken to prevent clogging • Typically only designed to collect direct precipitation not runoff from surrounding areas
Stormwater Planter	Small infiltration basin filled with vegetation.	• Can be used to treat water in space constrained areas • Beautifies City streets and sidewalks	• Only appropriate for small scale drainage areas • Requires landscaping attention to keep plants attractive
Vegetated Swale	Vegetated depressions often running along roadways to convey and infiltrate storm water.	• Can convey a large range of storm flows. • Some current usage within neighborhoods and along neutral grounds.	• Side slope requirements increase needed land area • Are not well highly thought of by the general public
Biofiltration Area	Shallow vegetated basins to collect and infiltrate storm water.	• Able to fit in underutilized areas with a variety of shapes. • Efficient for highly impervious areas such as parking lots. • Can be designed as an aesthetic feature.	• Requires landscaping attention to keep plants attractive.

Regulatory Review

A review of the existing City of New Orleans ordinances revealed that there are only minimal regulations regarding stormwater management within the City of New Orleans. Suggested ordinance language was developed to address the limited regulation of stormwater management within the city and to assist the city to manage stormwater more effectively. Suggested language for four different ordinances was developed.

Stormwater Management Utility Ordinance

Establishes a new agency within the city to provide for effective management and financing of a stormwater management system within the City, provide a mechanism for mitigating the damaging effects of uncontrolled and unplanned stormwater runoff, improve the public health, safety and welfare by providing for the safe and efficient capture and conveyance of stormwater runoff and the correction of stormwater problems, and authorize the establishment and implementation of a master plan for storm drainage including design, coordination, construction, management, operation, maintenance, inspection and enforcement.

Stormwater Permit Ordinance

The purpose of the ordinance is to regulate soil disturbance, filling, excavation, and grading of property and permit stormwater discharges on all construction projects in the City of New Orleans to safeguard life, limb, health, property and public welfare; to avoid pollution of the MS4, drainage infrastructure conveyances, and waterways with nutrients, sediments, clay, sand, dirt, construction debris and other pollutants generated on or caused by surface runoff on or across the permitted area; and to ensure that the intended user of a construction site is consistent with applicable City ordinances.

Stormwater Discharge Ordinance

Establishes regulations which aim to maintain and improve the quality of surface water and ground water within the City of New Orleans Watershed; prevent the discharge of contaminated stormwater runoff from industrial, commercial, residential, and construction sites into the municipal separate storm sewer system(MS4), drainage infrastructure, conveyances, and waterways within the city of New Orleans; promote public awareness of the hazards involved in the improper discharge of hazardous substances, petroleum products, household hazardous waste, industrial waste, sediment, pesticides, herbicides, fertilizers, and other contaminants into the MS4, drainage infrastructure, conveyances, and waterways of the city; encourage recycling of used motor oil and the safe disposal of other hazardous consumer products to prevent, contaminants from entering the conveyances and waterways of the city; facilitate compliance with state and federal water quality standards, limitations, and permits by owners and operators of industrial activities and construction sites within the city; and enable City of New Orleans to comply with the MS4 Permit all state, federal, and local regulations applicable to stormwater discharges

Construction Site Control Ordinances

The purpose of this ordinance is to establish requirements for stormwater discharges from construction activities so that the public health, existing water uses, and aquatic biota are protected. This ordinance establishes methods for controlling the introduction of pollutants into the municipal separate storm sewer system (MS4) in order to comply with requirements of the National Pollutant Discharge Elimination System (NPDES) permit process.

Rate Study

Currently the stormwater management program is funded through the general fund. Many of the other required municipal services also use the same general purpose fund and therefore, the priority of the stormwater management program can vary depending on other demands on the fund. Potential rate structures were developed to evaluate how a new stormwater management utility could raise revenue via fees. Implementing a fee system was recommended since it provided a dedicated source of funding for stormwater programs, equitably relates the amount of payment to the service provided, and allows for incentives to customers to implement stormwater improvements and BMPs.

Potential annual revenues based on the stormwater fee charged and type of parcels billed is shown in ***Tables ES-6 and ES-7***.

Table ES-6: Estimated Stormwater Monthly and Annual Revenue at $0.40

Individual Parcel Area (sq ft)	Total Parcel Area	Stormwater Charge $/100SF/Month	Monthly Revenue	Annual Revenue
< 64,325	927,978,588	$ 0.40	$ 3,712,000	$ 44,544,000
64,325 - 154690	1,055,683,487	$ 0.40	$ 4,223,000	$ 50,676,000
>154,690	945,810,857	$ 0.40	$ 1,892,000	$ 22,704,000
All Parcels	1,983,662,075	$ 0.40	$ 9,827,000	$ 117,924,000

Table ES-7 Estimated Monthly and Annual Stormwater Fee at $0.20

Individual Parcel Area (sq ft)	Total Parcel Area	Stormwater Charge $/100SF/Month	Monthly Revenue	Annual Revenue
< 64,325	927,978,588	$ 0.20	$ 1,856,000	$ 22,272,000
64,325 – 154690	1,055,683,487	$ 0.20	$ 2,111,000	$ 25,332,000
>154,690	945,810,857	$ 0.20	$ 946,000	$ 11,352,000
All Parcels	1,983,662,075	$ 0.20	$ 4,913,000	$ 58,956,000

Report Structure

The full report is organized into four volumes. ***Volume I*** describes the project process including background, model development, design methodology, a brief summary of results and the supporting material described above. ***Volume II*** gives the detailed model results separated by drainage area for both the existing system assessment and the required capacity upgrades to meet the desired level of service. ***Volume III*** is a map book of the existing system and ***Volume IV*** is a map book of the proposed system with all the capacity upgrades.

Table of Contents

Appendices

Section 1
Background

1.1 Introduction

The City of New Orleans is unique in its history, and this is reflected in its levee and drainage systems. Of the three places in the United States at elevations below sea level, the City of New Orleans is the only one with significant population and industry. The City is often referred to as "a bowl of water surrounded by water;" an indication of the City's continuous struggle with the differing water management challenges including the more recent problems of subsidence and sea level rise.

1.1.1 Purpose

To address some of these challenges, the City of New Orleans commissioned CDM Smith Inc. (CDM Smith) to develop a Stormwater Management Capital Improvements Plan (CIP). The purposes of this plan are to:

1. Develop an understanding of the existing drainage system level of service (LOS),
2. Identify opportunities to improve the LOS and functionality of the system,
3. Recommend a capital improvements program (CIP) to meet desired LOS, and
4. Provide database, models, and tools to support implementation of the system improvements.

1.1.2 System History

New Orleans was established by the French in 1718 along the high ground created from soil deposited from years of Mississippi riverine flooding. The City was developed to guard the natural portage between the Mississippi River and Bayou St. John/Lake Pontchartrain. Louisiana natives had long used the area as a depot and market for goods carried between the two waterways. The narrow strip of land also aided rapid troop movements, and the river's crescent shape slowed ships approaching from downriver. However, flooding from both water bodies has always been a hazard. Soon after the City was established the first levee was constructed along the East Bank of the Mississippi River.

In the 1830s, an ambitious system of underground drainage canals was proposed. The goal was to drain stormwater via gravity into the "back swamps," located between the City and Lake Pontchartrain. This gravity system was supplemented with canals and mechanical pumps. By 1871, approximately 36 miles of canals had been built in the city for both improved drainage and small vessel movement within town. However, at the end of the 19th century it was still common for water to inundate streets due to rainstorms, sometimes for days.

The city's residential district did not stray much beyond the Mississippi River levee mound until after 1895, when serious attempts to bolster the Lake Pontchartrain "back levee" and establish a meaningful system of drainage were initiated. As the city grew, demand for more land encouraged expansion into lower areas more prone to periodic flooding.

In 1893, the City government formed the Drainage Advisory Board to develop better solutions to the city's drainage problems. Extensive topographical maps were created and some of the nation's top engineers were consulted. In 1899, a bond was floated, and a 2 mill per dollar property tax approved. This tax was used to found and fund the Sewerage & Water Board of New Orleans (S&WB).

Between 1900 and 1920, after the City began development of the comprehensive drainage system, a large portion of the lowland cypress swampland located between Mid-City and Lake Pontchartrain was subdivided. Draining the swamps triggered a real estate boom that witnessed a 700% increase in the City's urban acreage. However, most of this area remained undeveloped until after World War I. Another 1,800 acres was reclaimed from the south shore of Lake Pontchartrain between 1928 and 1931 and the balance of the area was built out after WWII, between 1946 and 1975 (Rogers 2008).

Drainage System Responsibility

In 1992, responsibility of the city's internal drainage system was divided between the City of New Orleans, Department of Public Works (NO DPW) and the S&WB. The storm water drainage and conveyance system in New Orleans falls under the auspices of three different entities, NO DPW, S&WB, and the U.S. Army Corps of Engineers (USACE). The system is divided as follows:

City of New Orleans Department of Public Works (NO DPW)

The City of New Orleans, Department of Public Works is responsible for the construction and maintenance of the roadside ditches and the underground storm sewer and structures associated with lines smaller than 36-inches in diameter. These City facilities are the focus of the Stormwater Management CIP and this report.

Sewerage & Water Board (S&WB)

The Sewerage & Water Board of New Orleans is responsible for the construction, operation, and maintenance of the interior drainage canals, the underground storm sewer and structures associated with lines 36-inches in diameter and larger, as well as operating and maintaining the underpass and major drainage pumping stations.

U.S. Army Corps of Engineers (USACE)

The U.S. Army Corps of Engineers, through the Southeast Louisiana Flood Control Program (SELA) has provided federal funds to be matched with local funds for the design and construction of underground covered canals and several new drainage pumping stations. The Corps of Engineers and the SELA program do not provide any significant funding for the operations and maintenance of the constructed facilities.

1.2 Study Area Characteristics

The entire City of New Orleans is addressed in the Stormwater Management CIP. Orleans Parish has a total area of 223,686 acres (349.5 sq.mi.) of which 127,360 (199 sq.mi.) acres is land and 96,326 (150.5 sq.mi.) acres is water. The City has incorporated all of the Parish land acreage of which 91% is on the east bank and 9% is on the west bank of the Mississippi River. Historically, development of the City has gradually migrated northward and eastward from the ridges along the Mississippi River to the lower areas toward the Lake. New Orleans is currently almost completely developed.

1.2.1 Precipitation

Historic rainfall events may be placed in context by comparing them against frequency statistics. For the Eastern United States, including Louisiana, the National Weather Bureau's 1961 TP-40 atlas is the principal official source of rainfall statistics. TP-40 lists the 10-year, 24-hour storm for New Orleans to be 9.1 inches. However, many of the statistics in TP-40 cannot be considered valid today because of the much larger datasets now available. NetSTORM, a computer program developed by CDM Smith, has been used in many studies to compute updated rainfall statistics based on long-term precipitation datasets (CDM, 2008). ***Table 1-1*** presents depth-duration-frequency statistics for Orleans Parish using US Historical Climatology Network (USHCN) data and the New Orleans Audubon Station. The data was verified as representative of the area and for spatial and temporal trends using USHCN data for 50 stations in Louisiana and Mississippi. This national dataset includes 18 long-term daily precipitation records for Louisiana and 32 for Mississippi, with a median record length of 100 years. The table shows, for example, that the 10-year, 24-hour storm for the area is 8.5 inches.

Table 1-1: Precipitation Depth-Duration-Frequency Estimates for Orleans Parish (Inches)

		Average Recurrence Interval										
		1-Mo	3-Mo	6-Mo	1-Yr	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	500-Yr
Duration	**0.5 Hour**	0.7	1.1	1.4	1.6	2.0	2.3	2.6	3.0	3.4	3.8	5.1
	1 Hour	0.8	1.3	1.7	2.0	2.5	3.0	3.4	4.0	4.6	5.3	7.4
	2 Hour	1.0	1.6	2.0	2.5	3.0	3.6	4.2	5.3	6.5	8.1	14.3
	3 Hour	1.1	1.8	2.3	2.7	3.2	4.0	4.8	6.3	7.9	10.1	19.0
	6 Hour	1.2	2.0	2.6	3.1	3.9	4.9	5.9	7.8	9.7	12.1	21.5
	12 Hour	1.3	2.3	2.9	3.6	4.6	5.9	7.1	9.1	11.1	13.6	22.3
	24 Hour	1.4	2.5	3.3	4.2	5.4	7.1	8.5	10.9	13.3	16.1	25.9

The average annual precipitation in the past 30 years is 62.3 inches. The largest 24-hour rainfall on record in Louisiana is 22 inches from August 28 and 29, 1962, and occurred in southwest Louisiana near Lake Charles. Monthly rainfall amounts of as much as 20 inches have occurred at most gauged locations across Louisiana and 24-hour rainfall amounts of 10 inches are not a rare occurrence (NCDC: NOAA 2006b). ***Table 1-2*** contains values of the monthly mean, median, and highest daily precipitation for the 30-year span from 1971 through 2000, from the NCDC Station at the New Orleans International Airport in Kenner, Louisiana (Coop ID 166660).

Table 1-2: Monthly Precipitation Averages and Extreme, 1971 to 2001 (Inches)
(National Climatic Data Center)

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann
Mean	5.9	5.5	5.2	5.0	4.6	6.8	6.2	6.2	5.6	3.1	5.1	5.1	64.1
Median	4.4	5.1	4.9	3.8	3.7	7.1	5.8	5.5	4.6	2.5	4.1	4.7	60.8
Highest Daily*	4.7	4.9	5.1	6.4	9.9	6.0	4.3	4.8	5.6	4.2	8.5	6.5	
Date*	1998	1983	1973	1983	1995	2001	1996	1975	1998	1985	1975	1990	

* Year listed is for the highest daily rainfall for the respective month

Rain Events

April 1927

Rainfall for this event is approximated to be 14 inches in 24 hours. Streets in the Uptown area were flooded, with the Broadmoor and Mid-City areas inundated with approximately six feet of water. The French Quarter had approximately two feet of flooding (Rogers 2008).

May 1978

A line of rainstorms stalled over New Orleans and dropped ten inches of rain over 12 hours. The storm had a peak intensity of two inches per hour. Flooding from this storm lasted almost 24 hours (Rogers 2008).

April 1988

This flood was associated with squall lines ahead of a slow-moving cold front during early April. Storm totals were over 10 inches at numerous area stations. Most of the rain fell within a 12-hour period, with nearly 9 inches recorded across the area. Storm precipitation totals were over 13 inches in some areas (USACE).

November 1989

A prolonged storm event triggered flash floods throughout the New Orleans area. Rainfall amounts from 8 to 12 inches were recorded during a 9-hour span. Total storm 2-day totals ranged from 12 to over 17 inches in some area locations (USACE).

May 1995

Widespread rainfall with peak three-hour depths ranging from 4 to 12 inches caused most of the city to be temporarily flooded, including portions of Interstate 10. The New Orleans International Airport recorded 9.7 inches in the 3-hour period between 7:00 p.m. and 10:00 p.m. Audubon Park rain gage measured five inches over the same time period, with 12 inches within nine hours, and totals for the 24-hour storm measuring over 20 inches. This storm lasted 40 hours and damaged 44,500 homes and businesses causing 3.1 billion in damages. This was the costliest single non-tropical weather related event to ever affect the United States (NOAA: NCDC 2006 and Rogers 2008).

April 2004

Thunderstorms dumped up to 12 inches of rain during the afternoon and evening hours. Six and one-half inches of rain were recorded at the New Orleans International Airport (NOAA: NCDC 2006).

Hurricanes

Hurricanes strike the Louisiana Coast with a mean frequency of two every three years (Kolb and Saucier 1982). Between 1559 and 2000, 172 hurricanes have struck southern Louisiana (Shallat 2000).

October 1985 - Hurricane Juan

Most of the flooding from this hurricane was associated with storm surge and backwater flooding produced by strong prolonged winds. Backwater and surge flooding was intensified by heavy rainfall in the first 24 hours of the hurricane. The 3-day storm totals range from 5- to 10-inches across the area (USACE).

September 1998 - Tropical Storm Frances

Significant tidal flooding occurred during this event with tides averaging 2- to 4-feet above normal along the southeast Louisiana coastline and in Lakes Pontchartrain and Maurepas. In addition to the storm surge, very heavy rainfall occurred with some areas south of Lake Pontchartrain receiving 15 to 30 inches of rain. This heavy rainfall resulted in widespread flash flooding in the area south of Lake Pontchartrain. Rainfall runoff overwhelmed drainage pumping capacity, producing widespread and deep flooding in the streets of the New Orleans metropolitan area (NOAA: NCDC 2006).

September 2002 - Tropical Storm Isidore

Tropical Storm Isidore had tide levels across Lake Pontchartrain and Lake Maurepas of 4- to 5-feet above normal. Low-lying areas, roadways, and some non-elevated structures in parishes surrounding Lake Pontchartrain and Maurepas were flooded. Rain bands associated with Tropical Storm Isidore produced heavy rainfall in a wide area before and shortly after landfall. Four to eight inches of rainfall occurred within six hours. Drainage systems were overwhelmed by the heavy rain and numerous streets were flooded, automobiles were flooded, and water entered some homes. The storm's total rainfall measured from 10 to 15 inches across southeast Louisiana (NOAA: NCDC 2006).

August 2005 - Hurricane Katrina

Hurricane Katrina was one of the strongest and most destructive hurricanes on record to impact the United States. It is the worst natural disaster in the history of the United States to date resulting in catastrophic damage and numerous casualties in the southeast Louisiana areas and along the Mississippi coast. Damage in southeast Louisiana, especially in the coastal parishes, was catastrophic. Storm total rainfall amounts generally ranged from 7 to 14 inches (NOAA: NCDC 2006).

1.2.2 Topography

The topography of the city ranges from an approximate maximum high of 20 feet above mean sea level (MSL), or NGVD, at the levees along the Mississippi River and an overall 95-percentile elevation of 6.15 feet above MSL to a low of approximately 16 feet below MSL and a 5-percentile value of 7.75 below MSL in the areas of former marshes and swamps that have been drained. The topography of the city creates a bowl and requires that stormwater runoff collected within the system be pumped out, due to land elevations in the city being lower than the surrounding normal water surface elevations. Levees along the Mississippi River and Lake Pontchartrain protect the area and its inhabitants from normal water stages as well as high water stages produced by major storms and hurricanes.

Figure 1-1 shows the topography across New Orleans.

1.2.3 Soils

There are 15 major soil types in the New Orleans area. According to the US Department of Agriculture, Soil Conservation Service's (now the Natural Resources Conservation Service) 1989 Soil Survey, most of Orleans Parish is comprised of soils containing mostly clay mixed with silt, loam, or muck. Twelve out of the 15 soils in New Orleans have a poor infiltration classification. These soils are considered "functionally impervious." Soils may be functionally impervious due to either high clay content, high compaction from past construction activities, and/or a high groundwater table. All three of these conditions exist in the city. By prohibiting the percolation of rainfall runoff into the subsoil, functionally impervious soils may prevent significant volume reductions with infiltration BMPs. ***Table 1-3*** lists the New Orleans area soils' pertinent characteristics.

The combination of clay and silt, loam, or muck can also create soils with high shrink-swell potential as well as high subsidence rates. Subsidence, or sinking, of the New Orleans area has been studied extensively. Scientists have proposed several causes for subsidence in New Orleans. These causes include both natural as well as manmade sources: natural settlement of coastal sediments, shifting of the Michoud fault, and land development practices (draining wetlands, diverting and containing Mississippi River, and ground water pumping) (NASA 2006).

Table 1-3: New Orleans Soil Characteristics

Soil	Percent of Land Area	USDA Class	Shrink Swell Potential	Subsidence Potential	Notes
Allemands muck, drained (Ae)	4.6	D	High to very high	High	Mucky clay
Aquents, dredged (An)	5.8	D	No Data		
Aquents, dredged, frequently flooded (AT)	6.3	D	No Data		
Clovelly muck (CE)	20.5	D	Low	High	Silty Clay (N.O. East)
Cancienne silt loam (Cm)	3.5	C	Low to Moderate	Negligible	Silty Loam
Cancienne silty clay loam (Co)	1.8	C	Low to Moderate	Negligible	Silty Clay Loam
Cancienne, frequently flooded (CS)	0.7	C	Extremely Variable	Negligible	Silty Clay
Schriever, frequently flooded (CS)	0.7	D	Extremely Variable	Negligible	Silty Clay
Gentilly muck (GE)	3.5	D	Very High	Moderate	Silty Clay
Harahan clay (Ha)	10.5	D	Very High	Low	Clay
Kenner muck, drained (Ke)	3.5	D	High	Very High	Mucky Clay
Lafitte muck (LF)	15.1	D	Low	Very High	Muck
Schriever silty clay loam (Sh)	0.9	D	Extremely Variable	Negligible	Silty Clay
Schriever clay (Sk)	17.5	D	High to Very High	Negligible	Clay
Urbanland (Ub)	1.8		No Data		French Quarter/CBD
Westwego clay (Ww)	3.9	D	High	Moderate	Mucky Clay

In a paper published in the journal *Nature,* a multi-national team of scientists determined the subsidence velocity for the New Orleans area for the three-year period prior to Hurricane Katrina. The research discovered that the New Orleans area subsided at approximately 8 millimeters per year relative to mean sea level (Dixon, et al. 2006). A recent study found the maximum subsidence in the area over the past 100 years to be between 8 and 10 feet (URS 2006).

Figure 1-2 shows the location of the soil types across New Orleans. ***Figure 1-3*** shows the soil shrink swell potential across New Orleans. ***Figure 1-4*** shows the soil subsidence potential across New Orleans.

1.2.4 Land Use

For the purposes of planning, the City of New Orleans is divided into thirteen districts. The boundaries of the planning districts are shown in ***Figure 1-5***. Within these planning districts, the city is further separated into 72 neighborhoods. ***Figure 1-6*** shows the official neighborhoods within the City of New Orleans.

The city's land uses can be separated into seven categories. A breakdown of each type, including total acreage is listed in ***Table 1-4. Figure 1-7*** shows the distribution land use types.

Table 1-4: Land Use Area Distribution

Land Use Type	Total Acreage	Percent of Total
Residential – Low Density	30,220	24.8 %
Residential – Medium Density	12,804	10.4 %
Residential – High Density	6,058	4.9 %
Commercial	22,055	17.7 %
Industrial	8,421	6.8 %
Parks	2,525	2.0 %
Wetlands	41,107	33.4 %
Total	123,190	100.0%

1.3 System Inventory

1.3.1 Pipe and Structures

The NO DPW system encompasses approximately 1,287 miles of drainage lines that range in size from eight inches to less than 36 inches. ***Table 1-5*** categorizes the system by pipe diameter. Nearly one third of the system is less than 15 inches in diameter, and over half the system is less than 18 inches in diameter.

In addition to the pipe described in ***Table 1-5***, the NO DPW is also responsible for approximately 46,350 drainage manholes and 19,460 inlets.

Table 1-5: NO DPW Drainage Pipe

Nominal Diameter (In)	Length (Feet)	Length (Miles)	Percent of Total
8	31,698	6	0.5%
10	1,538,510	291	22.6%
12	673,132	127	9.9%
15	1,373,963	260	20.2%
18	1,114,430	211	16.4%
21	841,223	159	12.4%
24	739,675	140	10.9%
27	223,245	42	3.3%
30	245,716	47	3.6%
Elliptical	20,829	4	0.3%
Total	**6,802,421**	**1,287**	**100.0%**

1.3.2 Drainage Basin Delineation

The S&WB system's major drainage canals and pumping stations function as watershed boundaries within the city, therefore the drainage pump station service areas were used as the basis for delineating the drainage basins within the system. The hydrologic and hydraulic system was delineated into 13 drainage basins. The basin service area was defined with pipe flow direction with each pump station as the most downstream node, and was refined in determining overland flow direction using Light Detection And Ranging (LiDAR) topography.

Figure 1-8 illustrates the boundaries of the various drainage basins of the City's drainage system.

1.4 System Assessment

Collection and analysis of field data was essential to the development of the Stormwater Management CIP. To collect the required data, CDM Smith performed a significant amount of field investigation.

1.4.1 Correcting the Existing GIS System

GIS shapefiles of the existing drainage system were provided by NO DPW to facilitate creation of the hydrologic and hydraulic models for development of the Stormwater Management CIP. The GIS shapefiles were initially developed as a mechanism for documenting and tracking the drainage line cleaning performed during the Hurricane Katrina rehabilitation effort. The initial intention for the development of the drainage shapefiles was to serve as a tool for documenting cleaning; consequently, little effort was made to establish the proper projection of the elements. Therefore, the drainage lines, manholes, and catch basins, while being properly referenced to each other, were displayed in a position either shifted or rotated when referenced against aerial photography or other city shapefiles.

To remedy this issue, CDM Smith initially gathered GPS coordinates for over 200 manholes throughout the city using a Trimble GeoXH with antenna that was able to determine the horizontal location to within a four inch degree of accuracy.

This information was then used to rotate or bend, "rubbersheet", the drainage shapefiles into an initial projection using the capabilities of ArcMap®. The drainage structure locations were then finalized using the same ArcMap® utility, employing the 890 manhole surveyed locations, as detailed in ***Section 1.4.2***. The resulting drainage shapefiles became the foundation for the hydraulic models of the NO DPW system.

1.4.2 System Surveys

Light Detection And Ranging (LiDAR) data, was used to establish elevation information for the structure rims and overland conveyances in the hydrologic and hydraulic model. To account for inaccuracies in the LiDAR information, CDM Smith surveyed 890 manhole rims to determine the horizontal coordinates and rim elevation of the manholes. The surveyed information was then used to refine the LiDAR information being used to establish the elevation of the system.

Volume II, Appendix A lists the manholes that were surveyed along with the coordinates for the surveyed facilities.

In addition to establishing the rim elevation of the manhole using a combination of LiDAR and topographic survey information to provide necessary information for building the hydraulic and hydrologic models, CDM Smith also identified over 9,100 manholes to have depth measurements made to establish pipe inverts. ***Volume II, Appendix A*** also lists the manholes that were identified for depth measurements along with the measured depth information. ***Volume III*** shows the locations of the manholes identified for surveys.

1.4.3 Manhole Condition Evaluation

During the depth measurements, CDM Smith also collected information that provides an indication of the condition of the manhole. The following information was collected for selected manholes throughout the city:

Distance Above/Below Grade

This measurement identifies whether or not the manhole rim is significantly above or below the surrounding grade. Manholes that are more than 1-inch above or below grade can cause damage to vehicular traffic.

Manhole Frame Condition

Manhole frames that are deteriorated or broken are at risk of causing significant damages to the streets and limiting capacity of the drainage system.

Wall Condition

A cracked or deteriorated manhole wall has the potential for failure, causing damage to the streets and vehicular traffic, as well as allowing ground water to enter the drainage system and reducing the available capacity for conveying stormwater runoff.

Trough/Bench Condition

Similar to the wall condition, a cracked or deteriorated bench/trough has the potential to allow groundwater to enter the system and reduce the available carrying capacity of the system. Additionally, if left unrepaired, a cracked or deteriorated trough could eventually cause a blockage in the manhole or the outgoing line segment.

Pipe Seal Condition

The pipe seal condition describes the condition of the interface between the manhole and the pipes that are connected to it. This may indicate existing damage or the potential damage to the pipe and manhole if left unchecked.

Location

While location does not provide an indication of the condition of the manhole, it can be used to prioritize the necessity for repairs and further investigation. A manhole in the street may be a higher priority than a manhole in a sidewalk/driveway or one in a grass easement.

1.4.4 Manhole Rehabilitation Recommendations

CDM Smith developed a Microsoft Access ® database to analyze the manhole condition information collected for nearly 7,420 manholes. The manhole rehabilitation recommendations were based on criteria which is very similar to the criteria used under other infrastructure programs. Based on the condition information that was collected, CDM Smith determined that the following rehabilitation measures would be the most valuable for the drainage system.

RFF – Replace Manhole Frame and Cover

ADJ – Adjust Manhole Frame and Cover Horizontally or Vertically

LIN – Apply lining material to the interior of the manhole

Table 1-5 Summarizes manhole rehabilitation recommendations by pump station service area. Inspection results and rehabilitation recommendations for these manholes are presented in ***Volume I, Appendix A.***

Table 1-5: Manhole Rehabilitation Recommendation Summary

		Rehabilitation Method				
		RFC	ADJ	LIN	Projected Cost	Total MH Inspected
Pump Station Service Area	DPS01	2	1	8	$ 9,750	168
	DPS02	10	3	0	$ 11,250	288
	DPS03	17	5	0	$ 19,050	569
	DPS04	37	70	67	$ 146,100	878
	DPS05	25	5	0	$ 26,250	529
	DPS06	13	5	0	$ 15,450	340
	DPS07	25	3	0	$ 24,750	497
	DPS10	134	25	48	$ 182,550	697
	DPS11	0	4	0	$ 3,000	47
	DPS12	9	12	12	$ 27,900	246
	DPS13	82	85	23	$ 158,250	675
	DPS14	137	8	41	$ 166,200	536
	DPS16	107	30	7	$ 125,100	726
	DPS17	2	10	1	$ 10,200	94
	DPS18	48	5	7	$ 53,250	227
	DPS19	16	4	0	$ 17,400	354
Total		**664**	**275**	**214**	**$ 996,450**	**6,871**

Table 1-6 presents the results of projecting the rehabilitation recommendations over the full population of manholes in the drainage system. There was no analysis performed for catch basins, but it is recommended that an effort be made to collect condition information for catch basins and other inlets throughout the system.

Table 1-6: Summary of Projected Manhole Rehabilitation Needs

		Rehabilitation Method				
		RFC	ADJ	LIN	Projected Cost	Total MH In Area
Pump Station Service Area	DPS01	151	75	603	$ 735,300	12,670
	DPS02	129	39	0	$ 145,000	3,712
	DPS03	145	43	0	$ 162,300	4,847
	DPS04	211	400	383	$ 835,000	5,018
	DPS05	60	12	0	$ 63,250	1,275
	DPS06	107	41	0	$ 127,350	2,802
	DPS07	184	22	0	$ 182,200	3,659
	DPS10	279	52	100	$ 379,750	1,450
	DPS11	0	34	0	$ 25,200	395
	DPS12	45	60	60	$ 139,050	1,226
	DPS13	498	517	140	$ 961,700	4,102
	DPS14	355	21	106	$ 430,400	1,388
	DPS16	231	65	15	$ 269,500	1,564
	DPS17	9	45	4	$ 45,700	421
	DPS18	107	11	16	$ 118,250	504
	DPS19	128	32	0	$ 138,800	2,824
Total		**2,639**	**1,469**	**1,427**	**$ 4,758,750**	**47,857**

Looking at the projected rehabilitation needs, it is apparent that there is a value in performing inspections of the remaining manholes. Manhole and catch basin inspection costs are presented in the preventive maintenance plan.

1.4.5 Line Segment Condition Evaluation

A large amount of Dyed Water Testing was performed as a part of the Sewer System Evaluation and Rehabilitation Program (SSERP). The purpose of the dyed water testing was to determine locations where stormwater collected and conveyed through the drainage system was escaping the system and entering into the sewer system through defects in the system. CDM Smith used the available information as a tool for identifying which drainage line segments allow stormwater to escape through defects in the drainage system. Maps showing the line segments which are likely to have breaks or other defects which lead to stormwater escaping the system are included in ***Volume I, Appendix A***. Line segments which intersect or are adjacent to sewer lines which had a dyed water testing result of 3 (moderate) or 4 (heavy) are shown on the maps. These line segments are likely in the most need for further inspection to determine the extent of the defects.

Projection of Line Segment Rehabilitation Costs

CDM Smith performed further analysis of the dyed water testing results and available line segment rehabilitation information from the SSERP. Based on the additional analysis, it was determined that line segments falling into the 80th percentile with respect to rehabilitation costs had a rehabilitation cost of approximately $230 per linear foot. Line segments falling into the 50th to 80th percentile had a rehabilitation cost of approximately $110 per linear foot. If these estimates are applied to lines with moderate or heavy dyed water testing results, the projected rehabilitation cost are projected to be ***$243,000,000***. This projection is based on application of information collected for use in determining sewer rehabilitation needs to the stormwater system and is only presented as one methodology for developing budgetary values of the cost of repairs to the system. No information was available for the Central Business District, French Quarter, and Gentilly Areas of the city. Incorporation of these areas into the analysis would result in an increase of the projected cost.

Section 2
Model Development

2.1 Introduction

The City of New Orleans is a nearly completely developed urban area with low-lying topography. The S&WB canal and pumping system is relied on during storms to remove water from the city and pump to outfall canals or Lake Pontchartrain. The local climate (with high intensity rainfalls), the flat topography, limited soil storage (due to soil characteristics and a high water table), high degree of impervious area, and limited available surface storage all contribute to severe flooding potential from precipitation events.

2.1.1 Purpose

The purpose of the modeling phase of the Stormwater Management CIP was to use hydrologic and hydraulic (H&H) models to:

1. Identify probable causes of known flooding.
2. Analyze drainage improvement alternatives including conveyance, storage, and low impact development (LID) methods.
3. Develop and prioritize drainage improvement suggestions.

In order to achieve these goals, the City's system was divided into 13 project areas based on the S&WB's pump station service areas. H&H models were created for each of the project areas using U.S. Environmental Protection Agency (USEPA) Storm Water Management Model Version 5 (SWMM) to facilitate analysis of conveyance capacity problems and aid system improvement planning. The hydraulic flow routing routine of SWMM uses a link-node representation of the primary stormwater management system (PSMS) to dynamically route flows by continuously solving the complete one-dimensional Saint-Venant flow equations. This section details the methods used to establish data for, and to perform, the stormwater management evaluations.

2.2 Data Collection

In general, the data collected is either temporal (such as rainfall) and distributed evenly throughout the model, or spatial, and is first added to a Geographical Information System (GIS) dataset as a layer. If multiple gages are available, rainfall may be both temporal and spatial. Spatial data includes point layers such as survey and high water mark locations, linear layers such as the pipe network, and polygon layers such as soils and land use. Since SWMM is a node-link representation a hydraulic system, point and linear features are often imported from the GIS database into the model. The hydrologic portion of the model is represented by areas (subbasins) of distinct hydrologic units (HUs) at a scale where all hydrologic parameters may be considered constant. The model calculates runoff from the HUs, which is then loaded to nodes in the hydraulic system. The HUs are delineated by topography, hydrologic similarity, and load point.

Polygon layers or raster data in the GIS datasets are intersected with a polygon layer representing the HU boundaries. Once intersected, the data is area weighted within each HU, generally using a spreadsheet analysis, to determine the parameter values to import to the model.

2.2.1 Topography

The topography for each of the project areas was defined using the LiDAR data from the Louisiana Statewide LiDAR project. The Louisiana project LiDAR systems being used are accurate to 15 – 30 cm (6 – 12 inches) root mean square error (RMSE), which will support contours of 1-ft to 2-ft vertical map accuracy standards. The data are geo-referenced to the UTM Zone 15 – Meters and converted to the NAD 83 and NAVD 88 datum.

The information was obtained in quarter quadrangle sections as edited points from Atlas: The Louisiana Statewide GIS (atlas.lsu.edu). These points were then converted into a Triangulated Irregular Network (TIN) in GIS.

The topography data was used primarily for dividing the watershed into individual HUs. It was also used in determining approximate road elevations and inlet elevations for the system where survey was not obtained. For the Pilot Model, the topography was also used to determine stage-area relationships above inlets and other above ground elements to allow for measuring and calibrating the depth of flooding.

2.2.2 Land Use

The model utilizes the U.S. Environmental Protection Agency (USEPA) 2001 National Land Cover Data (NLCD 2001) which consists of measured imperviousness values on a 30-m grid throughout the United States. Each pixel in the imperviousness dataset has a unique imperviousness value (an integer from 0 to 100 percent). The complete NLCD 2001 dataset is described at www.mrlc.gov and is available from the USGS National Map Seamless Server at seamless.usgs.gov.

These grids were intersected with the HU boundary polygons to find the average imperviousness over each HU. Since SWMM includes the function directly connected impervious area (DCIA), a portion of the impervious area was directed to pervious areas (such as a sidewalk or driveway running off into a yard). This ratio was set at 33% in the initial model setup and then checked for sensitivity during calibration.

2.2.3 Soils

The most detailed standardized national soils mapping completed by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) was used to create the Soil Survey Geographic (SSURGO) database. SSURGO soil maps are compiled at scales from 1:12,000 to 1:63,360. Digital versions of SSURGO are available from the NRCS Soil Data Mart (SoilDataMart.nrcs.usda.gov). SSURGO data include soil polygons and extensive attribute data that define soil characteristics, properties, and potential uses.

