2010

DRAINAGE STUDY

City of Dickinson

HDR Engineering Inc., Texas Reg. No. 754

HDR ONE COMPANY | *Many Solutions*

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SECTION 1.1 – Statement of Problem

HDR|Claunch and Miller is under contract with the Texas Department of Rural Affairs (TDRA) on behalf of the City of Dickinson to complete a drainage study for the City of Dickinson. The study addresses areas that have been impacted by flooding, specifically from Hurricane Ike which occurred on September 13th, 2008. Drainage issues that were seen during the Hurricane Ike event were mainly tidally influenced and typical of larger issues that have repeatedly occurred in the area.

The initial phase was to obtain and compile available data for the City's drainage infrastructure including previous flood studies and associated models and the storm sewer system and outfall data provided in a Geographical Information System (GIS) database was obtained from Galveston County Water Control and Improvement District #1. This data was augmented by adding recently completed development and storm systems that were visually field verified.

At the onset of the project, our team worked with City staff, City officials, and residents of the area to identify current flooding problems. Nineteen hot spot areas were identified within the City limits. As each area was evaluated, the limits of the hot spots were refined to include other problematic spots that may have the same issues but were not specifically identified during public meetings.

Recommendations have been provided to address each of the nineteen hot spot areas. A description of the existing conditions analysis, results of the existing conditions, proposed improvements, and an Engineer's Estimate of Probable Construction Costs have been provided.

In addition to the hot spot evaluations, a citywide evaluation of the storm sewer system has been completed. The general evaluation helps to identify additional areas that may have drainage issues and an estimate of the system capacity.

SECTION 1.2 – Recommendations

Specific drainage improvements have been recommended at each of the nineteen hot spots evaluated throughout the City. In general, larger storm systems have been recommended based upon the City's design storm criteria. One key element for citywide improvements is to standardize drainage construction. Presently, numerous types of inlets and manholes exist and are unique to each area. The variety of inlets makes it difficult for the City to maintain the systems. We recommend standardizing the inlet construction to allow City crews to more predictably maintain the system, and area contractors to construct the facilities

more efficiently. All public storm sewer pipes should also be a minimum of 24" in diameter where possible. The pipe size will help to lower the City's maintenance requirements in some areas by providing additional storm water conveyance capacity.

To determine where efforts should be focused first, a priority list has been developed. A point system has been developed that considers six factors:

1. Repetitive Loss Data
2. Hot Spot Size
3. Storm System Level of Service
4. Available Overflow Path
5. Tidal Flooding Sources
6. Riverine Floodplain Flooding Sources

Based upon the severity of the flooding for each factor, each hot spot received a point total. The hot spot areas with the highest totals have been designated as having the highest priority. The following is a summary of the hot spot rankings.

Table 1.1
Hot Spot Priority List

Construction Priority	Hot Spot Description	Hot Spot ID
1	Bayou Chantilly	4
2*	Oakridge Drive	6
3	Gum Bayou	7
4	Elm Street	15
5	Liggio Street	2
6	Frostwood	5
7	Country Club Drive	14
8*	Tropical Gardens	10
9	Casa Grande Drive	19
10	Briarglen	9
11	Greenlee Lane	13
12	Hemlock Circle	8
13*	Lovers Lane	11
14	Salvato Drive	12
15	Plantation Drive	3
16	Bayou Drive	16
17	Pine Manor Lane	17
18	Manor Lane	18
19	FM 517	1

*Under Design Contract

SECTION 1.3– Estimated Construction Cost

An Engineer's Estimate of Probable Construction Costs has been developed for each hot spot improvement to assist the City in the planning of capital improvement projects. Costs are based upon the assumption that only the drainage infrastructure will be reconstructed. The costs include restoration of the surface improvements but do not include the full reconstruction of roadways or other utility infrastructure. If the storm system improvements are completed in conjunction with other infrastructure projects, the overall costs of the improvements may be reduced. Three of the hot spot project areas will have significant roadway reconstruction associated with the installation of the new drainage systems as noted below. The following table summarizes the estimated construction costs for the hot spot improvements.

Table 1.2
Summary of Hot Spot Probable Construction Costs

City of Dickinson Drainage Study Hot Spot Probable Construction Costs			
Hot Spot	Description	Construction Cost	Roadway Portion Only
1	FM 517	***$23,800***	
2	Liggio Street	***$374,200***	
3	Plantation Drive	***$92,550***	
4	Bayou Chantilly Subdivision	***$1,086,950***	**$483,800**
5	Frostwood Circle	***$419,800***	**$147,600**
6	Oak Ridge Drive	***$84,340***	
7	Gum Bayou	***$271,680***	
8	Hemlock Circle	***$79,110***	
9	Briarglen Subdivision	***$350,780***	
10	Tropical Gardens Subdivision	***$568,680***	
11	Lovers Lane	***$88,400***	
12	Salvato Street	***$110,860***	
13	Greenlee Lane	***$43,560***	
14	Country Club Drive	***$361,620***	
15	Elm Drive	***$33,080***	
16	Bayou Drive	***$112,320***	
17	Pine Manor Lane	***$185,200***	**$126,000**
18	Manor Lane	***$110,910***	
19	Casa Grande Drive	***$147,290***	
Total Hot Spot Construction Cost		$4,545,130	$757,400
Contingency (25%)		$1,136,290	$189,350
Engineering (15%)		$681,770	$113,610
Total Cost		**$6,363,190**	**$1,060,360**

Cost data is based upon similar sized projects and utilizes 2010 dollars. An escalation rate for construction costs should be considered as the capital improvement program is developed.

At the current time, three projects are underway that will include the drainage improvements recommended as part of this study.

- Hot Spot #6, Oak Ridge Drive
- Hot Spot #10, Tropical Gardens
- Hot Spot #11, Lovers Lane

The recommendations provided in this study have been coordinated with the other projects to ensure continuity between this study and the design of the three projects. Since the projects are under construction and are funded at this time, an adjustment to the overall CIP costs has been made to exclude these projects. The following table eliminates the three above mentioned projects.

Table 1.3
Summary of Projects Under Design

Projects Under Design/Construction		
Hot Spot	Description	Construction Cost
6	Oak Ridge Drive	***$84,340***
10	Tropical Gardens Subdivision	***$568,680***
11	Lovers Lane	***$88,400***
Construction Costs for Projects Under Design/Construction		$741,420
Contingency (25%)		$185,360
Engineering (15%)		$111,220
Total Cost for Projects Under Design/Construction		**$1,038,000**
Total Cost for Remaining Projects		**$5,325,190**

SECTION 1.4– FEMA Community Rating System

A significant portion of the City is either directly impacted by riverine flooding from FEMA regulatory floodplains or the capacity of storm sewers is limited due to high tail-water conditions resulting from the floodplain. Previous studies have been completed through the City's participation in the Dickinson Bayou Master Planning Project to refine the limits of the existing floodplain to assist the City in planning efforts. The limits of the floodplain have been mapped as part of this study, utilizing data from hydraulic models previously completed and 2010 LiDAR topographic data. In general, the floodplain delineated for this study extends beyond the regulatory floodplain established by FEMA. The floodplain has been mapped not to replace the existing floodplain, but to better understand how riverine flooding may impact the existing storm sewer systems.

Because the extents of the floodplain are so extensive throughout the City, one recommendation for future work is for the City to enroll into the Community Rating System (CRS) that is administered by the National Flood Insurance Program. The CRS is a voluntary incentive program that recognizes and encourages

floodplain management activities that exceed the minimum NFIP requirements. The goals of the program are to enhance public safety, reduce flood damages to insurable property, and encourage a comprehensive approach to floodplain management. The CRS rates each community 10 (no flood insurance discount) to 1 (premium flood insurance discounts) based upon the level of flood management requirements. All communities automatically start with a Class 10 rating. Current floodplain management activities in conjunction with higher regulatory standards previously adopted by the City provide an excellent basis for application for the CRS.

In addition to the CRS participation, it is further recommended that the City revise their Flood Drainage Prevention Ordinance to require a minimum 18" (24" preferred) of freeboard for home construction and substantial improvements constructed in the floodplain. The additional freeboard will help to reduce the potential for damage. This will provide consistency with the City's drainage criteria and provide additional protection for future structures. The City should also consider amending the drainage criteria to include street drainage and storm sewer design standards.

Due to the flat nature of the area topography, the City should also consider requiring Elevation Certificates for all new construction to help ensure that construction outside of the floodplain limits have the same freeboard requirements as those inside. If a property is located just outside the established floodplain limits, structures are typically not subject to the same floodplain requirements, which leaves them more venerable to flooding.

Section 2

Introduction

SECTION 2.1 – Project Authorization

HDR|Claunch and Miller (HDR|C&M) is under contract with the TDRA on behalf of the City of Dickinson in a joint effort with Hurricane Ike Relief Funding to complete a Drainage Study for the City of Dickinson. The intent of the Drainage Study is to provide a comprehensive and implementable evaluation of the City's storm sewer infrastructure. This study focuses on the storm sewer systems within the City limits and the areas designated as hot spots by the members of the community.

SECTION 2.2 – Project Objectives

To complete the Drainage Study, the project has been divided into several key tasks. The following scope of work has been completed.

- *Identify and Map Existing Infrastructure*. Sources of information included input from City Public Works Staff, record drawings, previous GIS data sets, field observations, and identification of facilities on aerial photographs.
    - An inventory of the City's drainage system infrastructure based on an on-the-ground site reconnaissance, available construction records and discussions with City staff. The inventory has been completed from available plans and on a visual basis only with some of the infrastructure estimated in size on known public facilities.
    - Using this information, HDR|C&M created a Geographic Information System (GIS) database to catalog the available information on the drainage infrastructure. Site visits were conducted to hot spot areas to verify the systems and help evaluate the general conditions of each area. Evaluations and mapping of private facilities were not included.
    - Additional plans and field reconnaissance updated the previous data to include development and areas not previously mapped. An additional benefit of this study was to meet the City's goal set out in their Storm Water Management Plan to identify and map their storm system and outfalls to help detect and eliminate potential illicit storm water discharges.
    - Mapped Repetitive Loss Properties (RLP) were mapped. HDR|C&M obtained the latest repetitive loss list form the National Flood Insurance Program (NFIP) representatives. A

RPL is defined under the NFIP as a property that has received two or more flood claims in a 10 year period. The City of Dickinson has 225 RLPs and mapping these properties provided another indicator of concentrated flooding occurrences helping to identify hot spots.

- Maps were prepared to reflect the City's drainage infrastructure, which also includes approximate property lines, aerial photographs, other GIS features, previously defined flood hazard areas, and Hurricane Ike storm surge inundation areas.
- A digital terrain model (DTM) was created using Light Detection and Ranging (LiDAR) data to create a computer model of the ground surface throughout the City of Dickinson. From DTM, elevation contours, drainage areas, overland flow paths, floodplain delineations, and storm surge delineations were derived.

- *Evaluate Existing Drainage Systems.* An evaluation has been completed for the City's existing drainage system infrastructure for selected hot spot areas. These problem areas have been identified by City staff and community members during City Council Meetings or through citizen complaints. In addition to the hot spot areas, a general evaluation has also been completed of citywide storm sewer systems. This study focuses primarily on the storm sewer infrastructure within the City. A limited number of ditches have been evaluated. Major drainage ways such as FEMA studied floodplains were previously studied and not included as part of this report.
- *Provide Storm Sewer Recommendations.* Once flooding issues have been identified and evaluated, storm sewer improvements have been proposed. The City's criterion as presented in the City of Dickinson Drainage Criteria Manual has been used to appropriately size drainage improvements. Specific recommendations have been provided in each of the 19 hot spot areas. These recommendations are conceptual in nature and based upon the available information and should be further evaluated prior to constructing any of the projects. Survey data will be required to refine the recommendations as well as preliminary and final engineering. Based upon constraints found in the field during the design of the systems, modifications may be required to the recommendations provided herein. Mapping for the improvements within the hot spot areas has been developed to illustrate the proposed system.

  To assist the City in developing capital improvement projects, an engineer's estimate of probable construction costs has been developed. The construction costs are based upon 2010 cost data for similar sized projects completed in the area. As projects are considered for construction, an escalation rate for the construction costs should be provided or the unit prices of each quantity revisited.

SECTION 2.3 – Background Data

To complete this study, several sources of information have been obtained, reviewed, and utilized. As described above, information has been collected and stored within a GIS database. The database provides a means to store a large amount of information, which can be graphically presented. Aerial photographs, LiDAR data, previous information form the GIS database maintained by Galveston County Water Control and Improvement District #1, discussions with City staff, and visual observations were all used to develop the background information needed for this study. On the ground" visual observations were made of the hot spot areas including offsite infrastructure that may impact the performance of the system located within the hot spot.

SECTION 2.4 – Prior Studies and References

Previous studies and as-built record drawings completed for the area have been reviewed to better understand the existing drainage system. TxDOT has provided several plan sets for drainage facilities along FM 517, SH 3, and IH-45 (Gulf Freeway). The plan sets include plan and profile drawings of various storm sewer systems and drainage area maps used to design the systems.

In addition to the record drawings, a previous study has been completed for all of the floodplain areas within the City:

> *Dickinson Bayou Watershed Floodplain Delineation*, JKC and Associates, December 2008.

The study evaluates the hydrology and hydraulics for the bayous and channels and proposes channel and detention improvements to help reduce the limits of the floodplain. The data provided in the existing conditions hydraulic models has been used in this study to estimate the current floodplain and help determine the flooding sources of the hot spot areas.

In addition to the above referenced study, previous HEC-1 hydrologic and HEC-2 hydraulic models were obtained and reviewed to better understand the floodplain within the area:

> *HEC-1 Hydrologic Model and HEC-2 Hydraulic Model for Dickinson Bayou*, Dodson and Associates, 1994.

Also of note, the City of Dickinson has developed a storm water management plan in accordance with the Clean Water Act regulated by the Environmental Protection Agency.

> *City of Dickinson Storm Water Management Plan*, City of Dickinson, March 10, 2008.

SECTION 2.5 – Environmental Considerations

As part of the design process for each of the projects, additional permitting requirements should be considered for each project that may impact any "navigable waters" (Section 10 Permit) or "waters of the United States" (Section 404 Permit).

A US Corps of Engineers (USACE) Section 10 Permit regulates any activities impacting navigable water of the United States. Activities that fall under a Section 10 Permit include, but may not be limited to, construction or modification of piers, wharfs, breakwaters, jetties, transmission lines, excavation, filling, etc. to the navigable waters of the United States. The limits of the navigable waters are typically located within the ordinary high water mark of a freshwater waterway, or within the mean high tide area for brackish or salt water tide areas. The areas most likely to be impacted by these regulations are primarily Dickinson Bayou and Gum Bayou where boat traffic occurs on a regular basis.

A USACE Section 404 Permit encompasses the same areas regulated by the Section 10 Permit but also includes tributary channels, adjacent wetlands, and other isolated waters which may degrade waters used for interstate or foreign commerce. Fill material such as soil or riprap used for construction may require such a permit. A Section 404 Permit is most commonly required for construction impacting waters of the United States.

Hot spot areas where improvements are proposed including storm sewer outfalls or other work within a channel should be coordinated with the USACE during the design phase of the project. The USACE will provide a final decision on the need for a Section 10 or Section 404 permit based upon their interpretation of the construction requirements.

Section

3

Existing Conditions

SECTION 3.1 – Mapping and LiDAR Based Topography

Several sources of information have been utilized to create base mapping information for the area. 2010 aerial photographs have been used to help identify existing drainage features, general land use conditions, and to serve as a backdrop for exhibits. LiDAR data has been used to develop elevation contours and establish drainage areas for this study. In certain hot spot areas, the LiDAR data was processed to provide a more detailed look at the topography of the area, and to help determine overland flow paths and low points that are susceptible to flooding.

A GIS data base obtained from Galveston County Water Control and Improvement District #1 was also used. Additional data has been incorporated into the system based on information obtained in the field or from record drawings. Exhibit 1, Drainage Hot Spot Map shows not only the hot spot areas within the City, but also shows the extent of the existing storm sewer system.

SECTION 3.2 – Hurricane Ike Storm Surge Data

The City of Dickinson was greatly impacted by the storm surge resulting from the landfall of Hurricane Ike. On September 13th, 2008, at approximately 2:00 am central daylight time, the hurricane made landfall near Galveston Texas. Although the storm was rated as a Category 2 hurricane based primarily on wind speed (96-110 miles per hour), the associated storm surge was typical of a Category 4 hurricane. Hurricane Ike extended approximately 120 miles from the eye of the storm. The peak storm surge depths along the Texas Gulf Coast typically ranged from 15 to 20 feet. The surge depths dissipate as it propagates inland via channels and bayous. To better understand the impacts of Hurricane Ike due to the storm surge, depths through the City were mapped, see Exhibit 2, Storm Surge Map. Out of bank flooding from the storm surge impacted many residents throughout the City. As part of the hot spot evaluations and in the development of a priority order for the projects, storm surge data from Hurricane Ike was considered.

Future development that occurs within areas that could be impacted by storm surges should be elevated sufficiently to reduce the potential for structural flooding. The areas impacted by storm surge are also vulnerable to riverine flooding. In general, if a development meets the minimum floodplain requirements the structures should be protected from flooding due to storm surge.

SECTION 3.3 – Flood Hazard Areas

Significant areas of the City are currently located within a 100-year (1% frequency) FEMA delineated floodplain. An earlier study undertaken for the City of Dickinson predicted higher 100-year base flood elevations resulting in a more extensive floodplain. The study was completed for planning purposes only and has not been submitted to or accepted by FEMA. The floodplain data presented in the study was mapped against 2010 LiDAR terrain data as part of this study to determine the extents of the planning level floodplain. A copy of the FEMA Effective floodplain has been included in the Appendix of this report. The revised floodplain limits have also been included on Exhibit 3, 100-year Floodplain Map, also found in the Appendix of this report.

SECTION 3.4 – Identified Hot Spot Areas

The City identified several hot spot areas for evaluation based upon known flooding issues. These areas were reviewed and in some cases, expanded upon to include other areas which may have similar issues. Input from residents and other interested parties were received during a City Council meeting held on April 7, 2010 to include other areas with flooding concerns. Each area has been identified on Exhibit 1, Drainage Hot Spot Map, see Appendix. Specific solutions for each area have been developed and prioritized based upon a combination of the technical evaluation and input received identifying community needs.

Section 4

Hydrology and Hydraulics

SECTION 4.1 – Analysis Objective

An analysis has been completed for this Drainage Study to evaluate the capacities of the existing storm sewer systems. The City of Dickinson 2008 Drainage Criteria Manual has been used to develop peak runoff rates for each storm sewer system and determine if sufficient capacity exists to meet the City's current criteria. If the systems do not have adequate capacity, general recommendations have been made to upgrade the systems when the time comes.

Detailed evaluations have been completed for areas identified as Hot Spots. Based upon the results of the analyses completed for each system, a priority list has been developed to determine which areas are in most need of drainage system upgrades.

SECTION 4.2 – Hydrologic Methodology

For the storm sewer evaluations, the criteria established by the City of Dickinson have been used. Peak runoff rates have been computed utilizing the Rational Method for areas less than 200 acres in size:

$$Q = C_f * (C * I * A)$$

Where:

Q = Peak Flow Rate (cfs)

C_f = Frequency Factor

C = Runoff Coefficient

I = Rainfall Intensity (in/hr)

A = Drainage Area (ac)

A frequency factor has been added to the Rational Method for the 25-year and 100-year storm events to account for varying antecedent moister conditions typically experienced for different storm events. The frequency factors used are as follows.

Table 4.1
Frequency Factors (C_f)

Storm Frequency	C_f
3-Year	1.00
5-Year	1.00
10-Year	1.00
25-Year	1.10
100-Year	1.25

In order to compute storm intensity, a time of concentration must be computed for each drainage area. Due to the relatively small sizes of the drainage areas evaluated and the fact that most areas are served by storm sewers or ditches, the time of concentration has been computed based upon area calculations, as recommended in the City's Drainage Criteria Manual.

$$T_c = 10*(A)^{0.1761} + 15$$

Where:

T_c = Time of concentration (minutes)

A = Drainage Basin area (acres)

The intensity for each storm event has been computed based upon the Texas Department of Transportation (TxDOT) intensity equation and values:

$$I = b/(T_c + d)^e$$

Where:

I = Rainfall Intensity (in/hr)

Tc = Time of concentration (minutes)

b, d, & e = coefficients

The coefficients within the intensity calculation are unique to various areas. The following coefficients have been used for this study:

Table 4.2
Rational Method Intensity Coefficients

Storm Frequency	b	d	e
3-Year	77	11.9	0.782
5-Year	66	7.6	0.739
25-Year	85	7.6	0.727
50-Year	88	7.6	0.704
100-Year	85	7.8	0.690

Various storm events have been evaluated based upon the type of facility. In areas that are particularly flood prone, more restrictive criteria has been used. For example, if a bank of inlets within a sump has no viable overflow path, then the storm sewer system should be designed to accommodate the peak flow rate for a 100-year storm. At each analysis point, an alternative that will meet the City's minimum criteria has been proposed. The following storm frequencies have been used:

Table 4.3
Drainage System Design Storm

Type of Drainage System	Design Storm Frequency
New Storm Sewers	3-Year
Ditch Culverts (drainage areas less than 50 acres)	5-Year
Ditch Culverts (drainage areas 50-100 acres)	25-Year
Ditch Culverts (drainage areas 100 acres or more)	50-Year
Bridge crossings City Ditches	100-Year
Major Ditches and City Channels	100-Year

SECTION 4.3 – Hydraulic Methodology

Limited information on the existing storm sewer system was available for this study. In most cases, the existence and approximate sizes of the systems are known. Inlet locations and outfall points were identified using a combination of record drawings, GIS data, field observations, and aerial photographs.

Storm sewer capacities were computed assuming full flow conditions and a flow velocity of 3 feet per second for a pipe and 5 feet per second for a box. If the pipe was found to have insufficient capacity based on these assumptions, improvements have been proposed. A detailed analysis using data from a topographic survey should be completed to determine the final sizing of the improvements. Proposed improvements have been assumed to have minimal pipe slope due to the flat terrain. If steeper grades can be achieved for the pipes during final design then smaller pipes may be used.

For the area along Gum Bayou, hot spot #7, the residential neighborhoods utilize roadside ditches, which outfall into the Bayou. Due to the lack of storm sewer infrastructure in this area, and the need to evaluate the hydraulic capacity of Gum Bayou, the existing conditions and the proposed improvements have been

hydraulically modeled utilizing XP-SWMM software with the XP-2D module. The entire system can be modeled simultaneously to include the roadside ditches, culverts, overland sheet flow, and channels.

The dynamic modeling capability of the program is time-based with flows and hydraulic conditions varying over time rather than using a "steady state" or peak flow model. Interfaces between the culverts and in bank channel flows are locations where flow is transferred between the 1-dimensional XP-SWMM system model and the 2-dimensional XP-2D surface flow model. The 2-dimensional flow model consists of a digital terrain model (DTM) developed from LiDAR data. The 1- and 2-demensional interface for this model is at the XP-SWMM collector system model nodes. At node locations where the hydraulic grade line exceeds the ground surface or designated channel banks, that volume of runoff is then routed across the surface through the 2D grid cells. Surface flow can also re-enter the drainage system via a 2D cell at the model node where the system has sufficient capacity.

Section 5

Drainage Analysis

SECTION 5.1 – General Drainage Recommendations

The City desires to standardize its new drainage infrastructure for future projects. In previous years, various design standards have been utilized. For example, a curb inlet located in one subdivision may be constructed with a fabricated custom grate that will be different than another subdivision. Variations in the construction of the top of the inlets have also been noted in several instances. Below is an example of two curb inlets located across from each other on the same street on Greenlee Lane. The variations of the type of construction can easily be noted. This creates maintenance issues for the City as well as difficulty in determining what type of inlets to use for reconstruction or new projects.

Figure 5.1
Curb Inlets

In an attempt to standardize citywide construction methods, it is proposed that all new storm inlets should follow the same standards as the City of Houston or TxDOT. As inlets need to be replaced, consideration should be given first to a City of Houston Type C inlet. The Type C inlet is constructed behind the curb of a roadway section and provides a large open area to intercept storm water flows. The large open area helps to reduce the chances of inlet clogging by allowing debris to flush through the system. In many instances around the City, the roadways have subsided at a faster rate than those of inlets or manholes. At the inlets, the differential settlement causes the inlet throat to remain above the surrounding pavement, which creates ponding issues. If the pavement is cracked, water can

infiltrate down to the subgrade. The pavement structure will then generally deteriorate more quickly, requiring the City to reconstruct roadways sooner.

Figure 5.2
Grate Inlet with Differential Settlement

Type C inlets have the advantage of ranging in width to accommodate various flow rates. A standard Type C inlet is 5' in length. If additional inlet capacity is needed, extensions can be constructed in 5' increments. An example of a City of Houston Type C inlet has been provided on the following page, see Figure 5.3. In areas where there are limitations of space to construct the inlets, a City of Houston Type B-B inlet should be considered. These inlets are constructed partly under the roadway and do not require as much room behind the curb. See Figure 5.4. In areas where grated inlets are required, City of Houston Type A inlets area recommended. These inlets have sufficient openings, which help to reduce the chances of clogging. A detail drawing of the City of Houston Type A inlet is also provided, see Figure 5.5.

To further maximize the ability to convey storm water flows, a minimum storm sewer pipe diameter of 24" should be used. This will help to reduce the maintenance requirements for the City by providing a larger cross sectional area that is less prone to clogging. In some cases, limitations in depth of soil cover may require the use of smaller pipe sizes. Consideration for roadside culverts and storm sewer leads serving one inlet may use 18" diameter pipe if depth of cover is not available.

These standards should be formally adopted through a revision to the City's Drainage Criteria along with other recommended amendments mentioned in this report.

Figure 5.3
City of Houston Type C Standard Inlet

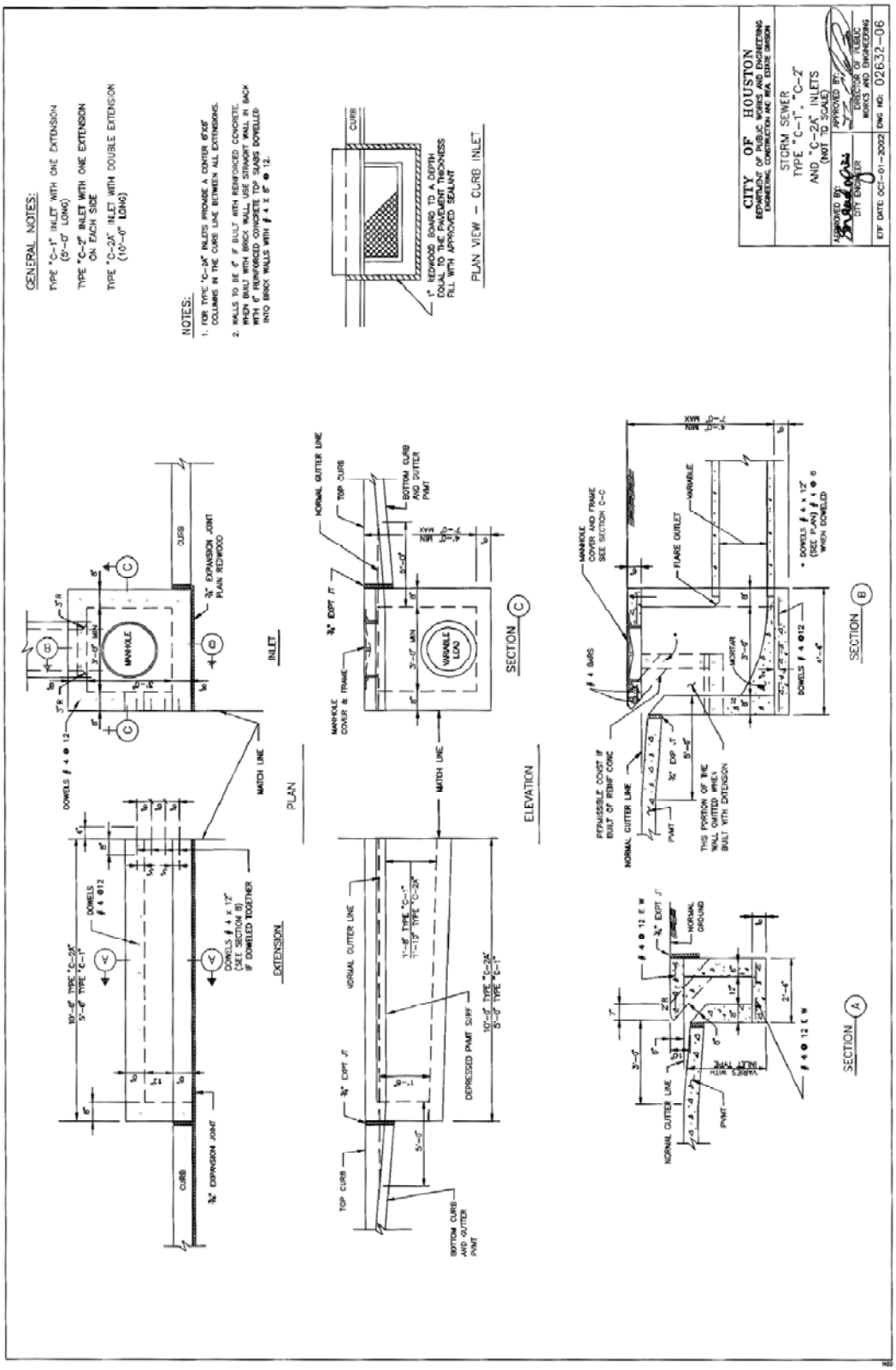


Figure 5.4
City of Houston Type B-B Standard Inlet

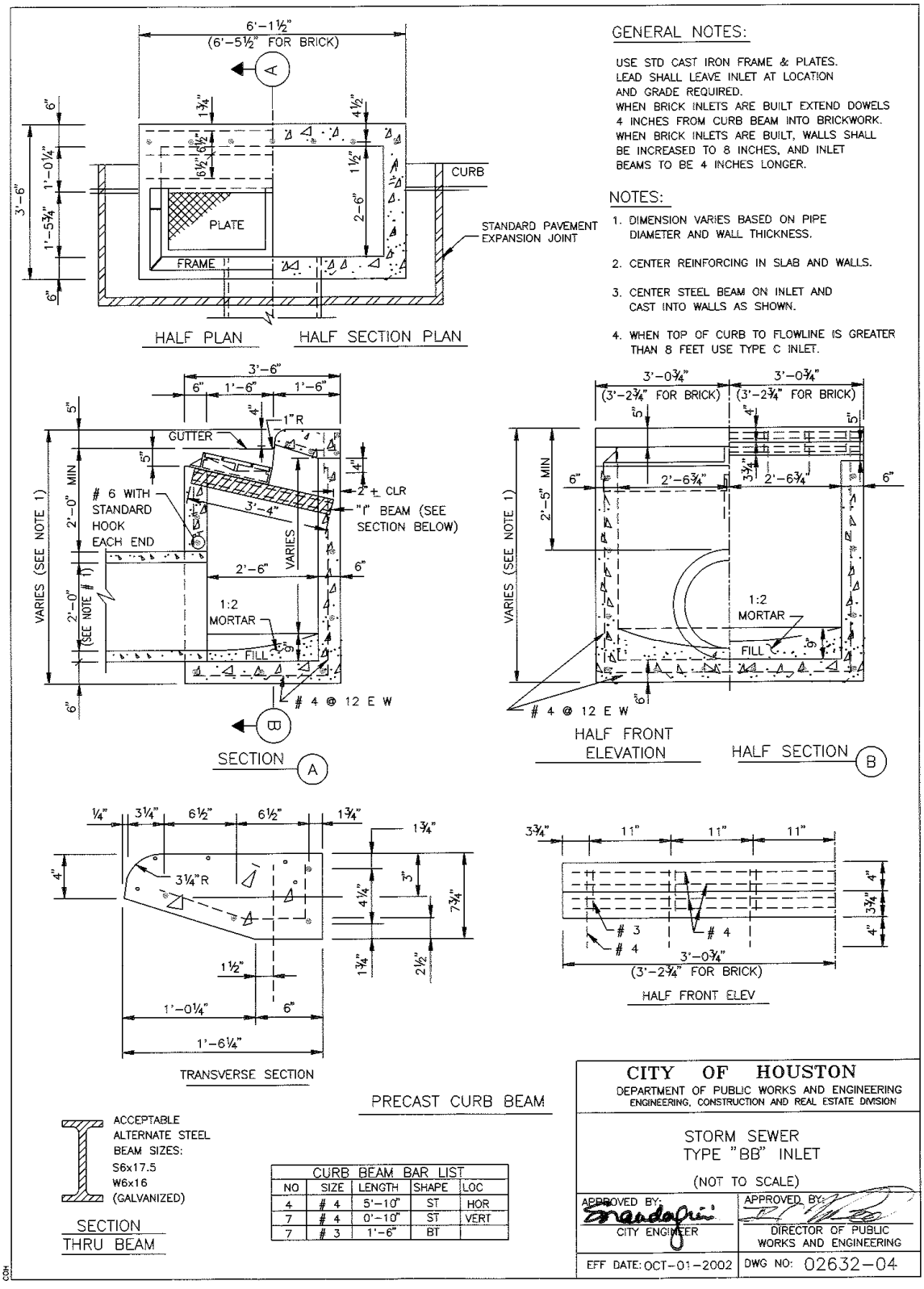
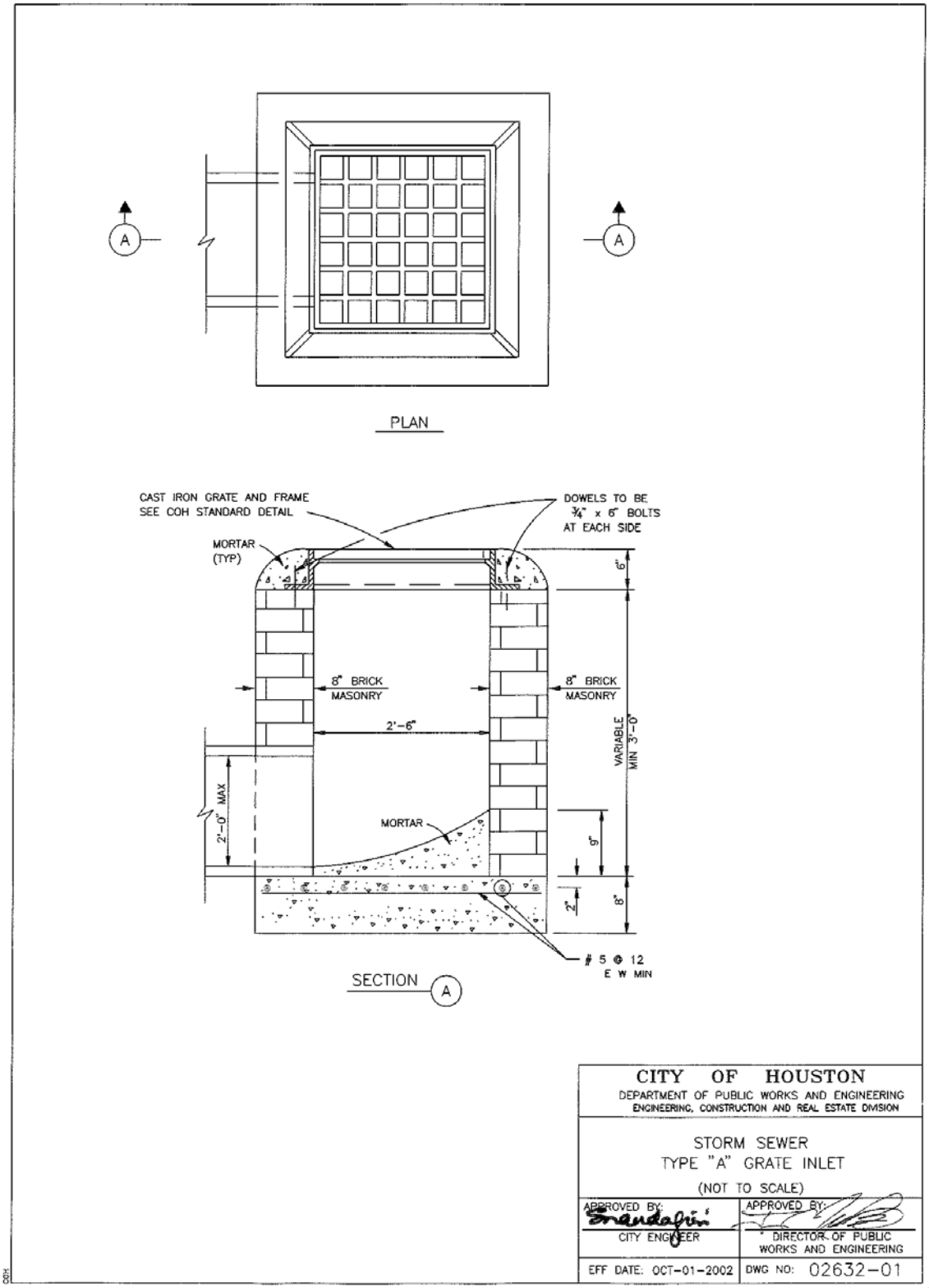


Figure 5.5
City of Houston Type A Standard Inlet



SECTION 5.2 – Drainage Analysis

Storm sewer outfall points have been identified on a citywide basis. The contributing area for each storm sewer system has been mapped on Exhibit 4, Citywide Storm System Drainage Map, see Appendix. The peak flow rate for each system has been computed using the Rational Method for the required design storm event per City criteria. At the outfall point for the systems, the peak flow rate has been compared to the pipe capacity to provide an overall understanding as to whether the system is adequately sized. The rated capacity of the storm sewer capacity is based on a pipe flow velocity of 3 feet per second. For storm sewers greater than 48" in size or boxes and a flow velocity of 5 feet per second was used.

The drainage area identifications are provided on Exhibit 5, Drainage Area Map. The open channel that each system discharges to is included in the tributary ID. For example, drainage area ID "Dickinson-01" is a system that discharges to Dickinson Bayou. Bayou designations have been given for Dickinson, Borden, Benson, Magnolia, and Gum Bayous. The estimated capacity of each outfall pipe has been provided. To provide an initial assessment on the adequacy of the outfall pipe, the percent of the pipe capacity used has also been provided based upon the storm event frequency used for each area. It should be noted that the majority of the systems have been designed under older City ordinances, which typically have been designed for 1 cfs per acre of residential development, and 2 cfs per acre for commercial development. Under the new drainage criteria accepted by the City in 2008, design flows have increased from the previous rates. Detailed computations for each outfall system have been provided in the Appendix of this report.

Section 6

Hot Spot Analysis

SECTION 6.1 – Description

As part of the Drainage Study, input has been obtained from various sources to help determine where flooding issues have occurred on a regular basis. Information sources include concerns expressed at a City Council workshop, identification of parcels with repetitive loss claims through flood insurance, discussions with City staff, and identification of upcoming Capital Improvement Projects. Nineteen areas of particular interest are listed below, each having their own unique concerns.

Table 6.1
Drainage Hot Spot Locations

Hot Spot ID	Impacted Areas/Subdivisions	General Location
1	FM 517 between Hanson Dr. & Pabst Rd.	West of IH-45
2	Oak Park	Church St. & SH 3 (Liggio St.)
3	Plantation Oaks	Plantation Dr
4	Bayou Chantilly	Dickinson Bayou & IH-45
5	Sherwood Oaks; JB King; Mason W. Schmidt	IH-45 & West Deats Rd.
6	Oak Hollow; Oak Forest	Sunset Dr. & Oak Dr.
7	Nicholstone	31st St. & Texas Ave.
8	Edgewood; Lexington Square	Edgewood Dr. & FM 1266
9	Briarglen	Owens St. & FM 517
10	Tropical Gardens	Gum Dr. & FM 517
11	Perry & Austin	Lovers Ln. & FM 517
12	Salvato; Emmite	Salvato St. & SH 3
13	Green Lee	Green Lee Ln.
14	Fairway & Country Club Estates; Whispering Pines; Mariners Mooring	Country Club Dr. & FM 517
15	Addition D Dickinson	Elm Dr. & FM 517
16	Forest Cove; Water Wonderland	Bayou Dr.
17	Pine Manor	Pine Manor Ln. & FM 517
18	McDonald Manor	Manor Ln. & FM 517
19	WK Wilson Abstract	Casa Grande Dr.

A more in-depth analysis has been completed for these drainage systems to determine what improvements can be made to help improve the existing localized flooding issues. Localized flooding issues are often the direct result of undersized or clogged storm sewer pipes, inlets or ditches. These drainage evaluations are at the planning stage and have been completed utilizing the best available information. In some areas, very limited information on the drainage infrastructure was found and the locations and sizes of drainage facilities were estimated based on field observations or input received from the City. The field observations do not constitute topographic survey information, so a field survey and a detailed drainage design must be completed prior to construction. The recommendations made herein are intended to identify where improvements are needed, and to propose reasonable solutions to problem areas. The design for each drainage area improvement may change during the final design phase based on additional constraints that may be found from survey data. Also, impacts to receiving systems should be identified and studied prior to implementing these recommendations. Recommended drainage improvements are shown on exhibits grouped with each hot spot description. Exhibit 6, Overall Drainage Area Hot Spot Map can be found in the Appendix of this report with supporting hydrologic calculations.

In some cases, the flooding issues are a result of high water from the bayous (riverine flooding) or storm surges that come from Galveston Bay. In these instances, storm sewers will not improve flooding problems resulting from the channels. General recommendations or requirements given by the Federal Emergency Management Agency should be used to give guidance for future improvements. Storm sewers may still be proposed in these areas to improve drainage issues during localized storm events.

In addition to the technical recommendations for each Hot Spot area, an engineer's estimate of probable construction costs has been developed to assist the City in estimating the funds needed to construct the improvements. The cost estimates are based on the drainage improvements only and do not include costs for reconstruction or improvements to streets, sidewalks, utilities, landscaping, etc. beyond what is directly impacted by the storm sewer construction. The construction cost estimates are based on 2010 data. An escalation rate for the construction costs should be considered for planning purposes.

