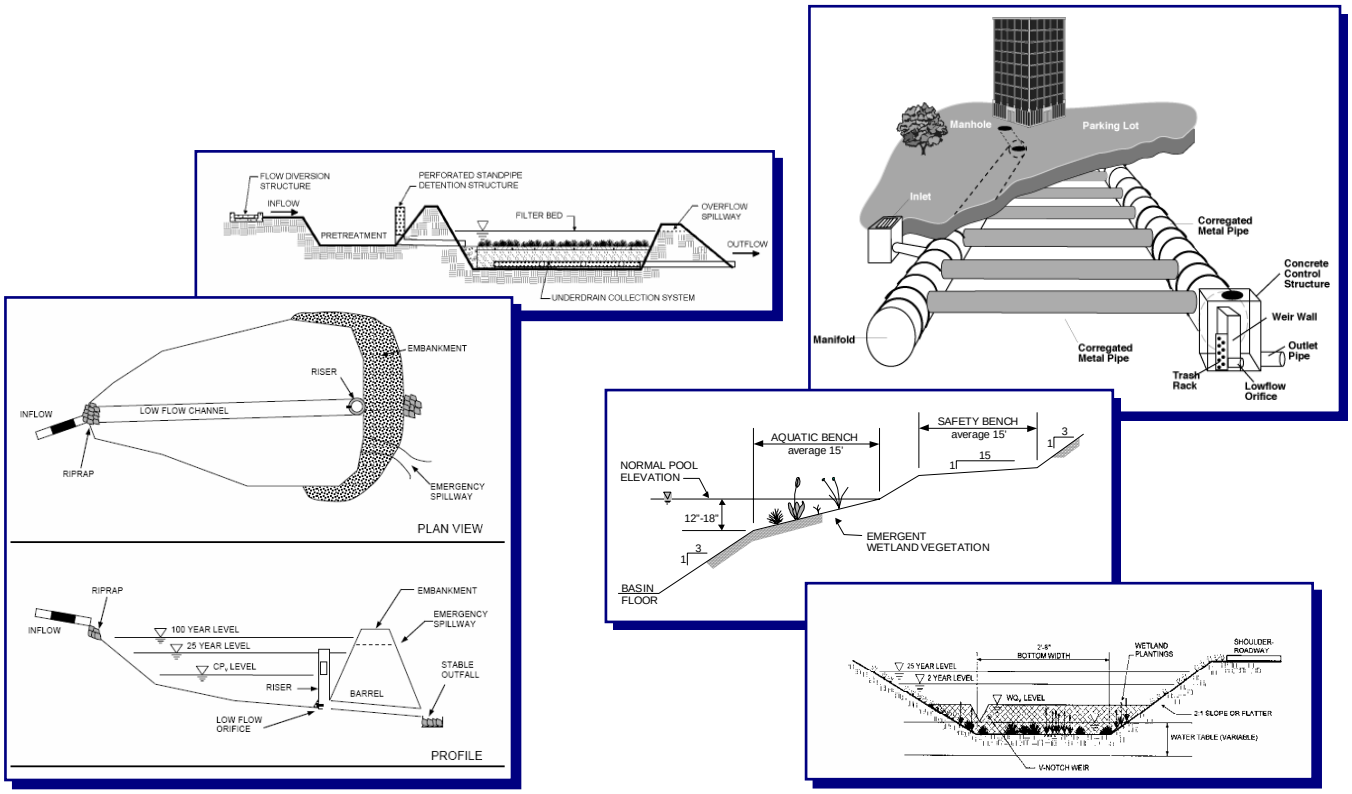
integrated Storm Water Management

Small Commercial Individual Site Case Study



iSWM

February 2005

Freese and Nichols

This report was prepared by Freese and Nichols, Inc for the North Central Texas Council of Governments. The purpose of this study is to provide a quantitative analysis to determine the impacts of implementing iSWM for development in North Texas. The report was reviewed by the Technical Review Team as well as the iSWM Steering Committee.

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Executive Summary

Integrated Storm Water Management (iSWM) is a new way of managing storm water in North Central Texas. With respect to site planning, iSWM encourages the integration of storm water quantity and quality considerations into the earliest stages of the development process. To evaluate the impacts and benefits of iSWM on development, six existing developments were selected from the North Central Texas region to be used as test sites.

For the small commercial development study, two Conceptual iSWM Site Plans were composed by applying the principles and guidelines of iSWM. These site plans are termed "Retrofit iSWM" and "New iSWM". Using the existing conditions development, or "As Developed", as a baseline, the cost difference between the existing development and each iSWM layout was determined, and the relative protective benefits were compared. Value-added benefits, such as the amount of parking, were also identified for each condition. The remainder of this Individual Site Case Study gives more detailed information about each site plan, as well as the benefits and impacts of each.