Tables of soil types are presented in ***Volume I, Section 1.2.3***. The predominant soil types in New Orleans are "D" class soils. Class D soils allow little infiltration due to both low rates of infiltrations and lack of soil storage. Therefore, most precipitation will become surface runoff that must be conveyed by either overland flow or subsurface drainage.

The two most common soil types in the project area are Schriever clay and Harahan clay. Schriever clay has a USDA soil classification of D. It is somewhat poorly drained on the alluvial plains. Water moves moderately slowly through the soil. The shrink-swell potential is moderate. Harahan clay also has a USDA soil classification of D. It is a poorly drained soil of former swamps. The soil is firm in the upper part and fluid in the lower part. It is clayey throughout. The soil has a very high shrink-swell potential and a medium total subsidence potential. These two soils types account for approximately half of the soils in the area.

The soil layer was intersected with the HU boundaries to get the percentages of each soil type within each HU. Values of infiltration and soil storage are assigned to each soil type (see below), and area weighted aggregates were determined using the assigned percentages.

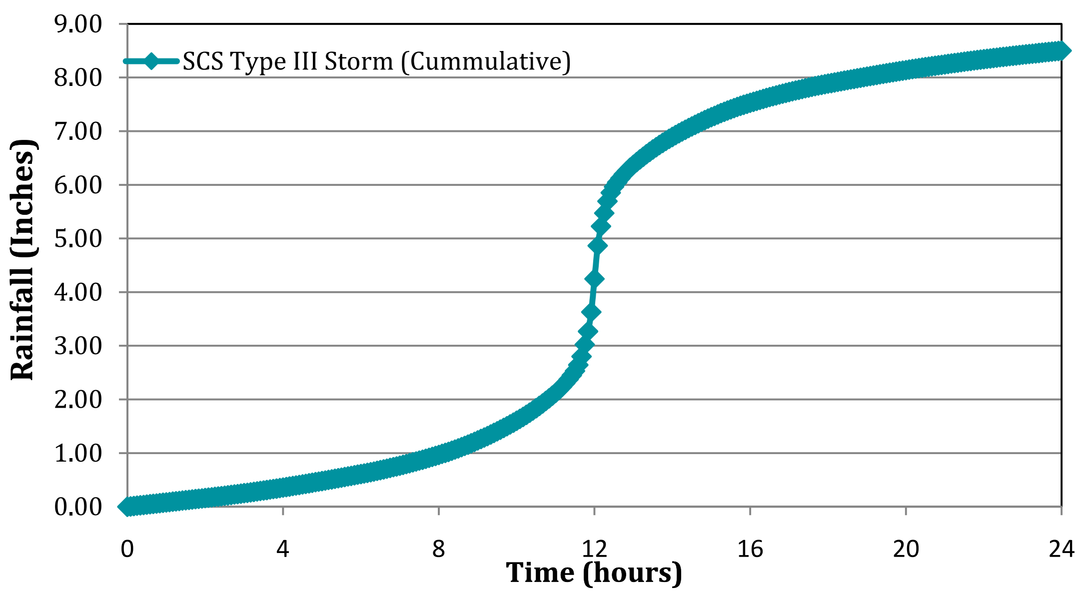
2.2.4 Precipitation

Design Storm Hyetographs

Precipitation information for the New Orleans area is presented in ***Volume I, Section 1.2.1***. ***Table 1-1*** presents depth-duration-frequency statistics for New Orleans based on the 1954 to 2009 records as computed in NetSTORM. This analysis determined the 10-year, 24-hour storm for the area is approximately 8.5 inches.

The depth of the 10-year, 24-hour storm was distributed over the 24 hours using a Type III SCS distribution. ***Figure 2-1*** shows the cumulative distribution of the 8.5 inch 10-year, 24-hour storm over 24 hours.

Figure 2-1: Cumulative Distribution of the 10-year, 24-hour storm over 24 hours

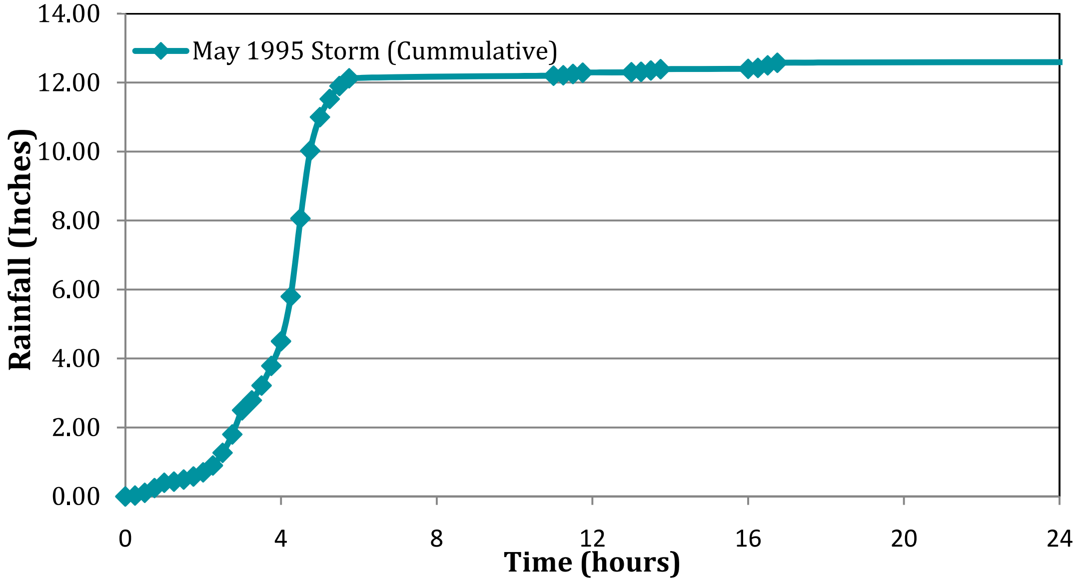


Calibration Storm (May, 1995)

To calibrate the Pilot Model of the Drainage Pump Station 01 (DPS 01) service area, the May 1995 storm was chosen, as it was the storm for which the S&WB model was calibrated and because high water marks were available throughout the DPS 01 service area.

Hourly rainfall data was collected from the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) for the nearest operating gage, Audubon Park, which recorded 12.6 inches of precipitation for the 24-hour period beginning at 17:00 hours on May 8, 1995 (the total volume was higher over the extended period of the storm). Due to the relatively small resolution of this model, it was determined that a one-hour time step would be too large compared for the travel time within each HU. NetSTORM was used to disaggregate the data from one-hour to 15-minute time steps. Instead of simply dividing the hourly volume by four, NetSTORM reviews preceding and trailing volumes for trends and disaggregates accordingly. ***Figure 2-2*** shows the rainfall hyetograph of this storm.

Figure 2-2: Rainfall Hyetograph of the May 1995 Storm



2.2.5 Peak Stage Data

The only stage data available for calibration were the high water marks for the May 8, 1995 storm. This data is recorded in Table C-9, "Uptown Area Basin, Model Results vs. Actual Field Data for the May 8 & 9, 1995 Event", from the *Southeast Louisiana Orleans Parish Section 533(D) Report, Uptown Area Subbasin Engineering Investigations Appendix(C)*, which was supplied with the DPS 01 XP-SWMM as a companion report by the S&WB (through BCG). The high water marks were surveyed in NGVD and Cairo datums by the U.S. Army Corps of Engineers, the S&WB, and Pepper & Associates. The locations of these data points and the peak elevations are presented in ***Figure 2-3***.

2.3 Model Development

SWMM is a dynamic hydrologic and hydraulic model capable of performing continuous or event simulations of surface runoff and groundwater base flow, and subsequent hydraulic conveyance in open channel and pipe systems.

The hydrologic system operates by applying precipitation across hydrologic units (HUs), and then through overland flow and infiltration, conveying surface runoff to loading points on the user-defined primary stormwater management system (PSMS). Runoff hydrographs for these loading points provide input for hydraulic routing in the downstream system.

The hydraulic flow routing routine of SWMM uses a link-node representation of the PSMS to dynamically route flows by continuously solving the complete one-dimensional Saint-Venant flow equations. The dynamic flow routing allows for representation of channel storage, branched or looped networks, backwater effects, free surface flow, pressure flow, entrance and exit losses, weirs, orifices, pumping facilities, rating curves, and other special structures or links.

The models were created using the vertical datum, North American Vertical Datum of 1988 (NAVD), and the geodetic reference system, Louisiana State Plane (NAD 1983, State Plane, Louisiana, South).

A total of 15 models were developed to cover the entire City of New Orleans. The models were mainly developed based on S&WB service area boundaries, with minor deviation due to topography as described below. The 15 models are: DPS01 (also known as the pilot model), DSP02, DPS03, DPS04, DPS05, DPS06, DPS07, DPS10, DPS12, DPS13, DPS14, DPS16, DPS17, DPS18, and DPS19. In order to check flow between models in low-lying areas and/or where there was a significant S&WB connection, DPS01 and DPS02 were combined into one model (DPS0102), as were DPS03 and DPS04 (DPS0304) and DPS07 and DPS12 (DPS0712).

2.3.1 Hydrology

Hydrologic Units

The project watersheds were sub-divided into hydrologically distinct subbasins defined as HUs. The divisions were based on a combination of topographic information, city stormwater pipes and catchments, and aerial photographs. The hydrologic parameters assigned to each HU include area, width, slope, directly connected impervious area (DCIA), surface roughness, initial abstraction, and infiltration parameters.

Area

The tributary areas for each HU were determined directly from GIS mapping.

Imperviousness

Imperviousness may be entered in SWMM as DCIA, also called effective impervious area. This methodology routes all the effective impervious area with the impervious parameters and zero infiltration, and all the pervious and non-directly connected impervious area (NDCIA) with the pervious parameters and infiltration. A second methodology, and the one used for this project, is to enter total impervious area as the imperviousness and then use the ROUTE TO function to route a given percentage of that to the pervious layer. The percentage to route to the pervious layer may then be a calibration parameter. The percent impervious was developed from the land use layer in GIS (see ***Volume I, Section 2.2.2***) and area weighted by HU area to develop a homogenous value for each HU.

Width

The width of each HU was computed by finding the square root of the area. Smaller scale projects with significantly fewer HUs would likely use a method of measuring multiple flow path lengths per HU and dividing the area by the average length to get width. In urban areas with approximately square HUs, these calculations will typically result in widths within a factor of two (less than double, more than half) of the square root of the area. The sensitivity analysis in ***Volume I, Section 2.4.3*** indicates that the model is not very sensitive to changes in widths within this range.

Slope

The Slope of each HU was estimated to be 1 percent. As with Width, the model is not sensitive to this parameter under variations that occur in this relatively flat terrain.

Evaporation

The evaporation default value of 0.1 inches per day was used in these models. The model is not sensitive to evaporation for design storm applications.

Overland Roughness and Depression Storage

The overland Manning's roughness values were set to 0.013 for impervious areas and 0.2 for pervious areas. The pervious area roughness values are higher than those used for a channel bottom because the depth of flow is much shallower for surface runoff. The model is not sensitive to changes in these values, within ranges that are physically reasonable.

Depression storage, also known as initial abstraction, represents the volume of water that does not flow off the surface into the PSMS due to ponding. The values are set to 0.05 inches over impervious areas and 0.1 inches over pervious areas. Again, the model is not sensitive to changes in these values, within ranges that are physically reasonable.

Infiltration

The SWMM infiltration function uses soil characteristics to define infiltration parameters. The Horton soil infiltration method was selected for this project.

For each of the project models, a single set of infiltration characteristics were assigned to each HU based on the predominant soil type in that catchment. The soil information was collected from the SSURGO dataset as described in the ***Section 2.2.3*** above. The composite soil make-up was then used to determine weighted Horton soil characteristics including maximum (initial) and minimum (final) infiltration rates, and soil storage. Soil storage varies depending on antecedent moisture conditions (AMCs). This model uses average antecedent moisture conditions (AMCII), which may be defined as the soil condition when the previous 5-day rainfall volume totals between 1.4 and 2.1 inches.

Table 2-1 below displays the soil parameters by soil type for the AMCII conditions.

Table 2-1: Global Soil Parameters

Soil Type	Max Infiltration Rate (in/hr)	Min Infiltration Rate (in/hr)	Decay Rate (1/sec x 10^{-4})	Dry Time (days)	Soil Storage (in)
A	12.0	1.00	5.56	1.0	5.4
B	9.0	0.50	5.56	1.0	4.0
C	6.0	0.25	5.56	1.0	3.0
D	4.0	0.10	5.56	1.0	1.3

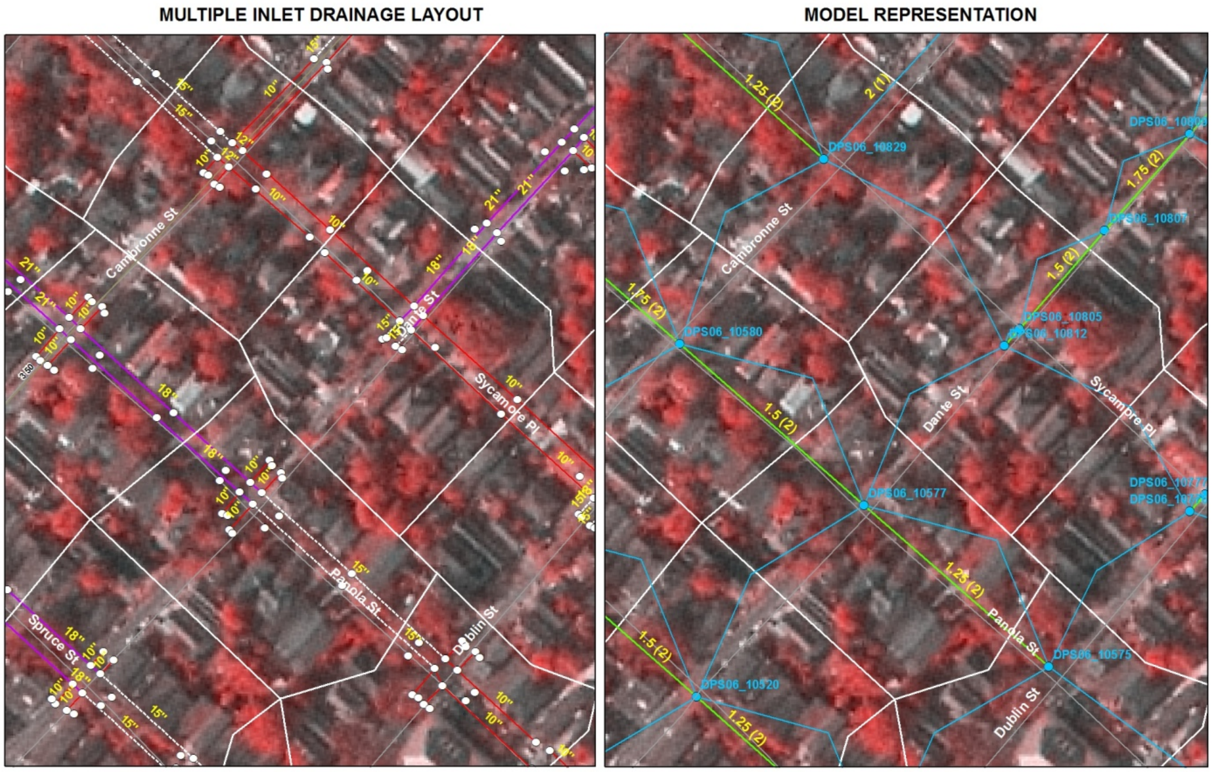
2.3.2 Hydraulics

In general, a PSMS may be comprised of canals, rivers, streams, lakes, bridges, culverts, pipes, pump stations, weirs, and other hydraulic structures. Most of these types of hydraulic elements are part of the larger, S&WB, system or are not present in the city. For the City's models, the PSMS is almost entirely made up of pipes.

Model Resolution

In many areas within the city, there are numerous inlets and smaller pipes leading to a main PSMS trunk. It is the objective of this study to determine whether the trunk on the PSMS is sized properly to meet desired level of service (LOS) goals. The inlets and smaller connecting pipes (15-inches and smaller) are considered secondary systems and are not always explicitly modeled. The local surface runoff is directed to the upstream end of the PSMS. In some of the older urban areas, there are often two pipes, one on each side of the street. Where streets such as these intersect, there are likely four manholes at the intersection of these pipes. Surrounding these manholes, there may be up to 12 inlets. In this case, the intersection is modeled with one model junction (node). The surface runoff from the surrounding block (estimated from the hydrologic layer of the model) would load to this single entry point on the hydraulic system. ***Figure 2-4*** provides an example of this equivalent representation.

Figure 2-4: Multiple Inlet Equivalent Model Representation



Since the NO DPW is responsible for pipes that are less than 36-inches in diameter, the analyses performed as part of this report concerns pipes below this size. The pipes which are 36-inches in diameter and larger are part of the S&WB system. In the course of conducting this project, it was determined that the S&WB system was not sufficient to meet the LOS goals of the project (this is discussed in more detail in ***Volume I, Section 3***). Therefore, these larger systems were added to the models using the GIS information and XP-SWMM models of the S&WB system provided by the S&WB.

Model Nodes

Model nodes may be in the form of junctions, storage junctions, or outfalls. Storage junctions are used to define a stage – storage area relationship above the top of an inlet. These help determine depths of flooding and have been used extensively in the calibration model. For the design models, stage-storage relations are confined to areas that include wetlands, ponds, detention areas, or other areas of excessive storage. Outfalls are placed at the boundaries of the model where flow is out of the model space. Outfalls will be discussed in detail in the paragraph on boundary conditions below. All other model nodes are labeled as junctions. Junctions are located at:

1. The ends of pipes which are 15-inches in diameter or greater (secondary systems of lesser diameter are coupled with surface runoff in the hydrologic layer);
2. Intersections of drainage systems;
3. Locations of pipe diameter change; and
4. Points representing the HU low point.

The loading from the hydrologic layer may be input to any node in the PSMS however, all junctions representing the upstream end of a pipe system should have hydrologic loading in order that "dry" pipes not be created. Dry pipes are those pipes that have no flow from an upstream element (either link or loading) and therefore are not useful in the system analysis. Dry pipes may also cause instabilities in this type of model.

Some pipe diameters smaller than 18 inches have been added where necessary to retain continuity of the system, such as where there are larger pipes on either side. In most cases, these are locations where upsizing will be necessary.

Model node inverts were set to the lowest pipe invert intersecting the given node.

Model Links

Model links may be conduits, pumps, orifices, weirs, or outlets. In these models, as noted above, all of the links are conduits or pumps. A conduit may be an irregular channel, a trapezoid, a circular pipe, a box culvert, or of a special shape. With few exceptions, all the conduits in these models are circular pipes or box culverts.

Pipe size and length were determined based upon the GIS information supplied by the NO DPW. Pipe inlet and outlet inverts were determined by using the survey data. Since the pipe invert survey did not cover all model elements (approximately 10%), the remainder of the inverts were interpolated or extrapolated from neighboring manhole surveys. Under design storm conditions when pipes are flowing full, minor changes to pipe invert elevations have little effect on model results. It is not expected that the actual pipe inverts would vary significantly from these estimates, such that it would impact model results or findings.

Minor entrance and exit losses were uniformly set to values of 0.2 and 0.3, respectively for the NO DPW system. Smaller losses were used for the larger S&WB system, especially where the S&WB system intersects with the relatively smaller NO DPW system, little head loss would occur. The sensitivity analysis indicated that the model is not very sensitive to minor losses for the intense storms where flooding is prevalent. The losses account for head losses at inlets, pipe diameter changes, intersections, and outfalls to the S&WB system.

Pipe roughness (Manning's n) was uniformly set at 0.013 which corresponds to concrete and is indicative of clean, well-maintained pipes. Maintenance issues are not included in the model. All pipes and inlets were modeled as well maintained, with no siltation included. The sensitivity of the model to a maintenance condition was tested as documented in ***Volume I, Section 2.4.2***; however, in general, a routine maintenance program will be required to meet the estimated LOS that the model predicts. Without maintenance, the likelihood of flooding cannot be predicted as any pipe or inlet in the system may act as a constraint.

A portion of the NO DPW system is comprised of parallel pipes, usually running down opposite sides of the same street. If these pipes are the same size, they were combined into one link with two barrels in the model representation. If they were not the same size, they were represented by two parallel links in the model. In the spreadsheet analyses described in ***Volume I, Section 3.3***, the combined cross-sectional area of two parallel links of differing sizes would not be properly calculated. Therefore, it was necessary to calculate an equivalent representation. This was done by computing the total cross-sectional area and dividing it equally between two equal sized "equivalent" pipes. The parallel pipes were then replaced in the base model with the equivalent pipes.

Above Ground Hydraulic Elements

As discussed above, the model has above ground elements in order to accurately estimate flood depths and to hydraulically connect road flooding between nodes. These elements include road conduits, equalizer conduits, and storage junctions.

A road conduit is a trapezoidal conduit representing the road above each pipe. Road conduits allow for a hydraulic connection along the road surface when pipes are surcharged. In flat areas, where adjacent nodes are surcharging, the volume in the link also provides above ground storage at these locations. The Manning's n value of the road was estimated to be 0.02, which represents a combination of asphalt and grassy areas. The inverts of these conduits were estimated from the LiDAR topographic surface. The lengths were measured from GIS. The road conduits generally are trapezoidal shapes with 50 ft wide bottom widths and 10:1 side slopes. Since road conduits are parallel to all pipes in the system, they cover nearly all of the model area. In some areas, there are roads without underground pipes, where flooding is likely to occur. These areas were connected with road conduits, as appropriate, to connect adjacent systems above ground. Although these represent a rough estimate of the conveyance and volume that occurs during flooding, the sensitivity to these elements versus the more accurate storage junctions of the calibration model showed the model was less sensitive to this equivalent representation than to other model parameters.

An equalizer conduit is another above ground irregular conduit, but one that does not include significant storage and is used to "equalize" the above ground HGL (or stage) between two nodes. This is often used where there is no pipe connection across an intersection between two neighboring systems. Without equalization, one side of the system could potentially surcharge to a higher level than the other. The equalizer acts as a weir from one side to the other, with the weir crest at the crown of the roadway.

Model Outfalls

Outfall nodes are used to represent connections to boundary conditions. SWMM has a limitation that only one link may be connected to each outfall. Because multiple drainage systems often intersect the S&WB canal system at the same location, it was necessary to create an outfall where multiple links connect to a node, then use a "virtual" conduit from this node to the outfall. This virtual conduit is a large, short box culvert that should have no effect on the results.

2.4 Model Calibration

For the DPS 01 service area, a calibration H&H model was developed to a resolution as described above and similar to the rest of the system. However, in order to calibrate the model, surface storage and overland links representing above ground connectivity were added. Storage junctions were spread throughout the DPS01 service area, with concurrent boundaries, such that the entire project area was covered. The storage junction has a stage-storage area relationship such that flood depths are measured based on the surcharge volume. The stage-storage area relationship is calculated from the LiDAR topographic surface. Because the road conduits also contain storage, it was important not to double count the above ground storage in areas where the road conduits are present, which encompasses most of the model. Therefore, a spreadsheet was setup that calculated the storage area, per stage elevation, for each road conduit within a storage junction area of influence. These areas were then subtracted from the storage junctions' stage-storage area relationships as calculated directly from the LiDAR surface. Thus, the lookup table in the model will calculate depth based upon excess storage volume available above an area, beyond the volume that the model automatically assigns to the trapezoidal conduits representing the roads in that area.

Calibration Model Boundary Conditions

The outfall of the Calibration Model is the downstream side of the DPS 01. However, due to the SWMM limitation of one link per outfall, a short segment of the canal downstream of the pump station (Channel NS_8250 from the S&WB model) was added to the model before the outfall. This was necessary, as the pump station is comprised of five parallel pumps. These pumps represent the system as it was operating in May 1995 during the calibration storm. The total peak flow pumped from the station was approximately

4,500 cfs. Recorded pump station flows were not available from the S&WB; however, these peak flows match what was used for the S&WB calibration of the XP-SWMM model.

All other model boundaries are considered no-flow boundaries. For flooding above ground, the boundaries were placed at topographical highs, where possible, such that there would not likely be too much flow into or out of the model along the streets. For this reason, the model boundary does not follow the DPS 01 service area exactly, as defined by the S&WB. There are a few pipe connections between the DPS 01 and DPS 06 service areas. Most of these are small and should not affect model results. The larger box culvert along Claiborne Avenue was divided at Pine Street, with all connections west of this intersection flowing to DPS 06 and all connections east of this intersection to DPS 01. This was done due to a weir that is currently located at this intersection, as well as an examination of the flows in the S&WB models for historical perspective. Along DPS 01's eastern boundary with DPS 02, most of the pipe connections are small. The box culvert along Broad Avenue is divided at Earhart Blvd, as modeled in the S&WB model.

The calibration model of the DPS 01 service area was calibrated using two separate approaches. The first was to compare model-simulated stages to available high water marks from a known storm (May 8-9, 1995). The second method included installing flow meters at selected outfalls of the DWP system and monitor flow versus precipitation over a period of time.

Since many of the hydrologic and hydraulic parameters outline in the previous section were set based on previous modeling experience, a sensitivity analysis to these parameters was also conducted.

2.4.1 Calibration to the May 1995 Storm

The 24-hour period beginning at 17:00 hours on May 8, 1995 produced 12.6 inches of rainfall at the Audubon Park precipitation gage. This gage was selected for use for this calibration because it is located within the model boundaries. The next closest gage with available hourly precipitation recordings is the New Orleans Louis Armstrong Airport, which is 10 miles to the west of the project site. Surveyed high water marks were available for these dates in this area, as described in ***Volume I, Section 2.2.5***. The high water marks were converted from NGVD datum to NAVD datum to match the model.

Table 2-2 below gives the results of the calibration comparing the calibrated model simulated peak stages versus surveyed peak stages for 21 locations (note that seven locations have multiple surveys). The average difference between the model results and the surveyed values was 0.3 ft. The modeled flood depths were generally lower than the surveyed flood depths. The maximum increase at any one location was 0.2 ft, while the maximum decrease was 0.7 ft. These results are very similar to the S&WB results (0.2 average, 0.3 maximum increase, 0.9 maximum decrease).

Although it may be possible to continue to calibrate this model and further lower these differences, the ambiguity in both the high water marks survey data and the model input parameters would negate such an effort. The high water marks were surveyed in the mid to late nineties, pre-Katrina. Surveying efforts post-Katrina, including the LiDAR data, is based upon benchmarks that may have been adjusted down as some of the older benchmarks were found to be too high. Thus, an average error on the low side may be a closer match than re-calibrating to a zero error. In addition, the level of accuracy of the model, including the LiDAR survey used for topography, is not better than the differences in these results. Therefore, the model was considered calibrated for peak stages with these results.

Table 2-2: Model Calibration Results, Peak Stage vs. Surveys

Location of Surveyed High Water Marks	Surveyed Depth (ft NGVD)	Surveyed Depth (ft NAVD)	Model Depth (ft NAVD)	Delta (ft)
2036 S Gayoso	-0.5	-0.7	-1.1	-0.4
2036 S Gayoso	-0.2	-0.4	-1.1	-0.7
2618 S Broad	-0.6	-0.8	-1.4	-0.6
3837 Napoleon	-0.6	-0.8	-1.1	-0.4
2816 Gen Pershing	-0.2	-0.4	-0.7	-0.2
2816 Gen Pershing	-0.2	-0.4	-0.7	-0.2
3001 Napoleon	-0.5	-0.7	-0.8	-0.1
3133 Napoleon	-0.4	-0.6	-0.9	-0.2
4315 S Claiborne	-0.6	-0.8	-0.7	0.1
2813 Gen Pershing	-0.3	-0.5	-0.7	-0.2
2813 Gen Pershing	-0.3	-0.5	-0.7	-0.2
2825 Gen Taylor	-0.2	-0.4	-0.6	-0.2
2813 Joseph	-0.4	-0.6	-0.6	-0.1
3418 Delachaise	-0.5	-0.7	-1.0	-0.3
2829 Joseph	-0.1	-0.3	-0.6	-0.3
4222 S Broad	-0.5	-0.7	-1.2	-0.4
2618 S Broad	-0.6	-0.8	-1.2	-0.4
2425 S Johnson	-0.9	-1.1	-1.0	0.1
4222 S Broad	-0.5	-0.7	-1.3	-0.6
3514 S Tonti	-0.8	-1.0	-1.1	0.0
3101 Gen Pershing	-0.6	-0.8	-0.9	-0.1
3641 Napoleon	-0.6	-0.8	-1.0	-0.3
3437 Napoleon	-0.5	-0.7	-1.0	-0.3
3526 Nashville	-0.6	-0.8	-1.0	-0.2
3526 Nashville	-0.3	-0.5	-1.0	-0.5
1516 Soniat	5.2	5.0	5.2	0.2
1530 Jefferson	6.1	5.9	5.3	-0.6
1530 Jefferson*	4.8	4.6	5.3	0.8

* The S&WB Report made note that the second survey at 1530 Jefferson may be off by one foot. This data point was not included in the statistics.

2.4.2 Calibration to Flow Monitoring Data

Flow monitoring and rainfall data was collected and used to further calibrate the models using three separate neighborhood models, with recording devices at (1) Delord and Palmer (DP), (2) Willow and Milan (WM), and (3) Napoleon and Carondolet (NC).

The three locations are all within the DPS 01 service area. These neighborhood models were built to a finer detail (6-inch diameter pipe) than the rest of the models, although there remains equivalent representation of the inlet structures. The tributary area to each flow meter was estimated using the extents of the NO DPW system and topography.

Although there were six weeks of data collected in November through December 2009, two storms at the end of the recording period on December 12th and December 15th were used to look at the calibration. Both were on the order of 7 inches of total rainfall.

The calibration included testing many hydrologic features including the percentage of impervious flows routed to pervious areas (i.e. non-directly connected impervious area), slope, overland roughness, etc. The parameters were adjusted until the peak and total flows for the model provided a best match with the three gages. The resultant changes made were an increase in depression storage (0.05 to 0.1 inch for impervious areas, and 0.1 to 0.25 inches for pervious areas), and an increase in soil storage. Therefore, the Class 'D' soils in this area are given values in the Class 'C' range. The last change had the most dramatic affect on the results.

These changes were made to the model of the entire DPS 01 service area to determine what the effect would be on the previous calibration. The new average difference between the model results and the surveyed values was -0.4 ft. The maximum increase at any one location was 0.1 ft, while the maximum decrease was -0.8 ft. These results remain similar to the S&WB results. Again, since the surveys are based upon benchmarks that may have been adjusted down post-Katrina, an average error on the low side may be a closer match than re-calibrating to a zero error. ***Table 2-3*** updates the comparison between the calibration model results and the surveyed high water marks.

Table 2-3: Revised Calibration Results, Peak Stage vs. Surveys

Location of Surveyed High Water Marks	Surveyed Depth		Model Depth	Delta (ft)
	(ft NGVD)	(ft NAVD)	(ft NAVD)	
2036 S Gayoso	-0.5	-0.7	-1.2	-0.5
2036 S Gayoso	-0.2	-0.4	-1.2	-0.8
2618 S Broad	-0.6	-0.8	-1.4	-0.6
3837 Napoleon	-0.6	-0.8	-1.2	-0.4
2816 Gen Pershing	-0.2	-0.4	-0.8	-0.3
2816 Gen Pershing	-0.2	-0.4	-0.8	-0.4
3001 Napoleon	-0.5	-0.7	-0.9	-0.2
3133 Napoleon	-0.4	-0.6	-1.0	-0.3
4315 S Claiborne	-0.6	-0.8	-0.8	0.0
2813 Gen Pershing	-0.3	-0.5	-0.8	-0.3
2813 Gen Pershing	-0.3	-0.5	-0.8	-0.3
2825 Gen Taylor	-0.2	-0.4	-0.7	-0.3
2813 Joseph	-0.4	-0.6	-0.8	-0.2
3418 Delachaise	-0.5	-0.7	-1.1	-0.4
2829 Joseph	-0.1	-0.3	-0.7	-0.4
4222 S Broad	-0.5	-0.7	-1.2	-0.5
2618 S Broad	-0.6	-0.8	-1.2	-0.4
2425 S Johnson	-0.9	-1.1	-1.0	0.1
4222 S Broad	-0.5	-0.7	-1.4	-0.7
3514 S Tonti	-0.8	-1.0	-1.1	-0.1
3101 Gen Pershing	-0.6	-0.8	-1.0	-0.2
3641 Napoleon	-0.6	-0.8	-1.1	-0.4
3437 Napoleon	-0.5	-0.7	-1.1	-0.4
3526 Nashville	-0.6	-0.8	-1.1	-0.3
3526 Nashville	-0.3	-0.5	-1.1	-0.6
1516 Soniat	5.2	5.0	5.1	0.1
1530 Jefferson	6.1	5.9	5.3	-0.6
1530 Jefferson*	4.8	4.6	5.3	0.7

* The S&WB Report made note that the second survey at 1530 Jefferson may be off by one foot. This data point was not included in the statistics.

2.4.3 Sensitivity Analysis

A sensitivity analysis has been performed on selected hydrologic and hydraulic parameters using the calibration model. Prior to performing this analysis, the calibration model was updated to existing conditions (as opposed to the 1995 condition) based upon the S&WB XP-SWMM existing conditions model. Since the sensitivity analysis is based on the relative changes to peak stages and flows caused by changes in H&H parameters, the model sensitivity should not be affected by the size of the S&WB system. The model was also revised to run the 10-year, 24-hour design storm and the mean annual, 24-hour design storm. The results of this analysis are presented in ***Table 2-4***.

Although the larger 10-year design storm is used to determine levels of service for this project, it should be noted that the model is more sensitive to these parameters for smaller storms. This is because small changes in runoff may produce large differences in peak stage as a system is very near capacity and about to surcharge. Since there is very little volume above a pipe until the stage reaches a ground elevation where the ponding may spread out, stages may increase rapidly at the upstream ends of pipe where the runoff is loaded. This is also why, in some cases, the maximum or minimum differences may be on the order of a few feet as the particular location may be on the precipice of surcharging although the average change may be small.

Table 2-4: Model Sensitivity to Selected Hydrologic and Hydraulic Parameters

Hydrology	Annual 24-Hour Storm Differences (ft)				10-Year, 24-Hour Storm Differences (ft)			
	Ave	STD	Max	Min	Ave	STD	Max	Min
Pervious Area / 2	0.20	0.26	2.19	-0.25	0.04	0.05	0.57	-0.38
Impervious / 2	-0.49	0.47	0.27	-3.88	-0.09	0.09	0.44	-1.26
DCIA Route to 50%	0.01	0.06	0.81	-2.00	0.00	0.03	0.78	-0.28
DCIA Route to 15%	0.01	0.07	1.16	-0.41	0.00	0.02	0.40	-0.21
Width x 2	0.14	0.16	1.21	-0.26	0.03	0.04	0.44	-0.78
Width / 2	-0.26	0.26	0.28	-2.23	-0.06	0.06	0.58	-0.99
Slope x 2	0.08	0.09	1.08	-0.16	0.02	0.02	0.37	-0.24
Slope / 2	-0.11	0.12	0.24	-1.09	-0.03	0.03	0.08	-0.46
Overland x 2	-0.29	0.29	0.63	-2.53	-0.06	0.06	0.71	-1.00
Overland / 2	0.14	0.16	1.49	-0.31	0.04	0.04	0.48	-0.51
Soil Storage x 2	-0.18	0.22	0.22	-1.99	-0.03	0.04	0.06	-0.94
Soil Storage / 2	0.09	0.17	2.18	-0.39	0.01	0.02	0.17	-0.54
Hydraulics	**Annual 24-hour Storm (4.2 inches)**				**10-year, 24-hour Storm (7.9 inches)**			
	Ave	**STD**	**Max**	**Min**	**Ave**	**STD**	**Max**	**Min**
Zero Entrance/Exit Losses	-0.02	0.14	1.06	-1.19	-0.01	0.06	0.38	-0.77
(Lack of) Maintenance	0.11	0.82	3.76	-2.15	0.09	0.22	2.94	-0.70

Ave: Average of 2,730 nodes – peak stage deltas between scenarios versus base model
STD: Standard deviation of same

It should also be noted that while increased runoff and/or increased pipe flows increases stages in one area, they may decrease stages in another and vice versa. This is particularly true of the hydraulic parameters where increased flows tend to decrease stages upstream while potentially increasing them downstream. This tends to skew the averages closer to zero; therefore, the standard deviation has been added for clarification. A low average with a relatively high standard deviation would indicate more sensitivity than the same average with a low standard deviation.

