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1. Introduction

1.1 Purpose and Scope

The purpose of this Master Drainage Plan of Existing Conditions report is to present the results of a detailed study of the existing drainage conditions of the City of League City, Texas.

The scope of services includes completing a graphical update of the previous master plan sheets utilizing ArcGIS. This software has made it possible for the Master Plan sheets to remain current with little effort. It will be possible to swap out aerials, overlay new LiDAR data or a new right-of-way line in order to ensure that the plan does not become outdated again. In this first phase, Dannenbaum has updated the exhibits through completion of the following tasks:

1. Collect Data needed to update exhibits; current hydrologic and hydraulic models, shapefiles, etc.
2. Update Aerials
3. Update Drainage Areas based on current Aerials, LiDAR, TSARP, League City Tributary Model updates completed for the Clear Creek Watershed Steering Committee, and other studies collected in Task 1
4. Show existing features
5. Utilize new FEMA floodplains for the areas with studied streams

The next phase of the scope of services includes identifying Master Plan opportunities, if possible. Since League City is mostly developed within the Clear Creek Watershed, master planning opportunities are limited. The Dickinson Bayou Watershed is not built-out yet; so many more master planning opportunities are possible. Improvements to Dickinson Bayou will be developer driven.

The previous master drainage plan prepared by LJA Engineering for the City of League City, 1990, was used as a basis for this master plan. The 1994 Dickinson Bayou master plan prepared by Dodson and Associates included mostly detention features. The primary objective of the study presented herein is to provide city officials with an inventory of existing drainage conditions. .

In addition to the Master Drainage Plan, other data and documents have been developed for the City. This includes a structural inventory within the 100-yr floodplain to determine areas with known flooding issues, and quantify those issues. The inventory of repetitive loss properties, ponding map and inventory of structures was utilized to help prioritize areas with flooding issues. The ponding map is shown behind the Ponding tab.

1.2 Use of Report

This report is designed to enable city officials, engineers and developers to readily identify existing drainage patterns within the City of League City.

1.3 Data Sources

Data utilized in the production of this report include LiDAR, aerial imagery, ArcGIS shapefiles, and previous reports and models. The source of the LiDAR, aerials, and models are noted in the Master Plan sheets.

1.3.1 LiDAR

For the Clear Creek watershed, the most up to date LiDAR was commissioned by the Houston Galveston Area Council (HGAC), was flown from February 2008 to March 2008 and is on the 2001 datum. The most up to date LiDAR for the Dickinson Bayou watershed was downloaded from the TNRIS website. The source of the LiDAR is indicated on each exhibit.

1.3.2 Aerial Imagery

Aerial Images that covered the entire City of League City were purchased from the HGAC. These images were flown from December 2007 to February 2008.

1.3.3 GIS Shapefiles

GIS shapefiles were collected from the City's GIS department, or created by Dannenbaum as part of the NPDES outfall collection program.

1.3.4 Previous Reports and Models

Previous models were collected from the libraries at the City and Dannenbaum. Dickinson Bayou models were collected from JKC's Dickinson Bayou Study completed for the Galveston County Consolidated Drainage District in December of 2008. Other consultants were contacted for models used for large planned communities.

The Clear Creek Master Plan completed in 1990, by LJA, and the Dickinson Bayou Master Plan dated 1994 by Dodson and Associates were also collected and considered for this master plan. The text for the 1990 League City Master Plan was the starting point for the text of this report.

2. Technical Evaluation

2.1 Overview

2.2 Hydrologic Concepts

Several fundamental concepts must be considered in the design of a comprehensive drainage system for a given area. Basic to these concepts is the determination of the amount of storm water runoff that will occur for design conditions. Urban drainage systems are designed for rainfall associated with a specific frequency of occurrence, referred to as a design storm. The rate of surface water runoff corresponding to the design storm must be estimated for the design of the drainage system. This estimate is determined by developing a relationship between the precipitation volume and intensity of the design storm and the drainage characteristics of the study area.

In order to predict the storm runoff resulting from a design rainfall, a fundamental understanding of the hydrologic budget of the region under study must be developed. A generalized hydrologic budget acts as an accounting system for water movement in an area. In general terms, precipitation in the form of rain, snow, hail, or sleet, develops from atmospheric water vapor and acts as the input to the hydrologic cycle. Some precipitation may be intercepted by trees grass and other vegetation and structural objects and will eventually return to the atmosphere by evaporation and transpiration. Once precipitation reaches the ground, some of it may fill depressions (referred to as depression storage), some may penetrate the ground (infiltrate) to become soil moisture or ground water, and the remainder will become surface runoff, which flows over the ground to a defined channel such as a creek, ditch or bayou.