Constraints and Assumptions

- Both iSWM site plans were developed in the current regulatory environment.
- It is possible that the regulatory requirements in place during existing conditions were less restrictive than current requirements. This difference may result in an understatement of iSWM benefits.
- "Retrofit iSWM" was prepared in accordance with the current local development standards and zoning ordinances, using the parking configuration as the "As Developed" site plan.
- "New iSWM" assumed the use of iSWM from the planning stage of the development process and was prepared with the flexibility to make minor adjustments in the local ordinances and zoning.
- The size, location, and situation of the facilities located on the small commercial site have remained unchanged from the "As Developed" condition.

Results

The table to the right compares each iSWM site plan to the "As Developed" approach for various elements. Green shading indicates a beneficial result, yellow represents a neutral result, and red indicates an unfavorable result. The positive and negative symbols indicate an increase or decrease in a particular element from the "As Developed" condition.

In the small commercial site example, the infrastructure cost and onsite maintenance cost increased, and the available parking decreased relative to the "As Developed" condition.

Element	As Developed	Retrofit iSWM	New iSWM
Downstream Flood Control			
Streambank Protection			
Water Quality Protection			
Infrastructure Cost		+	+
Parking Difference		-	-
Annual Onsite Maintenance Cost		+	+

Value-added Benefits

- Wide range of storms considered by focusing on three design criteria (Flood, Streambank, and Water Quality Protection).
- Planned placement of bioretention areas provides the site with aesthetic benefits from extensive landscaping.
- Grass covers on the sand filters provide additional water quality benefits, as well as improve the aesthetic value of the site.

iSWM Overview

Integrated Storm Water Management (iSWM) is a new way of managing storm water in North Central Texas. The main objective of iSWM is to mitigate negative impacts of development by integrating the management of the quality and quantity of storm water, as well as fully integrating storm water considerations into the earliest stages of the development and site planning process. This entails a comprehensive approach to site planning and a thorough understanding of the physical characteristics and natural resources of a site. The benefits of iSWM include minimized flood risks, protection of natural drainage systems, preventing pollution of water resources, and an alternative to End-of-Pipe treatment.

In order to effectively address storm water management objectives, an iSWM Site Plan is recommended for all new developments and redevelopments. The iSWM Site Plan is a comprehensive study which provides the technical information a community needs to determine whether a proposed development meets the local storm water regulations. Communities are encouraged to implement a formal iSWM Site Plan preparation, submittal, and review procedure to meet their storm water management objectives. The preparation of an iSWM Site Plan ideally follows the following 6 steps.

1. **Consider the (5) Principles of Storm Water Management Site Planning**
2. **Review of Local Requirements**
3. **Perform Site Analysis and Inventory**
4. **Prepare Conceptual iSWM Site Plan**
5. **Prepare Preliminary iSWM Site Plan**
6. **Complete Final iSWM Site Plan**

Each development or redevelopment site should evaluate the (5) principles of storm water management site to see how iSWM concepts can aid the site (Step 1). A review of the local requirements (Step 2) must be completed to determine design parameters for the site. This step includes researching the zoning codes and city ordinances, design frequencies, and development requirements. In addition, a site analysis and inventory (Step 3) allows the engineer to assess the site for different site features including topography, drainage patterns, soils, and adjacent areas. The first three steps provide the engineer information needed for preparation of a conceptual iSWM site plan.

The Conceptual iSWM Site Plan (Step 4) allows the design engineer to propose a preliminary site layout and provides the developer and local review authority an initial look at the storm water management concept for the proposed development. The integrated Design Criteria must be evaluated when developing a Conceptual iSWM site plan. These criteria address the key adverse impacts of storm water runoff from a developed site; Water Quality Control, Streambank Protection, and Flood Protection. When considering flood protection, a downstream assessment is necessary in accordance with the 10% rule. The 10% rule requires assessment to the point where the site area is 10% of the total contributing drainage area to that point.

The Preliminary iSWM Site Plan (Step 5) expands upon the Conceptual iSWM Site Plan by building upon and refining the data provided. This step includes maps, narrative, and design calculations for the proposed storm water management system. The Final iSWM Site Plan (Step 6) is completed after the Preliminary Site Plan has been reviewed. It also includes an Erosion and Sedimentation Control Plan, Landscaping Plan, Operations and Maintenance Plan, and Acquisition of Applicable Permits. The completed Final iSWM Site Plan is then submitted to the local review authority for final approval prior to any construction activities on the development site.

Case Study Objectives

This study will provide a quantitative analysis to determine the impacts of implementing iSWM for development in North Texas. Six selected development projects from the NCT region have been selected for a quantitative analysis of iSWM impacts. These real projects were developed using existing drainage criteria and development standards typical for the region. The sites consist of two residential developments, two commercial developments, and two redevelopments. Each site has been evaluated based on the existing development, or "As Developed", and two alternative layouts applying the iSWM principles. The first layout termed "Retrofit iSWM" applies the design principles within the existing zoning code and development ordinances. The second layout termed "New iSWM" allows flexibility in the zoning codes and development ordinances.