Hydrologic Parameters

Nearly all the hydrologic parameters that are input to the model were tested for sensitivity. The soil infiltration rates and decay rates were not tested as previous projects have shown that models are more sensitive to soil storage than the maximum and minimum rates (over reasonable ranges of values). Additionally, the overland roughness and depression storage parameters were lumped together, again due to previous sensitivity analysis performed by CDM Smith. An attempt was made to keep the variations uniform but also within physical limits. However, the physical range of the parameters varies greatly. For instance, doubling the slope of a catchment is not that large of a variation, whereas doubling the roughness of the overland flow is. Although the slope may locally vary beyond this range, it is not expected that the physical range model-wide is beyond this range, so the range was not expanded. For impervious area, doubling the area would create areas with greater than 100%; therefore, halving the pervious area was used instead. The model input for impervious area is directly connected impervious area (DCIA) as some impervious precipitation runs off to pervious areas before reaching the PSMS. Since the portion of the basin that is directly connected was unknown, 33% of the impervious areas were routed to pervious areas in the base condition. This “route to” adjustment was tested at 15% and 50% in this analysis, with little affect on final results.

The sensitivity analysis indicates that the model is most sensitive to impervious area, followed by overland parameters (pervious and impervious areas roughness values and depression storage), HU width, and soil storage. These are typical results, although generally the overland parameters have less sensitivity. The range on these parameters is extreme and likely causes this result.

Hydraulic Parameters

The hydraulic parameters tested were entrance and exit losses and a maintenance condition. Entrance and exit losses were added to the model in response to the sensitivity analysis. This is why the test is based on zero losses, as it was the original base condition. Although adding losses did not affect the final result as the averages are near zero and the standard deviations are low, it was determined that since some nodes had differences nearing one foot, it would be best to add them to the model. Not all pipes are going to have the same losses, but determining losses on a case-by-case basis for over 3000 pipes would be time consuming and ultimately not change the results. The losses chosen for use in the NO DPW system (0.2 entry, 0.3 exit) were roughly estimated based on the likely losses in the system.

The maintenance condition is tested because the model is based on a clean, well-maintained system with low roughness values (0.013 for concrete) and full capacity. This test evaluates a condition where pipes are silted to 30% of the diameter and the roughness is increased to 0.025. The model is more sensitive to this condition than for any other for the larger storm. This test provides some indication of the need for routine maintenance in the system as stages may rise as much as 3 feet even when most of the cross-sectional area remains. In cases where pipes and/or inlets are completely clogged, the increases may be much worse.

The sensitivity analysis shows that the model is not overly sensitive to any one parameter, especially for the larger storms. For the larger storms, precipitation overwhelms the soil storage in the pervious areas and becomes runoff despite the percentage of pervious area. Additionally, much of the model area has surcharged pipes and street flooding, therefore, minor hydraulic changes have little effect on peak stages.

2.4.4 Impervious Analysis

Given the model's sensitivity to impervious area, a cross-validation of the percent imperviousness of the project area was performed. The percent impervious cover used in the model was obtained from USGS National Land Cover Database (NLCD) for 2001, as detailed in ***Volume I, Section 2.2.2***.

The percent imperviousness verification was performed using 2004, pre-Katrina aerial photographs for an accurate representation of the 2001 land cover. The 2004 aerials for the entire drainage area were obtained from "Atlas", the Louisiana Statewide GIS website.

Approximately 690 samples within the City of New Orleans were chosen for geographic sampling. The number of sample points selected for each drainage pump station is listed in ***Table 2-5*.**

On an average, each cell in the raster represented 0.22 acres. For each random cell selected the area of imperviousness was determined from the aerial photograph and percent imperviousness was calculated from the cell's total area.

The following observations were noted from the impervious analysis:

For most of the drainage areas, the error was fairly distributed with little concentration at one location. The following are two of the reasons for the error observed, and are applicable to all areas.

1. Because each raster cell represents a small area (0.22 acres), small differences in the calculated impervious values may result in large difference in the error of the percent impervious;
2. and because of the lack of clarity in the aerial images.

Table 2-5: Sampling Points per Drainage Pump Station Area

	Pump Station ID	Area (Ac)	No: of Samples	Area/Samples (Ac)
	East Bank			
	DPS-01	5,539	62	89
	DPS-02	1,605	18	89
	DPS-03	2,424	27	90
	DPS-04	4,409	50	88
	DPS-05	1,458	16	91
	DPS-06	2,943	35	84
	DPS-07	2,932	34	86
	DPS-12	2,410	30	80
	DPS-17	437	5	87
	DPS-19	2,176	25	87
	New Orleans East			
	DPS Amid	3,339	39	86
DPS Lake Forest	DPS-10	2,639	28	94
	DPS-14	2,150	27	80
	DPS-16	2,790	31	90
	DPS-15	7,908	88	90
	DPS-18	829	11	75
	NASA	820	10	82
	West Bank			
	DPS-11	4,682	53	88
	DPS-13	6,426	75	86

In general, the deltas (error) between the NLCD database and the aerial photographs tended to be both positive and negative; therefore, the mean error is close to 0% for most of the model areas. This is a positive result in that it suggests that using the NLCD database to calculate imperviousness provides essentially the same result as a more rigorous aerial photograph analysis would. However, a mean near zero does not provide information about the variance in the data comparison. Therefore, the standard deviation of the error is proved as well. The results are tabulated below in ***Table 2-6***. All values in this table area based on impervious areas as percents.

In areas where the standard deviations are high, there were a large number of cells for which the database and the photography are not a close match. There are multiple reasons for the large variation in the percent imperviousness for these areas;

1. Trees obscuring the view of actual roadways;
2. Ponds/pools in residential area which could be interpreted as pervious land;
3. Pervious land near a parking lot being interpreted as part of impervious parking lots;
4. Small impervious areas such as concrete walkways, driveways, etc. within a residential community not being taken into account due to lack of clarity when magnified in GIS;

Additionally, there are many cells with a database value of zero, where the value from the aerial photograph was 100% and vice versa. For the DPS13, DPS 15, DPS 11, DPS Amid, and DPS Lake Forest drainage areas, a large number of database cells were grouped together and given impervious values of 100 percent. The following are possible explanations for this:

1. The database represented a water body (100 percent imperviousness) and could not be verified by the aerial image due to lack of clarity;
2. The database represented a swamp or a marsh (100% imperviousness) and the aerial is dominated by tree top (vegetation) which resulted in a misinterpretation of 0% imperviousness;
3. The aerial showed a water body that did not exist at the time the database was built.

Table 2-6: Summary of Percent Impervious Analysis

	Drainage Area	Mean	Standard Deviation	Error Range
	East Bank			
	DPS-01	1.4	7.7	0.0 22.6
	DPS-02	2.5	11.5	0.8 - 29.8
	DPS-03	0.2	5.1	0.0 10.7
	DPS-04	0.4	5.0	0.0 12.9
	DPS-05	0.4	4.3	0.1 - 10.8
	DPS-06	2.4	6.0	0.0 - 16.3
	DPS-07	4.0	8.1	0.2 – 25.0
	DPS-12	1.0	4.3	0.0 - 12.5
	DPS-17	2.3	3.3	0.4 - 6.6
	DPS-19	0.0	4.7	0.2 - 12.7
	New Orleans East			
	DPS AMID	4.4	18.2	0.3 - 51.3
DPS Lake Forest	DPS-10	3.2	10.4	0.4 - 25.6
	DPS-14	1.2	24.8	0.5 - 93.3
	DPS-16	1.2	8.5	0.3 - 22.5
	DPS-15	3.1	14.2	0.0 - 45.4
	DPS-18	5.8	18.3	0.7 - 40.6
	NASA	2.5	6.8	0.0 - 15.5
	West Bank			
	DPS-11	4.3	10.9	0.0 – 28.3
	DPS-13	0.0	6.5	0.0 - 31.3

The range of the error shows the error as distributed in all drainage areas. The table also shows that in areas such as DPS-13, DPS 15, DPS 11, DPS Amid, and DPS Lake Forest, the high end of the range is very high, which is attributed to the reasons mentioned above. For the remaining areas, the range of error is within acceptable range.

Section 4
System Assessment Summary

4.1 Overview

This section summarizes the hydrologic and hydraulic (H&H) model results for the NO DPW drainage system under existing conditions using SWMM. The existing conditions model simulations represent the anticipated performance of the subsurface drainage system throughout the service area with consideration of surface storage and conveyance. ***Volume I, Section 2*** describes the SWMM setup for existing conditions and the calibration of the pilot model. These calibrations were applied to all 15 models of the City drainage system and the models were run for the 2-Yr, 5-Yr, 10-Yr, and 100-Yr 24-hr design storms as described in ***Volume I, Sections 1 and 2***. The results of each model are presented in ***Volume II*** of this report. A summary of these results is presented below.

4.2 Existing System Assesment

Table 4-1 presents a summary of the model characteristics for the existing system.

Table 4-1: Summary of Model Characteristics

Area	Model	Area (Ac)	No. of HUs	Miles of Pipe[1]	No. of Links[2]	No. of Nodes[3]
East Bank	DPS 01	5,482	2,175	192.0	3,253	2,824
	DPS 02	1,585	513	40.8	969	840
	DPS 03	2,854	1,004	87.3	1,476	1,457
	DPS 04	4,991	1,691	128.9	2,324	2,330
	DPS 06	2,876	882	61.2	1,373	1,317
	DPS 07	2,531	728	58.7	1,328	1,230
	DPS 12	1,064	327	31.9	706	603
	DPS 17	420	155	9.4	234	230
	DPS 19	2,141	573	42.1	939	877
NO East	DPS 05	1,359	513	34.9	813	741
	DPS 10	2,105	717	54.1	925	1,089
	DPS14	1,852	670	45.3	954	1,158
	DPS16	2,637	805	57.5	1,166	1,278
	DPS 18	786	234	21.5	420	392
West Bank	DPS 13	5,197	1,723	285.3	2,726	2,767
	Total	**37,880**	**12,710**	**1,162**	**19,462**	**18,940**

1. Miles of pipe as modeled, actual length of pipe may be larger due to smaller sizes not being included.
2. Subsurface links (representing pipes) only. Overland links are not included in total.
3. Nodes include simple junctions and storage junctions, but not outfalls.

4.3 Results for Existing Condition Simulations

The results presented herein represent the drainage system in a well-maintained condition, with smooth pipes and no obstructions. Actual flooding may be significantly worse for systems that have damaged pipes, clogged catchments, and/or significant siltation.

Table 4-2 presents a summary of the number of model nodes flooded at the peak of the storm to greater than six inches above the inlet rim. Each model node may represent multiple catchments and/or inlets to the PSMS. The number of flooded nodes approximates the number of street intersections that are expected to flood.

Table 4-2: Summary of Flooded Nodes

Area	Model	Number of Flooded Nodes*			
		2-Yr Event	5-Yr Event	10-Yr Event	100-Yr Event
East Bank	DPS 01	685	1,262	1,769	2,651
	DPS 02	124	231	336	697
	DPS 03	246	478	566	967
	DPS 04	299	708	868	1,687
	DPS 06	114	311	480	948
	DPS 07	350	596	735	1,108
	DPS 12	90	194	275	520
	DPS 17	17	39	64	144
	DPS 19	199	361	485	732
NO East	DPS 05	96	264	719	698
	DPS 10	137	287	340	599
	DPS 14	26	48	63	191
	DPS 16	100	230	288	568
	DPS 18	33	60	68	121
West Bank	DPS 13	361	710	992	1,922
	Total	**2,877**	**5,779**	**8,048**	**13,553**

* A node is considered flooded if the peak stage in the model simulation exceeds the rim elevation by 0.5 ft.

Table 4-3 estimates the miles of streets that are expected to flood in each service area for the four design storms. For this estimate, a street is considered flooded if at least 50 linear feet of the street is covered by at least six inches of water.

Table 4-3: Summary of Flooded Streets

Area	Model	Miles of Flooded Streets*			
		2-Yr Event	5-Yr Event	10-Yr Event	100-Yr Event
East Bank	DPS 01	55.8	100.8	146.5	247.3
	DPS 02	11.3	21.0	32.2	70.3
	DPS 03	9.2	24.2	30.8	51.4
	DPS 04	22.9	52.0	63.5	115.9
	DPS 06	8.9	22.4	34.9	83.2
	DPS 07	62.7	78.8	86.3	101.8
	DPS 12	15.3	23.4	26.8	35.2
	DPS 17	1.2	2.7	4.5	10.0
	DPS 19	18.3	27.3	34.9	140.6
NO East	DPS 05	18.7	35.9	46.6	60.8
	DPS 10	3.8	9.3	15.0	27.3
	DPS 14	2.3	7.7	9.0	25.0
	DPS 16	0.8	0.8	0.8	3.0
	DPS 18	1.7	3.2	4.9	3.9
West Bank	DPS 13	22.7	45.6	61.3	96.4
	Total	**256**	**455**	**598**	**1,072**

* A street is considered flooded if the peak stage in the model simulation exceeds the street elevation by at least 0.5 ft over 50 linear feet of street.

The results of the existing conditions simulations illustrate that the subsurface drainage system is inadequate for conveyance for the design event, a 10-year, 24-hour storm in the following service areas: DPS 01, DPS 02, DPS 03, DPS 04, DPS 05, DPS 06, DPS 07, DPS 10, DPS 12, DPS 13, DPS 16 and DPS 19.

The results of the existing conditions simulations suggest that most of the roads will be passable for the design event in the following service areas: DPS 14, DPS 17and DPS 18.

4.4 Reduced Pipe Diameters

The GIS inventory indicates that there are many locations in the city where the pipe diameters are reduced in size over short distances in the downstream direction within a given system. For example, the pipe diameter size may be increasing in the downstream direction from 18-inch to 21-inch to 24-inch, and then for one block the size may be 10-inches in diameter before resuming at 24-inches in the next block downstream. In some cases, this bottleneck may only be across an intersection.

It is possible that these locations only represent an inconsistency in the GIS inventory; however, it is likely that some are the results of incomplete projects or design. Fixing these bottlenecks, where they occur, should significantly improve the performance of the systems in these neighborhoods. Just fixing the GIS, where applicable, will improve the performance of the models.

A full list of these locations is provided in ***Volume I, Appendix B***. The number of locations with reduced pipe diameters per service area is listed in ***Table 4-4***. The majority occur in the large systems that comprise the East Bank. Some of these may indicate only minor changes in conveyance capacity, but are recommended to be verified and upgraded as necessary.

Table 4-4: Summary of Locations with Reduced Pipe Diameters

Area	Model	Number of Locations
East Bank	DPS 01	119
	DPS 02	18
	DPS 03	39
	DPS 04	17
	DPS 06	34
	DPS 07	18
	DPS 12	5
	DPS 17	4
	DPS 19	28
NO East	DPS 05	6
	DPS 10	5
	DPS 14	5
	DPS 16	1
	DPS 18	5
West Bank	DPS 13	19
Total		**323**

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Section 5
Capital Improvements Plan Summary

5.1 Overview

This section summarizes the hydrologic and hydraulic (H&H) model results for the NO DPW stormwater management system under proposed conditions using SWMM. The proposed conditions model simulations represent the anticipated performance of the revised conveyance systems throughout the service areas. These alternative solutions are designed to meet a level of service (LOS) such that the streets are not flooded for the 8.5 inch (10-year, 24-hour SCS Type III) design storm, as with the existing condition results, streets are considered flooded when peak stages of the simulations are greater than six inches above the inlet rim elevation.

Volume I, Section 3 of this report described the methodology used to analyze the alternative systems that are necessary to meet this proposed LOS. Due to the fully-developed nature of most of the city, these alternatives are primarily increases in pipe sizes and additional pipe networks, with some detention provided in areas where pipe could not be adequately increased to meet the LOS.

The full results of the proposed alternative models for each of the service areas are presented in ***Volume II*** of this report. A summary of these results is presented below.

5.2 Revised Conveyance System Assesment

As with the existing condition assessment, the results presented herein represent the stormwater management system in a well-maintained condition, with smooth pipes, and no obstructions. Actual flooding may be significantly worse for systems with blocked or damaged pipes and channels, clogged catchments, and/or significant siltation.

5.2.1 DPS 01 Service Area

In the DPS 01 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Nashville Avenue, Napoleon Avenue, Martin Luther King Jr. Boulevard, 3rd Street, Louisiana Avenue, Jefferson Avenue, Claiborne Avenue, and Broad Street were not revised in this alternative solution.

As discussed in ***Volume I, Section 3***, per the scope these large box culverts were treated as boundary conditions such that they could handle unlimited tributary flow for the 10-yr, 24-hr design storm and maintain hydraulic grades at or near the top of the box culvert (i.e., below grade). This is true for all DPS areas described below.

In practice, these major systems may not need to be upgraded; however, model simulations indicate flooding in the lower reaches of the DPS 01 model for the proposed system when these boundary conditions are removed. It is anticipated that increasing the capacity of Drainage Pump Station No. 01 would fix this flooding, although it is outside of the scope of this project to analyze this alternative.

Most of the S&WB systems that are smaller than the major box culverts listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system have increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with significant size increases is the one that serves the Marlyville – Fontainbleau and Gert Town neighborhoods from Walmsley Avenue to the northern boundary of the service area. Major increases in conduit size are made along Walmsley avenue from Broad Street to Pine Street, along Jefferson Davis Parkway from Walmsley Avenue to Thalia Street and then along Thalia Street out to Pine Street.
2. A total of 17 new pipes have been added to the service area where none previously existed, primarily to move water downhill from one major system to the next (where the major systems run perpendicular to grade).
3. Although the Broadmoor neighborhood is estimated to have the worst flooding in the existing condition, there are not extensive increases in pipe sizes in the lower portion of this neighborhood. The predicted flooding in this neighborhood is due to the lack of capacity in the S&WB system, especially at the hydraulic grade level of the rim elevations along Louisiana Avenue between Claiborne Avenue and Broad Street. This grade level is well below the top of the box culverts of the major S&WB lines in the area.

5.2.2 DPS 02 Service Area

In the DPS 02 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Loyola Avenue, St. Louis Street, and Broad Street were not revised in this alternative solution.

Some of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with significant size increases is the one that serves the Tulane – Gravier neighborhood along Poydras Street from approximately I-10 to Broad Street. Major increases in conduit size are made to move water downhill to the major S&WB line along Broad Street. The larger S&WB systems run “sidehill” to the northeast along Galvez Street, I-10, and Loyola Avenue to St. Louis Street. By adding a more direct downhill system to the northwest, the LOS may be met in a more cost effective way (i.e. the sidehill system would need to be made very large to meet LOS without this increase along Poydras Street).
2. A total of five new pipes have been added to the service area where none previously existed, primarily to move water downhill from one major system to the next (where the major systems run perpendicular to grade).

5.2.3 DPS 03 Service Area

In the DPS 03 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along U.S. 90, Bernard Avenue and the railroad south of I-610 were not revised in this alternative solution. A fixed stage boundary condition was used at the outfalls to the Florida Avenue Canal.

Most of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with significant size increases is the one that serves the Bayou St. John neighborhood from Hagan Avenue to the major S&WB system along U.S. 90. Multiple new pipes have been added as well as a major upgrade along Orleans Avenue.
2. A total of 38 new pipes have been added to the service area where none previously existed, primarily to connect separate systems and move water more efficiently.
3. Nearly all of the NO DPW system in this service area needs to be upgraded to meet the proposed LOS.

5.4.1 DPS 04 Service Area

In the DPS 04 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Paris Avenue, Prentiss Avenue, Peoples Avenue, St. Anthony Avenue (north of Prentiss Avenue), and New York Street were not revised in this alternative solution. A fixed stage boundary condition was used at the outfalls to the Peoples Avenue Canal as described in ***Volume I, Section 3***.

Many of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. In the low-lying areas between New York Street and Mirabeau Avenue, multiple neighborhoods would require major increases in pipe size to meet the proposed LOS, including: the Fillmore neighborhood, west of Paris Avenue and the Milneburg neighborhood on both sides of Prentiss Aveneue.
2. Major increases in the size of the existing system, as well as multple new pipes would be needed in the Desire Area along and south of Higgins Boulevard.
3. A total of 48 new pipes have been added to the service area where none previously existed, primarily to connect separate systems and move water more efficiently.
4. Portions of the Milneburg neighborhood that are estimated to have some of the worst flooding in the existing conditions model are not expected to meet the LOS in the proposed condition. The

predicted flooding in these streets is in part due to the lack of capacity in the S&WB system, especially at the hydraulic grade level (HGL) of the rim elevations in the lowest areas. These HGLs are well below the top of the box culverts of the major S&WB lines in the area. There are a couple of other intersections in the service area for which this is also true.

5.2.5 DPS 05 Service Area

In the DPS 05 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Florida Avenue, Jourdan Avenue and Tupelo Street were not revised in this alternative solution.

Most of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with significant size increases in the Lower Ninth Ward is along Caffin Avenue, essentially moving water downhill to the system along Florida Avenue.
2. In the Holy Cross neighborhood, some of the larger increases are along Andry Street, Caffin Avenue, Tupelo Street, and Reynes Street.
3. A total of nine new pipes have been added to the service area where none previously existed, primarily to move water downhill from one major system to the next (where the major systems run perpendicular to grade).

5.2.6 DPS 06 Service Area

In the DPS 06 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Lowerline Street, Claiborne Avenue, Oleander Street and Leonidas Street were not revised in this alternative solution. A fixed stage boundary condition was used at the outfalls to the 17th Street Canal and the DPS 01 Receiving Canal as described in ***Volume I, Section 3***.

Most of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with significant size increases is the one that serves the Audubon neighborhood between Magazine Street and St. Charles Avenue, adjacent to Audubon Park, southeast of Lowerline Street. Major pipe upgrades are need along multiple streets including some new pipe to meet the proposed LOS.
2. One of the systems with significant size increases is the one that serves the Leonidas neighborhood between Willow Street and Sycamore Place, northwest of Carrollton Avenue. Major pipe upgrades are need along multiple streets, including multiple blocks of Carrollton Avenue, to meet the

proposed LOS. Seven different streets, many for more than one block, would need new pipe to move water downhill to the next system.

3. A total of 34 new pipes have been added to the service area where none previously existed, primarily to connect separate systems and move water more efficiently.

4. There are a few locations in the service area where the proposed LOS could not be met, either because the boundary condition (top of the S&WB box) was higher than the street elevation (based on rim invert), or because the elevation of the low-lying area was very close to the HGL of the boundary condition and therefore the size of pipe necessary to meet the LOS was not deemed to be feasible.

5.2.7 DPS 07 Service Area

In the DPS 07 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Jefferson Davis Parkway, Orleans Avenue, Canal Boulevard and a few blocks of multiple others were not revised in this alternative solution.

Most of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with significant size increases is the one that serves the Mid-City neighborhood from I-10 to Palmyra Street and Carrollton Avenue and further southeast near Jefferson Davis Parkway. Major pipe upgrades are need along multiple streets, including multiple blocks of Banks Street, to meet the proposed LOS. Six different streets would need new pipe to move water to the more efficient systems.

2. Significant size increases are expected to be needed in the Lakeview neighborhood on both sides of the Major S&WB system along Canal Boulevard, from West End Boulevard to Orleans Avenue. Most of the improvements are north of Harrison Avenue, although there will still need to be major improvements as far south as Polk Street. Major pipe upgrades are need along many streets, including multiple blocks of new pipe.

3. A large number of new pipes have been added to the service area where none previously existed, primarily to connect separate systems and move water more efficiently.

4. There are a few locations in the service area where the proposed LOS could not be met, either because the boundary condition (top of the S&WB box) was higher than the street elevation (based on rim invert), or because the elevation of the low-lying area was very close to the HGL of the boundary condition and therefore the size of pipe necessary to meet the LOS was not deemed to be feasible.

5.2.8 DPS 10 Service Area

In the DPS 10 service area, model simulations indicate that about three quarters of the pipe networks would require upgrades to meet the proposed LOS. Unlike the service areas listed above, a good portion are adequately sized to meet this LOS.

A fixed stage boundary condition was used for the DPS 10 service area at the outfalls to the Morrison, Dwyer, Benson, Citrus, and Farrar Canals as described in ***Volume I, Section 3***.

Some of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with larger size increases is the one that serves the Read Boulevard East neighborhood along Warren Drive and Airwood Street.
2. Another system with larger size increases is along Crowder Drive between Lake Forest Boulevard and the Dwyer Canal.
3. A total of 16 new pipes have been added to the service area where none previously existed, primarily to connect separate systems and move water more efficiently. In this service area, new pipe has been added along Hickman Street, Brevard Avenue, Trapier Avenue, and Shubrick Street in the Little Woods neighborhood. These streets have no existing subsurface stormwater management system, which will be necessary to meet the proposed LOS. Similarly, new pipe has been added along Lakewind Drive and Hearthwood Drive in the West Lake Forest neighborhood.

5.2.9 DPS 12 Service Area

In the DPS 12 service area, model simulations indicate that many of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Robert E Lee Boulevard and Fleur De Lis Drive were not revised in this alternative solution.

A portion of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Compared to the neighboring service areas DPS 06 and DPS 07, there are relatively few major improvements to the existing systems:

1. In the Lakeshore – Lake Vista neighborhood, some larger increases are expected to be needed connecting Egret Street, Flamingo Street, and Dove Street to Robert E Lee Boulevard.
2. In the West End, between 32nd Street and 38th Street, many of the lines will need larger size increases than normal, although most of the West End needs some increase in pipe sizes.

5.2.10 DPS 13 Service Area

In the DPS 13 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Lamarque Street, L B Landry Avenue, Mardi Gras Boulevard, Eton Street, and Sunflower Street were not revised in this alternative solution. A fixed stage boundary condition was used at the outfalls to the Magellan, Algiers, Donner, and Norman Canals as described in ***Volume I, Section 3***.

Most of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. Two existing pipes were removed as flooding from a neighborhood north of Wall Boulevard was being conveyed to the neighborhood south of this road. By removing these pipes, each 30 inches in diameter, at Murl Street and Pace Boulevard, the neighborhoods could be upgraded with separate systems to meet the proposed LOS.
2. One of the systems with large increases in size was located along Bodenger Boulevard, Atlantic Avenue and Newton Street in the McDonogh and Whitney neighborhoods.
3. Another of the systems with large increases in size was along Plymouth Place and Somerset Drive in the Old Aurora neighborhood.
4. A total of 31 new pipes have been added to the service area where none previously existed, primarily to move water downhill from one major system to the next (where the major systems run perpendicular to grade).

5.2.11 DPS 14 Service Area

In the DPS 14 service area, model simulations indicate that less than 40% of the pipe networks would require upgrades to meet the proposed LOS. Therefore, this is one of the service areas with the best performing existing systems.

Fixed stage boundary conditions for the DPS 14 service area were used at the outfalls to the Morrison, Dwyer, Berg, Jahncke, Gannon, and Vincent Canals as described in ***Volume I, Section 3***.

Some of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. One of the systems with larger size increases is the one that serves the Read Boulevard East neighborhood along Bullard Avenue and Lake Forest Boulevard.
2. A total of 11 new pipes have been added to the service area where none previously existed, primarily to connect separate systems and move water more efficiently.

5.2.12 DPS 16 Service Area

In the DPS 16 service area, model simulations indicate that many of the pipe networks would require upgrades to meet the proposed LOS.

The major S&WB box culvert along Dwyer Road, west of the Dwyer Canal was not revised in this alternative solution. A fixed stage boundary condition for the DPS 16 service area was used at the outfalls to the Morrison, Dwyer, Lamb, Charles, and Lawrence Canals as described in ***Volume I, Section 3***.

Some of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. Some of the larger increases in pipe size required to meet the proposed LOS are located along: Crowder Boulevard, south of the Morrison Canal; Chantilly Drive, south of Dwyer Road; Pines Boulevard, west of the Lamb Canal; and Townsend Place, north of the Morrison Canal.
2. A total of 8 new pipes have been added to the service area where none previously existed, primarily to connect separate systems and move water more efficiently. In this service area, new pipe has been added along Seabrook Place, Chimney Wood Lane, Bridgehampton Drive and Rockingham Drive in the Little Woods neighborhood. These streets have no existing subsurface stormwater management system, which will be necessary to meet the proposed LOS.

5.2.13 DPS 17 Service Area

In the DPS 17 service area, model simulations indicate that many of the pipe networks would require upgrades to meet the proposed LOS.

Fixed stage boundary conditions were used for the DPS 17 service area at the outfalls to the Florida Avenue Canal as described in ***Volume I, Section 3***.

The S&WB system along St Roch Avenue would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. Some of the larger increases in size necessary to meet the proposed LOS are along Elysian Fields Avenue and Pleasure Street in the northern part of the service area, and along Arts Street, south of the Florida Avenue Canal.
2. One new pipe has been added to this service area, across Elysian Fields Avenue at Lafreniere Street.

5.2.14 DPS 18 Service Area

In the DPS 18 service area, model simulations indicate that many of the pipe networks would require upgrades to meet the proposed LOS.

Fixed stage boundary conditions were used for the DPS 18 service area at the outfalls to the Michoud Bayou as described in ***Volume I, Section 3***.

Although there are not many S&WB systems in the service area, most of the S&WB systems that are in the area would need to be upgraded, along with the NO DPW systems, to convey the additional flows to the Michoud Bayou (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Significant size increases were needed in the upgrades along Michoud Boulevard in the southern portion of the service area and from Chateau Court to the canal. Other large increases occur along Alsace Street, Nemours Street, Lemans Street, Biscay Street and Chateau Court.

5.2.15 DPS 19 Service Area

In the DPS 19 service area, model simulations indicate that most of the pipe networks would require upgrades to meet the proposed LOS.

In general, the major S&WB box culverts along Almonaster Avenue, and Louisa Street were not revised in this alternative solution. Fixed stage boundary conditions were used for the DPS 19 service area at the outfalls to the Florida Avenue Canal as described in ***Volume I, Section 3***.

Some of the S&WB systems that are smaller than those listed above would need to be upgraded, along with the NO DPW systems, to convey the additional flows to these major systems (additional flows occur when formerly flooded areas of the NO DPW system now increase conveyance to the S&WB system once upgraded).

Some items of note:

1. Significant size increases and new pipes were added along France Avenue near the eastern boundary of the service area, to provide parallel conveyance to the existing S&WB system along Alvar Street (which also was upgraded). Both systems convey water downhill (north) to the Florida Avenue Canal. Connecting sidehill (east-west) systems have been upgraded to connect the two systems.
2. Major upgrades are also made along Montegut Drive south of the Florida Canal and Alvar Street north of the canal.
3. A total of 13 new pipes have been added to the service area where none previously existed, primarily to move water downhill from one major system to the next (where the major systems run perpendicular to grade).

5.3 Probable Construction Costs

Table 5-1 provides the probable construction cost opinions that were developed for the revised conveyance systems of the 15 service areas. These probable construction cost opinions are of a preliminary level and includes a 25% contingency to account for multiple unknowns as well as 15% for engineering design fees.

Table 5-1: Summary of Probable Construction Costs

Area	Model	Costs*	
		NO DPW	S&WB
East Bank	DPS 01	$ 445,698,000	$ 177,708,000
	DPS 02	$ 166,060,000	$ 60,370,000
	DPS 03	$ 261,483,000	$ 133,525,000
	DPS 04	$ 454,459,000	$ 184,930,000
	DPS 06	$ 239,738,000	$ 96,360,000
	DPS 07	$ 250,490,000	$ 139,250,000
	DPS 12	$ 83,339,000	$ 54,670,000
	DPS 17	$ 21,892,000	$ 20,800,000
	DPS 19	$ 51,437,000	$ 117,530,000
NO East	DPS 05	$ 158,453,000	$ 61,750,000
	DPS 10	$ 161,369,000	$ 69,960,000
	DPS 14	$ 92,772,000	$ 96,070,000
	DPS 16	$ 193,429,000	$ 111,200,000
	DPS 18	$ 66,772,000	$ 54,010,000
West Bank	DPS 13	$ 489,959,000	$ 279,380,000
Total		**$ 3,137,350,000**	**$ 1,657,513,000**

* Costs include Road Rehabilitation, Pipe Rehabilitation, Contingency and Fees.

5.4 Alternative Options

In meeting the proposed LOS, the improvements described focus almost entirely on pipe capacity increases. Other measures, such as increased system storage, have the potential to help meet the proposed LOS while diminishing the need for pipe capacity increases. Some of these Best Management Practices (BMPs) are outlined within ***Volume I, Section 7***. The scenario described of meeting the LOS solely through pipe upgrades should act as a baseline against which other proposed strategies can be measured.

Section 6
Management & Maintenance Programs

Maintenance of the data collected and generated during the development of the Stormwater Management Capital Improvements Plan (CIP) will be essential to the continued improvement of stormwater management planning and design in the City of New Orleans. Similarly, the maintenance of the physical system will be critical to the beneficial use of the existing system and future system upgrades. This section describes the measures recommended to efficiently manage and maintain the data and physical systems that comprise the City of New Orleans Department of Public Works stormwater management systems.

6.1 Management & Maintenance Overview

The City of New Orleans Department of Public Works (NO DPW) is responsible for the stormwater collection and conveyance system that consists of lines that are less than 36 inches in diameter. The NO DPW stormwater management and maintenance responsibilities include design and development of the system as well as regular repairs to ensure the system continues to function well.

Data management and system maintenance work in concert with one another to improve the function of the stormwater system. Effective data collection and management help determine the best maintenance frequencies and practices. Regular inspection and maintenance adds more system data which allows for a better determination of needed system improvements.

Therefore, this section is divided into two principal focuses. First is the data management plan which lays out the fundamentals of system information collection. Second is the system maintenance plan which outlines the system inspection, operation and maintenance needs.

Data Management Plan

The purpose of the Data Management Plan is to outline the development of data management protocols and processes, as well as the resources needed to implement those processes. This plan presents information documenting the data used in development of the Stormwater Management CIP and its components as well as a long term approach to data management.

The objective of this Data Management Plan is to develop a series of data management processes which, when working in concert with one another, form a robust and cohesive data management system. This system then allows users to access accurate and complete information on the stormwater system. This objective will be achieved through identification and definition of the following elements of the system:

1. Resource needs (***Section 6.2***)
2. Protocols and processes for data management
    a. Data management information needs (***Section 6.3***)
    b. Data management collection protocols (***Section 6.4***)
3. Data management work plan (***Section 6.5***)

System Maintenance Plan

The Maintenance Division of NO DPW has a specific mission to maintain streets, bridges, and overpasses, as well as the secondary stormwater management system. The objectives of the stormwater management system preventive maintenance program are to:

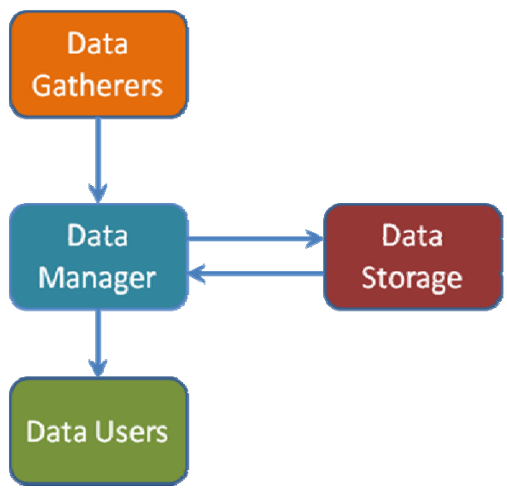
1. Assure functionality
2. Extend the life of the system
3. Preserve structural integrity
4. Reduce repetitive flooding caused by blocked stormwater drainage system components.

These goals may be achieved through the implementation of preventive maintenance activities as well as inspection and monitoring of both expected and unforeseen events. It is the intent of this ***Section 6.6*** to recommend preventive maintenance protocols and practices in order to support meeting these program objectives.

6.2 Management & Maintenance Resources

The success of a data management system will be impacted greatly by the ability to provide the resources needed to effectively staff, organize, and maintain the system. This plan will address the needs and make recommendations for the staffing of human resources, the purchase of computer hardware and software resources, as well as suggest available information resources.

Figure 6-1: Main Data Management Relationships



There is a wide variety of data sources that are available for collection and use in further development and maintenance of a stormwater management program. Implementing an organizational structure for routine data management is an essential piece of the puzzle in collecting, updating, and managing data.

This section of the report focuses on the identification and description of the roles and responsibilities recommended for the successful implementation of a data management program as it relates to stormwater management in the City. ***Figure 6-1*** shows the proposed flow of data through the data management program.

6.2.1 Personnel

Data Manager

The City uses geographic information system (GIS) technology as a component of their business operations. The primary aim of the GIS Services group is to support internal City staff in their ability to produce maps, charts, and graphs that allow the city government to operate more effectively and efficiently. The GIS Services group serves a very broad group on an incredibly wide variety of needs. Because information for stormwater management will be specific and widely ranging in scope, the NO DPW will need to maintain its own information that will also be integrated into the GIS Services Group.

