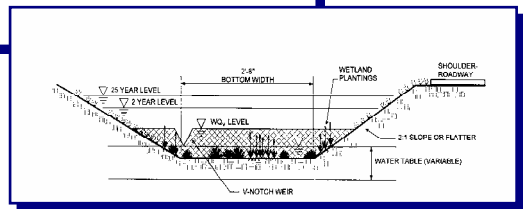
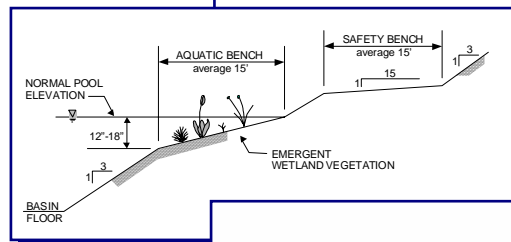
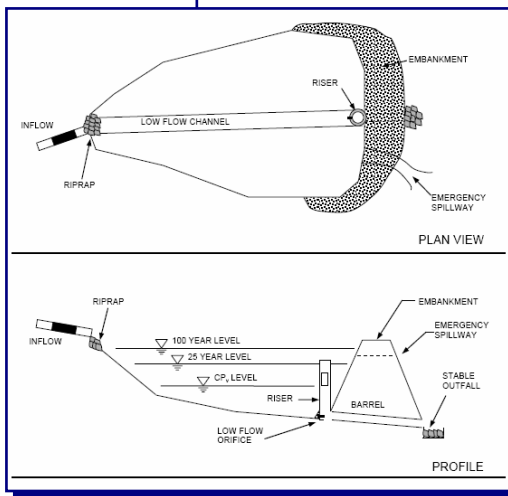
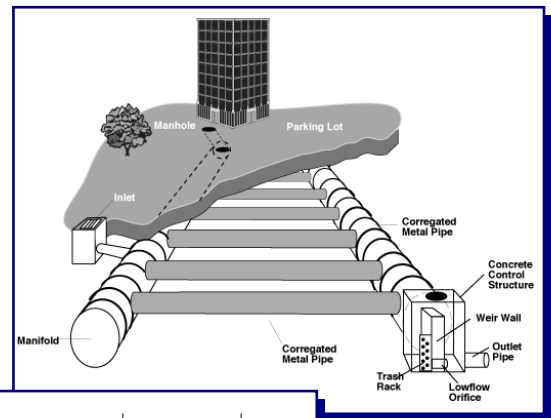
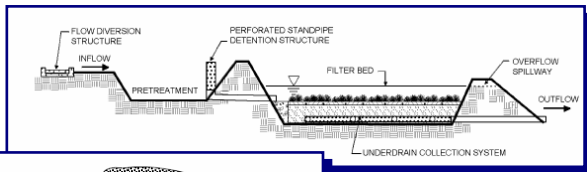


integrated Storm Water Management

Large Residential Individual Site Case Study



February 2005



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 large residential 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 number of home sites, 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 same lot sizes in 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.

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 large residential site example, the infrastructure cost, regulatory review time, and onsite maintenance cost increased, and the lot and net revenue decreased relative to the "As Developed" condition. The number of lots generated in "Retrofit iSWM" is decreased, but increases in "New iSWM" compared to "As Developed".

Element	As Developed	Retrofit iSWM	New iSWM
Downstream Flood Control			
Streambank Protection			
Water Quality Protection			
Infrastructure Cost		+	-
Lot Difference		-	+
Lot Revenue		-	-
Net Revenue		-	-
Regulatory Review Time		+	+
Annual Onsite Maintenance Cost		+	+

Value-added Benefits

- Wide range of storms considered by focusing on three design criteria (Flood, Streambank, and Water Quality Protection).
- Aesthetic benefits from amenities in and around storm water ponds.
- Natural Area Conservation in treed area provides opportunity for park and recreational uses.
- Linear park and trail system in utility easement takes place of park dedication fee; provides amenity for subdivision and increased market value for property owners.
- Enhanced swales offer aesthetic benefits as well as reduced runoff velocities.

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" plans adhered to the local ordinances and design guidelines at the time 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.