The infrastructure, time, and maintenance cost impacts have been determined for each iSWM layout and compared to the "As Developed" development. Present-day costs and regulatory environment have been applied for this evaluation. This eliminates the need to consider recent changes in local or federal ordinances, policies or regulations. Region-wide average costs are used so that a fair comparison of iSWM benefits and impacts can be determined.

The analyses presented in this study should be considered conceptual as only steps 1 through 4 have been completed. Steps 5 and 6 have not been completed for the projects and are beyond the scope of this study. The selected controls, sizes, and siting are subject to modifications during the first review by the city. It had been assumed for the purposes of this study that the "As Developed" development plans adhered to the local ordinances and design guidelines at the tine they were completed.

The purpose of this study is to more clearly define what development using iSWM means to Developers, Contractors, Cities, and Designers. It can also be used as a tool for local City representatives to promote the implementation of the iSWM manual to their council, mayor, elected officials, and management staff.

Introduction

In November of 2003 a request for project nominations was sent out to the iSWM Steering Committee. The request was for large residential, medium commercial and small mixed-use redevelopment projects. In response to that request we received twenty-six (26) project nominations. The nominations included twelve (12) residential projects, seven (7) commercial projects, and seven (7) mixed-use redevelopment projects. The nominated projects can be seen in **Exhibit 1**. A field visit was conducted to observe the drainage development practices used for the project including natural drainage ways, storm drain systems, curb and gutter vs. vegetated swales, wetlands, floodplains, detention, swales, and ponds.

A small number of the projects nominated were observed to be good examples of how to design the project to enhance natural drainage patterns that created amenities rather than nuisances. A few of the projects nominated were still under construction, and could not be evaluated. Most of the projects nominated were good examples of the "As Developed" design mindset, and were appropriate for a case study comparison.

Six (6) projects were chosen for evaluation, two each for residential, commercial and mixed-use redevelopment. The residential sites selected include a small and large site. A car dealership and a large shopping complex were selected as commercial developments, while the mixed-use redevelopment sites selected included a home improvement store, and a downtown revitalization project.

For each of the 6 sites, the local requirements were reviewed (Step 2), and a site analysis and inventory was performed (Step 3). Using this information, two Conceptual iSWM Site Plans (Step 4) were prepared for each site. The first site plan, "Retrofit iSWM", was prepared in accordance with the existing local development standards, using existing lot sizes, and implementing iSWM procedures and principles. The second site plan, "New iSWM", was prepared to show optional site configurations that were possible if local ordinances and zoning changes were made. The following steps were followed when preparing the Conceptual iSWM Site Plans:

Step 1. Use integrated site design approaches as applicable to develop the site layout, including:
   a. Preserving the natural feature conservation areas defined in the site analysis.
   b. Fitting the development to the terrain and minimizing land disturbance.
   c. Reducing impervious surface area through various techniques.
   d. Preserving and using the natural drainage system wherever possible

Step 2. Calculate preliminary estimates of the integrated design criteria for water quality control, streambank protection, and flood protection based on the conceptual plan site layout.

Step 3. Determine the reduction credits for integrated site design to be accounted for in the design of structural storm water controls handling the water quality volume.

Step 4. Perform screening and preliminary selection of appropriate structural storm water controls and identification of potential siting locations.

As discussed in the iSWM Overview, only a Conceptual Site Plan was completed for each option. The following principles were kept in mind when developing the iSWM Conceptual Site Plans for each of the 6 chosen projects, Step 1 is the same for all projects and summarized below.

Step 1: Consider the 5 Principles of Storm Water Management Site Planning

- The site design should use an integrated approach to deal with storm water quantity, quality and streambank protection requirements.
- Storm water management practices should strive to use the natural drainage system and require as little maintenance as possible
- Structural storm water controls should be implemented only after all site design and nonstructural options have been exhausted.

- Structural storm water solutions should attempt to be multi-purpose and be aesthetically integrated into a site's design.
- Storm water management solutions are unique to each site design.

Steps 2, 3, and 4 are discussed in detail in the Case Study portion of this report. Steps 5 and 6 have not been completed for the purposes of this study. The Preliminary iSWM Site Plan is prepared in Step 5, and the Final iSWM Site Plan is completed in Step 6. A generalized overview of what Steps 5 and 6 should contain is discussed in the Appendix.

