CITY OF GALVESTON
MASTER DRAINAGE PLAN

Prepared for:

CITY OF GALVESTON

Prepared by:

DANNENBAUM ENGINEERING CORPORATION (Prime)

Project Team:

Berg Oliver Associates, Inc.
Dodson & Associates, Inc.
Kathy Thomas Barr
TerraPoint

July, 2003

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May, 2003

GALVESTON MASTER DRAINAGE PLAN

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EXECUTIVE SUMMARY

This report presents the findings of the City of Galveston Master Drainage Plan. The primary purpose of this report is to develop a plan for the City of Galveston to comply with the U.S. Environmental Protection Agency (EPA) mandate regarding the storm water quality or National Pollution Discharge Elimination System (NPDES), with help from Dodson and Associates (in separate reports). The secondary purpose of this Plan is to evaluate existing drainage conditions on Galveston Island and Pelican Island controlled by the City of Galveston (including Galveston County MUD #1, but not including Jamaica Beach a separate City), and to recommend improvements that can be phased in over a period of years. This Plan will include elements of NPDES (Dodson and Associates), storm sewer, surface drainage (Dannenbaum Engineering), environmental conditions (Berg Oliver Associates), and public involvement (Kathy Thomas Barr Communications). This plan is not intended to address flooding issues associated with tropical weather events such as hurricanes, tropical storms and depressions. The high tides and storm surges that occur during these events are beyond the scope of this study.

Galveston Island is a barrier island along the Texas Gulf Coast, and the City of Galveston is the largest island community in the United States established on a barrier island. The Gulf of Mexico is the southern boundary, and Galveston Bay forms the northern boundary of the island. This geographic location results in a number of natural events and conditions that impact drainage on the island. These events include periodic tropical storms, or Hurricanes that originate in the Gulf of Mexico and create intense rainfall and are also accompanied by high tides that cause severe flooding of the lower elevations on the island. After the 1900 Hurricane the eastern portions of the island were raised behind a seawall completed in various stages from 1904 to 1961. Areas west of the seawall retain the natural barrier island characteristics.

In addition to storm water run-off another contributor to the drainage system on Galveston Island is the sand itself. Galveston sand is very fine and easily gets airborne due to the prevailing onshore breeze. This sand is deposited over the areas directly adjacent to the beach side of the island and eventually drains into and gets deposited into the storm sewer system. The sand in addition to other sediments draining into the storm sewer system creates an on-going maintenance concern.

This study includes a comprehensive look at the current drainage conditions on Galveston Island.

The primary objectives were to:

a) obtain good topographical information of the island to determine existing flow patterns;
b) collect information on the existing storm sewer and culvert drainage systems and evaluate their performance;
c) evaluate the current drainage criteria;
d) determine the minimal improvements necessary to bring the current drainage system into line with the existing drainage criteria;
e) determine construction cost for a CIP program; and
f) determine an equitable storm water fee funding program for the City that could replace the current system and meet funding needs for a NPDES program, maintenance of the existing storm drainage systems and CIP.

The following is a general summary of the main points of the Master Drainage Plan for Galveston Island and some general conclusions.

This report is part of a team approach to the issues facing the City of Galveston, as such; the independent area of Jamaica Beach is not included since it is not part of the City of Galveston. The primary goal was to assess the upcoming NPDES rules put in place by the EPA and administered by the Texas TCEQ (Texas Commission of Environmental Quality), by Dodson and Associates. Dodson compiled the following separate reports that deal with NPDES issues on Galveston Island and accompany this study:

- Draft Storm Water Management Plan (NPDES Phase II) for the City of Galveston – This report outlines the requirements of the TCEQ Small MS4 Permit that is required for the City of Galveston. Included is a minimum of six measures to reduce storm water pollution. These include; public education, public participation, illicit discharge detection, good housekeeping, construction site permitting, and post-construction storm water management.

Storm Water Pollution Prevention Plans listed below were required to bring City facilities in compliance with the current NPDES regulations.

- Storm Water Pollution Prevention Plan – Main Wastewater Treatment Facility
- Storm Water Pollution Prevention Plan – Airport Wastewater Treatment Facility
- Storm Water Pollution Prevention Plan – Island Transit Maintenance Facility
- Storm Water Pollution Prevention Plan – Scholes International Airport

The second goal was an evaluation of the existing drainage systems on Galveston Island and determines specific drainage improvements, a CIP, and determines funding levels necessary to implement the NPDES program, maintain the current drainage system and funding for a CIP, by Dannenbaum Inc. Mapping the current drainage system and identifying outfall locations is required under the current NPDES regulations. TerraPoint developed elevation and contour data for Galveston Island that established the base topography for this study using the latest laser range finding technology. Berg Oliver and Associates, Inc. evaluated environmental conditions on Galveston and Pelican Island. Berg-Oliver has produced the following separate reports to accompany this study:

- Environmental Baseline Overview – Galveston and Pelican Island, Texas – Gives an overview of the environmental conditions on Galveston and Pelican Island based on historical information. This includes wetlands, endangered species habitat, and the location of other potential environmental hazards created by human activities on the islands.
- Environmental Baseline Exhibits – These are exhibits of both islands that graphically show the information presented in the baseline report.
- Preliminary Environmental Assessment of Selected Storm Sewer Routes – This report is a preliminary assessment of some of the primary storm sewer routes selected based on the analysis of the existing storm sewer presented in this report. An outline of potential environmental and archeological hazards is included.

All public relations matters were coordinated with Kathy Thomas Barr who has been working in the Galveston area for a number of years. She has extensive knowledge of the existing

organizations on the island and helped prepare the public surveys and the September 16th, 2002 Public Hearing. The following is a listing of general summaries from the report.