The theoretical flow response of a drainage area to a given rainfall may be defined in terms of a storm hydrograph. By definition, a hydrograph is a continuous graph showing the amount of flow occurring with respect to time at a particular location. Each rainfall occurrence results in a particular runoff pattern and thus is associated with a characteristic storm hydrograph. The properties of rainfall intensity and duration combine with the physical characteristics of the drainage area, such as soil type, vegetative cover, depression storage, and the type of drainage system to form a characteristic runoff hydrograph which is unique to the storm pattern, season and drainage area. A hydrograph for an undeveloped area with no significant drainage system will have a lower peak and a longer time to peak than that of the same area if it were developed. The undeveloped area would have considerable ponding in the fields and along small roadside ditches. Construction of streets, buildings and drainage system improvements such as storm sewers and ditches within the area will result in a decrease in infiltration of rainfall to the soil, remove the natural depression storage and provide a more efficient storm water drainage system. Control of the impact of development is the primary objective for the Mater Drainage Plan for League City. Development of the rural areas within the City can increase flood flow rates. The proposed channels and detention basins discussed in this report have been planned to control the increased discharge that may result from development.

2.3 Hydraulic Concepts

In addition to the fundamental hydrologic concepts mentioned above, an understanding of hydraulics is also essential for development of an efficient drainage system design. Basically, the overland flow occurring during a storm event becomes shallow concentrated flow and is carried into the gutters, streets, storm sewers, ditches or natural streams which comprise the channelized drainage system of the area. An urban drainage system consists of four distinct elements:

1) Major receiving streams or bodies of water in their natural existing condition.
2) The primary channels which include improved natural streams, bayous and creeks.
3) The lateral outfall channels which are tributaries of the primary channels.
4) The secondary system of storm sewers, small ditches and roadside ditches in developed areas.

The major receiving streams serve to transmit the surface runoff downstream to a major river, lake or ocean. The water surface elevation in these channels should ideally allow for full conveyance of flows from improved primary channels and lateral channels. In some situations, detention is needed because primary channels and laterals do not have enough conveyance, and it is not cost effective to add conveyance. . No downstream impact is required. In the League City area, the major receiving streams include the tide-affected reaches of Clear Creek and Dickinson Bayou, both of which ultimately drain into Galveston Bay.

The primary channels serve to collect storm runoff from each area served by the drainage system. In addition, the primary channels of a drainage system must be able to convey water efficiently from the lateral channels and secondary system to the major receiving streams. The primary channels draining to Clear Creek or Clear Lake include Magnolia Creek, Newport/Landing Ditch, Corum Ditch, Interurban Ditch, Robinson Bayou, and Jarbo Bayou. West Dickinson Bayou, Dickinson Bayou By-Pass Channel, Cedar Creek, Bordens Gulley, Magnolia Bayou, Benson Bayou and Gum Bayou outfall into the tide-affected portion of Dickinson Bayou. The primary channels and the drainage areas are shown on Exhibit 1.

The lateral outfall channels are tributaries designed to convey storm sewer drainage and roadside ditch drainage to the primary drainage system.

The secondary system functions as the collector of overland runoff. This system may be nonexistent in undeveloped areas or may be in the form of minor swales or rural roadside ditches. In urban areas, gutters of city streets, the streets themselves, storm sewers, roadside ditches, and small improved channels function as the secondary drainage system and serve to collect and convey runoff to the lateral outfall channels.

2.4 Analysis of Drainage Basins

In order to predict the peak flow to be used in the design of a drainage system for a given area, the physical characteristics of the area must be defined and analyzed. The volume of runoff represented by a hydrograph is dependent on rainfall volume and rate, antecedent rainfall, depression storage, interception, infiltration, evaporation, and the contributing drainage area size. The effect of each of these factors is dependent on basin characteristics, hydrologic conditions, and soil type.