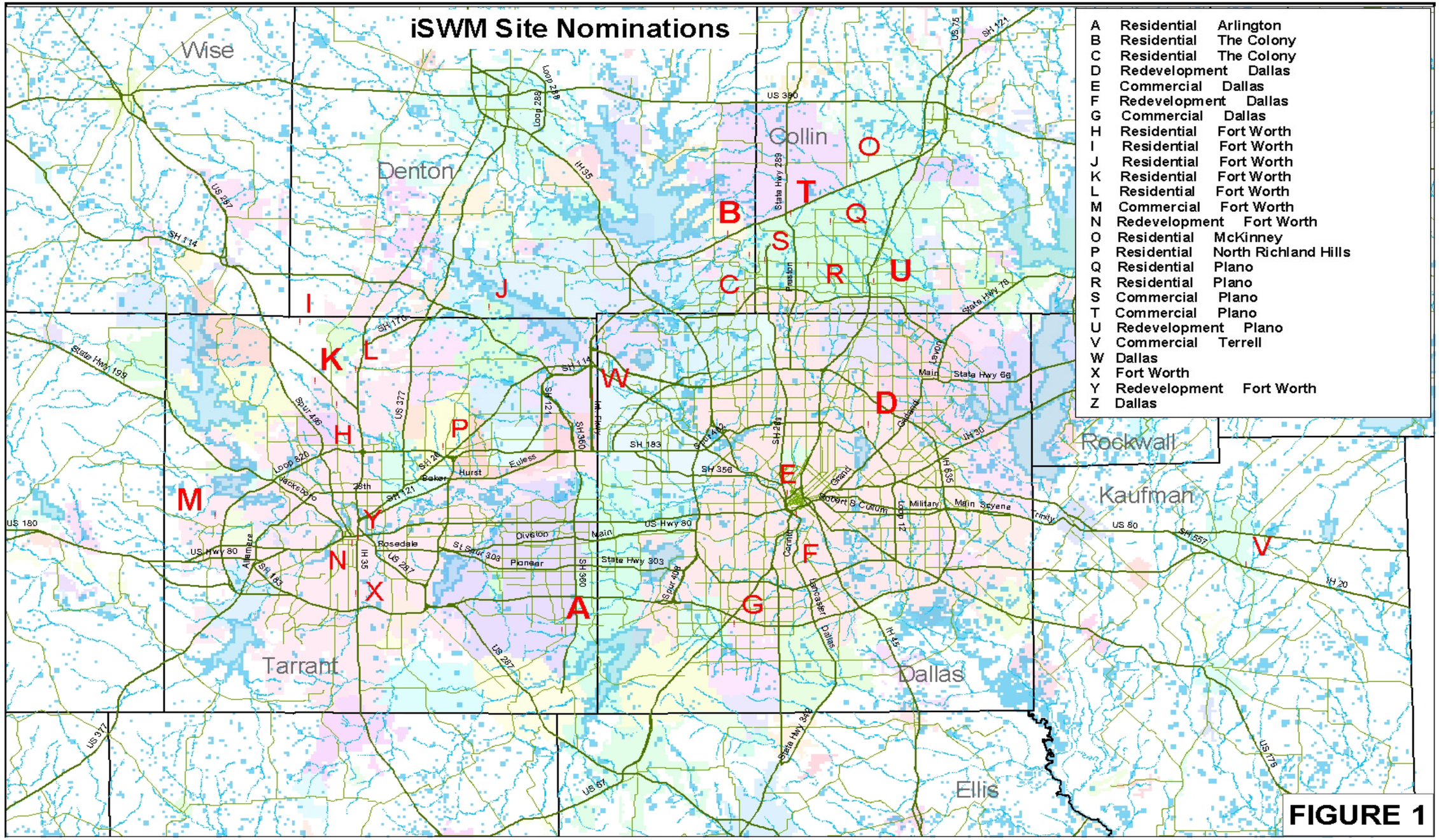

Exhibit 1: iSWM Site Nominations

Small Commercial Case Study:

This 20.26 acre commercial/retail tract was developed in 2001. The site is bound by a new roadway along the south and west borders, a highway frontage road to the east, and an undeveloped tract to the north. The Property prior to development was an open field with some underbrush and trees along the fence lines. The drainage pattern of the property is in two directions. Area A contains approximately 8.84 acres and consists of the southwestern portion of the site. Runoff form this area sheet flows south to an existing earthen channel. Area B contains approximately 11.42 acres and consists of the northeast portion of the site. Runoff from this area sheet flows east to the highway access road, and then south along the road to a series of curb inlets. The system ultimately discharges into Farmers Branch. The pre-developed conditions are shown in **Exhibit SC1**.

Under the "As Developed" development the site is divided into seven drainage areas. Several closed storm water systems are used to capture and convey onsite runoff from the proposed areas to the existing systems in the new roadway along the southwest, and the highway access road along the east. A drainage channel along the northern edge of the property intercepts runoff from the undeveloped tract north of the site and conveys it east to a new closed storm water system which connects to the existing system in the access road. The drainage area map for "As Developed" conditions can be found in **Exhibit SC2**. A photograph of the outfall location can be seen in **Figure SC1**.

It is assumed that the local storm water management and development requirements and design criteria were applied and followed when developing this commercial/retail tract; these are summarized in Step 2.