"Soft costs" or indirect construction costs that commonly include engineering, surveying, geo-technical, environmental, and construction administration expenses have been included and estimated at 15% of the construction costs. The magnitude of the soft costs is dependent on the project size, complexity of the project, and the required coordination efforts with other agencies.

Allowances for project contingencies have been included to reflect the degree of uncertainty associated with forecasting improvement costs at the master study level. A value of 25%, expressed as a percent of the construction costs has been used.

SECTION 6.2 – Hot Spot Evaluations

Hot Spot #1 – FM 517

A. General Description

Hot Spot #1 consists of approximately 2,900 linear feet of FM 517 between Hanson Drive and White Oak Drive. FM 517 is a curb and gutter section with a center left turn lane. Storm water is primarily collected by TxDOT Type C inlets drained by a storm sewer system. The storm sewer transports flows to the east to a drainage channel located east of White Oak Drive and on to Dickinson Bayou.

It was reported to HDR|C&M that this area experiences shallow flooding within FM 517 during extreme rainfall events. In general, the roadway appears to be lower than the surrounding area and provides a path for overland sheet flow during extreme events (100-year storms). Commercial developments on either side of the roadway drain directly to the TxDOT storm sewer system. To the south, portions of single family developments with roadside ditches drain to the FM 517 through grate inlets. The ditches and inlets at the time of the field site visit were observed to be well-maintained. This area is located within the 100-year floodplain and is heavily influenced by the backwater effects from Dickinson Bayou. High tailwater conditions limit the conveyance ability of the existing storm sewer system. The storm system drains to a tributary to Dickinson Bayou located at the eastern limits of the hot spot area.

FM 517 appears to be in good overall condition. Some deterioration of the inlets can be seen such as exposed re-bar on the face of the inlets. Any improvements that are done to the roadway or its drainage system will have to be coordinated with the area TxDOT Area Engineer's office for review and approval.

B. Existing Conditions Analysis

Based upon LiDAR data and an overland sheet flow analysis, FM 517 receives flows from a significant area to the north and south. The hot spot area identified is located at a low point in the topography. The low spot combined with the high tailwater conditions from Dickinson Bayou limit the conveyance ability of the storm sewer system. When high tailwater within the bayou exists, flooding along FM 517 is expected. The hot spot encompasses only the roadway right of way. No repetitive loss claims were found for the properties adjacent to the roadway.

C. Proposed Improvements

The storm sewer system is under the jurisdiction of TxDOT and any modifications or maintenance to this system must be either coordinated and approved or performed by TxDOT. As-Built record drawings were not found for this portion of the road. We recommend that TxDOT be contacted so that the system be cleaned and inspected to ensure the system can convey flow with the maximum efficiency possible.

D. Estimated Construction Cost Estimate

To maximize the efficiency of the system, it is recommended the storm sewer in this area be inspected and cleaned as needed. A TV inspection will document the condition of the storm sewer. The total

estimated cost to complete the inspection and cleaning of the system is $23,800. Details for the cost estimate can be found on the next page. This inspection should be discussed with TxDOT representatives for possible implementation.

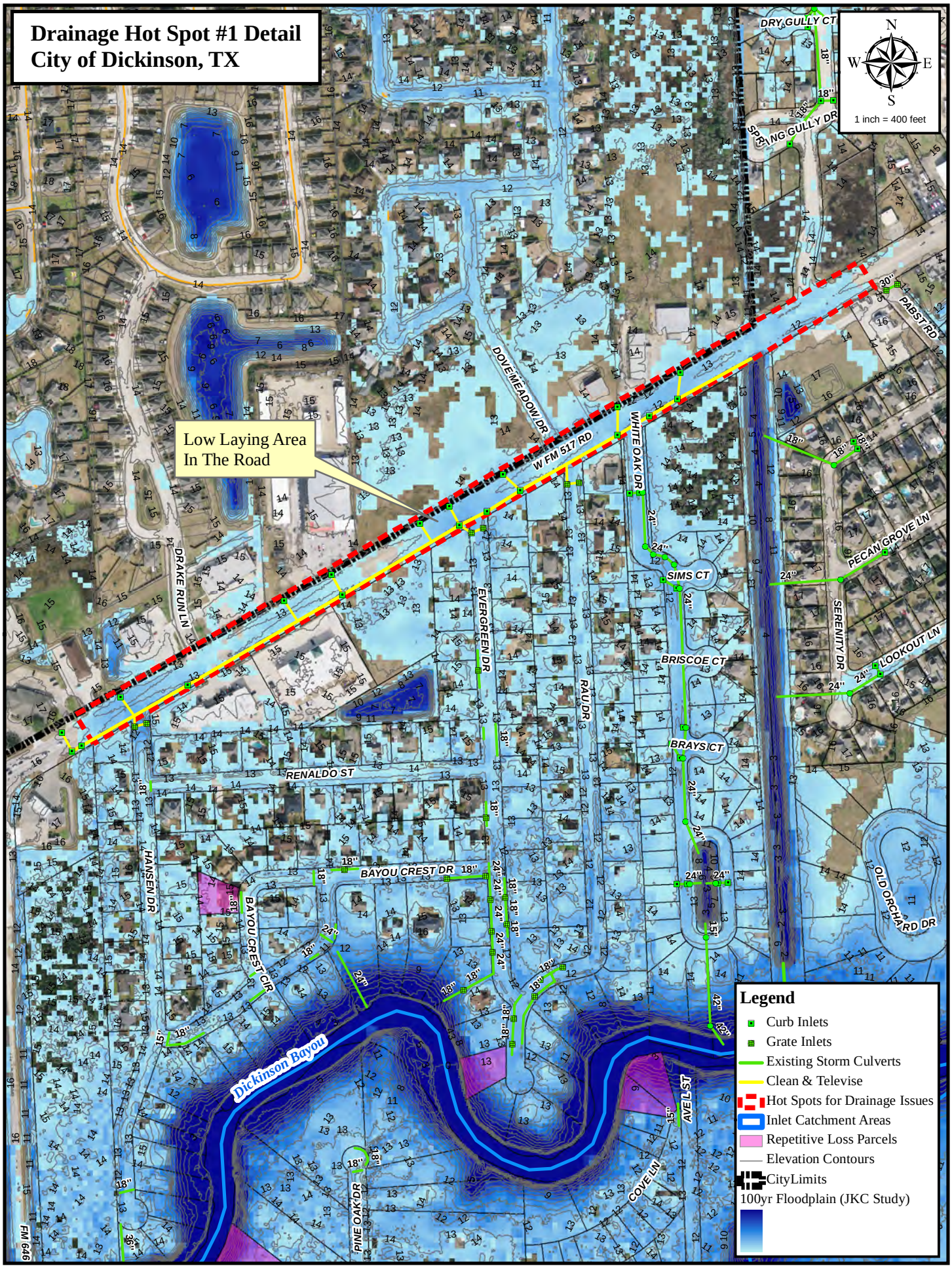
City of Dickinson Drainage Study

Hot Spot #1 - FM 517

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	TV/Inspect and Clean Storm Sewer	L.F.	3,400	***$7.00***	***$23,800***
Total Construction Cost					$23,800
Contingency (25%)					n/a
Engineering (15%)					n/a
Total Cost					**$23,800**

Notes:
1. These estimates are presented for planning purposes only and are subject to change as the project progresses
2. Fm 517 is under the jurisdiction of TxDOT. Any work shall be coordination with TxDOT.


Drainage Hot Spot #1 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
Low Laying Area
In The Road
DRY GULLY CT
SPRING GULLY DR
PABST RD
DOVE MEADOW DR
W FM 517 RD
WHITE OAK DR
PECAN GROVE LN
SIMS CT
SERENITY DR
LOOKOUT LN
BRISCOE CT
BRAYS CT
DRAKE RUN LN
EVERGREEN DR
RENALDO ST
BAYOU CREST DR
BAYOU CREST CIR
HANSEN DR
OLD ORCHARD DR
Dickinson Bayou
AVE I ST
COVE LN
PINE OAK DR
FM 646
Legend
Curb Inlets
Grate Inlets
Existing Storm Culverts
Clean & Televise
Hot Spots for Drainage Issues
Inlet Catchment Areas
Repetitive Loss Parcels
Elevation Contours
CityLimits
100yr Floodplain (JKC Study)

Hot Spot #2 – Liggio Street

A. General Description

Hot spot #2 encompasses the residential and commercial lots located north of Liggio Street and south of Video Street between Oak Park Road and Church Street. Both single-family and multi-family exist in the area. To the north, an existing school is being demolished and there are plans for the construction of a new Dickinson Independent School District Transportation Center.

The hot spot is located outside of the regulatory 100-year floodplain. Four lots within this area have repetitive loss claims – three along Liggio Street and one along Video Street. Review of LiDAR data indicates that these four lots are located in a low laying area which provides a natural overland path for storm water in the event that the area is flooded.

There are two primary drainage systems impacting this hot spot. To the north and upstream of the area, three (3)-36" storm sewer pipes extend through the school property within the exiting Oak Park right of way. The 36" pipes drain the school site as well as a portion of a rail road right of way. Limited flows from north of the railroad enter the system via dual 30". On the south side of Oak Park, a sizable roadside ditch conveys flows to dual 5'x2' RCB culverts transporting flows under SH 3. Review of the record drawings for SH 3 indicates that the RCB culverts were originally intended to be dual 5'x4' in size. Flows cross SH 3 and are conveyed southwest via a ditch and an existing 72" steel pipe crossing the Amegy Bank development located at 2401 Termini Street. The 72" steel pipe appears to have been fabricated from retired tanker containers welded into succession with each other. The 72" steel pipe outfalls to a 54" RCP constructed by TxDOT at FM 517 and Timber Drive. The 54" RCP storm sewer is drained by a 7'x5' RCB under FM 517 and discharges to Benson Bayou.

The second drainage system is located to the south of the hot spot area consisting of a 36" RCP storm sewer under Church Street. The majority of the hot spot area drains to the south toward this system. On the west side of Liggio Street, a 24" storm sewer drains the City Police Station. There is also a 12" pipe that extends from this system to the road side ditch on the east side of Liggio Street.

B. Existing Conditions Analysis

Peak flow rates for this area have been computed utilizing the Rational Method. The 27.2 acres of area south of the railroad contributing flows to the dual 5'x2' RCB culverts under SH 3 has been calculated at 80.65 cfs for the 5-year storm event. It is estimated that an additional 30 cfs of flow from north of the railroad tracks enter the system based on a flow velocity of 3 feet per second within the dual 30" culverts. The 5'x2' RCB culverts combined with the limited capacity of the ditch along the south side of Oak Park causes storm water to divert down Video Street and Liggio Street via sheet flow and by flowing backward through 24" culverts causing flooding issues. These flow patterns have been verified by descriptions given by area residents.

Additional concerns of the limited downstream capacity of the 72" steel pipe and 54" stub out at FM 517 and Timber Drive may also limit the capacity of the overall system, however these pipes are well downstream of the hot spot location. Further coordination with TxDOT to upsize the 54" RCP stub out accepting flows into the TxDOT storm sewer under FM 517 is recommended. The 54" stub out

creates a "choke point" and leads to localized flooding issues. The FM 517 storm sewer system is under the jurisdiction of TxDOT.

C. Proposed Improvements

To address the drainage issues located within the hot spot area, several improvements have been proposed. Additional dual 5'x2' RCB box culverts constructed under SH 3 will accommodate the computed 5-year design flow. Upstream of SH 3, dual 5'x4' RCBs are proposed to help reduce the maintenance costs to the City by eliminating a portion of the ditch and to provide additional capacity to the system at this point. The proposed dual 5'x4' RCB's should be extended from SH 3 to Liggio Street. Type E inlets should be installed to provide sufficient inlet capacity to allow flows to enter the system. As an alternative to the RCB's, concrete lining may also be considered, however this may require additional safety measures and the driveway culverts will still have to be replaced. For the purposes of this study, the RCB extension has been designated as the preferred alternative.

The roadside ditch along Liggio Street appears to have sufficient capacity to accommodate flows from only the hot spot area. To improve the performance of this portion of the system, the ditches need to be isolated from other offsite flows. The ditch along Oak Park surcharges and storm water flows backward into Liggio via a 24" and 12" pipes. To maximize the efficiency of draining the area, check valves or flap gates are proposed for these pipes to allow Liggio Street to drain when the Oak Park Street ditch allows, but prevents flows from flowing backward and overwhelming the roadside ditch. Regrading and cleaning of the ditches along Liggio Street is also important so that driveway culverts are kept clear. If desired, residents may want to install small private area drains to help reduce standing water in back yard areas that have been observed in the field and described by the residents. The area drains are a private improvement and are not included as part of the proposed work to be undertaken by the City.

D. Estimated Construction Cost Estimate

The total estimated construction cost for these improvements is $523,880 as shown on the following page. The costs assume only the drainage improvements will be completed. Costs to cut and patch roads have been included to construct the system. Costs to replace or modify the insufficient downstream system have not been included and will require close coordination with TxDOT.

City of Dickinson Drainage Study

Hot Spot #2 - Liggio Street

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Check Valve on Pipe (12")	EA.	1	***$500.00***	***$500***
2	Install 24" Flap/Check Valve	EA.	1	***$5,000.00***	***$5,000***
3	Regrade Existing Ditch	L.F.	550	***$2.00***	***$1,100***
4	5'x2' Jack and Bore	L.F.	200	***$350.00***	***$70,000***
5	5'x4' RCB	L.F.	820	***$250.00***	***$205,000***
6	Type E Inlets	E.A.	5	***$5,000.00***	***$25,000***
7	Remove Storm Pipe/Culverts (48" or smaller)	L.F.	320	***$10.00***	***$3,200***
8	Remove Existing Pavement	S.Y.	525	***$20.00***	***$10,500***
9	6" Thick Concrete Driveway	S.Y.	175	***$40.00***	***$7,000***
10	6" Thick Concrete Public Road	S.Y.	350	***$62.00***	***$21,700***
11	Landscape Restoration	S.F.	11,600	***$2.00***	***$23,200***
12	Remove Concrete Headwall	EA.	2	***$1,000.00***	***$2,000***
Total Construction Cost					$374,200
Contingency (25%)					$93,550
Engineering (15%)					$56,130
Total Cost					**$523,880**

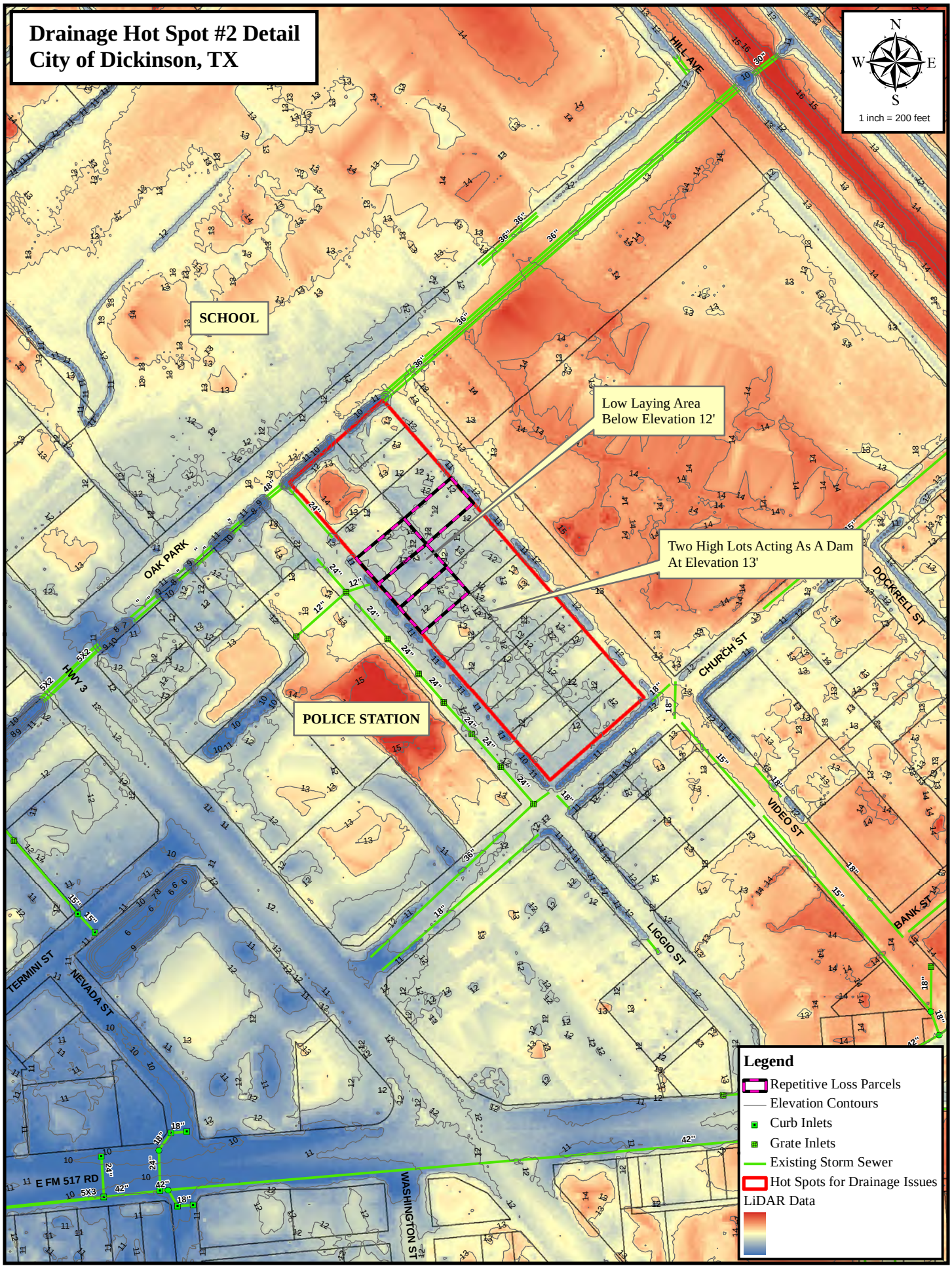
Notes:

1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Coordination with TxDOT is required

3. Costs for easements or right of way are not included

4. The improvements assume the storm sewer system will be a stand alone project and no additional roadway improvements will be completed


Drainage Hot Spot #2 Detail
City of Dickinson, TX
N
W
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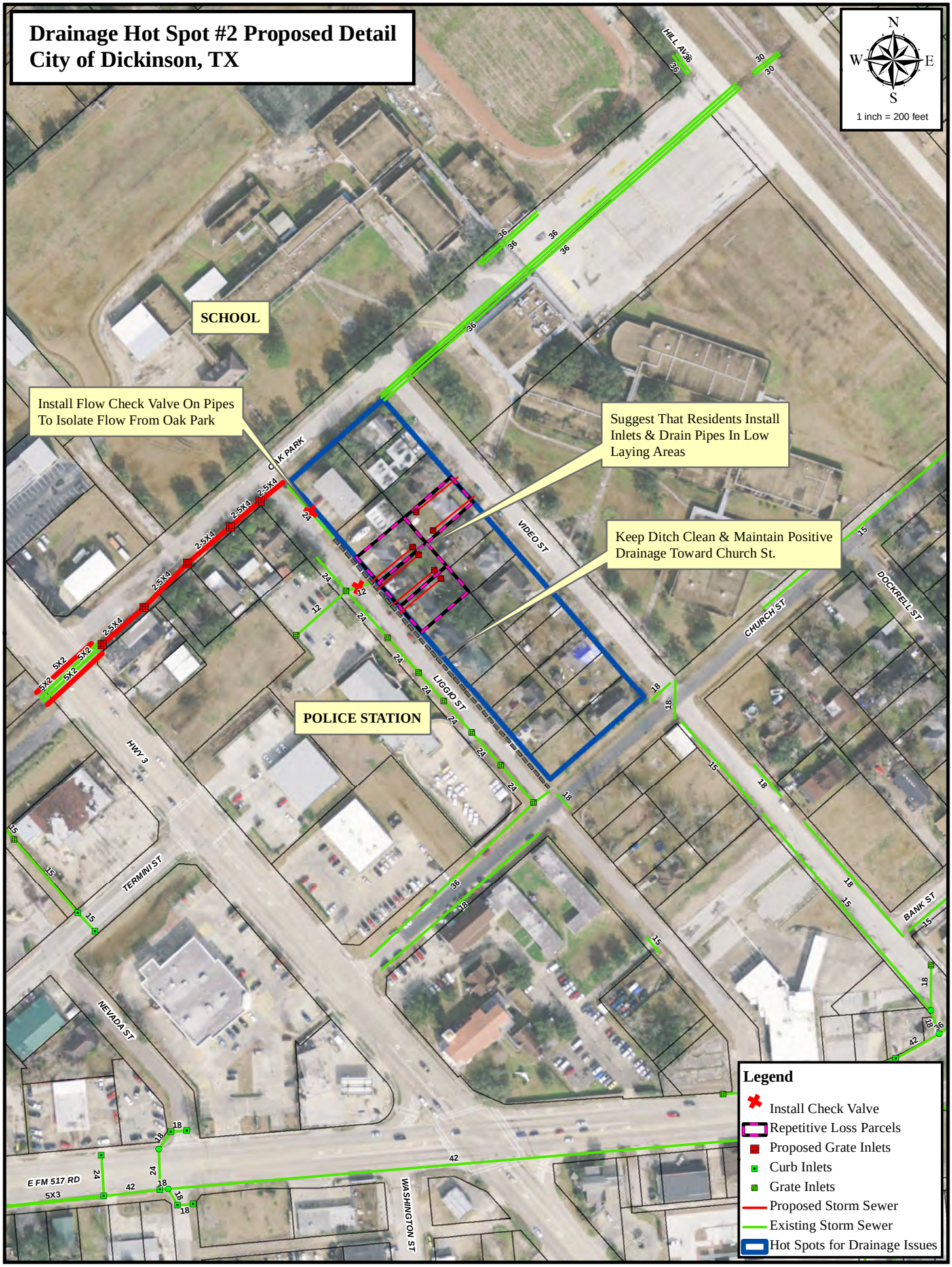
S
1 inch = 200 feet
SCHOOL
Low Laying Area
Below Elevation 12'
Two High Lots Acting As A Dam
At Elevation 13'
POLICE STATION
HILL AVE
OAK PARK
HWY 3
CHURCH ST
DOCKRELL ST
VIDEO ST
BANK ST
LIGGIO ST
TERMINI ST
NEVADA ST
E FM 517 RD
WASHINGTON ST
Legend
Repetitive Loss Parcels
Elevation Contours
Curb Inlets
Grate Inlets
Existing Storm Sewer
Hot Spots for Drainage Issues
LiDAR Data


Drainage Hot Spot #2 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
SCHOOL
Install Flow Check Valve On Pipes To Isolate Flow From Oak Park
Suggest That Residents Install Inlets & Drain Pipes In Low Laying Areas
Keep Ditch Clean & Maintain Positive Drainage Toward Church St.
POLICE STATION
OAK PARK
VIDEO ST
CHURCH ST
DOCKRELL ST
LIGGIO ST
HWY 3
TERMINI ST
NEVADA ST
BANK ST
WASHINGTON ST
E FM 517 RD
HILL AV
Legend
Install Check Valve
Repetitive Loss Parcels
Proposed Grate Inlets
Curb Inlets
Grate Inlets
Proposed Storm Sewer
Existing Storm Sewer
Hot Spots for Drainage Issues

Hot Spot # 3 – Plantation Drive

A. General Description

Hot spot #3 consists of the area along Plantation Drive between Maple Drive and Magnolia Bayou. There are 24 lots within this hotspot area with no reported repetitive loss claims. This area is located within the 100-year floodplain from Magnolia Bayou as shown on the following exhibit.

Plantation Drive is a two lane street with roadside ditches that drain to the northeast to Magnolia Bayou. Various culvert sizes exist under driveway, with the most common size being 15" RCP. A number of the culverts are partially filled in, thereby limiting the storm water conveyance capacity through the system. It was reported that shallow flooding occurs in the area, which appears to be due to the restrictions at the culverts.

B. Existing Conditions Analysis

Peak flow rates for this area have been calculated using the Rational Method and the 5-year storm event. The area has been divided into two drainage areas to account for areas that will require upsizing of the culverts.

Limited capacity of the existing ditches and driveway culverts has created localized drainage issues. As sediment fills culverts and the ditches, standing water may be experienced within the ditches that either have to seep into the ground or evaporate. The hot spot is also located within the 100-year floodplain and some riverine flooding from Magnolia Bayou may occur during a regional extreme storm event.

C. Proposed Improvements

The roadside ditches along Plantation Drive need to be cleaned and regraded so that flows can reach Magnolia Bayou to the northeast. Toward Maple Drive, the culverts should be a minimum of 24" in diameter. At the downstream end of Plantation Drive, culverts should be upsized to 30" in diameter as shown on the following Proposed Detail exhibit. Existing drainage patterns should be maintained as much as possible during the regrading of the roadside ditches and replacement of the culverts.

D. Estimated Construction Cost Estimate

The estimated construction cost for the improvements is $129,580 as shown on the following page. The cost estimate assumes that only the reconstruction of the driveway culverts and roadside ditch regrading by an outside contractor. This is a project that may be implemented as routine maintenance by Public Works crews. The costs include cutting and patching of driveways only and not the full replacement of Plantation Drive.

City of Dickinson Drainage Study

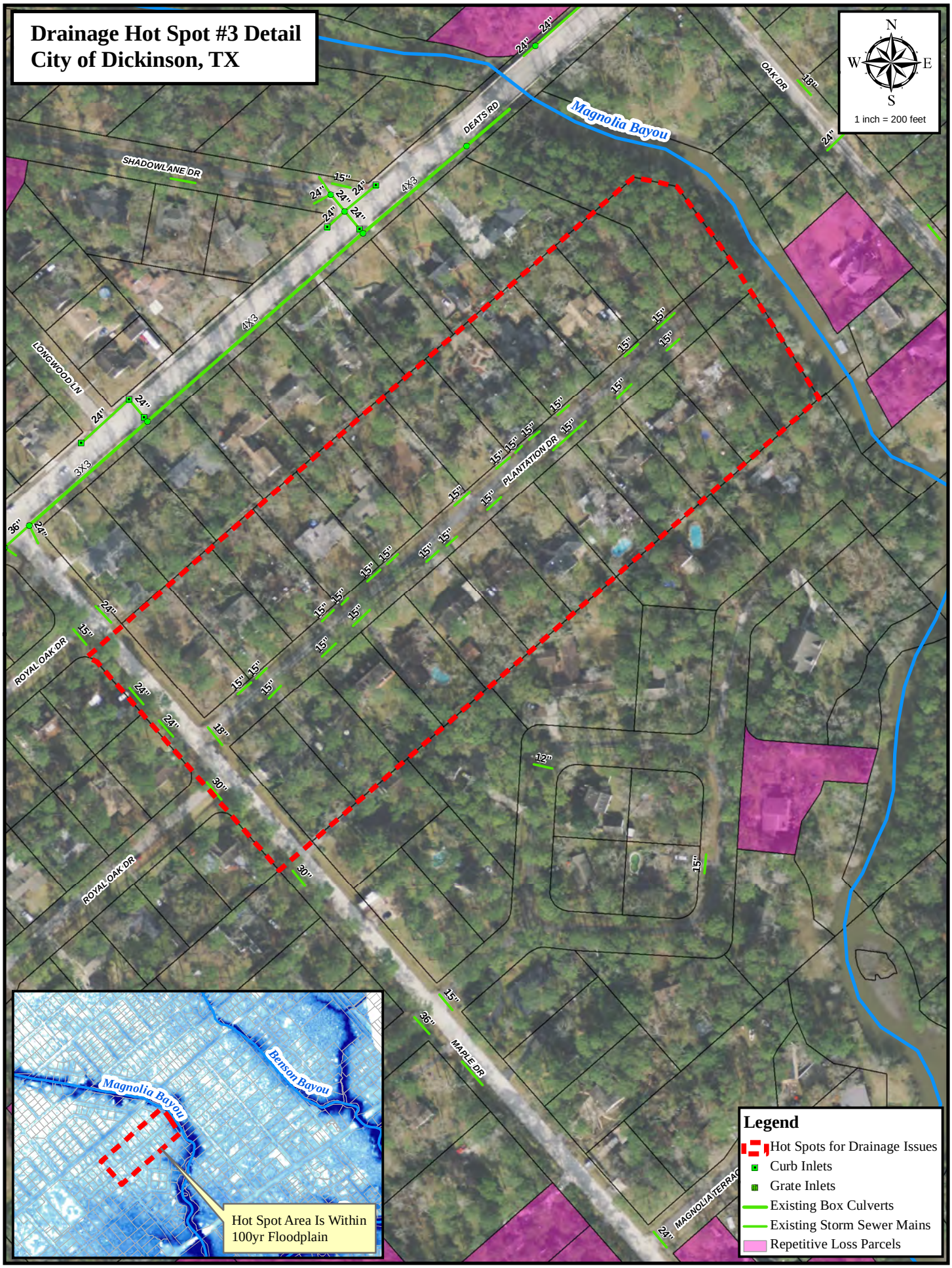
Hot Spot #3 - Plantation Drive

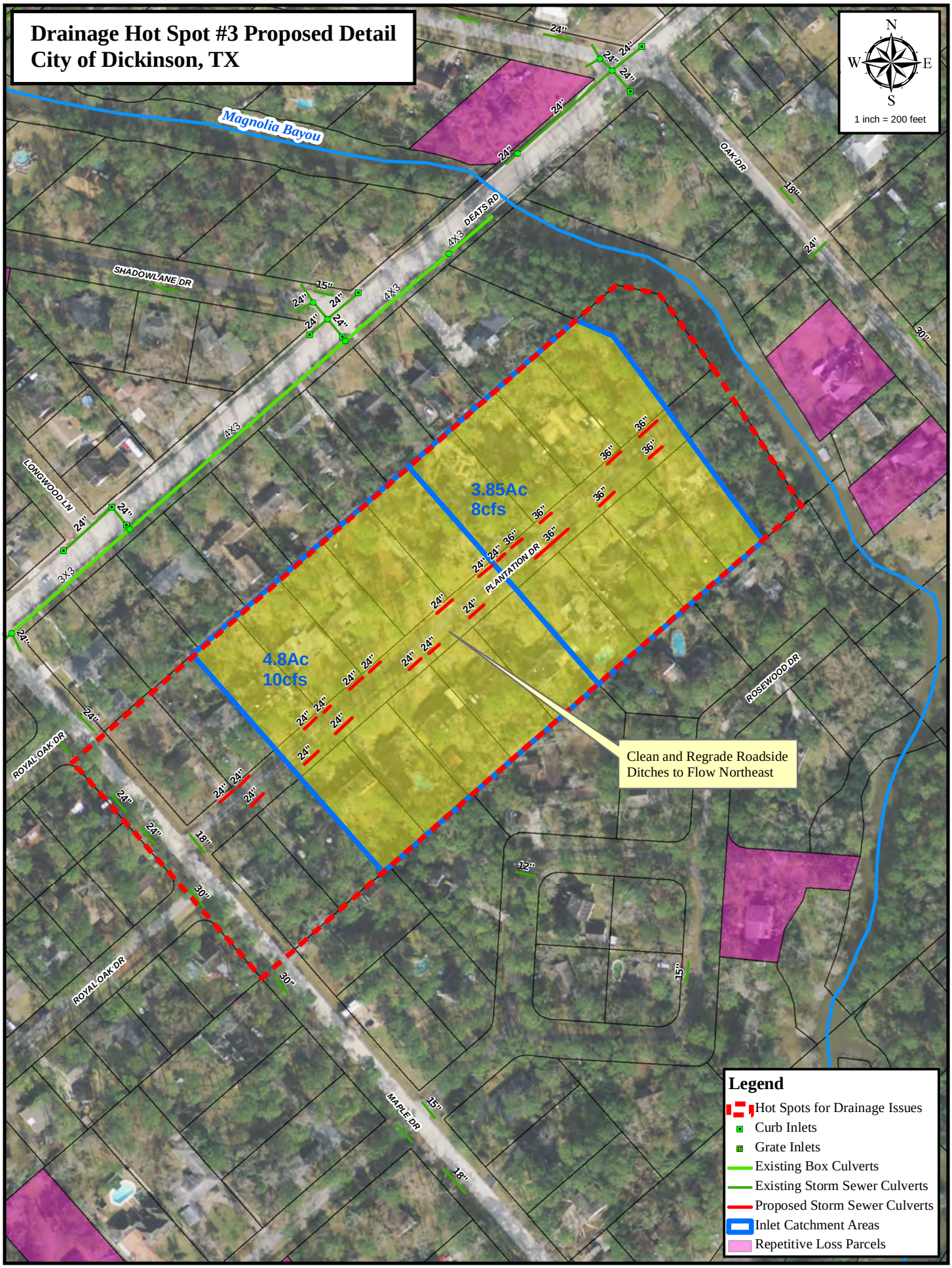
CMI Job No. 09-112

Plantation Drive - Maple Drive to Magnolia Bayou

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	2,200	***$2.00***	***$4,400***
2	Remove Existing RCP Culverts	L.F.	550	***$10.00***	***$5,500***
3	Remove Existing Pavement	S.Y.	615	***$20.00***	***$12,300***
4	24" RCP Driveway Culverts	L.F.	500	***$80.00***	***$40,000***
5	30" RCP Driveway Culverts	L.F.	50	***$95.00***	***$4,750***
6	6" Thick Concrete Driveway	S.Y.	615	***$40.00***	***$24,600***
7	Landscape Restoration	S.F.	500	***$2.00***	***$1,000***
Total Construction Cost					$92,550
Contingency (25%)					$23,140
Engineering (15%)					$13,890
Total Cost					**$129,580**

Notes:
1. These estimates are presented for planning purposes only and are subject to change as the project progresses
2. Costs for easements or right of way are not included
3. Design Storm is the 5-year event


Drainage Hot Spot #3 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
Magnolia Bayou
DEATS RD
SHADOWLANE DR
LONGWOOD LN
PLANTATION DR
ROYAL OAK DR
ROYAL OAK DR
OAK DR
MAPLE DR
MAGNOLIA TERRACE
Benson Bayou
Magnolia Bayou
Hot Spot Area Is Within 100yr Floodplain
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Repetitive Loss Parcels


Drainage Hot Spot #3 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
Magnolia Bayou
DEATS RD
SHADOWLANE DR
LONGWOOD LN
OAK DR
PLANTATION DR
ROSEWOOD DR
ROYAL OAK DR
ROYAL OAK DR
MAPLE DR
3.85Ac
8cfs
4.8Ac
10cfs
Clean and Regrade Roadside Ditches to Flow Northeast
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Culverts
Proposed Storm Sewer Culverts
Inlet Catchment Areas
Repetitive Loss Parcels

Hot Spot # 4 – Bayou Chantilly

A. General Description

Hot spot #4 consists of the Bayou Chantilly residential subdivision. The area consists of medium sized single-family lots. The drainage infrastructure includes roadway curb and gutter, and storm sewers that extend to Dickinson Bayou. In general, the existing homes are slab-on-grade construction that has been elevated with fill higher in elevation than the existing roadways. The roadways are significantly lower than most of the adjacent home finished floor elevations, providing protection from localized flooding due to rainfall within the subdivision. Old Bayou Drive is the lowest roadway in elevation that parallels Dickinson Bayou on the northwest extents of the subdivision. There are no well defined overland flow paths for storm water should the storm sewer system become clogged.

The hotspot is located within the 100-year floodplain of Dickinson Bayou. Flooding appears to occur from riverine flooding from Dickinson Bayou during large storm events or as a result of storm surge. There are 23 repetitive loss properties identified within the subdivision.

B. Existing Conditions Analysis

There are five drainage systems within the subdivision that have been evaluated. Based upon mapping obtained for the area and visual observation, the existing inlets in the area have limited capacity to allow flows into the existing storm sewer. The storm sewer is also inadequate to accommodate the peak flow rates for the 3-year storm event. The age and condition of the visible portions of the system indicate the pipes may have reached their useful design life and are in need of replacement on a structural basis.

C. Proposed Improvements

Due to the fact that the system has no well defined overflow path, a storm sewer has been proposed to accommodate the 100-year storm event. City criteria requires that the system accommodate a minimum of the 3-year storm event. All inlets, pipes, and manholes should be replaced. To provide some additional protection from the riverine flooding resulting from the 100-year floodplain from Dickinson Bayou, back flow preventers or tide flaps have also been recommended to reduce the occurrence of storm water from the Bayou from entering the subdivision. It should be noted the entire subdivision is located within the 100-year floodplain and the back flow preventer will only provide protection for the subdivision until the lowest elevation point in the sub division is overtopped by flows from the Bayou. The recommended improvements will lessen the frequency of flooding within the subdivision but will not eliminate the riverine flooding issue.

To complete the storm sewer reconstruction project, a significant portion of the roadway will need to be removed and replaced. This evaluation assumes that a minimum of half of the roadway section will be reconstructed. Several of the residential roadways that intersect Old Bayou Drive will be impacted. The following roadways and the approximate lengths impacted are as follows:

Table 6.2
Roadways Impacted by Storm Sewer Reconstruction (Bayou Chantilly)

Roadway	Length Impacted (linear feet)
Old Bayou Drive	350’
Live Oak Drive	350’
Meadow Lark Street	350’
Old Castle Lane	400’
Green Willow Lane	350’
Blue Water Lane	250’

D. Estimated Construction Cost Estimate

The estimated construction cost for the improvements is $1,521,740 as shown on the following page. The costs include the drainage improvements and the associated roadway reconstruction that will be required as part of the storm sewer construction. Additional funds have been included to account for landscaping replacement that may be required when the storm systems located within easements along lot lines are reconstructed.

For reference, the removal of the roadway and reconstruction of the pavement totals $677,320 for this project.