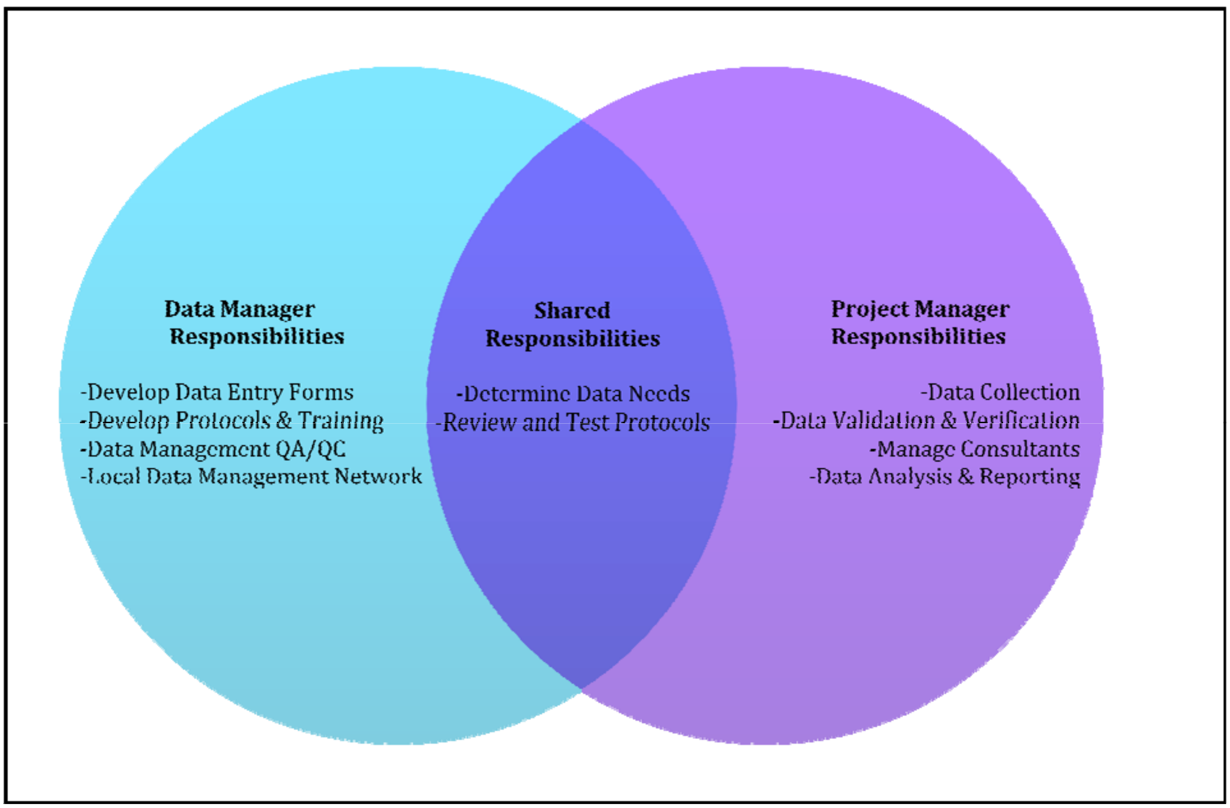
The position of Data Manager (DM) is the central position in ensuring a successful data management program. The DM has the overall responsibility to implement and enforce data management protocols. This includes acting as the conduit and control mechanism between data gathers/producers, data users, and data storage. The DM is responsible for data archiving, security, dissemination and systems design. Additionally, the DM, in collaboration with project managers and the Maintenance Manager, develops data entry forms to ensure quality and automatic report generation for specific reports. The DM is ultimately responsible for developing adequate quality control procedures within the data management system and ensuring that the appropriate data handling procedures are followed. Some other responsibilities of the data manager include:

1. Refining and maintaining the data management plan
2. Working with project managers to ensure that data sets are fully documented and validated
3. Maintaining data archives and appropriate documentation
4. Integrating tabular asset data with spatial data in the GIS
5. Maintaining and updating elements of the data network relevant to stormwater management data, and
6. Providing basic training in the use of GIS and other data management tools.

Project Managers

In the current organizational structure of the Department of Public Works, project managers (PM) play the role of coordinating the efforts of third-party consultants in the design and administration of construction projects. Their access to developing designs, proposed new developments, and as-built drawings establishes the project manager as a prime source of information. Under the proposed data management program, this responsibility will not change. Under the proposed program, the project manager would also be responsible for data collection, entry, verification, and validation as well as data analysis and reporting.

Figure 6-2: Data Management Responsibilities



Maintenance Manager

The Maintenance Manager (MM) is responsible for implementation of the preventive maintenance plan, outlined in ***Section 6.6***, and therefore controls the assignments of the inspectors, field crews, and third party contractors that regularly perform maintenance and inspections on the system. This role is therefore critical in the implementation of the data management program. Like the DM and PM staff, the MM should be trained in the use of GIS, spreadsheet, and database tools that are recommended for implementation of the data management program. Specifically, training in the overall goals of the data management program and how data will be used in applications is critical so that the MM can reinforce the importance of data collection and field-based quality procedures with field crews and third party contractors.

Field Staff

The field staff is a critical part of an effective data management program. Since field staff members have the most routine interaction with the stormwater surface assets, and the opportunity to observe subsurface assets through maintenance and repair work, they can provide critical input on the extent and accuracy of programmatic data. Field staff members are often the initial sources of information in the data management program. Incorporating NO DPW field staff can effectively multiply NO DPW's ability to collect useful field data by providing many sets of eyes that can continually inspect and verify field data. Providing City field staff members with the proper tools and training to optimize this opportunity should increase their value to the data management program and increase the value of the data management program to the City.

Non- NO DPW Staff

As is typical with most agencies, there is an opportunity for a large amount of collaboration between NO DPW staff and other City department staff. These other staff members can serve as an effective resource in gathering inspection and location information on system assets as well as enforcing and reporting on elements of the regulations that are suggested in other areas of the Stormwater Management CIP. These outside staff members fall into one of three categories:

1. ***General Observers*** This group includes any City staff able to provide first-hand observations of surface system condition as well as areas of flooding during rain events. Surface condition observations potentially include clogged/blocked catch basins, overflowing manholes, standing water, and raised/depressed catch basins. All City staff could provide observations on the system using a convenient electronic form. This form would be used to populate a database, which would be monitored and maintained by the DM. The DM would provide validated information to the MM and/or the PMs, as appropriate. A preliminary example of the form is included in ***Volume I, Appendix E.***

2. ***Trained Observers*** This group includes staff members that have been trained in stormwater programs and activities, and could include departments such as Parking Enforcement, and Parks and Parkways. In addition to the above general observations, this group would be expected to observe and report on violations of stormwater regulations. Staff would be provided with an increased level of training on the regulations and the proper methods of documentation needed to support enforcement actions. The form to be used for these observations would be the same as for general observation, with an additional section to document infractions. This information would be provided to the DM for validation and verification prior to any action being taken by NO DPW.

3. ***Data Gathers*** Data gathers represent the smallest group of City staff. This group represents staff from Safety and Permits that is tasked with completing forms and making detailed observations on a regular basis. These staff members could be provided with hand held computers which will allow them to collect information in the field as they go about their daily routine. At the end of

the day, the hand held device data could be uploaded to a central system that would be controlled by the DM for validation and processing.

Contractor Staff

NO DPW routinely has private firms under contract to provide a variety of services. The contractors' staff could be tasked with making observations that fall into any of the categories that are assigned to City department staff in addition to their primary duties, as an incremental cost to the services they provide. As members of contractor staff are deployed to perform inspections, preventive maintenance, and repairs throughout the system, it would be a valuable activity for them to use supplied handheld computers for logging field information to be uploaded and controlled by the DM.

6.2.2 Equipment

This section provides a list of general hardware and software resources necessary to accomplish the stated data management objectives.

Hardware

To implement the recommendations identified at the end of this document, it is suggested that the City invest in hardware specific for the management of the data collected and used by personnel in managing the stormwater management system. This section provides general equipment descriptions for some of the hardware elements of the data management system. Specific equipment specifications should be coordinated through the City's Department of Information Technology and Innovation. Product specifications for some elements are included in ***Volume I, Appendix C***.

Networking

The City maintains a robust computer network for sharing, processing, and storing data. It is recommended that a sub-network be created and dedicated to the personnel involved with stormwater management. The sheer volume of data that has been collected to date for development of the Stormwater Management CIP exceeds 20 gigabytes (GB). It is expected that this amount will grow greatly as elements of the Stormwater Management CIP are implemented.

It is recommended that a separate router, switch, and local server all be acquired for implementation of the Data Management Plan. The specifics of the equipment should be coordinated through the Department of Information Technology and Innovation. Network cards and equipment should be 1-gigabit to maximize local data access.

Workstations/Computers

Desktop workstations and/or laptop computers should be equipped with dual processors so that the complex Hydrologic and Hydraulic (H&H) modeling and GIS applications can be run efficiently and reliably. Desktop workstations configured for GIS and H&H modeling use should also be configured with dual monitors to simplify multi-tasking and the need to reference multiple applications or documents at the same time. Machines should be equipped with a moderately sized hard drive of at least 500 GB. Very large hard drives are not recommended as they could offer the opportunity for personnel to store working documents on machines that are not backed up. The machines should be equipped with the ability to burn and read CDs and DVDs as it is possible that project related files could become too large for transfer via e-mail.

Because many of the software applications that will be used for stormwater management are Windows based, it is recommended that desktop and laptop computers have a Windows or equivalent operating system as well.

Peripheral Equipment

In addition to the network and individual computing needs, there is also a need for several additional pieces of equipment to facilitate successful implementation of the Stormwater Management CIP. ***Volume I, Appendix A*** presents some of the options for large format printing, handheld computing, and digital photography. This document does not make any recommendations of one tool over another, but a needs analysis should be performed prior to acquiring any equipment.

Printing/Scanning

As implementation of the Stormwater Management CIP progresses, it will be necessary to prepare reports, maps, and other documents for communicating with stakeholders in stormwater management as well as for scanning inspection reports, as-built drawings, and other documents used to collect data on the system. To accomplish this, it is recommended that one or more large format printers be acquired to print system maps and GIS maps. It is recommended that the plotter have the capacity to output prints of at least 42-inches in width. This will give the capacity to print documents on E-sized sheets (42" x 44"). Popular brands are Océ and HP. Each vendor provides local service to New Orleans.

Handheld Computing

For NO DPW and outside staff that will be collecting inspection information, it is recommended that handheld computers be acquired for use in capturing information and uploading inspection information into the data management system. A series of computerized forms corresponding to the forms presented in the preventive maintenance plan could be developed and loaded into the handheld devices to provide for efficient and effective data collection. Alternatively, GIS-based applications could be developed that allow for both spatial data entry (usually by redlining) and/or similar form-based data capture. Redlining refers to the process of being able to "sketch" lines, point, text, etc. over the top of the GIS image to make field notes. Redline features can then be saved and provided to GIS data maintenance specialists to make corrections in the city geodatabase. Any form-based data capture in the field should make extensive use of pull-down menus and "data-driven selections" to maximize quality control in the field. There are various technological solutions, but the main features to consider are portability, GPS integration and compatibility with the wider data management system.

Photographic Data

Similar to the handheld computing tools, photographic data will be essential in validating and verifying inspection information, specifically if there are items of work that need to be addressed. Maintaining a collection of high resolution digital cameras will prove to be a valuable asset in documenting condition of the system and violations of regulations that may be established. It is important to establish a process for connecting the correct photograph to the correct location or asset in the system. This can be accomplished manually or in some cases using GPS-enabled cameras that capture the photograph location.

6.2.3 Software

Maintaining a software library that will allow the Data Manager and other NO DPW staff to utilize the tools developed for stormwater management and develop additional tools as necessary is equally important as maintaining the appropriate hardware tools in order to manage stormwater. The tools for stormwater management are not overly complex in nature. They are primarily centered on following proper data management protocols, described ***Section 6.4***. Generally, the software needs will fit into one of four categories:

1. General Computing
2. GIS Software

3. Modeling Software and
4. Miscellaneous Software

General Computing

General computing can be described as software applications used for everyday computer usage. Applications that facilitate spreadsheet analysis, track inspection information in a relational database, or generate correspondence fall into this category. The Microsoft Suite of applications including Excel, Access, Word, PowerPoint and others is suitable for all needs associated with this group of software.

GIS

The recommended GIS software components (some may already be present in NO DPW, or be available through shared licensing with other City departments) include:

1. A database management system (most likely *Microsoft SQL Server*) to store and manage the geodatabase repository
2. Enterprise GIS software (based on ESRI *ArcSDE* and *ESRI ArcGIS* Server) to serve as middleware to allow individual data maintainers and other users to access the enterprise geodatabase repository for data maintenance and analysis purposes
3. Desktop GIS software (ArcInfo, ArcEditor and/or ArcView) for data maintenance and viewing
4. Field GIS software (ArcServer Mobile or ArcEngine) for specialized field applications designed for either field-based data editing or synchronization and/or redlining applications. The former might be used by data editors working in the field to collect or verify data. The latter would be used by less advanced field observers to make notes in the GIS without affecting the actual GIS data.

From the standpoint of database software, the City's familiarity with and widespread use of *Microsoft SQL Server* makes it the most logical choice for implementation.

ArcSDE is a gateway that facilitates managing spatial data within a database management system. SDE stands for Spatial Data Engine. For the GIS implementation, *ArcSDE* will manage geographic information stored in *Microsoft SQL Server*.

ArcSDE can serve spatial data to *ArcGIS* desktop users *(ArcView, ArcEditor*, and *ArcInfo*), to Intranet or Internet users through *ArcGIS Server*, as well as to other applications. *ArcSDE* is also the key component to managing multi-user, multi-editor transactions with the centralized geodatabase across potentially multiple locations within the NO DPW.

ArcSDE provides the infrastructure required to manage multiple users editing the same spatial database with long transactions, alternate versions, and history. *ArcSDE* will handle the following functions for NO DPW:

1. Provides the business logic software for not only creating simple geometric data, but also technology for supporting advanced GIS data types such as images, networks, features with integrated topology and shared geometry, and associating these with rules, behavior, and other object properties
2. Allows GIS data to be directly maintained in the format of "spatial types" supported by the DM

CDM Smith recommends an enterprise GIS implementation environment based on ESRI and Microsoft products due to the widespread use of both products, which will allow for a relatively open environment wherein many potential companies can provide the resources necessary to assist the NO DPW in its GIS efforts well into the future.

In terms of field computing, the exact software to be used would be dependent on the actual field-based computing needs, which should be determined through a brief needs assessment study. In any event, field computing applications would typically not be implemented until after robust data maintenance processes are in place and successful.

Hydraulic & Hydrologic Modeling

The Stormwater Management CIP was created using the public domain Stormwater Management Model (SWMM) prepared and maintained by U.S. EPA. SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. SWMM tracks the quantity and quality of runoff generated within each runoff area, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

It was first developed in 1971, and has since undergone several major upgrades. SWMM continues to be widely used throughout the world for planning, analysis, and design related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas. The specific version used for the Stormwater Management CIP was SWMM 5. It provides a more robust integrated environment for editing study area input data, running hydrologic, hydraulic and water quality simulations, and viewing the results in a variety of formats than previous versions.

Miscellaneous Software

Miscellaneous software applications include those that may be useful for a variety of purposes. Some software should be installed on all users' computers for general use, some may be only necessary for certain individuals. Sample software packages include:

1. Adobe Acrobat Professional – used by stormwater personnel with a need to produce PDF format files from various sources, primarily from Microsoft Office projects
2. Adobe Acrobat Reader – used by all personnel to enable reading of PDF files – this software should be available as a free download from Adobe
3. Image viewing software – most new computers will come with some form of image viewing software pre-installed. Many digital camera purchases will also include useful photo viewing software
4. Microsoft Project or similar – used by stormwater project managers to track and measure project workloads and progress
5. Visio – used by Data Manager to make modifications to the geodatabase data model when necessary

6.3 Data Management Information

Understanding all of the data types and sources is essential for efficiently and effectively using the data for stormwater management. This section presents a description of both the data classifications and some of the current data resources.

6.3.1 Classification

The information currently available for use in stormwater management can be classified into five groups:

1. Physical data
2. Operational data
3. Hydraulic data
4. Hydrologic data
5. Other Project data

Each group focuses on a different area that includes a unique set of activities.

Physical Data

This data set includes the physical characteristics of the land surface topography, imperviousness, and stormwater management system assets, e.g., pipes, inlets, and manholes. In general, the physical data sources include NO DPW drainage network maps, existing GIS files, NO DPW standard details, field observations, previous studies and reports, and interviews with NO DPW staff. Specific data fields include the asset dimensions (diameter, length, structure type, etc.). The physical data was used to build the computerized representation of the drainage network which serves as the backbone of the hydraulic model. Physical data is most frequently stored in a GIS database and therefore also includes spatial data that define the physical location.

Operational Data

This data set consists of data with a one to one correspondence to the physical asset data, but with a focus on operations and maintenance, and asset management. This might include data indicative of condition and criticality for each asset. Frequently, operational data also includes an operations and maintenance history that is stored in a Computerized Maintenance Management System (CMMS) and linked to the GIS.

Hydraulic Data

Hydraulic data measured in the field or estimated based on best practices. Examples include flow rate in a pipe or depth and velocity of stormwater through a pipe, channel or inlet. The hydraulic data was used in simulating various model runs to evaluate the hydraulic capacity of the stormwater drainage system. The model is used to calculate peak stages, flows and velocities, which could subsequently be linked back to the GIS data and stored for future reference.

Hydrologic Data

This data consists primarily of the characteristics of storm events and runoff. These characteristics include intensity, duration, frequency and distribution of storm events. Rainfall data was captured through measurement of precipitation (depth and time) in several locations around the city. The hydrologic data collected in this project was used to build Hydraulic and Hydrologic (H&H) model and in the determination of design storm to evaluate and analyze the stormwater drainage system network. Future efforts to provide long-term rainfall monitoring would also be stored as hydrologic data.

Other Project Data

Data sets that do not fall in any of the previous three data groups can be classified as other project data. Example of such data include data related to cost projections such as unit costs, cost types, cost assumptions, as well as scheduling data such as project and activity duration. Other data also includes miscellaneous data such as entities/department names, date of specific events, age of assets, priority rating score, project identification number, etc. The other project data set is utilized throughout this project and was critical in development of the Stormwater Management CIP.

6.3.2 Sources

Data to be incorporated into stormwater management planning is available from a variety of sources:

1. Construction Reports
2. As-built Drawings
3. Inspection Reports
4. Existing Paper Maps
5. Geographic Information Systems

Construction Reports

When projects are constructed, contracted resident inspectors prepare daily reports of the work accomplished. Specifically, these reports document the exact length, size, and material of the pipe that is installed.

As-Built Drawings

As construction projects are completed, consultants typically are required to prepare a set of As-Built drawings to document, in a computer-aided drafting and design (CADD) format, any deviations from the As-Bid drawings that were produced during the construction phase. Typical changes include: modification in pipe diameter, changes in pipe slope, slight re-routing to accommodate utility and other conflicts, and the addition or deletion of work.

Field Inspection Forms

As preventive maintenance efforts are undertaken, reports and other documents used to identify the facility addressed in the preventive maintenance effort as well as the condition, and any corrective measures taken will be generated. These forms will be essential in helping to determine the effectiveness of the preventive maintenance program.

Existing Paper Maps

A collection of approximately 440 drainage maps exist in a paper format to document the stormwater management system within the City. Currently, these maps represent the only complete documentation of the drainage system.

Geographic Information System

Following Hurricane Katrina in 2005, a GIS data set was developed based on the paper maps. This GIS data set became the basis for the development of the Hydraulic & Hydrologic (H&H) model. The initial GIS data set was not properly projected and the system does not include many of the attributes that could make it a more valuable tool in stormwater management. Much of this information can be collected through use of the data collection group/methods described above.

6.4 Data Aquisition

6.4.1 Data Flow Models

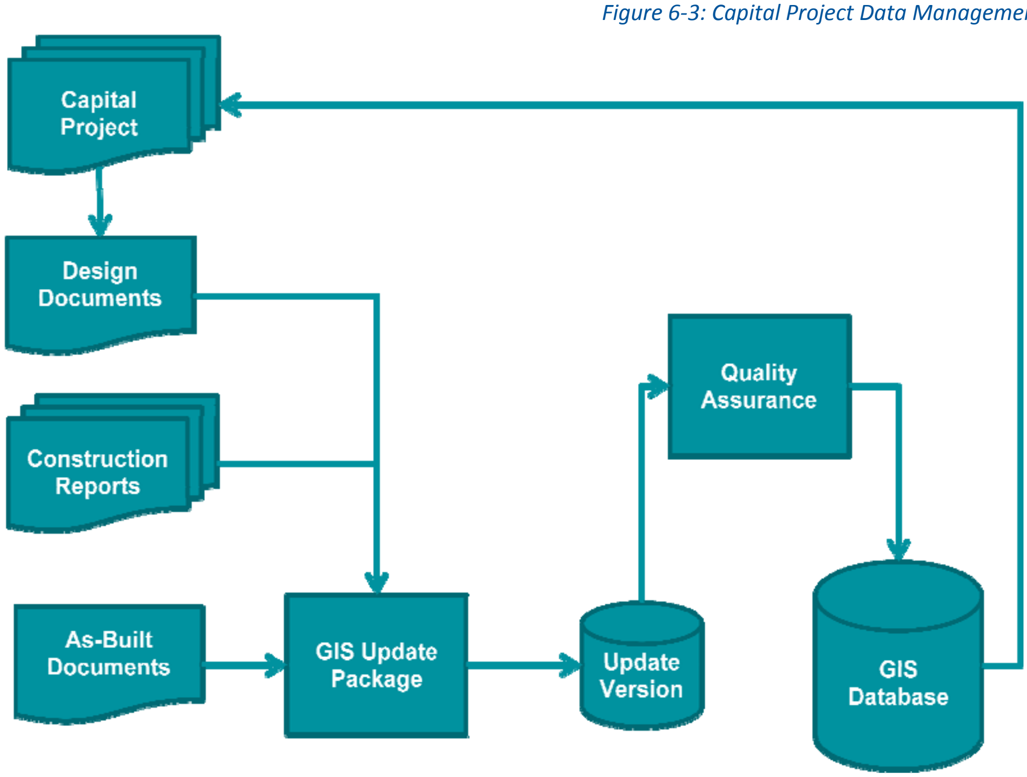
Currently, as described earlier, NO DPW has developed a GIS data set representing the stormwater information depicted on paper maps, but not all attributes have been captured. Additionally, the system may not be capturing changes to the stormwater infrastructure as they occur. To manage data needs, availability and cost, CDM Smith recommends a "management system" approach wherein the existing data gaps are identified and systematically addressed through regular, documentable progress.

Capital Projects

At the core of a management system approach is the identification of the routine methods in which the existing data can be improved. One way is for the construction of new capital projects to be captured efficiently and accurately into the GIS database. ***Figure 6-3*** below illustrates the activities and data sets produced during a typical capital project, and how data flows into the GIS database.

A capital project will produce a set of design documents, construction reports and as-built plans. This information becomes a package that can be assembled and reviewed to add the new infrastructure information into the GIS and related data management systems (such as a CMMS) as applicable. It is recommended that a GIS technician or operator perform these updates in a version of the enterprise geodatabase, that can then be checked by the Data Manager (quality assurance) before the updates are added into the geodatabase.

Figure 6-3: Capital Project Data Management Process



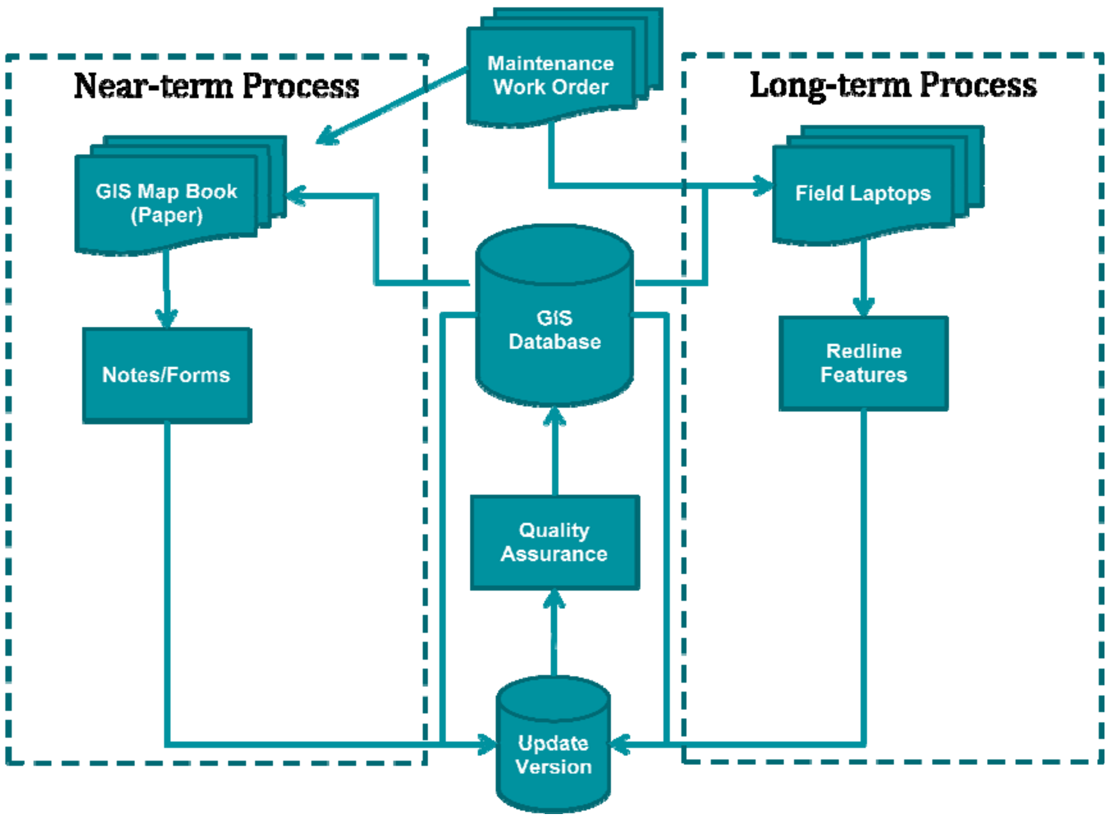
It is important to manage this process both in terms of the length of time that it takes to get an as-built produced (normally reliant on contractors) and in managing the backlog of completed plans that need to be added to the GIS. We have seen a number of agencies and utilities fall significantly behind on GIS updates (even years), which normally results in the need for a sizable outsourcing contract to catch up. One way around this is to add the data at the design phase and to then make updates after the as-built is produced, but this needs to be carefully managed so that users can understand which facilities shown in the GIS are actually in the ground versus planned.

Another recommendation is to establish a digital submittal standard so that design drawings and as-built plans coming in from contractors are formatted in such a way that they can be more easily integrated into the GIS by technicians. Such a standard would include a CADD format deliverable (mostly coordinates and layering scheme) and alternatively a GIS format deliverable.

Maintenance Projects

Each maintenance event presents an opportunity to inspect infrastructure and to confirm or add to the details captured in the GIS. ***Figure 6-4*** illustrates a near-term and long-term model for capturing the information that may be learned during these visits and incorporating it into the GIS. In the short-term, inexpensive field tools could include a map book that can be marked up as necessary in the field. A map book would be a GIS generated set of maps very similar to the existing paper maps. Field staff could mark up the maps and/or fill out forms to indicate additional or changed data in the field.

Figure 6-4: Maintenance Project Data Management Process



In the longer term, we recommend that each crew be outfitted with a GPS-enabled field computer that includes red-lining tools. Red-lines can be provided back to GIS staff in geographic format such that they will load into the GIS at the correct locations, and can then be used in updating a new version of the GIS, much like the capital project workflow.

Maintenance staff should be trained in the importance of an accurate GIS to the overall program and their insight sought in establishing the field procedures.

Other Observers

Section 6.1 presented information on other potential observers that could contribute information to a GIS program in support of stormwater management. Some of the specific tools recommended for these users are more consistent with the more mature phases of a program. These include:

1. A web-based GIS site where any observer could provide data to NO DPW staff. This could be done in a system wherein an observer navigates a map to a specific location using address or intersection data, places a point related to an observation, and optionally attaches other documents or photographs to the point. Uploaded information would be checked and verified by NO DPW staff before being loaded or formatted to be viewable by others. Observations could include high water levels, maintenance issues (such as a clogged inlet) or other observation. Very simple web sites can be specifically tailored to assist with this type of data gathering.
2. Trained observers or contractors could use or be supplied with custom tools to collect field data in a similar manner, using a combination of GPS-enabled cameras, field computers and/or forms. Most data from this type of observer could come in from red-lined documents. Red-lining capabilities should also be provided in a web site similar to the above, for more advanced users.

6.4.2 Data Evaluation

Data can be evaluated to serve several roles in an effective data management program as described below.

System Condition

Once a basic GIS is in place that contains attributes such as year built and construction material, a first evaluation of system condition should be automated using these attributes and known maintenance experience.

Over time, pipe condition ratings should be expanded upon through procedures such as facility inspections and/or televising, using an agreed upon standard defect system such as that established by the National Association of Sewer Service Companies (NASSCO).

System Criticality

A criticality rating should be established for each feature using a system of metrics geared toward the consequences of an asset failure. Data that should be easily available to establish an initial rating include asset size and location – for example, a 30-inch pipe that is located in a Central Business District or is under the street that is the only entrance to a hospital would have a higher criticality than an 8-inch collector in a residential neighborhood.

Together, criticality (consequence of failure) and condition (likelihood of failure) constitute two attributes that can direct operations and maintenance funding decisions, particularly in the beginning years of a utility program when available funding for maintenance and repairs is limited.

6.4.3 Data Verification & Validation

There are two types of data verification that may occur. One type is for a NO DPW staff person to verify data that is coming in from outside observers, normally in the form of photos documenting violations, or in some other attribute that provides critical information that should be checked by a NO DPW employee prior to being logged permanently in the GIS database. This can be achieved by training GIS staff to identify which types of incoming data must be verified before incorporation into the GIS or related databases.

Data validation or quality assurance is used to ensure that data being added to the GIS database meets a specific accuracy tolerance. A tolerance is usually established in the 95% to 99% range. CDM Smith recommends that an American National Standards Institute (ANSI) standard for quality assurance be taught to and applied by NO DPW staff. This standard allows quality assurance to be applied by specifying a random sample of attributes and features that must be checked manually prior to accepting data into the database. The size of the sample is a function of the desired quality level and the total size of the data update. Each sample will have an allowable number of errors – if the allowable number is exceeded, then the delivery will be rejected and procedures must take place to improve data quality. If the allowable number of errors is not exceeded, then any errors identified will be corrected and the new data will be incorporated into the GIS.

6.4.4 Data Maintenance

Data will be maintained by NO DPW staff that has been trained in the use of ESRI ArcGIS technology for stormwater data maintenance. In the short term, this may be only one staff person supplemented as necessary with contractor staff, depending on the total load of new information entering the GIS database. In some cases, CDM Smith has performed the database management, version functions, and quality assurance while training our clients in the application of the GIS technology. After the basic maintenance tools have been mastered, enterprise hardware and software can be installed and more advanced training on taking over the whole process can be established. This approach is consistent with a stormwater utility implementation wherein funding will be lighter in early years and will allow for technological advances in later years.

Versioning refers to the ability of ArcGIS to store and work with more than one version of the GIS. The way this works is that a contractor could manage and maintain a centralized GIS database for NO DPW. When updates need to be made, a "check-out" version is created that represents a copy of the GIS database. NO DPW staff will be trained on and work on this copy of the GIS database to make changes. Contractor staff will apply quality control procedures against the copy, using the available source documents to manually check and accept (or reject) the updates. Rejected data and in fact any consistent errors will be identified and the contractor will work with NO DPW staff to understand the types of errors occurring to provide continuous improvement in the data quality. Once a database copy has passed quality assurance, it is "checked in" to the centralized GIS database and the new data is appended to or supersedes the original version. Multiple versions can be maintained in the ArcGIS environment, so it is possible for multiple users to be editing their own versions simultaneously over an extended period of time, and to reconcile and integrate those versions into the centralized GIS database.

6.4.5 Data Storage

Data will be stored primarily in an ArcGIS enterprise geodatabase. Ideally, a current copy of the data can be stored and managed by the City of New Orleans Information Systems Department and used for any internal City needs. At the same time, the "live" database would be stored and managed by a contractor and this version would be used for training and maintenance purposes, as described in the above section. The contractor supporting the process would periodically, perhaps quarterly, provide an update to the City GIS department. Both the City GIS and offsite GIS database should be routinely backed up in the event of a catastrophic hardware failure.

6.4.6 Data Dissemination & Availability

Data are normally provided to outside users in one three ways:

1. **Web site.** A web site can be "open" or password protected and further could be hosted on the Internet so that any user with the proper link and credentials could see it, or on an Intranet so that only internal City users could see it. Most web sites would be used primarily for *viewing* data only, and would include functions for zooming to a specific address or street to streamline the process of locating the area of interest. NO DPW should develop policies concerning who can see what types of stormwater data on internal or external facing web sites. This can be a function of the Steering Committee and Data Manager.
2. **Local copy**. This could be a secure FTP site where data are stored, or data provided as e-mail attachments or on a CD or DVD. Local copies are most often used in support of projects that

benefit or are contracted by NO DPW – for example existing GIS data might be provided to a contractor that is developing a new stormwater design for the City that will tie into the existing stormwater system.

3. **Paper maps.** Paper maps are most often used for public inquiries at an information desk and can be printed quickly for an area of interest using a MapBook application. Like a web site, paper copies allow viewing of the information but no direct data access.

Overall, how NO DPW data are distributed and/or made available to other parties should be a function of NO DPW decisions, and normally these decisions would be made by a GIS Steering Committee and carried out by the Data Manager.

6.4.7 Data Management Infrastructure

To implement the recommendations identified elsewhere in this document, it is suggested that the City invest in hardware and software specific for the management of the data collected and used by personnel in managing the stormwater management system. This section provides general equipment descriptions and planning level costs for some of the hardware elements of the data management system. Specific equipment specifications should be coordinated through the City of New Orleans Department of Information Technology and Innovation. ***Table 6-1*** below provides specific hardware and software recommendations over the next four years. Recommendations assume a gradual start into GIS data maintenance and applications with an enterprise GIS environment established during years three (2013) and four (2014).

Table 6-1: Hardware and Software Recommendations

Year	Item	Purpose	Cost
2011	Desktop Workstation (2)	Data maintenance	$ 8,000
2011	ArcGIS ArcEditor (2)	Data maintenance	$ 15,000
2011	Replacement Plotter	GIS production	$ 15,000
		Total 2011	**$ 38,000**
2012	Large Format Scanner	Scan plan sheets for digitizing	$ 15,000
2012	Laptop Workstation (1)	Laptop for Data Manager	$ 4,000
2012	ArcGIS ArcInfo	Advanced GIS capabilities	$ 12,000
2012	ArcGIS Spatial Analyst (2)	Enable GIS grid analysis	$ 6,500
2012	ArcGIS 3D Analyst (2)	Enable GIS 3D analysis	$ 6,500
2012	Data Interoperability (2)	High-end CAD to GIS capability	$ 6,500
2012	Field Laptop	Pilot field data capture	$ 5,000
2012	ArcGIS Server Mobile	GIS software for laptop	$ 5,000
		Total 2012	**$ 60,500**
2013	Database Server	Store enterprise GIS data	$ 25,000
2013	ArcGIS Server/ArcSDE	Manage enterprise GIS data	$ 25,000
2013	Database Software	Database solution for GIS	$ 25,000
2013	RTD Grade GPS (2)	Capture field data	$ 12,000
2013	Field Laptop (5)	Production field data capture	$ 25,000
		Total 2013	**$ 112,000**
2014	GIS Application Server	Production server	$ 30,000
2014	Database Software	Database for application server	$ 25,000
2014	Desktop Workstation (2)	Replacements for 2011 desktops	$ 8,000
		Total 2014	**$ 63,000**
		Program Total	**$ 273,500**

Support needs relative to the above hardware and software implementation, and estimated outsourcing costs, are presented at the end of this section. Some support may be available through other City departments or programs at reduced costs.

6.5 Work Plans

This section describes the intended NO DPW self-performance capabilities at the end of each year of a four-year implementation cycle. Consistent with the philosophy applied elsewhere in this document, the overall approach is to implement within a management system framework, with identifiable progress made each year consistent with funding availability and the time needed to implement more robust processes.