Purpose of the Study – The main goal of the Master Drainage Plan is to comply with the EPA mandate regarding the storm water quality or NPDES. With that in mind, the City of Galveston decided, in addition, to evaluate the existing drainage system (storm sewer and surface drainage), identify flood prone problem areas and make recommendations that could be phased over the years. The Master Drainage Plan, in order to be comprehensive has several elements such as: storm sewer and surface drainage, environmental, public involvement, and NPDES. Due to the age of the current system and the amount of sand blown from the Bay and deposited into the system, maintenance is a serious concern that affects the performance of the existing system. This document is intended as a planning tool and the recommendations are flexible and subject to additional scrutiny with some additional preliminary engineering before developing construction plans. Factors including utility conflicts and other physical and/or political constraints while considered to some degree, the level of detail in this study is not to the level required for final design. However, the potential for improvements should be factored into the design of capital improvement projects around the City where funding is available.

Data Collection – As part of this study the available data on existing storm drainage systems was collected in addition to some land survey by LandData to spot check the system and to verify datum conversions of the LIDAR data from Terra Point. A number of field visits were also made to confirm plans and view sediments in the existing system. Work to itemize and locate drainage structures specifically for GIS was not included in this study. Sediments in the system have been located in spot areas based on the manholes surveyed and field checked with City personnel. Bridge blocks have also been located along Broadway, however the numerous bridge blocks on driveways and other roads within the city have not been located. Evaluations of the structural integrity of the system are not part of this study. Also as part of the data collection process a questionnaire was distributed to the citizens of Galveston through their water bills to determine the drainage needs perceived by the public. The results of these questionnaires are included in the Appendix, and the location of these problem areas are shown on the exhibits where address information was provided. There was a significant response of almost 10-15% of the residents responding. Only those surveys that reported drainage problems were recorded, the surveys that said there are no problems are not included in this study. This information was reviewed and factored into the determination of proposed system priorities. With areas of significant drainage problems that impact a larger group of residents getting a higher priority.

GIS Mapping – GIS digital terrain data provided by Terra Point is limited to 1-ground contours (based on a NGS 2000 adjustment), DEM, DTM, dune locations, and approximate footprints of tall buildings. Also included is information from the Galveston County Appraisal District (land parcel maps, land parcel data, and aerial photos). Other layers developed by DEC include the mapping of existing drainage areas, flow directions, storm sewer locations and sizes, and proposed improvements.

Review of Existing Drainage Criteria – Most of the existing drainage criteria for the City of Galveston is consistent with the information developed in the 1960 Galveston Master Plan by TC&B. This work determined the 2-yr design storm rainfall frequency data based on rainfall observations from 1903 to 1951. The addition of new data from 1951 to present day does not

significantly alter the original estimates. Therefore, no changes to these intensities are recommended. The minimum time of concentration of 25-minutes allows for the use of the intensity curves beyond the initial losses due to storage and infiltration. Some recommended items to add to the existing drainage criteria for development are as follows.

1. Include a formula for calculating the Rational Method Time of Concentration – TC = $15+10xA^{0.1761}$. With an area greater than 1-acre this will calculate a time of concentration equal to or greater than 25-minutes. However, the minimum 25-minutes should be used for the calculation of run-off in areas less than 1-acre.
2. Specify that proposed roadway centerline elevation shall be constructed a minimum of 1-ft. above the calculated 2-year Hydraulic Grade Line (HGL) for the drainage system, minimum roadway elevation of 5-ft. MSL (slightly higher than a 5-year Tidal Elevation for Galveston Bay), or as approved by the City Engineer. Current regulations designate an elevation of 8.2-ft, however, this is not feasible for many areas on the west end of the island. Variances should not go below the recommended 5-ft. MSL.
3. Minimum right-of-way for proposed roadways – This requirement is recommend with new developments to make sure that adequate ROW is available for storm water facilities including storm sewer and open channels. Open channel systems would require a minimum of 15-ft. on either side of the pavement limits. Storm sewer curb and gutter systems can have less than 15-ft. from back of curb to right-of way, but not less than 10-ft. for utilities or other uses. This translates to a minimum ROW of 60-ft.

Analysis of the Existing Drainage System – It was found that a significant portion of the existing drainage system is undersized for the existing drainage criteria. This evaluation was done using the assumption of a clean and debris free system. Factoring in the existing levels of sand and silt in the system and this situation gets worse. During the study period in 2002 a number of storm events caused flooding within the City of Galveston. The most significant of these was a storm on August 15th 2002. 11.46-inches was recorded at Scholes Airport in a 24-hour period that was determined to be just below a 50-year storm event (12-inch, 24 hour). However, looking at the 12-hour rainfall data this event is almost a 100-year 12-hour (11.1-inch) event since a majority of this rainfall (10.8-inch) occurred in a 12-hour period. Other observations in the City were higher but were not able to be confirmed.

Based on reviews of old construction plans much of the system was constructed using monolithic box culverts and clay pipe inlet leads. Many of these inlet leads are smaller than 18-inches in diameter. These small pipes are easily blocked by debris and silt that limit conveyance capacity. Bridge blocks, or small pipes that connect roadside gutters across intersections are also a problem in the urbanized areas of Galveston. These structures are sometimes square, or small concrete pipes (<15-inch) and generally serve areas where existing storm sewers do not exist.