Initially, the areas within the City of League City and its extraterritorial jurisdiction, as well as adjoining areas which influence drainage conditions in League City, were taken from the previous master plan (1990). The areas were then refined based on new LiDAR, new subdivision development, and the layout of the storm sewer system. After the drainage areas were delineated, basin characteristics were measured. Two different methodologies were used to model the basins in League City; TSARP and Pre-TSARP. In both methodologies, for each drainage basin or sub-basin, computations were performed to determine the total area and the percentage of the basin which is currently developed. An estimate of the percentage of impervious cover (i.e. buildings, parking lots, roads, etc.) in each basin was also determined.

Pre-TSARP methodology included:

- An infiltrations loss method of Initial and Constant.
- Onsite detention was not taken in to account for the Tc & R calculations.
- The rainfall peak that was used was 12 hours, and the rainfall data was TP-40 plus 2%.
- Contraction and expansion coefficients of 0.1 and 0.3 respectively were used at all locations were applicable.
- Manning's N values of 0.07 for overbanks and 0.045 for channels were used on all streams.
- These streams were also junctioned together in one model, so the tailwater conditions were set by the model except for at the mouth of Dickinson Bayous, which was normal depth.

TSARP methodology included:

- An infiltrations loss method of Green and Ampt method compatible with previous analysis by HCFCD.
- Onsite detention was considered in the Tc & R calculations.
- A rainfall peak of 16 hours was used as well as the rainfall that was developed by HCFCD as part of TSARP.
- Contraction and expansion coefficients of 0.3 and 0.5 respectively
- Manning's n-values varied based on field observations and aerial images.
- The streams were modeled separately, and the downstream boundary condition was set to normal depth.

The following table shows which model was used for each of the profile sheets included.

Stream Name	Methodology	Company	Date
Clear Creek	TSARP	DEC	2006
Magnolia Creek	TSARP	DEC	2006
Corum Ditch	TSARP	AECOM	2009
Interurban Ditch	TSARP	DEC	2006
Landing Ditch	TSARP	DEC	2006
Robinson Bayou	TSARP	DEC	2006
Jarbo Bayou	TSARP	DEC	2006
Dickinson Bayou	Pre-TSARP	JKC	2008
Magnolia Bayou	Pre-TSARP	JKC	2008
Borden's Gully	Pre-TSARP	JKC	2008
Benson Bayou	Pre-TSARP	JKC	2008
Gum Bayou	TSARP	DEC	2009

2.5 Evaluation of Channel System

Existing lateral outfall channels and primary channel systems has to be defined before the planning of drainage improvements could be implemented. Each drainage basin designed for the League City area was evaluated in detail with respect to the number, type, size and pattern of drainage channels. Drainage systems in each basin ranged from virtually nonexistent in the more remote rural areas, to well-defined channels in developed urban areas within League City.

For each of the studied lateral drainage systems, characteristic physical parameters were defined for use in developing the existing runoff hydrograph for each drainage basin. Channel lengths and average slopes were calculated using LiDAR. Representative roughness coefficients were determined from the aerial photographs, previous hydrologic studies performed in the area and field observation. Channel geometry was developed using LiDAR and field survey.

3. Design Considerations and Requirements

3.1 Overview

Based on the general hydrologic and hydraulic concepts described in Section 2, design criteria were developed specifically for the City of League City in conjunction with the Master Drainage Plan and are presented in this section. Additionally, the current design criteria being used in the City of League City according to the 1990 Master Plan, and the City's Subdivision Ordinance, as well as current criteria for Galveston County, the City of Houston, Harris County, and other surrounding areas was reviewed. Specific design criteria defined in the following paragraphs include the appropriate rainfall frequency and discharge methodology selected for use in the study area, as well as specific hydrologic and hydraulic criteria used for the planning of storm sewers, channel improvements and detention facilities in the Master Drainage Plan.

Briefly, the design criteria currently in use by most governmental entities in the vicinity of the City of League City follows the Harris County Flood Control District's (HCFCD) Policy Criteria & Procedure Manual (PCPM). The HCFCD design criteria manual specifies that all open channels will be designed to contain the runoff from the 1% exceedance probability storm event. Together with the curb-and-gutter system, site grading, and roadside ditches, the secondary system is designed to hold and convey the 100-year frequency storm runoff to the lateral outfall channel without structural flooding.