6.5.1 Data Collection & Management Work Plan

Below is the work plan for the next four years that will advance NO DPW toward implementation of efficient GIS data collection and management

2011 Work Plan

By the end of 2011, NO DPW will make the following progress related to GIS data collection and management:

1. Two staff equipped with new computers and GIS software, and capable of several GIS data maintenance processes working against a personal geodatabase or shape files
2. Capability to geo-reference a scanned document, capture spatial data and attributes from the document into the GIS, and to link the scanned document to the features in the GIS
3. Capability to retrieve red-line features and to incorporate the notes and changes reflected into the GIS
4. Capability to perform basic GIS vector analyses (intersect, clip, dissolve, etc.) on demand and to produce high quality maps indicative of results
5. Capability to produce a map book of stormwater infrastructure represented in the GIS, with annotations.

2012 Work Plan

By the end of 2012, NO DPW will make the following progress related to GIS data collection and management:

1. GIS Steering Committee and Data Manager in place to guide further decision-making relative to the stormwater GIS program
2. Staff will manage an impervious cover GIS database that is used to determine stormwater utility fees for non-residential properties
3. Capability to scan documents in-house in support of the stormwater management program
4. Capability to work in a check-out, edit, check-in environment with enterprise GIS database management services performed by outside consultants or another City department
5. Capability to work with more advanced GIS extensions such as Spatial Analyst for grid processing, 3D Analyst for three-dimensional work and the Data Interoperability Extension for more direct CADD to GIS conversion
6. Capability to test field data procedures using a field laptop

2013 Work Plan

By the end of 2013, NO DPW will make the following progress related to GIS data collection and management:

1. Capability to take over and manage an enterprise GIS database in-house, together with application of quality assurance procedures and the check-out and check-in process
2. Capability to use real time field GPS units for data capture related to the stormwater management program
3. Capability to oversee field data collection process for maintenance staff and others using field laptop computers
4. Capability to train maintenance staff and other users in the applications associated with GPS and field computers

2014 Work Plan

By the end of 2014, NO DPW will, in addition to the above achievements, be managing their own internal application server for departmental and/or citywide intranet applications.

6.5.2 Data Dissemination Work Plan

Below is the work plan for the next four years that will advance the NO DPW toward implementation of an efficient data dissemination program

2011 Work Plan

During 2011, data dissemination will be primarily by providing local copies of data on CD or DVD, or as e-mail attachments. If funding permits, a simple web site for data viewing may be constructed and operational, and hosted by another City department or externally.

2012 Work Plan

By the end of 2012, a robust web viewing tool will be available for a user base as determined by the GIS Steering Committee and implemented by the Data Manager. This tool may be hosted in-house for internal use only, on the Internet, or by a third-party contractor. File transfer protocol (FTP) access may also be provided for larger data sets. Further, paper maps will be available for walk-in requests, consistent with data dissemination decisions made by the GIS Steering Committee.

2013 Work Plan

By the end of 2013, NO DPW will be capable of disseminating data through a variety of methods as desired by the GIS Steering Committee and implemented by the Data Manager. This will include robust capabilities to manage the check-out, quality assurance and check-in process for versioned databases that are being worked on by qualified outside contractors and NO DPW or other authorized City staff.

6.5.3 Contractor Support

The NO DPW may require outside support for certain activities related to the implementation of stormwater management programs, especially in the areas of data and skills acquisition. ***Table 6-2*** outlines potential contractor support activities and order-of-magnitude costs associated with these activities.

Table 6-2: Contractor Support Activities

Year	Item	Cost
2011	Hardware/Software Specification and Installation Support	$ 5,000
	Geodatabase Design	$ 20,000
	Basic GIS Training (Hands-on, three sessions)	$ 15,000
	Customized GIS Data Maintenance Training (six sessions)	$ 30,000
	Total	**$ 70,000**
2012	Aerial Photography and Planimetric Mapping	$ 200,000
	Hardware/Software Specification and Installation Support	$ 10,000
	Advanced GIS Training (Hands-on, three sessions)	$ 15,000
	Customized GIS Data Maintenance Training (six sessions)	$ 30,000
	Initial Web Application Development	$ 20,000
	Initial Field Application Development	$ 15,000
	Total	**$ 290,000**
2013	Hardware/Software Specification and Installation Support	$ 10,000
	Advanced GIS Training (Hands-on, two sessions)	$ 10,000
	Customized GIS Data Maintenance Training (six sessions)	$ 30,000
	Continued Web Application Development	$ 20,000
	Continued Field Application Development	$ 15,000
	Total	**$ 85,000**
2014	Hardware/Software Specification and Installation Support	$ 5,000
	Miscellaneous GIS Training and Support	$ 20,000
	Continued Web Application Development	$ 15,000
	Continued Field Application Development	$ 10,000
	Total	**$ 50,000**
	Program Total	**$ 495,000**

6.6 Preventive Maintenance

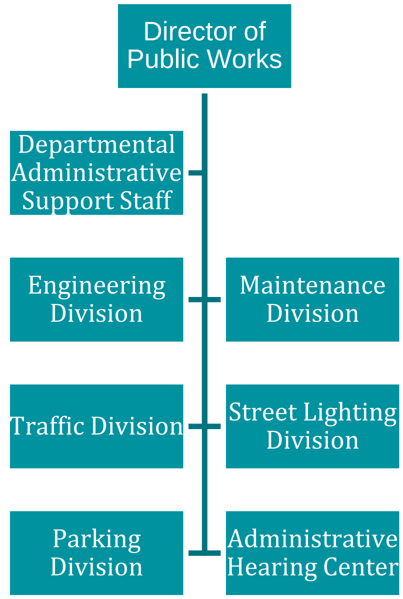
A one day workshop was held on January 20, 2010 with the purpose of providing an open forum for communication, obtaining input on current operational processes, and discussing modifications and new processes. The goal was to reach a consensus on recommendations. During the workshop the Maintenance Program, Design Standards and Guidelines and Data Management were explored. A questionnaire was presented to obtain insight on the NO DPW Planning Review Process, Guidelines for Drainage System Permits, and Maintenance Procedures. The questionnaire was completed and offered in a hard copy to those who were not able to attend. Results of the survey are included in ***Volume I, Appendix D***.

Preventive Maintenance Program research of other municipalities and public entities was conducted through phone interviews, internet research and the questionnaire. In Louisiana the City of Shreveport, Jefferson Parish, the City of Baton Rouge, and the City of Slidell were contacted regarding their Maintenance Programs. Maintenance Programs from throughout the country were also studied, including Stormwater Management Programs from the States of Tennessee, Georgia, and Nevada.

6.6.1 NO DPW Organization

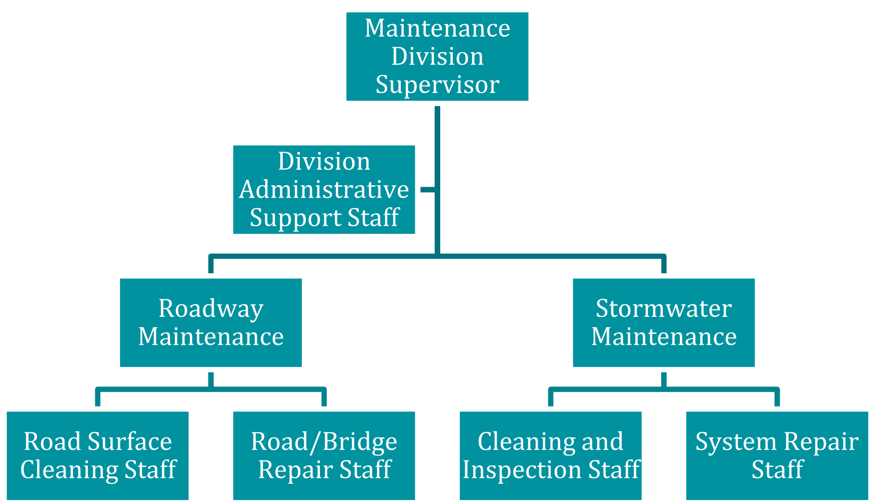
The Department of Public Works is made up of 6 divisions to carry out its departmental mission. ***Figure 6-5*** presents the overall structure of the department.

Figure 6-5 – Overall NO DPW Organization



The key division in the implementing the preventive maintenance program will be the Maintenance Division. A proposed organizational structure for the Maintenance Division is presented in ***Figure 6-6***.

Figure 6-6 - Proposed Maintenance Department Organization



6.6.2 Goals & Objectives

The overall goal of the stormwater drainage system preventive maintenance program is to assure functionality, extend the life of the system, preserve structural integrity, and reduce flooding. This goal may be achieved through the planning of preventive maintenance activities and the implementation and monitoring of both planned and unforeseen activities. It is recommended that the NO DPW adopt more specific goals and establish measureable objectives for the maintenance and operation of the stormwater drainage system. Some suggested goals are presented below.

Keep drain lines free of silt, sand, and debris.

Excessive amounts of silt, sand, and other debris in the stormwater drainage system reduces the available capacity of the system to collect and convey stormwater to the S&WB system, increasing the potential for damage to public and private property throughout the area. Therefore the following procedures should be performed:

1. Clean at least 8% of the stormwater drainage system each year and 100% in 10 years.
2. Clean at least 15% of problem areas each year and 100% in 5 years.
3. Procure contracts for cleaning or develop capacity to self-perform.

Identify and repair damaged elements of the system

In addition to limiting the ability of the stormwater drainage system to convey stormwater to the S&WB system, breaks in drainage lines sometimes result in significant increases in flows in the sewer system. Damaged manholes and catch basins can also contribute to the inability of the system to perform at optimal levels. Therefore the following procedures should be performed:

1. Visually inspect at least 8% of catch basins each year and 100% in 10 years.
2. Visually inspect at least 15% of open ditches each year and 100% in 5 years.
3. Visually inspect/CCTV at least 8% of drain lines each year and 100% in 10 years.
4. Procure contracts for inspection or develop capacity to self-perform.
5. Procure maintenance management tools or develop in-house tools

Identify and correct bottlenecks in the system

Bottlenecks unintentionally built into the system present immediate opportunities for improvement of system efficiency. If left uncorrected, these bottlenecks can pose significant challenges to the operation of the system. Therefore the following procedures should be performed:

1. Check GIS system for bottlenecks in non-modeled system (<18-inch)
2. Confirm GIS investigation with field investigation
3. Procure contracts to correct bottlenecks or develop capacity to self-perform.

6.6.3 Methods for Preventive Maintenance

Generally, preventive maintenance activities will fall into one of three categories: Facility Cleaning, Facility Inspection, and Facility Repair. Typical methods and procedures for each are presented. The practices described below are not comprehensive nor are they exhaustive. Special conditions will arise and specific solutions to address these conditions will be required.

Facility Cleaning

The primary tool for cleaning line segments, manholes, and catch basins is a combination cleaning truck which combines a high velocity jetting vehicle and a vacuum unit. The cleaning operation typically requires a two person team made up of a driver and a laborer or cleaning technician. It is recommended that at least one member of the team has been trained and maintains a certification from the National Association of Sewer Service Companies (NASSCO).

Facility Inspections

Routine inspection of drain lines, manholes, and catch basins by the Maintenance Division may be performed for, but are not limited to, the following purposes:

1. Inspect new construction prior to acceptance.
2. Assure sound pipes prior to paving.
3. Find problems in troubled areas.
4. Pinpoint the case, source and magnitude of breaks in the pipe.
5. Ascertain the applicability of various rehabilitation methods.

Closed circuit television inspections (CCTV) provide an effective method for determining the condition of the subsurface piping. A CCTV inspection will identify the structural condition of a pipe and required maintenance actions. CCTV inspections can provide detailed information of manhole-to-manhole sections of pipe not available using other inspection methods. The technique is well suited for determining joint condition, root intrusion, and locating structural deficiencies.

Inspection documentation should be made on CCTV log forms and tracked using a computerized tracking system and supplemented with videotape of the inspection.

Facility Repairs

With increased inspection of the system, it is inevitable that there will be a need to perform repairs to elements of the system. It is recommended that the NO DPW either develop the skill set and capacity to perform emergency repairs with in-house staff or establish an agreement with the S&WB that their field crews will be able to respond in a timely manner to emergency repair needs. Repairs that are of a less urgent nature or exceed the capacity and capability of in-house staff should be assigned to a maintenance contractor procured on an annual or bi-annual basis.

6.6.4 Preventive Maintenance Program Costs

Information made available at the time of preparation of this document indicated that approximately 1,656,000 linear feet of drain lines were cleaned between October 2005 and December 2005 and that an additional 1,265,000 linear feet was cleaned between September 2006 and June 2007. During these time periods, approximately 62,950 catch basins and manholes were also cleaned. The initial 10 year cycle for system cleaning is based on cleaning the elements of the system which were not cleaned. Subsequent cycles will be based on cleaning the full system.

The cleaning cycle should begin by addressing the areas of greatest need. This prioritization may be guided by frequent complaints, results of dyed water testing performed under the Sewer System Evaluation and Rehabilitation Program as shown in the System Characterization Report or modeled problem areas. This methodology calls for significant coordination between task completion and data collection to assure adequate data management and cycle tracking.

Facility Cleaning Cost

The estimated costs for the cleaning of drain lines less than 36-inches in diameter with clean and flush vehicles and for manhole and inlet cleaning are included in ***Table 6-3***. Cleaning costs for the entire system, based on 2007 unit costs, are estimated at $73.6 Million. These costs do not include repair or replacement of system assets.

Table 6-3 Total NO DPW System Cleaning Costs

Description	Quantity	Unit	Estimated Cost	Cost
Clean 6 to 10-Inch Storm Drain	1,570,200	LF	$ 3.00	$ 4,710,600
Clean 12 to 15-Inch Storm Drain	2,047,100	LF	$ 3.50	$ 7,164,900
Clean 16 to 18-Inch Storm Drain	1,114,400	LF	$ 5.00	$ 5,572,000
Clean 21 to 24-Inch Storm Drain	1,580,900	LF	$ 7.00	$ 11,066,300
Clean 27 to 30-Inch Storm Drain	489,700	LF	$ 8.00	$ 3,917,600
			Total Line Cleaning Estimate	**$ 32,431,400**
Inlet and Catch Basin Cleaning	117,770	EA	$ 350.00	$ 41,219,500
			Total System Cleaning Estimate	**$ 73,650,900**

Annual quantities and costs for stormwater facility cleaning during the initial preventive maintenance cycle are presented in ***Table 6-4***. Annual quantities and costs for stormwater facility cleaning during subsequent preventive maintenance cycles are presented in ***Table 6-5***.

Table6-4 Initial Preventive Maintenance Cleaning Cycle

Year	Percentage	Drain Lines		Catch Basins and Inlets	
		Quantity	Cost	Quantity	Cost
1	8 %	293,000	$ 1,396,000	4,400	$ 1,535,000
2	8 %	293,000	$ 1,396,000	4,400	$ 1,535,000
3	8 %	293,000	$ 1,396,000	4,400	$ 1,535,000
4	10 %	366,000	$ 1,745,000	5,500	$ 1,919,000
5	10 %	366,000	$ 1,745,000	5,500	$ 1,919,000
6	10 %	366,000	$ 1,745,000	5,500	$ 1,919,000
7	10 %	366,000	$ 1,745,000	5,500	$ 1,919,000
8	12 %	439,000	$ 2,094,000	6,600	$ 2,303,000
9	12 %	439,000	$ 2,094,000	6,600	$ 2,303,000
10	12 %	439,000	$ 2,094,000	6,600	$ 2,303,000
	Total	**3,660,000**	**$ 17,450,000**	**55,000**	**$ 19,190,000**

Table 6-5 Typical Preventive Maintenance Cleaning Cycle

Year	Percentage	Drain Lines		Catch Basins and Inlets	
		Quantity	Cost	Quantity	Cost
1	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
2	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
3	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
4	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
5	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
6	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
7	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
8	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
9	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
10	10 %	680,230	$ 3,243,140	11,777	$ 4,121,950
	Total	**6,802,300**	**$ 32,431,400**	**117,770**	**$ 41,219,500**

Facility Inspection Cost

Inspections performed on the stormwater system are categorized into two types: Visual Inspections and CCTV Inspections. Visual inspections include manholes, inlets, catch basins, ditches, and street level inspection of subsurface piping and can be performed concurrently with the cleaning of the drainage facilities or NO DPW staff could be specifically assigned to perform the inspections.

If performed with in-house resources, annual costs are estimated at approximately $240,000 for a two person full-time inspection crew and associated data management personnel. To meet the objectives for system inspection, the inspection crew would be expected to inspect approximately 650 manholes, inlets, and catch basins and 12,500 linear feet of open ditch per month.

Volume I, Appendix E includes sample inspection forms for manholes and inlets, ditches, and street level inspection of subsurface piping.

CCTV Inspections

Closed circuit television inspections (CCTV) provide an effective method for determining the condition of the subsurface piping. A CCTV inspection will identify the structural condition of a pipe and required maintenance actions. Based on information made available for development of the preventive maintenance program, the weighted average cost per linear foot for CCTV inspection is $1.60. Drain lines selected for CCTV inspection should be based on information gathered during cleaning and visual inspections. For the purposes of developing costs, it was assumed that 20% of the drain lines cleaned in a given year will require CCTV inspection.

Table 6-6 Initial Preventive Maintenance CCTV Cycle

Year	Length Cleaned (LF)	CCTV Estimate (LF)	Cost
1	293,000	59,000	$ 94,000
2	293,000	59,000	$ 94,000
3	293,000	59,000	$ 94,000
4	366,000	73,000	$ 117,000
5	366,000	73,000	$ 117,000
6	366,000	73,000	$ 117,000
7	366,000	73,000	$ 117,000
8	439,000	88,000	$ 141,000
9	439,000	88,000	$ 141,000
10	439,000	88,000	$ 141,000
Total	**3,660,000**	**733,000**	**$ 1,173,000**

Table 6-7 Typical Annual Preventive Maintenance CCTV Cycle

Year	Length Cleaned (LF)	CCTV Estimate (LF)	Cost
1	680,000	136,000	$ 218,000
2	680,000	136,000	$ 218,000
3	680,000	136,000	$ 218,000
4	680,000	136,000	$ 218,000
5	680,000	136,000	$ 218,000
6	680,000	136,000	$ 218,000
7	680,000	136,000	$ 218,000
8	680,000	136,000	$ 218,000
9	680,000	136,000	$ 218,000
10	680,000	136,000	$ 218,000
Total	**6,800,000**	**1,360,000**	**$ 2,180,000**

The annual costs associated with the implementation of the recommended preventive maintenance program will vary as presented in ***Tables 6-8*** and ***Table 6-9***.

Table 6-8 Total PMP Implementation Costs for Initial Cycle

Year	Line Cleaning	CB Cleaning	CCTV	Visual Inspection	Total Cost
1	$ 1,396,000	$ 1,535,000	$ 94,000	$ 240,000	$ 3,265,000
2	$ 1,396,000	$ 1,535,000	$ 94,000	$ 240,000	$ 3,265,000
3	$ 1,396,000	$ 1,535,000	$ 94,000	$ 240,000	$ 3,265,000
4	$ 1,745,000	$ 1,919,000	$ 117,000	$ 240,000	$ 4,021,000
5	$ 1,745,000	$ 1,919,000	$ 117,000	$ 240,000	$ 4,021,000
6	$ 1,745,000	$ 1,919,000	$ 117,000	$ 240,000	$ 4,021,000
7	$ 1,745,000	$ 1,919,000	$ 117,000	$ 240,000	$ 4,021,000
8	$ 2,094,000	$ 2,303,000	$ 141,000	$ 240,000	$ 4,778,000
9	$ 2,094,000	$ 2,303,000	$ 141,000	$ 240,000	$ 4,778,000
10	$ 2,094,000	$ 2,303,000	$ 141,000	$ 240,000	$ 4,778,000
Total	**$ 17,450,000**	**$ 19,190,000**	**$ 1,173,000**	**$ 2,400,000**	**$ 40,213,000**

Table 6-9 Total PMP Implementation Costs for Typical Cycle

Year	Line Cleaning	CB Cleaning	CCTV	Visual Inspection	Total Cost
1	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
2	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
3	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
4	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
5	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
6	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
7	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
8	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
9	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
10	$ 3,243,000	$ 4,122,000	$ 218,000	$ 240,000	$ 7,823,000
Total	**$ 32,430,000**	**$ 41,220,000**	**$ 2,180,000**	**$ 2,400,000**	**$ 78,230,000**

Section 7
Design Standards & Guidelines

This section evaluates the plan review process within the City of New Orleans, Department of Public Works, examines guidelines provided during the permit review process, and recommends new construction products for incorporation into drainage system improvement projects.

7.1 Review and Evaluate Planning Review Process

In order to evaluate the planning review process, a one day workshop was held on January 20, 2010 with the purpose of providing an open forum for communication, obtaining input on current plan review processes, and discussing modifications and new processes. The goal was to reach a consensus on recommendations. A questionnaire was presented to obtain insight on the City of New Orleans, Department of Public Works (NO DPW) Planning Review Process, Guidelines for Drainage System Permits, and Maintenance Procedures. The survey was completed during the workshop and offered in hard copy to those who were not able to attend. Results of the survey are included in ***Volume I, Appendix D*** and findings relevant to the Planning Review Process and Drainage System Permits are summarized within this section.

Additionally meetings were held with a member of the City Planning Commission to discuss how their efforts to revise the New Orleans Master Plan and Comprehensive Zoning Ordinance (CZO) might affect the planning review process in the future.

7.1.1 General Planning Review Process

The NO DPW plan review process is a component of the major or minor subdivision request and approval process administered by the City Planning Commission (CPC) which includes the Sewerage and Water Board (S&WB), Safety and Permits, Parks and Parkways, in addition to NO DPW and others.

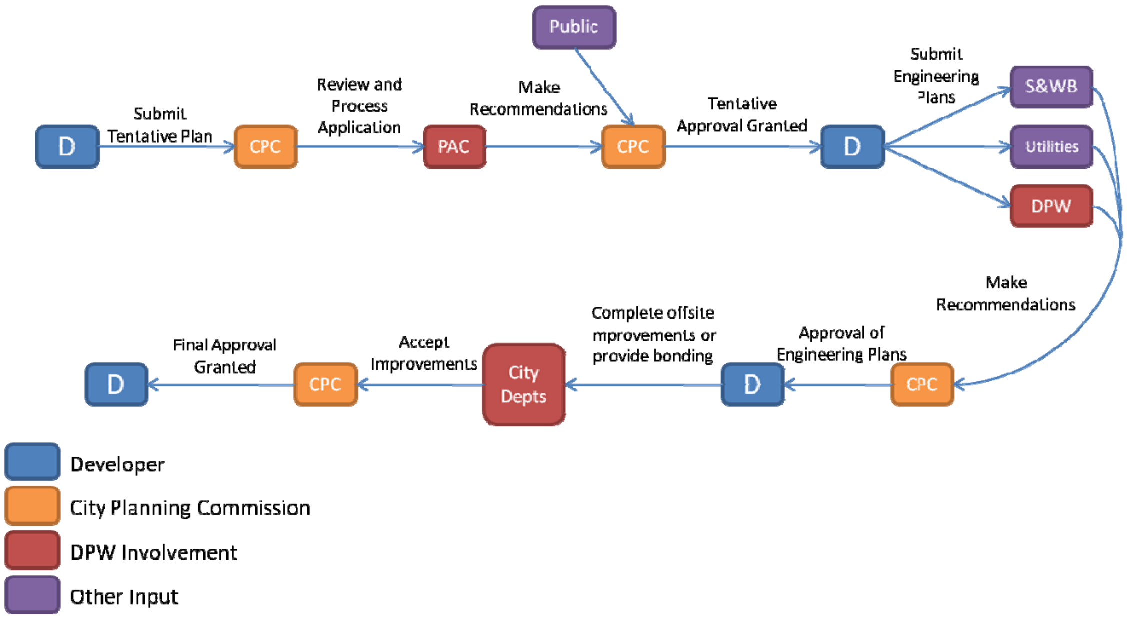
The review process for major subdivisions containing greater than five (5) lots is outlined in ***Figure 7-1***. The process starts with a tentative plan and application being submitted by the developer to CPC who will check it against minimum standards. The Public Advisory Committee (PAC), which is made up of representatives from various City Departments and includes a member of NO DPW, will then have a chance to review and comment on the plan along with the public. This is an opportunity for each representative to ensure the tentative plan meets their departmental regulations and to make recommendations for additional conditions, if necessary, before tentative approval is given.

Once tentative approval is given, the developer submits engineering plans for a more detailed review from the relevant public agencies. Along with other items not associated with stormwater management, plans sent to NO DPW must include proposed topography and drainage patterns, subsurface drains and outfalls, storm drainage and sanitary sewer system locations with elevation profiles, canals, outfall inverts, and gutter line profiles. Plans submitted to S&WB must include a master stormwater management plan as well.

Once reviewed, either approval letters or conditions for approval of the Engineering Plans are then sent to CPC. Before Final Approval is granted, offsite improvements must be completed or adequate bonding provided along with other requirements not applicable to stormwater management.

The process for minor subdivisions of five or fewer lots is shortened by removing the need for PAC review before plans are submitted to the relevant agencies for review. In the case of minor subdivisions, this period of review is typically limited to 30 days. Currently, minor subdivision applications are more commonly submitted to CPC; and redevelopment is more common than new development which could fall outside the review process of the subdivision regulations.

Figure 7-1: Schematic of Major Subdivision Review Process



7.1.2 Internal Plan Review Process

NO DPW involvement with respect to stormwater management is handled largely by a single staff member within the Engineering Division who sits on the Public Advisory Committee and handles the review of engineering plans submitted by the developers.

During a review, NO DPW uses a tracking system to manage projects which includes a file number placed on all drawings for each application received by NO DPW. These file numbers are kept in a hard copy log. While there is typically a single main NO DPW reviewer, input is gathered from others on issues such as traffic impacts or coordination with S&WB. Quality assurance is provided by the head of the NO DPW Engineering Division and all documents leaving NO DPW are approved by the Director.

Typical NO DPW involvement in the plan review process is approximately one month; however this timeframe may be accelerated at the developer's request. Once approval is received for a project, it is valid for two years although all future design changes must be approved.

Developers are not permitted to construct without approval; however there is no real penalty other than the need to break up paving and install proper drainage if the unapproved construction was not initially sufficient. Field verifications are performed via final inspections with additional inspection as necessary throughout construction. Mandrel tests are performed on PVC piping to ensure an acceptable internal diameter. There is currently no monetary penalty for non-compliance or rejection of approval. However, if NO DPW does not sign off on construction, the applicant will not obtain use and occupancy permission.

Once constructed, S&WB will log the size of new drainage infrastructure as documented by the as-built drawings. Any testing results are stored in the NO DPW Engineering Department while the whole file containing correspondence, drawings, and as-builts are stored wherever room is available.

7.1.3 Additional Regulations

In addition to the 1999 Subdivision Regulations, stormwater requirements from the Louisiana Department of Environmental Quality (LDEQ) must be followed for construction development over one (1) acre in size. The Louisiana Department of Transportation and Development (LA DOTD), AASHTO and S&WB also have stormwater regulations that must be followed, where applicable, as well as sidewalk regulations, and zoning and planning considerations. Main regulations along with the applicable developments and specific requirements concerning drainage are described in ***Table 7-1***.

One key future consideration is the new Master Plan and Comprehensive Zoning Ordinance (CZO) CPC is currently creating. Part of this effort is a focus on sustainability and the CZO will likely have requirements for sustainable stormwater management efforts while allowing flexibility in how developers wish to retain and treat their stormwater runoff.

Table 7-1: Drainage Regulations and Guidance

Guidelines	Drainage requirements
NO DPW Roadway Design Guide	Section 4.03: The design of drainage systems shall be in accordance with LA DOTD Hydraulics and Drainage Manual unless otherwise specified by the S&WB.
LDEQ: Various General Permits	• Create a Stormwater Pollution Prevention Plan and install BMPs during construction activities to prevent pollution and provide erosion and sediment control. • Provide the technical basis used to select practices to control pollution after construction where flows exceed pre-development levels.
New Orleans Code of Ordinances Chapter 26: Buildings, Building Regulations and Housing Standards Sec. 26-180: Grading and drainage	• Grading shall not permit water to drain to adjacent properties. • Property must drain in a way that prevents standing water from accumulating. • The fill of a lot must be maintained and replaced when erosion or subsidence occurs.
Louisiana State Law RS 33:4081	• Plans and specifications for any drainage connections shall be approved by the properly authorized officer of the sewerage and water board and the construction of the work shall be subject to his inspection. • Copies of plans and profiles for all other underground structures shall be filed in the sewerage and water board office before construction.
CPC Master Plan and Comprehensive Zoning Ordinance (still under development)	• Promote the use of water conservation and innovative stormwater management techniques in site planning and new construction. • Promoting the use of semi-pervious paving materials and encouraging sustainable stormwater management practices through techniques such as bioswales, green roofs, and landscaped parking lot islands that are designed to absorb stormwater.

7.1.4 Plan Review Process Recommendations

Suggestions for improving the plan review process were developed and fall into the four categories of internal process standardization, improved communication, process advancements, and fee adoption.

Internal Process Standardization

The NO DPW plan review process could be improved through internal standardization. Currently, process organization relies heavily on a single staff member, which poses a risk if that staff member becomes unavailable. Recommendations for internal standardization include:

1. A formal inventory system which tracks projects throughout the review process. This would allow all staff to know the current status of projects under review.

2. Creation of a simple flow diagram and checklist of standard review procedures so that staff unfamiliar with the process can more easily become engaged when needed.

3. Standardized storage, filing, and disposal procedures for retaining and discarding information.

Improved Communication

As a large portion of development within New Orleans comes in the form of redevelopment, which can occur outside of the subdivision regulations review process, it is important that the needs and requirements of NO DPW are understood by other city agencies. For example, the Office of Safety and Permits handles many redevelopment permit requests and should know when NO DPW input may be required. Having a clear set of guidelines developed as discussed in ***Volume I, Section 7.2*** can help both developers and other agencies understand NO DPWs requirements.

Process Advancements

With the development of the SWMM models for the Stormwater Management CIP, scenario modeling may be incorporated in the planning review process for large or complex developments to better determine potential effects on the drainage infrastructure.

A stronger focus on incorporating Best Management Practices (BMPs) into the onsite drainage plan should be developed, specifically for large scale residential and commercial developments. Jefferson Parish currently requires lots of 10,000 square feet or greater to provide onsite retention when changing the impervious nature of the lot. Baton Rouge requires a full stormwater management plan for all development and redevelopment projects which details how the development will address drainage and water quality issues. Within New Orleans, similar items may be required as part of the new Comprehensive Zoning Ordinances which is more reason for NO DPW to become acquainted with relevant options for the local setting. BMP options and expectations should be discussed during the pre-application meeting between NO DPW and the developers. Information about recommended BMPs applicable to the NO DPW system is provided in ***Volume I, Section 7.3***.

Fee Adoption

Currently there is no fee to cover NO DPW's portion of the planning review process. A fee should be considered to cover copying and basic administration costs at a minimum.

Additionally, there are currently minimal penalties for non-compliance. Monetary penalties may be incorporated to cover staff time and expenses to address non-compliance issues. Model ordinances from Tennessee declare a penalty of not less than fifty dollars and not more than five thousand dollars per day for each day of violation of the stormwater ordinances. However, Louisiana limits fines for violations to not more than one thousand dollars for each offense (RS 33:4081).

As an alternative revenue source for capital improvements and maintenance of drainage infrastructure, a rate structure for all developments contributing runoff to the drainage system should be considered. More detail of how this might be created is provided in ***Volume I, Section 9***.

7.2 Technical Guidelines for Drainage System Permits

Permit guidelines provide direction to developers helping them understand the exact requirements for their application. This is a benefit both to the developers and NO DPW as having documents submitted in the proper format and following the required procedures improves the efficiency of the review process.

7.2.1 Existing Drainage Guidelines

Currently, guidance for designing storm drainage infrastructure is dispersed between the subdivision regulations, LA DOTD Hydraulics and Drainage Manual, NO DPW website, and S&WB specifications. This is likely to be confusing for developers and a consolidated set of guidance materials should strongly be considered. Some of the guidance provided within each of these sources is discussed below.

Subdivision Regulations

Specific NO DPW Guidelines are provided within Appendix 3.A of the Subdivision Regulations. Components relating to drainage include:

1. The developer or his engineer should meet with NO DPW to discuss preparation of the Engineering Plans.
2. Plans must conform to the NO DPW Standard Drawings and General Specifications.
3. The recommended minimum design slope for gutter lines is 0.35% towards the drainage structures.
4. Lots will be graded to drain toward the street over the top of the curb unless a rear lot subsurface drainage system is provided and approved by the S&WB.
5. Storm drain manholes, as well as any other underground utility manholes, should be located in the area between the back-of-curb and the property line to the maximum extent possible.
6. Roof and house drains are permitted to connect directly to the RCP drain line using the core drilling method.

LA DOTD Hydraulics and Drainage Manual

NO DPW relies on the LA DOTD Hydraulics and Drainage Manual which includes the following requirements:

1. Progressing downstream, pipe sizes should never decrease.
2. Acute turns should be avoided between inflow line and outflow line.
3. Pipe slope should conform approximately to existing surface grade.
4. Flow line elevations should be set so that pipe centerlines in a manhole will be approximately in the same plane.
5. The most desirable location of trunk lines is outside the pavement area, to facilitate future repairs.
6. Maximum lengths of pipe without a manhole are provided.
7. A minimum clearance of 9 inches shall be maintained between the top of the pipe and the lowest part of the subgrade.
8. Closed conduits are designed under surcharge-full flow conditions whenever applicable. Hydraulic grade line should be computed and maintained at least one foot below the intake lip of any inlet.

Other

NO DPW also relies on the S&WB general specifications which provide technical specifications for various materials and the construction of canals and storm drain pipes. NO DPW also provides standard drawings within the Engineering Division section of their website.

7.2.2 Permit Guideline Recommendations

Currently, variability in submitted drawings and calculations from different developers decreases the efficiency of NO DPW review. Improved guidance for submitting drawings and other documents to review agencies may facilitate increased efficiency.

Updated planning standards and design criteria were developed in ***Volume I, Appendix F*** of this master plan and should be made available to developers in full and in factsheets containing the most relevant material for particular circumstances.

Additional recommendations for improving project guidance include:

1. Provide guidelines on the NO DPW website describing how plans and calculations should be performed and created. This could include a link to the updated planning standards and design criteria developed in ***Volume I, Appendix F*** as well as factsheets of essential information.
2. Insert information into the CPC initial application pack which directs developers to information specific to NO DPW and clarifies the relationship between S&WB and NO DPW since this has been a past cause of confusion.
3. Provide standard specifications on the NO DPW website, or provide information on how to obtain standard specifications.

7.3 Review Standard Construction Products

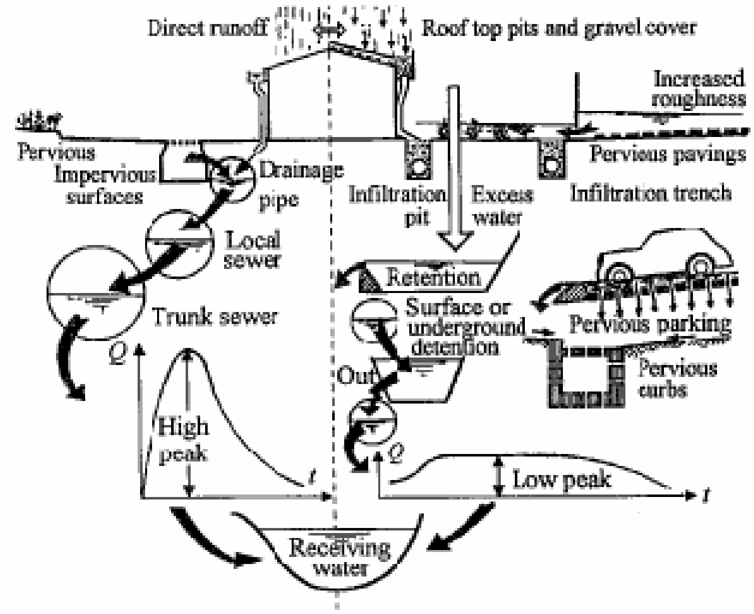
There is an increased focus nationwide on sustainable urban drainage and the best management practices (BMPs) available to achieve better stormwater management both for reducing peak flows and water quantity concerns, as well as for improving water quality. This section will describe the basic concept of sustainable urban drainage, criteria most relevant to New Orleans, and recommendations for BMPs best suited for incorporation into NO DPWs stormwater system improvements.