Proposed Drainage System Improvements – Recommendations for proposed drainage system improvements were done for all of Galveston and Pelican Island and are shown on Exhibit 3 under a separate cover. Due to the numerous systems identified as having capacity problems with the existing criteria, the City asked for the evaluation of proposed systems based on a surcharged system with a HGL that remains below the existing ground elevations. Areas on the west side of the island were evaluated based on existing drainage patterns. If there was an area that did not have an evident outfall location then a channel and culvert was proposed. These

proposed improvements are based on the available information and represent the current conditions. Considerations for future development were not made. The primary intent is to provide information regarding the required conveyance capacity of proposed systems. Improvements shown are an assessment based on the best available information and can be modified to address changing conditions over time. The City did identify a number of specific subdivisions on the west side of Galveston Island to investigate and determine specific improvements. These include, Habla Drive, Gulf Palms Drive, Bay Harbor, Terramar Beach, Sea Isle, Bermuda Beach area and Pabst Street. The assessment of these areas is included in Section 7.C.2. Many of the problems in these subdivisions and other areas of west Galveston are localized. Some of the areas are within low-lying areas that are susceptible to tidal flooding, or are impacted by the lack of outfalls and conveyance capacity. There are a number of outfalls proposed for FM 3005 to provide increased protection of this main traffic route for the west side of the island. There are also a number of arterial roads that are low. Raising these roads to a minimum of 5-ft. MSL would provide better access to existing properties and to allow more time for evacuation during tropical storm events.

Construction Cost Estimates – Construction cost data was compiled from area contractors and available data from TxDOT and other cities in the area. Included in the cost estimates are:

- cost for earthwork
- storm sewer structures
- pavement repairs
- inlet and lateral improvements (along proposed trunk line routes only)
- dewatering along the project,
- and outfall and bulkhead construction.

Contingencies may not address all extra cost for the projects since many of these are site dependent. Environmental investigations show that there are a number of potential environmental risks that will need additional evaluation before construction on all projects. These include regulations by the Corps of Engineers (COE) for wetlands and outfalls as well as potential environmental contamination from previous activities on the island. A compilation of cost data used for this project is included in the Appendix under separate cover.

Operations and Maintenance – Currently the City of Galveston performs storm sewer maintenance using primarily the roadway maintenance crews within the roadway portion of the Public Works Department. This work generally includes street clean up of inlets and street areas as necessary. Crews usually inspect inlets before island events such as Mardi Gras and then remove trash and other debris after the events to prevent clogging. These crews are also asked to fix drainage problems during storm events by clearing blocked storm drains. Street sweepers are used along seawall and downtown areas on a daily basis. Recently a newer group has started within the Recycling Group part of the Sanitation Department. This group does a more extensive clean-up effort that is geared to cleaning the entire drainage system starting with the roadway gutters and continuing to the inlets, storm sewer leads and main storm sewer trunk lines. These efforts have improved drainage in some areas considerably and are identifying structural problems within the existing drainage system. However, this process is slow and the work is only being done when time and personnel are available. Due to the limited maintenance of the past there has been a large accumulation of debris in the existing system. The addition of more

crews dedicated to the extensive cleaning of the existing storm sewer is necessary to make progress and to provide evidence of improvements for the residents and businesses on the island. While this work is going on, specific drainage problems such as inadequate driveway drains, structural problems or other drainage impediments can be identified and dealt with as part of the ongoing maintenance of the system. Enforcement of existing drainage regulations and the development of additional statutes may be necessary to provide incentive for property owners to correct problems identified with property owners, or give the City authority to correct problems within the public right-of-way if necessary.

Capital Improvement Program and Determination of Equitable Storm Water Rate Fee – Based on the evaluation of proposed storm sewer improvements within the City of Galveston two major system improvements have been given the highest priority. This includes the 11th-13th Street System and the 18th Street System. 11th-13th Street was selected due to proximity to UTMB, which is a major employer for the City of Galveston. A number of complaints were collected from people having trouble reaching the hospital during rain events. 18th Street was selected due to the number of drainage problems reported per acre of drainage area as well as the number of structural flooding events in this area. The total of these improvements is approximately $10.8 million dollars including an estimate of 35% of construction cost for construction management engineering and design. The Mid Priority systems are spread across the main portion of the City, and the Low Priority systems are very large projects that will take a significant amount of investment before results are seen in neighborhood areas. Priorities were primarily distributed based on flooding complaints. Areas where elevations are low and where tidal flooding is more prevalent are given less priority. The cost of additional storm sewers in these areas would only provide minimal improvements and would not be cost effective. Areas on the west side of Galveston Island were not given a high priority since many of the projects are small. It is likely that these projects can be fit in to when funds are available over a period of time. Cost for additional minor stems from these major trunk line improvements are not included in this study. This is primarily due to the budget limitations. These extensions will become necessary over time to extend the drainage system to unserved areas and to replace bridge blocks where necessary.

The estimated cost of all drainage projects in the Capital Improvement Plan (CIP) including the airport plan is $94 million. Due to the high cost of the CIP a breakdown of different CIP plan levels was prepared on Table 9. This shows three different CIP plan options. Plan 1 includes everything except the airport work that is considered under a separate budget. Plan 2 includes both the high priority and mid priority projects, and Plan 3 includes both the 51st Street and 29th/30th Street projects. Based on the totals on this table other combinations can be considered as needs become evident. Table 10 presents the expected annual cost based on different spending plans and CIP periods. Inflation is not considered in these estimates and all dollars are based on current value.

An Equitable Storm Sewer Rate Fee was calculated separately based solely on the standard run-off rates used for the City of Galveston. Table 11 provides a breakdown of the expected revenue based on three different collection methods. All single family homes will be set at a fixed rate, currently $3/mo. The cost to commercial, industrial and multifamily will be adjusted based on how much more run-off drains from these properties in comparison to an average single family home. Based on this analysis, using the City's rational coefficients, these properties roughly

create 8.25 times more runoff than an average single family home. This ratio has the single-family residences paying roughly 30% of the total fee and the commercial areas paying 60% of the total fee. There is not a significant area of industry on the island so these areas contribute roughly 9% of the fee. The commercial areas are paying twice as much as the residential areas. Below is a list of the expected revenue collections based on three different single family home monthly rates. Different funding levels can be determined by adjusting the cost by the ratios presented.