3.2 Rainfall Frequency Analysis

3.2.1 Dickinson Bayou Watershed

The U.S. Weather Bureau Technical Paper No. 40 (TP-40) is the most widely used reference for storm frequency data in Galveston County. Published in 1967, TP-40 analyzed historical rainfall data and developed rainfall frequency curves across the United States. From the historical data, a rainfall intensity (inches per hour) versus duration curve particular to each local area was developed. The 100-year, 24-hour rainfall produced by TP-40 for the Houston area is 12.7 inches, which varies in intensity to reflect 100-year volumes for smaller durations. For the Galveston area, the 100-year, 24-hour rainfall predicted by TP-40 is 13.4 inches. A mean value for the 100-year, 24-hour rainfall for the City of League City is 13.0 inches as interpolated between the values for the City of Houston and the City of Galveston. Based on this, the rainfall values used in TP-40 should be increased by two percent for use in the Dickinson Bayou part of League City.

3.2.2 Clear Creek Watershed

As part of the Tropical Storm Allison Recovery Project (TSARP), the rainfall frequency and duration curves were updated and put into a table. The 100-year, 24 hour rainfall produced by these updated tables is 13.5 inches for the Clear Creek watershed. The tables were developed from rainfall obtained from the United States Geological Service (USGS). The HCFCD Hydrologic and Hydraulic Guidance Manual includes rainfall data for different frequencies and durations and should be used for the Clear Creek watershed part of League City.

3.3 Hydrologic Analysis

Hydrologic methodology used by the Harris County Flood Control District and the City of Houston was used in development of the master drainage plan. The same methodology is required for use in future hydrologic analysis and design in the City of League City,

3.3.1 Storm Sewers

The storm sewer should be designed to convey the 2-year frequency flow based on the City of Houston design curves which were derived from the rational formula, Q = CIA, where

Q = discharge in cubic feet per second,

C = runoff coefficient,

I = rainfall intensity, in inches per hour, and

A = drainage area, in acres.

The rational method is applicable to areas less than 600 acres for storm sewer, and less than 500 acres for roadside ditches. For areas larger than that, the Clark Unit Hydrograph Tc & R should be used. The City of League City C values, taken from the City of Houston, are summarized as follows:

Land Use Type	Run-off Coefficient (C)
Residential District	
Lots more than ½ acre	0.35
Lots ¼ - ½ acre	0.45
Lots less than ¼ acre	0.55
Multi-Family areas	
Less than 20 Service Units/Acre	0.65
20 Service Units/Acre or Greater	0.80
Business Districts	0.8
Industrial Districts	
Light Areas	0.65
Heavy Areas	0.75
Railroad Yards Areas	0.3
Parks/Open Areas	0.18

3.3.2 Drainage Channels

The HCFCD methodology for determining channel design flows and hydrographs is described in detail in the previously referenced HCFCD Policy, Criteria and Procedures Manual, published by HCFCD in 2004. This method uses the coefficients Tc (representing time of concentration) and R (representing a storage factor), calculated from the drainage basin physical parameters, to develop an U.S. Army Corp of Engineers' HEC-HMS computer model. The HEC-HMS model produces a storm hydrograph by using precipitation data, basin areas, percent imperviousness, rainfall loss rates and channel characteristics to develop a specific runoff pattern for the particular storm and drainage area. HCFCD hydrologic methodology and comprehensive documentation are the required methodology for use in the City of League City in the areas where detailed development of a runoff hydrograph is required for design.

3.3.3 Detention Basins

For planning and design of detention basins the methods presented in the HCFCD design criteria manual are required for use in League City.

3.4 Hydraulic Design Requirements

3.4.1 Storm Sewers and Roadside Ditches

3.4.1.1 Tailwater

It is required that storm sewers be designed based on City of Houston tailwater criteria. The starting tailwater will be different based on two factors, distance from receiving stream and storm frequency. For storm sewers that outfall less than 2,000 ft from the receiving stream, the criteria will be as follows:

1. For the 2-yr design rainfall event with non-submerged outfall to the receiving channel, the starting tailwater shall be top of pipe.
2. For the extreme rainfall event and outfall to the receiving channel, the starting tailwater shall be the 10-yr WSEL or 24-in below top of bank, whichever is lower depending on the level of service of the receiving channel.