7.3.1 Basic Concept of Sustainable Urban Drainage

The purpose of sustainable urban stormwater management is to improve water quality while also decreasing the peak rate, volume and velocity of stormwater runoff caused by urbanization. This is achieved by retaining and infiltrating more stormwater within its local basin, thus more closely mimicking the natural hydrologic cycle. By increasing the time of concentration within local watersheds, downstream areas receive smaller peak flows and flooding risks are diminished. Stormwater quality is typically improved by bio-filtration through soil and plant life, allowing for the sedimentation and absorption of pollutants. ***Figure 7-2*** displays the difference in concept between standard stormwater management where runoff is quickly piped and conveyed to the receiving water and sustainable urban drainage where runoff is purposefully slowed, collected and infiltrated along its path to receiving waters.

The concept of sustainable urban drainage or low impact development for the management of stormwater resources first arose in the mid 1990s from the Department of Environmental Resources in Prince George's County Maryland (HUD, 2003). Today the concept is actively encouraged by the USEPA after the National Water Quality Inventory Report of 2000 identified urban runoff as one of the leading sources of water quality impairment for the nation's surface waters (USEPA, 2005). Cities throughout the world have begun to take advantage of sustainable urban stormwater management techniques often called Best Management Practices (BMPs). This section will help identify which BMPs are most appropriate for immediate incorporation into the City of New Orleans.

Figure 7-2: Standard vs Sustainable Stormwater Management Practices (Associated Programme on Flood Management, 2008)



7.3.2 Selection Criteria for BMPs

A list of criteria was developed to assist with determining which stormwater best management practices are currently most relevant for use within New Orleans. The criteria include both desired characteristics for the BMPs and limiting conditions inherit to New Orleans which will need to be considered. Each criterion is described below and then BMPs are discussed in relation to meeting the desired criteria and constraints.

Flood Reduction

Sustainable urban stormwater management will assist most with localized flooding and water treatment for smaller scale storm events. However, since longer duration and higher intensity storms are common, an important design consideration will be the incorporation of overflow outlets or increased capacity underdrains to convey runoff from more extreme rain events.

Underdrains will also be necessary due to the local soil conditions. The majority of soils throughout New Orleans are classified in Hydrologic Group D and considered “functionally impervious”. This is due to a combination of high clay content, high compaction from past activities, and a high groundwater table. The high groundwater table must be considered during design, as groundwater entering the underdrains would add extra volume to the drainage system rather than reducing peak flows as desired by the BMPs. This can be addressed through geotextile linings to limit groundwater infiltration into the underdrains.

Retrofit Opportunities

Because New Orleans is already highly developed, many of the BMPs suggested will need to be designed for retrofitting into the existing cityscape, rather than in a new build context. The BMPs must also be suitable for use in the streets and publicly owned land under the jurisdiction of the New Orleans Department of Public Works.

Pollutant Removal

It is the 'first flush' of stormwater, often the first inch, which picks up most pollutants from urbanized areas and carries them into the drainage system and local waterways. Water Quality BMPs are designed to help treat the stormwater from these smaller events with overflows provided for larger flow events.

A common metric used to determine water quality improvements from BMPs is the percent reduction of total suspended solids (TSS). Removal of the suspended solids within runoff often removes other pollutants which adhere to the suspended material. Additionally, reduced TSS helps to diminish sedimentation within the piped conveyance system.

In their Updated Storm Water Management Plan from 2002, the S&WB identified specific constituents of concern as shown in ***Table 7-2*** (LDEQ, 2006). These determinations were based on local wet weather sampling and LDEQ Water Quality Inventory reports.

Table 7-2: S&WB Constituents of Concern

Constituents of Concern	Significance Level
Nutrients	High
BOD5	High
Fecal Coliform	Medium
Metals (Cu, Pb, Hg, Ag, Zn)	Medium
Sediments	Medium
Oil & Grease	Low
Dissolved Oxygen	Low
Pesticides	Low
Priority and Non-priority Organics	Low

Maintenance

BMPs should be designed to minimize maintenance requirements but there are no specific limiting factors in selecting a BMP in regards to maintenance. The specific maintenance requirements for each BMP considered will be discussed.

Cost

BMPs must be cost effective; however for initial selection there is no specific cost requirement. Basic cost estimates will be provided for comparison purposes.

7.3.3 Recommended BMPs

The BMPs recommended as viable for immediate utilization within the City of New Orleans are pervious pavement, storm water planters, vegetated swales, and biofiltration areas. The following sections provide a detailed description of the recommended BMPs. ***Table 7-3*** shows a summary of the major advantages and limitations of each recommended BMP.

Table 7-3: Recommended BMPs

Recommended BMPs	Description	Advantages	Limitations
Pervious Pavement	Paving material which allows for the infiltration of water through the surface and into a gravel reservoir below.	• Blends well into the urban environment. • Numerous retrofit locations to replace impervious pavement. • Eliminates surface level ponding. • Improved moisture access for tree root systems.	• Not appropriate for high traffic areas. • Care must be taken to prevent clogging. • Typically only designed to collect direct precipitation not runoff from surrounding areas.
Stormwater Planter	Small infiltration basin filled with vegetation.	• Can be used to treat space constrained areas. • Beautifies city streets and sidewalks	• Only appropriate for small scale drainage areas. • Requires landscaping attention to keep plants attractive.
Vegetated Swale	Vegetated depressions often running along roadways to convey and infiltrate storm water.	• Can convey a large range of storm flows. • Some current usage within neighborhoods and along neutral grounds.	Side slope requirements increase needed land area
Biofiltration Area	Shallow vegetated basins to collect and infiltrate storm water.	• Able to fit in underutilized areas with a variety of shapes. • Efficient for highly impervious areas such as parking lots. • Can be designed as an aesthetic feature.	• Requires landscaping attention to keep plants attractive. • Not suitable for areas with steep slopes

Pervious Pavement

Pervious pavement allows for the rapid infiltration of water through the paving material and into a gravel reservoir typically below the surface. This increases stormwater water detention and can improve water quality through sedimentation. There are various types of pervious pavements including pervious concrete, pervious asphalt, pervious concrete unit pavers, reinforced gravel paving or reinforced grass paving.

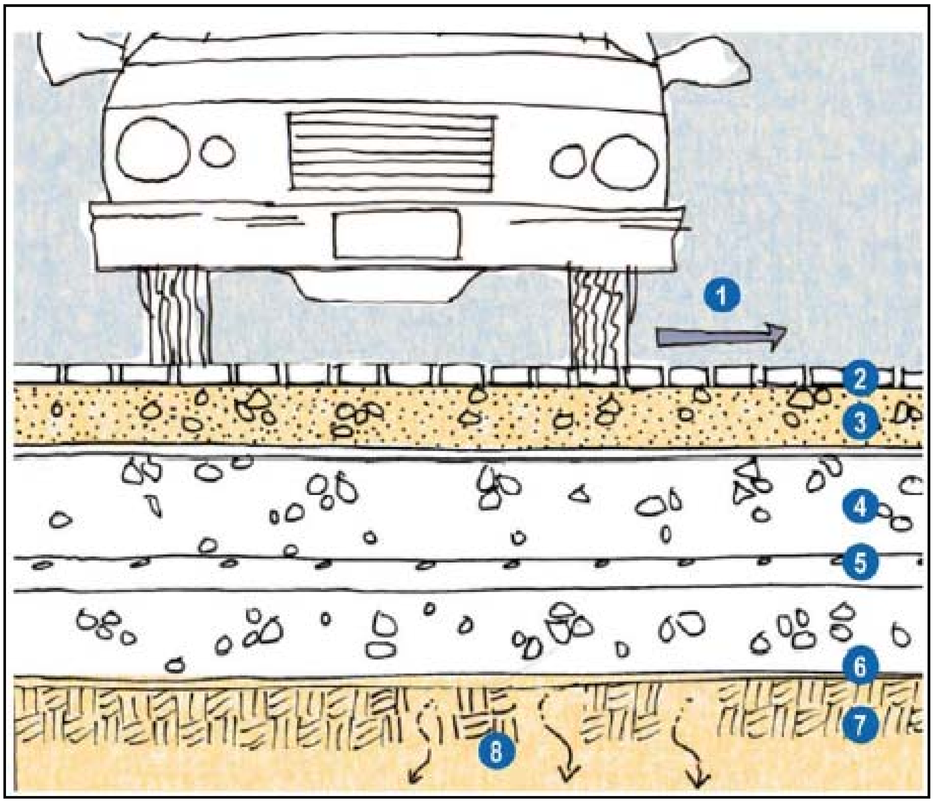
Flood Reduction

Pervious pavement detains precipitation beneath the ground level in a gravel storage reservoir before moving into an underdrain. Moving runoff below the pavement surface reduces puddles as compared to traditional pavement and can be safer and more convenient for pedestrians. Typically pervious pavement accepts only direct precipitation and not storm water runoff from surrounding areas. The volume of precipitation collected and transferred to the storm water system will not significantly decrease with the use of pervious pavement, due to the low infiltration rate of most soils within New Orleans. However, in some instances the pervious pavement can provide improved moisture access for tree root systems, increasing water uptake and evapotranspiration. Depending on how the underdrain and gravel storage reservoir is designed the peak flow rate of runoff leaving the area can be reduced, potentially limiting flooding downstream.

Retrofit Opportunities

Pervious pavement can be installed to replace many uses of currently impervious pavement, blending into the urban environment easily. Common locations for incorporation include parking lots, parking strips, bike lanes, alleys, patios and sidewalks. One restriction to pervious pavement use is that heavy vehicle traffic should be restricted, so it is not applicable for high traffic locations. Also, pervious pavement should not be used on sites likely to have high oil and grease concentrations or large amounts of fine sediment as this can clog the pores and lead to impervious conditions.

Figure 7-3: Pervious Pavement Schematic (Minick &Jenchs, 2009)



One example of where pervious pavement can be incorporated within New Orleans is roadside parking strips such as that shown in ***Figure 7-4***.

Figure 7-4: Sample Location for Incorporation of Pervious Pavement

Pollutant Removal

Pollutant removal from pervious pavement will be less than vegetated BMPs due to the absence of filtering through bioactive soils. However, as runoff travels through the sand and gravel layers below the pervious pavement, total suspended solids will be filtered out along with pollutants adhered to the suspended material. The pavement itself acts as a pretreatment step in keeping debris and large sediment out of the sand and gravel layers below. Moving the runoff below the pavement surface also prevents heating of the stormwater which can occur when flowing across hot asphalt surfaces and affect aquatic life at eventual outfalls.

Typical mass removal rates for various pollutants are shown in ***Table 7-4***.

Table 7-4: Pervious Pavement Pollutant Mass Removal Rates (CDM, 2006)

Constituent	Percent Removal
BOD5	No data
COD	60%-90%
TSS	60%-100%
TDS	No data
Total-P	40%-90%
Dissolved-P	No data
TKN	80%-95%
NO2+NO3	40%-90%
Lead	60%-90%
Copper	No data
Zinc	60%-90%
Cadmium	No data

Maintenance

The pores within the pavement can become clogged with clays and silts requiring periodic pressure washing or vacuuming to help unclog the pores of fine material. Leaves and other debris which can block the infiltration of water should also be seasonally removed. Unit pavers or reinforced gravel or grass paving should have seasonal weed suppression.

Care must also be taken that the porous pavement is not accidently sealed or repaved causing it to become impervious. High summer temperatures can also melt porous asphalt therefore decreasing its permeability and potential applicability within New Orleans meaning pervious concrete and unit pavers may be a better choice.

Cost

The majority of the cost required to install pervious pavement comes from the high level of workmanship necessary for installation. This increases the cost over that of traditional pavement. The Charles River Watershed Association in Massachusetts has estimated installation of pervious pavement to be $7 to $15/square foot including the underground infiltration bed. Maintenance costs are approximated as $400 to $500 a year for vacuum sweeping of a half acre area which is about $0.02/square foot.

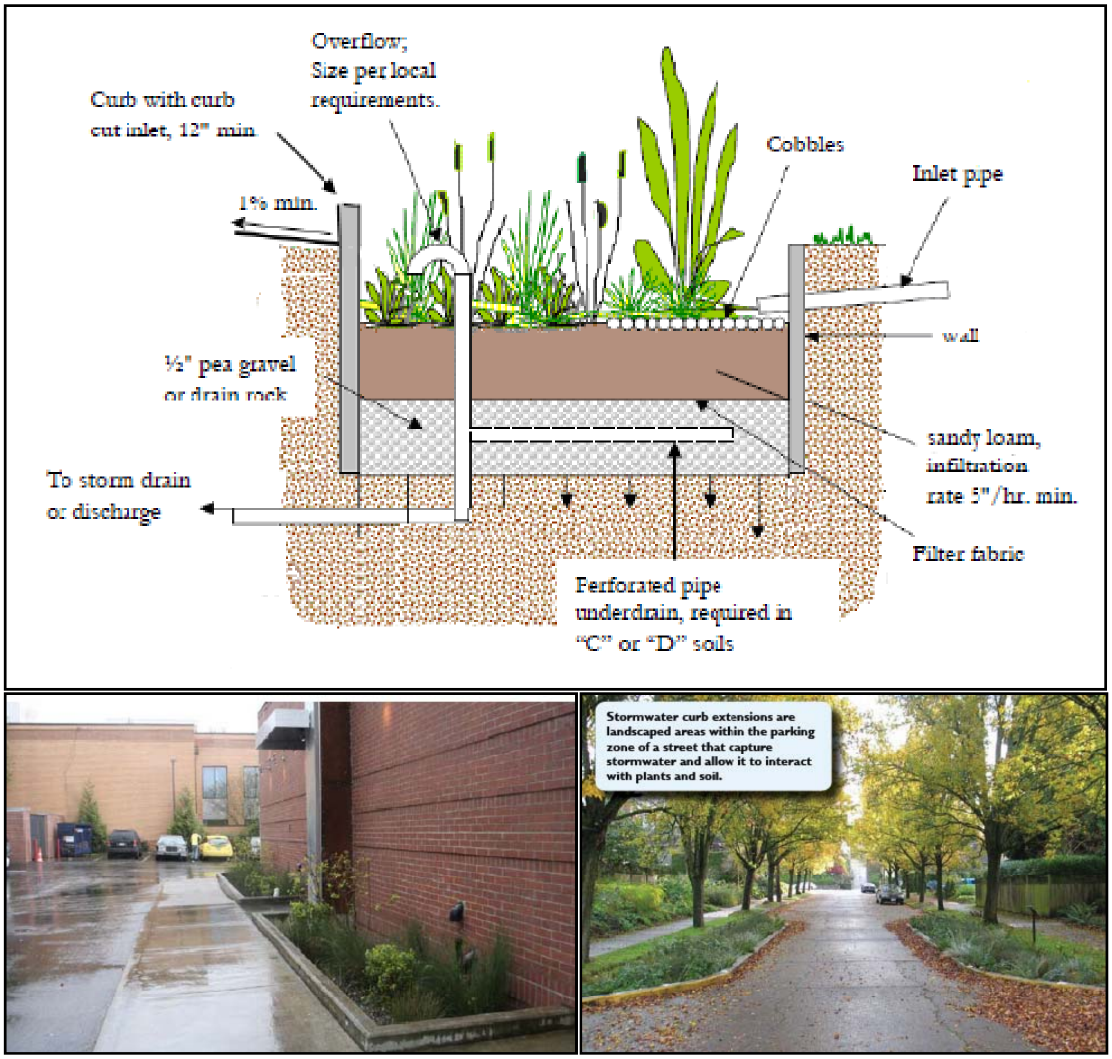
Paving blocks are of similar cost but typically a bit cheaper with an installation price range of $8 to $12 per square foot with the same maintenance required for vacuum sweeping.

Stormwater Planters

Stormwater planters are typically rectangular landscaped areas with vertical walls and flat bases. Runoff usually enters the planters either through overland flow or via a roof downspout. Disconnecting roof downspouts from immediate transfer to the drainage system and moving the runoff through a stormwater planter instead can improve water quality and reduce the peak flow and volume of runoff for smaller rain events.

Water flows into the planter, seeps through the soil, and is either taken up by the vegetation, travels into a perforated underdrain, or in large storms, exits through an overflow structure. Besides stormwater treatment, the planters have the added effect of helping to beautify urban spaces dominated by concrete and asphalt.

Figure 7-5: Schematic of a Stormwater Planter (CCCWP, 2006)
Example of Curb Extensions (Sanitation District No 1, 2009)
Example of Roof Runoff Entering a Rain Garden (Sanitation District No 1, 2009)



Flood Reduction

Stormwater planters store water within the soil and gravel layers with some diminished runoff through uptake and evapotranspiration by the vegetation. As a storage device to reduce peak flow rates, some stormwater planters can store more water than swales in a confined area due to vertical sides instead of the side slope required for swales.

Retrofit Opportunities

Stormwater planters are ideal for situations where space is limited, such as highly urbanized landscapes. Typically planters are utilized to treat stormwater runoff coming from areas less than 15,000 square feet. Rooftop gutters can be disconnected from storm drains and into stormwater planters to promote infiltration and reduce peak flows. Planters can also be utilized within curb extensions to provide more space for infiltration and detention while helping to slow and control traffic. This is a good option within New Orleans due to the width of many residential streets, allowing for installation of curb extensions (***Figures 7-5 and 7-6***). Sidewalk tree planters can also be combined into a stormwater planter to better irrigate trees and treat stormwater runoff.

Where installation is next to building foundations, care must be taken to avoid seepage from undermining the foundation.

Figure 7-6: Example Street for Incorporation of Stormwater Curb Extensions

Pollutant Removal

Stormwater planters can typically reduce TSS by 80%. Pollution is removed through various processes within the planter. Filtration occurs as the water moves through the soil layers. Additionally, organic material encourages the growth of microorganisms which help degrade many types of hydrocarbons and organic pollutants. Clay within the soil also acts as absorption media for heavy metals, nutrients, and other pollutants.

Maintenance

Maintenance is typical of any containerized garden. Plants will need to be weeded and trimmed to maintain aesthetics. Plant selection should be of native plants suitable for the local climate. Care must be taken in the choice of fertilizers or pesticides since the planter is a direct connection to the stormwater system.

The entry and exit points of the planters will need to be occasionally cleared of debris. Ideally, standing stormwater should drain from the planter within 3 to 4 hours of a storm event. If planters are not draining, they should be excavated and cleaned with new soil and gravel to correct the infiltration rates.

Cost

The Charles River Watershed Association in Massachusetts has approximated installation cost as $8 per square foot and maintenance costs as $1 per year per square foot.

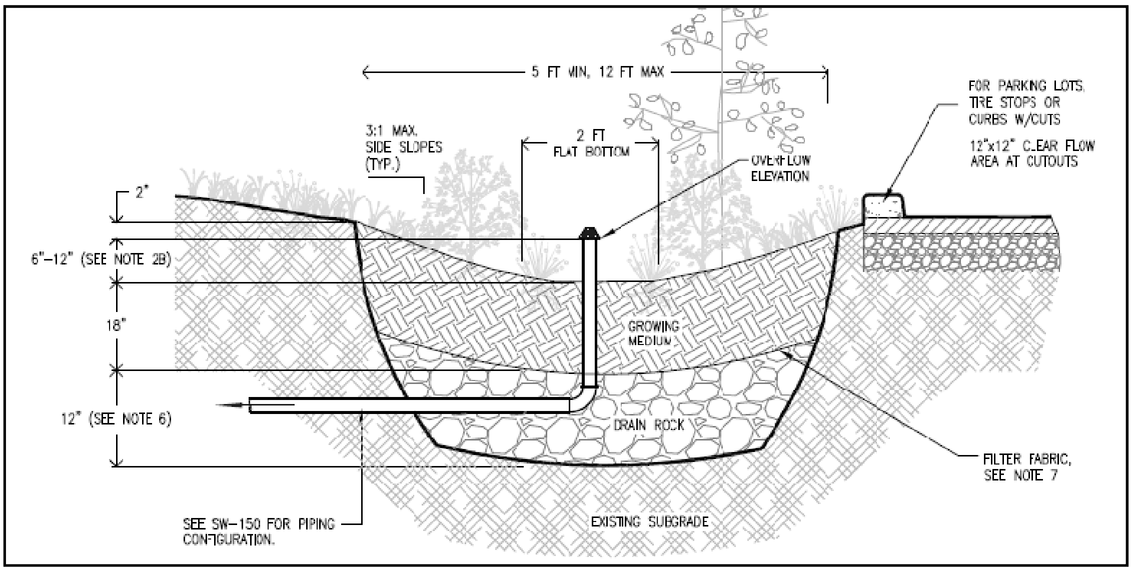
Vegetated Swales

Vegetated or grassy swales are small, vegetated depressions which slow down the movement of stormwater. As water enters the swales, the plants and soil slow down the flow as compared to pipe conveyance which can help reduce peak flows downstream. The slower velocity and movement through soil also helps pollutants to settle out, improving water quality.

The swale consists of a flat bottom typically 2 to 8 feet in width with slide slopes recommended at a 4:1 ratio. The longitudinal slope is typically between 0.2% and 6%. Check dams should be placed at intervals along the swale to slow down flow and promote infiltration into the soil. In poorly draining soils, a perforated pipe underdrain is utilized to move stormwater to a storm drain after infiltration.

Figure 7-7: Vegetated Road Median Swale (Atlanta Regional Commission, 2001)

Figure 7-8: Profile View of Vegetated Swale (Portland Bureau of Environmental Services, 2004)



Flood Reduction

Vegetated swales slow the velocity of stormwater runoff compared with pipe conveyance to reduce downstream peak flows. Due to their trapezoidal shape, swales can convey a wide range of flow volumes allowing for decreased localized flooding during a wide range of storm events.

Retrofit Opportunities

Due to side slope recommendations, swales require a significant amount of land to construct. They are best suited for long straight sections, typically beside roads and within medians. For the swales to collect runoff, roads may need to be re-graded to direct stormwater to the swales for treatment.

Within New Orleans, road medians (neutral grounds) can be converted to a vegetated swale.

Figure 7-9: Road Medians Can Be Re-graded to Act as a Vegetated Swale

Pollution Removal

Pollution is removed through various processes within the vegetated swale. Filtration occurs as the water moves through the soil layers. Additionally, organic material encourages the growth of microorganisms which help degrade many types of hydrocarbons and organic pollutants. Clay within the soil also acts as absorption media for heavy metals, nutrients, and other pollutants.

The Georgia Stormwater Management Manual predicts an 80% removal of total suspended solids for a properly designed and maintained vegetated swale. Additional typical mass removal efficiencies are provided in ***Table 7-5***.

Table 7-5: Vegetated Swale Pollutant Mass Removal Rates(CDM, 2006)

Constituent	Percent Removal
BOD5	20%-40%
COD	20%-40%
TSS	70%-90%
TDS	10%-20%
Total-P	30%-50%
Dissolved-P	10%-30%
TKN	20%-40%
NO2+NO3	10%-30%
Lead	60%-90%
Copper	40%-60%
Zinc	40%-50%
Cadmium	50%-80%

Maintenance

Swales should be inspected for erosion after large rain events, especially after initial installation. Bare spots should be replanted to maintain a healthy stand of vegetation. To help prevent erosion, flow spreading devices or rock splash pads should be considered during design to reduce the velocity of flow entering the swale. If the swale does not drain within 48 hours of a storm event, underdrains should be inspected and cleaned or the engineered soil should be tilled and replanted. Debris and excess sediment should also be regularly cleared from the swale and vegetation properly maintained.

Cost

The Charles River Watershed Association in Massachusetts has estimated the cost of vegetated swales to be approximately $10 per linear foot and approximately $200 per year to maintain a 900 square foot swale which is around $0.25 per square foot.

Biofiltration Areas or Rain Gardens

Biofiltration areas are shallow, vegetated basins that can be any variety of shape. The bottom of the basin is typically flat with gently sloping sides with an underdrain incorporated for poorly infiltrating soils.

Flood Reduction

Biofiltration areas allow for the collection of stormwater into the basin with flood reduction largely proportional the size of the basin. An underdrain must be incorporated to transport stormwater from the bottom of the basin, which can be complicated due to the non-standard shapes allowable for basins.

Figure 7-10: Example of Underutilized Space (Sanitation District No 1, 2009) & Example Bioretention Area (Portland Bureau of Environmental Services, 2004)

Retrofit Opportunity

Common locations for biofiltration areas include roadway median strips, parking lot islands, or odd shaped, ill utilized pieces of road intersections. The space required is typically 5% of the tributary impervious area. ***Figure 7-11*** shows a neutral area within New Orleans which could be converted into a large biofiltration area. Much like stormwater planters, biofiltration areas can help to beautify streets and building fronts by adding natural features.

Pollution Removal

Pollution is removed through various processes within the biofiltration area. Filtration occurs as the water moves through the soil layers. Additionally, organic material encourages the growth of microorganisms which help degrade many types of hydrocarbons and organic pollutants. Clay within the soil also acts as absorption media for heavy metals, nutrients, and other pollutants. Predicted mass removal efficiencies are provide in ***Table 7-6***

Maintenance

Debris should be cleared and biofiltration areas checked for potential erosion after large storms events. Erosion can be controlled by the addition of rock splash pads around inlets and slope stabilization techniques. Infiltration rates through the soil should also be monitored after large rain events and standing water remaining after 48 hours should trigger an inspection for sources of possible clogging. The basin may need to be raked or soil excavated, cleaned and replaced. If significant sediment builds up on the soil surface this should also be removed so as to not affect infiltration to the underdrains.

Table 7-6: Biofiltration Area Pollutant Mass Removal Rates(CDM, 2006)

Constituent	Percent Removal
BOD5	20%-30%
COD	20%-30%
TSS	20%-80%
TDS	0%-10%
Total-P	10%-30%
Dissolved-P	0%-10%
TKN	10%-20%
NO2+NO3	0%-10%
Lead	30%-50%
Copper	20%-40%
Zinc	20%-40%
Cadmium	20%-40%

Figure 7-11: Sample Area for Incorporation of a Bioretention Area

Cost

The Charles River Watershed Association in Massachusetts has estimated installation costs as $10-12 per square foot.

7.3.4 Limited Use BMPs

Detention ponds, underground storage vaults and gravity separators have been highlighted as having the potential for limited use within New Orleans. Each of the BMPs is described briefly in this section and reasoning for their limited use characterization is provided.

Detention Ponds

Biodetention ponds can be either wet or dry. Wet ponds maintain a permanent pool of water and runoff from storm events, which is then retained and treated within the pool. Wet ponds are largely impractical for use within New Orleans due to space requirements within the urban environment; however incorporation of stormwater benefits into the water features within parks and golf courses should be considered.

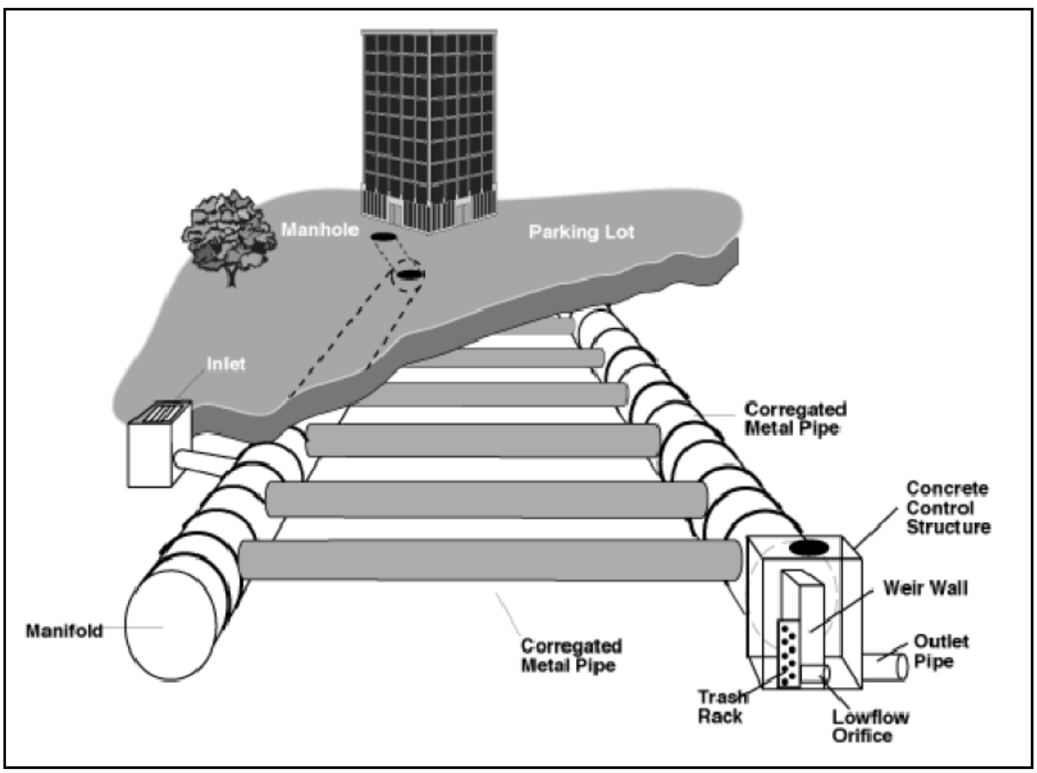
Figure 7-12: Example of Multipurpose Detention Basin in Japan (Associated Programme on Flood Management, 2008)

Dry ponds can be constructed which are only utilized to retain water only in large storm events. The advantage is that the land area can be utilized for other uses during non-flood events such as the tennis courts utilized for stormwater storage in ***Figure 7-12***. Dry detention ponds provide a good option for controlled flooding within Orleans Parish; however, safety considerations, land use planning and required grading to direct stormwater flow into the detention ponds are limitations needing careful consideration.

Underground Detention

With space as a limiting factor, underground detention tanks and vaults are an option for stormwater detention which does not take up significant surface space. Underground storage would only address water quantity issues and would not provide significant water quality improvements. Detention structures typically consist of either underground vaults made from reinforced concrete or tanks constructed with large diameter metal or plastic pipe.

Figure 7-13: Example Schematic for an Underground Detention Tank (Atlanta Regional Commission, 2001)



Underground detention was chosen as being of limited use do to the significant construction costs of retrofitting into the existing cityscape, the lack of water quality improvement and the high water table adding difficultly to design.

Gravity Separator

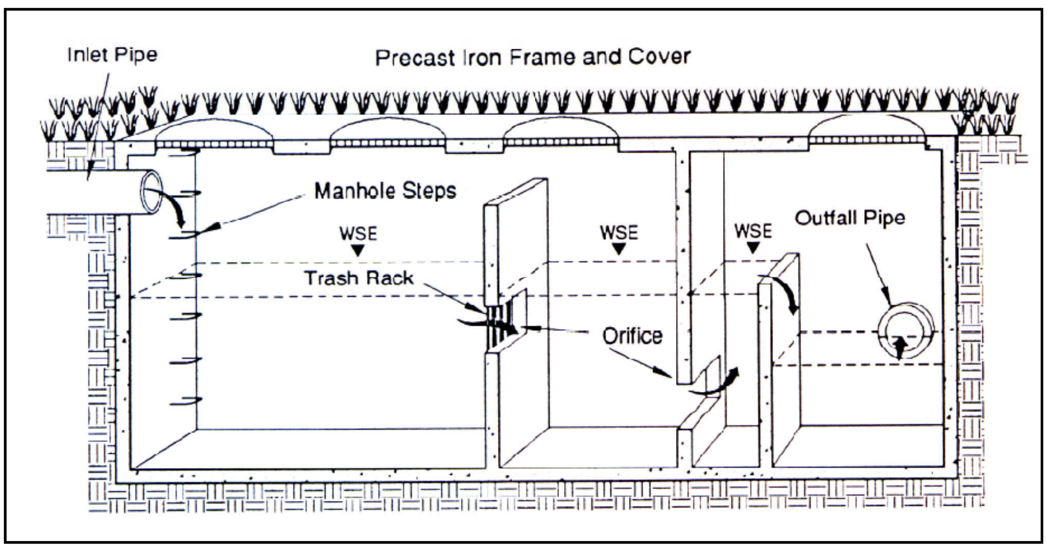
Gravity separators are a type of hydrodynamic device designed to remove debris, floatables, settable solids and oil and grease from stormwater runoff. This is typically achieved through gravitational settling and the trapping of pollutants. A gravity separator typically contains an inlet chamber, a separation/storage chamber and an outlet chamber. Gravity separators are designed specifically for water quality improvement in hotspot areas and will not have a significant effect of flood reduction. They are typically installed below ground level and will easily blend into the surrounding urban environment. They are applicable for space limited areas but will need an access point for maintenance activities.

Heavy sediments and solids will drop out via gravity within the inlet chamber. As flow moves into the main chamber further settling of suspended solids occurs and fills up the base of the chamber, while oil and grease rise to the top of the chamber and are isolated for future removal. The clarified central portion of the runoff then moves to the outlet chamber for discharge. Hydrodynamic devices are best utilized in pollution hotspots where there is a known problem with either suspended solids or oils and grease entering the stormwater system. Dissolved pollutants will not be significantly removed.

The frequency of maintenance depends on the level of pollution in the incoming runoff. An access port is provided to the chamber for inspection and maintenance purposes. Settled solids and floating grease and scum will need to be removed on a regular schedule to ensure they do not build up and pass into the discharge chamber.

Gravity separators were chosen to be of limited use since they are only appropriate for hotspot locations in need of significant water quality improvement and will not provide any improved flood protection.

Figure 7-14: Schematic for Gravity Separator (Atlanta Regional Commission, 2001)



Non-Structural BMPs

There are a variety of non-structural BMPs which can be utilized in an effort to decrease stormwater pollution loads. One common method is public outreach and education on topics such as automotive product disposal, proper housekeeping at commercial and industrial sites, inlet stenciling and guidance for proper pesticide and herbicide use.

Waste disposal programs can also help by collecting items such as household toxics or leaf and yard waste before they have the change to enter the stormdrain system. Parking lot and street sweeping as well as catch basin cleaning can also keep leaves and debris out of the storm drain system.

Simply maintaining green spaces and undeveloped areas will also help stormwater management by limiting the amount of impervious area. With the large number of abandoned structures within Orleans Parish, removing impervious surfaces to limit runoff production is a viable option to decrease peak flow rates and volumes. ***Figure 7-15*** shows an example abandoned lot, unnecessarily covered by asphalt and collecting water which is unable to infiltrate or move into the drainage system.

Figure 7-15: Example Area for Removal of Impervious Surfaces

7.3.5 BMPs Not Considered

Not all BMPs are currently appropriate for adoption within Orleans Parish as a part of the Stormwater Management CIP. ***Table 7-7*** briefly describes some of the BMPs not considered and reason for omission.

Table 7-7: BMPs Not Considered

BMP	Description	Reason for Omission
Green Roofs	Green roofs incorporate landscaping on building roofs to collect and evapotranspire runoff.	• Building roofs are outside of the Department of Public Works jurisdiction. • The increased structural loading must be considered for incorporation onto existing buildings.
Rainwater Harvesting	Rainwater can be collected and stored for reuse in applications such as toilet flushing or irrigation.	• Rainwater harvesting only applicable where there is a needed end use. • Harvesting typically the decision of individual land owners although PWB could encourage
Constructed Wetlands	Artificially constructed wetlands to provide stormwater treatment and natural wildlife habitat.	Not good retrofit potential for highly urbanized areas.

7.3.6 Onsite & Multi-Site Stormwater Management

As facility plans are considered for development, redevelopment, rehabilitation, and retrofit, it is recommend that multi-site opportunities be considered to increase benefits for the cost of the stormwater management investment. The following paragraphs present considerations of multi-site versus onsite facilities. In many cases, a combination of onsite (e.g., landscape swales) and multi-site (e.g., detention pond) can be considered.

Onsite Approach

In the case of future urban development, this option involves the delegation of responsibilities for BMP deployment to local land developers. Each developer is responsible for constructing structural BMPs at his development site for volume control and to control nonpoint pollution loadings from the site. The NO DPW would be responsible for reviewing each structural BMP design to ensure conformance with specified design criteria, for inspecting the constructed facility to ensure conformance with the design, and for ensuring that a maintenance plan is implemented for the facility.

A benefit of the onsite approach is that since the systems are small and widely dispersed they detain rainfall before it has a chance to significantly accumulate. This is naturally what happens prior to development as vegetation and surface ponding traps a significant portion of rainfall near where it fell.

Multi-Site or Regional Approach

This option involves strategically siting regional structural BMPs for volume control and to control nonpoint pollution loadings from multiple development projects. The front-end costs for constructing the structural BMP may be covered by the NO DPW with the BMP capital costs recovered from upstream developers on a "pro-rata" basis as development occurs. Individual regional BMPs are phased in as development occurs rather than constructing all regional facilities at one time. Maintenance responsibility for regional structural BMPs would be assumed by NO DPW.