1. Rate 1 - $3/mo – This is the current cost to homeowners. Commercial, Industrial and Multi-family pay $25/acre/month – Total Revenue is $1.9 million.
2. Rate 2 - $4/mo – This is the amount presented to the City in a public notice. Commercial, Industrial and Multi-family pay $33/acre/month – Total Revenue is $2.5 million.
3. Rate 3 - $8/mo – This doubles Rate 2. Commercial, Industrial and Multi-family pay $66/acre/month – Total Revenue is $5.1 million.

It is recommended that the City pursue a minimum NPDES program to meet the new Federal guidelines. Also, it is recommended that the City start to pursue additional funding to develop a storm water utility that will be responsible for increasing funding to storm water facility maintenance across the island and to implement a CIP program. An increase in maintenance funding is recommended to get control of existing sediment problems. Once the system is clean and a maintenance program is able to keep up then a focus can shift to a major CIP plan. For this study the existing storm water rate fees were reviewed and determined to be inadequate to fund this proposed plan. The current system was developed on a preliminary basis to get the program going and to anticipate the effect of the EPA rules. This system does not consider runoff rates, since it is based on water meter size. Based on this analysis Rate 2 would be the best option to create a utility and moderate CIP program. Rate 3 may be required in the future for additional funding. These rates will need to be evaluated on a regular basis to make sure that funding levels are representative with the City's needs.

Galveston County Appraisal District provided all information on land uses to DEC. It is assumed that it will be possible to collect from all of these land tracts. Some areas have been exempted including; City owned property, Galveston ISD property, and State/Federal land including the Coast Guard and Galveston Island State Park. Churches, hospitals and private utilities will not be exempted. Current City of Galveston regulations designate the same rational "C" value for Industrial, Commercial and Multifamily tracts resulting in the same assessment per acre. A detailed Utility Rate Study is recommended before implementation of revised storm water utility rates. This type of study would collect additional information on existing impervious cover on individual properties. While this proposed rate structure is equitable based on City run-off methods it may not reflect the true increased run-off due to impervious area since areas can be zoned commercial without significant development. Therefore, it must be emphasized that the rates determined in this study are preliminary. New fees are likely to be legally challenged and this additional study would provide additional information to address legal challenges.

Adding additional staff based on a revised fee structure should be approached tentatively. Revenue estimates should be checked against actual collection rates to make sure that the

expected revenues are available. If revenues fall short it may be necessary to adjust rates when possible and limit implementation of the plan.

1. INTRODUCTION

This report presents the findings of the City of Galveston Master Drainage Plan. The primary purpose of this report is to develop a plan for the City of Galveston to comply with the U.S. Environmental Protection Agency (EPA) mandate regarding the storm water quality or National Pollution Discharge Elimination System (NPDES). The secondary purpose of this Plan is to evaluate existing drainage conditions on Galveston Island and Pelican Island controlled by the City of Galveston (including Galveston County MUD #1, but not including Jamaica Beach, a separate city), and to recommend improvements that can be phased in over a period of years. This Plan will include elements of NPDES, storm sewer, surface drainage, environmental conditions, and public involvement. This plan is not intended to address flooding issues associated with tropical weather events such as hurricanes, tropical storms and depressions. The high tides and storm surges that occur during these events are beyond the scope of this study.

Galveston Island is a barrier island along the Texas Gulf Coast, and the City of Galveston is the largest island community in the United States established on a barrier island. The Gulf of Mexico is the southern boundary, and Galveston Bay forms the northern boundary of the island. This geographic location results in a number of natural events and conditions that impact drainage on the island. These events include periodic tropical storms, or hurricanes that originate in the Gulf of Mexico and create intense rainfall and are also accompanied by high tides that cause severe flooding of the lower elevations on the island. After the 1900 Hurricane, the eastern portions of the island were raised behind a seawall completed in various stages from 1904 to 1961. Areas west of the seawall retain the natural barrier island characteristics.

In addition to storm water another contributor to the storm drainage system on Galveston Island is the sand itself. Galveston Island sand is very fine and easily gets airborne due to the prevailing onshore breeze. This sand is deposited over the areas directly adjacent to the beach side of the island and eventually drains into and gets deposited into the storm sewer system. The sand in addition to other sediments draining into the storm sewer system creates an on-going maintenance problem on the island that is a major concern.

2. PROJECT TEAM

As part of the new Federal Phase II NPDES requirements the City of Galveston is required to submit a plan regarding their storm water facilities. A project team was assembled to address the City's needs. Dannenbaum Engineering Corporation is the prime and is responsible for the final plan that includes the analysis of the existing drainage systems on Galveston Island, the development of a Capital Improvement Program and an estimation of an equitable storm water fee for funding new drainage related programs and projects. Subconsultants were assembled to address other portions of the plan. The primary goal was to meet the new NPDES guidelines. Dodson compiled the following separate reports that deal with NPDES issues on Galveston Island:

- Draft Storm Water Management Plan (NPDES Phase II) for the City of Galveston – This report outlines the requirements of the TCEQ Small MS4 Permit that is required for the City of Galveston. Included is a minimum of six measures to

reduce storm water pollution. These include; public education, public participation, illicit discharge detection, good housekeeping, construction site permitting, and post-construction storm water management.

Storm Water Pollution Prevention Plans listed below were required to bring City facilities in compliance with the current NPDES regulations.