If the receiving channel for the storm system being analyzed is greater than 2,000 ft from the project limits, then the starting tailwater may be determined from an outfall point, or truncation, downstream of the project interconnect point, as noted below:

1. For the 2-yr design rainfall event the starting HGL shall be the top of pipe 2,000 ft downstream of the project interconnect point assuming pipes are connected at soffit. If pipes are connected at flow line, the top of the larger receiving pipe must be used. If a starting tailwater other than the top of pipe is chosen, the consultant shall analyze the storm system from outfall at the receiving channel upstream to the point of interconnect to demonstrate the alternate starting HGL value. Low resolution dynamic modeling or simple trunkline analyses using WinStorm are reasonable methods.
2. For the extreme rainfall event the starting HGL shall be 24 in above the top of pipe 2,000 ft downstream of the project interconnect point. If a starting tailwater other than 24 in above the top of pipe is chosen, the consultant shall analyze the storm system outfall at the receiving channel upstream to the point of interconnect to demonstrate the alternate starting HGL value. Low resolution dynamic modeling or simple trunkline analysis using WinStorm are reasonable methods. Static tailwater allowed.

For the hydraulic impact analysis, a variable tailwater at the downstream end of the model may be used.

3.4.1.2 Ponding and Roadway Elevation

All of the following criteria must be considered for ponding:

- The design frequency for consideration of overland sheet flow will consider the 1% events. These events, which exceed the capacity of the underground storm sewer system and result in ponding and overland sheet flow, shall be routed to drain along street rights-of-way or open areas and through the development to a primary outlet.
- Streets shall be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet.
- The maximum depth of ponding at high points shall be 6 inches above the gutter line during a 1 % event. .
- The maximum depth of ponding at low points shall be 18 inches above the gutter line during a 1 % event.
- Along major thoroughfares and principal arterial streets, the inside lane should be dry during the 1% event. .
- The maximum depth of ponding elevation for the 100-year event at any point along the street shall not be higher than the natural ground elevation at the right-of-way line.

Setting Roadway Elevations:

- New thoroughfares should have a minimum low point (gutter line) that is at or above the base flood elevation.

3.4.2 Drainage Channels

Hydraulic design of drainage ditches should be based on HCFCD criteria. Per HCFCD criteria, the 100-year flood should be contained within the right-of-way.

Starting water surface elevation for backwater computations using HEC-RAS should also be based on HCFCD criteria. Starting water surface elevation at the mouths of open channels should be based on the normal depth in the design channel calculated using Manning's equation, or the normal depth function in HEC-RAS. However, starting water surface elevations for streams entering tidal zones should use average high tide as a starting water surface.

Side slopes in the HCFCD criteria manual for unlined earthen or grass-lined channels are no steeper than 4 horizontal to 1 vertical with a 20 ft maintenance berm for channels with a top width of less than 60 ft and less than 7 ft deep or

30 ft maintenance berm for larger channels. In the League City area, side slopes for unlined earthen or grass-lined channels should be no steeper than 4 horizontal to 1 vertical to provide easier maintenance.

A soils report is required to verify the angle of repose and shall be provided to the City of League City.

3.4.3 Detention Basins

The HCFCD criteria manual presents a detailed methodology for hydraulic analysis and design criteria for detention basins which is required for use in the City of League City. One modification to HCFCD criteria is that outfall structures subject to tailwater inundation may have flap gates to prevent back flow.

3.4.4 Drainage Structures

Drainage structures consist of drop structures (energy dissipaters), culverts, bridges, storm sewer outfalls, and detention basin control structures. Detention basin control structures are covered in the detention section. It is required that these structures be design based on HCFCD criteria.

3.4.5 Right-of-Way Requirements

Right-of-way requirements should be based on HCFCD criteria as shown in the Table below.

Channels That Are	The Minimum Berm Width Is
Grass-lined with a top width > 60 feet or a depth of > 7ft	30 feet
Grass-lined with a top width <= 60 feet or a depth of <= 7ft	20 feet
Grass-lined where side slopes are 8 (horizontal): 1 (vertical) or flatter	10 feet
Grass-lined with the 20-foot maintenance access on a bench	10 feet
Lined with riprap or articulated concrete blocks or partially concrete-lined	Same as grass-lined channel
Fully concrete-lined	20 feet one side, 10 feet other side