City of Dickinson Drainage Study

Hot Spot #4 - Bayou Chantilly

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Removal of Inlet	E.A.	27	***$400.00***	***$10,800***
2	Remove Storm Pipe/Culverts (54" or smaller)	L.F.	3,065	***$10.00***	***$30,650***
3	Remove Existing Pavement	S.Y.	5,900	***$20.00***	***$118,000***
4	Remove Storm Manhole	E.A.	12	***$400.00***	***$4,800***
5	24" RCP Storm Pipe	L.F.	250	***$80.00***	***$20,000***
6	30" RCP Storm Pipe	L.F.	80	***$95.00***	***$7,600***
7	36" RCP Storm Pipe	L.F.	1,600	***$110.00***	***$176,000***
8	42" RCP Storm Pipe	L.F.	360	***$130.00***	***$46,800***
9	36" RCP Storm Pipe (Jack and Bore)	L.F.	300	***$210.00***	***$63,000***
10	42" RCP Storm Pipe (Jack and Bore)	L.F.	325	***$230.00***	***$74,750***
11	54" RCP Storm Pipe (Jack and Bore)	L.F.	150	***$265.00***	***$39,750***
12	Type C Inlet	E.A.	27	***$2,500.00***	***$67,500***
13	Storm Sewer Manhole	E.A.	12	***$2,000.00***	***$24,000***
14	Concrete Street Replacement	S.Y.	5,900	***$62.00***	***$365,800***
15	Tide Flaps	E.A.	5	***$7,500.00***	***$37,500***
Total Construction Cost					$1,086,950
Contingency (25%)					$271,740
Engineering (15%)					$163,050
Total Cost					**$1,521,740**
	Roadway Portion Only				
3	Remove Existing Pavement	S.Y.	5,900	***$20.00***	***$118,000***
14	Concrete Street Replacement	S.Y.	5,900	***$62.00***	***$365,800***
Total Construction Cost (Roadway Only)					$483,800
Contingency (25%)					$120,950
Engineering (15%)					$72,570
Total Cost (Roadway Only)					**$677,320**

Notes:

1. These estimates are presented for planning purposes only and are subject to change as the project progresses

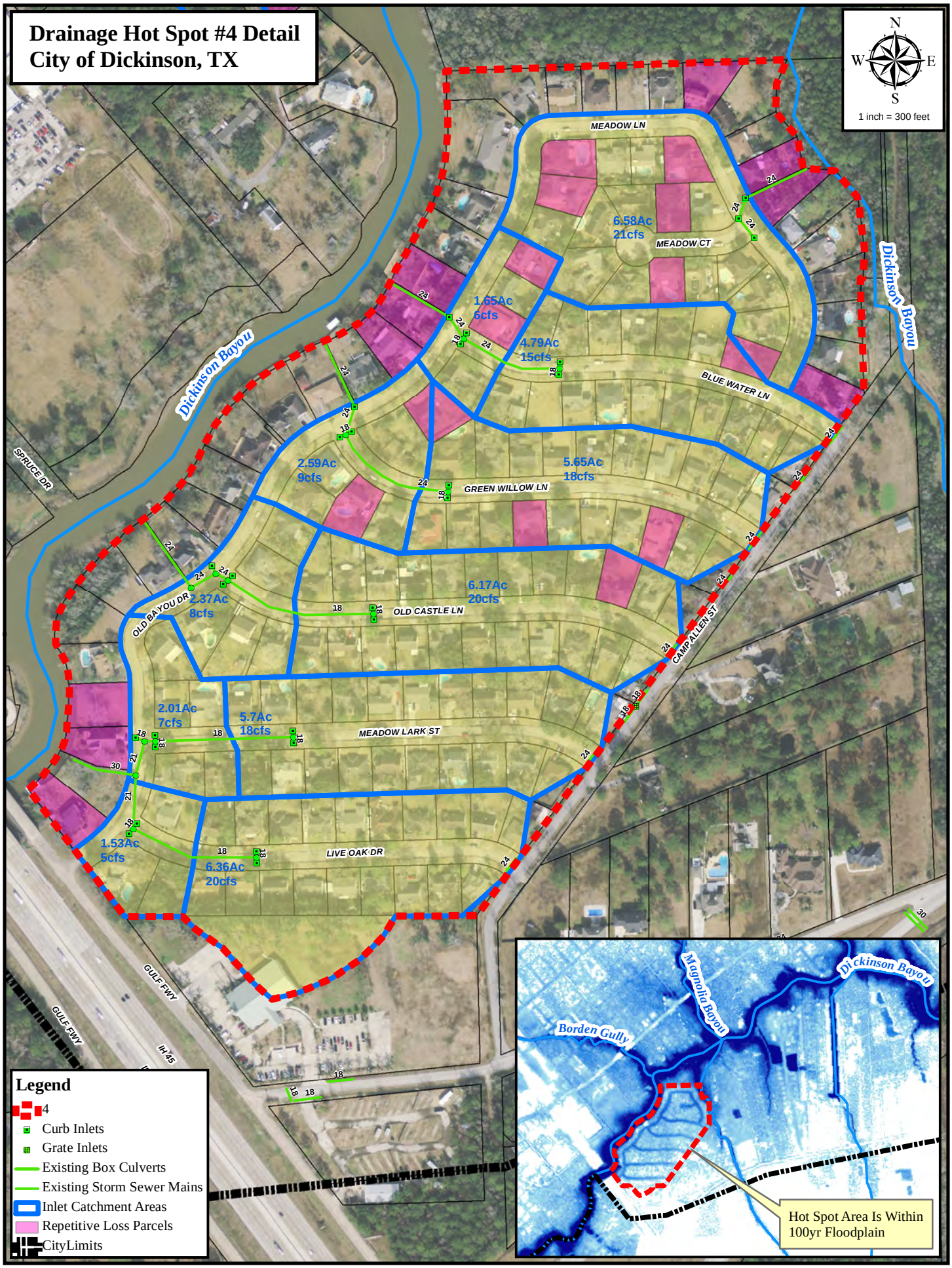
2. Costs for easements or right of way are not included

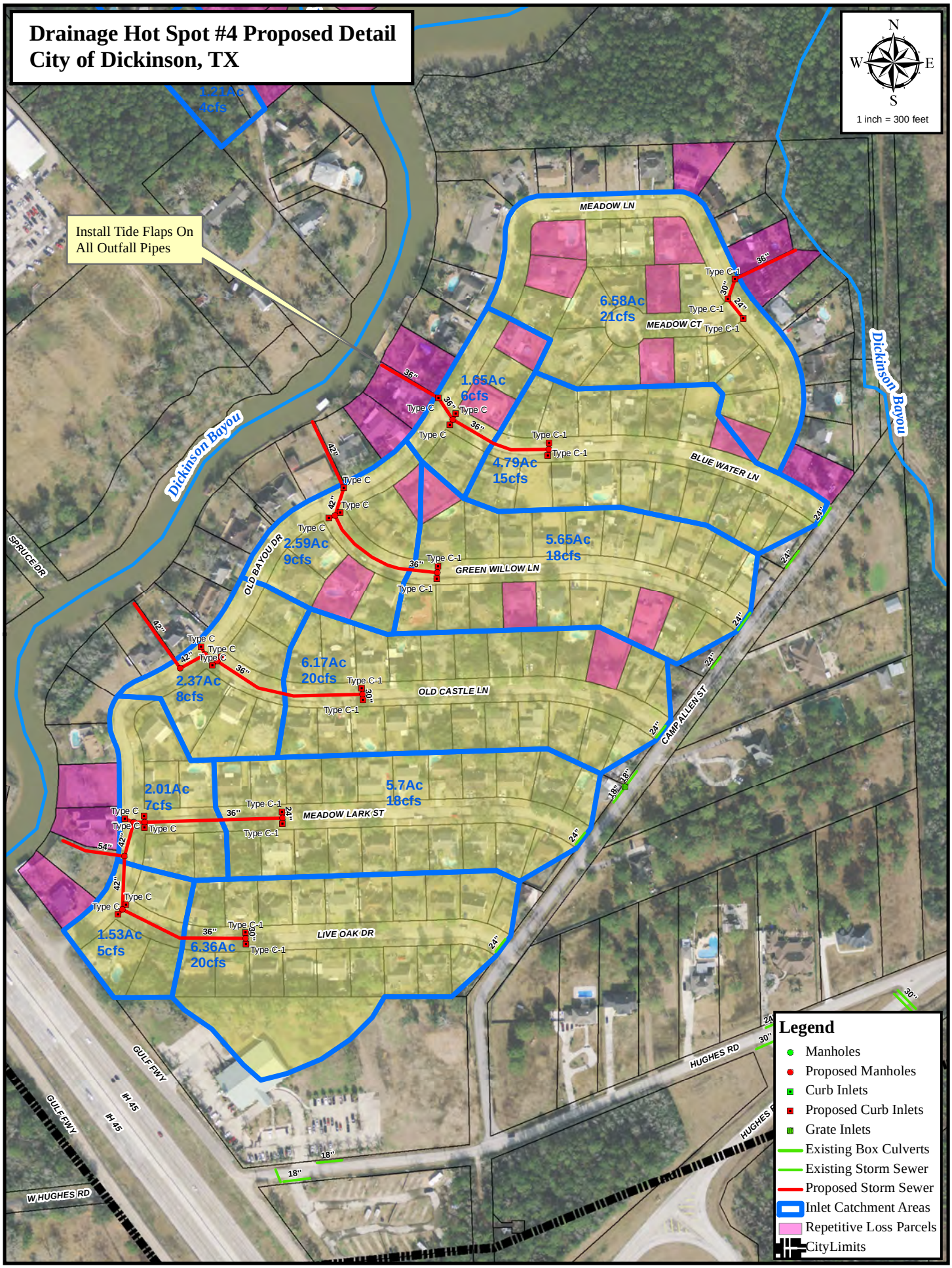
3. Design storm is 3-year event; due to no overland flow path 100-year system proposed

4. Area is within 1% frequency (100-year) floodplain - tide gates will help minimize floodplain backwater impacts

5. Due to the age of the subdivision and general visual observations, it has been assumed the entire system will need to be replaced due to the structural design life of the storm sewer pipe. The system should be inspected prior to replacement

6. No underground utility line adjustments or replacements have been assumed


Drainage Hot Spot #4 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
MEADOW LN
MEADOW CT
BLUE WATER LN
GREEN WILLOW LN
OLD CASTLE LN
MEADOW LARK ST
LIVE OAK DR
OLD BAYOU DR
SPRUCE DR
CAMP ALLEN ST
GULF FWY
IH 45
Dickinson Bayou
6.58Ac
21cfs
1.65Ac
6cfs
4.79Ac
15cfs
2.59Ac
9cfs
5.65Ac
18cfs
2.37Ac
8cfs
6.17Ac
20cfs
2.01Ac
7cfs
5.7Ac
18cfs
1.53Ac
5cfs
6.36Ac
20cfs
Legend
4
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels
CityLimits
Magnolia Bayou
Borden Gully
Hot Spot Area Is Within
100yr Floodplain


Drainage Hot Spot #4 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
Install Tide Flaps On
All Outfall Pipes
1.21Ac
4cfs
MEADOW LN
6.58Ac
21cfs
MEADOW CT
1.65Ac
6cfs
4.79Ac
15cfs
BLUE WATER LN
Dickinson Bayou
Dickinson Bayou
SPRUCE DR
OLD BAYOU DR
2.59Ac
9cfs
5.65Ac
18cfs
GREEN WILLOW LN
6.17Ac
20cfs
2.37Ac
8cfs
OLD CASTLE LN
CAMP ALLEN ST
2.01Ac
7cfs
5.7Ac
18cfs
MEADOW LARK ST
1.53Ac
5cfs
6.36Ac
20cfs
LIVE OAK DR
GULF FWY
IH 45
HUGHES RD
W HUGHES RD
Legend
Manholes
Proposed Manholes
Curb Inlets
Proposed Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer
Proposed Storm Sewer
Inlet Catchment Areas
Repetitive Loss Parcels
CityLimits

Hot Spot # 5 – Frostwood Circle

A. General Description

Hot spot #5 is comprised of two (2) single family residential subdivisions located east of IH-45 (Gulf Freeway), south of Sunset Drive, and north of Deats Road. The subdivision has roads with curb and gutter with limited storm sewer systems. The area is located within the limits of the 100-year floodplain from Borden Gully.

Within the hot spot area, four repetitive loss claims have occurred. It is not clear if the losses are due to localized flooding issues, or due to riverine flooding from Borden Gully. The hot spot area is located at the outside edge of the 100-year floodplain.

B. Existing Conditions Analysis

An evaluation of the existing conditions reveals that storm water must travel a significant distance via curb and gutter to reach any inlets within the subdivision. These long gutter runs allow flows to accumulate and create deeper flows within the street. It also creates "nuisance" flows during smaller storm events. The inlets within the subdivision are also undersized. In one case at the southernmost limits of Frostwood Circle, an existing inlet constructed in the roadway allows flows to enter an 18" RCP storm sewer, see Figure 6.1 below. The storm sewer invert for the system is only a few inches below the gutter flow line. To achieve the full capacity of this storm sewer, significant ponding (approximately 18") must occur, which will create additional flooding issues. No defined overland flow path exists at this point.

Figure 6.1
Frostwood Circle Inlet

At Sunset Drive and Frostwood Circle, an existing 18" RCP culvert conveys flow to the northeast along Sunset Drive. Sunset Drive is higher in elevation than Frostwood Circle. Due to the elevation difference at this point, flows from the roadside ditch along Sunset Drive are unintentionally diverted into the hot spot area contributing to localized flooding issues.

C. Proposed Improvements

Three main improvements have been proposed to help improve drainage issues within this hot spot. The first recommendation is to reconstruct a portion of Frostwood Circle at Sunset Drive to allow for the installation of a 30" RCP culvert at the intersection. Minor regrading of the area within the right of way will be needed to maintain flow patterns along Sunset Drive and avoid storm water from being diverted into the residential subdivision.

The second recommendation is to upsize and extend the storm sewer system within the Frostwood Drive right of way. Inlets should be installed at the intersection of Inwood Drive and Frostwood Drive to reduce the storm water travel length required in the street. The improvements will require the removal and replacement of an 18" pipe that crosses commercial development.

The third proposed change to the system is to reconstruct the inlets at the intersections of Inwood Drive and Deats Road, and Sherwood Oaks Street and Deats Road. The current inlets have limited capacity and limit the amount of storm water that can enter the storm sewer system.

To construct the storm sewer, approximately 1,100 linear feet of the roadway will be impacted. This evaluation assumes that a minimum of half of the roadway section along Frostwood Circle will require reconstruction.

D. Estimated Construction Cost Estimate

To complete the proposed recommendations, the estimated construction cost for the improvements is $587,720 as shown on the following page. The costs include the drainage improvements and the associated roadway reconstruction that will be required as part of the storm sewer construction. Additional funds have been included to account for landscaping replacement that may be required when the storm systems located within easements along lot lines are reconstructed.

For reference, the removal of the roadway and reconstruction of the pavement totals $206,640 for this project.

City of Dickinson Drainage Study

Hot Spot #5 - Frostwood

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Removal of Inlet	E.A.	5	***$400.00***	***$2,000***
2	Remove Storm Sewer Pipe/Culverts (18")	L.F.	1,010	***$10.00***	***$10,100***
3	Remove Existing Pavement	S.Y.	1,800	***$20.00***	***$36,000***
4	Remove Storm Manhole	E.A.	1	***$400.00***	***$400***
5	24" RCP Storm Pipe	L.F.	25	***$80.00***	***$2,000***
6	30" RCP Storm Pipe	L.F.	2,160	***$95.00***	***$205,200***
7	Type C Inlet	E.A.	7	***$2,500.00***	***$17,500***
8	Type C-2 Inlet	E.A.	4	***$4,000.00***	***$16,000***
9	Storm Sewer Manhole	E.A.	2	***$2,000.00***	***$4,000***
10	6" Concrete Street Replacement	S.Y.	1,800	***$62.00***	***$111,600***
11	Landscape Restoration	S.F.	3,000	***$5.00***	***$15,000***
Total Construction Cost					$419,800
Contingency (25%)					$104,950
Engineering (15%)					$62,970
Total Cost					**$587,720**
	Roadway Portion Only				
3	Remove Existing Pavement	S.Y.	1,800	***$20.00***	***$36,000***
10	6" Concrete Street Replacement	S.Y.	1,800	***$62.00***	***$111,600***
Total Construction Cost (Roadway Only)					$147,600
Contingency (25%)					$36,900
Engineering (15%)					$22,140
Total Cost (Roadway Only)					**$206,640**

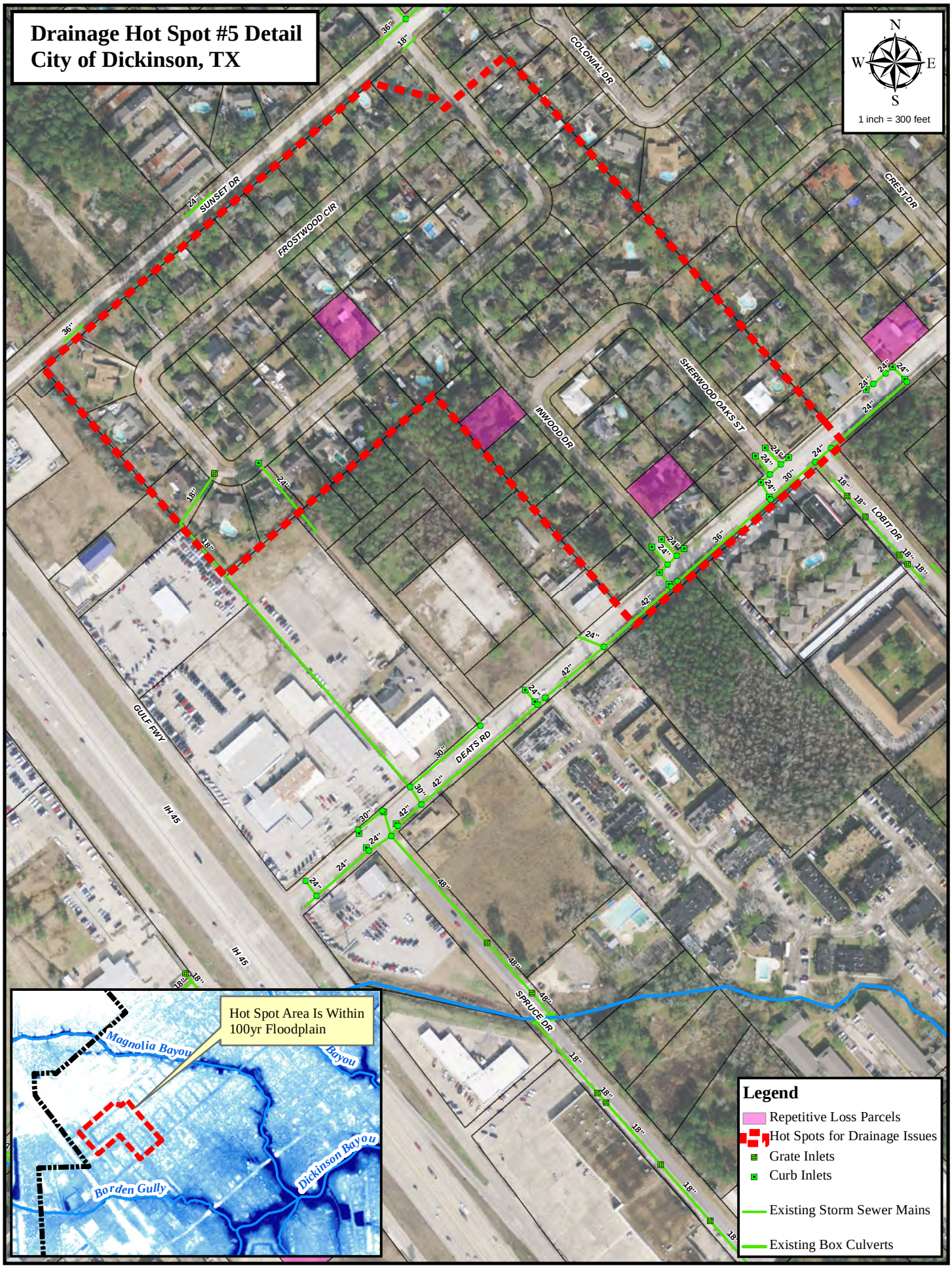
Notes:

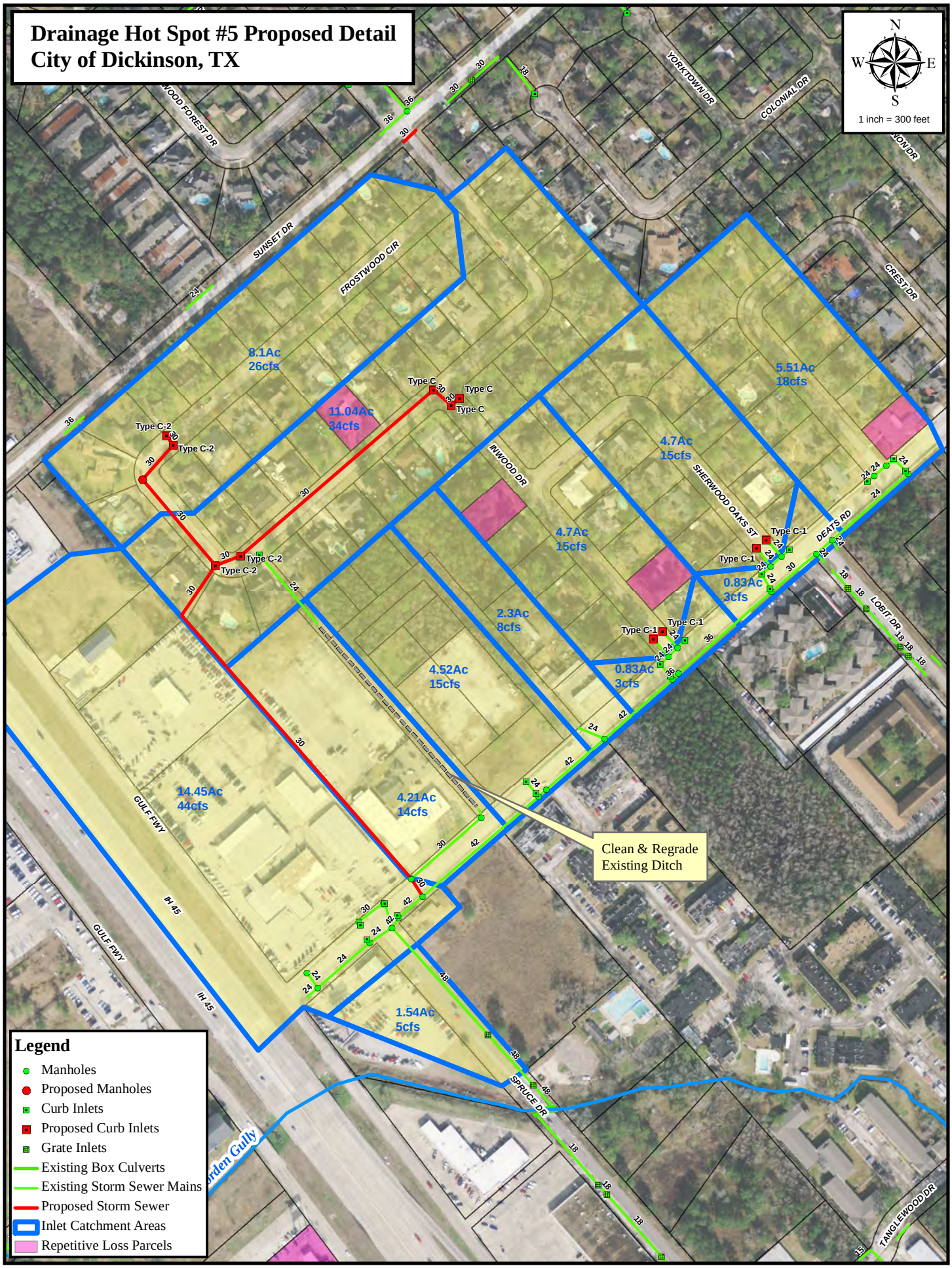
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Costs for easements or right of way are not included

3. Design storm is 3-year event

4. No underground utility line adjustments or replacements have been assumed


Drainage Hot Spot #5 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
COLONIAL DR
SUNSET DR
FROSTWOOD CIR
CREST DR
SHERWOOD OAKS ST
INWOOD DR
LOBIT DR
DEATS RD
GULF FWY
IH-45
SPRUCE DR
Hot Spot Area Is Within 100yr Floodplain
Magnolia Bayou
Dickinson Bayou
Borden Gully
Legend
Repetitive Loss Parcels
Hot Spots for Drainage Issues
Grate Inlets
Curb Inlets
Existing Storm Sewer Mains
Existing Box Culverts


Drainage Hot Spot #5 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
SUNSET DR
FROSTWOOD CIR
YORKTOWN DR
COLONIAL DR
CREST DR
INWOOD DR
SHERWOOD OAKS ST
DEATS RD
LOBIT DR
SPRUCE DR
TANGLEWOOD DR
GULF FWY
IH 45
8.1Ac
26cfs
11.04Ac
34cfs
5.51Ac
18cfs
4.7Ac
15cfs
4.7Ac
15cfs
0.83Ac
3cfs
2.3Ac
8cfs
4.52Ac
15cfs
0.83Ac
3cfs
14.45Ac
44cfs
4.21Ac
14cfs
1.54Ac
5cfs
Type C
Type C-1
Type C-2
Clean & Regrade
Existing Ditch
Legend
Manholes
Proposed Manholes
Curb Inlets
Proposed Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Proposed Storm Sewer
Inlet Catchment Areas
Repetitive Loss Parcels

Hot Spot # 6 – Oak Ridge Drive

A. General Description

Hot spot #6 is comprised of four streets located between Sunset Drive and Oak Ridge Drive:

- Oak Drive
- Woodlawn Street
- Belmont Street
- Greenbriar Street

Each of these streets drain to inlets located at the southern limits of the designated hot spot area. The inlets are undersized and show signs of deterioration. They connect into a recently constructed storm sewer system located under Oak Ridge Drive. Based upon the hydraulic computations completed for the roadway project to reconstruct Oak Ridge Drive, the storm sewer system has sufficient capacity to accommodate the 3-year storm event, which meets the City's criteria. The elevation of Oak Ridge Drive and Sunset Drive create a sump within each of the four streets that can only be drained by the inlets. Improvements to Oak Ridge Drive are underway at this time.

Within the hot spot limits, there are records of five repetitive loss properties. The area is also located within the 100-year floodplain from Magnolia Bayou.

B. Existing Conditions Analysis

With the recent improvements that have been completed to the Oak Ridge Drive storm sewer system, there is a noticeable improvement in the performance of the system. Detailed hydraulic computations have been completed for the storm sewer system and indicate that it can accommodate the 3-year storm event.

C. Proposed Improvements

The inlets at each of the four streets need to be replaced with standard C-1 inlets. The laterals connecting the inlets to the trunk system should also be upsized from 18" to 24" diameter pipes. The reconstruction of this portion of the system will allow for flows to enter the storm sewer more quickly and help reduce the chance of structural flooding due to localized flooding issues.

D. Estimated Construction Cost Estimate

The proposed improvements have an estimated construction cost of $118,090. The construction quantities and prices used to develop this estimate are provided on the following page. The construction costs are for the replacement of the inlets, storm sewer lateral pipes, and roadway repair.

City of Dickinson Drainage Study

Hot Spot #6-Oak Ridge Drive

CMI Job No. 09-112

Oak Ridge Drive from Magnolia Bayou to Greenbriar Street

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Removal of Inlet	E.A.	8	***$400.00***	***$3,200***
2	Remove Storm Sewer Pipe/Culverts (18")	L.F.	700	***$10.00***	***$7,000***
3	Remove Existing Pavement	S.Y.	270	***$20.00***	***$5,400***
4	24" RCP Storm Pipe	L.F.	400	***$80.00***	***$32,000***
5	Type C Inlet	E.A.	8	***$2,500.00***	***$20,000***
6	6" Concrete Street Replacement	S.Y.	270	***$62.00***	***$16,740***
Total Construction Cost					$84,340
Contingency (25%)					$21,090
Engineering (15%)					$12,660
Total Cost					**$118,090**

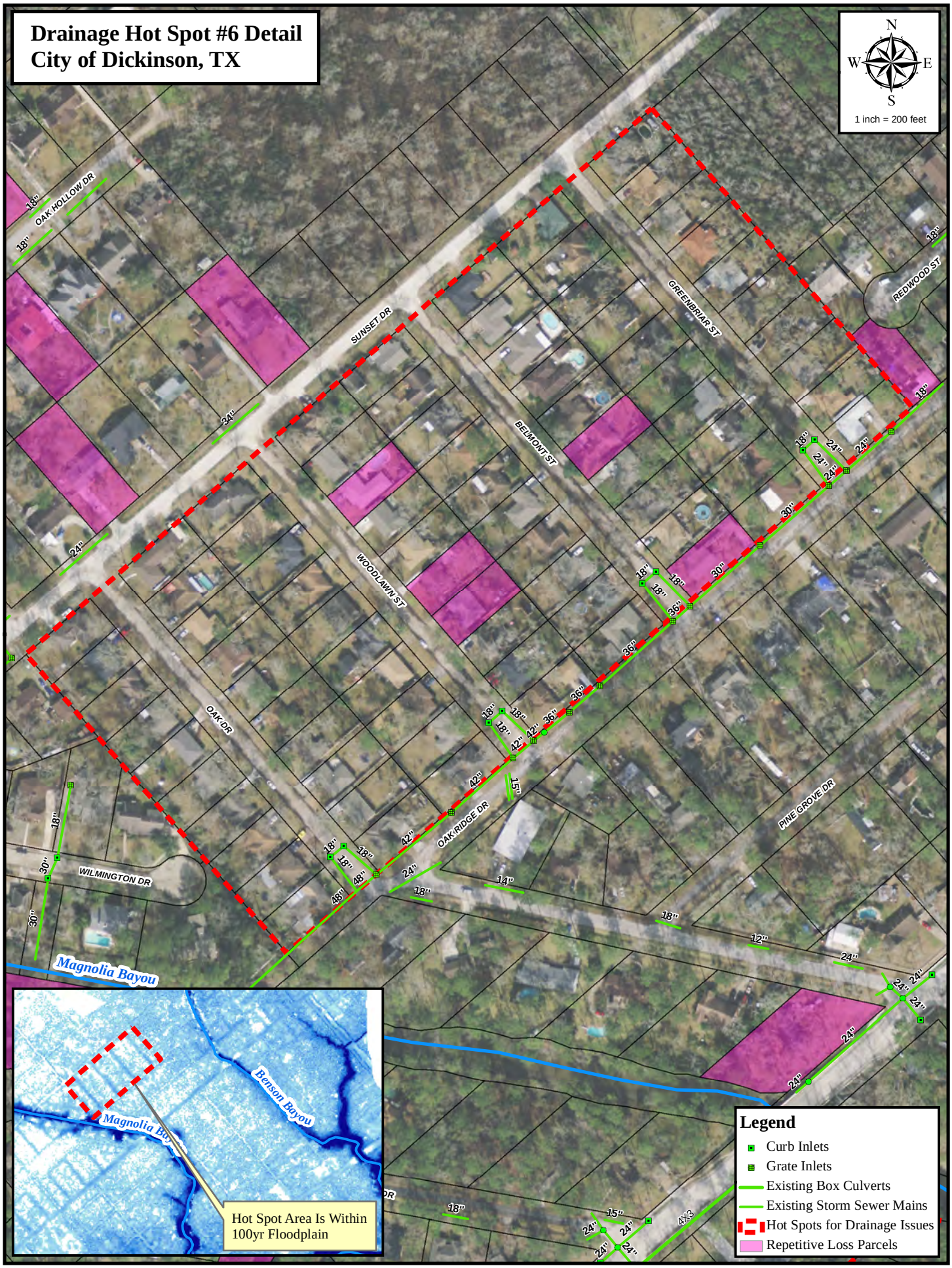
Notes:

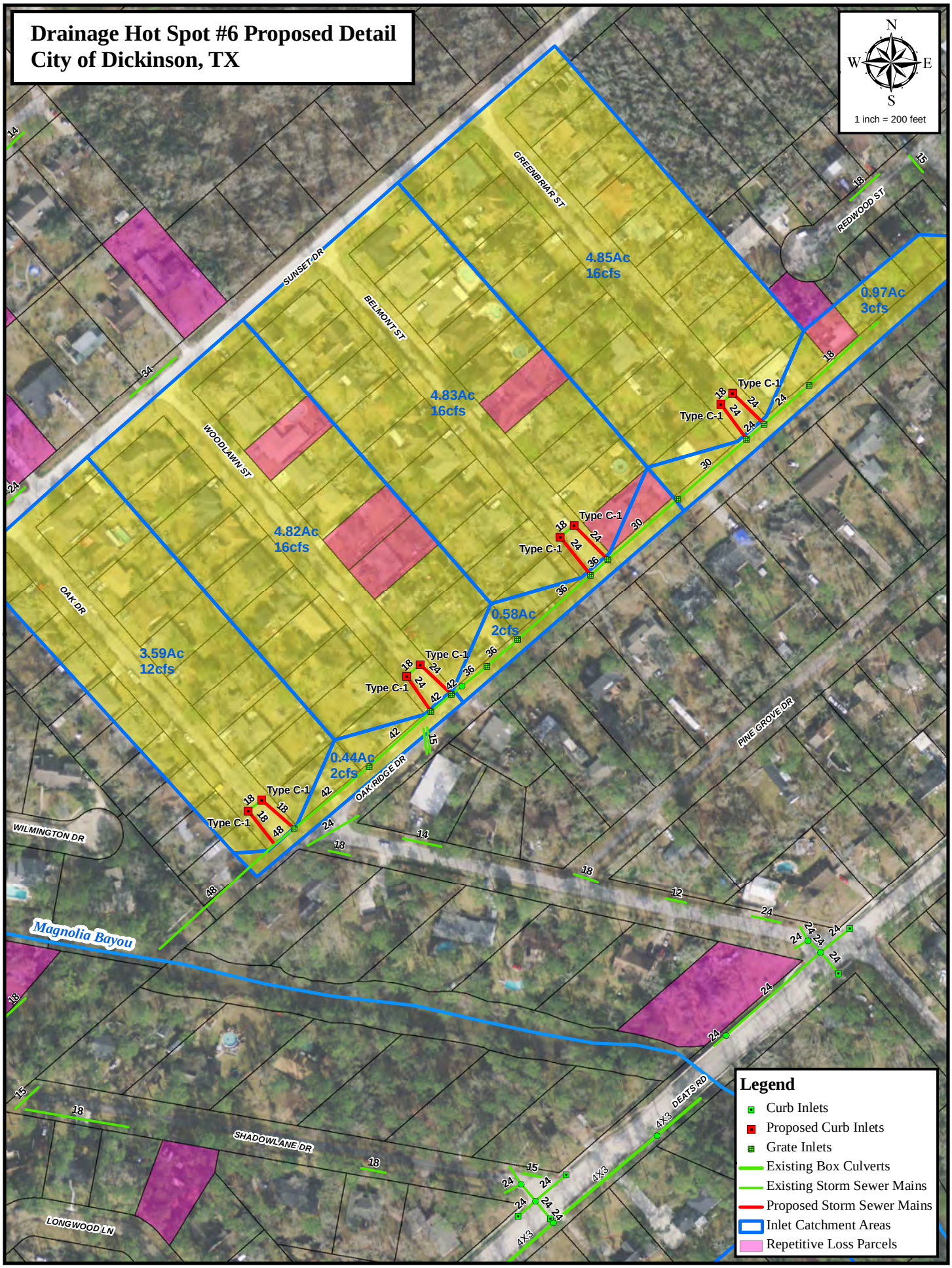
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Costs for easements or right of way are not included

3. Design storm is 3-year event

4. No underground utility line adjustments or replacements have been assumed


Drainage Hot Spot #6 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
OAK HOLLOW DR
SUNSET DR
GREENBRIAR ST
REDWOOD ST
BELMONT ST
WOODLAWN ST
OAK DR
OAK RIDGE DR
PINE GROVE DR
WILMINGTON DR
Magnolia Bayou
Benson Bayou
Hot Spot Area Is Within 100yr Floodplain
Legend
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Hot Spots for Drainage Issues
Repetitive Loss Parcels


Drainage Hot Spot #6 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
4.85Ac
16cfs
0.97Ac
3cfs
4.83Ac
16cfs
4.82Ac
16cfs
0.58Ac
2cfs
3.59Ac
12cfs
0.44Ac
2cfs
Type C-1
GREENBRIAR ST
SUNSET DR
BELMONT ST
WOODLAWN ST
OAK DR
OAK RIDGE DR
PINE GROVE DR
REDWOOD ST
WILMINGTON DR
SHADOWLANE DR
LONGWOOD LN
DEATS RD
Magnolia Bayou
Legend
Curb Inlets
Proposed Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Proposed Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels

Hot Spot # 7 – Gum Bayou

A. General Description

Hot spot #7 consists primarily of single-family residential lots with homes that are constructed slab on grade. The roads through this hot spot are generally two lanes with roadside ditches. Over the years, roadway maintenance, including pavement overlays, have raised the centerline elevations of the roads to the same level or in some instances, higher than the finished floor elevations of the adjacent homes. The roadways create barriers that can allow water to back up into homes.

To convey flows from the roadside ditches to Gum Bayou located to the north, two main drainage corridors have been established along Texas Avenue and Kansas Avenue. The ditches and culverts along these roadways have been intermittently installed creating reverse grades within the ditches in some areas. These reverse grades create ponding areas and can reduce the flow capacity of the ditches. In some areas, storm water can only flow out of the system after it builds up sufficiently and this has the potential to cause structural damage.

The area is located within the 100-year floodplain of Gum Bayou. Gum Bayou is maintained by the City at this hot spot. Due to physical limitations around the Bayou, one side is easily maintained by the City. The other side has a top of bank that is located at the right of way/easement line of the channel and does not allow for sufficient area to maintain that bank on a regular basis.

B. Existing Conditions Analysis

To determine where storm water was flowing to, a two-dimensional XP-SWMM model of the area was developed. The existing conditions analysis indicate that not only does significant riverine flooding occur in the area, but also limitations to the existing ditches and driveway culverts also contribute to flooding. As stated above, many culverts have reverse grades that limit the ability to convey storm water. In addition, culverts were also observed to be filled with sediment in some areas further limiting flows or blocking the culverts completely.

C. Proposed Improvements

Throughout the area, all driveway culverts should be replaced with 24” RCP, where possible, and the ditches regraded to have positive drainage. The ditches should drain to the east toward Texas Avenue or Kansas Avenue. Along Texas and Kansas Avenues, the roadside ditches should be regraded and selected culverts reconstructed. The regrading of these two main drainage corridors will provide significant relief to the surround areas.

In addition, maintenance to Gum Bayou should occur to provide additional storm water capacity for the hot spot area. Consideration should also be given to the existing roadway culvert crossings of Gum Bayou. Improvements will lessen frequency of flooding but due to the area being within floodplain and elevation of homes relative to the streets, flooding during extreme events will continue to occur.

D. Estimated Construction Cost Estimate

Replacement of the culverts, driveways, cleaning and regrading the roadside ditches, and clearing of Gum Bayou has an estimated construction cost of $380,360. A detailed breakdown of the construction materials and unit costs are provided on the following page. No roadway reconstruction is included in the estimate beyond the pavement patching needed after the culverts are installed.

City of Dickinson Drainage Study

Hot Spot #7-Gum Bayou

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Remove Culverts	L.F.	960	***$10.00***	***$9,600***
2	Remove Existing Pavement	S.Y.	640	***$20.00***	***$12,800***
3	24" RCP Culvert	L.F.	180	***$80.00***	***$14,400***
4	30" RCP Culvert	L.F.	300	***$95.00***	***$28,500***
5	36" RCP Culvert	L.F.	450	***$110.00***	***$49,500***
6	48" RCP Culvert	L.F.	30	***$150.00***	***$4,500***
7	Regrade Existing Ditch	L.F.	5,600	***$2.00***	***$11,200***
8	6" Concrete Street Replacement	S.Y.	640	***$62.00***	***$39,680***
9	Gum Bayou Maintenance	L.F.	2,900	***$35.00***	***$101,500***
Total Construction Cost					$271,680
Contingency (25%)					$67,920
Engineering (15%)					$40,760
Total Cost					**$380,360**

Notes:

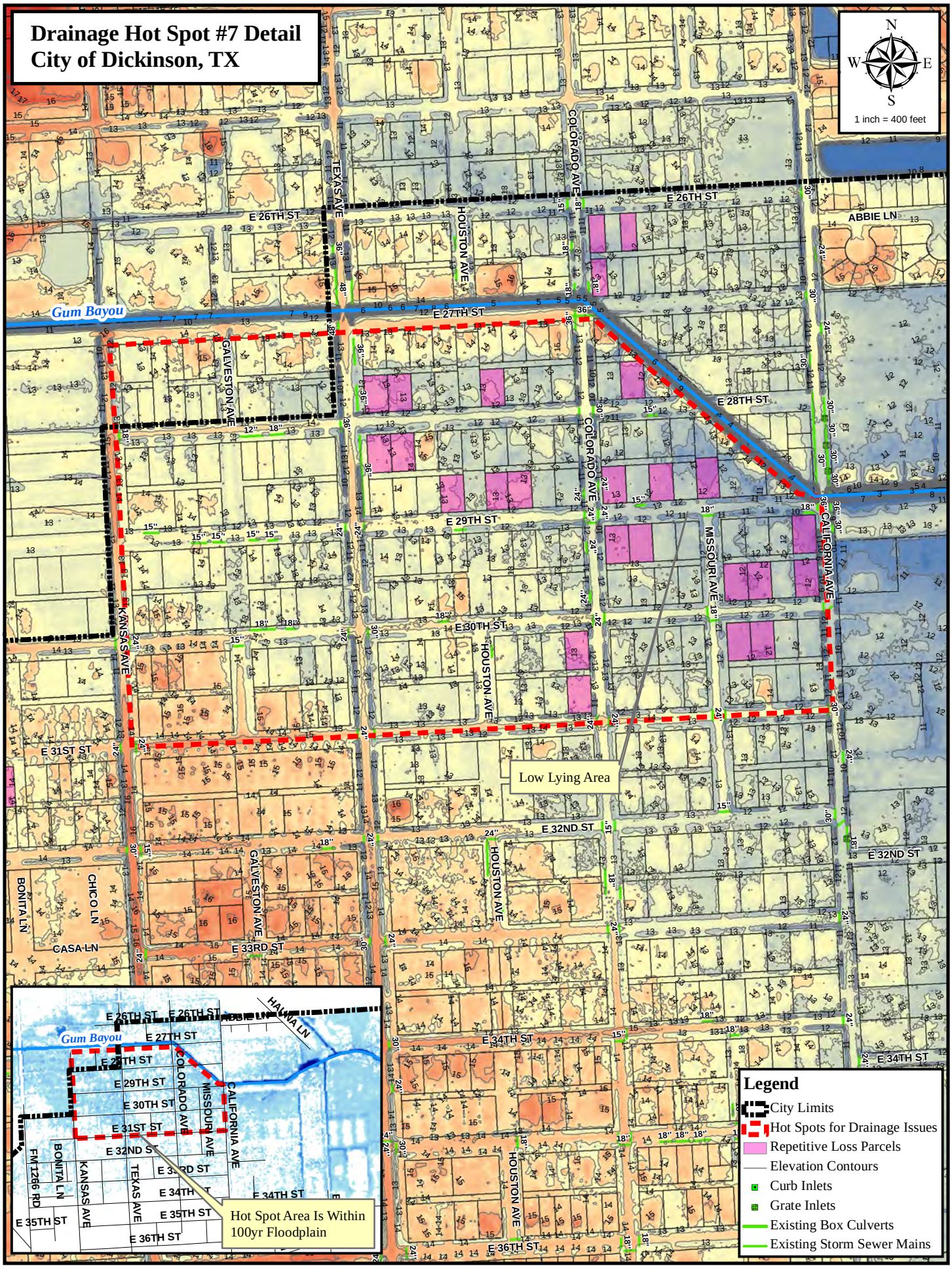
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

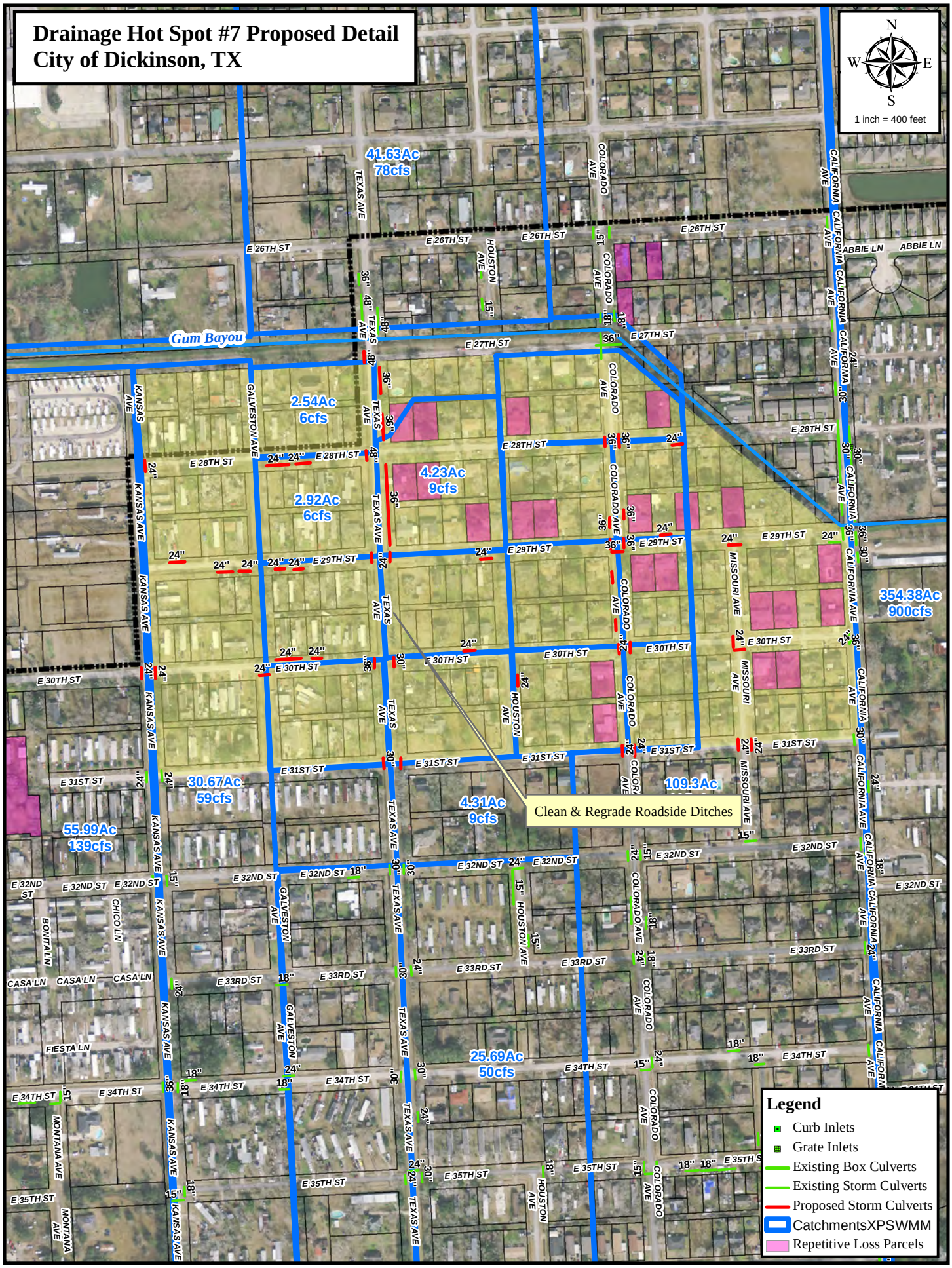
2. Costs for easements or right of way are not included

3. Design storm is 5-year event

4. No underground utility line adjustments or replacements have been assumed

5. Estimated driveway culvert replacement/ditch cleaning per home = $2840 (assumes double car driveway) w/ 114 lots = $323,760


Drainage Hot Spot #7 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
Gum Bayou
E 26TH ST
E 27TH ST
E 28TH ST
E 29TH ST
E 30TH ST
E 31ST ST
E 32ND ST
E 33RD ST
E 34TH ST
E 35TH ST
E 36TH ST
TEXAS AVE
HOUSTON AVE
COLORADO AVE
GALVESTON AVE
MISSOURI AVE
CALIFORNIA AVE
KANSAS AVE
ABBIE LN
BONITA LN
CHICO LN
CASA LN
Low Lying Area
Hot Spot Area Is Within 100yr Floodplain
Legend
City Limits
Hot Spots for Drainage Issues
Repetitive Loss Parcels
Elevation Contours
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains


Drainage Hot Spot #7 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
41.63Ac
78cfs
2.54Ac
6cfs
4.23Ac
9cfs
2.92Ac
6cfs
354.38Ac
900cfs
30.67Ac
59cfs
55.99Ac
139cfs
4.31Ac
9cfs
109.3Ac
25.69Ac
50cfs
Clean & Regrade Roadside Ditches
Gum Bayou
E 26TH ST
E 27TH ST
E 28TH ST
E 29TH ST
E 30TH ST
E 31ST ST
E 32ND ST
E 33RD ST
E 34TH ST
E 35TH ST
TEXAS AVE
COLORADO AVE
HOUSTON AVE
CALIFORNIA AVE
MISSOURI AVE
KANSAS AVE
GALVESTON AVE
ABBIE LN
CASA LN
CHICO LN
BONITA LN
FIESTA LN
MONTANA AVE
Legend
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Culverts
Proposed Storm Culverts
CatchmentsXPSWMM
Repetitive Loss Parcels

Hot Spot # 8 – Hemlock Circle

E. General Description

Hot spot #8 is comprised of single-family residential lots along Hemlock Circle and a portion of Edgewood Drive. Hemlock Circle and Edgewood Drive are paved two-lane roadways with roadside ditches. The entire residential subdivision in this area was originally identified as a hot spot due to reported street flooding issues, however only the portion of the area located within the City limits have been evaluated for improvements. The area is located outside of the 100-year floodplain.