Advantages of Multi-Site or Regional Approach

A multi-site BMP system offers benefits that are equal to or greater than onsite BMP benefits at a lower cost. Most of the advantages of the regional approach over the onsite approach can be attributed to the need for fewer structural facilities that are strategically located within the watershed. The specific advantages of the regional approach are summarized below.

1. *Reduction in capital costs for structural BMPs*: The use of a single stormwater detention facility to control runoff from 5 to 15 development sites within a 500-1,000 acre area permits the local government to take advantage of economies-of-scale in designing and constructing the regional facility. In other words, the total capital cost (e.g., construction, land acquisition, engineering design) of several small onsite detention BMPs is greater than the cost of a single regional detention pond BMP which provides the same total storage volume in a strategic place.

2. *Reduction in maintenance costs*: Since there are fewer stormwater detention facilities to maintain, the annual cost of maintenance programs is significantly lower. Examples of design features that are typically only feasible at regional BMP facilities to reduce maintenance costs include: access roads that facilitate the movement of equipment and work crews onto the site (by comparison, detention facilities implemented under the onsite approach are often located in residential backyards); additional sediment storage capacity (e.g., sediment forebay) to permit an increase in the time interval between facility clean-out operations; and onsite disposal areas for sediment and debris removed during clean-out.

3. *Greater reliability*: The bottom line is that a regional BMP system will be more reliable than an onsite BMP system because it will more likely be maintained. With fewer facilities to maintain and design features that reduce maintenance costs, the regional BMP approach is much more likely to result in an effective long-term maintenance program. Due to the greater number of facilities, the onsite BMP approach tends to result in a large number of facilities that do not get adequately maintained and therefore soon cease to function as designed. Most cities and counties that start off with the onsite approach eventually switch to the regional approach to

address the lack of maintenance of the onsite systems and to increase the overall effectiveness of the stormwater management program.

4. *Opportunities to manage existing nonpoint pollution loadings*: Nonpoint pollution loadings from existing developed areas can be affordably controlled at the same regional facilities that are sited to control future urban development. This is because the provision of additional storage capacity to control runoff from existing development in the facility's contributing area is reasonable in cost due to economies-of-scale. By comparison, the costs of retrofitting existing development sites with onsite detention BMPs to control existing nonpoint pollution loadings may be prohibitively expensive.

5. *Fair to land developers*: Land developers recognize that economies-of-scale available at a single regional BMP facility should produce lower capital costs in comparison with several onsite detention facilities. They also tend to prefer the regional BMP approach because it eliminates the need to set aside acreage for an onsite facility, and therefore could permit an increase in the number of dwelling units within the development site.

6. *Multi-purpose uses*: Regional facilities can often be landscaped to offer recreational and aesthetic benefits. Jogging and walking trails, picnic areas, ball fields, and canoeing or boating are some of the typical uses. For example, portions of the facility used for flood control can be kept dry, except during floods, and can be used for exercise areas, soccer fields, or football fields. Wildlife benefits can also be provided in the form of islands or preservation zones which allow a view of nature within the park schemes. Gradual swales can also be worked into the park concept to provide pretreatment around paved areas, such as parking lots or access roads.

Section 8
Regulatory Review

This section has been prepared to provide the City of New Orleans with proposed language to develop a series of ordinances that will establish a department specifically assigned to manage and maintain the stormwater collection system, define regulations for discharges to the stormwater system, and outline a permitting process.

The following section is meant as a starting point for the language which should be reviewed and considered for incorporation into final City ordinances which would be presented to the City Council and Mayor for approval. These are examples of the types of language that can be used to help meet the City's goals of developing ordinances to more effectively manage stormwater. Final ordinance language shall be prepared by the City's general counsel.

8.1 Stormwater Management Utility

8.1.1 Purpose and Objectives

The purpose and objectives of this ordinance are as follows:

1. To provide for effective management and financing of a stormwater management system within the City,
2. To provide a mechanism for mitigating the damaging effects of uncontrolled and unplanned stormwater runoff,
3. To improve the public health, safety and welfare by providing for the safe and efficient capture and conveyance of stormwater runoff and the correction of stormwater problems, and
4. To authorize the establishment and implementation of a master plan for stormwater drainage including design, coordination, construction, management, operation, maintenance, inspection and enforcement.

8.1.2 Stormwater Management Utility Established

The Stormwater Management Department is created as a City enterprise and utility to operate, maintain, and fund the stormwater management system within the jurisdiction of the City as described herein. The purpose of this department includes, but is not limited to, planning, design, permitting, operation, maintenance, construction, regulation, surveying, water quality testing, and inspection relating to stormwater management facilities and shall be responsible for the City's stormwater master plan, subject to appropriations from the City Council.

8.1.3 Jurisdiction

The jurisdiction of the Stormwater Management Department shall be defined in terms of both geography and facilities. Geographically, the jurisdiction of the department shall be described as all stormwater management facilities within the city limits. With respect to facilities, the jurisdiction of the department shall be described as:

1. Pipes, with a diameter of less than thirty-six inches (36-in.);
2. Manholes and Inlets with connection to pipes less than thirty six inches (36-in.) in diameter;
3. Catch Basins;
4. Road side ditches, channels, and swales with a nominal width of less than three feet (3-ft).

8.1.4 Stormwater Utilities Director

The Stormwater Utilities Director shall be responsible for administering and managing the operations of the stormwater management system in accordance with the provisions of management programs adopted by the City Council.

Duties and Powers

The director shall have all powers necessary for the exercise of responsibility of the managing stormwater runoff from all properties with the City covered by this Chapter, including, but not limited to, the following:

1. Preparation of plans for improvements and betterments to the stormwater management system;
2. Construction of improvements and betterments to the stormwater management system;
3. Promulgation of regulations for the use of the stormwater management utility and system, including provisions for enforcement of such regulations;
4. Review and approval of procedures, regulations and criteria by which all new development permits within the City for compliance with stormwater management regulations included in present City ordinances or ordinances later adopted;
5. Performance of routine maintenance and minor improvement to the stormwater management system;
6. Recommend the establishment and adjustment of user fees and charges, which shall be submitted to City Council for approval, for the City's stormwater management utility and system;
7. Evaluation of water quality concerns for discharges to the stormwater management system;
8. Performance of all normal utility functions to include construction, operation, and maintenance of the city's stormwater management system, including, but not limited to, the hiring of staff, the selection of special consultants, the entering into contracts for services and construction of facilities, and the handling of purchase, lease, sale or other rights to property for the stormwater management system; all consistent with the personnel and procurement requirements of the City;
9. Recommendation of the issuance of revenue bonds for the purpose of performing those duties as described herein.

8.1.5 Private Facilities

The property owner shall be responsible for stormwater drainage facilities located on private property where runoff will principally be collected, stored or conveyed within that property. The owner shall clean and maintain the facility or channel, as required, to ensure efficient and proper operation of the facility, and shall obtain the City Engineer or the Director’s prior written approval for any proposed changes or alterations to any private stormwater drainage facilities that, in the City's sole discretion, may substantially or adversely affect stormwater drainage. The Director shall provide for inspection of private facilities to ascertain that the stormwater facilities are functioning as designed and approved. The Director shall provide for remedial maintenance of facilities based upon the severity of stormwater problems and potential hazard to the public health, safety, and welfare.

8.1.6 Flooding Liability

Floods from stormwater runoff may occasionally occur which exceed the capacity of storm drainage facilities constructed, operated, or maintained by funds made available under this ordinance. This ordinance shall not be construed or interpreted to mean that property subject to this ordinance will always (or at any time) be free from stormwater flooding or flood damage, or that stormwater systems capable of handling all storm events can be cost-effectively constructed, operated, or maintained. Nor shall this ordinance create any liability on the part of, or cause of action against, the City, or any official or employee thereof, for any flood damage that may result from such storms or the runoff thereof. Nor does this ordinance purport to reduce the need or the necessity for obtaining flood insurance by individual property owners.

8.1.7 Definitions

City - shall mean the City of New Orleans, Louisiana and its staff and elected officials.

Department **-** shall mean the Public Works Department of the City.

Director **-** shall mean the Director of Public Works, who has been designated as the Director of the Stormwater Management Department or his designee.

Stormwater - shall mean stormwater runoff, surface runoff and drainage.

Stormwater management system **-** shall mean and include all elements, within the jurisdiction of the department, used to convey and/or store stormwater from the first point of impact with the ground surface to a suitable receiving water body or system.

8.2 Stormwater Permit Ordinances

8.2.1 Purpose

The purpose of the ordinance is to regulate soil disturbance, filling, excavation, and grading of property and permit stormwater discharges on all construction projects in the City to safeguard life, limb, health, property and public welfare; to avoid pollution of the MS4 drainage infrastructure conveyances, and waterways with nutrients, sediments, clay, sand, dirt, construction debris and other pollutants generated on or caused by surface runoff on or across the permitted area; and to ensure that the intended user of a construction site is consistent with applicable City ordinances.

8.2.2 Stormwater Permit Exemptions

The following are activities that shall not require a grading permit in order to perform cleaning, excavation or related earth work,

1. Any building permit for a less than 500 square foot addition to an existing structure, an interior remodel or a commercial build-out of a shell.
2. City capital maintenance and capital projects, road or drainage improvements or projects. City projects shall comply with all other state, federal, and local stormwater permit requirements.
3. Any emergency activity that is deemed immediately necessary by the City for the protection of life, property, or natural resources.

4. Septic system repair and/or alteration.
5. Excavation of graves in cemeteries.
6. Accepted agricultural practices such as plowing, cultivation, construction of agricultural structures, nursery operations, tree cutting, logging operations that leave the stump and root mat intact, and cultivated sod operations.
7. Minor landscaping and sprinkler installation that employ adequate BMPs to prevent stormwater pollution.

Responsibility Not Waived

The stormwater permit exemptions listed herein do not relieve the owner, developer, contractor, or other legal representative of the responsibility of installing and properly maintaining the appropriate erosion/sedimentation control measures or other liability resulting from such activities.

8.2.3 Projects Requiring a Stormwater Permit

Unless otherwise stated, no person shall perform any clearing, excavation, dirt work, grading, filling, construction, or development within the City without a Stormwater Permit.

Unless otherwise stated, no person(s) shall be issued any permit or work order for a construction project that requires performing any clearing, excavation, dirt work, filling, or construction within the City without first having obtained a stormwater permit. Stormwater permit requirements include but are not limited to the following:

1. New construction, residential and commercial
2. Additions greater than 500 square feet
3. New construction of accessory buildings greater than 500 square feet
4. Excavation, grading, filling
5. Land clearing
6. Pool installation or pond excavation
7. Flatwork, parking lot, and road installation
8. Subdivision development
9. Stockpiling fill material
10. Any soil disturbance immediately adjacent to, on, or in, a waterway

The stormwater permit is applicable but is not limited to the following activities:

1. Excavating, cutting, filling, grading, draining, or paving of lots, parcels, or other areas;
2. Altering, rerouting, deepening, widening, obstructing, or changing in any way an existing drainage system or feature.
3. Development for: residential, commercial, institution, industrial, utility or other activities:
4. Commencing any other development for excavation which may; significantly increase or decrease the rate and/or quantity of surface water runoff degrade the quality of water; adversely affect any sinkhole, water course, or water body.

8.2.4 Stormwater Site Plan Requirements

A City approved Stormwater Pollution Prevention Plan (SWPPP) or an approved stormwater site plan is required to obtain a Stormwater Permit. The site plan shall contain, as a minimum, the following items or information, as applicable.

1. Site Plan - The site plan shall contain the property owner's name, address, date, survey, legal description, and parcel or lot number, and the following:
   a. The actual shape, location, and dimension of the lot to be built upon;
   b. The shape, size, and location of all existing and proposed buildings or other structures;
   c. The location and approximate dimension of driveways, entrances, and all points of access to a public street or road;
   d. Locations of areas subject to flooding or limits of floodplain, if applicable;
2. Total Land Area
3. The locations of all existing and proposed streets, alleys, utilities, stormwater conveyances, drainage features, sanitary sewers and drainage, utility or access easements/servitudes.
4. All existing and proposed impervious areas
5. Natural or man-made watercourses
6. All existing and proposed slopes, terraces, bulkheads, or retaining walls
7. Erosion and sedimentation control plans.
8. Drainage and/or fill calculations when required
9. Direction of flow indicators
10. BMPs to control runoff and pollution.

Stormwater Site Plan Submittal, Review, and Approval Process

If site, drainage, grading, and erosion/sedimentation plans for the purpose of obtaining a Stormwater Permit are required, they shall be submitted to the Stormwater Management Department for review. They are to be submitted no less than thirty (30) days prior to the intended date to begin site alterations. The issuance of all applicable City permits is based upon approval of submitted site plans or SWPPPs.

The Stormwater Permit is valid for a period of two (2) years from the date of issue.

Stormwater Permit Fee

The fee for the Stormwater Permit is intended to assist in recovering some of the expenses associated with the permitting process. These costs consist primarily of administration, inspection, and enforcement activities and shall be approved and set by the City.

The suggested fee schedule for Stormwater Permits is as follows:

For projects with areas:

1.	Less than or equal to one (1) acre	$100.00
2.	Greater than one (1) acre	$200.00

8.2.5 Stormwater Permit and Stormwater Pollution Prevention

Developers and/or property owners shall use appropriate erosion and sedimentation control measures to ensure that erosion, or adverse conditions caused by erosion or sedimentation, are eliminated or held to an acceptable minimum and do not cross to an adjoining property, right-of-way, or pipe/channel system.

Stormwater controls must be employed for all City permits in a manner adequate to keep dirt, construction debris, and pollutants on the construction site and out of waterways and conveyances to the maximum extent practical.

All required state, federal, and local permits must be in place prior to issuance of Stormwater Permit.

Routine stormwater inspections will be performed by City stormwater inspectors, as stipulated in the Stormwater Permit.

8.2.6 Stormwater Inspection Fees

Routine stormwater inspections will be performed by City stormwater inspectors, as stipulated in the Stormwater Permit. The first stormwater inspection shall be scheduled prior to the commencement of construction and the final stormwater inspection shall be scheduled at the completion of construction when final site stabilization and landscaping is accomplished. The stormwater hold on occupancy shall be released upon approval of the final stormwater inspection.

Inspection fees are included in the Stormwater Permit fee. There is no additional charge to the permitee for inspections with the exception of re-inspections following a failed inspection. Fees for re-inspections are as stipulated in the Stormwater Permit.

8.3 Stormwater Discharge Ordinance

8.3.1 Purpose and Objectives

The purpose and objectives of this ordinance are as follows:

1. To maintain and improve the quality of surface water and ground water within the City of New Orleans Watershed.
2. To prevent the discharge of contaminated stormwater runoff from industrial, commercial, residential, and construction sites into the municipal separate storm sewer system(MS4), drainage infrastructure, conveyances, and waterways within the City.
3. To promote public awareness of the hazards involved in the improper discharge of hazardous substances, petroleum products, household hazardous waste, industrial waste, sediment, pesticides, herbicides, fertilizers, and other contaminants into the MS4 stormwater drainage infrastructure, conveyances, and waterways of the City.
4. To encourage recycling of used motor oil and the safe disposal of other hazardous consumer products to prevent, contaminants from entering the conveyances and waterways of the City.
5. To facilitate compliance with state and federal water quality standards, limitations, and permits by owners and operators of industrial activities and construction sites within the City.
6. To enable the City to comply with the MS4 Permit as well as all state, federal, and local regulations applicable to stormwater discharges.

8.3.2 Definitions

Unless a provision explicitly states otherwise, the following terms and phrases, as used in this Ordinance, shall have the meanings thereinafter designated

Abatement – Any action taken to remedy, correct, or eliminate a condition within, associated with, or impacting a stormwater drainage system.

City – City of New Orleans, Louisiana and its staff and elected officials.

Department – The City of New Orleans Department of Public Works.

Director – The Director of the Stormwater Management Department or his designee.

Discharge – The flow of any substance into the stormwater system.

Illicit Connection – Any drain or conveyance, whether on the surface or subsurface, that allows an illicit discharge to enter the City's MS4. This would include, but not be limited to, any conveyance that discharges sanitary sewage, process wastewater or wash water from sources such as indoor drains and sinks, regardless of whether said drain or connection had been previously allowed, permitted or approved by an authorized enforcement agency. Also, any drain or conveyance connected from a commercial or industrial land use to the storm drain system that has not been documented in plans, maps or equivalent records and approved by an authorized enforcement agency.

Illicit Discharge – Any discharge to a conveyance, other than stormwater and naturally occurring floatables, such as leaves or tree limbs. Sources of illicit discharges may include sanitary wastewater, septic tank effluent, oil disposal, radiator flushing disposal, laundry wastewater, roadway accident spillage, and household hazardous wastes.

Junk Motor Vehicle – Any vehicle which shall include by way of example but not be limited to the following vehicle types: automobiles, construction equipment, motorcycles, and trucks, which meets all of the following requirements:

1. Is three years old or older;
2. Is extensively damaged, such damage including, but not limited to any of the following: A broken window or windshield or missing wheels, engine or transmission;
3. Is apparently inoperable;
4. Is without a valid current registration;
5. Has a fair market value equivalent only to the value of the scrap in it

Municipal Separate Storm Sewer System (MS4) – The system of conveyances owned by the City and designed or used to collect and convey stormwater (including storm drains, pipes, ditches, etc.).

Stormwater – The stormwater runoff, surface runoff and drainage.

Stormwater Management System – All elements, within the jurisdiction of the department, used to convey and/or store stormwater from the first point of impact with the ground surface to a suitable receiving water body or system.

Trained Individual – An individual who is trained and experienced in the principles of stormwater quality, including erosion and sediment control as may be demonstrated by state registration, professional certification, experience, or completion of coursework that enables the individual to make judgments regarding stormwater control or treatment and monitoring.

8.3.3 Unauthorized Discharge – Public Nuisance

Discharge of stormwater in any manner in violation of this chapter; or any violation of any condition of a permit issued pursuant to this chapter; or any violation of any condition of a stormwater discharge permit issued by the LDEQ is hereby declared a public nuisance and shall be corrected or abated.

8.3.4 Enforcement

The City may institute appropriate actions or proceedings at law or equity for the enforcement of this chapter. Any court of competent jurisdiction shall have the right to issue restraining orders, temporary or permanent injunctions, and other appropriate forms of remedy or relief. Each day of noncompliance is considered a separate offense; and nothing herein contained shall prevent the city from taking such other lawful action as is necessary to prevent or remedy any violation, including application for injunctive relief. Any of the following enforcement remedies and penalties shall be available to the City in response to violations of this chapter. If the person, property or facility has or is required to have a storm water discharge permit from the Louisiana Department of Environmental Quality, the City shall alert the appropriate state authorities of the violation.

Notice of violation (NOV) – Whenever designated City staff find that any person, company or facility owning or occupying a premises has violated or is violating this chapter or order issued hereunder, the enforcement official may serve, by personal service, or by registered or certified mail, upon said person a written NOV. Within 30 days of the receipt of this notice, or shorter period as may be prescribed in the NOV, an explanation of the violation and a plan for the satisfactory correction and prevention thereof, which shall include specific required actions, shall be submitted to the director. Submission of this plan shall in no way relieve liabilities for violations occurring before or after receipt of the NOV.

Revocation of permit – The director or his/her designee may revoke and require the return of a permit or certificate by notifying the permit holder in writing, stating the reason for the revocation. Permits or certificates shall be revoked for any substantial departure from the approved application plans, or specifications; refusal or failure to comply with the requirements of state or local law; or for false statements or misrepresentations made in securing the permit or certificate. Any permit or certificate mistakenly issued in violation of any applicable state or local law may also be revoked.

Compliance order – If any person, company or facility shall violate the provisions of this chapter, the director of engineering, or his/her designee, may give notice to the owner or to any person in possession of the subject property, ordering that all unlawful conditions existing thereupon be abated within a schedule defined from the date of such notice.

Correction and Discontinuance of Prohibited Discharge –

> The Director may order the correction of any unsafe, nonconforming or unauthorized condition which is in violation of any provision of this code or regulation adopted hereunder. The Director may also order the discontinuance of any activity causing such condition.
>
> Whenever the Director orders the correction or discontinuance of any condition or activity on any premises, the Director, or their designee, shall notify the owner or other person responsible for such condition or activity in writing which notice shall state the nature of the violation, direct the person to correct or discontinue the condition or activity, and provide a reasonable time limit for

the satisfactory correction thereof. The offender shall, within the time period stated in such notice, permanently cease or correct all violations. Failure to comply with such order shall constitute a violation of the provisions of this ordinance.

The enforcement official shall have the authority to establish elements of a stormwater pollution prevention plan, and to require any business to adopt and implement such a plan, as may be reasonably necessary to fulfill the purposes of this chapter. The enforcement official may establish the requirements of best management practices for any premises.

The notice and order may be given provided, that if, in the opinion of the director, or his/her designee, the unlawful condition is such that it is of imminent danger or peril to the public, then an authorized City representative may, without notice, proceed to abate the same, and the cost thereof shall be charged against the property. The City, as described further in this subsection, may recover the cost of such actions from the property owner.

Civil penalties –

Any person, company or facility who has been found to have been in violation of any provision of this chapter, may be assessed a civil penalty not to exceed the amount presented in this subsection.

The penalty shall increase by 25 percent of the previous penalty amount for every subsequent but separate offense made by the same person, company or facility. The penalty shall be additional to other enforcement actions of this section.

The penalty may be assessed for each day beyond schedules applied in compliance orders or other schedules issued to the property owner or other person responsible for unauthorized activity defined in this chapter.

In determining the amount of the penalty the City shall consider the following:

The degree and extent of the harm to the natural resources, to the public health, or to the public or private property resulting from the violation;

The duration and gravity of the violation;

The effect on ground or surface water quality;

The cost of rectifying the damage;

The amount of money saved by noncompliance;

Whether the violation was committed willfully or intentionally;

The cumulative effect of other enforcement actions applied for the same offense;

The prior record of the violator in complying or failing to comply with the stormwater quality management program; and

The costs of enforcement to the City of New Orleans.

The maximum civil penalties will be determined by the type of offense. This indicates the maximum that may be imposed for a first offense and does not reflect the increases described above for repeat offenses.

Development without permit – To engage in any development, use, construction, remodeling, or other activity of any nature upon land or improvements thereon subject to the jurisdiction of this chapter without all required permits, certificates, or other forms of authorization as set forth in this chapter.

Development inconsistent with permit – To engage in any development, use, construction, remodeling, or other activity of any nature in any way inconsistent with any approved plan, permit, certificate, or other form of authorization granted for such activity.

Violation by act or omission – To violate, by act or omission, any term, variance, modification, condition, or qualification placed by the City or its agent departments upon any required permit, certificate, or other form of authorization of the use, development, or other activity upon land or improvements thereon.

Illicit discharge – Any person, company or facility that is found to have improperly disposed of any substance that is not defined herein or causes the city to be in noncompliance with any applicable environmental permit.

Household products – Any person, company, or facility who is found to have improperly disposed of any substance not included herein that was purchased over-the-counter for household use, in quantities considered normal for household purposes, which, upon discharge to the municipal separate storm sewer system or drainage network, would have an adverse impact on water quality or cause the city to be in noncompliance with any applicable environmental permit.

In the event there are penalties assessed by the state against the city caused by any person, company, or facility, said person, company or facility shall be assessed the equivalent amount of civil penalty. This shall include but is not limited to penalties for improper disposal or illegal dumping, or illicit connection into the municipal separate storm sewer system.

Administrative fee – Any person, company or facility who undertakes any development activity requiring a stormwater management plan hereunder without first submitting the plan for review and approval shall pay to the city, in addition to any permit or inspection fee, an administrative fee.

Order to clean and abate/restore – Any violator may be required to clean and/or restore land to its condition prior to the violation.

Cost recovery – If corrective action, including maintenance delinquency, is not taken in the time specified, or within a reasonable time if no time is specified, the City may take the corrective action, and the cost of the corrective action shall be the responsibility of the owner and the developer. The cost of the abatement and restoration shall be borne by the owner of the property and the cost therefore shall be invoiced to the owner of the property. If the invoice is not paid within 90 days, the enforcement official shall have the authority to place a lien upon and against the property. If the lien is not satisfied within 90 days, the enforcement official is authorized to take all legal measures as are available to enforce the lien as a judgment, including, without limitation, enforcing the lien in an action brought for a money judgment, by delivery to the assessor or a special assessment against the property.

Injunctions and or proceedings at law or in equity – Any violation of this chapter or of any condition, order, requirement, or remedy adopted pursuant hereto may be restrained, corrected, abated, mandated, or enjoined by other appropriate proceeding pursuant to state law.

Fee or utility credit revocation – This enforcement tool is intended to be available or used if there are, at any time, provisions for a funding mechanism managed by the City. This enforcement tool permits that credits or other measures to reduce fees or utility charges may be revoked, in full or in part, if any provision of the stormwater management chapter, or given authority herein are violated.

Civil actions – In addition to any other remedies provided in this chapter, any violation of this chapter may be enforced by civil action brought by the city attorney. Monies recovered under this subsection shall be paid to the city to be used exclusively for costs associated with implementing or enforcing the provisions of this chapter. In any such action, the city may seek, as appropriate, any or all of the following remedies:

1. A temporary and/or permanent injunction;
2. Assessment of the violator for the costs of any investigation, inspection, or monitoring survey which leads to the establishment of the violation, and for the reasonable costs of preparing and bringing legal action under this subsection;
3. Costs incurred in removing, correcting, or terminating the adverse effects resulting from the violation;
4. Compensatory damages for loss or destruction to water quality, wildlife, fish and aquatic life.

Emergency orders and abatements – The enforcement official may order the abatement of any discharge from any source to the stormwater conveyance system when, in the opinion of the enforcement official, the discharge causes or threatens to cause a condition which presents an imminent danger to the public health, safety, or welfare, or the environment, or a violation of a NPDES permit. In emergency situations where the property owner or other responsible party is unavailable and time constraints are such that service of a notice and order to abate cannot be effected without presenting an immediate danger to the public health, safety, or welfare, or the environment or a violation of a NPDES permit, the city may perform or cause to be performed such work as shall be necessary to abate said threat or danger. The costs of any such abatement shall be borne by the owner and shall be collectable in accordance with the provisions of this subsection.

Appeals – Upon issuance of a citation or notice of violation of this article it shall be conclusive and final unless the accused violator submits a written notice of appeal to the director of engineering within ten days of the violation notice being served. If the director of engineering does not issue a decision within ten days of the written notice of appeal then the violation is considered upheld. If the director of engineering does not reverse the decision, the aggrieved party may appeal to the transportation committee or successor, by filing a written request for hearing within ten days of the director of engineering's decision on the appeal. The request for hearing shall state the specific reasons why the decision of the director of engineering is alleged to be in error, and shall be accompanied by a cost bond with sufficient surety to secure the costs of the appeal, including the cost of court reporters, transcripts, plan reviews and other costs.

8.3.5 Improper Disposal & Illicit Discharges

It shall be unlawful for any person to improperly dispose any contaminant into the City MS4. Contaminants include, but are not limited to the following:

1. Trash or debris;
2. Construction materials;

3. Petroleum products including but not limited to oil, gasoline, grease, fuel oil, or hydraulic fluids;
4. Antifreeze and other automotive products;
5. Metals in either particulate or dissolved form;
6. Flammable or explosive materials;
7. Radioactive material;
8. Batteries, including but not limited to, lead acid automobile batteries, alkaline batteries, lithium batteries, or mercury batteries;
9. Acids, alkalis, or bases;
10. Paints, stains, resins, lacquers, or varnishes;
11. Degreasers and/or solvents;
12. Drain cleaners;
13. Pesticides, herbicides, or fertilizers;
14. Steam cleaning wastes;
15. Soaps, detergents, or ammonia;
16. Swimming pool backwash including chlorinated swimming pool discharge;
17. Chlorine, bromine, and other disinfectants;
18. Heated water;
19. Animal waste from commercial animal or feeder lot operations;
20. Any industrial and sanitary wastewater, including leaking sewers or connections;
21. Recreational vehicle waste;
22. Animal carcasses;
23. Food wastes;
24. Medical wastes;
25. Collected lawn clippings, leaves, branches, bark, and other fibrous materials;
26. Collected silt, sediment, or gravel;
27. Dyes, except as stated below;
28. Chemicals, not normally found in uncontaminated water;
29. Any hazardous material or waste, not listed above;
30. Washing of fresh concrete for cleaning and/or finishing purposes or to expose aggregates;
31. Junk motor vehicles, as defined herein;
32. Liquid from solid waste disposal containers.

Dye testing is allowed but requires verbal notification to the Director a minimum of 24 hours prior to the date of the test. The City is exempt from this requirement.

Penalties for minor discharges that have no significant adverse impact on safety, health, the welfare of the environment, or the functionality of the City's stormwater collection system may be waived at the discretion of the director

8.3.6 Illicit Discharge Reporting

As soon as any person responsible for a facility or operation, or responsible for emergency response for a facility or operation, has information about any known or suspected release of material that may result in illegal discharges or pollutants entering the storm sewer system or watercourses, said person shall take all necessary steps to ensure the timely discovery, containment and cleanup of such release.

In the event of a release of hazardous material, said person shall immediately notify emergency response agencies of the occurrence via emergency dispatch services.

In the event of a release of non-hazardous materials, said person shall notify the DPW or authorized enforcement agency in person or by phone or facsimile no later than the next business day.

If the report is made in person or by phone, the reporting party shall confirm the notice in writing addressed to the DPW within five (5) days. The written report shall specify:

1. The composition of the discharge and the cause thereof;
2. The date, time, and estimated volume of the discharge;
3. All measures taken to clean up the accidental discharge and all measures proposed to be taken to prevent any recurrence;
4. The name and telephone number of the person making the report, and the name and telephone number of a person who may be contacted for additional information on the matter.

A properly reported accidental discharge shall be an affirmative defense to a civil proceeding brought under this Chapter against a discharger for such discharge. The report itself shall not, however, be a defense to a legal action brought to obtain an injunction, to obtain recovery of costs or to obtain other relief because of or arising out of the discharge. A discharge shall be considered properly reported only if the discharger complies with all the requirements of this section. This requirement does not relieve the discharger from notifying other entities as required by State or Federal regulations

8.3.7 Conditional Discharges

The following types of discharges shall not be considered prohibited discharges for the purpose of this chapter unless the director determined that the type or quantity of discharge, whether singly or in combination with others, is causing significant contamination of the City's MS4;

1. Potable water;
2. Potable water line flushing;
3. Air conditioning condensate;
4. Discharges from emergency fire fighting activities and exercises (a stormwater pollution prevention plan should be prepared to address discharges or flows from fire fighting only where such discharges are identified as significant sources of pollutants to waters of the United States);
5. Uncontaminated water from crawl space, pumps or footing drains;
6. Lawn watering;

7. Residential car and boat washing;
8. Dechlorinated swimming pool water;
9. Materials placed as part of an approved habitat restoration or bank stabilization project;
10. Rising ground waters, uncontaminated ground water infiltration, uncontaminated pumped ground water, uncontaminated springs, diverted stream flows; riparian habitats and wetlands;
11. Flows from riparian habitats and wetlands;
12. Common practices for water well disinfections;
13. Discharges within the constraints of a National Pollutant Discharge Elimination System (NPDES) permit from the Louisiana Department of Environmental Quality (LDEQ);
14. Unless otherwise prohibited by this ordinance, any discharge that could be made directly to waters of the state without a federal or state permits being required;
15. Dye testing in compliance with this ordinance;
16. Other types of discharges as determined by the Director.

8.3.8 Illicit Connections

Any connection, existing or future, identified by the director, as that which could convey anything not composed entirely of stormwater directly to the City's MS4 is considered an illicit connection and is prohibited with the following exceptions:

1. Connections conveying allowable discharges as defined in the previous section.
2. Connections conveying discharges pursuant to an NPDES Permit (other than an NPDES stormwater permit).

Existing illicit connections must be stopped, at owner's expense.

8.3.9 Monitoring & Inspection

Monitoring

The director shall periodically monitor compliance of the stormwater permit holder.

The director, or their designee, shall take appropriate steps to detect and eliminate illicit connections to the City's MS4, including the adoption of programs to identify illicit discharges and their source or sources and provide for public education, public information and other appropriate activities to facilitate the proper management and disposal of used oil, toxic materials and household hazardous waste.

Inspections

The director or his designee, bearing proper credentials and identification, may enter and inspect properties for inspections, investigations, monitoring, observation, measurement, enforcement, sampling and testing, to effectuate the provisions of this chapter, the stormwater management plan, and/or the stormwater permit. The director or his designee shall duly notify the owner of said property or the representative on site and the inspection shall be conducted at reasonable times.

Upon refusal by any property owner to permit an inspector to enter or continue an inspection, the inspector shall terminate the inspection or confine the inspection to areas wherein no objection is raised.

The inspector shall immediately report the refusal and the circumstances to the director. The director may seek appropriate action.

In the event the director or his designee reasonably believes that discharges into the City's MS4 may cause an imminent and substantial threat to human health or the environment, the inspection may take place at any time and without notice to the owner of the property or a representative on site. The inspector shall present proper credentials upon request by the owner or representative.

If at any time during the conduct of an inspection or at such other times as the director or his designee may request information from an owner or representative, the owner or representative may identify areas of the facility or establishment, material or processes which contains or may contain a trade secret. If the director or his designee has no clear and convincing reason to question such identification, the inspection report shall note that trade secret information has been omitted. To the extent practicable, the director shall protect all information that is designated as a trade secret by the owner or their representative.

8.4 Construction Site Control Ordinances

8.4.1 Purpose and Objectives

The purpose of this ordinance is to establish requirements for stormwater discharges from construction activities so that the public health, existing water uses, and aquatic biota are protected. This ordinance establishes methods for controlling the introduction of pollutants into the municipal separate storm sewer system (MS4) in order to comply with requirements of the National Pollutant Discharge Elimination System (NPDES) permit process.

The objectives of this Chapter are:

1. To regulate construction activities disturbing land; and
2. To require construction site operators to develop and implement a Construction Plan including a Storm Water Pollution Prevention Plan (SWPPP) in order to receive a land disturbance permit from the City

8.4.2 General Requirements for Construction Sites

All Operators of construction sites shall use best management practices (BMPs) to control discharge to waterways and conveyances of the City. Pollutants such as silt, sediment, mud, clay, and other construction materials associated with clearing, filing, grading, excavation, and construction and construction shall be controlled to the maximum extent practical. Operators may refer to the Stormwater Management Design Manual for design criteria water quality standards, removal efficiency, hydrology requirements, and BMP selection and maintenance.

Existing vegetation shall be preserved, where feasible, and disturbed portions of the site shall be stabilized immediately upon the temporary or permanent cessation of construction activities. In no case shall disturbed soil remain destabilized for more than 14 days.

Structural BMPs shall be utilized, where feasible, to divert flow away from exposed soil, store stormwater, or otherwise reduce runoff and the discharge of pollutants from the construction site.

A stabilized construction exit shall be utilized to minimize the tracking of mud, clay, sediment, and other construction material onto roadways and streets.

The discharge of construction of building materials, including cement, concrete, lime, mortar, slurries, and paints is prohibited. On-site containment or off-site disposal is required.

Good housekeeping measures shall be employed to prevent and contain spills of paints, solvents, fuel, sewage, and any hazardous chemicals, and pollutants associated with construction and to assure proper clean-up and disposal of any such spills in compliance with state, federal and local regulations.

Proper waste disposal and management technologies shall be implemented including, but not limited to covering construction materials, construction debris, etc. and limiting ground contact with hazardous chemicals and construction waste.

Installation, inspection, and maintenance of erosion and sediment control measures, and other BMPs shall be consistent with the effective operating condition of the erosion and sediments controls and BMPs. Operators of construction sites are responsible for the installation and maintenance of all stormwater management measures until final stabilization of the site is accomplished and are not responsible for maintenance after stormwater discharges associated with construction activity have terminated.

The operator of construction sites shall provide site inspections, in accordance with the LPDES Stormwater Permit of disturbed areas that have not been permanently stabilized, storage areas for construction materials, structural control measures, and construction exit pads. All erosion and sediment control measures and other BMPs shall be inspected to ensure that they operate correctly and are effective in preventing significant impacts to roadways, waterways, and drainage conveyances. Based on the results of the inspections, BMPs shall be revised as necessary as soon as is practical.