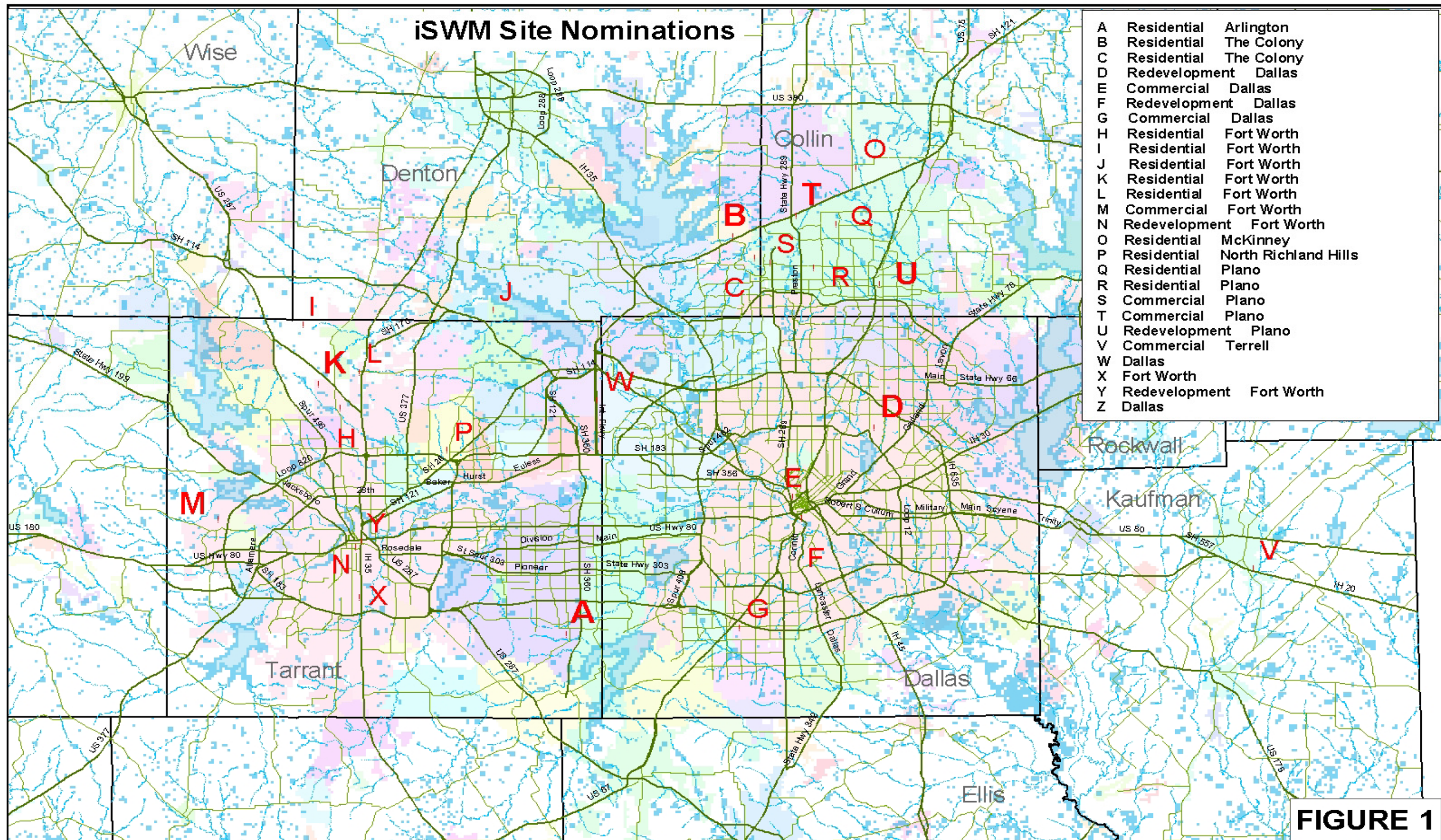


Exhibit 1: iSWM Site Nominations

Large Residential Case Study:

The 100-acre large residential subdivision was developed in 1999. The site is bound by an existing subdivision and electrical easement to the west, a future thoroughfare alignment proposed by the City to the north, an undeveloped agricultural tract to the east, and an existing two lane asphalt roadway with vegetated swales. There is also an electrical easement which divides the southeast corner of the property from the rest of the acreage. The land cover was mostly open space with a stand of trees in the northeast corner of the property where a large portion of the area drains naturally. A natural high just north of the electrical easement drains the northern portion of the site to Fish Creek. The southern portion of the property drains south to a natural tributary to Lynn Creek. There is no off-site flow contributing to the developed acreage. The pre-developed conditions are shown in **Exhibit LR1**.