F. Existing Conditions Analysis

The roadside ditch along Hemlock Circle has become filled with silt and overgrown with turf. The turf is well maintained my residents. Driveway culverts have been constructed ranging in size from 15" to 18" in diameter. The majority of the culverts have been filled in with sediment severely limiting the conveyance capacity of the culvert and roadside ditches. Flows along Hemlock Circle are conveyed to the southwest toward Ohio Avenue. Flows along Edgewood Drive are conveyed to the northwest toward two parallel 18" pipes within the overall development.

G. Proposed Improvements

The roadside ditches along Hemlock Circle and Edgewood Drive need to be cleaned. Storm culverts under driveways should be replaced with 24" RCP. The larger pipes will not only accommodate the peak flow rates from the area, but will also help to reduce the interval between maintenance periods for the City.

H. Estimated Construction Cost Estimate

Replacement of the culverts, driveway, and to clean and regrade the roadside ditches have an estimated construction cost of $110,760. This work can be accomplished by the City Public Works Department as part of a maintenance project. A detailed breakdown of the construction materials and unit costs are provided on the following page. No roadway reconstruction is included in the estimate beyond the pavement patching needed after the culverts are installed.

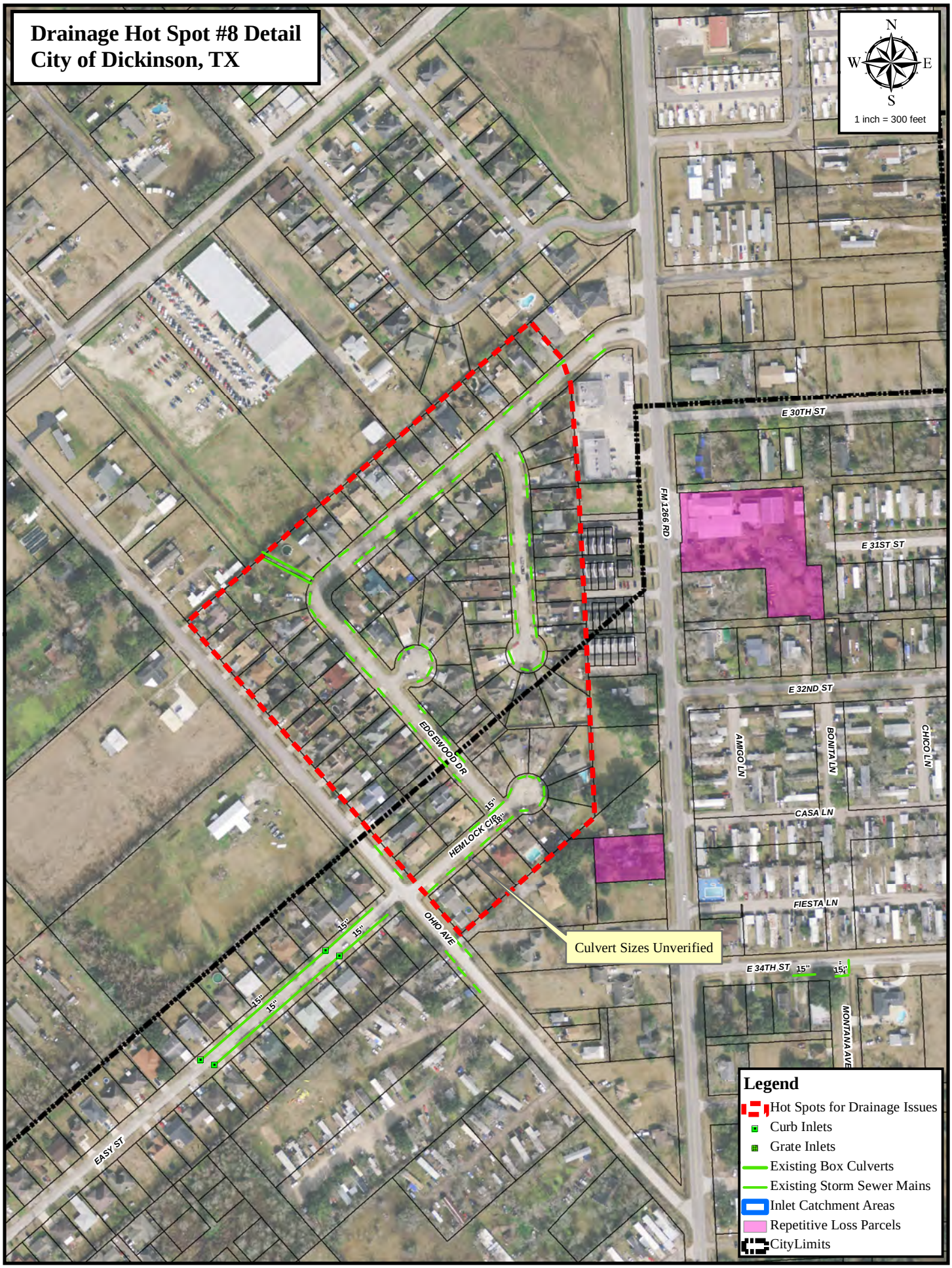
City of Dickinson Drainage Study

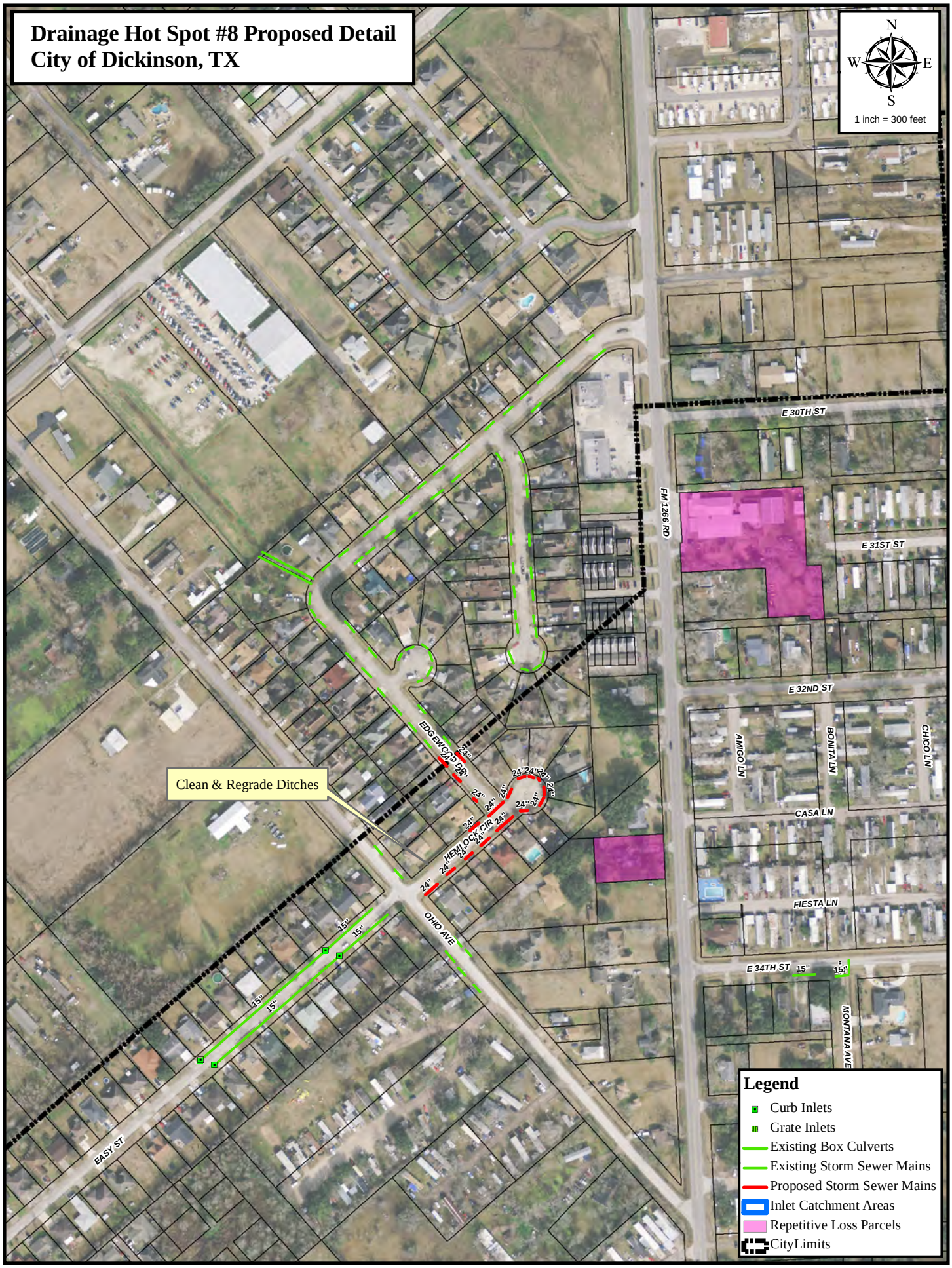
Hot Spot #8 - Hemlock Circle

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	1,520	***$2.00***	***$3,040***
2	Remove Existing RCP Culverts	L.F.	440	***$10.00***	***$4,400***
3	Remove Existing Pavement	S.Y.	475	***$20.00***	***$9,500***
4	24" RCP Culverts	L.F.	440	***$80.00***	***$35,200***
5	6" Thick Concrete Driveway	S.Y.	440	***$40.00***	***$17,600***
6	6" Thick Concrete Public Road	S.Y.	35	***$62.00***	***$2,170***
7	Landscape Restoration	S.F.	3,600	***$2.00***	***$7,200***
Total Construction Cost					$79,110
Contingency (25%)					$19,780
Engineering (15%)					$11,870
Total Cost					**$110,760**

Notes:
1. These estimates are presented for planning purposes only and are subject to change as the project progresses
2. Costs for easements or right of way are not included
3. Design Storm is the 5-year event


Drainage Hot Spot #8 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
E 30TH ST
FM 1266 RD
E 31ST ST
E 32ND ST
AMIGO LN
BONITA LN
CHICO LN
CASA LN
FIESTA LN
E 34TH ST
MONTANA AVE
EDGEWOOD DR
HEMLOCK CIR
OHIO AVE
EASY ST
15"
Culvert Sizes Unverified
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels
CityLimits


Drainage Hot Spot #8 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
E 30TH ST
FM 1266 RD
E 31ST ST
E 32ND ST
AMIGO LN
BONITA LN
CHICO LN
CASA LN
FIESTA LN
E 34TH ST
MONTANA AVE
OHIO AVE
EASY ST
EDGEWOOD DR
HEMLOCK CIR
Clean & Regrade Ditches
24"
15"
Legend
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Proposed Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels
CityLimits

Hot Spot # 9 – Briarglen Subdivision

A. General Description

Hot spot #9 consists of a single-family residential development located to the north of FM 517, east of Dickinson High School, and south of Gum Bayou. Portions of the hot spot are located within the 100-year floodplain from Gum Bayou. Roadways through the subdivision are concrete with curbs that exhibit significant cracking. A variety of grated and curb inlets collect storm water and convey flows to an existing ditch located within the heart of the development.

Homes in the area are generally elevated well above the top back of curb, which helps to eliminate the chances of structural flooding. No repetitive loss claims have been found for the Hot Spot, however the limitations of the storm sewer system reportedly creates mobility issues during storm events. Excessive regular ponding of storm water can also impact the structural integrity of the roadway by causing shifting of the underlying soils.

A variety of grated and curb inlets collect storm water and convey flows to an existing ditch located within the heart of the development. Several inlets are located at sump locations with no defined overflow path allowing for storm water to accumulate during intense storm events.

Owens Drive, located to the west of the subdivision, will be reconstructed as part of a County project. The project will help to better define offsite drainage patterns. The work being completed for this study has been coordinated with the design of the Owens Drive.

B. Existing Conditions Analysis

The majority of the subdivision drains through inlets to an existing vegetated drainage swale located in the center of the development. The swale has significant erosion causing damage to the fence lines of area residents that abut to the swale. The limited right of way for the swale also creates challenges for the City to maintain the ditch and as a result, the capacity of the ditch is limited by heavy vegetative growth.

Storm water flows from the area are conveyed to the swale via inlets and short segments of storm sewer pipe. Within the area, pipelines exist limit the ability to construct new storm sewers or regrade the existing swale located in the heart of the property.

At the end of Bramble Lane, two grated inlets exist that collect runoff and discharge to the drainage swale. The grates of these inlets are a few inches above the flow line of the curb creating a ponding issue during any storm event. The vertical difference between the top of grate and the road combined with the non-standard inlet type create maintenance issues for the City.

South of the intersection of Night Shade Drive and Winding Brook Drive, an existing 18” CMP exists along a property line and drains to the storm sewer system under Owens Drive. The 18” CMP appears to be failing structurally and is in need of replacement. Two inlets located along Winding Brook Drive drain to the pipe.

C. Proposed Improvements

One key recommendation for this hot spot is to increase the conveyance capacity of the drainage swale located in the heart of the subdivision. The swale should be regraded and lined with concrete. The concrete lining will help to maximize the conveyance ability, reduce the chances of the swale clogging, and help stop erosion in the area that is impacting adjacent property owners.

In general, the inlets within the subdivision should be replaced with Type C inlets and the storm sewer segments replaced with a minimum of 24" diameter pipe. The inlets and storm sewer located to the south of Night Shade Drive and Winding Brook Drive should also be replaced. We understand the City is currently working with property owners at this location to complete this construction. Due to the limitations within the area, the storm sewer pipe may require jack and bore construction.

D. Estimated Construction Cost Estimate

Replacement of portions of the storm sewer system, inlets, and ditch improvements has an estimated construction cost of $491,100. A detailed breakdown of the construction materials and unit costs are provided on the following page. No roadway reconstruction is included in the estimate beyond the pavement patching needed for the storm sewer replacement.

City of Dickinson Drainage Study

Hot Spot #9 - Briarglen

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Removal of Inlet	E.A.	14	***$400.00***	***$5,600***
2	Remove Storm Pipe/Culverts (36" or smaller)	L.F.	760	***$10.00***	***$7,600***
3	Remove Existing Pavement	S.Y.	190	***$20.00***	***$3,800***
4	24" Storm Pipe - Jack and Bore	E.A.	150	***$225.00***	***$33,750***
5	24" RCP Storm Pipe	L.F.	280	***$80.00***	***$22,400***
6	30" RCP Storm Pipe	L.F.	330	***$95.00***	***$31,350***
7	36" RCP Storm Pipe	L.F.	150	***$110.00***	***$16,500***
8	4'x2' RCB Storm	L.F.	200	***$125.00***	***$25,000***
9	5'x3' RCB Storm	L.F.	60	***$175.00***	***$10,500***
10	Type C Inlet	E.A.	13	***$2,500.00***	***$32,500***
11	Type A Inlet	E.A.	2	***$2,500.00***	***$5,000***
12	6" Thick Concrete Public Road	S.Y.	190	***$62.00***	***$11,780***
13	Landscape Restoration	S.F.	6,000	***$5.00***	***$30,000***
14	Concrete Lined Channel	L.F.	920	***$125.00***	***$115,000***
Total Construction Cost					$350,780
Contingency (25%)					$87,700
Engineering (15%)					$52,620
Total Cost					**$491,100**

Notes:

1. These estimates are presented for planning purposes only and are subject to change as the project progresses

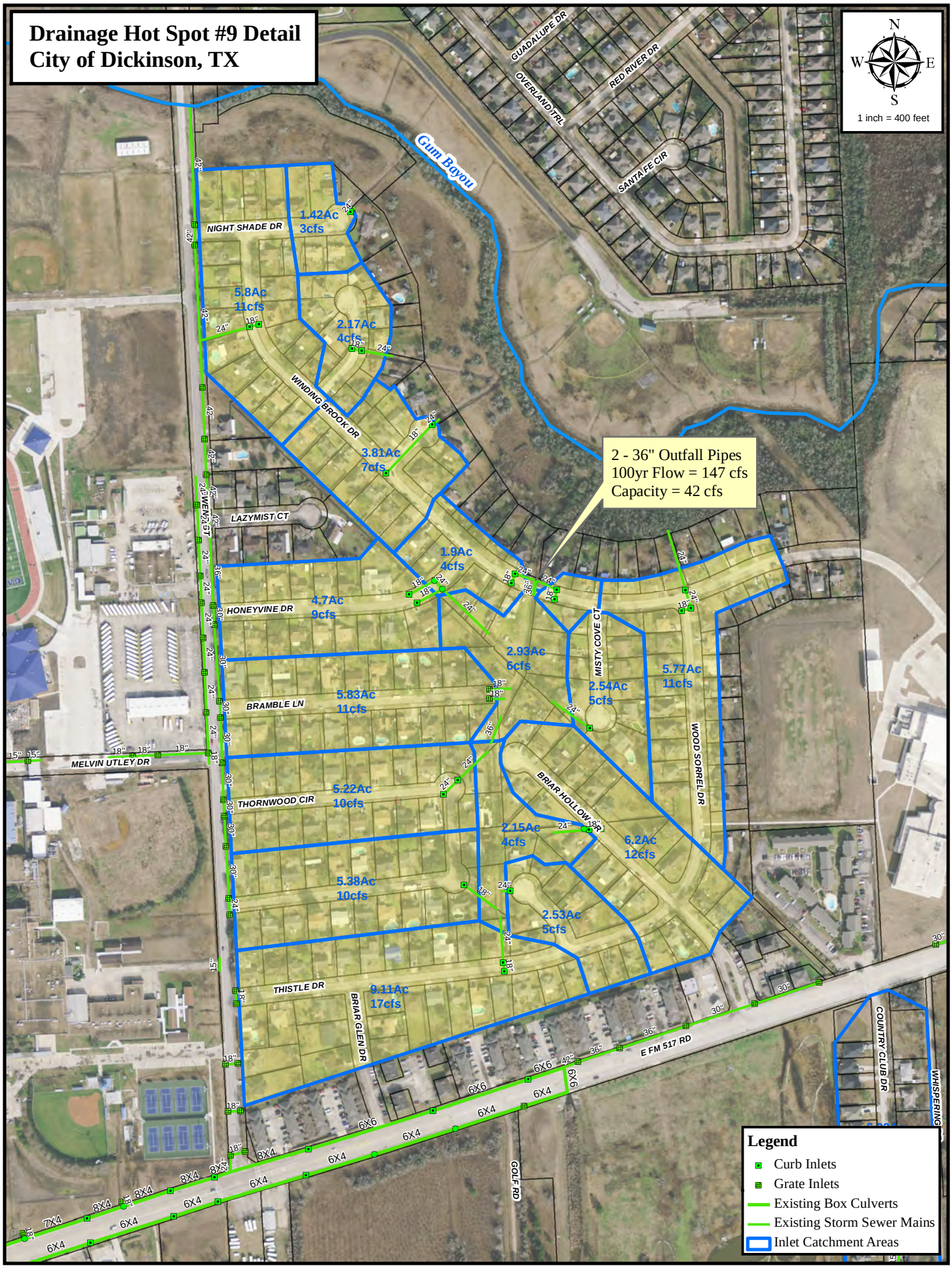
2. Costs for easements or right of way are not included

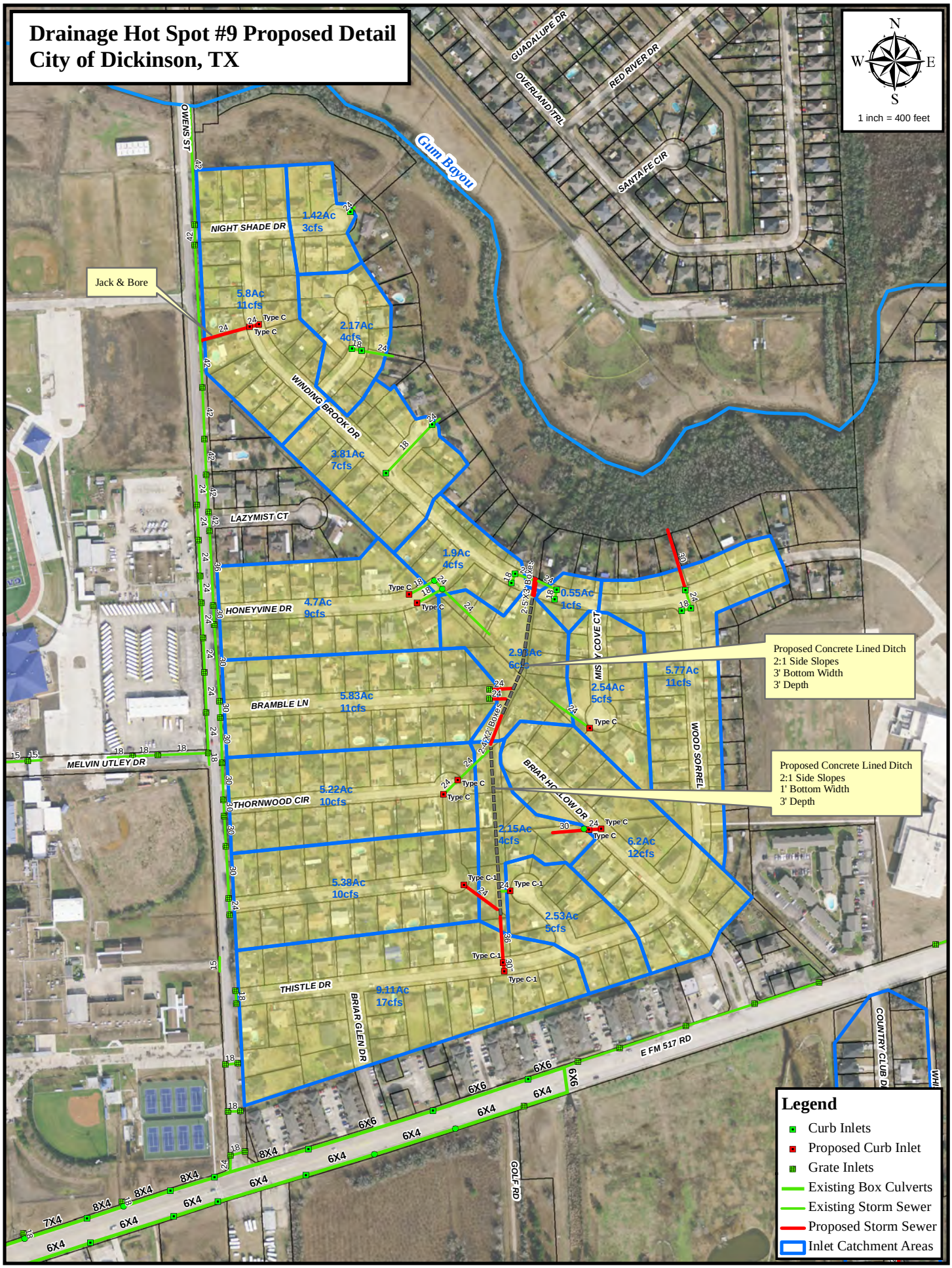
3. Design storm is 3-year event; due to no overland flow path 100-year system proposed

4. Portions of the area are within 1% frequency (100-year) floodplain

5. The structural integrity of the existing system to be left in place should be verified

6. No underground utility line adjustments or replacements have been assumed


Drainage Hot Spot #9 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
Gum Bayou
GUADALUPE DR
OVERLAND TRL
RED RIVER DR
SANTA FE CIR
NIGHT SHADE DR
1.42Ac
3cfs
5.8Ac
11cfs
2.17Ac
4cfs
WINDING BROOK DR
3.81Ac
7cfs
2 - 36" Outfall Pipes
100yr Flow = 147 cfs
Capacity = 42 cfs
LAZYMIST CT
1.9Ac
4cfs
HONEYVINE DR
4.7Ac
9cfs
2.93Ac
6cfs
MISTY COVE CT
5.77Ac
11cfs
2.54Ac
5cfs
BRAMBLE LN
5.83Ac
11cfs
WOOD SORREL DR
MELVIN UTLEY DR
THORNWOOD CIR
5.22Ac
10cfs
BRIAR HOLLOW DR
2.15Ac
4cfs
6.2Ac
12cfs
5.38Ac
10cfs
2.53Ac
5cfs
THISTLE DR
9.11Ac
17cfs
BRIAR GLEN DR
E FM 517 RD
COUNTRY CLUB DR
WHISPERING
GOLF RD
Legend
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Inlet Catchment Areas


Drainage Hot Spot #9 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
GUADALUPE DR
OVERLAND TRL
RED RIVER DR
SANTA FE CIR
Gum Bayou
OWENS ST
NIGHT SHADE DR
1.42Ac
3cfs
Jack & Bore
5.8Ac
11cfs
Type C
2.17Ac
4cfs
WINDING BROOK DR
3.81Ac
7cfs
LAZYMIST CT
1.9Ac
4cfs
HONEYVINE DR
4.7Ac
9cfs
2.5'X3' Boxes
0.55Ac
1cfs
MISTY COVE CT
2.90Ac
6cfs
Proposed Concrete Lined Ditch
2:1 Side Slopes
3' Bottom Width
3' Depth
5.77Ac
11cfs
2.54Ac
5cfs
BRAMBLE LN
5.83Ac
11cfs
2.4'X2' Boxes
WOOD SORREL
MELVIN UTLEY DR
BRIAR HOLLOW DR
Proposed Concrete Lined Ditch
2:1 Side Slopes
1' Bottom Width
3' Depth
THORNWOOD CIR
5.22Ac
10cfs
2.15Ac
4cfs
6.2Ac
12cfs
5.38Ac
10cfs
Type C-1
2.53Ac
5cfs
THISTLE DR
9.11Ac
17cfs
BRIAR GLEN DR
E FM 517 RD
COUNTRY CLUB DR
GOLF RD
6X6
6X4
8X4
7X4
Legend
Curb Inlets
Proposed Curb Inlet
Grate Inlets
Existing Box Culverts
Existing Storm Sewer
Proposed Storm Sewer
Inlet Catchment Areas

Hot Spot #10 – Tropical Gardens

A. General Description

Tropical Gardens is a development that provides access to residential, single-family homes. This neighborhood is located on the confluence of Gum Bayou and Dickinson Bayou. The entire development is within the 100-year floodplain, and there are nine lots that have been defined as repetitive loss properties. Based on the information collected, it is thought that the repetitive loss claims are most likely due to riverine flooding from Dickinson Bayou during large storm events.

This hot-spot consists of several streets, as seen in the following exhibits, such as Grand Boulevard, Scenic Drive, Bruce Avenue and Gum Drive. The development drains directly into Dickinson Bayou by way of various outfall culverts. Other lots in the neighborhood sheet flow directly to the bayou. An existing conditions exhibit can be seen on the following pages.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 100-year design storm was used to calculate the runoff flow, since there is no defined overflow path to Dickinson Bayou except by sheet flow across private property. Also, this development is very low in elevation so tidal changes could bring water into the streets and private property.

Extreme storm event flooding caused from Dickinson Bayou cannot be resolved without extensive downstream channel improvements. Elevations of roadways range from 2’ to 8’, which are significantly lower than the 100-year base flood elevation for the area. Improvements have been proposed to resolve drainage issues due to the pipe and ditch capacity. This will help improve the storm drainage system’s level of service for the smaller storm events.

C. Proposed Improvements

The proposed storm runoff flow was based on a total contributing area of 35.89 acres, which was used to calculate the 100-year storm runoff. 24” Diameter pipes are proposed to replace the driveway culverts, as shown on the following exhibits. Cleaning and regrading of the existing roadside ditches is also proposed. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations that include storm improvements only. Design drawings have been completed for this development.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $796,160. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #10 - Tropical Gardens

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	15,500	***$2.00***	***$31,000***
2	Remove Existing 15" RCP Culverts	L.F.	3,640	***$10.00***	***$36,400***
3	Remove Existing Pavement	S.Y.	2,900	***$20.00***	***$58,000***
4	24" RCP	L.F.	3,640	***$80.00***	***$291,200***
5	Type E Inlets	EA.	3	***$3,000.00***	***$9,000***
6	6" Thick Concrete Driveway	S.Y.	2,760	***$40.00***	***$110,400***
7	6" Thick Concrete Public Road	S.Y.	140	***$62.00***	***$8,680***
8	Landscape Restoration	S.F.	12,000	***$2.00***	***$24,000***
Total Construction Cost					$568,680
Contingency (25%)					$142,170
Engineering (15%)					$85,310
Total Cost					**$796,160**

Notes:

1. These estimates are presented for planning purposes only and are subject to change as the project progresses

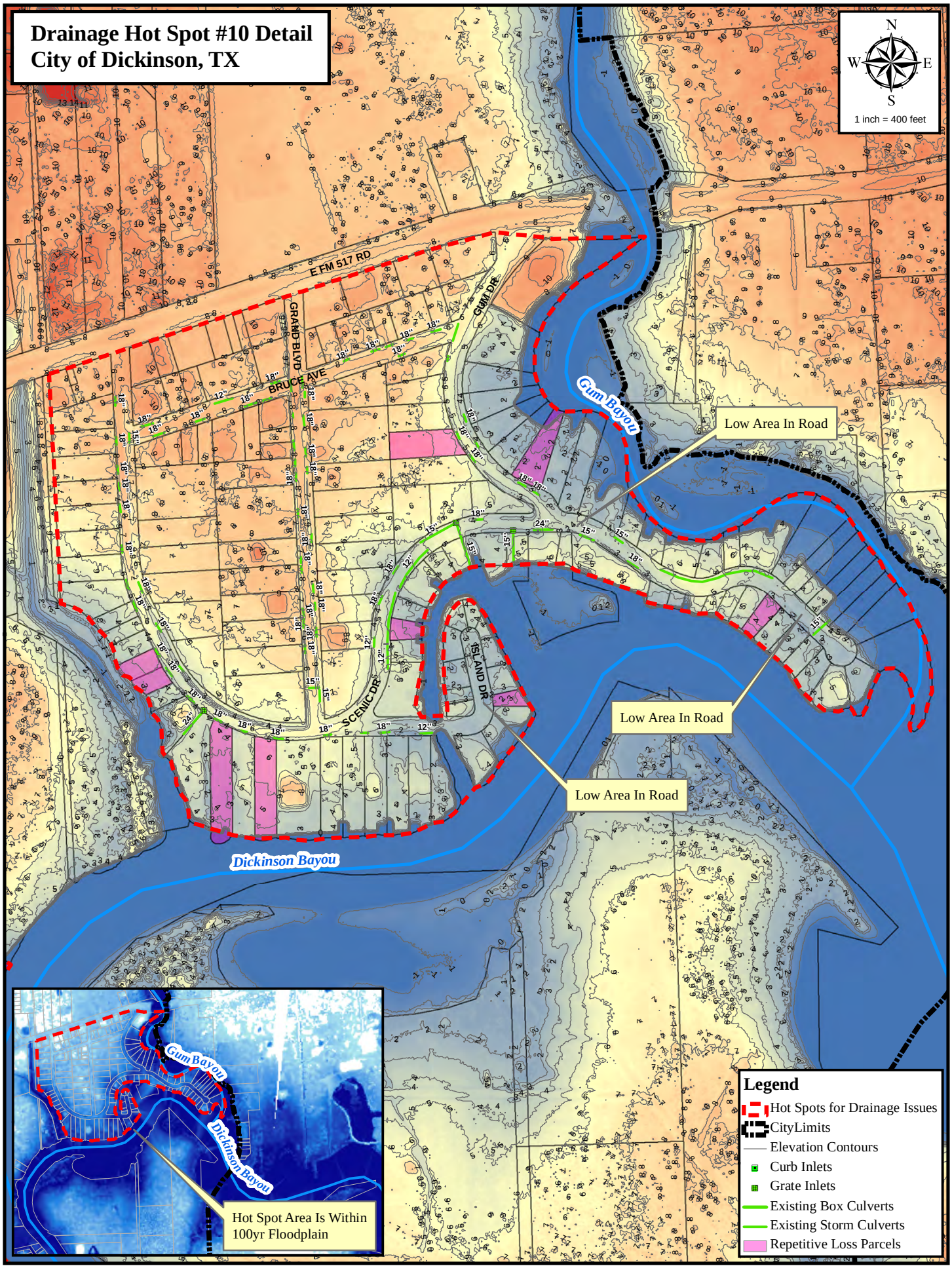
2. Costs for easements or right of way are not included

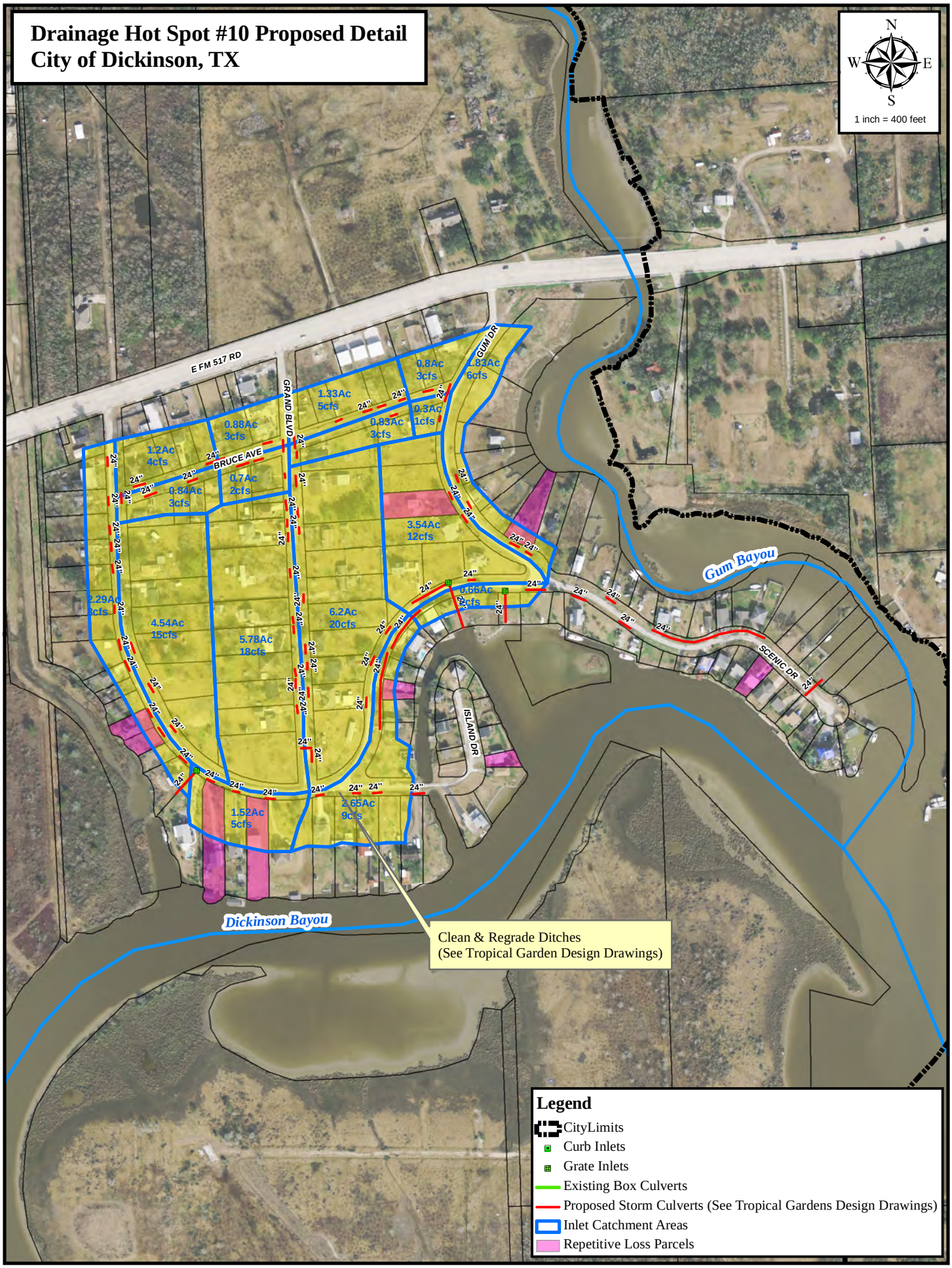
3. Design Storm is the 5-year event

4. The subdivision is located within the limits of the 1% frequency (100-year) floodplain

5. The subdivision was inundated by the storm surge from Hurricane Ike due to the elevation of the area.

6. Portions of the subdivision are prone to inundation by the high tide


Drainage Hot Spot #10 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
E FM 517 RD
GRAND BLVD
BRUCE AVE
GUM DR
SCENIC DR
ISLAND DR
Gum Bayou
Dickinson Bayou
Low Area In Road
Low Area In Road
Low Area In Road
Gum Bayou
Dickinson Bayou
Hot Spot Area Is Within
100yr Floodplain
Legend
Hot Spots for Drainage Issues
CityLimits
Elevation Contours
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Culverts
Repetitive Loss Parcels


Drainage Hot Spot #10 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
E FM 517 RD
GRAND BLVD
BRUCE AVE
GUM DR
SCENIC DR
ISLAND DR
Gum Bayou
Dickinson Bayou
0.88Ac 3cfs
1.2Ac 4cfs
0.84Ac 3cfs
0.7Ac 2cfs
1.33Ac 5cfs
0.8Ac 3cfs
0.83Ac 3cfs
0.3Ac 1cfs
1.83Ac 6cfs
3.54Ac 12cfs
0.66Ac 2cfs
6.2Ac 20cfs
4.54Ac 15cfs
5.78Ac 18cfs
2.65Ac 9cfs
1.52Ac 5cfs
Clean & Regrade Ditches
(See Tropical Garden Design Drawings)
Legend
CityLimits
Curb Inlets
Grate Inlets
Existing Box Culverts
Proposed Storm Culverts (See Tropical Gardens Design Drawings)
Inlet Catchment Areas
Repetitive Loss Parcels

Hot Spot #11 – Lovers Lane

A. General Description

Lovers Lane is a dead end street that provides access to residential, single-family homes. This neighborhood is located on Dickinson Bayou. There are no repetitive loss properties on this street.

The street is asphalt with open ditches and driveway culverts. The development drains directly into Dickinson Bayou. No specific drainage issues have been mentioned regarding this development; however, it was mentioned by the City Council as a street that has drainage issues. An existing conditions exhibit can be seen on the following pages.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 5-year design storm was used to calculate the runoff flow, since the runoff can overflow to Dickinson Bayou by way of the end of the street. Improvements have been proposed to resolve drainage issues due to the pipe and ditch capacity. This will help improve the storm drainage system's level of service for the smaller storm events.