Figure SC1: Outfall Location Photograph

Step 2: Review Local Requirements

The main design storm frequency is the 100-year return period. Storm drain lines may be designed based on a minimum of the 5-year storm; however the total system must convey the 100-year storm. Culvert requirements are based on TXDOT regulations, and the velocity in culverts and storm drains can not exceed 15 fps. Channel improvements must be concrete-lined unless approved otherwise. Natural channels must have a minimum bottom width of 12 ft, minimum side slopes of 4:1, and a maximum velocity of 6 fps. In the 100-year storm, both natural and concrete-lined channel must have 1' freeboard. A fence must be constructed along a concrete-lined channel.

When developing or improving existing structures within the floodplain, the lowest finish floor must be at an elevation 1' above the BFE (100-year water surface elevation).

Commercial buildings in the F-R zoning district must not exceed a height of three stories, or forty-five feet. No front yard distance is required for this property, a back yard having minimum depth of 10 feet is required; in addition to a side yard setback of 5 feet.

No wetland provisions are required by the City. Designs must be based on fully-developed watershed conditions. A table of runoff coefficients is provided in the drainage manual, as well as IDF curves, time of concentration limitations, and a table of Manning's *n*-values. The City requires the bed and banks of any channel or pond to be maintained by the property owner. If proper maintenance is not performed by the owner, the City will conduct the work needed and place a lien on the property. No physical site evaluations are required by the City.

Development site plans should include a grading plan, an erosion and sedimentation control plan, and a Storm Water Pollution Prevention Plan (SWPPP). These plans should be developed in accordance with all national, state and local regulations and should be implemented prior to the commencement of construction activities.

Step 3: Site Analysis and Inventory

The pre-developed and "As Developed" site conditions for the small commercial site were collected and reviewed, and have been summarized in **Table SC1** below.

Site Feature	Pre-developed	"As Developed"
Topography	Development Plans	Development Plans
Drainage patterns and areas	Development Plans/USGS Quad Maps	Development Plans
Intermittent and perennial streams	Perennial	Both
Soils	Type D	Type D
Ground cover and vegetation	Native grasses with some underbrush	Paved/roofed surfaces with few landscape islands
Existing development	None	Commercial/Retail
Existing storm water facilities	Sheet flow to frontage road and drainage swale	Storm drain lines and inlets, grass channel
Adjacent areas	See **Exhibit SC1**	See **Exhibit SC2**
Property lines and easements	Powerline Easement	Powerline Easement
Wetlands	None	
Critical habitat areas	None	None
Boundaries of wooded areas	None	
Floodplain boundaries	See **Exhibit SC1**	See **Exhibit SC2**
Steep slopes	None	
Required buffers	N/A	N/A
Proposed stream crossing	None	

Table SC1: Small Commercial Site Inventory

Step 4: Conceptual iSWM Site Plan

Two Conceptual iSWM Site Plans have been developed for the small commercial site. For each alternative, the size and location of storm water controls were selected to meet the integrated Sizing Criteria in accordance with iSWM principles. The size, location, and situation of the facilities located on this site have remained unchanged from the "As Developed" condition.

The small commercial site is divided into 3 drainage areas for "Retrofit iSWM" and "New iSWM", totaling 20.75 acres. Drainage areas B and C drain to the closed storm drain system along the eastern border of the site, and drainage area A drains to the system along the southwestern border. Both systems drain south and outfall into a tributary to Farmers Branch.

For flood control analysis, a hydrologic model was established for the pre-developed and developed conditions. The model extends to a tributary to Farmers Branch according to the 10% rule for downstream assessment. In order to meet the flood control requirements, it is necessary to provide sufficient storage to reduce the peak flow rate by approximately 17 cfs in the small commercial site for both options.

As previously discussed, "Retrofit iSWM" has been prepared in accordance with the existing local development standards, and implementing iSWM principles and procedures. "New iSWM" has been prepared solely by iSWM regulations, allowing flexibility in the local development standards. Each option will be discussed in detail on the following pages.

Step 4A: "Retrofit iSWM"

In "Retrofit iSWM", the runoff from Drainage Area A is intercepted by catch basins and conveyed by the existing underground storm drainage system along the southwestern border of the site. The catch basins filter out trash, sediment, debris, and pollutants during all storm events. The water quality volume from this area is diverted to six offline proprietary units before they join the storm drain conveyance system. These units are designed to treat the water through a filtering and settling process, and then return it to the drainage system for safe conveyance to the downstream outfall. The runoff from Drainage Area A3 is conveyed to a Dry Extended Detention (ED) Basin before joining the existing drainage system. The Dry ED Basin is 7-ft deep, with vertical walls lined for protection with modular blocks and covering 0.28 acres, including a 5' grass buffer strip around the perimeter. The storage provided by the pond meets the streambank protection requirements for Drainage Areas A, OA, and part of C by releasing the 1-year storm over a 24 hour period. It also provides additional water quality protection and downstream flood control.