Under the "As Developed" development the on-site flows are split into four systems, two of which outfall to the north and two to the south. The contributing areas can be found in **Exhibit LR2**, they have been named A, B, C and D. A portion of the natural site flows were re-directed to the north during development, increasing the flows to Fish Creek. The average lot size is approximately 1/6 acre. Typical 29-ft.-wide concrete curbed street sections are contained within 50-ft rights-of-way. It is assumed that the local storm water management and development requirements and design criteria were applied and followed when developing this large residential subdivision; these are summarized in Step 2.

Step 2: Review Local Requirements

The main design storm frequency is the 25-year return period. Storm drain lines may be designed based on a minimum of the 5-year storm; however the street ROW must convey the 100-year storm. Culverts are to be designed for the 25-year storm, and the velocity in culverts and storm drains can not exceed 15 fps. Channel armoring improvements must be concrete-lined unless approved otherwise. Grassy channels must have a minimum bottom width of 6 ft, minimum side slopes of 4:1, and a maximum velocity of 8 fps. A channel clear zone and/or a creek buffer zone may be required for any channel.

When developing or improving existing structures within the floodplain, or near open drainage facilities, the lowest finish floor must be at an elevation 2' above the 100 year fully developed water surface elevation.

Residential buildings must provide a front yard having a minimum depth of twenty feet, measured from the property line to the face of the main wall of the building; a back yard having minimum depth of 5 feet; and side yards having a minimum width of 5 feet for interior lots and a minimum width of 15 feet for sides adjacent to side streets for corner lots.

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. At the time of this development the City has no criteria for storm water quality.

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.

The City requires lot grading in accordance with the Type A, B or C drainage for each lot within the subdivision as described in HUD (FHA) data Sheet 72, as amended. Type 1 or 2 block grading is preferred, 3 and 4 are allowed with additional considerations for drainage.

Step 3: Site Analysis and Inventory

The pre-developed and “As Developed” site conditions for the large residential subdivision were collected and reviewed, and are summarized in **Table LR1** below.

Site Feature	Pre-developed	“As Developed”
Topography	USGS quad map	NCTCOG lydar data and plans
Drainage patterns and areas	USGS quad map	NCTCOG lydar data and plans
Intermittent and perennial streams	None	None
Soils	Type D	Type D
Ground cover and vegetation	Open space with grass and some underbrush and trees	Residential dwellings, paved roads, and grassy yards
Existing development	none	Residential
Existing storm water facilities	Earthen drainage swale	Storm drain lines and inlets
Adjacent areas	See Exhibit LR1	See Exhibit LR 2
Property lines and easements	Electric easements	Electric easements
Wetlands	None	
Critical habitat areas	None	None
Boundaries of wooded areas	See Exhibit LR1	
Floodplain boundaries	None	None
Steep slopes	None	
Required buffers	N/A According to local zoning ordinance see step 1 summary	
Proposed stream crossing	None	

Table LR1: Large Residential Site Inventory

Step 4: Conceptual iSWM Site Plan

Two Conceptual iSWM Site Plans have been developed for the large residential site. Each alternative involved replatting the development site; including the preservation of natural areas and addition of control locations in accordance with iSWM principles. The streets will be maintained within 50-ft rights-of-way and have typical 29-ft. concrete curbed street sections according to City standards.

Using the Snyder's Unit Hydrograph Methodology, a preliminary hydrologic model was developed to compare pre-developed and developed conditions. Since the site is roughly divided in half, with the northern portion draining to a stream north of the development and the southern portion draining to a stream south of the development, a model was developed for each of these portions. The model was extended downstream along each channel according to the 10% Rule for Downstream Assessment.

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 and lot sizes. Each option will be discussed in detail on the following pages.

The large residential site has four major outfalls. The northwest, northeast, and southwest portions of the site drain to individual road culverts, which outfall into separate open channels. These drainage areas are consistently termed A, B, and C, respectively in "Retrofit iSWM" and "New iSWM". The southeast portion drains to a roadside bar ditch. This area is termed D in "New iSWM" and divided between drainage areas D and E in "Retrofit iSWM".

Site Design Credit #1 (Natural Area Conservation) is applicable to the large residential site, since portions of the treed area in the northern part of the site are conserved for both options. When applying this credit, the undisturbed areas are not considered when determining water quality protection requirements.