C. Proposed Improvements

The proposed storm runoff flow was based on a total contributing area of 25.89 acres, which was used to calculate a 5-year storm runoff. 24", 36" and 42" diameter culverts are proposed to replace the existing driveway culverts, as shown on the following exhibits. Cleaning and regrading of the existing roadside ditches is also proposed. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis is underway by others for the final design. There are also limitations to the width of the existing right of way that may limit the size of the culverts that can be constructed without requiring easement or right of way acquisition. The larger the culvert, the larger the roadside ditch will also need to be. Based upon coordination efforts with the engineers providing the final design for the roadway, culvert sizes may need to be limited to 24" diameters. If larger culverts cannot be constructed within the constraints of the right of way, a lower level of service for the ditches will result.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $123,760. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #11 - Lovers Lane

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	5,600	***$2.00***	***$11,200***
2	Remove Existing RCP Culverts	L.F.	420	***$10.00***	***$4,200***
3	Remove Existing Pavement	S.Y.	470	***$20.00***	***$9,400***
4	24" RCP	L.F.	420	***$80.00***	***$33,600***
5	6" Thick Concrete Driveway	S.Y.	470	***$40.00***	***$18,800***
6	Landscape Restoration	S.F.	5,600	***$2.00***	***$11,200***
Total Construction Cost					$88,400
Contingency (25%)					$22,100
Engineering (15%)					$13,260
Total Cost					**$123,760**

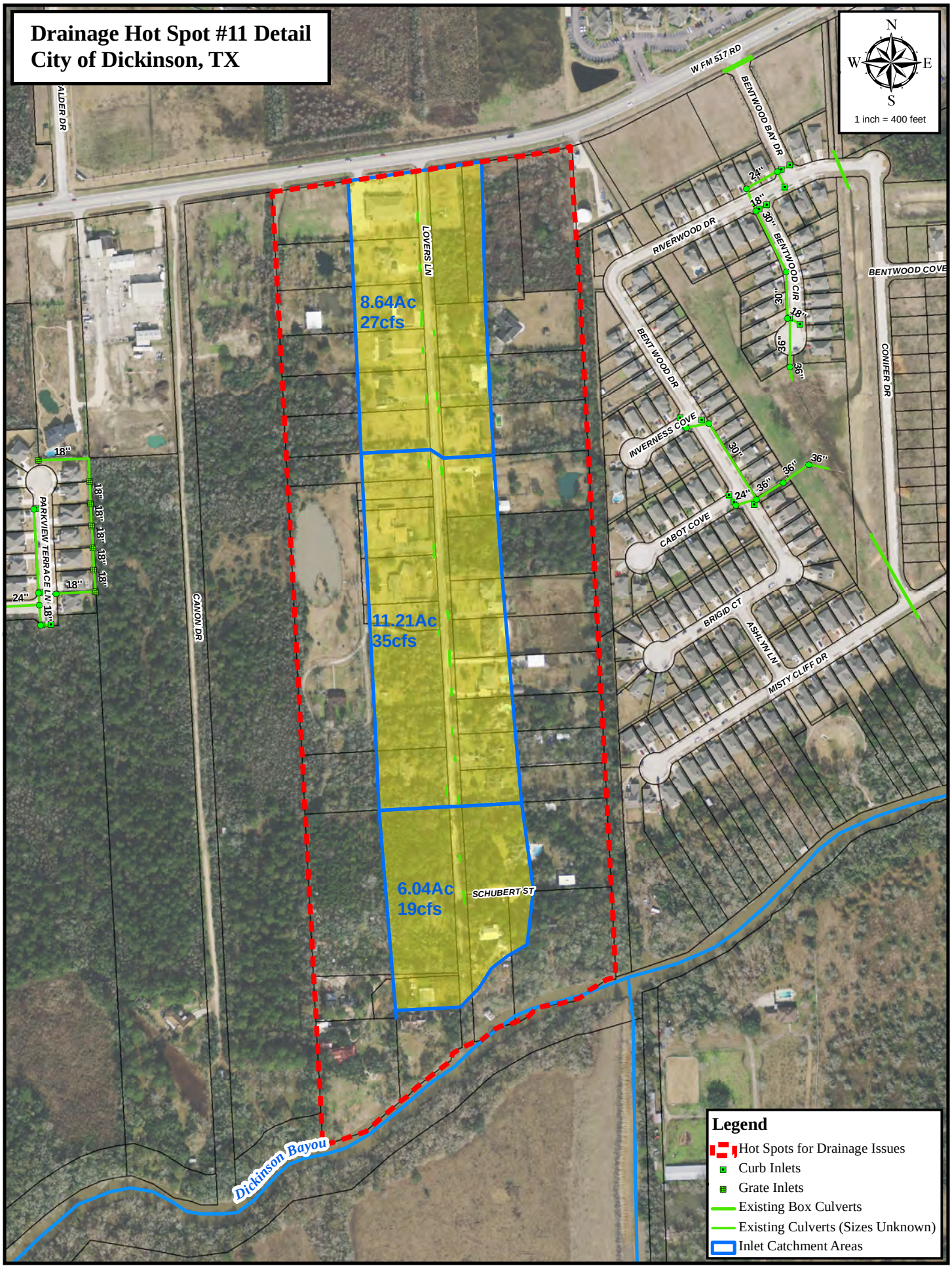
Notes:

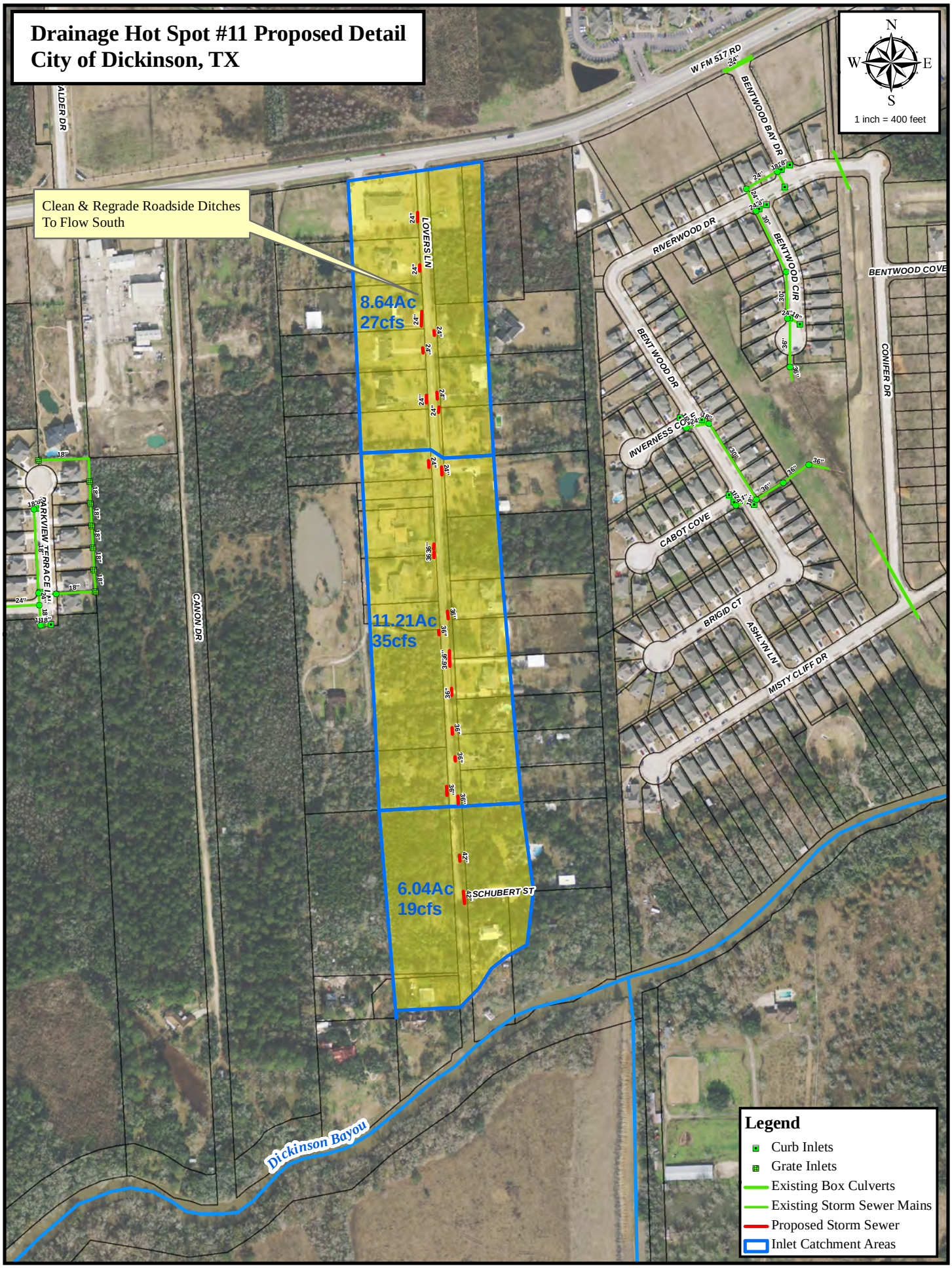
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Costs for easements or right of way are not included

3. Design Storm is the 5-year event

4. Portions of the area located within the limits of the 1% frequency (100-year) floodplain


Drainage Hot Spot #11 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
W FM 517 RD
ALDER DR
BENTWOOD BAY DR
RIVERWOOD DR
BENTWOOD CIR
BENTWOOD COVE
BENT WOOD DR
CONIFER DR
INVERNESS COVE
CABOT COVE
BRIGID CT
ASHLYN LN
MISTY CLIFF DR
LOVERS LN
CANON DR
PARKVIEW TERRACE LN
SCHUBERT ST
8.64Ac
27cfs
11.21Ac
35cfs
6.04Ac
19cfs
Dickinson Bayou
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Culverts (Sizes Unknown)
Inlet Catchment Areas


Drainage Hot Spot #11 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 400 feet
Clean & Regrade Roadside Ditches
To Flow South
8.64Ac
27cfs
11.21Ac
35cfs
6.04Ac
19cfs
W FM 517 RD
ALDER DR
BENTWOOD BAY DR
RIVERWOOD DR
BENTWOOD CIR
BENTWOOD COVE
BENT WOOD DR
INVERNESS CT
CONIFER DR
CABOT COVE
BRIGID CT
ASHLYN LN
MISTY CLIFF DR
LOVERS LN
PARKVIEW TERRACE LN
CANON DR
SCHUBERT ST
Dickinson Bayou
Legend
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Proposed Storm Sewer
Inlet Catchment Areas

Hot Spot #12 – Salvato Street

A. General Description

Salvato Street is an asphalt road that provides access to residential, single-family homes, and several businesses. Salvato Street intersects State Highway 3 to the west. There are two lots that have been defined as repetitive loss properties on the south side of the roadway.

The south half of Salvato Street drains to an 18" storm sewer and outfalls to the State Highway 3 storm sewer system. On the north side of the Salvato Street, a 24" storm sewer system with grate inlets exists between State Highway 3 and Avenue D Street that drain to the TxDOT system. On the east side of Avenue D Street runoff is drained by a roadside ditch. No specific drainage issues have been mentioned regarding this development; however, it was mentioned by the City Council as a street that has drainage issues. An existing conditions exhibit can be seen on the following pages.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 5-year design storm was used to calculate the runoff flow. Since all the water drains to the end of the street, there is an overflow path available out to State Highway 3.

C. Proposed Improvements

The proposed storm runoff flow was based on a total contributing area of 4.41 acres, which was used to calculate a 5-year storm runoff of 9 cfs. The proposed storm sewer and culverts are based upon the recommended minimum 24" diameter pipe size. Cleaning and regrading of the roadside ditches on along the roadway is also proposed.

On the north side of the roadway, the storm sewer system is relatively shallow and any significant grade changes over the pipe may warrant reconstructing this system. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $155,210. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #12 - Salvato Street

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	610	***$2.00***	***$1,220***
2	Remove Existing RCP Storm Sewer/Culverts	L.F.	50	***$15.00***	***$750***
3	Remove Existing Pavement	S.Y.	245	***$40.00***	***$9,800***
4	24" RCP Storm Pipe	L.F.	830	***$80.00***	***$66,400***
5	Proposed Type 'A' Inlet	E.A.	7	***$2,500.00***	***$17,500***
6	6" Thick Concrete Public Road	S.Y.	245	***$62.00***	***$15,190***
Total Construction Cost					$110,860
Contingency (25%)					$27,720
Engineering (15%)					$16,630
Total Cost					**$155,210**

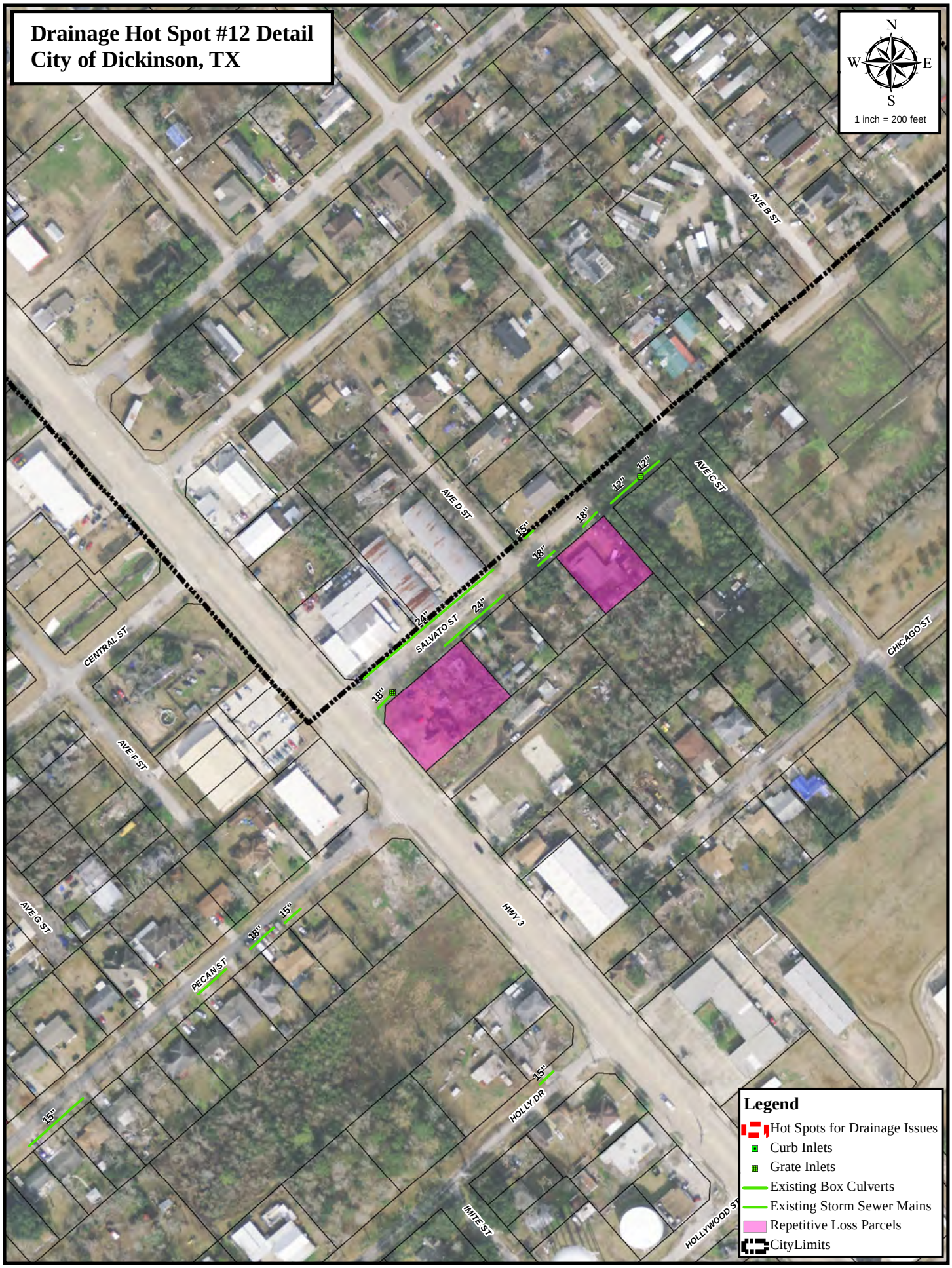
Notes:

1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. No underground utility line adjustments or replacements have been assumed

3. Design Storm is the 5-year event

4. Must be coordinated and approved by TxDOT due to the proposed outfall to SH 3


Drainage Hot Spot #12 Detail
City of Dickinson, TX
N
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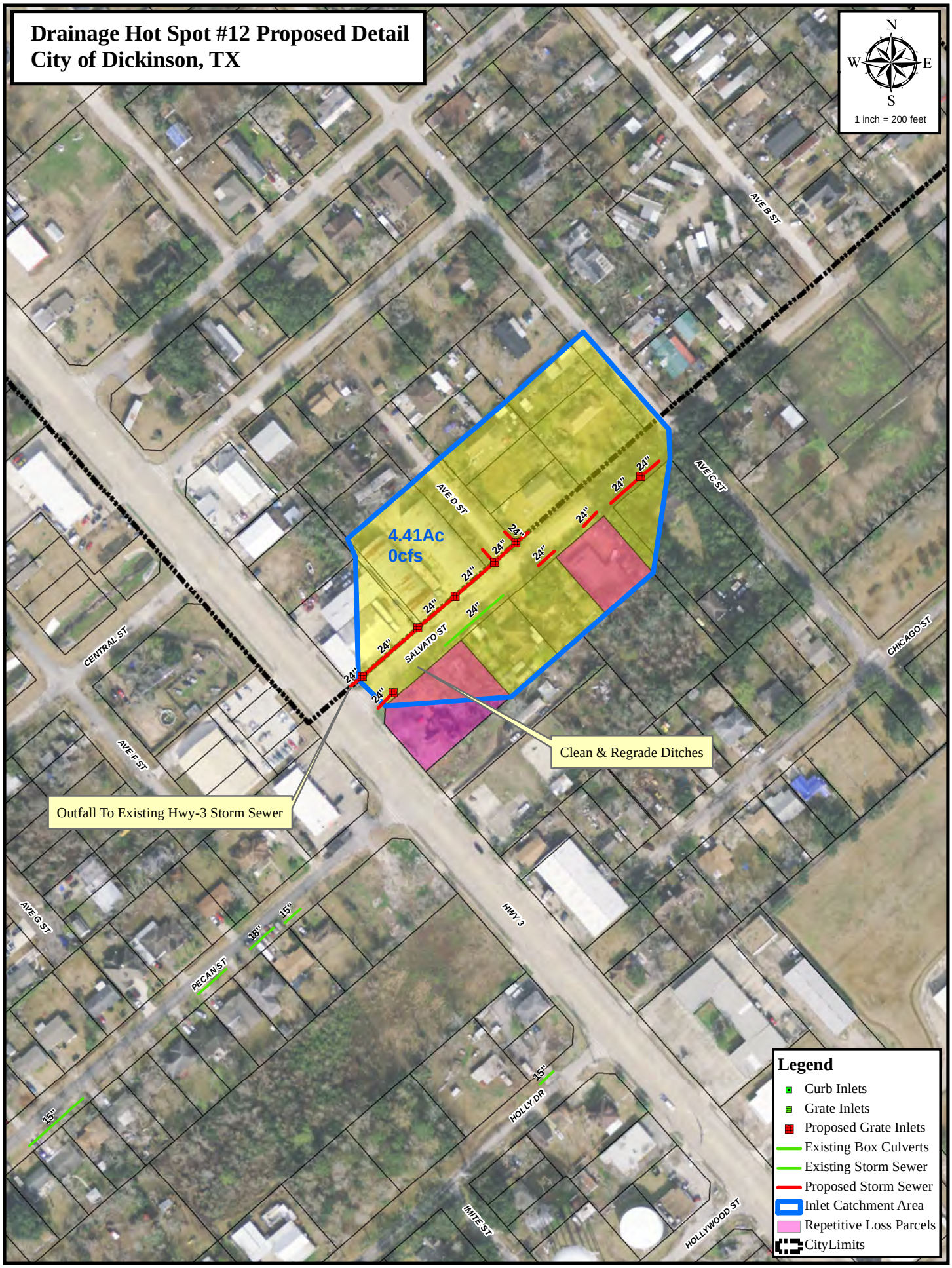
E
S
1 inch = 200 feet
AVE B ST
AVE C ST
AVE D ST
CENTRAL ST
SALVATO ST
CHICAGO ST
AVE F ST
AVE G ST
PECAN ST
HWY 3
HOLLY DR
IMITE ST
HOLLYWOOD ST
12"
12"
18"
15"
18"
24"
24"
18"
18"
15"
15"
15"
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Repetitive Loss Parcels
CityLimits


Drainage Hot Spot #12 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
4.41Ac
0cfs
AVE D ST
AVE B ST
AVE C ST
CENTRAL ST
SALVATO ST
CHICAGO ST
AVE F ST
AVE G ST
HWY 3
PECAN ST
HOLLY DR
IMITE ST
HOLLYWOOD ST
24"
18"
15"
Clean & Regrade Ditches
Outfall To Existing Hwy-3 Storm Sewer
Legend
Curb Inlets
Grate Inlets
Proposed Grate Inlets
Existing Box Culverts
Existing Storm Sewer
Proposed Storm Sewer
Inlet Catchment Area
Repetitive Loss Parcels
CityLimits

Hot Spot #13 – Greenlee Drive.

A. General Description

Greenlee Drive is a dead end street with a cul-de-sac, which provides access to residential, single-family homes. This development is located off of Timber Drive close to Benson Bayou. There are three lots that have been defined as repetitive loss properties. Two of which are located on Greenlee Drive and the other is located on Timber Drive.

The street is concrete curb-and-gutter, and there are two inlets at the north end of the street that collect all the runoff flow for this development. The inlets outfall to the ditch along Timber Drive, then 24" storm sewer collects the ditch flow and drain to the Deats Road storm sewer system. No specific drainage issues have been mentioned regarding this development; however, it was mentioned by the City Council as a street that has drainage issues. An existing conditions exhibit can be seen on the following pages.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 100-year design storm was used to calculate the runoff flow since there is no defined overflow path for the water to take once it reaches the inlets sump. If the inlets are overloaded under this condition, the water will collect in the street or overflow through private lots in order to get to the ditch along Timber Drive because Timber Drive is higher in elevation then Greenlee Lane.

Extreme storm event flooding caused from Benson Bayou cannot be resolved without extensive downstream channel improvements. Improvements have been proposed to resolve drainage issues due to the storm sewer system and inlets. This will help improve the storm sewer system's level of service for the smaller storm events.

C. Proposed Improvements

The proposed storm inlets and pipe were sized based on a total contributing area of 6.28 acres, which was used to calculate the 100-year storm runoff. Two type C-1 inlets are proposed, as well as a 36" outfall pipe to pick up the flow from Timber Drive. The inlets are standard City of Houston. Cleaning and regrading of the south ditch along Timber Drive is proposed so that no water will back up into Greenlee Lane. Cleaning and television inspection of the storm sewer pipes that outfall from Greenlee Lane is also proposed so that the structural integrity of the storm pipes can be confirmed. There is also a back-lot ditch west of Timber Drive that drains directly to Benson Bayou. This ditch should be cleaned as well, since water could backup in this ditch and sheet flow toward Greenlee Lane. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $60,990. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #13-Greenlee Lane

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Roadside Ditch	L.F.	580	***$2.00***	***$1,160***
2	Regrade and Clean Benson Bayou Tributary	L.F.	700	***$50.00***	***$35,000***
3	Clean and TV Storm Sewer	L.F.	160	***$10.00***	***$1,600***
4	Removal of Inlet	EA.	2	***$400.00***	***$800***
5	Type C Inlet	EA.	2	***$2,500.00***	***$5,000***
Total Construction Cost					$43,560
Contingency (25%)					$10,890
Engineering (15%)					$6,540
Total Cost					**$60,990**

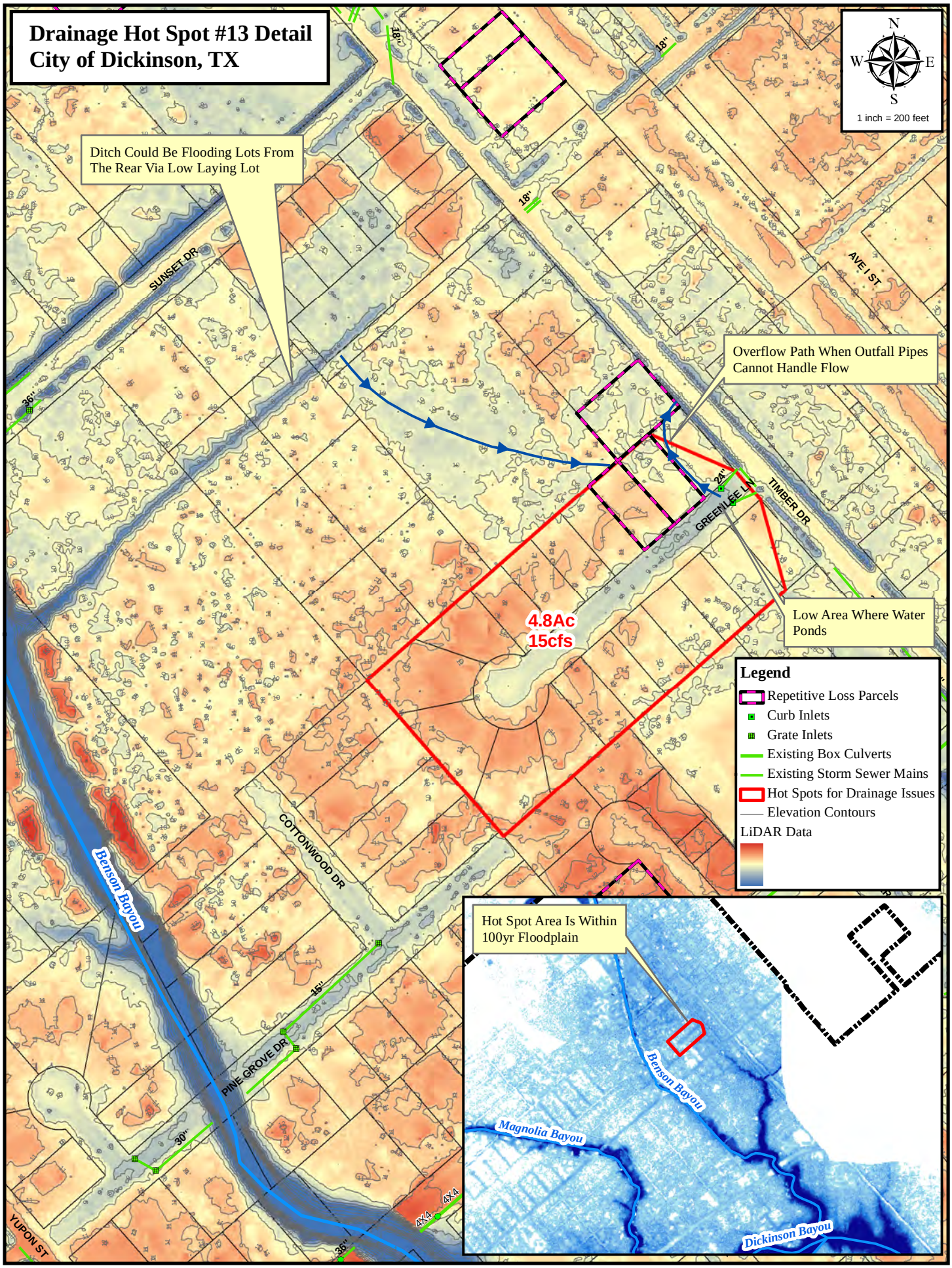
Notes:

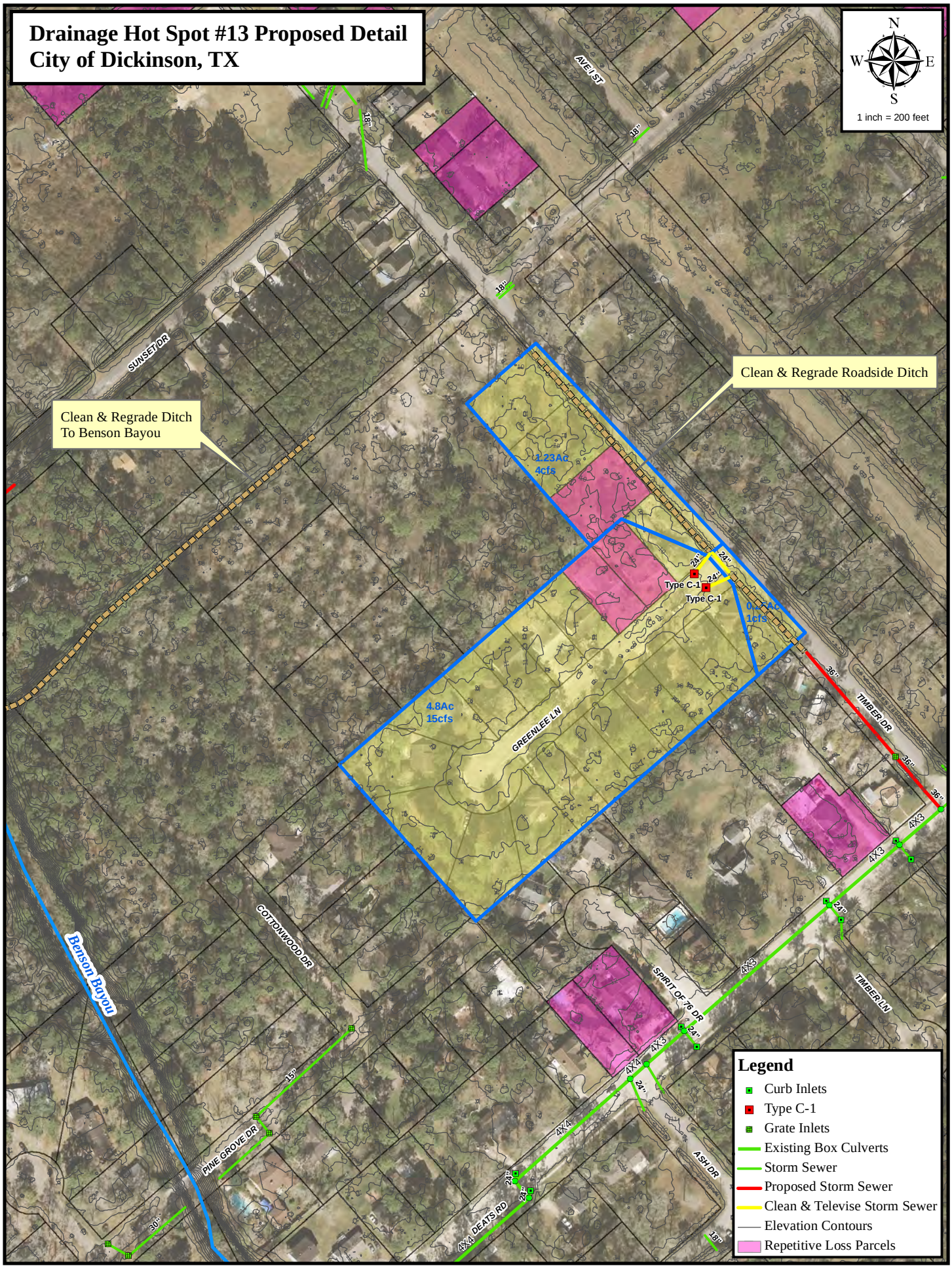
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Costs for easements or right of way are not included

3. Design Storm is the 5-year event

4. Portions of the area located within the limits of the 1% frequency (100-year) floodplain


Drainage Hot Spot #13 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
Ditch Could Be Flooding Lots From The Rear Via Low Laying Lot
Overflow Path When Outfall Pipes Cannot Handle Flow
Low Area Where Water Ponds
4.8Ac
15cfs
SUNSET DR
AVE I ST
TIMBER DR
GREENLEE LN
COTTONWOOD DR
PINE GROVE DR
YUPON ST
Benson Bayou
18"
24"
15"
30"
36"
4X4
Legend
Repetitive Loss Parcels
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Hot Spots for Drainage Issues
Elevation Contours
LiDAR Data
Hot Spot Area Is Within 100yr Floodplain
Benson Bayou
Magnolia Bayou
Dickinson Bayou


Drainage Hot Spot #13 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
Clean & Regrade Roadside Ditch
Clean & Regrade Ditch
To Benson Bayou
1.23Ac
4cfs
4.8Ac
15cfs
0.2Ac
1cfs
Type C-1
Type C-1
GREENLEE LN
TIMBER DR
TIMBER LN
SUNSET DR
AVE I ST
COTTONWOOD DR
PINE GROVE DR
SPIRIT OF 76 DR
ASH DR
DEATS RD
Benson Bayou
18"
24"
36"
30"
15"
4X3
4X4
Legend
Curb Inlets
Type C-1
Grate Inlets
Existing Box Culverts
Storm Sewer
Proposed Storm Sewer
Clean & Televise Storm Sewer
Elevation Contours
Repetitive Loss Parcels

Hot Spot #14 – Country Club Drive

A. General Description

Country Club Drive is a development that provides access to residential, single-family homes. This neighborhood is located on Dickinson Bayou. Most of the development is within the 100-year floodplain, and there are fifteen lots that have been defined as repetitive loss properties. Based on the information collected, it is thought that the repetitive loss properties are most likely due to riverine flooding from Dickinson Bayou during large storm events.

This hot-spot consists of several streets, as seen in the following exhibits, such as Leonetti Lane, Lininger Lane, Mariners Mooring Street, Captains Drive and Bayou Bend Drive. The development drains directly into Dickinson Bayou via two 24" outfall pipes. One pipe is at the end of Bayou Bend Drive, and the other is at the end of Country Club Drive. Other lots in the neighborhood sheet flow directly to the bayou. It was mentioned by the City Council as a street that has drainage issues that may result from both area rainfall and riverine flooding. An existing conditions exhibit can be seen on the following pages.

As part of a Galveston County Water Control and Improvement District #1 project, a sanitary sewer line and lift station will be constructed along the western portion of the Country Club Drive right of way. The project is currently in the planning stages. The anticipated sewer alignment will be located outside of the existing pavement limits; however it may impact the western roadside ditch and driveways. The construction of the sewer is anticipated to occur in late summer of 2011. We recommend that coordination should occur between the City of Dickinson and the District to ensure that proper drainage patterns are maintained and are in accordance with this study.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 5-year design storm was used to calculate the runoff flow. This development is very low in elevation and extremely high tides have brought water into the streets and private property.

Extreme storm event flooding caused from Dickinson Bayou cannot be resolved without extensive downstream channel improvements. Improvements have been proposed to resolve drainage issues due to the pipe and ditch capacity. This will help improve the storm drainage system's level of service for the smaller storm events.

C. Proposed Improvements

The proposed storm runoff flow was based on a total contributing area of 35.85 acres, which was used to calculate the 5-year storm runoff. 24" And 36" pipes are proposed to replace the driveway culverts, as shown on the following exhibits. A 7'x4' box culvert is proposed as the outfall for Country Club Drive, and a 30" pipe is proposed as the outfall for Bayou Bend Drive. The larger outfall systems will help to provide a well defined path for storm water to enter the Bayou. Cleaning and regrading of the existing roadside ditches is also proposed. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $506,280. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #14 - Country Club Drive

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	14,000	***$2.00***	***$28,000***
2	Remove Existing RCP	L.F.	3,640	***$10.00***	***$36,400***
3	Remove Existing Pavement	S.Y.	935	***$20.00***	***$18,700***
4	Removal of Inlet	EA.	5	***$400.00***	***$2,000***
5	24" RCP	L.F.	1,660	***$80.00***	***$132,800***
6	30" RCP	L.F.	200	***$95.00***	***$19,000***
7	36" RCP	L.F.	200	***$110.00***	***$22,000***
8	7'x4' RCB	L.F.	140	***$300.00***	***$42,000***
9	Type A Inlet	EA.	5	***$2,500.00***	***$12,500***
10	6" Thick Concrete Driveway	S.Y.	625	***$40.00***	***$25,000***
11	6" Thick Concrete Public Road	S.Y.	310	***$62.00***	***$19,220***
12	Landscape Restoration	S.F.	2,000	***$2.00***	***$4,000***
Total Construction Cost					$361,620
Contingency (25%)					$90,410
Engineering (15%)					$54,250
Total Cost					**$506,280**

Notes:

1. These estimates are presented for planning purposes only and are subject to change as the project progresses

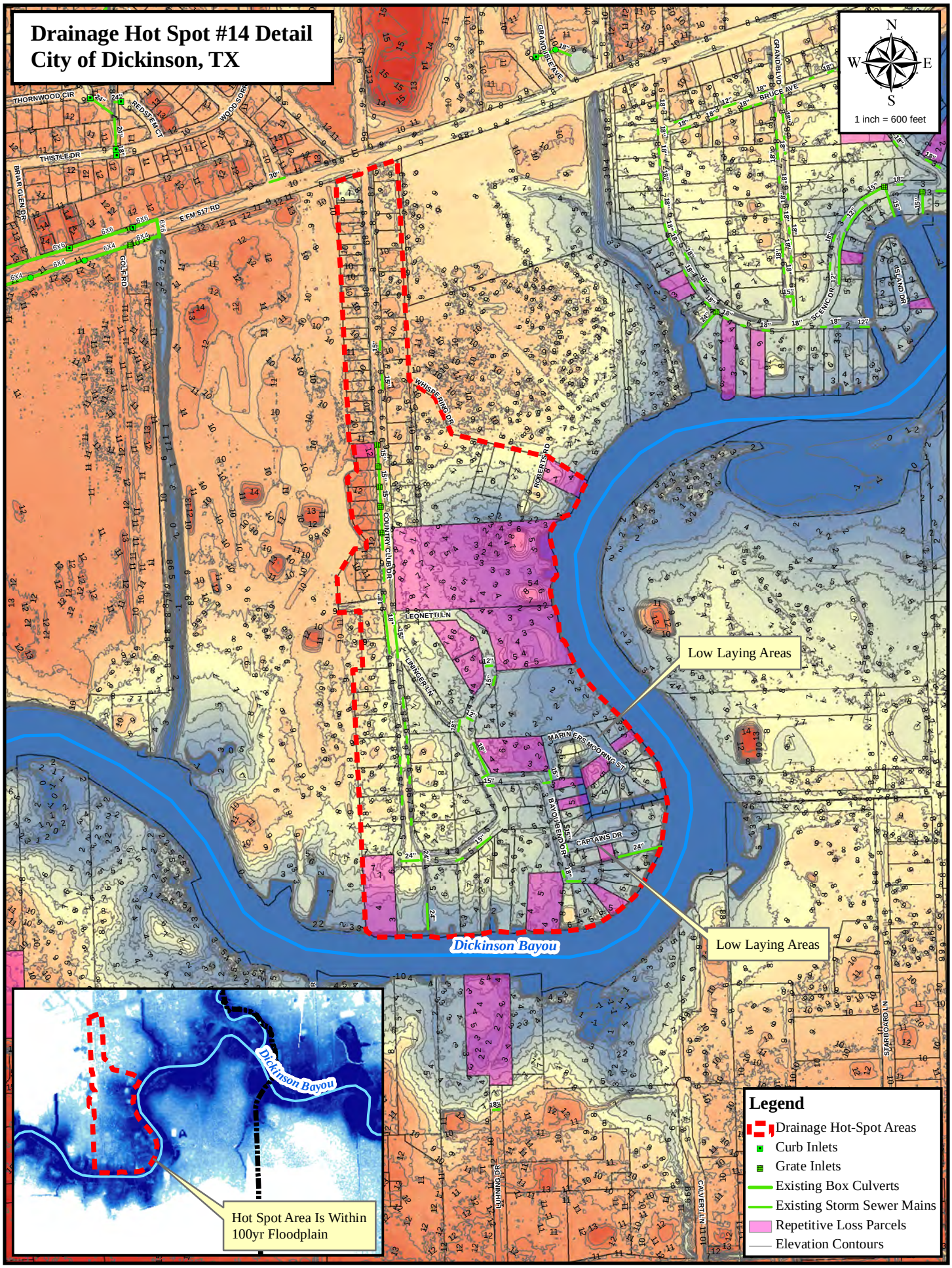
2. Costs for easements or right of way are not included

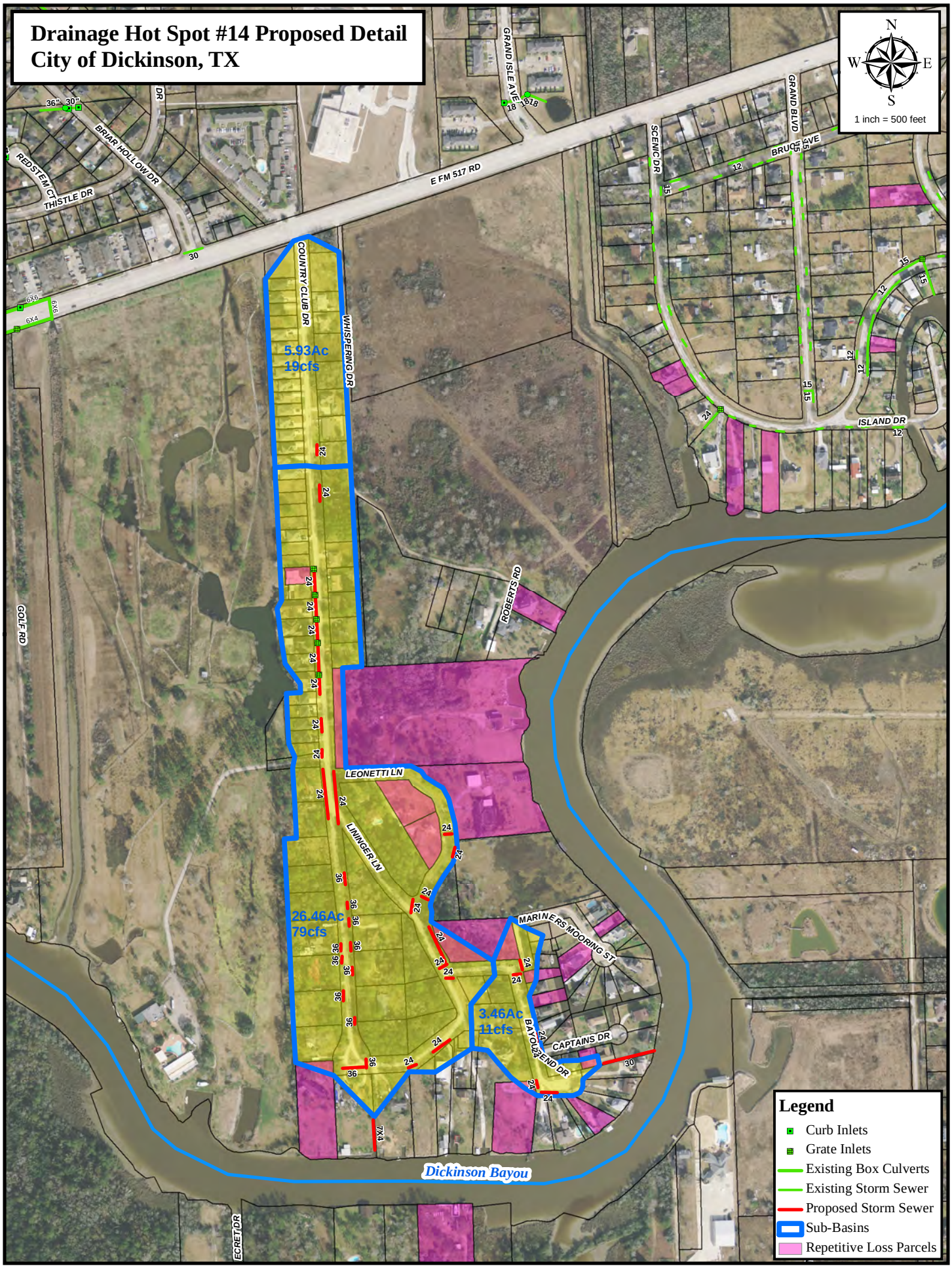
3. Design Storm is the 5-year event

4. The subdivision is located within the limits of the 1% frequency (100-year) floodplain

5. The subdivision was inundated by the storm surge from Hurricane Ike due to the elevation of the area.

6. Portions of the subdivision are prone to inundation by the high tide


Drainage Hot Spot #14 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 600 feet
THORNWOOD CIR
REDSTEM CT
WOODSORREL
THISTLE DR
BRIAR GLEN DR
E FM 517 RD
GOLF RD
GRANDISLE AVE
GRANDI BLVD
BRUCE AVE
ISLAND DR
SCENIC DR
WHISPERING DR
ROBERTS RD
COUNTRY CLUB DR
LEONETTI LN
LININGER LN
MARINERS MOORING ST
BAYOU BEND DR
CAPTAINS DR
STARBOARD LN
LUHMING DR
CALVERT LN
Low Laying Areas
Low Laying Areas
Dickinson Bayou
Dickinson Bayou
Hot Spot Area Is Within
100yr Floodplain
Legend
Drainage Hot-Spot Areas
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Repetitive Loss Parcels
Elevation Contours


Drainage Hot Spot #14 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 500 feet
E FM 517 RD
GRAND ISLE AVE
GRAND BLVD
SCENIC DR
BRUCE AVE
ISLAND DR
BRIAR HOLLOW DR
REDSTEM CT
THISTLE DR
COUNTRY CLUB DR
WHISPERING DR
5.93Ac
19cfs
ROBERTS RD
GOLF RD
LEONETTI LN
LININGER LN
26.46Ac
79cfs
MARINERS MOORING ST
3.46Ac
11cfs
CAPTAINS DR
BAYOU END DR
Dickinson Bayou
ECRET DR
Legend
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer
Proposed Storm Sewer
Sub-Basins
Repetitive Loss Parcels

Hot Spot #15 – Elm Drive

A. General Description

Elm Drive is a dead end street, which provides access to residential, single-family homes, and two businesses. The average lot size is 0.57 acres. Pine Manor Lane connects to FM 517 to the south. FM 517 is at a higher elevation than Elm Drive. The entire development is within and inundated by the 100-year floodplain. There are twelve lots that have been identified as repetitive loss properties. The repetitive loss claims included more lots than are on Elm Drive alone. They also include lots on Maple Drive and Rosewood Drive. Based on the information collected, it is thought that the repetitive loss claims are most likely due to a combination of riverine flooding from Magnolia Bayou during large storm events, and a low lying back-lot drainage path with no overflow path.