Drainage Area B is divided into two areas (B1 and B2) in "Retrofit iSWM". The water quality volume from B1 is treated with a bioretention area. This shallow landscaped area uses engineered soils and vegetation to capture and treat the runoff. The runoff enters the area through a grass buffer (filter) strip for pretreatment. It then flows to the "treatment area", consisting of a shallow ponding area, 3" mulch layer, 4' planting soil layer, and 1' sand filter layer. A gravel and perforated pipe underdrain system collects the filtered runoff and transports it to the underground storm drainage system. Storm volumes greater than the water quality volume bypass the bioretention area via a special diversion structure. The water quality volume from B2 is treated underground by four proprietary units. The cumulative drainage area (B) drains to a Dry ED Basin before joining the existing drainage system. The Dry ED Basin is 6.5-ft deep, with vertical walls lined for protection with modular blocks and covering 0.25 acres, including a 5' grass buffer strip around the perimeter. The storage provided by the pond meets the streambank protection requirements for Drainage Areas B, OB, and part of C and provides additional water quality protection and downstream flood control.

The water quality volume from Drainage Area C is treated with a bioretention area, similar to that in B1. A pea gravel diaphragm is located around the perimeter of the pond to spread the flow evenly so that it is efficiently treated by the grass buffer (filter) strip. Storm volumes greater than the water quality volume bypass the bioretention via a special diversion structure. The streambank and flood protection requirements for this area are met by oversizing the Dry ED Basins in areas A and B, as described above.

In offsite areas, filter strips are placed for additional water quality treatment.

Refer to **Exhibit SC3** for the site layout for "Retrofit iSWM". There are approximately 91 less parking places available in "Retrofit iSWM" as compared to the "As Developed" condition. This converts to a 6.1% parking loss. The integrated Design Criteria and Control sizes for "Retrofit iSWM" are summarized in **Table SC2** and **Table SC3** below.

Drainage Area	Area (ac)	WQ_V (ac-ft)	Control Type	SP_V (ac-ft)	Control Type	Flood Protection
A	8.10	0.85	Proprietary Systems (6)	1.06	Dry ED Basin	Dry ED Basin
B	8.01	0.96	Proprietary Systems (4); Bioretention Area	1.19	Dry ED Basin	Dry ED Basin
C	2.96	0.30	Bioretention Area	0.38	**	**

**The required streambank detention for Drainage Area C is accounted for with the ponds.

Table SC2: integrated Design Criteria for Small Commercial Site – "Retrofit iSWM"

Drainage Area	Control Type	Storage Volume (ac-ft)	Surface Area (ac)
A	Dry ED Basin	1.45	0.28
A1	Proprietary Systems (3)	N/A	N/A
B	Dry ED Basin	1.13	0.25
B1	Bioretention Area	0.03	0.08
B2	Proprietary Systems (4)	N/A	N/A
C	Bioretention Area	0.06	0.16
Offsite	Filter Strip	N/A	0.09

Table SC3: Controls used in "Retrofit iSWM" for Small Commercial Site

Step 4B: "New iSWM"

In "New iSWM", the runoff from drainage area A is intercepted by catch basins and conveyed by the existing underground storm drainage system along the southwestern border of the site. The water quality volume from this area is diverted to three offline proprietary units before they join the storm drain system. The streambank and flood protection requirements for this area are met by oversizing the Dry Extended Detention (ED) Basin located in drainage area D.

The water quality volume from drainage area B is treated with a Surface Sand Filter. This multi-chamber structure is designed to treat stormwater runoff through filtration by using a sediment forebay, a sand bed as its primary filter media, and an underdrain collection system. The water quality volume is diverted to the filter facility through the use of a flow diversion structure and flow splitter. Stormwater flows greater than the water quality volume are conveyed by the existing underground storm drain along the east boundary of the site. The sand filter also provides storage for downstream streambank protection. The remaining volume required for streambank protection is provided by the Dry ED Basin in area D.

As in area B, the water quality volume from drainage area C is also diverted to a Surface Sand Filter for treatment. The runoff from this area is conveyed to the Dry ED Basin in area D via an underground storm drainage system.

The water quality volume from drainage area D is diverted to two offline proprietary units for treatment. The Dry ED Basin, along with the two sand filters located in areas B and C, provides the volume required for downstream streambank and flood protection for the entire site. The Dry ED Basin outfalls to an underground storm drainage system, eventually discharging into Farmers Branch.

In offsite areas, filter strips are placed for additional water quality treatment for direct overland flow leaving the site.

Refer to **Exhibit SC4** for the site layout for "New iSWM". There are approximately 12 less parking places available in "New iSWM" as compared to the "As Developed" condition. This converts to a 0.8% parking loss. The integrated Design Criteria and Control sizes for "New iSWM" are summarized in **Table SC4** and **Table SC5** on the following page.