Step 4A: “Retrofit iSWM”

“Retrofit iSWM” has a total developed area of 94.8 acres, of which 85.88 acres is zoned for single family residential, 0.54 acres of open space, 3.94 acres of treed area and 4.44 acres dedicated for storm water control locations. There are 329 total lots of which 253 have approximate areas of 1/8 acre with 67 lots approximately 1/4 acre in size, and 9 lots 1/3 acre or larger. A curb-and-gutter roadway system serves to convey runoff from the residential home sites. The runoff is then intercepted by a curb inlet and storm drain system or by drainage swales. The storm drain pipes and swales convey the storm water runoff to one of five control locations, and it eventually discharges into a downstream channel. Refer to **Exhibit LR3** for the site layout for “Retrofit iSWM”.

The development is divided into 5 drainage areas, each of which has a Micropool Extended-Detention Storm Water pond that serves to meet the integrated Design Criteria. The ponds maintain a concrete-lined wet forebay at the inlet, and a permanent micropool at the outlet, each of which is sized to contain 0.1 inches per impervious acre of contributing drainage. The outlet structure of each pond is sized to detain the water quality volume for 24 hours, to release the streambank protection volume over 24 hours, to provide adequate storage for downstream flood control, and to safely convey the runoff from the 100-year storm event.

Portions of drainage areas C and D are treated by enhanced wet swales. These vegetated channels capture and treat the storm water runoff within wet cells formed by check dams. They also convey the flood volume and serve to provide downstream streambank protection and flood control. The areas treated by an enhanced swale are subtracted from the total drainage area when sizing the storm water ponds for water quality protection. The integrated Design Criteria and Control sizes for “Retrofit iSWM” are summarized in **Table LR2** and **Table LR3** below.

Drainage Area	Drainage Area (ac)	WQ _v (ac-ft)	Control Type	SP _v (ac-ft)	Control Type	Flood, ΔQ (cfs)	Control Type
A	27.74	1.81	Micropool ED Pond	2.29	Micropool ED Pond	75	Micropool ED Pond
B	20.94	1.38	Micropool ED Pond	1.72	Micropool ED Pond	56	Micropool ED Pond
C	24.58	1.64	Enhanced Swales; Micropool ED Pond	2.13	Enhanced Swales; Micropool ED Pond	41	Enhanced Swales; Micropool ED Pond
D & E	20.08	1.43	Enhanced Swales; Micropool ED Pond	1.76	Enhanced Swales; Micropool ED Pond	56	Enhanced Swales; Micropool ED Pond

Table LR2: integrated Design Criteria for Large Residential Site – “Retrofit iSWM”

Drainage Area	Control Type	Volume (ac-ft)	Surface Area (ac)
A	Micropool ED Storm Water Pond	4.45	1.05
B	Micropool ED Storm Water Pond	3.54	0.89
C	Micropool ED Storm Water Pond	1.64	0.50
D	Micropool ED Storm Water Pond	0.89	0.33
E	Micropool ED Storm Water Pond	0.69	0.27
C1	Enhanced Swale (Wet)	0.07	0.14
C2	Enhanced Swale (Wet)	0.13	0.16
C3	Enhanced Swale (Wet)	0.26	0.29
C4	Enhanced Swale (Wet)	0.10	0.16
D1	Enhanced Swale (Wet)	0.26	0.36
D2	Enhanced Swale (Wet)	0.05	0.09
D1+D2	Enhanced Swale (Wet)	0.05	0.07

Table LR3: Controls used in “Retrofit iSWM” for Large Residential Site

Step 4B: “New iSWM”

“New iSWM” has a total developed area of 94.8 acres, of which 81.71 acres is zoned for single family residential, 0.88 acres of open space, 5.88 acres of treed area and 6.33 acres dedicated for storm water control locations. There are 373 total lots of which 327 have approximate areas of 1/8 acre with 36 lots approximately 1/4 acre in size, and 9 lots larger. A curb-and-gutter roadway system serves to convey runoff from the residential home sites. The runoff is then intercepted by a curb inlet and storm drain system or by a drainage swale. The storm drain pipes and swale convey the storm water runoff to one of four control locations, and it eventually discharges into a downstream channel. Refer to **Exhibit LR4** for the site layout for “New iSWM”.

The development is divided into 4 drainage areas, each of which has a Micropool Extended-Detention Storm Water pond that serves to meet the integrated Design Criteria. The ponds maintain a concrete-lined wet forebay at the inlet, and a permanent micropool at the outlet, each of which is sized to contain 0.1 inches per impervious acre of contributing drainage. The outlet structure of each pond is sized to detain the water quality volume for 24 hours, to release the streambank protection volume over 24 hours, to provide adequate storage for downstream flood control, and to safely convey the runoff from the 100-year storm event.