The street is asphalt with open ditches, and has a pair of TxDOT Type-C inlets at the corner of FM 517 and Elm Drive. There are two outfall box culverts that drain this area. One culvert is 5'x3' and drains Elm Drive along with some other areas. There is also a 3'x3' box roadway culvert under Maple Drive that drains the back-lot open ditch, which carries runoff from most of the area north of Elm Drive.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 100-year design storm was used to calculate the runoff flow since there is no defined overflow path to Magnolia Bayou. The 3'x3' roadway culvert under Maple Drive accepts flow from a total area of 22.63 acres. This culvert does not have the capacity for an area of this size. It should be noted that at the box culvert a low point in the street profile exists where storm water can overtop the roadway section. The box culvert and concrete roadway have been recently reconstructed. The main drainage channel runs along the back lots between Elm Drive and Maple Drive with every lot along this ditch being a repetitive loss property.

Extreme storm event flooding caused from Dickinson Bayou and Magnolia Bayou cannot be resolved without extensive downstream channel improvements. Improvements have been proposed to resolve drainage issues due to the roadway culvert and ditch capacity. Currently, Maple Drive is a choke point for the runoff draining from the north. Increasing the size of this culvert will help the water pass under Maple Drive during smaller storm events.

C. Proposed Improvements

The proposed storm runoff flow was based on a total contributing area of 22.63 acres, which was used to calculate a 100-year storm runoff of 68 cfs. A 5'x3' box culvert should be jacked and bored under the roadway to supplement the existing culvert under Maple Drive. As noted earlier, the existing 3'x3' box culvert and roadway in the immediate vicinity has been recently reconstructed and should be left in place.

Cleaning and regrading of the existing roadside ditches along Rosewood Drive and Maple Drive was also proposed. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $46,320. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #15 - Elm Drive

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	2,540	***$2.00***	***$5,080***
2	5'x3' RCB Jack and Bore	L.F.	60	***$350.00***	***$21,000***
3	Expand Concrete Headwall	EA.	2	***$3,500.00***	***$7,000***
Total Construction Cost					$33,080
Contingency (25%)					$8,270
Engineering (15%)					$4,970
Total Cost					**$46,320**

Notes:

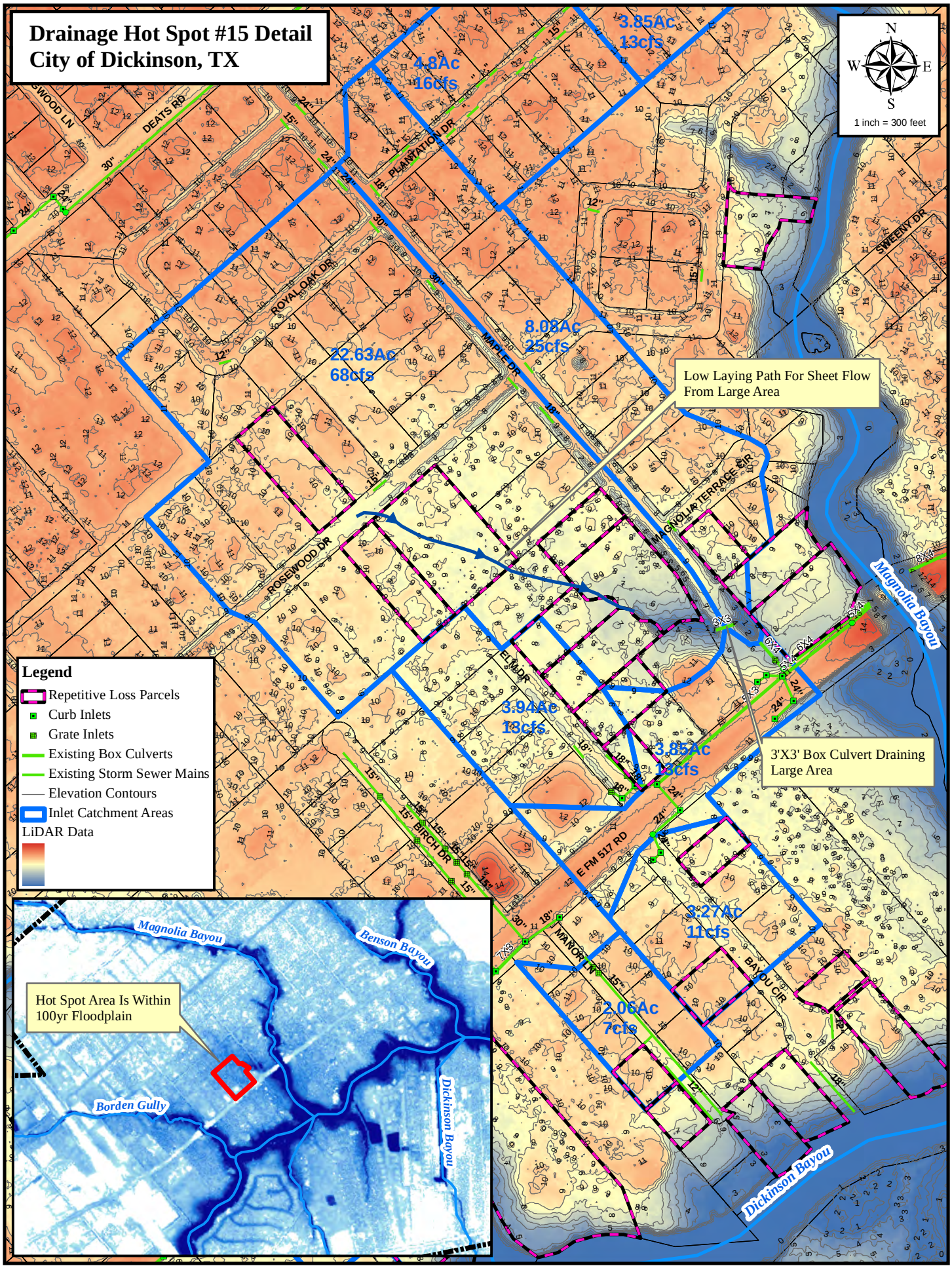
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

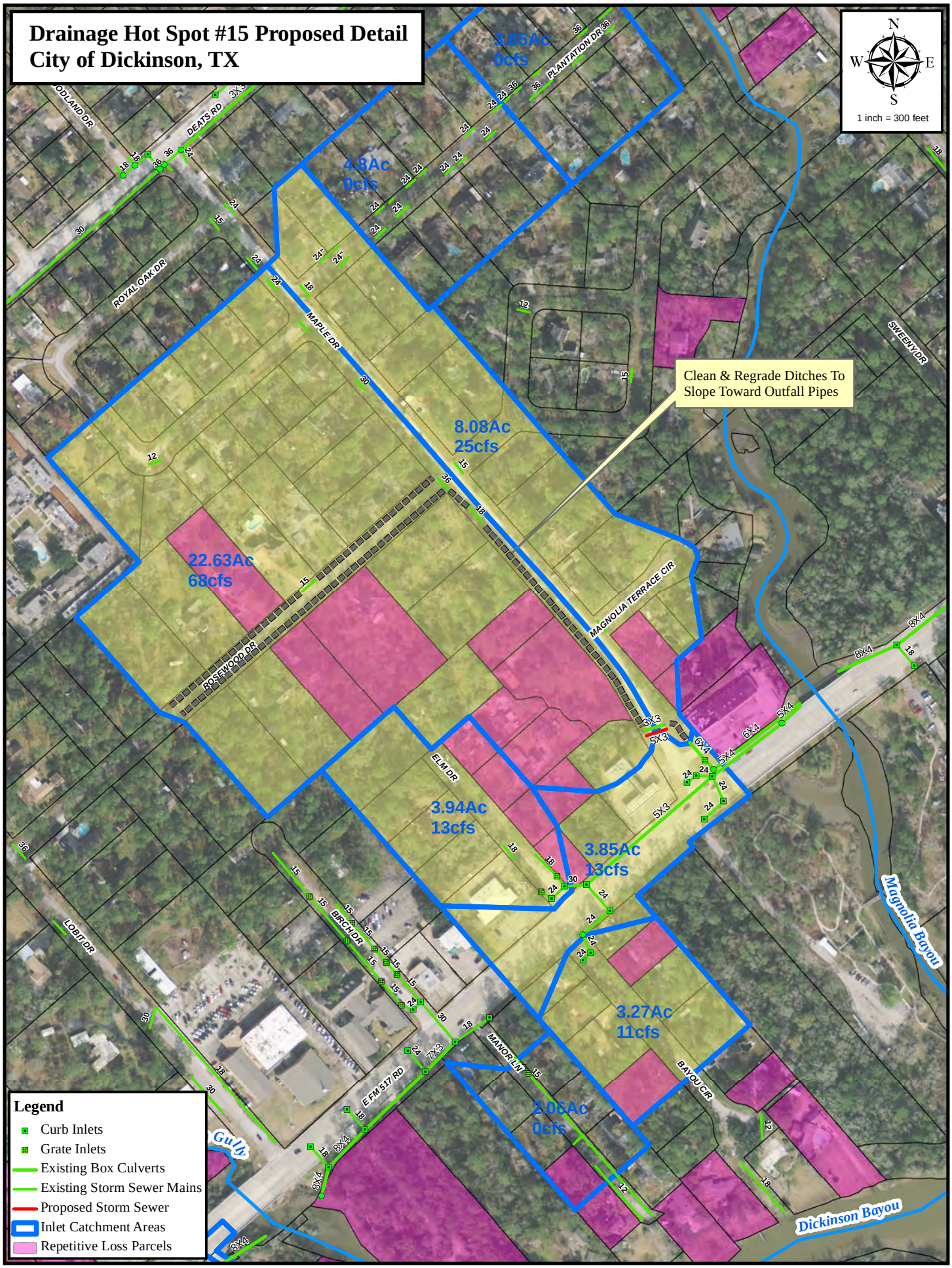
2. Coordination with TxDOT is required

3. Costs for easements or right of way are not included

4. Design storm is 3-year event; due to no overland flow path 100-year system proposed

5. The improvements assume the storm sewer system will be a stand alone project and no additional roadway improvements will be completed


Drainage Hot Spot #15 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
3.85Ac
13cfs
4.8Ac
16cfs
8.08Ac
25cfs
22.63Ac
68cfs
3.94Ac
13cfs
3.85Ac
13cfs
3.27Ac
11cfs
2.06Ac
7cfs
Low Laying Path For Sheet Flow
From Large Area
3'X3' Box Culvert Draining
Large Area
Legend
Repetitive Loss Parcels
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Elevation Contours
Inlet Catchment Areas
LiDAR Data
Hot Spot Area Is Within
100yr Floodplain
Magnolia Bayou
Benson Bayou
Borden Gully
Dickinson Bayou
DEATS RD
PLANTATION DR
ROYAL OAK DR
MAPLE DR
ROSEWOOD DR
ELM DR
BIRCH DR
E FM 517 RD
MANOR LN
MAGNOLIA TERRACE CIR
SWEENY DR
BAYOU CIR


Drainage Hot Spot #15 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
3.85Ac
0cfs
4.8Ac
0cfs
8.08Ac
25cfs
22.63Ac
68cfs
3.94Ac
13cfs
3.85Ac
13cfs
3.27Ac
11cfs
2.06Ac
0cfs
Clean & Regrade Ditches To
Slope Toward Outfall Pipes
PLANTATION DR
DEATS RD
ODLAND DR
ROYAL OAK DR
MAPLE DR
ROSEWOOD DR
MAGNOLIA TERRACE CIR
SWEENY DR
ELM DR
BIRCH DR
LOBIT DR
MANOR LN
BAYOU CIR
E FM 517 RD
Magnolia Bayou
Dickinson Bayou
Gully
Legend
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Proposed Storm Sewer
Inlet Catchment Areas
Repetitive Loss Parcels

Hot Spot #16 – Bayou Drive

A. General Description

Bayou Drive is part of a development that provides access to residential, single-family homes. The average lot size is 0.25 acres. This development is located on Dickinson Bayou. Most of the development lies within the 100-year floodplain, and there is one lot that has been identified as a repetitive loss property.

The street is asphalt with open ditches and driveway culverts. Bayou Drive has a detention pond outfall. The detention pond then drains directly into Dickinson Bayou. No specific drainage issues have been mentioned regarding this development; however, a general comment was made by the City Council as a street that has drainage issues. Along the west side of Bayou Drive, driveways and culverts are relatively new and appear to have a consistent vertical alignment and drain relatively well. Along the eastern side of the road the culverts vary in size and elevation. An existing conditions exhibit can be seen on the following pages.

B. Existing Conditions Analysis

Extreme storm event flooding caused from Dickinson Bayou cannot be resolved without extensive downstream channel improvements. Improvements have been proposed to resolve drainage issues due to the pipe and ditch capacity. This will help improve the storm drainage system's level of service for the smaller storm events.

C. Proposed Improvements

Along the eastern side of the roadway, all driveway culverts should be replaced or reset with 24" diameter pipes and the roadside ditch should be cleaned and regraded to help eliminate reverse grades that severely reduce the ability to convey storm water and create ponding issues. The proposed pipes were sized based on a minimum pipe size for storm sewer improvements of 24" diameter. The minimum culvert size was selected based on the history of clogging of storm pipes smaller than 24", and standard criteria for other cities nearby. On the west side, the existing culverts appear to have consistent grades that will drain to the existing detention pond area. Cleaning and regrading of the roadside ditch is recommended for this side of the roadway. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $157,250. This includes only drainage improvements and only includes pavement repair needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

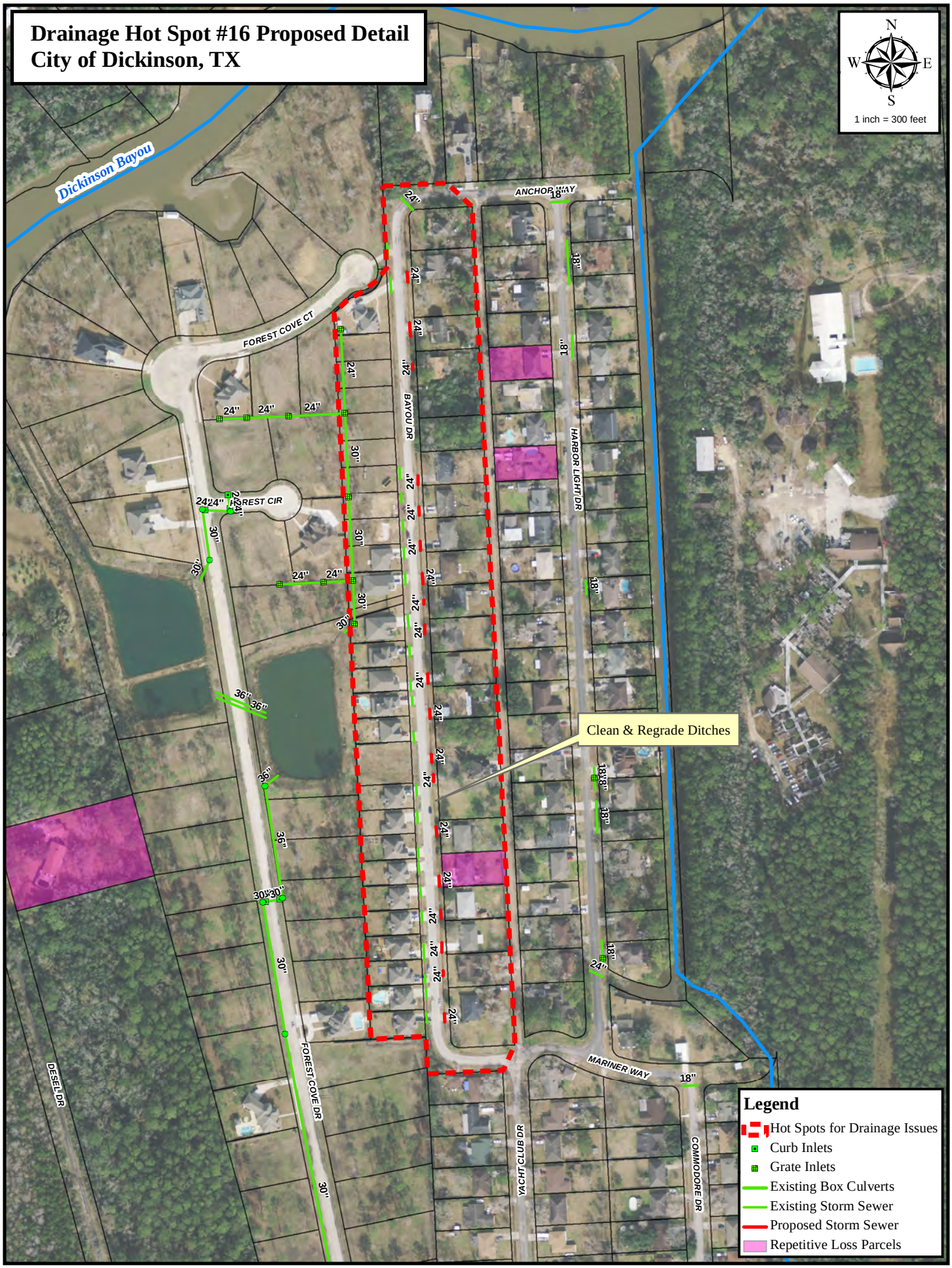
City of Dickinson Drainage Study

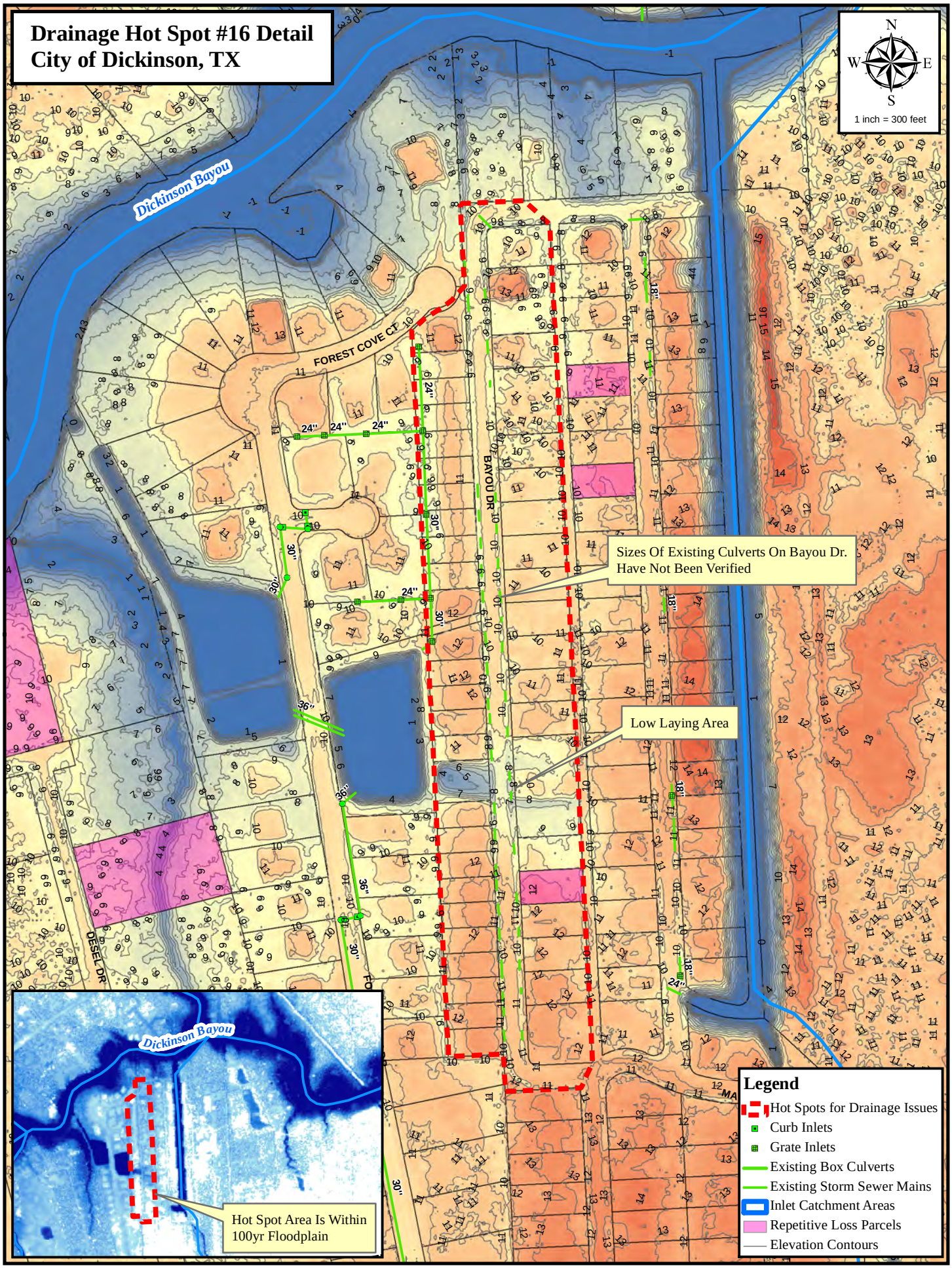
Hot Spot #16 - Bayou Drive

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Clean and Regrade Existing Ditch	L.F.	2,160	***$2.00***	***$4,320***
2	Remove Existing RCP Culverts	L.F.	400	***$10.00***	***$4,000***
3	Remove Existing Pavement	S.Y.	1,200	***$20.00***	***$24,000***
4	24" RCP Driveway Culverts	L.F.	400	***$80.00***	***$32,000***
5	6" Thick Concrete Driveway	S.Y.	1,200	***$40.00***	***$48,000***
Total Construction Cost					$112,320
Contingency (25%)					$28,080
Engineering (15%)					$16,850
Total Cost					**$157,250**

Notes:
1. These estimates are presented for planning purposes only and are subject to change as the project progresses
2. Costs for easements or right of way are not included
3. Design Storm is the 5-year event


Drainage Hot Spot #16 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
Dickinson Bayou
ANCHOR WAY
FOREST COVE CT
FOREST CIR
BAYOU DR
HARBOR LIGHT DR
FOREST COVE DR
DESEL DR
MARINER WAY
YACHT CLUB DR
COMMODORE DR
Clean & Regrade Ditches
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer
Proposed Storm Sewer
Repetitive Loss Parcels


Drainage Hot Spot #16 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 300 feet
Dickinson Bayou
FOREST COVE CT
BAYOU DR
DESEL DR
Sizes Of Existing Culverts On Bayou Dr.
Have Not Been Verified
Low Laying Area
Dickinson Bayou
Hot Spot Area Is Within
100yr Floodplain
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels
Elevation Contours

Hot Spot #17 – Pine Manor

A. General Description

Pine Manor Lane is a private dead end street that provides access to multi-family and single-family residential developments. This hot spot is located at the confluence point of Borden Gully and Dickinson Bayou. Pine Manor Lane connects to FM 517 to the north. FM 517 is at a much higher elevation than Pine Manor Lane.

Pine Manor Lane is a two-lane asphalt roadway with concrete curb and gutter. The roadway exhibits severe cracking and deterioration. The curb and gutter has shifted causing the lip of the curb to project a few inches above the asphalt. The area is located within the 1% frequency (100-year) floodplain. The roadway profile and curb and gutter flow line undulate along the entire length of the street causing standing water, which causes further deterioration. Due to the roadway undulation and lack of defined drainage patterns, runoff now sheet flows through private property to either Borden Gully or Dickinson Bayou. There are two parcels on this street that have been identified as repetitive loss properties. Based on the information collected, it is thought that the repetitive loss claims are most likely due to riverine flooding from Dickinson Bayou during large storm events.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 100-year design storm was used to calculate the runoff flow since there is no defined overflow path for the water to take once it reaches the inlets sump. If the inlets are overloaded under this condition, the water will collect in the street or overflow through private lots in order to get to Dickinson Bayou.

Pine Manor Lane is intended to have two inlets located at the northern limits of the drainage area that will accept runoff and drain into the trunk 8'x4' RCB storm sewer under FM 517. The elevation of Pine Manor Lane is significantly lower than that of FM 517. Due to this fact, it was observed that if the RCB trunk sewer under FM 517 becomes full, water may flow backward through the inlets on Pine Manor.

C. Proposed Improvements

Due to the low elevation of Pine Manor Lane it is proposed to construct two extra inlets and split the drainage area into two separate outfalls. A total contributing area of 1.06 acres and 1.21 acres was used to calculate the drainage flows for the north and south banks of inlets respectively. Four Type-C inlets and 24" diameter pipes are proposed. The inlets are standard City of Houston. Full street reconstruction (approximately 600 liner feet) is also proposed to provide an adequate flow path to the inlets. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design. Further, the City should consider requiring dedication of the right of way and acceptance of this street as a public roadway prior to implementing the recommendation.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $259,280. This includes drainage improvements and full street reconstruction. The detailed cost estimate can be seen on the following page. For reference, the roadway reconstruction portion of this project is $176,400.

City of Dickinson Drainage Study

Hot Spot #17 - Pine Manor Lane

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Remove Existing Inlet	E.A.	2	***$400.00***	***$800***
2	Remove Existing RCP Storm Sewer	L.F.	120	***$10.00***	***$1,200***
3	Remove Existing Pavement	S.Y.	1,340	***$20.00***	***$26,800***
4	24" RCP Storm Pipe	L.F.	340	***$80.00***	***$27,200***
5	Type C Inlet	E.A.	4	***$2,500.00***	***$10,000***
6	6" Thick Concrete Public Road	S.Y.	1,600	***$62.00***	***$99,200***
7	Landscape Restoration	S.F.	4,000	***$5.00***	***$20,000***
Total Construction Cost					$185,200
Contingency (25%)					$46,300
Engineering (15%)					$27,780
Total Cost					**$259,280**
	Roadway Portion Only				
3	Remove Existing Pavement	S.Y.	1,340	***$20.00***	***$26,800***
6	6" Thick Concrete Public Road	S.Y.	1,600	***$62.00***	***$99,200***
Total Construction Cost (Roadway Only)					$126,000
Contingency (25%)					$31,500
Engineering (15%)					$18,900
Total Cost (Roadway Only)					**$176,400**

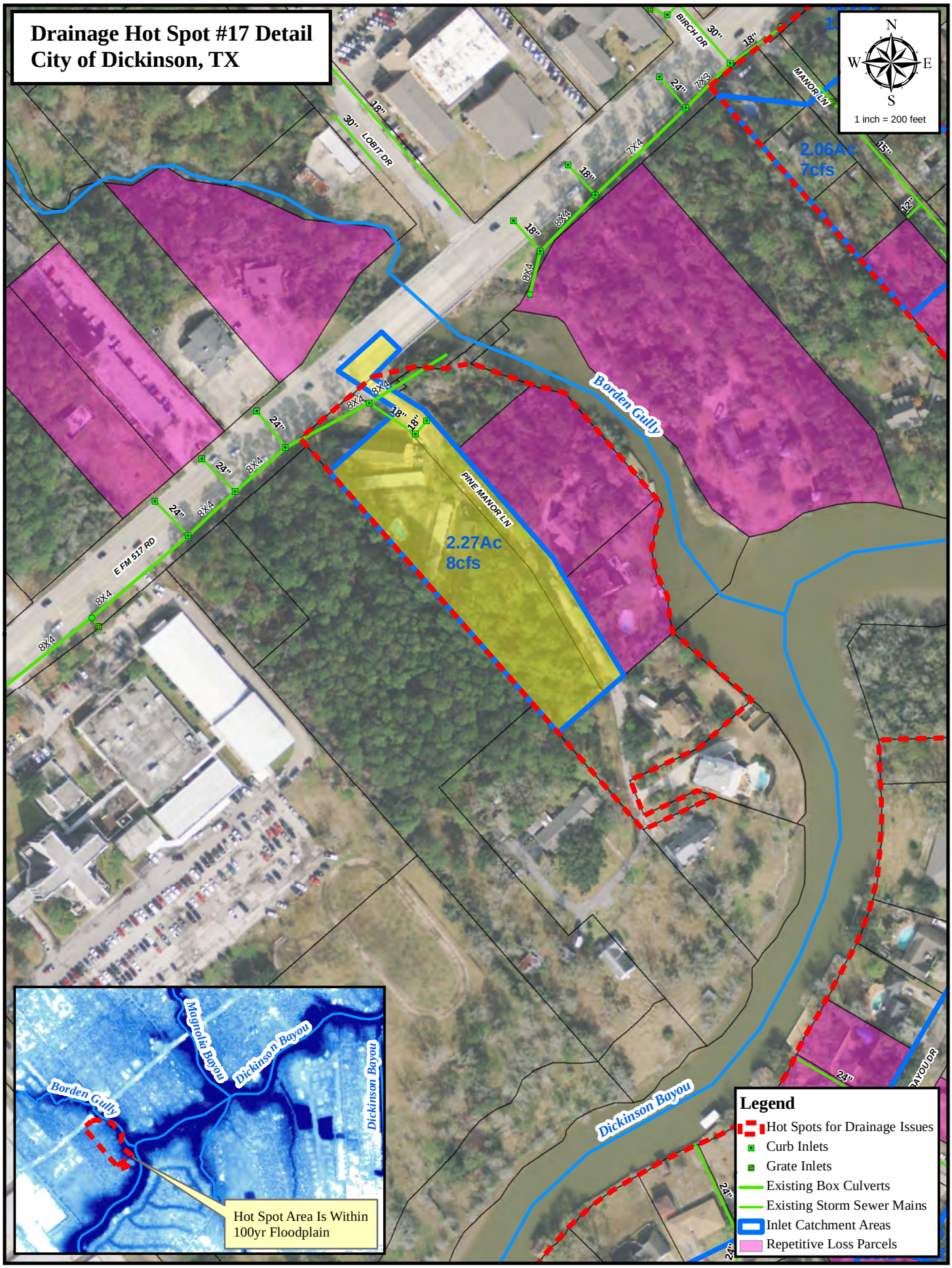
Notes:

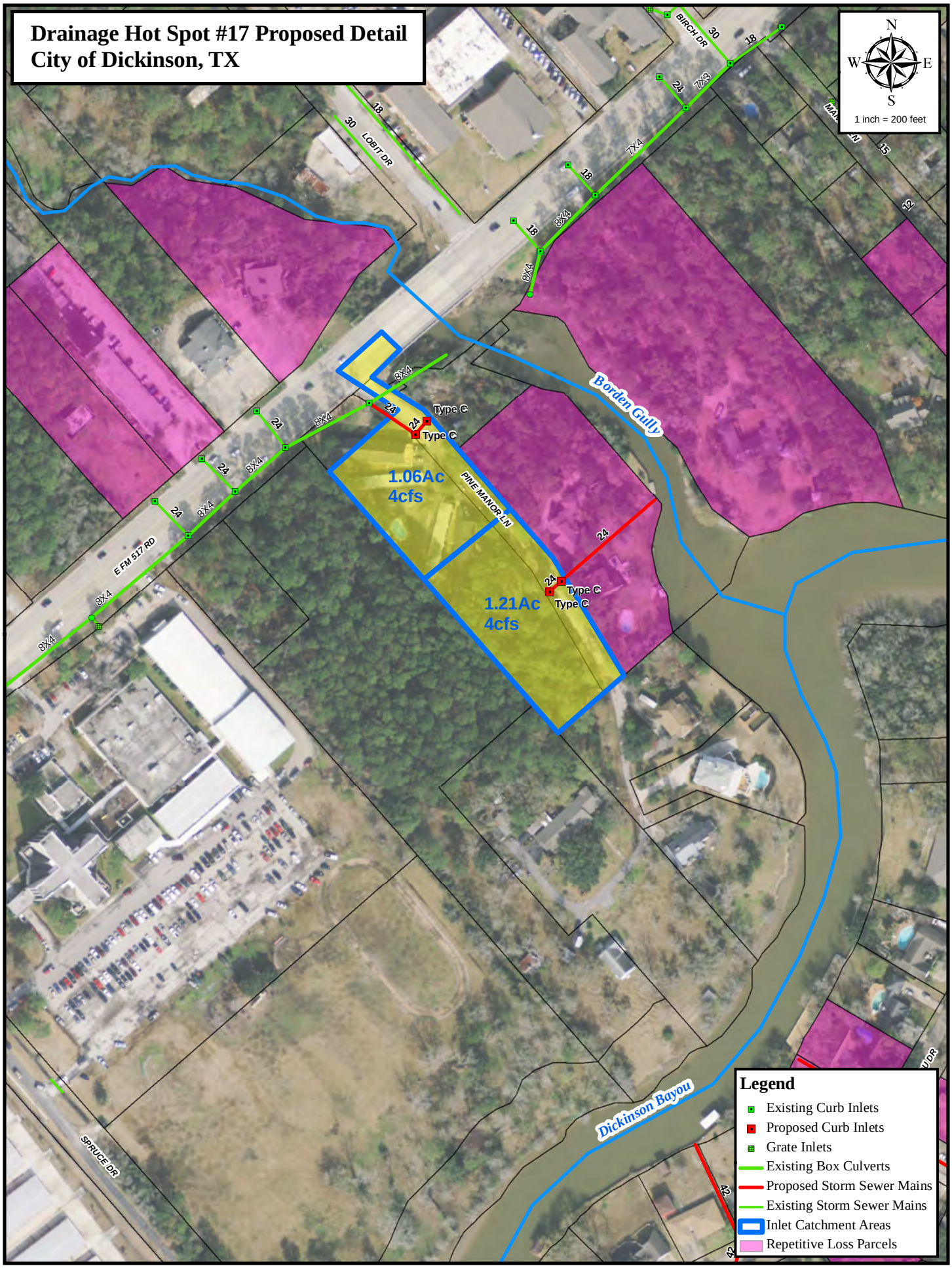
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Costs for easements or right of way are not included

3. Design storm is 3-year event; due to no overland flow path 100-year system proposed

4. No underground utility line adjustments or replacements have been assumed


Drainage Hot Spot #17 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
2.06Ac
7cfs
2.27Ac
8cfs
Borden Gully
PINE MANOR LN
MANOR LN
BIRCH DR
LOBIT DR
E FM 517 RD
BAYOU DR
Dickinson Bayou
Magnolia Bayou
Dickinson Bayou
Borden Gully
Hot Spot Area Is Within
100yr Floodplain
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels


Drainage Hot Spot #17 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
BIRCH DR
LOBIT DR
E FM 517 RD
PINE MANOR LN
SPRUCE DR
Borden Gully
Dickinson Bayou
1.06Ac
4cfs
1.21Ac
4cfs
Type C
Type C
Type C
Type C
Legend
Existing Curb Inlets
Proposed Curb Inlets
Grate Inlets
Existing Box Culverts
Proposed Storm Sewer Mains
Existing Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels

Hot Spot #18 – Manor Lane

A. General Description

Manor Lane is a dead end street, which provides access to residential, single-family homes. The average lot size is 0.29 acres. This development is located on Dickinson Bayou between the confluences of Borden Gully and Magnolia Bayou. The entire development is within the 100-year floodplain, and there are five lots that have been identified as repetitive loss properties. Based on the information collected, it is thought that the repetitive loss claims are most likely due to riverine flooding from Dickinson Bayou during large storm events.

The street is asphalt with open ditches, although, most of the east side ditch has been filled in and replaced with 15" concrete pipe. Manor Lane has two outfall pipes. They are 12" and 15" and they drain the west and east ditches respectively. The development drains directly into Dickinson Bayou. It was mentioned by the City Council as a street that has drainage issues due to the lack of a defined system large enough to accommodate a frequent storm event. An existing conditions exhibit can be seen on the following pages.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 5-year design storm was used to calculate the runoff flow. Since all the water drains to the end of the street, there is an overflow path available to Dickinson Bayou.

Extreme storm event flooding caused from Dickinson Bayou cannot be resolved without extensive downstream channel improvements. Improvements have been proposed to resolve drainage issues due to the pipe and ditch capacity. This will help improve the storm drainage system's level of service for the smaller storm events.