- Storm Water Pollution Prevention Plan – Main Wastewater Treatment Facility
- Storm Water Pollution Prevention Plan – Airport Wastewater Treatment Facility
- Storm Water Pollution Prevention Plan – Island Transit Maintenance Facility
- Storm Water Pollution Prevention Plan – Scholes International Airport

The second goal was an evaluation of the existing storm sewers on Galveston Island and determines specific drainage improvements, a CIP, and determines funding levels necessary to implement the NPDES program, maintain the current drainage system and funding for a CIP, by Dannenbaum Inc. Mapping the current drainage system and identifying outfall locations is required under the current NPDES regulations. TerraPoint developed elevation and contour data for Galveston Island that established the base topography for this study using the latest laser range finding technology. Berg Oliver and Associates, Inc evaluated environmental conditions on Galveston and Pelican Island. Berg-Oliver has produced the following documents to accompany this study:

- Environmental Baseline Overview – Galveston and Pelican Island, Texas – Gives an overview of the environmental conditions on Galveston and Pelican Island based on historical information. This includes wetlands, endangered species habitat, and the location of other potential environmental hazards created by human activities on the islands.
- Environmental Baseline Exhibits – These are exhibits of both islands that graphically show the information presented in the baseline report.
- Preliminary Environmental Assessment of Selected Storm Sewer Routes – This report is a preliminary assessment of some of the primary storm sewer routes selected based on the analysis of the existing storm sewer presented in this report and includes an outline of potential environmental and archeological hazards.

All public relations matters were coordinated with Kathy Thomas Barr who has been working in the Galveston area for a number of years. She has extensive knowledge of the existing organizations on the island and helped prepare the public surveys and the September 16th, 2002 Public Hearing.

3. PROJECT DATUMS AND BENCHMARKS

Elevation data for this project was collected by using the LIDAR system by TerraPoint. This system is based on laser range finding equipment mounted on an airplane and flown over Galveston Island. Data is acquired using the WGS84 reference ellipsoid. All GPS data was processed to Orthometric Heights (Mean Sea Level) using the Geoid99 model using the Harris-Galveston Costal Subsidence District 2000 network survey of benchmarks. The final data sets are projected to State Plane, Texas South-central, Datum NAD83 (North America Datum 1983). All units for information are in feet. The accuracy of this data is plus or minus 6-inches in level

areas. Contours are provided at 1-foot intervals. The following monuments were used for the LIDAR data (HGCSD 60, HGCSD 62, HGCSD 63).

Other field survey work was also done to confirm the LIDAR data, confirm storm sewer elevation conversions, and determine sediment levels within the existing storm sewer at various locations in the system. This data was tied into the LIDAR elevation data and based on a GPS. Benchmarks tied into this survey include the HGCSD 60, 62 and 63, TxDOT and GI-3. Elevations are based on the State Plane Coordinate System, South Central Zone, Grid, NAD 83, NAVD 88, HGCSD 2000 Adjusted. Detailed below are some City of Galveston benchmarks that were tied to the NGS, 2000 adjustment for this project:

HGCSD 60	Elevation = 5.31-ft., (2000 adj.)
HGCSD 62	Elevation = 6.18-ft., (2000 adj.)
HGCSD 63	Elevation = 2.35-ft., (2000 adj.)
City of Galveston GI-2	Elevation = 4.43-ft., (2000 adj.)
TxDOT	Elevation = 4.23-ft., (2000 adj.)

4. DATA COLLECTION/GIS MAPPING

Data collection included the review of previous studies and recommendations, interviewing City staff for first hand knowledge, reviewing construction plans where available, and a general reconnaissance of the island to get an assessment of the current conditions and view areas where drainage problems have been noted. A large amount of information on the existing storm sewer systems from previous studies, survey and construction drawings was collected, however, not all of this information can be verified completely and some inaccuracies may exist. As part of this effort the data collected is added to a GIS (Graphical Information System) for Galveston Island. This includes aerial photos of the island, ground contours, locations of existing storm sewer trunk lines and sizes, resident survey locations, environmental data, and locations for proposed improvements. This study focuses on the storm sewer trunk lines. Inlets and other small laterals are not identified within this study. However, locations of Bridge Blocks (small culverts passing under the roadways connecting gutters) along Broadway Boulevard have been located. The following is a listing of previous studies and information used for this project:

- Paving and Drainage System Improvements for the City of Galveston, April 1960 – by Turner & Collie Consulting Engineers
- City of Galveston Comprehensive Storm Sewer Plan, Topic: Update 1983-1998 – by Harvey Scheffer & Associates, Inc.
- Pelican Island Drainage Study 1990 – by the City of Galveston
- Broadway Drainage Study February 1994 – by the City of Galveston
- Scholes International Airport Galveston, Texas Drainage Study- November 2001 – Klotz Associates, Inc.
- City of Galveston – Minimum Requirements for Internal (Site) Drainage
- FM 3005 Drainage Study – by TxDOT and currently in progress, expected completion late 2003

5. DRAINAGE CRITERIA EVALUATION

The existing drainage and development criteria for the City of Galveston was collected and reviewed. Much of the current criteria is based on the Paving and Drainage Improvement Study by Turner and Collie in 1960. The following is a summary of the primary drainage criteria that pertains to storm sewer drainage on Galveston Island.