A portion of drainage area C is treated by an enhanced wet swale. The area treated by the swale is subtracted from the total drainage area when sizing the storm water pond for water quality protection. The integrated Design Criteria and Control sizes for “New iSWM” are summarized in **Table LR4** and **Table LR5** below.

Drainage Area	Drainage Area (ac)	WQ _v (ac-ft)	Control Type	SP _v (ac-ft)	Control Type	Flood, ΔQ (cfs)	Control Type
A	31.71	1.99	Micropool ED Pond	2.53	Micropool ED Pond	77	Micropool ED Pond
B	21.53	1.40	Micropool ED Pond	1.77	Micropool ED Pond	65	Micropool ED Pond
C	27.39	1.90	Enhanced Swales; Micropool ED Pond	2.38	Micropool ED Pond	53	Micropool ED Pond
D	11.28	0.81	Micropool ED Pond	0.98	Micropool ED Pond	13	Micropool ED Pond

Table LR4: integrated Design Criteria for Large Residential Site – “New iSWM”

Drainage Area	Control Type	Volume (ac-ft)	Area (ac)
A	Micropool ED Storm Water Pond	5.05	1.17
B	Micropool ED Storm Water Pond	3.75	0.94
C	Micropool ED Storm Water Pond	3.64	0.92
D	Micropool ED Storm Water Pond	1.17	0.41
C1	Enhanced Swale (Wet)	0.06	0.11

Table LR5: Controls used in “New iSWM” for Large Residential Site

Results

Table LR6 gives a Cost Comparison for the small residential 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 As Developed 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.

A lot breakdown is also included in the Cost Comparison. A unit cost (per area) was applied to various lot sizes to estimate the total Lot Revenue for each scenario. "Premium" lots were identified and assigned a 20% markup in revenue. The premium lots are adjacent to an amenity, such as open space, undisturbed natural areas, a storm water pond, or an existing natural channel. The Lot Revenue **Difference** represents the difference between each alternative and As Developed. If the difference is negative, the developer will realize *less revenue* on lot sales. If the difference is positive, the developer will realize *more revenue* on lot sales.

The **Difference in Net Return** represents the difference between the Lot Revenue **Difference** and the **Total Infrastructure Difference**. A negative value indicates *less revenue* to the developer, whereas a positive value indicates *more revenue* to the developer.

The Total **Review Time** also represents a difference between each alternative and As Developed. 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 large residential comparison between "Retrofit iSWM" and "As Developed" decreased the difference in net return to the developer by approximately \$619,000. The development lost thirty-seven (37) homesites. The regulatory review time for the subdivision was increased by two (2) months. Annual maintenance costs associated with "Retrofit iSWM" development are estimated at \$25,400.

The large residential comparison between "New iSWM" and "As Developed" decreased the difference in net return to the developer by approximately \$319,000. The development gained six (6) homesites. The regulatory review time for the subdivision was increased by two (2) months. Annual maintenance costs associated with "New iSWM" are estimated at \$25,400.

Other Considerations

There were no other controls considered for the large residential site.

The local government requires a park dedication fee for all residential developments, based on a per lot basis. In "New iSWM" it is possible to allocate a portion of this fee toward the development of a linear park and trail system. The recreational trail would extend from the large residential site north to the existing linear park along the north bank of Fish Creek. In collaboration with the local government, this park and trail system would be developed as part of the existing residential development. The additional construction cost of the park would be subtracted from the park dedication fee required by the local government.

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 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 use of storm water ponds in residential communities is a widely accepted practice and provides excellent aesthetic benefits for the development. Since the conserved forested areas in the large residential site are adjacent to the storm water ponds, the surrounding area can easily be converted to parkland by adding such amenities as benches or walking trails. Furthermore the vegetative buffer surrounding the perimeter enhances the appearance of the pond, conceals unsightly trash and debris, and helps to stabilize side slopes. The partnering of conserved forested areas and storm water ponds also provides an additional habitat for wildlife.

In addition to providing water quality treatment, the enhanced swales in the large residential site offer aesthetic benefits that are not obtainable with an underground storm drainage system. Additional benefits associated with the swales include reduced runoff velocities and low maintenance burden.