Drainage Area	Area (ac)	WQ_V (ac-ft)	Control Type	SP_V (ac-ft)	Control Type	Flood Protection
A	4.28	0.44	Proprietary Systems (3)	0.49	Dry ED Basin	Dry ED Basin
B	7.21	0.73	Surface Sand Filter	0.89	Dry ED Basin	Dry ED Basin
C	4.77	0.49	Surface Sand Filter	0.58	Dry ED Basin	Dry ED Basin
D	2.84	0.29	Proprietary Systems (2)	0.34	Dry ED Basin	Dry ED Basin

Table SC4: integrated Design Criteria for Small Commercial Site – "New iSWM"

Drainage Area	Control Type	Storage Volume (ac-ft)	Surface Area (ac)
A	Proprietary Systems (3)	N/A	N/A
B	Surface Sand Filter	0.55	0.10
C	Surface Sand Filter	0.36	0.07
D	Dry ED Basin	1.39	0.28
D	Proprietary Systems (2)	N/A	N/A
Offsite	Filter Strips	N/A	0.10

Table SC5: Controls used in "New iSWM" for Small Commercial Site

Results

Table SC6 gives a Cost Comparison for the small commercial site. The conceptual costs are divided into three categories: Infrastructure, Time, and Maintenance.

For the infrastructure portion, only the difference in cost between each alternative and the "As Developed" condition was evaluated. In other words only the elements that represent a change in cost (from "As Developed") are included in the table. The life cycle of the structural storm water controls used on each site was not considered when determining infrastructure costs. The **Total Infrastructure Difference** represents the difference in infrastructure cost between each alternative and "As Developed". If this value is negative, the corresponding site plan will cost *less than* the "As Developed" site plan. If this value is positive, the corresponding site plan will cost *more than* the "As Developed" site plan.

The Total **Review Time** also represents a difference between each alternative and the "As Developed" condition. If this duration is negative, the review time for the corresponding site plan will be *less than* the "As Developed" plan. Conversely, if this duration is positive, the review time will be *more than* "As Developed".

The **Annual Maintenance Cost** is always positive, and represents the iSWM impacts on maintenance costs. This number is not the total maintenance cost, but the cost in addition to that of the "As Developed" condition. For the maintenance portion, only elements that represent a change from "As Developed" are included.

The small commercial comparison between "Retrofit iSWM" and "As Developed" conditions increased the infrastructure cost by approximately $692,000. The total available parking was decreased by ninety-one (91) parking stalls. The regulatory review time for the site remained the same. Annual maintenance costs associated with "Retrofit iSWM" are estimated at $16,600.

The small commercial comparison between "New iSWM" and "As Developed" conditions increased the infrastructure cost by approximately $469,000. The total available parking was decreased by twelve (12) parking stalls. The regulatory review time for the site remained the same. Annual maintenance costs associated with "New iSWM" are estimated at $12,300.

Other Considerations

A storm water pond was considered in the small commercial site. However due to the dispersed nature of the dedicated control locations, it was not feasible to incorporate this control into the layout of the site.

iSWM Value-added Benefits

Although the financial impact of implementing iSWM is an important aspect, it is also imperative to consider the various value-added benefits that result from this new approach to storm water management. In general, by attempting to imitate the natural hydrologic conditions of the site, the iSWM site plan recognizes greater sustainability than the "As Developed" development.

By implementing iSWM, communities will be benefited with a new level of flood and streambank protection for onsite and downstream controls. The downstream assessment is beneficial for large sites that have the potential to dramatically impact downstream areas, as well as the small sites whose cumulative effect can be just as dramatic. As a result of this downstream assessment, the physical integrity of downstream storm water and flood control facilities is protected. Also, a decrease in sediment transport in the channels will reduce the silt loading on downstream reservoirs. As a result, the maintenance burden on these structures may be reduced, and the life of drinking water supply extended.

The offline bioretention areas used in the small commercial site will capture, store, and effectively treat the water quality protection volume. As an added benefit these areas have good retrofit capability and require relatively low maintenance. Since the areas require extensive landscaping, they can also be planned as an aesthetic feature for the development.

The surface sand filters used in “New iSWM” provide water quality protection as well as storage for downstream flood control. They also have good retrofit capability, and can be designed with a grass cover to aid in pollutant removal and prevention of clogging.

Table SC6: Cost Comparison for Small Commercial Site

Infrastructure Cost Difference	"Retrofit iSWM"	"New iSWM"
Bioretention System	$160,000	$0
Construction BMP Cost Savings for Pond	-$61,750	-$25,530
Earthwork Controls	$89,670	$33,540
Filter Strips	$1,680	$2,020
Forbay: Concrete Lined	$12,900	$7,400
Headwalls	$4,500	$4,500
Outlet Structures	$40,000	$10,000
Proprietary Systems	$150,000	$75,000
Retaining Walls	$139,940	$56,710
Sand Filtration	$0	$75,450
Slotted Inlets	$20,650	$0
Storm Drain Inlets	$6,000	$39,000
Storm Drain Pipes	$127,980	$190,890
Total Infrastructure Difference	**$691,570**	**$468,970**
Total Infrastructure Difference per acre	**$34,150**	**$23,160**