C. Proposed Improvements

The proposed storm runoff flow was based on a total contributing area of 2.06 acres, which was used to calculate a 5-year storm runoff of 5 cfs. The proposed pipes were sized based on a minimum pipe size for storm sewer improvements of 24" diameter. The minimum pipe size was selected based on the history of clogging of storm pipes smaller than 24", and standard criteria for other cities nearby. Cleaning and regrading of the existing roadside ditches was also proposed. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $155,280. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #18 - Manor Lane

CMI Job No. 09-112

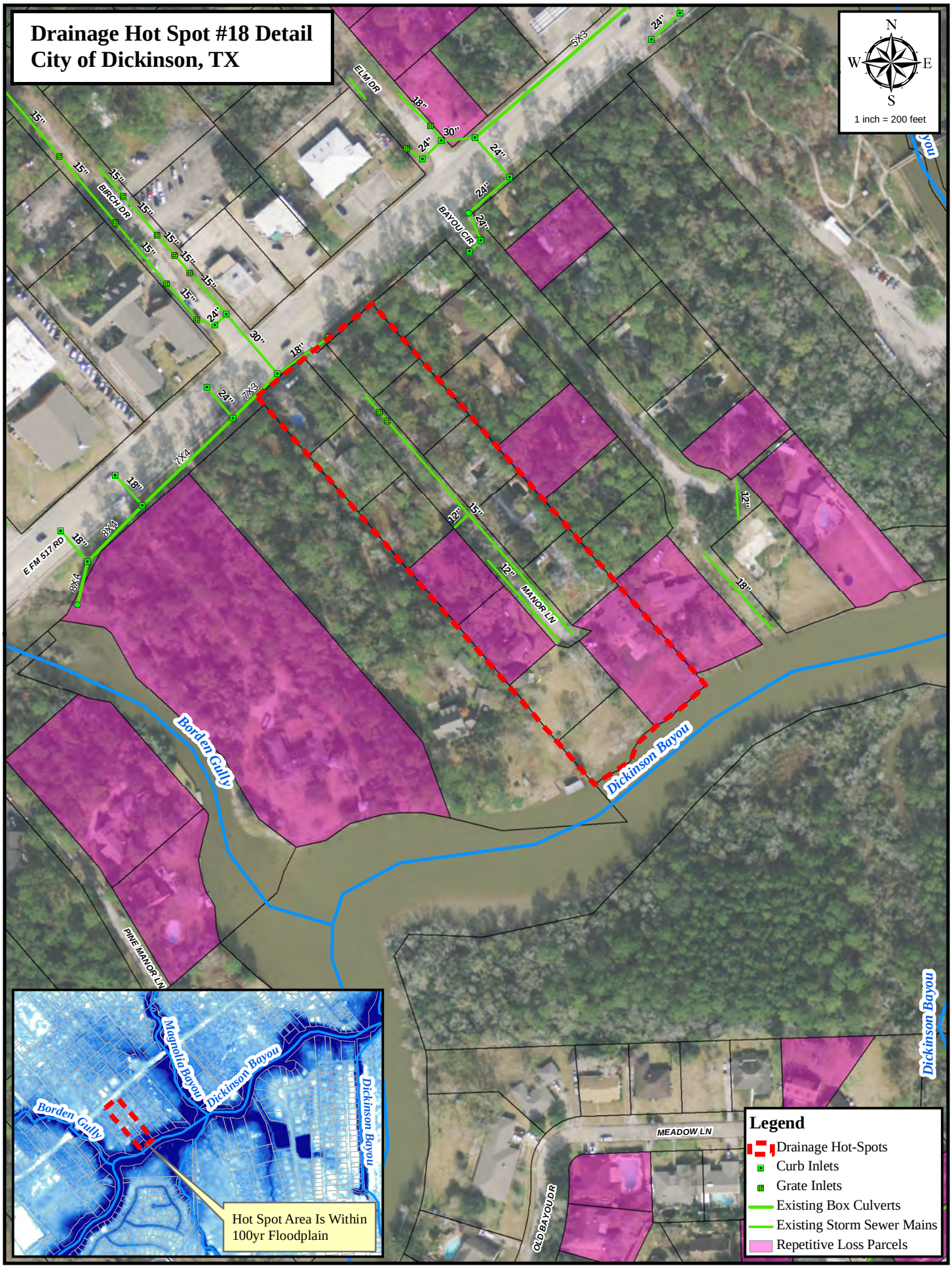
Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Regrade Existing Ditch	L.F.	1,230	***$2.00***	***$2,460***
2	Remove Existing Inlet	E.A.	2	***$400.00***	***$800***
3	Remove Existing RCP Storm Sewer	L.F.	700	***$10.00***	***$7,000***
4	Remove Existing Pavement	S.Y.	75	***$20.00***	***$1,500***
5	24" RCP Storm Pipe	L.F.	700	***$80.00***	***$56,000***
6	Proposed Type 'A' Inlet	E.A.	2	***$2,500.00***	***$5,000***
7	6" Thick Concrete Public Road	S.Y.	75	***$62.00***	***$4,650***
8	Landscape Restoration	S.F.	6,700	***$5.00***	***$33,500***
Total Construction Cost					$110,910
Contingency (25%)					$27,730
Engineering (15%)					$16,640
Total Cost					**$155,280**

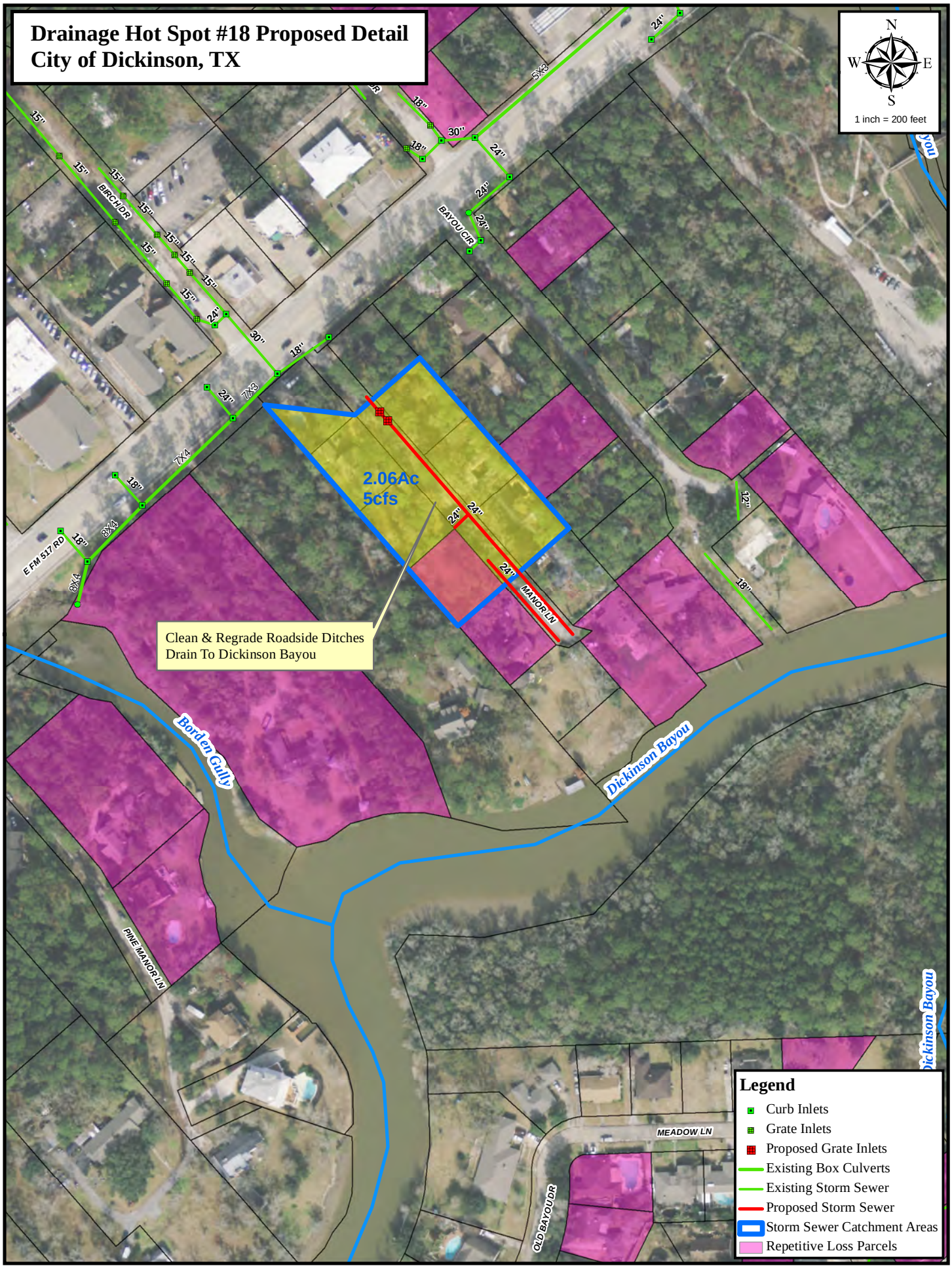
Notes:

1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Costs for easements or right of way are not included

3. No underground utility line adjustments or replacements have been assumed


Drainage Hot Spot #18 Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
ELM DR
BIRCH DR
BAYOU CIR
E FM 517 RD
MANOR LN
PINE MANOR LN
MEADOW LN
OLD BAYOU DR
Borden Gully
Dickinson Bayou
Magnolia Bayou
Hot Spot Area Is Within 100yr Floodplain
Legend
Drainage Hot-Spots
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Repetitive Loss Parcels


Drainage Hot Spot #18 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
2.06Ac
5cfs
Clean & Regrade Roadside Ditches
Drain To Dickinson Bayou
BIRCH DR
BAYOU CIR
MANOR LN
E FM 517 RD
Borden Gully
Dickinson Bayou
PINE MANOR LN
MEADOW LN
OLD BAYOU DR
Legend
Curb Inlets
Grate Inlets
Proposed Grate Inlets
Existing Box Culverts
Existing Storm Sewer
Proposed Storm Sewer
Storm Sewer Catchment Areas
Repetitive Loss Parcels

Hot Spot #19 – Casa Grande Drive

A. General Description

Casa Grande Drive is a dead end street with a cul-de-sac, which provides access to residential, single-family homes. The average lot size is 0.40 acres. This development is located on Dickinson Bayou, and several of the lots are within the 100-year floodplain. Of the lots located within the 100-year floodplain, three of these have been identified as repetitive loss properties. Based on the information collected, it is thought that the repetitive loss claims are most likely due to riverine flooding from Dickinson Bayou during large storm events.

The street is asphalt curb-and-gutter, and there are two inlets toward the end of the street that collect all the runoff flow for this development. They have a 24" outfall pipe, and the inlets are connected by an 18" lead. No specific drainage issues have been mentioned regarding this development; however, it was mentioned by the City Council as a street that has drainage issues. An existing conditions exhibit can be seen on the following pages.

B. Existing Conditions Analysis

The flow for this development was calculated using the Rational method. The 100-year design storm was used to calculate the runoff flow since there is no defined overflow path for the water to take once it reaches the inlets sump. If the inlets are overloaded under this condition, the water will collect in the street or overflow through private lots in order to get to Dickinson Bayou.

Extreme storm event flooding caused from Dickinson Bayou cannot be resolved without extensive downstream channel improvements. Improvements have been proposed to resolve drainage issues due to the storm sewer system and inlets. This will help improve the storm sewer system's level of service for the smaller storm events.

C. Proposed Improvements

The proposed storm inlets and pipe were sized based on a total contributing area of 8.4 acres, which was used to calculate a 100-year storm runoff of 26 cfs. Two Type C-1 inlets connected by a 30" lead are proposed, as well as a 42" outfall pipe. The inlets are standard City of Houston. An exhibit showing the proposed conditions can be seen on the following pages. It should be noted that these are general recommendations, and a detailed analysis will be required for the design.

D. Construction Cost Estimate

The total estimated construction cost for these improvements is $206,220. This includes only drainage improvements and does not include street replacement except when needed for storm facilities construction. The detailed cost estimate can be seen on the following page.

City of Dickinson Drainage Study

Hot Spot #19 - Casa Grande Drive

CMI Job No. 09-112

Item	Item Description	Unit	Quantity	Unit Price	Cost
1	Remove existing Inlet	E.A.	2	***$400.00***	***$800***
2	Remove Existing RCP Storm Sewer	L.F.	590	***$10.00***	***$5,900***
3	Remove Existing Pavement	S.Y.	55	***$20.00***	***$1,100***
4	30" RCP Storm Pipe	L.F.	24	***$95.00***	***$2,280***
5	42" RCP Storm Pipe	L.F.	560	***$130.00***	***$72,800***
6	Type C-1 Inlet	E.A.	2	***$2,500.00***	***$5,000***
7	6" Thick Concrete Public Road	S.Y.	55	***$62.00***	***$3,410***
8	Landscape Restoration	S.F.	11,200	***$5.00***	***$56,000***
Total Construction Cost					$147,290
Contingency (25%)					$36,830
Engineering (15%)					$22,100
Total Cost					**$206,220**

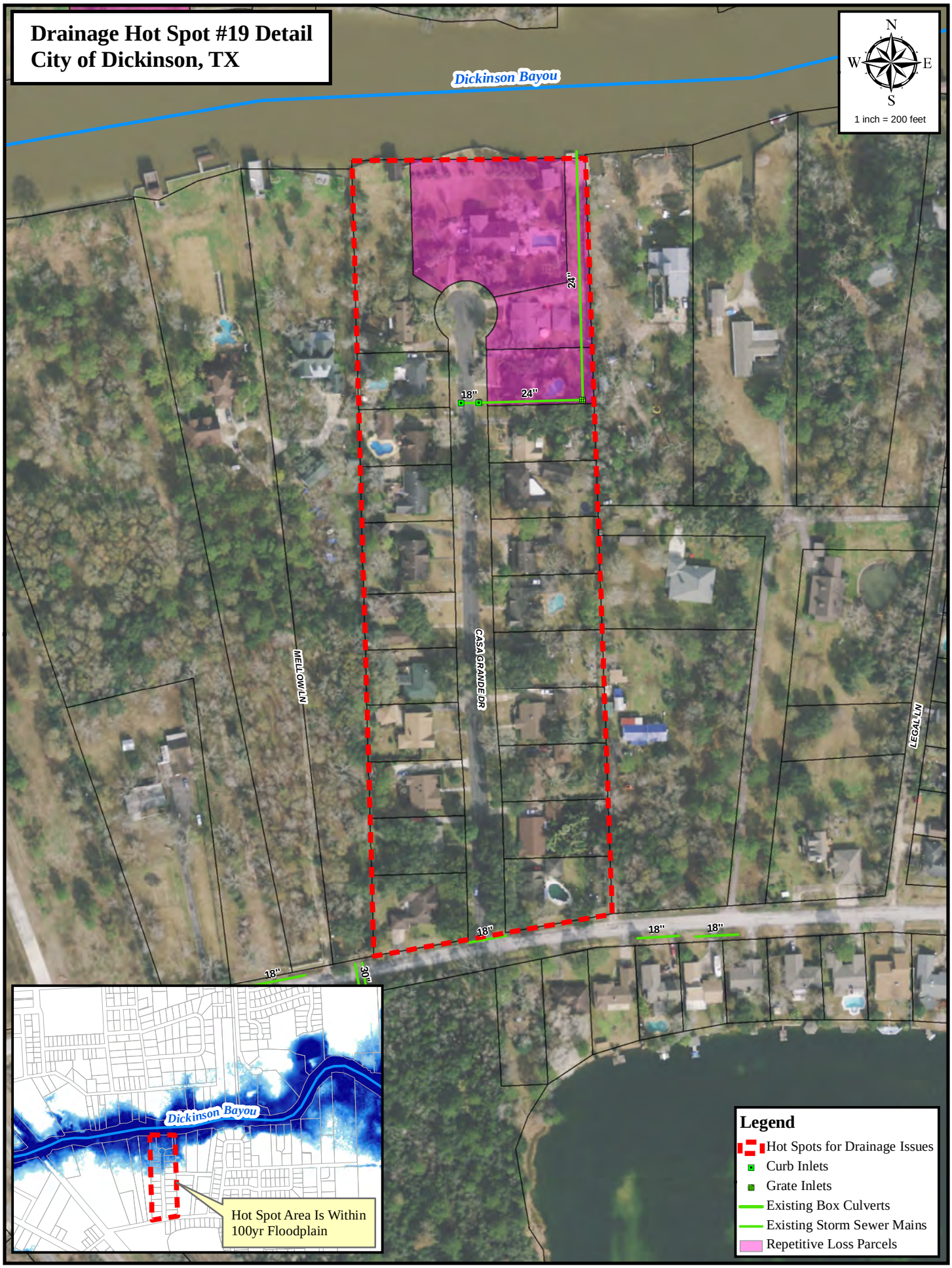
Notes:

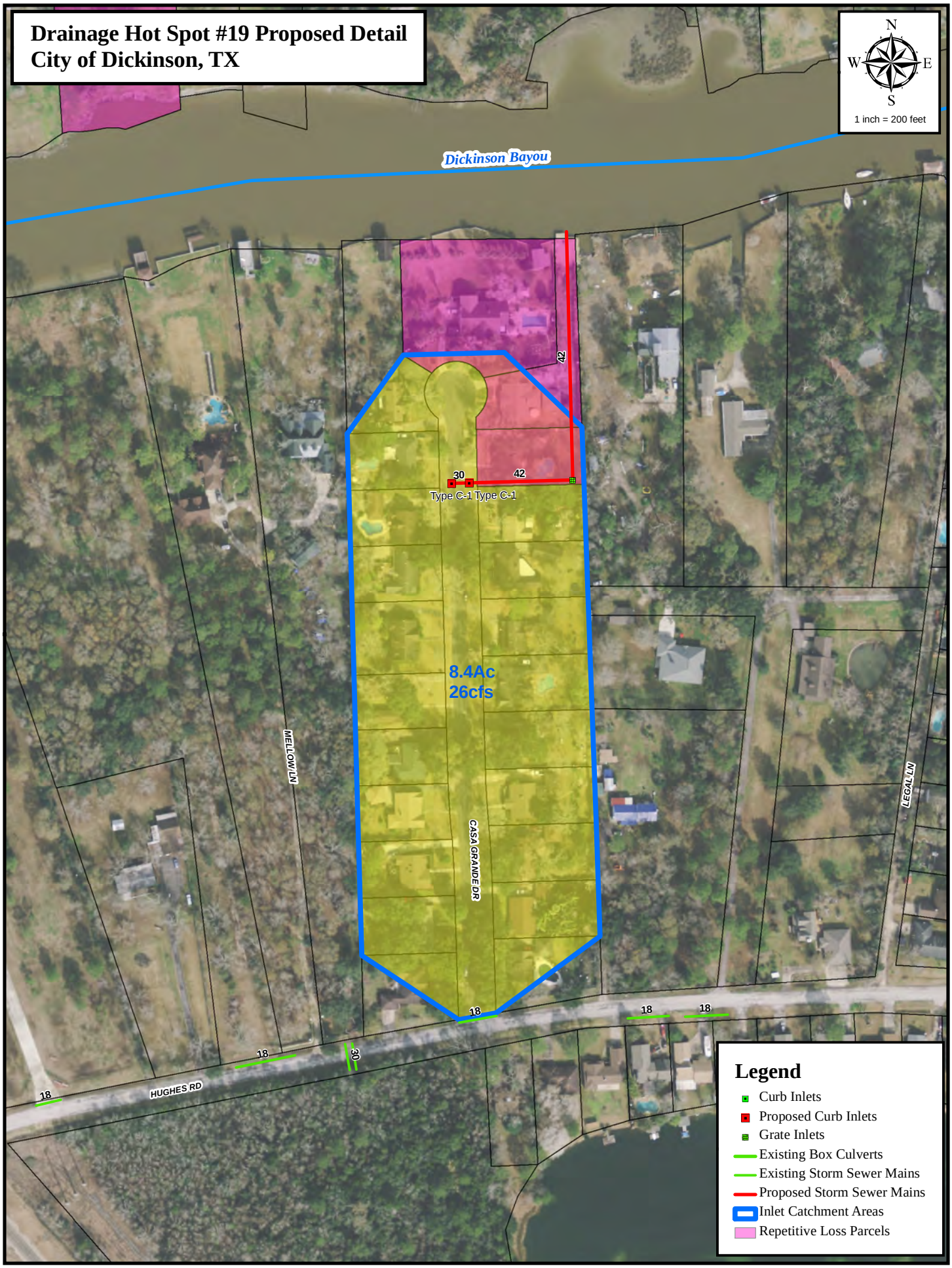
1. These estimates are presented for planning purposes only and are subject to change as the project progresses

2. Costs for easements or right of way are not included

3. Design storm is 3-year event; due to no overland flow path 100-year system proposed

4. No underground utility line adjustments or replacement have been assumed


Drainage Hot Spot #19 Detail
City of Dickinson, TX
Dickinson Bayou
N
W
E
S
1 inch = 200 feet
24"
18"
24"
MELLOW LN
CASA GRANDE DR
LEGAL LN
18"
18"
18"
18"
30"
Dickinson Bayou
Hot Spot Area Is Within 100yr Floodplain
Legend
Hot Spots for Drainage Issues
Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Repetitive Loss Parcels


Drainage Hot Spot #19 Proposed Detail
City of Dickinson, TX
N
W
E
S
1 inch = 200 feet
Dickinson Bayou
42
30
42
Type C-1 Type C-1
8.4Ac
26cfs
MELLOW LN
CASA GRANDE DR
LEGAL LN
HUGHES RD
18
18
30
18
18
18
Legend
Curb Inlets
Proposed Curb Inlets
Grate Inlets
Existing Box Culverts
Existing Storm Sewer Mains
Proposed Storm Sewer Mains
Inlet Catchment Areas
Repetitive Loss Parcels

Section 7

Hot Spot Project Prioritization

SECTION 7.1 – Methodology

The number of projects and the associated construction costs will require the City to complete improvements in phases based upon available funds. A prioritization list based upon technical merits has been developed to help provide guidance on which projects should be considered for construction first. Adjustments to this prioritization list may be deemed necessary based upon factors not considered in this report. These factors may include available City funds, financial assistance through other various programs, changing community needs, construction cost savings by combining the drainage projects with other infrastructure improvements projects, etc.

To determine where efforts should be focused first, several factors were considered. A point system was developed based upon each factor to help quantify the priority of each project. The hot spot area with the highest point total has been identified at the highest priority project. Considerations include:

1. Repetitive Loss Data. The number of properties with repetitive loss claims has been ranked from 1 to 19. A repetitive loss is defined as a property that has two or more insurance claims due to flooding. It should be noted that in some instances only a single claim has been made, or a claim has never been made even though there may have been flood damage. The hot spot area that with the most repetitive loss claims has been assigned a point value of 19. The area with the fewest has a point value of 1.

2. Hot Spot Size. The size of the overall hot spot has been considered and ranked from 1 to 19. The largest hot spot has a point value of 19. The size of the hot spot has been included to help consider improvements that will benefit the largest number of people.

3. Storm System Level of Service. The type of drainage facility (i.e. storm sewer, roadside ditch, etc.) along with the design storm for each hot spot area has been identified. Based upon the analysis completed for each hot spot, the performance of the overall system has been determined. If the trunk storm system has the capacity to accommodate the design storm, no points were given. If the system does not have the capacity to accommodate the peak flows, a value of five (5) points were given.

4. Overflow Path. Each hot spot area is located within developed areas of the City. In some cases, a reasonable overflow path for storm water does not exist in the event a larger rainfall event occurs,

or if the system were not to function as intended (i.e. inlets or pipes get clogged with debris, etc.). In areas that do not have a reasonable overflow path, five (5) points were given. Areas that have an overflow path that do not appear to create structural flooding were given zero (0) points.

5. Tidal Flooding Sources. Bayous and drainage ways within the City are heavily influenced by the tide levels from the Gulf. As the tides rise, water propagates upstream from the Gulf. Low lying areas can be impacted by tide levels and in some instances, flooding occurs on a regular basis due to high tide levels. The storm systems are intended to accommodate the design rainfall events and cannot accommodate the volume of water due to high tides. The proposed improvements will allow tide flooding to drain more effectively as the tides recede. Because the drainage systems are only intended to accommodate rainfall, areas that are located outside of areas influence by tides were given a five (5) points. Areas that flood due to tide influences were given a value of zero (0).

6. Floodplain Flooding Sources. Hot spot areas that are located within the limits of the 1% frequency (100-year) storm event have been identified. For areas located outside of the 1% frequency floodplain have been given five (5) points. Areas within the floodplain have been given zero (0) points based upon the assumption that flooding issues may be the result of riverine flooding as opposed to undersized local drainage system. This study focus primarily on localized issues.

Based upon the methodology listed above, a total point value was determined and each hot spot was subsequently ranked in order as shown on the following page.

Table 7.1
Hot Spot Priority List

Construction Priority	Hot Spot Description	Hot Spot ID	Hot Spot Priority Score
1	Bayou Chantilly	4	47
2	Oakridge Drive	6	43
3	Gum Bayou	7	43
4	Elm Street	15	43
5	Liggio Street	2	41
6	Frostwood	5	40
7	Country Club Drive	14	38
8	Tropical Gardens	10	37
9	Casa Grande Drive	19	35
10	Briarglen	9	34
11	Greenlee Lane	13	28
12	Hemlock Circle	8	25
13	Lovers Lane	11	25
14	Salvato Drive	12	25
15	Plantation Drive	3	24
16	Bayou Drive	16	22
17	Pine Manor Lane	17	21
18	Manor Lane	18	21
19	FM 517	1	16

Section 8

Floodplain Management

SECTION 8.1 – Description and CRS Participation

The City of Dickinson is a participant in the National Flood Insurance Program (NFIP) and enforces floodplain regulations with the City in accordance with its Flood Damage Prevention Ordinance. The NFIP is administered by the Federal Emergency Management Agency (FEMA) and municipalities must be participants in good standing to allow their residents the opportunity to obtain flood insurance. The City Administrator is the designated Floodplain Administrator and is supported by the Building official and Community Development Department for interpretations, technical expertise, and enforcement. The current Building Official and Building Inspector are both Certified Floodplain Managers (CFM), a certification that requires knowledge of floodplain rules and regulations. The certification also requires that the CFM must obtain continuing education on an annual basis to stay abreast on floodplain issues that may affect the City.

The City's current flood damage prevention ordinance is based upon the standard ordinance recommended by FEMA was adopted on May 13, 2008. The City Floodplain regulations can be found under Part II, Chapter 14, Article V of the City Ordinance. FEMA requires that Cities adopt and enforce their minimum standards to be a participant in the NFIP and allows Cities to adopt higher regulatory standards to better protect their residents. The City of Dickinson's ordinances require new residential or commercial construction to be elevated a minimum of 12" above the 1% frequency (100-year) base flood elevation established on the City's Flood Insurance Rate Maps (FIRM).

The City adopted a Drainage Criteria Manual in 2008 that set standards for preparation of drainage plans, storm water detention, floodplain fill compensation and finished floor requirements. This ordinance requires an 18" freeboard for the minimum first floor over the 100-year base flood elevation whereas the City's floodplain ordinance requires on 12". The Criteria Manual exempts "individuals engaging in construction of a single homestead" from the definition of "developer" and further requires that all "developers" to comply with the requirements of the Criteria Manual. The City should consider a revision of their Flood Damage Prevention Ordinance to require the 18" freeboard to be consistent with the Criteria Manual.

The City's Drainage Criteria Manual does not currently address requirements for provision of street drainage infrastructure such as curb and gutter, storm sewers, inlets, ditches, culverts and other required appurtenances. The manual would be the appropriate mechanism for the City to utilize to insure that previously mentioned inlet and storm sewer requirements are implemented. Additional design requirement documentation such as the provision of drainage area maps, storm sewer

calculations, extreme event analysis, and drawing standards should also be added to the Manual to insure that future development and capital projects are designed consistent with the adopted criteria.

The City's current Effective FIRM was adopted on August 16, 1982. Typically, any recently studied floodplain by FEMA also has additional information compiled within a Flood Insurance Study (FIS), which provides background information, channel data, and water surface profiles for various storm events. No FIS supplemental information for the City of Dickinson was completed by FEMA during the original floodplain study.

The NFIP program entitled the Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages floodplain management activities that exceed the minimum NFIP requirements. The goals of the program are to enhance public safety, reduce flood damages to insurable property, and encourage a comprehensive approach to floodplain management. The CRS rates each community 10 (no flood insurance discount) to 1 (premium flood insurance discounts) based upon the level of flood management requirements. All communities automatically start out with a Class 10 rating, which receives no discounts to the flood insurance premiums. There are eighteen (18) activities the CRS recognizes as measures that will reduce the chances for damages due to riverine flooding. The activities are grouped into four general categories:

1. Public Information
2. Mapping and Regulation
3. Flood Damage Reduction
4. Flood Preparedness

Discounts to property owners range from 0% up to 45% on flood insurance premiums based upon the community's classification. The following table is a summary of the current available discounts based for each classification as published by the CRS.

Table 7.1
CRS Floodplain Insurance Discounts

Class	Discount	Class	Discount
1	45%	6	20%
2	40%	7	15%
3	35%	8	10%
4	30%	9	5%
5	25%	10	0%

Based on the City's ordinance and activities of the staff it is recommended that the City apply for the CRS to provide the discount to the residents. According to NFIP representatives, the City's residents pay over $1.1 million in flood insurance premiums annually so discounts could amount to substantial savings citywide.

Exhibits

Exhibit 1 - Drainage Hot-Spot Map
City of Dickinson, TX

N
W E
S
1 inch = 800 feet

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Legend

- CityLimits
- Curb Inlets
- Grate Inlets
- Box Culverts
- Storm Sewer Mains
- Repetitive Loss Parcels
- Hot Spots for Drainage Issues
- FEMA Effective Floodplain
- 100yr Floodplain (JKC Study)

HDR | CLAUNCH & MILLER
Engineering Consultants

Exhibit 2 - Hurricane Ike Storm Surge Map
City of Dickinson, TX

N
W E
S
1 inch = 800 feet

Legend

- Rivers
- CityLimits
- Repetitive Loss Parcels
- Parcels

Storm Surge Depths
Vertical Feet

- 0
- 0-0.5
- 0.5-1
- 1-2
- 2-3
- 3-4
- >4

HDR | CLAUNCH & MILLER
Engineering Consultants

Exhibit 3 - 100yr Floodplain Map
City of Dickinson, TX

N
W E
S
1 inch = 800 feet

Legend

- Rivers
- CityLimits
- Repetitive Loss Parcels
- 100yr Floodplain (Dodson Study, Feb. 1998)
- Existing Floodway

FEMA Effective 100yr Floodplain

- Zone-A
- Parcels

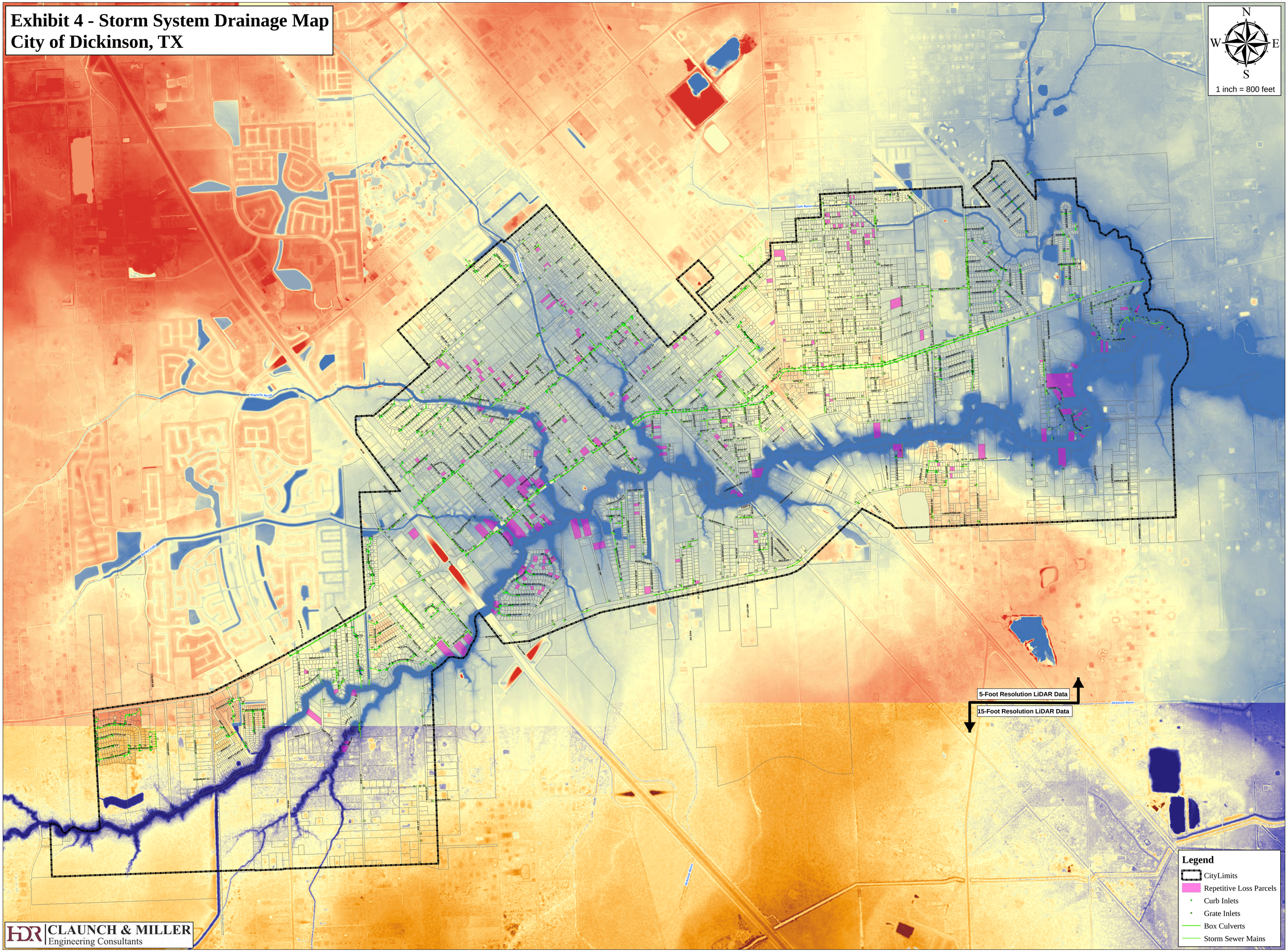
100yr Floodplain (JKC Study, Nov. 2008)

Depth, Vertical Feet

- 0-0.5
- 0.5-1
- 1-2
- 2-3
- 3-4
- >4

HDR | CLAUNCH & MILLER
Engineering Consultants

Exhibit 4 - Storm System Drainage Map
City of Dickinson, TX



HDR | CLAUNCH & MILLER
Engineering Consultants

Exhibit 5 - Drainage Area Map
City of Dickinson, TX

N
W E
S
1 inch = 800 feet

5-Foot Resolution LiDAR Data

15-Foot Resolution LiDAR Data

Legend

- Storm Sewer Drainage Basins
- Catchment Areas
- CityLimits
- Repetitive Loss Parcels
- Curb Inlets
- Grate Inlets
- Box Culverts
- Storm Sewer Mains

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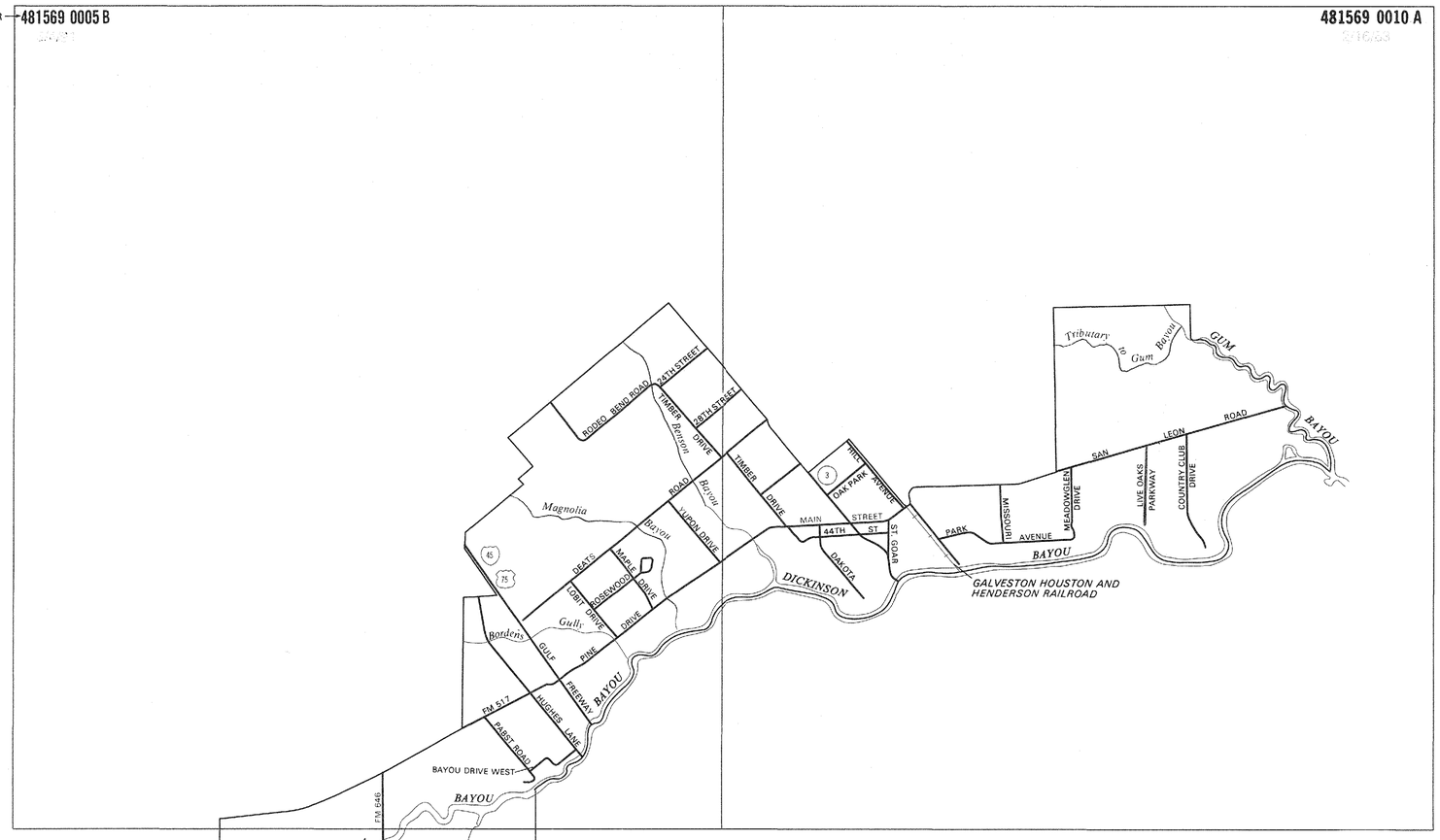
Engineering Consultants

COMMUNITY-PANEL NUMBER — 481569 0005 B

481569 0010 A



N

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
DICKINSON, TEXAS
GALVESTON COUNTY

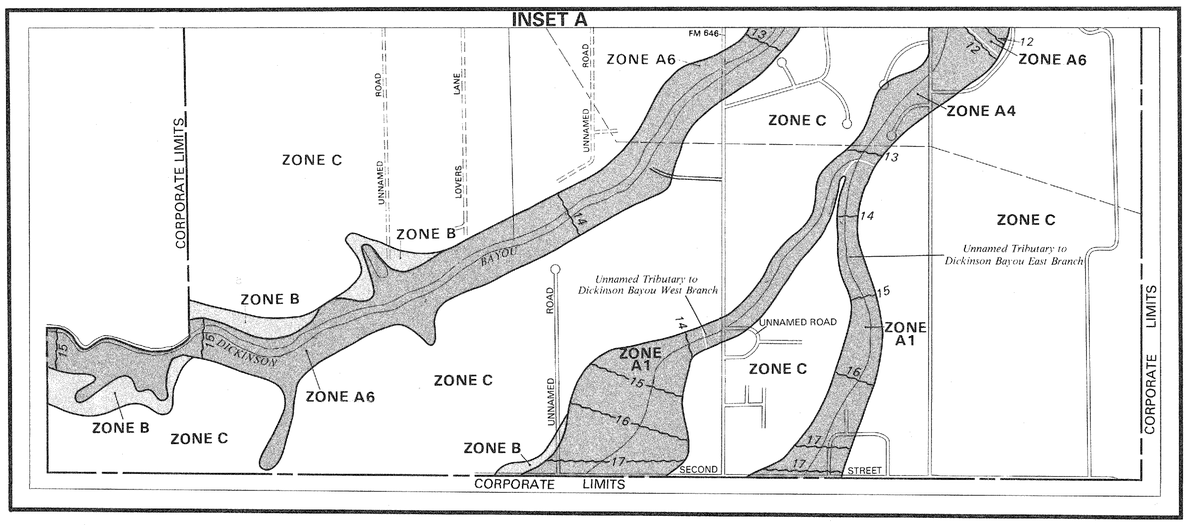
MAP INDEX
PANELS PRINTED: 5, 10

COMMUNITY-PANEL NUMBERS
481569 0001-0010

MAP REVISED:
MARCH 4, 1991

Federal Emergency Management Agency

EXHIBIT 6 –
FEMA EFFECTIVE FIRM PANEL
DICKINSON DRAINAGE STUDY



1 20TH STREET
2 21ST STREET
3 22ND STREET
4 23RD STREET
5 24TH STREET
6 25TH STREET
7 26TH STREET
8 27TH STREET
9 28TH STREET
10 COLONIAL DRIVE
11 YORKTOWN DRIVE
12 MT. VERNON DRIVE
13 WILLIAMSBURG DRIVE
14 JAMESTOWN DRIVE
15 SHERWOOD OAK
16 CREST DRIVE
17 WOODLAND DRIVE
18 GREEN LEE LANE
19 COTTONWOOD DRIVE
20 REDWOOD
21 WILMINGTON DRIVE
22 YUPON DRIVE
23 ROYAL OAKS DRIVE
24 TIMBER LANE
25 CEDAR DRIVE
26 MAGNOLIA CIRCLE
27 TANGLEWOOD DRIVE
28 HOLLOW CIRCLE
29 TALLOW DRIVE
30 CHERRY LANE
31 UNNAMED STREET
32 BAYOU CIRCLE
33 PINE MANOR LANE
34 BAYOU DRIVE WEST

ELEVATION REFERENCE MARKS

REFERENCE MARK	ELEVATION (FT. NGVD)	DESCRIPTION OF LOCATION
RM 16	18.63	A C&GS bench mark disk, 2.75 miles southwest along Farm Market Road 517 from the intersection of State Highway 3 at Dickinson, thence 0.05 miles south along Farm Market Road 646, 4.75 miles north of Alta Loma, 0.3 miles north of a long concrete bridge over Dickinson Bayou, 52.0 feet west of the centerline of the road, 112 feet southwest and across the road from the second telephone pole south of the junction, 34 feet east of an evergreen tree, 1.0 feet west of a fence, 0.5 feet northwest of a witness post, about 1 foot higher than the road, and set in the top of a concrete post projecting 0.2 feet above the ground.

KEY TO MAP

500-Year Flood Boundary	
100-Year Flood Boundary	ZONE B
Zone Designations*	ZONE A1 / ZONE A5
100-Year Flood Boundary	
500-Year Flood Boundary	ZONE B
Base Flood Elevation Line With Elevation In Feet**	513
Base Flood Elevation in Feet Where Uniform Within Zone**	(EL 987)
Elevation Reference Mark	RM7×
Zone D Boundary	
River Mile	•M1.5
Undeveloped Coastal Barriers	

**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
AO	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas. The community map repository should be consulted for possible updated flood hazard information prior to use of this map for property purchase or construction purposes.