Table LR6: Cost Comparison for Large Residential Site

Infrastructure Cost Difference			"Retrofit iSWM"		"New iSWM"	
Channel Volume			\$14,880		-\$9,900	
Check Dams			\$6,000		\$1,000	
Concrete Lining			-\$84,000		-\$123,000	
Construction BMP Cost Savings for Pond			-\$102,326		-\$114,469	
Control Earthwork			\$271,305		\$328,875	
Developed Area			-\$17,090		-\$17,090	
Forebay: Concrete Lined			\$67,000		\$84,500	
Headwalls			\$21,000		\$4,500	
Hike and Bike Trail			\$0		\$49,791	
Outlet Structures			\$50,000		\$40,000	
Park Dedication Fee			-\$27,750		-\$64,688	
Roadway Length			-\$58,515		-\$99,053	
SD Inlets			\$21,000		\$21,000	
SD Manholes			\$45,000		\$25,000	
SD Pipe			\$17,010		\$130,410	
W/WW Pipe			-\$155,210		-\$262,735	
Total Infrastructure Difference			\$68,304		-\$5,858	
Lot Breakdown	As Developed		"Retrofit iSWM"		"New iSWM"	
	No.	Lot Revenue	No.	Lot Revenue	No.	Lot Revenue
1/8	289	\$5,491,000	226	\$4,294,000	289	\$5,491,000
Premium 1/8	-	-	27	\$615,600	38	\$866,400
1/4	68	\$2,584,000	63	\$2,394,000	28	\$1,064,000
Premium 1/4	-	-	4	\$182,400	8	\$364,800
1/3	7	\$355,740	4	\$203,280	4	\$203,280
Premium 1/3	-	-	2	\$121,968	2	\$121,968
1/2	2	\$152,460	3	\$228,690	2	\$152,460
Premium 1/2		-		-	1	\$91,476
Total	366	\$8,430,740	329	\$7,811,248	372	\$8,111,448
Difference			-37 lots	-\$619,492	+6 lots	-\$319,292
Difference in Net Return			-\$687,796		-\$313,434	
Difference in Net Return per acre			-\$6,634		-\$3,023	

Review Time	“Retrofit iSWM”	“New iSWM”
FEMA (Floodplain Permits)	-	-
Individual/Nationwide 404 Permit	-	-
TCEQ	2 Months	2 Months
Total	2 Months	2 Months

Annual Maintenance Costs	“Retrofit iSWM”	“New iSWM”
Micropool ED Pond	\$20,298	\$24,803
Enhanced Swales	\$5,049	\$585
Total	\$25,347	\$25,387

Worksheet for Conceptual iSWM Site Plan Large Residential Site

I. Review of integrated Site Design Practices

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

Example Worksheet for Conceptual iSWM Site Plan (Continued)

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

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

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

	<u>Comments</u>
A. How will the <i>integrated</i> Design Criteria be achieved for Water Quality Protection?	<u>Enhanced Swales; Micropool ED Pond</u>
B. How will the <i>integrated</i> Design Criteria be achieved for Streambank Protection?	<u>Enhanced Swales; Micropool ED Pond</u>
C. How will the <i>integrated</i> Design Criteria be achieved for On-Site Flood Control?	<u>Curb & Gutter; Enhanced Swales;</u> <u>Inlets/Pipe Systems</u>
D. How will the <i>integrated</i> Design Criteria be achieved for Downstream Flood Control?	<u>Enhanced Swales; Micropool ED Pond</u>

4. Review of potential **hot spots**

	<u>Yes</u>	<u>No</u>	<u>Comments</u>
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?.....	<u> </u>	<u>X</u>	<u> </u>
B. Vehicle maintenance areas?.....	<u> </u>	<u>X</u>	<u> </u>
C. Vehicle washing/steam cleaning areas?.....	<u> </u>	<u>X</u>	<u> </u>
D. Auto recycling facilities?.....	<u> </u>	<u>X</u>	<u> </u>
E. Illegal dumpsites?	<u> </u>	<u>X</u>	<u> </u>
F. Outdoor material storage areas?	<u> </u>	<u>X</u>	<u> </u>
G. Loading and transfer areas?	<u> </u>	<u>X</u>	<u> </u>
H. Landfills?	<u> </u>	<u>X</u>	<u> </u>
I. Industrial facilities?.....	<u> </u>	<u>X</u>	<u> </u>
J. Other areas that may be a potential pollution source?	<u> </u>	<u>X</u>	<u> </u>

Worksheet for Conceptual iSWM Site Plan (Continued)

5. Review of integrated Storm Water Controls

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