Review Time	"Retrofit iSWM"	"New iSWM"
FEMA (Floodplain Permits)	-	-
Individual 404 Permit	-	-
Nationwide 404 Permit	-	-
TCEQ	-	-
Total	-	-

Annual Maintenance Costs	"Retrofit iSWM"	"New iSWM"
Bioretention Area	$11,200	-
Dry ED Pond	$2,425	$977
Proprietary System	$3,000	$1,500
Sand Filter	-	$9,809
Total	**$16,625**	**$12,285**

Worksheet for Conceptual iSWM Site Plan
Small Commercial Site

I. Review of ***integrated*** **Site Design Practices**

	Yes	No	Comments
A. Conservation of Natural Features and Resources			
Are there opportunities to:			
1. conserve undisturbed vegetation?		X	
2. conserve floodplains?		X	
3. conserve steep slopes?		X	
4. conserve natural drainageways?		X	
5. conserve streams?		X	
6. conserve wetlands?		X	
7. conserve other natural features?		X	
8. conserve critical areas?		X	
B. Lower Impact Site Design Techniques			
Are there opportunities to:			
1. reduce clearing and grading?	X		
2. locate development in less sensitive areas?		X	
3. utilize open space development?		X	
5. utilize other techniques?		X	
C. Reduction of Impervious Cover			
Are there opportunities to:			
1. reduce roadway lengths?		X	
2. reduce roadway widths?		X	
3. reduce building footprints?		X	
4. reduce parking lots?	X		
5. utilize fewer or alternative cul-de-sacs?		X	
6. utilize pervious pavement?	X		
7. utilize other reduction measures?		X	
D. Utilization of Natural Features for Storm Water Management			
Are there opportunities to:			
1. utilize buffers?		X	
2. utilize undisturbed areas?		X	
3. utilize natural drainageways vs storm drain systems?		X	
4. utilize vegetated swales vs curb and gutter?		X	
5. drain runoff to pervious areas?	X		
6. utilize other measures or features?		X	

Worksheet for Conceptual iSWM Site Plan (Continued)

2. Review of **Reduction Credits for *integrated* Site Design**

	Yes	No	Comments
Can Reduction Credits be applied for the:			
A. **conservation and/or restoration of natural areas?**		X	
B. use of **stream buffers?**		X	
C. use of **vegetated channels?**		X	
D. use of **overland flow filtration/groundwater recharge?**		X	
E. use of **low imperviousness development?**		X	

3. Review ***integrated* Design Criteria**

	Comments
A. How will the *integrated* Design Criteria be achieved for **Water Quality Protection?**	**Proprietary Units; Filter Strips; Dry ED Basin; Bioretention Areas**
B. How will the *integrated* Design Criteria be achieved for **Streambank Protection?**	**Dry ED Pond**
C. How will the *integrated* Design Criteria be achieved for **On-Site Flood Control?**	**Inlets; Pipe Systems**
D. How will the *integrated* Design Criteria be achieved for **Downstream Flood Control?**	**Dry ED Basins**

4. Review of potential **hot spots**

	Yes	No	Comments
Are any of the following located or to be located on the site which may require special treatment and design consideration?			
A. Gas/fueling stations?		X	
B. Vehicle maintenance areas?	X		
C. Vehicle washing/steam cleaning areas?	X		
D. Auto recycling facilities?		X	
E. Illegal dumpsites?		X	
F. Outdoor material storage areas?	X		
G. Loading and transfer areas?	X		
H. Landfills?		X	
I. Industrial facilities?		X	
J. Other areas that may be a potential pollution source?		X	

Worksheet for Conceptual iSWM Site Plan (Continued)

5. Review of ***integrated* Storm Water Controls**

	Yes	No	Comments
Which of the following controls will potentially be used on the site?			
A. Alum Treatment System?		X	
B. Bioretention System?	1, 2		
C. Culverts?	1, 2		
D. Dry Detention?	1, 2		
E. Energy Dissipation?		X	
F. Enhanced Swales?		X	
G. Extended Dry Detention?	1, 2		
H. Filter Strips?	2		
I. Grass Channels?		X	
J. Gravity (Oil-Grit) Separator?		X	
K. Infiltration Trenches?		X	
L. Modular Porous Paver Systems?		X	
M. Multi-Purpose Detention Areas?		X	
N. Open Channels?		X	
O. Organic Filters?		X	
P. Porous Concrete?		X	
Q. Proprietary Systems?	1, 2		
R. Sand Filters (Surface/Perimeter)?		X	
S. Storm Water Ponds?		X	
T. Storm Water Wetlands?		X	
U. Street Gutters/Inlets/Pipe Systems?		X	
V. Submerged Gravel Wetland?	1, 2		
W. Underground Detention?		X	
X. Underground Sand Filters?		X	
Y. Other controls?		X	