3.5 Master Drainage Plan

The Master Drainage Plan for the City of League City is presented in plan and profile at a scale of 1 inch = 1,000 feet. The plan exhibits and profiles are presented by drainage basins. Exhibit 1 identifies the individual basins within the city. In addition to the individual basins, there are several intervening areas which drain directly to either Clear Creek or Dickinson Bayou. Exhibit 2 presents an index of exhibits. The watersheds in Clear Creek are in Exhibits 3 through 7 under the MDP tab. The watersheds for Dickinson Bayou are in Exhibits 8 though 11 under the MDP tab. The plan views for a particular basin are presented first followed by the existing channel profiles for that basin. In the next phase of this project, proposed features will be modeled, and the profiles for these models will be updated to include proposed profiles. Any proposed features would be intended to alleviate existing problems, not to mitigate for future development. Any future development would be required to provide mitigation for any impacts introduced by the development. Specific details of existing conditions of each watershed are in the following text.

3.6 Clear Creek

Exhibits 3 through 7 under the MDP tab present the existing conditions for the areas of League City which drain into Clear Creek and Clear Lake. Since the previous master plan was completed in 1990, this watershed has developed significantly and is mostly developed. There is little undeveloped area remaining that would require new features. It has been assumed that runoff for areas upstream of League City will be controlled by the appropriate jurisdiction to prevent any increase in peak flood flows along Clear Creek through League City.

The following is a specific discussion of the basins which drain to Clear Creek.

3.6.1 Magnolia Creek

Magnolia Creek drains approximately 3,492 acres in northwest League City. The most recent model for this area was completed by DEC in 2006 and was completed using TSARP methodology. The eastern portion of the watershed is fully developed, however an undeveloped section remains in the western portion of the watershed.

Since no stream currently exists in the undeveloped part, future development should consider the possibility of extending Magnolia Creek to the west to provide an outfall ditch. The proposed extension will require modeling to determine if the decrease in time of concentration due to the proposed channel causes impacts, and therefore requires detention. It is assumed that any development would provide detention to mitigate for the increase in impervious cover. As seen in Exhibit 3E, the current channel has capacity, so no improvements are needed on the existing channel.

3.6.2 Newport – Landing Ditch Basin

Landing Ditch is the main drainage system of the total Newport-Landing Ditch basin. Since Landing Ditch outfalls to Clear Creek near the mouth of Newport Ditch, these two systems can generally be considered as separate basins. The drainage area for Landing Ditch is 1,734 acres, as shown on Exhibit 5. This basin is mostly developed, except for the south eastern corner. Newport Ditch drains about 340 acres above the mouth of Landing Ditch and is shown in Exhibit 5.

The most up to date model was completed in 2006 by DEC. As seen in the profile on Exhibit 5D under the MDP tab, the 1% Chance Flood WSEL is in the banks.

3.6.3 Corum Ditch

Corum Ditch, as shown on Exhibit 5 under the MDP tab, drains 402 acres. The channel begins west of Interstate Highway 45 (IH-45), as an IH-45 feeder ditch, and drains through the Corum Ditch Shopping Center, then under FM 518 to Clear Creek. The most up to date model was completed in 2009 by AECOM. As seen in Exhibit 5E under the MDP tab, the 1% Chance Flood WSEL is in the banks with the exception of the portion downstream of the crossing at Wesley.

3.6.4 Interurban Ditch

Interurban Ditch is partially located within the Centerpoint Energy easement. Interurban Ditch drains 914 acres. The ditch is adjacent to and under the east power line towers. This basin is mostly developed, and channels have been built to serve the areas that have not been fully developed.

There is street flooding in the Oaks of Clear Creek subdivision due to the lack of elevation drop between the subdivision and the mouth of Interurban Ditch. This subdivision is located at the upstream end of the Interurban Ditch, where the ditch is in a box. This area has been studied and improvements have been proposed as part of a separate report entitled Evaluation of Drainage Improvements for Oaks of Clear Creek Sections 1 and 2, by Dannenbaum Engineering, dated August 2010. There are no further improvements proposed.

3.6.5 Robinsons Bayou

Robinsons Bayou is shown on Exhibit 6. Robinsons Bayou drains 3,236 acres. Since the previous master plan, much of the previously undeveloped area has been developed.

As seen on Exhibit 6E under the MDP tab, the 1% Chance Flood WSEL is within the banks. The current model shows the channel to have sufficient capacity. Upstream drainage improvements may be necessary to serve future development.

3.6.6 Jarbo Bayou

Jarbo Bayou drains 3,420 acres and is shown on Exhibit 7. This basin is almost fully developed with channels built to serve the areas that are not yet fully developed.