Rainfall Frequency	2-Years (Based on 1960 Study)
Minimum Time of Concentration	25 Minutes
Starting Water Surface Elevation	1.5-ft (msl-mean tide) (Design Standards) 1.6-ft (msl) in City Study
Manning's Roughness	0.013 (RCP)
Runoff Coefficients	0.30 – Undeveloped Areas 0.50 – Minimum Developed Areas 0.70 – Lots less than 7,000 SF or areas where there are extensive paved areas
Minimum Storm Sewer Size	18-inch
Storm Sewer Material	- Concrete with rubber joints, alternates must be approved by City Engineer - Use of CMP is prohibited

The drainage criterion for the City has been researched very thoroughly in past studies. Rainfall intensities for the 2-year storm frequency were developed considering typical infiltration and evaporation rates. Much of the design criteria are very similar to other communities within the Houston/Galveston area. However, the tidal impacts do set Galveston apart from other communities. An elevation of the 3.0-ft. MLT (mean low tide) converted to mean sea level by – 1.41-ft. to 1.59-ft. MSL (mean sea level) was presented in the 1960 report. As outlined in the previous study there is no justification for using a higher elevation that would be more stringent and impact the size and cost of proposed storm sewer facilities. Use of this elevation for a design tailwater respects the probability that during most normal rain events tides are not abnormally high, and that there is no correlation between rainfall and tide elevations. Other stronger storm events that do impact tidal elevations occur less frequently than the 2-year storm event and should not be considered in the determination of the design tailwater. Some differences have been found in past studies, and the tailwater criteria ranges from 1.5-ft. in the City drainage criteria to 1.6-ft. in studies by the City Engineer and differ only slightly from that used in the 1960 report.

The evaluation of existing storm sewer systems within Galveston Island was done using the hydrologic criteria above as used with previous studies. Pelican Island and west end areas generally do not have storm sewer systems, however, the same 2-year rainfall rates apply. In addition to the above drainage criteria, the following is a list of other drainage related criteria for Galveston Island development. This information was taken from the City's "Minimum Requirements for Internal (Site) Drainage" and rules outlined in the Subdivision Regulations:

1. Internal site drainage plans are required for sites larger than 15,000 square feet or having a frontage wider than 150-ft. Tracts 15,000 square feet and/or no deeper than 150-ft. can drain directly to the City system without an internal drainage system, as long as none of the drainage is directed to adjacent property owners. Subdividing tracts to meet this minimum size will not be permitted.
2. All new developments must drain north to Galveston Bay or connect to an existing drainage system that drains to the north side of the island. Drainage to the seawall, or beach areas is prohibited.
3. Where existing drainage crosses the site, the developer shall be required to provide an adequate drainage easement to allow for the conveyance of existing and future flows across the site. The developer shall in no way interfere with the existing or future drainage of upstream property unless alternate drainage facilities are provided at the expense of the developer.
4. Minimum developed run-off rates:
   A. Commercial – 2 cfs/acre
   B. Residential – 1.5cfs/acre
   C. Undeveloped – 0.8cfs/acre
5. Any development draining to a TxDOT facility must get TxDOT approval prior to City approval. TxDOT shall be notified prior to construction activities for inspection purposes.
6. Driveway culverts or other cross-drainage facilities within the City right-of-way must be sized based on upstream drainage areas and expected level of development. The City currently specifies the required driveway culvert sizes if not submitted by a registered engineer. Minimum culvert size is 18-inch in areas unserved by a curb and gutter storm sewer system.
7. Current rules allow the use of 15-inch pipe from private areas to City right-of-way.
8. Maximum distance to an inlet is 1,000 ft.
9. Minimum roadway crown elevation is 8.2-ft.unless given written approval of a lower elevation by the City Engineer. (This elevation is the approximate 25-yr tidal elevation for Galveston Bay)
10. New buildings shall be not less than 1-ft. above the centerline elevation of the street, or 1-ft. above the highest elevation within 6-ft. of the building site.
11. For developments over 5-acres, minimum first floor elevations based on FEMA information for homes east of 103rd Street shall be 12-ft, and west of 103rd Street shall be 13-ft.
12. Minimum gradient of streets and gutters is 0.15%.

Other sources of existing building standards include the City of Galveston Subdivision Regulations from the Planning Department. Based on review there are no specific drainage regulations in these documents. However, all proposed developments should be discussed with the City Engineer to identify potential problems in proximity to the project prior to design.

6. EXISTING STORM WATER FACILITY MAINTENANCE OPERATIONS

The storm sewer maintenance operations primarily focus on street cleaning and removing debris from storm drain inlets in the streets. Sources of debris include trash from the public, leaves,

grass and other yard debris, and sand from beach areas. Based on interviews with the City staff the current City of Galveston storm sewer maintenance operations consist of two teams. The primary team is under the Public Works Department and is responsible for most street and inlet cleaning activities. A second team has recently been started within the Sanitation Department (a start of a Drainage Utility Division) and has been focusing on extensive cleaning of the existing storm sewers in neighborhoods. Each team has access to a pump truck that can clean out storm sewers once the sediment material has been turned into slurry. The pump trucks are also shared with the wastewater services if necessary, trucks operated by the Wastewater Division are generally not available to the storm sewer crews. Two street sweepers are available to periodically sweep the streets. Generally the sweepers currently are scheduled to sweep the seawall area, and central downtown areas near the Strand. Staff reports that vehicles on the side of the road usually hinder their sweeper activities. Much of the work to clean the existing drainage systems has been cosmetic to date due to limited resources and failed to remove sediments within the storm sewer system. This has allowed a large quantity of sediment to collect in the storm sewer system. Utility crossings within the storm sewer system and other physical constrictions have contributed to this problem. The recent focus on neighborhoods and the removal of material within the roadway gutters, inlets and storm sewers has been much more effective on improving drainage in small areas. However, this work is very labor intensive and in some cases takes days to complete a block. Staff reports that with the current staffing levels they will likely never get ahead of the sediment problems on the island unless more crews and equipment are implemented.