Upon the approval of the SWPPP and the issuance of all other required permits and approvals by the City, the following shall occur during the period of construction activities:

1. The Director, or his designee, shall have the authority to conduct inspections of the site to ensure full compliance with the provisions of this ordinance, the design standards and technical specifications by the department and the terms and conditions of the approved SWPPP or Stormwater Permit.
2. A self-monitoring program shall be implemented by the project site owner to ensure the stormwater pollution prevention plan is working effectively. The program must include a trained individual who shall perform an inspection and prepare a written evaluation of the project site:
    a. By the end of the next business day following each 0.5 inch of rain; and
    b. At a minimum of one time per week.
3. The evaluation must address the maintenance of existing stormwater quality measures to ensure they are functioning properly and identify additional measures necessary to remain in compliance with all applicable laws and ordinances.
4. Written evaluation reports must include the name of the individual performing the evaluation; the date of the evaluation; problems identified at the project site; and details of corrective actions recommended and completed.
5. All evaluation reports for the project site must be made available to the inspecting authority within forty-eight (48) hours of a request.

Upon completion of the construction activities the following shall occur perpetually in accordance with the SWPPP regardless of site usage and land ownership:

1. All constructed stormwater quality facilities shall be maintained by the property owner, or per agreements on file with the Stormwater Management Department, and be in good condition and in accordance with the approved SWPPP operation and maintenance procedures and schedules and the Stormwater Management Department approved technical standards.

2. The approved stormwater quality facilities shall not be subsequently altered, revised or replaced except in accordance with the approved SWPPP or in accordance with Stormwater Management Department approved amendments or revisions to the SWPPP.

3. The Stormwater Management Department, or its designee, shall have the authority to conduct inspections of the site and the installed BMPs to ensure full compliance with the provisions of this Chapter, the design standards and technical specifications approved by the Stormwater Management Department and terms and conditions of the SWPPP.

4. The SWPPP, (sedimentation and erosion control plan), including stormwater inspection reports shall be available on site, as required by the LPDES Permit. The SWPPP is a dynamic document and shall be updated with BMP revisions and inspection reports.

The City may withhold issuance of any building permit, grading permit, development permit, inspection approval, or occupancy certificate on the grounds that the BMPs installed and/or described in the plans are inadequate to control or effectively reduce the discharge of sediment, silt, clay, mud, and any other material associated with clearing, grading, filling, excavation, and other construction activities to the maximum extent practical.

Any owner of a construction site, whether or not he/she is the operator is jointly and severally responsible for compliance with the requirements of this ordinance.

Any contractor or sub-contractor who is contractually responsible for a construction site; whether or not he/she is the operator; is jointly and severally responsible for compliance with the requirements of this ordinance.

Upon completion of site inspections, the erosion and sediment controls and BMPs shall be maintained, repaired, replaced, or corrected no later than one (1) calendar day following the inspection. Any modifications shall be recorded in the SWPPP.

Upon final stabilization of the construction site, the owner or duly authorized representative shall submit written certification to the City that the site is fully stabilized. The City may withhold occupancy certificates related to the site until certification of final stabilization has been filed and the City has determined, following a final stormwater inspection that final stabilization of the site has in fact occurred and that any required permanent structural controls are in place.

8.4.3 General Requirements for Stormwater Quality Control

All stormwater quality measures and erosion and sediment controls necessary to comply with this Chapter must be implemented in accordance with the stormwater pollution prevention plan (SWPPP) and comply with the technical standards adopted by the Stormwater Management Department. All water quality measures must be sufficient to satisfy the following conditions.

1. Minimize the potential for soil erosion by designing a development that complements the topography and soils of the site. Deep cuts and fill in areas with steep slopes should be avoided wherever possible, and natural contours should be followed as closely as possible.

2. Plan the phases of development so that only areas which are actively being developed are exposed. All other areas should have a good cover of temporary or permanent vegetation or mulch. Grading should be completed as soon as possible after it is begun. Immediately after grading is complete, permanent vegetative cover should be established in the area. Cut slopes and fill slopes should be revegetated as soon as they are brought to proper grade. Minimizing grading of large or critical areas during the season of maximum erosion potential reduces the risk of erosion.

3. Existing natural vegetation should be retained and protected wherever possible. Areas immediately adjacent to watercourses and lakes also should be left undisturbed wherever possible. Non-vegetated or vegetated areas with less than 70% cover that are scheduled or likely to be left inactive for 15 days or more must be temporarily or permanently stabilized with measures appropriate for the season to reduce erosion potential. Alternative measures to site stabilization may be acceptable if the project site owner or their representative can demonstrate they have implemented and maintained erosion and sediment control measures adequate to prevent sediment discharge from the inactive area.

4. Seeding, mulching, sodding, and/or other acceptable methods shall be performed as required to prevent undue erosion during all construction activities. The developer shall be required to keep accumulations of sand and earth out of the curb and gutter. Temporary siltation basins may be required during construction

5. All activities on a site should be conducted in a logical sequence so that the smallest practical area of land will be exposed for the shortest practical period of time during development.

6. The length and steepness of designed slopes should be minimized to reduce erosion potential. Drainage channels and swales must be designed and adequately protected so that their final gradients and resultant velocities will not cause erosion in the receiving channel or at the outlet. Runoff velocities must be kept low and water not allowed to concentrate, otherwise gully erosion can cause severe problems, particularly on slopes and fill areas. Slope lengths can be broken up by contour benching and furrowing, selective grading and roughening of slopes and through the use of berms, diversions and ditches.

7. Sediment-laden water which otherwise would flow from the project site shall be treated by erosion and sediment control measures appropriate to minimize sedimentation.

8. A stable construction site access shall be provided at all points of construction traffic ingress and egress to the project site. Material collected from sediment-laden water shall not be stockpiled or disposed of in a manner which makes them readily susceptible to being washed into any watercourse by runoff or high water.

9. Appropriate measures shall be implemented to prevent wastes or unused building materials, including, garbage, debris, packaging material, fuels and petroleum products, hazardous materials or wastes, cleaning wastes, wastewater, concrete truck washout, and other substances from being carried from a project site by runoff or wind. Identification of areas where concrete truck washout is permissible must be clearly posted at appropriate areas of the site. Wastes and unused building materials shall be managed and disposed of in accordance with all applicable State statutes and regulations. Proper storage and handling of materials such as fuels or hazardous wastes, and spill prevention and cleanup measures (including having spill response equipment on site) shall be implemented to minimize the potential for pollutants to contaminate surface or ground water or degrade soil quality.

10. Public or private roadways shall be kept cleared of accumulated sediment that is a result of runoff or tracking. Bulk clearing of accumulated sediment shall not include flushing the area with water. Cleared sediment shall be redistributed or disposed of in a manner that is in accordance with all applicable statutes and regulations.

11. Collected and treated runoff (i.e., allowing suspended solids to have settled out and been removed) leaving a project site must be either discharged directly into a well-defined, stable receiving channel.

12. Natural features, including wetlands, shall be protected from pollutants associated with stormwater runoff. All erosion and sediment control measures necessary to comply with this Chapter must be implemented in accordance with the submitted plans.

13. Erosion and sediment control measures shall be adequately maintained to perform their intended function during construction of the project. A site cannot be effectively protected without thorough, periodic checks of the erosion and sediment control practices. Proper installation and maintenance of practices is a must if they are to effectively perform their functions. A routine "end of day check" to make sure all control practices are working properly is an easy and quick way to maintain the site.

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Section 9
Rate Study

Development of the rate structure is the second step in the process of evaluating and recommending stormwater management fees to address the capital and ongoing O&M costs associated with effectively managing stormwater in the City of New Orleans. The funding sources available to the City are varied and can be used in combination. Provided herein is the basic structure for a stormwater utility fee.

9.1 Introduction to Stormwater Utility Fees

The establishment of a stormwater utility to generate revenue provides funding for the five significant aspects of a comprehensive stormwater management program (administration, operation and maintenance, renewal/replacement, capital improvements, and monitoring). The income can also be used to pay the debt service for a stormwater capital improvement program, thereby leveraging the utility's annual revenue into a major program.

Using revenues from a user charge system to fund stormwater management programs is a concept that has been in place for quite some time around the country. The concept was initially developed in the western U. S. and has been used there for a number of years. The City of Tallahassee was the first city in Florida to implement such a program in 1986. Since then many other municipalities and counties have adopted ordinances to initiate a stormwater utility with the ability to charge a fee for providing stormwater management services. Many cities and counties in states throughout the eastern and southeastern United States, including Florida, North Carolina, Maryland, Kentucky and Tennessee, have established stormwater management fees to fund improvements and O&M of their stormwater systems.

9.2 Advantages of a Stormwater Utility

The advantages associated with the implementation of a stormwater utility program are:

1. Dedicated Funding Source
   Revenue generated by a stormwater utility can be used as a new, dedicated source of funds to supplement or replace the community's current stormwater management funding, enabling tax-based funding to be used for other community needs.

2. Sustainable Revenue
   Revenue generated by a stormwater utility is based on user fees and provides a constant, sustainable funding source that increases with the community's growth. Sustainable funding allows municipal stormwater programs to operate on a stable basis to support staff, maintain existing infrastructure, and adopt long-term planning for capital investments, maintenance enhancement, and staff development.

3. Shared Cost
   A stormwater utility more equitably shares the costs of stormwater management among the users of the stormwater system than a property tax-based system, and increases the number of properties contributing funding of the stormwater management system by including tax-exempt properties.

4. Improved Watershed Stewardship
   Through incentive programs that reduce user fees, a stormwater utility encourages better stormwater management, such as the use of low impact development practices (LID).
5. Facilitation of National Pollutant Discharge Elimination System (NPDES) Compliance
   Communities with a stormwater utility that are regulated under the Federal NPDES Stormwater Permitting Program are, financially, more readily able to comply with the specific permit conditions contained in their Municipal Storm Sewer System (MS4) Permits.
6. Address Existing Stormwater Issues
   Stormwater utilities provide dedicated funding to address flooding, water quality, and aging infrastructure.

9.3 Other Public Utility Fees

The fundamental premise for stormwater utility is fairness and equitability. Similar to other public utilities, a unit of measurement must be determined as well as a method of measurement. Three common public utilities which can be examined for comparison include water, sewerage and solid waste.

Water

For the water utility, each customer serviced has a meter which measures the amount or volume of water consumed. This is a direct method of measurement. Payment is based directly on the amount of water consumed.

Sewer

Sewer service is handled differently. Because the amount of household sewerage can be related to the water consumption, sewerage volumes are estimated based on that relation. Therefore, each service site is not metered, and the basis of payment is dependent on the amount of water consumption. This is an indirect measurement of the utility.

Solid Waste

Solid waste is anther utility which is estimated and not directly measured. The rates are established based on the average weight or volume generated by specific user classes (i.e. residential, commercial, etc.). For this service, a flat rate is typically established for residential customers based on estimates of expected solid waste generation.

Stormwater

For the stormwater utility, the fee payer is assigned an equitable share of the cost of the stormwater management program, based on the relative contribution to the stormwater problem. This share is determined by the amount of runoff attributed to the property; the greater the runoff, the greater the contribution of the problem. The relative amount of runoff is estimated by the actual amount of impervious area on the parcel. This allows the utility to equitably and fairly distribute the stormwater management program costs.

Unlike the water utility, runoff for each rainstorm cannot be metered or measured directly from each land parcel. However, it can be estimated from factors which are known to affect runoff, principally the impervious area. The impervious area is easily measured and is a good indicator of the runoff potential for a parcel.

9.4 Comparable Municipal Stormwater Funding

Presented below are the current stormwater fees established for several municipalities similar to New Orleans. While the stormwater management needs of New Orleans are very unique, the cities and counties described below share several other common elements with the city.

9.4.1 The City of Philadelphia

The City of Philadelphia has had a stormwater fee for quite some time. Their stormwater billing methodology has recently undergone a significant shift in that the fees are now based on a combination of impervious cover and gross area of a particular parcel. As a result, 80 percent of the city's new stormwater fee is based upon a property's impervious area, with the remaining 20 percent based upon the property's gross area. In this way, stormwater fees will reach non-metered customers such as vacant lots, parking lots and utility right-of-ways that account for significant impervious space (and stormwater runoff) within the city.

Based on the 2008 Western Kentucky University, Stormwater Utility Survey, the average monthly stormwater fee for Philadelphia is $9.21.

9.4.2 Florida Stormwater Fees

The state of Florida has over 150 municipalities and counties that receive funding for stormwater management through utility fees. The monthly fees range from $.75 per Effective Residential Unit (ERU) in Auburndale, FL to $20.80 per ERU in Cooper City, FL. These examples reflect the extremes of stormwater fees in Florida. Cities like Orlando and Jacksonville are more comparable.

Orlando, FL Stormwater Fee

The City of Orlando charges a base stormwater fee of $4.00 per month plus $5.99 per month per ERU. The ERU for Orlando has been established at 2000 SF of imperviousness. The maximum and minimum annual fees are presented in ***Table 9-1*** below:

Table 9-1: City of Orlando Stormwater Fees

Property Type	Minimum Annual Fee	Maximum Annual Fee
Vacant	$62.40	62.40 per acre
Single Family Home	$84.99	$137.85
Multi Family Homes	$119.88 per ERU	$137.85 per unit
Commercial	$119.88 per ERU	N/A
Office Condo	$119.88 per ERU	N/A

Jacksonville, FL Stormwater Fee

The City of Jacksonville charges a base stormwater fee of $5.00 per month per Single Family Unit (SFU). The size of an SFU for Jacksonville has been established as 3100 SF of imperviousness. The annual stormwater fees are presented in ***Table 9-2***.

Table 9-2: City of Jacksonville Stormwater Fees

Property Type	Number of SFU	Annual Fee
Small Single Family	0.50	$30
Typical Single Family	1.00	$60
Large Single Family	1.50	$90
Multi-Family (2-4 Units)	.49	$29.40 per unit
Multi-Family (5-9 Units)	.32	$19.20 per unit
Multi-Family (>10 Units)	.44	$26.40

9.4.3 Texas Stormwater Fees

As of 2008, there were more than 35 cities, counties, or stormwater utilities in the state of Texas that charged a stormwater management fee. These fees range from $1.00 per month in McKinley Texas to $8.00 per month in Southlake TX. Selecting cities that would be comparable to the City of New Orleans resulted in choosing the cities of Grand Prairie and San Antonio.

Grand Prairie, TX Stormwater Fee

The City of Grand Prairie has separated its billings into two classes: Residential and Non-Residential. Separate rates are charged for single family homes based on the impervious footprint of the property. The fees for each is presented in ***Table 9-3***

Table 9-3: City of Grand Prairie Stormwater Fees

Category	Impervious Footprint	Annual Fee
Single Family	Up to 1,000 SF	$18.00
Single Family	1,001 SF to 2,500 SF	$45.12
Single Family	Larger than 2,500 SF	$52.20
Multi-Family	All Sites	$34.68 per unit
Non Residential	Actual Measurement	$1.28 per 100 SF

San Antonio, TX Stormwater Fee

The City of San Antonio bases its stormwater fee on the impervious foot print of the structure as well. San Antonio has chosen to separate its billings into separate classes: Single Family Residential; Multi-Family Residential; Commercial; and Public Facilities. The fees for each class are presented in ***Table 9-4*** below.

Table 9-4: City of San Antonio Stormwater Fees

Class	Impervious Footprint	Annual Fee
Single Family	Up to 4,999 SF	$38.64
Single Family	5,000 SF or Larger	$51.00
Multi-Family	Up to 21,999 SF	$86.28
Multi-Family	22,000 SF to 43,999 SF	$268.68
Multi-Family	44,000 SF to 131,999 SF	$814.80
Multi-Family	132,000 SF or Larger	$3,877.08
Commercial	Up to 21,999 SF	$219.84
Commercial	22,000 SF to 43,999 SF	$601.44
Commercial	44,000 SF to 86,999 SF	$1,077.94
Commercial	87,000 SF or 131,999 SF	$1,857.72
Commercial	132,000 SF or Larger	$4,104.36
Public	Up to 21,999 SF	$217.80
Public	22,000 SF to 43,999 SF	$595.68
Public	44,000 SF to 86,999 SF	$1,075.92
Public	87,000 SF or Larger	$1,818.84

9.4.4 Tennessee Stormwater Fees

In 2008, the State of Tennessee included 13 counties, Cities, and/or utilities that charged a fee for stormwater management services. The fees raged from a minimum of $1.00 per month in Dyersburg to a maximum of $4.00 per month in the cities of Franklin and Alcoa. For the purpose of this evaluation, the cities of Franklin and Memphis were chosen for further research.

Franklin, TN Stormwater Fee

The City of Franklin, TN uses a simple two class fee structure. Properties are designated as either residential or non-residential. For the purposes of determining the stormwater fee, an ERU of 3350 SF was established along with a monthly fee of $3.65 per ERU. The fees for each class are presented in ***Table 9-5***.

Properties that are less than 3350 SF pay a monthly fee equal to 75% of the charge for one ERU and properties larger than 3350 SF pay a monthly fee equal to 120% of the charge for one ERU. The fees for each class are presented in ***Table 9-5*** below.

Table 9-5: City of Franklin Stormwater Fees

Category	Building Size	Annual Fee
Residential	Less than 3,350 SF	$32.85
Residential	Greater than 3,350 SF	$52.56
Non Residential	Actual Measurement	$3.65 per ERU

Memphis, TN Stormwater Fee

The City of Memphis, TN two classes for the purpose of establishing a fee structure; residential and non-residential. Additionally, the City of Memphis has established 3147 SF of impervious surface as its unit of measure (SFU). In 2010, the monthly fee per SFU was $3.64. The fees for each class are presented in ***Table 9-6*** below. Monthly charges for properties that are non-single family are collected on a per unit basis.

Table 9-6: City of Memphis Stormwater Fees

Class	Impervious Footprint	% of SFU Rate	Annual Fee
Single Family	Up to 1841 SF	58%	$25.33
Single Family	1842 SF to 4794 SF	100%	$43.68
Single Family	Greater than 4794 SF	152%	$66.39
Multi-Family	Per unit	41%	$17.91
Townhouse/Condo	Per unit	57%	$24.90
Mobile Home	Per unit	77%	$33.63
High Rise/Apartment Complex	Per unit	13%	$5.67
Non-Residential	Per SFU	100%	$43.68

9.5 Alternative Funding Sources

The management of stormwater runoff is one of the services that the City of New Orleans provides to the public. Because of the historical lack of adequate funding from existing sources of revenue, new funding mechanisms for stormwater management need to be considered. The funding sources available to local jurisdictions are varied and can be used in combination. Some alternatives are available to fund all aspects of the stormwater management program, while others are particularly suited to fund only specific components. Included below is a general description of the types of funding sources that can be used to fund the components of stormwater management.

9.5.1 For Operating Costs

For the purpose of this section, operating costs refer to expenses related to management services (design, planning, permitting, administration, etc.), and operation and maintenance (minor repair, cleaning, etc.). Operating costs are generally labor-related, although the O&M program has a capital funding requirement for equipment and materials for minor construction.

General Fund/Ad Valorem Taxes

The City's current source of stormwater management funds is the General Fund. The General Fund can be best considered as a bank into which a number of revenues are placed and out of which many of the local government programs are funded. The major income source for the General Fund is real estate taxes (also known as ad valorem taxes since they are based on the value of property) for the City. This income is based upon assessed valuation of property within the City minus the homestead exemption for eligible properties. The current tax rate in New Orleans is $13.59 per $100 of assessed value.

The advantage of the General Fund is that it has normally been used to fund the stormwater program for many years so a long history of use has been achieved. It also is usually a large bank of money so it is able to fund the entire program. The major disadvantage of the General Fund is that revenues lose their identity once placed into the bank. That is, General Fund money can be used for any of the services and activities provided by the local government. This means that the competition for the funds is intense and history has shown that stormwater management does not compete well for General Fund revenues. It is for this reason that many government entities are looking toward another source of funding for stormwater management. Also, ad valorem taxes (which make up the largest portion of the General Fund) are based on property valuation and are not related to the stormwater service being provided to the taxpayer. A large property with a large amount of impervious area can pay the same amount of ad valorem taxes as a high-rise building with a small footprint (i.e., small imperviousness) if the property value is the same. General Fund money can be used for all aspects of the stormwater management program (management services, compliance activities, O&M and CIP).

Local Sales and Use Taxes

Louisiana General Statue authorizes the imposition of a sales and use tax. All sales tax revenues are placed in the General Fund and, therefore are available to be used for any activity, including stormwater management. However, as noted previously, the General Fund is used for all City activities and services so that use of the revenue for stormwater management is subject to competition with the other legitimate services provided by the City.

User Fees (Stormwater Utility)

Louisiana General Statutes allows all municipalities constructing, operating, or maintaining storm water or flood control facilities to establish a graduated storm water user's fee, which may be assessed and collected from each user of the storm water facilities provided by the municipality.

These stormwater user fees must be reasonable in amount and used exclusively by the municipality for stormwater purposes. The user fee must be based on actual or estimated use of the stormwater and/or flood control facilities of the municipality, and each user or user class shall only be required to pay its proportionate share of the construction, administration, operation and maintenance including replacement costs of such facilities based on the user's actual or estimated proportionate contribution to the total storm water runoff from all users or user classes. To ensure a proportionate distribution of all costs to each user or user class, the user's contribution shall be based on factors such as the amount of impervious area utilized by the user, the water quality of user's stormwater runoff or the volume or rate of stormwater runoff.

Properties such as owners and operators of agricultural land that do not discharge to the City's stormwater system should be exempted from payment of the stormwater user fee. The fee structure must provide credits for users who construct facilities to retain and control the quantity of stormwater runoff.

The stormwater utility can be used for all aspects of the stormwater management program. The net revenues can also be used to pay the debt service incurred by bonding a stormwater management CIP thereby leveraging the utility into a major program. Advantages of the program are:

1. dedicated funding for stormwater management activities;
2. a fee schedule based upon potential contribution to the stormwater runoff problem rather than property valuation;
3. the ability to incentivize stormwater stewardship practices by providing fee credits for those that reduce stormwater runoff from their property;

4. bonding capabilities to provided significant capital funding early in the program; and,
5. a stable funding source for all stormwater management activities.

9.5.2 For Capital Improvements

The Capital Improvement Program (CIP) usually includes construction and associated costs for major stormwater management facilities. As noted above, the General Fund, Sales Taxes, and Stormwater Utility can fund this component of the program. Listed below are additional mechanisms related to CIP funding.

Bonds

General obligation, revenue, or special assessment bonds are normally used by governments to pay for large capital improvement programs. Repayment of the bond can be through the General Fund (e.g., ad valorem tax renewal for general obligation bond); however, storm water utility revenues can be used to pay the debt service. The advantage of a bond program is that a large-scale capital improvement program can be initiated when the facilities are needed rather than waiting until the funds are available. The disadvantage is the long-term debt service payments. In fact, bonds represent a method to finance projects (make funds available in the short term) but do not generate new revenues.

Pay-As-You-Go Sinking Fund

Besides the use of bonds, a pay-as-you-go sinking fund is the most common type of stormwater management funding for capital improvements. Essentially, a sinking fund is a bank fed with revenues from numerous sources such as ad valorem taxes or stormwater utility fees. The fund is not used until sufficient money is available for an identified project upon whereupon the total project amount is removed from the fund and the growth stage starts over. No money is borrowed so it is pay-as-you-go and since it periodically is depleted, it is a sinking fund.

This method is generally used for capital improvement programs and can be used in conjunction with other revenue systems such as the stormwater utility. The major advantage is that no long-term debt service is created. On the other hand, capital projects must wait until the fund is of sufficient size to pay for the significant components of the project.

9.5.3 Related To Growth

One of the major issues in many states, including Louisiana, is the management of growth. As a consequence, new interest has been focused on mechanisms to fund the infrastructure needs of new developments, including stormwater management. Discussed below are methods by which a community can pay for the capital costs related to growth and redevelopment.

Fee-In-Lieu-Of Charge

An alternative to requiring developers to construct stormwater management facilities is to require them to pay an upfront charge for the capital improvements needed to service their development. The charge would be representative of the contribution of the development to the regional facility in the watershed. A fee-in-lieu-of charge is a technique to generate the funding needed for capital improvements in a watershed. It is derived from the case in which a developer is required to construct infrastructure including stormwater management systems. Since small-scale systems are not always advisable, particularly because of the problems associated with the acceptance of the O&M costs, the better choice is a fee paid to the municipality to construct a larger system. The fee is the developer's share of the regional facility.

There are two general areas when a fee-in-lieu-of charge is appropriate. First, it is appropriate where there is a large marginal cost of constructing additional facilities. For example using a water utility system for illustration, often developers are charged the cost of expanding a water system. If only additional pumping is required then the charge would be related to the average cost of providing an additional unit of water so that the marginal cost is small. On the other hand, if a new water supply source is required to accommodate the expansion, then a large marginal cost occurs and the developer must pay for the system expansion. In the same manner, if the addition of a development to the stormwater management infrastructure causes a large increment of cost, then the developer should pay a site-specific charge.

The second area is when the introduction of a sizable development precipitates the need for a new type of stormwater management system. For example, the stormwater management problem may be adequately controlled within a watershed with the use of drainage ditches and swales. With the introduction of a new development, a detention/retention facility may be required. In this case, the developer should pay a site specific development charge for the construction of the facility.

The major advantage of this method is that regional systems are promoted rather than the small-scale individual systems. The larger stormwater facility is easier to maintain and can address large-scale problems. The disadvantage could be that the developer must wait until sufficient funding is available for the regional system and until the municipality can construct the system. Nevertheless, the site-specific charge can be reasonably associated with a stormwater utility in newer communities for the augmentation of capital improvement funds.

Availability Charge

Similar to the site-specific development charge, the availability charge is applied to a developer of a parcel or a resident to recover the cost of the previously constructed facilities. In the case where a structure had been designed for an ultimate capacity, it is appropriate to charge new residents for their respective contribution to the capacity. The original cost of the structure may be funded by a stormwater utility or as part of the General Fund. In theory, the revenue generated by an availability charge should be returned to the long-time residents who have been supporting the debt service or utility cost. However, for practical reasons, this can be accomplished by allocating the revenue to the O&M funds to thereby decrease rate pressure. The revenue could also be allocated to a sinking fund for future capital needs in the area.

Developer Incentives

Through the zoning ordinances, incentives could be offered to induce developers to use proper stormwater management planning techniques. Such incentives, for example, could allow the developer to construct a density greater than normally allowed if land is dedicated to stormwater management purposes. This method would still require the construction of the stormwater management facility by the municipality; however, the land costs would be reduced.

9.5.4 Comparison of Alternatives

Based upon the discussion provided in the previous subsections, the various funding alternatives can be compared and assessed for use in the City of New Orleans. Three major sources of funding are considered further as they can generate sufficient revenue for the stormwater program needs of the City: real estate taxes, sales taxes and stormwater user fee or charge. Each of these alternatives was assessed in five areas: authority to implement, equity, revenue capacity, ease of implementation and initial costs.

Authority to Implement – Each of the three methods is authorized by Louisiana state code. The real estate tax and sales tax are already used by the City.

Equitability – The most equitable alternative is the stormwater utility since it is based upon the payer's potential contribution to the stormwater runoff in the study area. Real estate or ad valorem taxes are related to property valuation that is not related to stormwater runoff contribution.

Revenue Capacity – The General Fund currently is the revenue source for the stormwater management program for the City. Indications are that only limited expansion, if any, is available through this alternative and that the elected officials are reluctant to expand the use of this source for stormwater management funding.

Except for the stormwater utility, all of the other options have very limited capacities to produce funds for the overall program. Generally, these options provide funds for a localized O&M or CIP program. Bonds are used for CIP funding as well as capitalized O&M and depending on the ability to pay a long-term debt service, the revenue capacity is large. Because the payment of the fee is spread over a large base, the stormwater utility can certainly fund the existing program as well as an expanded one.

Ease of Implementation – The General Fund is already in place so that no effort is needed for implementation. The stormwater utility requires a moderate effort to implement since it is a new funding mechanism that will require public hearings as well as the preparation of a billing mechanism. The majority of the other alternatives are complex to implement because the associated ordinances must define the criteria for the charges.

Initial Costs – For the most part, the initial costs relative to the revenue capacity of the funding source are low. Stormwater Utility costs are moderate due to the need to collect area data and to update the data periodically. The system operation costs are generally minimal or moderate in comparison to the total program costs. The costs were judged as moderate when stormwater management services are increased because the City must be involved in the day-by-day judgments associated with the fees. The stormwater utility operational costs are low because the billing costs can be integrated with the City's existing water, sewer, and solid waste bills, making these costs small compared to the revenues collected.

9.5.5 Summary

The stormwater management program for the study area is currently funded by the general fund. Many of the other required governmental services also use the same general purpose fund and thus, the priority of the stormwater management program can vary depending on other demands on the fund.

A better source of funding is the stormwater utility fee (enterprise fees) for the following reasons:

1. The fee provides a dedicated source of funding for stormwater programs
2. The fee more equitably relates the amount of the payment to the stormwater service provided
3. The utility fee allows for incentives to customers to implement stormwater improvements and best management practices

9.6 Rate Structure Alternatives

Most of the stormwater utilities in the United States are based on the impervious area of the customer's property. The majority of stormwater utilities have a uniform rate for all residential and nonresidential parcels, with the residential customer's fee based on the number of dwelling units and the nonresidential customer's fee based on the impervious area. Based on results from a recent survey performed by Western Kentucky University, there are over 1,000 stormwater utility fee programs in the United States, a majority of which are based on the property's impervious surface. The purpose of this section is to discuss the alternatives for the stormwater utility rate structure. Alternatives include uniform and variable rates for both residential and non-residential customers and fee adjustment alternatives.

9.6.1 Parcel Data

For the purposes of this section, parcel specific information was obtained and assessed by CDM Smith. Data obtained from City sources included the number of parcels for all parcel types and number of dwelling units for residential parcel types. These data are summarized in ***Table 9-7***. The table shows that there are 186,000 parcels in the City.

The GIS data obtained for execution of this task allowed CDM Smith to obtain area measurements for all parcels within the City. CDM Smith initially sampled the residential developed parcels to obtain statistically significant areas for detached single family residence and attached single family developments. ***Table 9-7*** identifies ten significant groupings for all classes of parcels within the City. Simultaneously, CDM Smith summarized the entire area for distinct classes of small parcels into five subclasses below 2,849 square feet and groups 2 through 5 into subtotals, while group 6 was subdivided into eleven distinct subgroups.

These subgroups were used to potentially identify billing units that might be applied to the total number of groups or fractions of groups predicated upon land use. As these analyses continued, these subgroups appeared to be viable ways to classify billing units within the city.

Table 9-7: Available Parcel Data for Stormwater Charge

Group Identifier	Range of Parcel Areas (SqFt)	Number of Billable Parcels	Sub -Total Parcel Area (SqFt)	Total Parcel Area (SqFt)
1.1	< 1,830	7,213	9,867,393	
1.2	1,831 – 2,295	7,213	14,965,498	
1.3	2,296 – 2,485	7,213	17,407,671	
1.4	2,486 – 2,615	7,213	18,238,243	
1.5	2,616 – 2,850	6,458	19,708,841	80,187,645
2	2,851 – 3,450	33,567	105,052,386	105,052,386
3	3,451 – 4,100	33,183	124,080,876	124,080,876
4	4,101 – 5,450	33,699	159,933,101	159,933,101
5	5,451 – 7,500	29,661	187,940,891	187,940,891
6.1	7,500 – 7,765	2,243	17,119,037	
6.2	7,766 – 8,095	2,242	17,782,548	
6.3	8,096 – 8,530	2,242	18,621,194	
6.4	8,531 – 9,105	2,241	19,738,710	
6.5	9,106 – 10,000	2,242	21,360,583	
6.6	10,001 – 11,515	2,242	23,962,665	
6.7	11,516 – 14,300	2,242	28,498,873	
6.8	14,301 – 22,540	2,242	39,696,974	
6.9	22,541 – 64,325	2,242	84,003,106	270,783,690
6.10	64,326 – 154,690	1,121	109,872,630	109,872,630
6.11	> 154,691	1,121	945,810,857	945,810,857
			Total Billable Parcel Area	**1,983,662,075**

9.6.2 Equivalent Units

Stormwater utilities are generally based upon developed parcels (i.e. parcels that have impervious area on them). In order to provide an equitable measure of areas for both residential and non-residential developed parcels, stormwater utilities have used an equivalent unit to measure the impervious areas by a uniform billing unit. This unit is typically called an "equivalent runoff unit" and is based on a measure of either single family parcels alone or a mixture of all residential parcels. Similar to other types of utilities, the equivalent runoff unit for a stormwater utility is the relative amount of contribution of a fee payer compared to a residential unit. In other words, the residential unit is the billing unit for the utility fee.

In order to develop a rational process for allocating costs throughout the City, CDM Smith has developed preliminary billing units based upon charges distributed per 100 square feet of parcel land area. This approach would allow considerations for reduced charges if a specific parcel has a less percentage of impervious area than the average development. Likewise, an increased charge could be applied to parcels that have an impervious area that exceeds the average development.

9.6.3 Uniform or Variable Residential Rates

CDM Smith has utilized the land area presented in ***Table 9-7*** and generated the representative rates for different parcel sizes in ***Tables 9-8 and 9-9***. Because the soils in the area are functionally impervious after a short period of rain, the storm water fee is calculated based on the total parcel area. The values presented in ***Tables 9-8 and 9-9*** reflect the impacts of 2 distinct charges per 100 square feet per month. CDM Smith assumed that only 50 percent of the parcels greater than 154,691 SF would be charged and pay the respective fees. CDM Smith has also included a representative charge per typical parcel sizes in ***Tables 9-10 and 9-11***.

Table 9-8: Optional Stormwater Monthly Revenue and Yearly Revenue at $0.40

Individual Parcel Area (sq ft)	Total Parcel Area	Stormwater Charge $/100SF/Month	Monthly Revenue	Annual Revenue
< 64,325	927,978,588	$ 0.40	$ 3,712,000	$ 44,544,000
64,325 - 154690	1,055,683,487	$ 0.40	$ 4,223,000	$ 50,676,000
>154,690	945,810,857	$ 0.40	$ 1,892,000	$ 22,704,000
All Parcels	1,983,662,075	$ 0.40	$ 9,827,000	$ 117,924,000

Table 9-9: Optional Stormwater Monthly Revenue and Yearly Revenue at $0.20

Individual Parcel Area (sq ft)	Total Parcel Area	Stormwater Charge $/100SF/Month	Monthly Revenue	Annual Revenue
< 64,325	927,978,588	$ 0.20	$ 1,856,000	$ 22,272,000
64,325 - 154690	1,055,683,487	$ 0.20	$ 2,111,000	$ 25,332,000
>154,690	945,810,857	$ 0.20	$ 946,000	$ 11,352,000
All Parcels	1,983,662,075	$ 0.20	$ 4,913,000	$ 58,956,000

Table 9-10: Stormwater Monthly and Yearly Revenue Sample at $0.40

Parcel Area	Stormwater Charge $/100SF/Month	Monthly Charge	Annual Charge
5,000	$ 0.40	$ 20.00	$ 240
7,500	$ 0.40	$ 30.00	$ 360
10,000	$ 0.40	$ 40.00	$ 480
20,000	$ 0.40	$ 80.00	$ 960
50,000	$ 0.40	$ 200.00	$ 2,400

Table 9-11: Stormwater Monthly and Yearly Revenue Sample at $0.20

Parcel Area	Stormwater Charge $/100SF/Month	Monthly Charge	Annual Charge
5,000	$ 0.20	$ 10.00	$ 120
7,500	$ 0.20	$ 15.00	$ 180
10,000	$ 0.20	$ 20.00	$ 240
20,000	$ 0.20	$ 40.00	$ 480
50,000	$ 0.20	$ 100.00	$ 1,200

9.6.4 Adjustments & Credits

Adjustments (also known as errors and exemptions) are related to a reduction in the fee for a customer due to an error in the determination in billing units. For example, the customer has a reduced payment because of special circumstances, such as a reduction in imperviousness due to a portion of the property not draining to the City's stormwater system. On the other hand, a credit is related to the reduction in fees due to special action taken by the fee payer such as the design, construction and maintenance of an on-site stormwater pond that reduces both stormwater flows and pollutants associated with runoff. In both cases, however, the amount of the reduction can depend on the service being provided the customer.

With the examples presented for the city, the primary adjustment would be the quantity of parcel area on a given lot. If the absolute value is different from the value calculated by CDM Smith, the lot owner would have a decreased charge for a lesser land area or an increased charge for more land area. Likewise, a credit to the charge calculated for a specific land area would depend upon the percent imperviousness on a given lot. The customer must submit an application to support this reduction and the City will decide upon the appropriate reduced fee. During Phase II – Implementation, the City will need to develop the specific evaluation procedure and the appropriate forms to be utilized. The goal of this activity is to be "user friendly", while maintaining technical support for any reduction.