As seen in Exhibit 7E, the 1% Chance Flood WSEL is within the channel banks based on the model completed in 2006 by DEC.

3.7 Dickinson Bayou

Exhibits 8 through 11 present the drainage plan for the area draining to Dickinson Bayou. Dickinson Bayou and its tributaries through the Village of Dickinson have limited capacity[1]. Environmental concerns, existing structures and permitting problems generally prohibit improvement of these channels. Due to these factors, most development within the Dickinson Bayou Basin will require stormwater detention basins. The following is a specific discussion of the Dickinson Bayou system.

3.7.1 West Dickinson Bayou Basin

The West Dickinson Bayou designation applies to the portion of the Dickinson Bayou Basin west of Cedar Creek.. The West Dickinson Bayou drainage area is approximately 16 square miles, of which 2.6 square miles (1,646 acres) are within the City of League City. The main drainage feature of the West Dickinson Bayou Basin is the By-Pass Channel. The channel originates just east of Alvin and crosses Dickinson Bayou once before entering Dickinson Bayou through Cedar Creek. An existing diversion structure allows a portion of the flow to be diverted to Dickinson Bayou which flows south under FM 517 and then flows east towards the Village of Dickinson. The remainder of the By-Pass Channel flow and flow from adjacent areas enter Cedar Creek upstream of FM 517. Cedar Creek drains south under FM 517 to Dickinson Bayou

3.7.2 Prairie Estates Ditch Area

The 560-acre area east of Cedar Creek, as shown on Exhibit 8E under the MDP tab, drains south into two small channels. The western channel has been master planned to drain the area north of FM 517. One 20 acre detention basin was proposed to serve the area in the previous Master Plan. This basin and channel should be investigated for future development to determine its effectiveness.

3.7.3 Magnolia Bayou – Bordens Gully Drainage Basins

Magnolia Bayou and Bordens Gully drain approximately 4,988 acres. Both stream flow easterly under IH-45 through the Village of Dickinson to Dickinson Bayou.

The areas east and immediately west of IH-45 have been developed. Detention storage will be required for the remainder of the Magnolia Bayou and Bordens Gully basins. The master plan completed in 1990 includes the construction of a diversion channel from north of Magnolia Bayou, across Bordens Gully and south to Dickinson Bayou, but much of this area has been developed making the complete diversion channel no longer feasible. Portions of diversion channel

[1] League City Master Plan, LJA, 1990

could be built; further analysis would be required to see if this feature still provides benefits.

3.7.4 Benson Bayou Drainage Basin

Benson Bayou drains a 3,107 acre area between IH-45 and Dickinson Avenue, with 2,103 acres within the City of League City. Exhibit 10 presents the existing conditions for Benson Bayou. This basin is mostly developed; however, the detention pond area proposed in the master plan completed in 1990 has not been developed and may still be available for detention. This detention will require investigation when future development occurs.

3.7.5 Gum Bayou

Gum Bayou, and its main tributary, West Gum Bayou, drain approximately 7,533 acres, of which 3,200 acres are within the City of League City. Exhibit 11 shows Gum Bayou basin. Since the previous master plan (1990), most of the basin has been developed, so the proposed features can no longer be built. There are no new proposed features for this basin. Future development will determine the addition of drainage features in this area.

4. Ponding Map

A ponding analysis, based on the most current LiDAR, was performed within the City of League City boundary. This analysis was performed to give the City general knowledge of where ponding of water is located during rainfall events.

For the purpose of this analysis, DEC considered a pond as any cell(s) in the DEM surrounded by cells with a higher elevation in which water is trapped and is unable to flow out freely. In order to create a DEM that does not contain any ponding areas, the “Fill Sinks” function of ArcHydro, an extension of ArcGIS, was utilized. The resulting DEM was then subtracted from the original DEM through the “Raster Calculator” function within the Spatial Analyst extension of ArcGIS. This process produced a DEM of areas where ponding exists within the city limits. The ponding areas were classified based on depth and can be viewed under the Ponding tab.

5. Future Development

All proposed features shall be modeled using current conditions. The City of League City has had significant development since the previous master plan and the modeling methods have been updated, so it is crucial that the proposed features be reevaluated.

Drainage reports must include a no adverse impact statement. The City of League City requires that developments create no rise or have no adverse impact on receiving streams.