City maintenance crews are also responsible for maintaining existing roadsides and other earthen ditches on the island. These areas are primarily west of Scholes International Airport. The City has some equipment available to clean out existing ditches, however, currently there is no rotating maintenance program for the routine cleaning of existing drainage ditches on the island. The Texas Department of Transportation (TxDOT) maintains a number of the roadways on the island including SH 87 (Broadway), SH 275 (Harborside), Spur 342(61st Street), FM 3005, FM 188(Teichman Road), and Spur 168(to Corps of Engineers and Coast Guard). However, the maintenance agreement with the City is limited to only roadway maintenance. TxDOT does maintain the storm sewer and ditch systems on Interstate Highways (IH-45). All other storm sewers and outfall ditches are generally the maintenance responsibility of the City of Galveston. TxDOT does, however, provide periodic maintenance, but is not directly involved in the drainage facility maintenance on the island on a day-to-day basis.

7. EXISTING CONDITIONS SYSTEM

This section reviews the current status of the existing drainage systems of Galveston Island. Essentially the island can be broken into two separate areas. Storm sewer served areas or surface drainage areas. Storm sewer is the primary collection system within the east side of Galveston Island behind the seawall from Scholes Airport east. West of the airport the primary drainage system is open channels with culverts and/or bridges. There are some subdivisions on the west side of the island that have storm sewer systems, however, these systems generally supplement the open channel collection system in place. Drainage areas have been determined based on the LIDAR contour data obtained for this project. General high and low areas forming the drainage boundaries were initially found by running an analysis with the ArcMAP GIS software. This

resulted in numerous odd shaped boundaries and identified high and low areas. Using this information on top of the existing storm sewer and drainage channel networks on the island allowed for the determination of drainage system boundaries. For this study a "drainage system" is considered an area draining to a particular outfall location. However, on Galveston there are a number of systems that are interconnected with each other. System boundaries in some areas are arbitrary, and divided based on the interconnection of storm sewers. Generally, drainage areas were modified to fit better with the general alignment of roadways and properties if appropriate. Drainage boundaries were set at roadways to facilitate the calculation of flows for existing, or proposed roadway cross-drainage structures in primarily the west half of Galveston Island.

Based on field visits to the Island and the inspection of drainage facilities, the primary problem at this time is the collection of sediments and debris within the current drainage systems that limit storm sewer and inlet conveyance capacities, in addition there is an absence of inlets and lateral storm sewers. For the following analysis the storm sewer drainage systems are assumed to be clean of debris, and that inlet capacities are sufficient to collect the run-off from adjacent areas. Many inlets on the island are easily clogged or have small 8-12-inch clay pipe leads. However, the analysis of individual storm inlet capacity and minor laterals of the system is beyond the scope of this report. This study focuses on the evaluation of the existing storm sewer trunk lines. Inlets and leads may or may not be sufficient to collect the Galveston 2-year frequency storm flows. An evaluation of these existing inlets and storm sewer leads needs to be done during the preliminary engineering of proposed storm sewer improvements.

Information regarding storm sewer flowline elevations and depths were taken from as-built plans when available and supplemented with spot field survey information. In many cases existing manholes are covered and there is no way to verify depths. For a majority of the existing storm sewer systems, assumptions were needed to develop a model of the existing storm sewer systems. Ground elevations were determined based on the LIDAR elevations within the street intersections. Where minimal information was available storm sewer profiles were developed based on typical storm sewer depths determined upon review of other storm sewer plans. For example, many monolithic box storm sewers were built with approximately 1-2-ft. of cover and at the slope of the roadway. Capacities of open channels are determined by using an estimate based on the Manning's formula using an average existing cross-section and slope. The following is a summary of our findings:

A. Storm Sewer Systems

The existing storm sewer systems were mapped based on previous studies and supplemented based on information collected from the City of Galveston. Each storm sewer system was labeled based on the primary outfall point location. A storm sewer outfall at the Ship Channel and 20th Street the system would be identified as the 20th Street System. Systems that are interconnected and have multiple outfall points many include a range of street names to identify the outfall location.

The storm sewer analysis was done using the Haestad Methods computer program StormCAD. This tool was chosen because it allowed multiple drainage systems to be run concurrently and include flow diversions between systems. Another advantage was the ability to transfer results to the GIS for presentation purposes. Naming conventions for the storm sewer elements are based on previous work by the City Engineer. Storm sewer

calculation points or nodes are labeled based on the roadway intersection. If a node is located at 20th Street and Ave E then the node is named 20E. Storm sewer elements between the nodes are named based on the name of the upstream and downstream node name. For example a storm sewer from 20th Street and Ave E to 20th Street and Ave A would be named "20E-20A". Some streets have more than one name and for simplicity the avenue letter or street number was used where appropriate. Other areas street names are longer and abbreviations were necessary to limit the length of labels.

Results of the analysis are shown on the maps provided, and Table 1 presents the hydraulic results for each system, and Exhibit 3 (The City of Galveston Block Maps under separate cover, also Appendix 1 without aerial photos) provides a layout of the existing drainage system labeling analysis locations. Also, included on Exhibit 3 are locations of residential drainage surveys based on either intersection or address where available. The following is a summary of the general condition of the existing major storm sewer and drainage facilities within Galveston Island.

Ferry Road – The Ferry Road System is approximately 144-acres and collects a majority of the Lindale subdivision area. Near the ferry landing there is a drainage channel parallel and east of Ferry Road that drains toward an area just southeast of the ferry landing beyond the parking areas. This channel also drains portions of the Corps of Engineers property just east of the ferry landing area. Based on available information the outfall is a 54-inch pipe from Ferry Road and the system has an average grade of 0.10%. Field visits show that there are 2-54-inch outfall pipes just north of the north ferry landing. Both of these pipes extend east towards a drainage ditch just east of Ferry Road (described above). The Ferry Road storm sewer (54-inch) ties into these pipes. Estimated 2-year flow is 204 cfs for the system. The entire system has capacity problems with the lowest areas from Whiting to Avalon Bay experiencing the worst ponding. Flooding reports have been documented at Albacore, Bonita and Tuna. Elevations in this area are from 6 to 8-ft. Inlet capacities in this area along with the storm sewer limitations contribute to ponding in this area. However, based on this analysis the outfall does have capacity for the 2-year storm event.