Coastal base flood elevations apply only landward of 0.0 NGVD, and include the effects of wave action; these elevations may also differ significantly from those developed by the National Weather Service for hurricane evacuation planning.

Areas of special flood hazard (100-year flood) include Zones A, A1-A30, AH, AO, A99, V, and V1-V30.

Certain areas not in Special Flood Hazard Areas may be protected by flood control structures.

For adjoining map panels see separately printed Map Index.

INITIAL IDENTIFICATION
APRIL 8, 1971

FLOOD HAZARD BOUNDARY MAP REVISION
NONE

FLOOD INSURANCE RATE MAP EFFECTIVE
APRIL 8, 1971

FLOOD INSURANCE RATE MAP REVISIONS

Interim Map revision effective July 1, 1974 to change Zone Designations

Map revised June 24, 1977, to reflect Curvilinear Flood Boundary, to change Base Flood Elevations and to revise Corporate Limits

Map revised February 16, 1983 to increase and decrease Base Flood Elevations, to revise Zone Designations, and to revise Special Flood Hazards

March 4, 1991 - to update corporate limits, to change base flood elevations and to change special flood hazard areas.

To determine if flood insurance is available in this community, contact your insurance agent, or call the National Flood Insurance Program, at (800) 638-6620.

APPROXIMATE SCALE
1000 0 1000 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
DICKINSON, TEXAS
GALVESTON COUNTY

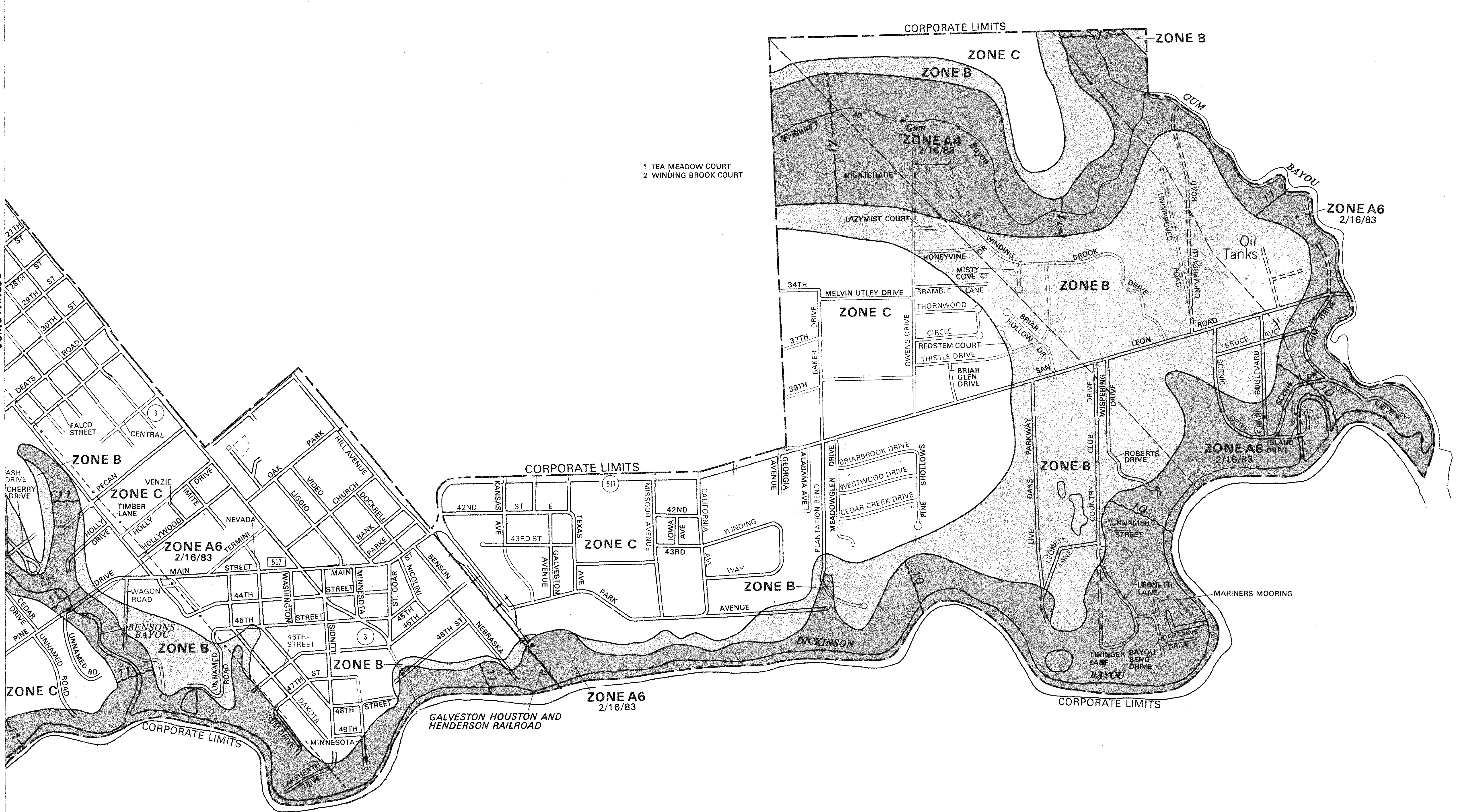
PANEL 5 OF 10
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
481569 0005B

MAP REVISED:
MARCH 4, 1991

Federal Emergency Management Agency

EXHIBIT 7 –
FEMA EFFECTIVE FIRM PANEL
DICKINSON DRAINAGE STUDY



KEY TO MAP

- 500-Year Flood Boundary — ZONE B
- 100-Year Flood Boundary
- Zone Designations* With Date of Identification e.g., 12/2/74 — ZONE A1 DATE / ZONE A5 DATE
- 100-Year Flood Boundary
- 500-Year Flood Boundary — ZONE B
- Base Flood Elevation Line With Elevation In Feet** — 513
- Base Flood Elevation in Feet Where Uniform Within Zone** — (EL 987)
- Elevation Reference Mark — RM7×
- Zone D Boundary
- River Mile — •M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
A0	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

For adjoining map panels, see separately printed Index To Map Panels.

INITIAL IDENTIFICATION:
APRIL 8, 1971

FLOOD INSURANCE RATE MAP EFFECTIVE:
APRIL 8, 1971

FLOOD INSURANCE RATE MAP REVISIONS:

Interim Map revision effective July 1, 1974 to change Zone Designations.

Map revised June 24, 1977; to reflect Curvilinear Flood Boundary, to change Base Flood Elevations and to revise Corporate Limits

Map revised February 16, 1983 to increase and decrease Base Flood Elevations, to revise Zone Designations, and to revise Special Flood Hazards.

Refer to the FLOOD INSURANCE RATE MAP EFFECTIVE date shown on this map to determine when actuarial rates apply to structures in the zones where elevations or depths have been established.

To determine if flood insurance is available in this community, contact your insurance agent, or call the National Flood Insurance Program at (800) 638-6620.

N

APPROXIMATE SCALE

1000 0 1000 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
DICKINSON, TEXAS
GALVESTON COUNTY

PANEL 10 OF 10

COMMUNITY-PANEL NUMBER
481569 0010 A

MAP REVISED:
FEBRUARY 16, 1983

Federal Emergency Management Agency

EXHIBIT 8 –
FEMA EFFECTIVE FIRM PANEL
DICKINSON DRAINAGE STUDY

Appendix #1

Drainage Calculations and Work Maps

City of Dickinson Drainage Study
Hot Spot Drainage Calculations

Basin ID	Area (ac)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	i-100yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	100yr Flow (cfs)
2-A	137.8	38.81	0.45	0	0	0	0	6	0	0	0	0	372
2-B	27.2	32.89	0.45	0	0	0	0	6.59	0	0	0	0	81
2-C	21.33	32.14	0.45	0	0	0	0	6.67	0	0	0	0	64
3-A	4.8	28.18	0.45	0	4.69	0	0	0	0	10	0	0	0
3-B	3.85	27.68	0.45	0	4.74	0	0	0	0	8	0	0	0
4-A	6.36	28.85	0.45	0	0	0	0	7.08	0	0	0	0	20
4-B	5.7	28.59	0.45	0	0	0	0	7.12	0	0	0	0	18
4-C	2.01	26.31	0.45	0	0	0	0	7.44	0	0	0	0	7
4-D	1.53	25.78	0.45	0	0	0	0	7.52	0	0	0	0	5
4-E	6.17	28.78	0.45	0	0	0	0	7.09	0	0	0	0	20
4-F	2.37	26.64	0.45	0	0	0	0	7.39	0	0	0	0	8
4-G	5.65	28.56	0.45	0	0	0	0	7.12	0	0	0	0	18
4-H	2.59	26.83	0.45	0	0	0	0	7.37	0	0	0	0	9
4-I	4.79	28.18	0.45	0	0	0	0	7.17	0	0	0	0	15
4-J	1.65	25.92	0.45	0	0	0	0	7.5	0	0	0	0	6
4-K	6.58	28.93	0.45	0	0	0	0	7.07	0	0	0	0	21

City of Dickinson Drainage Study
Hot Spot Drainage Calculations

Basin ID	Area (ac)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	i-100yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	100yr Flow (cfs)
5-A	8.1	29.45	0.45	0	0	0	0	7	0	0	0	0	26
5-B	11.04	30.26	0.45	0	0	0	0	6.9	0	0	0	0	34
5-C	4.21	27.88	0.45	0	0	0	0	7.22	0	0	0	0	14
5-D	14.45	31.01	0.45	0	0	0	0	6.81	0	0	0	0	44
5-E	1.54	25.79	0.45	0	0	0	0	7.52	0	0	0	0	5
5-F	5.51	28.51	0.45	0	0	0	0	7.13	0	0	0	0	18
5-G	4.7	28.13	0.45	0	0	0	0	7.18	0	0	0	0	15
5-H	0.83	24.68	0.45	0	0	0	0	7.7	0	0	0	0	3
5-I	4.7	28.13	0.45	0	0	0	0	7.18	0	0	0	0	15
5-J	0.83	24.68	0.45	0	0	0	0	7.7	0	0	0	0	3
5-K	2.3	26.58	0.45	0	0	0	0	7.4	0	0	0	0	8
5-L	4.52	28.04	0.45	0	0	0	0	7.19	0	0	0	0	15
6-A	0.97	24.95	0.45	0	0	0	0	7.65	0	0	0	0	3
6-B	4.85	28.21	0.45	0	0	0	0	7.17	0	0	0	0	16
6-C	4.83	28.19	0.45	0	0	0	0	7.17	0	0	0	0	16
6-D	0.58	24.08	0.45	0	0	0	0	7.8	0	0	0	0	2
6-E	4.82	28.19	0.45	0	0	0	0	7.17	0	0	0	0	16
6-F	3.59	27.52	0.45	0	0	0	0	7.27	0	0	0	0	12
6-G	0.44	23.65	0.45	0	0	0	0	7.87	0	0	0	0	2
7-A	94.8	37.29	0.45	0	0	19.46	0	0	0	0	251	0	0

City of Dickinson Drainage Study
Hot Spot Drainage Calculations

Basin ID	Area (ac)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	i-100yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	100yr Flow (cfs)
9-A	5.8	28.63	0.45	4.26	0	0	0	0	11	0	0	0	0
9-B	1.42	25.63	0.45	4.52	0	0	0	0	3	0	0	0	0
9-C	2.17	26.47	0.45	4.44	0	0	0	0	4	0	0	0	0
9-D	3.81	27.66	0.45	4.34	0	0	0	0	7	0	0	0	0
9-E	9.11	29.76	0.45	4.17	0	0	0	0	17	0	0	0	0
9-F	2.53	26.77	0.45	4.42	0	0	0	0	5	0	0	0	0
9-G	5.38	28.45	0.45	4.27	0	0	0	0	10	0	0	0	0
9-H	6.2	28.79	0.45	4.24	0	0	0	0	12	0	0	0	0
9-I	5.22	28.38	0.45	4.28	0	0	0	0	10	0	0	0	0
9-J	2.15	26.44	0.45	4.45	0	0	0	0	4	0	0	0	0
9-K	5.83	28.64	0.45	4.26	0	0	0	0	11	0	0	0	0
9-L	2.54	26.78	0.45	4.42	0	0	0	0	5	0	0	0	0
9-M	4.7	28.14	0.45	4.3	0	0	0	0	9	0	0	0	0
9-N	2.93	27.09	0.45	4.39	0	0	0	0	6	0	0	0	0
9-O	1.9	26.2	0.45	4.47	0	0	0	0	4	0	0	0	0
9-P	0.55	24	0.45	4.68	0	0	0	0	1	0	0	0	0
9-Q	5.77	28.62	0.45	4.26	0	0	0	0	11	0	0	0	0

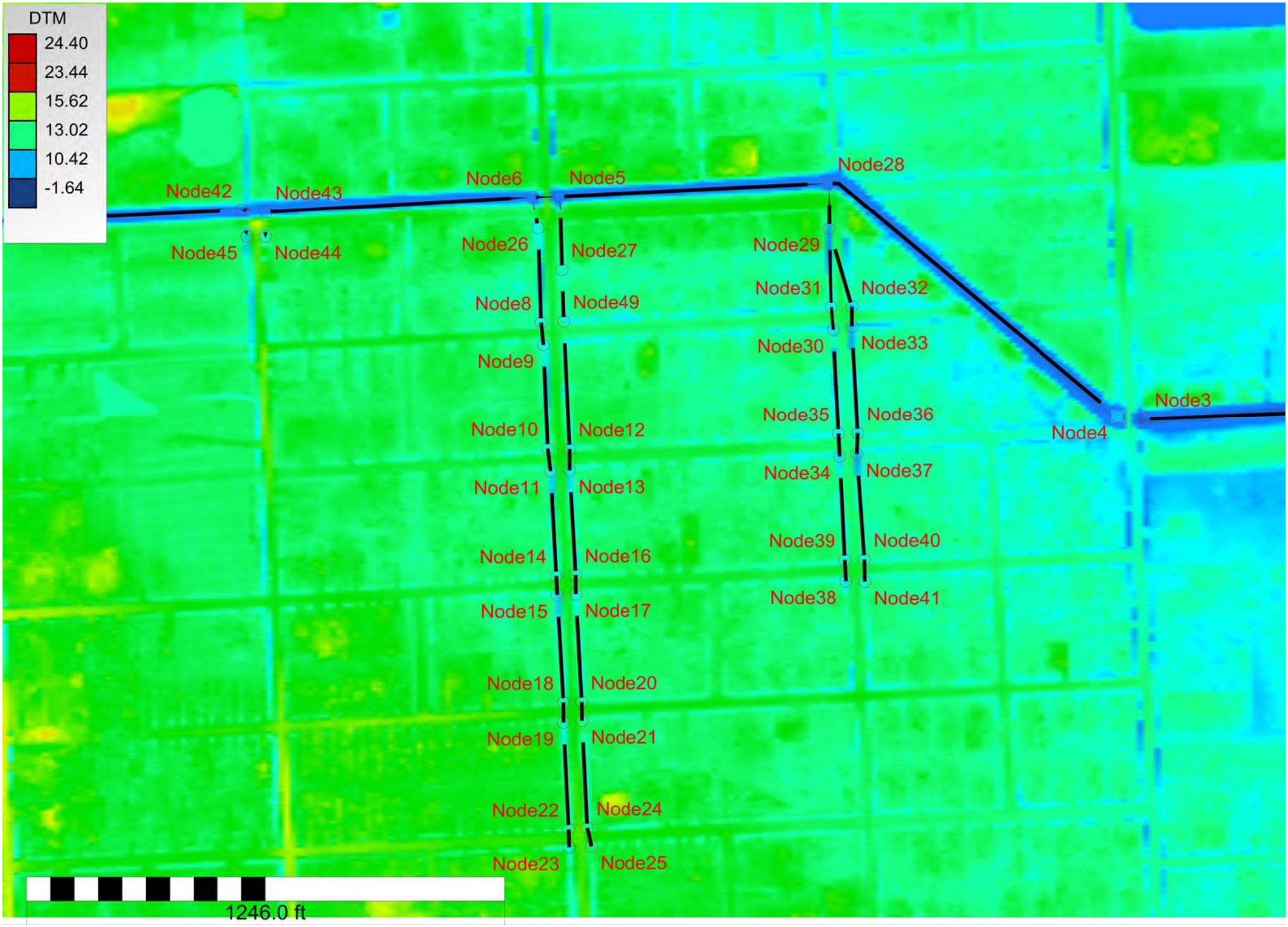
City of Dickinson Drainage Study
Hot Spot Drainage Calculations

Basin ID	Area (ac)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	i-100yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	100yr Flow (cfs)
10-A	0.88	24.77	0.45	0	0	0	0	7.68	0	0	0	0	3
10-B	0.7	24.4	0.45	0	0	0	0	7.74	0	0	0	0	2
10-C	1.2	25.32	0.45	0	0	0	0	7.59	0	0	0	0	4
10-D	0.84	24.7	0.45	0	0	0	0	7.69	0	0	0	0	3
10-E	5.78	28.62	0.45	0	0	0	0	7.11	0	0	0	0	18
10-F	4.54	28.05	0.45	0	0	0	0	7.19	0	0	0	0	15
10-G	1.52	25.77	0.45	0	0	0	0	7.53	0	0	0	0	5
10-H	2.29	26.57	0.45	0	0	0	0	7.4	0	0	0	0	8
10-I	1.33	25.52	0.45	0	0	0	0	7.56	0	0	0	0	5
10-J	0.83	24.68	0.45	0	0	0	0	7.7	0	0	0	0	3
10-K	0.8	24.61	0.45	0	0	0	0	7.71	0	0	0	0	3
10-L	0.3	23.1	0.45	0	0	0	0	7.97	0	0	0	0	1
10-M	2.65	26.87	0.45	0	0	0	0	7.36	0	0	0	0	9
10-N	6.2	28.79	0.45	0	0	0	0	7.09	0	0	0	0	20
10-O	3.54	27.49	0.45	0	0	0	0	7.27	0	0	0	0	12
10-P	0.66	24.28	0.45	0	0	0	0	7.76	0	0	0	0	2
10-Q	1.83	26.13	0.45	0	0	0	0	7.47	0	0	0	0	6

City of Dickinson Drainage Study
Hot Spot Drainage Calculations

Basin ID	Area (ac)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	i-100yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	100yr Flow (cfs)
11-A	8.64	29.62	0.45	0	4.56	0	0	0	0	18	0	0	0
11-B	11.21	30.3	0.45	0	4.5	0	0	0	0	23	0	0	0
11-C	6.04	28.73	0.45	0	4.64	0	0	0	0	13	0	0	0
12-A	4.41	27.99	0.45	4.31	0	0	0	0	9	0	0	0	0
13-A	1.23	25.38	0.45	0	0	0	0	7.59	0	0	0	0	4
13-B	4.8	28.18	0.45	0	0	0	0	7.17	0	0	0	0	15
13-C	0.25	22.83	0.45	0	0	0	0	8.02	0	0	0	0	1
14-A	5.93	28.68	0.45	0	0	0	0	7.11	0	0	0	0	19
14-B	26.46	32.8	0.45	0	0	0	0	6.6	0	0	0	0	79
14-C	3.46	27.44	0.45	0	0	0	0	7.28	0	0	0	0	11
15-A	8.08	29.45	0.45	0	0	0	0	7	0	0	0	0	25
15-B	22.63	32.32	0.45	0	0	0	0	6.65	0	0	0	0	68
15-C	3.94	27.73	0.45	0	0	0	0	7.24	0	0	0	0	13
15-D	3.27	27.32	0.45	0	0	0	0	7.29	0	0	0	0	11
15-E	3.85	27.68	0.45	0	0	0	0	7.24	0	0	0	0	13
17-A	1.21	25.34	0.45	0	0	0	0	7.59	0	0	0	0	4
17-AB	2.27	26.56	0.45	0	0	0	0	7.41	0	0	0	0	8
17-B	1.06	25.11	0.45	0	0	0	0	7.63	0	0	0	0	4
18-A	2.06	26.36	0.45	0	4.88	0	0	0	0	5	0	0	0
19-A	8.4	29.55	0.45	0	0	0	0	6.99	0	0	0	0	26

Hot Spot # 7 XP-SWMM Results



Scale 1 : 3800.43

Node Data

Name	Subcatchment	Hydrograph Shape	Pervious Area Curve Number	Area ac	Time of Concentration (or Parameter 2) min	Hydrology Methods
Node1		Curvilinear	0.000		0.000	SWMM Meth
Node2		Curvilinear	0.000		0.000	SWMM Meth
Node3	1	Curvilinear	80.000	354.375	43.200	SWMM Meth
Node4		Curvilinear	0.000		0.000	SWMM Meth
Node5	1	Curvilinear	80.000	41.634	34.300	SWMM Meth
Node6		Curvilinear	0.000		0.000	SWMM Meth
Node7	1	Curvilinear	80.000	857.761	55.800	SWMM Meth
Node8		Curvilinear	0.000		0.000	SWMM Meth
Node9	1	Curvilinear	80.000	2.918	27.100	SWMM Meth
Node10		Curvilinear	0.000		0.000	SWMM Meth
Node11	1	Curvilinear	80.000	2.859	27.000	SWMM Meth
Node12		Curvilinear	0.000		0.000	SWMM Meth
Node13	1	Curvilinear	80.000	2.999	27.100	SWMM Meth
Node14		Curvilinear	0.000		0.000	SWMM Meth
Node15	1	Curvilinear	80.000	2.863	27.000	SWMM Meth
Node16		Curvilinear	0.000		0.000	SWMM Meth
Node17	1	Curvilinear	80.000	3.098	27.200	SWMM Meth
Node18		Curvilinear	0.000		0.000	SWMM Meth
Node19	1	Curvilinear	80.000	2.803	27.000	SWMM Meth
Node20		Curvilinear	0.000		0.000	SWMM Meth
Node21	1	Curvilinear	80.000	4.306	27.900	SWMM Meth
Node22		Curvilinear	0.000		0.000	SWMM Meth
Node23	1	Curvilinear	80.000	17.095	31.500	SWMM Meth
Node24		Curvilinear	0.000		0.000	SWMM Meth
Node25	1	Curvilinear	80.000	25.695	32.700	SWMM Meth
Node26	1	Curvilinear	80.000	2.542	26.800	SWMM Meth
Node27		Curvilinear	0.000		0.000	SWMM Meth
Node28	1	Curvilinear	80.000	109.298	37.900	SWMM Meth
Node29	1	Curvilinear	80.000	3.427	27.400	SWMM Meth
Node30	1	Curvilinear	80.000	2.564	26.800	SWMM Meth
Node31		Curvilinear	0.000		0.000	SWMM Meth
Node32		Curvilinear	0.000		0.000	SWMM Meth
Node33	1	Curvilinear	80.000	1.609	25.900	SWMM Meth
Node34	1	Curvilinear	80.000	2.728	26.900	SWMM Meth
Node35		Curvilinear	0.000		0.000	SWMM Meth
Node36		Curvilinear	0.000		0.000	SWMM Meth
Node37	1	Curvilinear	80.000	1.702	26.000	SWMM Meth
Node38	1	Curvilinear	80.000	2.721	26.900	SWMM Meth
Node39		Curvilinear	0.000		0.000	SWMM Meth
Node40		Curvilinear	0.000		0.000	SWMM Meth
Node41	1	Curvilinear	80.000	1.692	26.000	SWMM Meth
Node42		Curvilinear	0.000		0.000	SWMM Meth
Node43	1	Curvilinear	80.000	48.691	34.800	SWMM Meth
Node44	1	Curvilinear	80.000	30.671	33.300	SWMM Meth
Node45	1	Curvilinear	80.000	55.989	35.300	SWMM Meth
Node48		Curvilinear	80.000		0.000	SWMM Meth
Node49	1	Curvilinear	80.000	4.234	27.900	SWMM Meth

Node Data

Name	Subcatchment	Total Runoff Depth in	Total Rainfall in	Invert Elevation ft
Node1		0.000	0.000	-0.190
Node2		0.000	0.000	-0.020
Node3	1	3.987	6.400	2.690
Node4		0.000	0.000	2.720
Node5	1	3.986	6.400	5.380
Node6		0.000	0.000	6.130
Node7	1	2.368	6.400	8.190
Node8		0.000	0.000	10.310
Node9	1	4.046	6.400	10.320
Node10		0.000	0.000	10.240
Node11	1	4.058	6.400	10.250
Node12		0.000	0.000	10.900
Node13	1	4.046	6.400	11.220
Node14		0.000	0.000	11.570
Node15	1	4.058	6.400	10.340
Node16		0.000	0.000	11.570
Node17	1	4.062	6.400	11.140
Node18		0.000	0.000	11.630
Node19	1	4.058	6.400	11.550
Node20		0.000	0.000	12.210
Node21	1	4.048	6.400	12.250
Node22		0.000	0.000	11.770
Node23	1	4.069	6.400	11.480
Node24		0.000	0.000	12.080
Node25	1	4.058	6.400	11.920
Node26	1	4.062	6.400	9.440
Node27		0.000	0.000	8.300
Node28	1	3.986	6.400	4.500
Node29	1	4.074	6.400	10.120
Node30	1	4.062	6.400	9.930
Node31		0.000	0.000	9.890
Node32		0.000	0.000	9.820
Node33	1	4.054	6.400	10.020
Node34	1	4.069	6.400	10.370
Node35		0.000	0.000	10.260
Node36		0.000	0.000	10.730
Node37	1	4.065	6.400	10.090
Node38	1	4.069	6.400	10.680
Node39		0.000	0.000	10.840
Node40		0.000	0.000	10.840
Node41	1	4.065	6.400	11.610
Node42		0.000	0.000	7.850
Node43	1	3.986	6.400	7.340
Node44	1	4.061	6.400	10.520
Node45	1	4.059	6.400	10.520
Node48		0.000	0.000	-1.270
Node49	1	4.048	6.400	10.320

Storm Sewer Sub-Basin Map
City of Dickinson, TX

N
W E
S
1 inch = 1,000 feet

Benson Bayou
Magnolia Bayou
Borden Gully
Gum Bayou
Dickinson Bayou
Kelsey Bayou
Old Kilroy Bayou

Legend

- City Limits
- Rivers
- Catchment Areas

HDR | CLAUNCH & MILLER
Engineering Consultants

City of Dickinson Drainage Study
Storm Sewer Outfall Calculations
Benson Bayou Outfall

Basin ID	Area (acres)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	Existing Outfall	Capacity (cfs)	Design Vel. (fps)	% Capacity
Benson-01	17.49	31.55	0.45	4.03	0	0	0	32	0	0	0	42"	29	3	110%
Benson-02	11.68	30.42	0.45	4.12	0	0	0	22	0	0	0	42"	29	3	75%
Benson-03	34.59	33.66	0.45	0	4.22	0	0	0	66	0	0	2-24"	19	3	349%
Benson-04	16.61	31.4	0.45	0	4.4	0	0	0	33	0	0	36"	21	3	155%
Benson-05	22.03	32.24	0.45	0	4.33	0	0	0	43	0	0	2-36"	42	3	101%
Benson-06	19.92	31.94	0.45	4	0	0	0	36	0	0	0	36"	21	3	170%
Benson-07	25.43	32.68	0.45	3.95	0	0	0	45	0	0	0	4'X4'	78	5	58%
Benson-08	55.58	35.29	0.45	3.78	0	0	0	95	0	0	0	4'X3'	58	5	162%
Benson-09	4.41	27.99	0.45	4.31	0	0	0	9	0	0	0	18"	5	3	162%
Benson-10	1.27	25.43	0.45	0	4.98	0	0	0	3	0	0	2-36"	42	3	7%
Benson-11	1.84	26.13	0.45	0	4.9	0	0	0	4	0	0	24"	9	3	43%
Benson-12	1.69	25.96	0.45	0	4.92	0	0	0	4	0	0	2-24"	19	3	20%
Benson-13	2.41	26.68	0.45	0	4.84	0	0	0	5	0	0	2-24"	19	3	28%
Benson-14	1.91	26.21	0.45	0	4.89	0	0	0	4	0	0	18"	5	3	80%
Benson-15	270.77	41.82	0.45	3.42	0	0	0	416	0	0	0	10'X5'	243	5	171%
Benson-16	42.15	34.33	0.45	3.84	0	0	0	73	0	0	0	8'X4'	156	5	47%
Benson-17	4.27	27.91	0.45	4.32	0	0	0	8	0	0	0	5'X5'	123	5	7%

City of Dickinson Drainage Study
Storm Sewer Outfall Calculations
Borden Bayou Outfall

Basin ID	Area (acres)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	Existing Outfall	Capacity (cfs)	Design Vel. (fps)	% Capacity
Borden-01	15.43	31.19	0.45	4.06	0	0	0	28	0	0	0	42"	29	3	98%
Borden-02	9.34	29.82	0.45	0	4.54	0	0	0	19	0	0	18"	5	3	361%
Borden-03	54.59	35.23	0.45	3.78	0	0	0	93	0	0	0	48"	38	3	247%
Borden-04	24.65	32.58	0.45	0	4.31	0	0	0	48	0	0	30" & 18"	20	3	239%
Borden-05	9.56	29.88	0.45	4.16	0	0	0	18	0	0	0	8'X4'	156	5	12%
Borden-06	35.87	33.78	0.45	3.88	0	0	0	63	0	0	0	8'X4'	156	5	40%

City of Dickinson Drainage Study
Storm Sewer Outfall Calculations
Dickinson Bayou Outfall

Basin ID	Area (acres)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	Existing Outfall	Capacity (cfs)	Design Vel. (fps)	% Capacity
Dickinson-01	68	36.02	0.45	3.74	0	0	0	114	0	0	0	n/a	0	0	0%
Dickinson-02	25.89	32.74	0.45	0	4.29	0	0	0	50	0	0	n/a	0	0	0%
Dickinson-03	61.11	35.63	0.45	3.76	0	0	0	103	0	0	0	n/a	0	0	0%
Dickinson-04	6.05	28.73	0.45	0	4.64	0	0	0	13	0	0	36"	21	3	60%
Dickinson-05	8.78	29.66	0.45	0	4.55	0	0	0	18	0	0	24"	9	3	191%
Dickinson-06	39.46	34.1	0.45	0	4.19	0	0	0	74	0	0	18"	5	3	1409%
Dickinson-07	16.43	31.37	0.45	4.05	0	0	0	30	0	0	0	42"	29	3	104%
Dickinson-08	4.46	28.01	0.45	4.31	0	0	0	9	0	0	0	18"	5	3	164%
Dickinson-09	6.33	28.84	0.45	4.24	0	0	0	12	0	0	0	24"	9	3	128%
Dickinson-10	8.63	29.62	0.45	4.18	0	0	0	16	0	0	0	24"	9	3	172%
Dickinson-10.1	16.82	31.44	0.45	4.04	0	0	0	31	0	0	0	42"	29	3	106%
Dickinson-10.2	2.32	26.6	0.45	4.43	0	0	0	5	0	0	0	24"	9	3	49%
Dickinson-11	39.79	34.13	0.45	0	4.19	0	0	0	75	0	0	24"	9	3	796%
Dickinson-12	3.44	27.43	0.45	0	4.77	0	0	0	7	0	0	18"	5	3	140%
Dickinson-13	42.76	34.37	0.45	0	4.17	0	0	0	80	0	0	24" & 36"	31	3	262%
Dickinson-14	15.6	31.22	0.45	4.06	0	0	0	28	0	0	0	30"	15	3	194%
Dickinson-15	8.57	29.6	0.45	4.18	0	0	0	16	0	0	0	24"	9	3	171%
Dickinson-16	8.23	29.49	0.45	4.19	0	0	0	16	0	0	0	24"	9	3	165%
Dickinson-17	6.45	28.88	0.45	4.24	0	0	0	12	0	0	0	24"	9	3	131%
Dickinson-18	6.56	28.93	0.45	4.23	0	0	0	12	0	0	0	24"	9	3	133%
Dickinson-19	2.06	26.36	0.45	0	4.88	0	0	0	5	0	0	15" & 12"	6	3	75%
Dickinson-20	30.28	33.23	0.45	0	4.26	0	0	0	58	0	0	n/a	0	0	0%
Dickinson-21	9.46	29.85	0.45	4.16	0	0	0	18	0	0	0	36"	21	3	84%
Dickinson-22	30.18	33.22	0.45	0	4.26	0	0	0	58	0	0	24"	9	3	614%
Dickinson-23	512.1	45	0.45	0	0	0	5.41	0	0	0	1370	2-96"	503	5	273%
Dickinson-24	49.92	34.91	0.45	0	4.13	0	0	0	93	0	0	2-24"	19	3	493%
Dickinson-25	8.4	29.55	0.45	4.18	0	0	0	16	0	0	0	24"	9	3	168%
Dickinson-26	3.9	27.71	0.45	4.34	0	0	0	8	0	0	0	24"	9	3	81%
Dickinson-27	4.16	27.86	0.45	4.32	0	0	0	8	0	0	0	24"	9	3	86%
Dickinson-28	7.93	29.4	0.45	4.2	0	0	0	15	0	0	0	24"	9	3	159%
Dickinson-29	13.21	30.75	0.45	4.09	0	0	0	24	0	0	0	24"	9	3	258%
Dickinson-30	152.73	39.24	0.45	3.55	0	0	0	244	0	0	0	6'X6'	177	5	138%
Dickinson-31	93.38	37.23	0.45	0	0	5.35	0	0	0	248	0	84"	192	5	129%
Dickinson-32	35.85	33.78	0.45	0	4.21	0	0	0	68	0	0	2-24"	19	3	361%
Dickinson-33	2.73	26.93	0.45	4.4	0	0	0	5	0	0	0	18"	5	3	102%
Dickinson-34	20.02	31.95	0.45	4	0	0	0	36	0	0	0	6'X5'	147	5	25%

City of Dickinson Drainage Study
Storm Sewer Outfall Calculations
Gum Bayou Outfall

Basin ID	Area (acres)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	Existing Outfall	Capacity (cfs)	Design Vel. (fps)	% Capacity
Gum-01	60.48	35.59	0.45	0	0	5.5	0	0	0	150	0	n/a	0	0	0%
Gum-02	5.45	28.48	0.45	4.27	0	0	0	10	0	0	0	18"	5	3	198%
Gum-03	5.37	28.44	0.45	4.27	0	0	0	10	0	0	0	18"	5	3	195%
Gum-04	52.67	35.1	0.45	0	0	5.55	0	0	0	145	0	42"	29	3	501%
Gum-05	5.8	28.63	0.45	4.26	0	0	0	11	0	0	0	24"	9	3	118%
Gum-06	1.42	25.63	0.45	4.52	0	0	0	3	0	0	0	24"	9	3	31%
Gum-07	2.17	26.47	0.45	4.44	0	0	0	4	0	0	0	24"	9	3	46%
Gum-08	3.81	27.66	0.45	4.34	0	0	0	7	0	0	0	24"	9	3	79%
Gum-09	49.07	34.85	0.45	3.81	0	0	0	84	0	0	0	2-36"	42	3	199%
Gum-10	5.77	28.62	0.45	4.26	0	0	0	11	0	0	0	24"	9	3	117%
Gum-11	49.81	34.9	0.45	0	4.13	0	0	0	93	0	0	2-60"	118	3	79%
Gum-12	20.64	32.04	0.45	4	0	0	0	37	0	0	0	30"	15	3	253%
Gum-13	35.89	33.79	0.45	0	4.21	0	0	0	68	0	0	2-15" & 24"	17	3	407%
Gum-14	14.13	30.94	0.45	4.08	0	0	0	26	0	0	0	48"	38	3	69%

City of Dickinson Drainage Study
Storm Sewer Outfall Calculations
Magnolia Bayou Outfall

Basin ID	Area (acres)	Tc (min)	C	i-3yr (in/hr)	i-5yr (in/hr)	i-25yr (in/hr)	i-50yr (in/hr)	3yr Flow (cfs)	5yr Flow (cfs)	25yr Flow (cfs)	50yr Flow (cfs)	Existing Outfall	Capacity (cfs)	Design Vel. (fps)	% Capacity
Magnolia-01	5.59	28.54	0.45	4.27	0	0	0	11	0	0	0	24"	9	3	114%
Magnolia-02	7.59	29.29	0.45	4.2	0	0	0	14	0	0	0	24"	9	3	152%
Magnolia-03	11.34	30.34	0.45	4.12	0	0	0	21	0	0	0	30"	15	3	143%
Magnolia-04	6.11	28.75	0.45	4.25	0	0	0	12	0	0	0	24"	9	3	124%
Magnolia-05	53.34	35.14	0.45	0	0	5.54	0	0	0	146	0	2-36"	42	3	346%
Magnolia-06	8.1	29.45	0.45	4.19	0	0	0	15	0	0	0	n/a	0	0	0%
Magnolia-07	20.08	31.96	0.45	0	4.36	0	0	0	39	0	0	48"	38	3	104%
Magnolia-08	41.29	34.25	0.45	3.85	0	0	0	71	0	0	0	4'X3'	58	5	123%
Magnolia-09	7.27	29.18	0.45	4.21	0	0	0	14	0	0	0	24"	9	3	146%
Magnolia-10	8.65	29.62	0.45	0	4.56	0	0	0	18	0	0	n/a	0	0	0%
Magnolia-11	41.78	34.3	0.45	3.84	0	0	0	72	0	0	0	5'X4' & 6'X4'	214	5	34%
Magnolia-12	12.99	30.71	0.45	4.09	0	0	0	24	0	0	0	8'X4'	156	5	15%

Storm Sewer Outfall Map
City of Dickinson, TX

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1 inch = 1,000 feet

Benson Bayou
Magnolia Bayou
Gum Bayou
Dickinson Bayou
Dickinson Bayou
Benson Bayou
Dickinson Bayou
Dickinson Bayou
Dickinson Bayou
Dickinson Bayou
Dickinson Bayou
Dickinson Bayou
Borden Gully
Old Town Bayou

Benson-01
Benson-02
Benson-03
Benson-04
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Dickinson-34

Legend

- City Limits
- Rivers
- Storm Sewer Outfall Basins

HDR | CLAUNCH & MILLER
Engineering Consultants

Appendix #2

Hot Spot Priority Scoring

City of Dickinson Master Drainage Plan

Hot Spot Priorty Considerations

Hot Spot ID	Description	Rep. Loss Parcels	Approximate Lots	Current LOS	Meets City Criteria LOS	Overflow Path?	Flooding Source Tidal or Rainfall	100-Year Floodplain
1	FM 517	0	0	2-Year	No	Yes	Rainfall	Yes
2	Liggio Street	4	23	2-Year	No	No	Rainfall	No
3	Plantation Drive	0	24	2-Year	No	Yes	Rainfall	Yes
4	Bayou Chantilly	23	176	3-Year	Yes	No	Rainfall	Yes
5	Inwood Drive	3	77	2-Year	No	No	Rainfall	Yes
6	Oakridge Drive	5	80	2-Year	No	No	Rainfall	Yes
7	Gum Bayou	22	114	2-Year	No	No	Rainfall	Yes
8	Hemlock Circle	0	16	2-Year	No	Yes	Rainfall	No
9	Briarglen	0	235	3-Year	Yes	No	Rainfall	Yes
10	Tropical Gardens	9	134	2-Year	No	Yes	Tidal	Yes
11	Lovers Lane	0	29	2-Year	No	Yes	Rainfall	Yes
12	Salvato Drive	2	5	2-Year	No	Yes	Rainfall	No
13	Greenlee Lane	3	20	3-Year	Yes	No	Rainfall	Yes
14	Country Club Drive	15	129	2-Year	No	Yes	Tidal	Yes
15	Elm Street	14	66	2-Year	No	No	Rainfall	Yes
16	Bayou Drive	1	45	5-Year	Yes	Yes	Rainfall	Yes
17	Pine Manor Lane	2	6	2-Year	No	No	Tidal	Yes
18	Manor Lane	3	13	2-Year	No	Yes	Tidal	Yes
19	Casa Grande Drive	3	23	3-Year	No	No	Rainfall	Yes

City of Dickinson Master Drainage Plan

Hot Spot Point System

Hot Spot ID	Rep. Loss Rank	Hot Spot Size Rank	Meets Criteria	Overflow Path	Flooding Source	Located in Floodplain?	Total	Hot Spot Description
1	5	1	5	0	5	0	16	FM 517
2	13	8	5	5	5	5	41	Liggio Street
3	5	9	5	0	5	0	24	Plantation Drive
4	19	18	0	5	5	0	47	Bayou Chantilly
5	12	13	5	5	5	0	40	Inwood Drive
6	14	14	5	5	5	0	43	Oakridge Drive
7	18	15	0	5	5	0	43	Gum Bayou
8	5	5	5	0	5	5	25	Hemlock Circle
9	5	19	0	5	5	0	34	Briarglen
10	15	17	5	0	0	0	37	Tropical Gardens
11	5	10	5	0	5	0	25	Lovers Lane
12	8	2	5	0	5	5	25	Salvato Drive
13	12	6	0	5	5	0	28	Greenlee Lane
14	17	16	5	0	0	0	38	Country Club Drive
15	16	12	5	5	5	0	43	Elm Street
16	6	11	0	0	5	0	22	Bayou Drive
17	8	3	5	5	0	0	21	Pine Manor Lane
18	12	4	5	0	0	0	21	Manor Lane
19	12	8	5	5	5	0	35	Casa Grande Drive

City of Dickinson Master Drainage Plan

Hot Spot Priority List
Point Total and Priority Ranking

Total Points	Construction Priority	Hot Spot Description	Hot Spot ID
47	1	Bayou Chantilly	4
43	2	Oakridge Drive	6
43	3	Gum Bayou	7
43	4	Elm Street	15
41	5	Liggio Street	2
40	6	Frostwood	5
38	7	Country Club Drive	14
37	8	Tropical Gardens	10
35	9	Casa Grande Drive	19
34	10	Briarglen	9
28	11	Greenlee Lane	13
25	12	Hemlock Circle	8
25	13	Lovers Lane	11
25	14	Salvato Drive	12
24	15	Plantation Drive	3
22	16	Bayou Drive	16
21	17	Pine Manor Lane	17
21	18	Manor Lane	18
16	19	FM 517	1