The 4th Street System – This is a relatively small system (approximately 24-acres) that drains the intersection of Harborside and 4th Street north through the Galveston Yacht Club area. The outfall for this system is a 42-inch pipe and the average slope of the system is 0.08%. Estimated 2-year flow is 41 cfs for this system. The outfall channel has a full capacity of 32 cfs, however, the system is adequate for the 2-year design flow and there is a minimum of 1-foot of freeboard within the system.

9th Street System – This system drains approximately 157-acres of land from the seawall area near 1st Street west to 6th Street/University. University is a drainage boundary for this system and is located along an old seawall alignment. The primary trunk lines for this system extend along 2nd Street down Texas to the UTMB area, and a second line extending south along 4th and 5th Streets. The main trunk through UTMB is a 7'x 5' box culvert that goes under a building and outfalls to a harbor just north of UTMB near the heliport on Harborside Drive. Full flow capacity is 161 cfs. Estimated 2-year flow at the outfall is 210 cfs. Modeling shows that the trunk line on 4th and 5th Street has the worst

problems with the HGL out of the ground in these areas. There has been some flooding reported in the San Marino neighborhood that may be due to a lack of inlets and storm sewer connections to the 2nd Street System that has excess capacity available. The lowest points in this system are at Harborside and Ferry Road and at Harborside just north of UTMB between 5 and 6-ft.

11th Street System – This system drains approximately 225-acres of land from 6th/University to approximately 12th Street. The primary trunk line extends along 11th Street to Ave K and outfalls via a 72-inch pipe, which drains an estimated 2-yr peak flow of 328 cfs. Full flow capacity of this 72-inch pipe is approximately 160 cfs. System updates along Winnie from 7th Street to 11th and along 11th Street have not eliminated ponding problems in this area. The worst ponding areas are near UTMB at Market from 8th to 9th Street. This is one of the lowest parts of the area and sheet flow collects from areas to the south and UTMB areas to the north. Harborside Drive is higher and along with the elevated buildings in UTMB acts to trap water in this area. A pump station, operated by UTMB, pumps storm water to the 9th Street System when necessary. The storm sewer trunk in this area is inadequate and due to the utility and building conflicts in the area would be difficult to enlarge. Capacities at the outfall show that the system outlet needs to double in size to provide sufficient conveyance for the design 2-year flows for this drainage system. There is an existing 4'x 3' box that ties the 11th Street System with the 14th Street System along Ave B. Based on the information provided by the City, this box storm sewer has a high area at 13th Street. Our study of this pipe bypass shows that there is little bypass flow through this box. Therefore, to simplify modeling, this line was split at 13th Street. The general trend is for water to flow from 14th Street to 11th Street through this bypass along Ave B due to the elevation difference. Areas with the worst capacity problems include 11th Street from Winnie to Broadway and a storm lateral along 9th Street south of Winnie. Hydraulic grade lines are out of the ground for most of this system. The drainage survey reports show that the worst areas are along Ball Street south to Ave K as well as the UTMB area discussed above. Along Broadway there are only inlets at 9th Street with no bridge blocks evident within this area. Ave K is the primary collector in this area and it has about half of the capacity required for the existing drainage area.

14th Street System – This system drains approximately 172-acres along 14th Street from the seawall north to Harborside. The outfall is an 8'x 3' box culvert and a 36-inch pipe from Ave B, and the system has an average slope of 0.06%. Estimated 2-year flow for this system is 244 cfs. Full flow capacity for both pipes is approximately 103 cfs. Existing storm sewer analysis indicates that the HGL would be above the ground for most of this system. The lowest areas are from Harborside to Ave B with ground elevations between 4 and 5-ft. Storm water ponding problems are calculated at intersections with Ave H and Ave D. Drainage survey reports from this area also describe problems within the area just east of 14th Street away from the main trunk line, and at Ave K, Broadway and Ball Streets.

15th Street System – This is a small system with a drainage area of approximately 15-acres. The design flow of this system is 17 cfs through a 30-inch outfall pipe. Information on this system is limited and slopes are unknown. Flows are representative

of a 3-4 ft/s design velocity that is desirable. This system is adequate to keep design 2-year HGL below the existing ground level, however, the freeboard is less than 1-foot. Survey results show some ponding problems at the Mechanic intersection that may be due more to a combination inlet capacity, elevation and location more than trunk line capacity.

16th Street System – This system drains approximately 21-acres from Harborside north to Market Street. The design flow of this system is 45 cfs through a 24-inch outfall pipe with a full flow capacity of 8.8 cfs. HGL's are above the ground in this area. Survey results describe storm water ponding at Market Street. However, elevations at Harborside are between 3 and 4-ft, and indicate that this area is susceptible to tidal flooding.

18th Street System – This system drains approximately 32-acres from Market Street to Harborside. Previous studies showed the outfall to be a 36-inch pipe, however, the City noted that this outfall has been replaced with a 48-inch pipe. The design flow for this system is 60 cfs through a 48-inch outfall pipe with a capacity of approximately 45 cfs. The HGL of this system is in the ground. Survey results are limited in this area but do indicate drainage problems at Market Street. This could be caused by limited inlet capacity in the area.

19th Street System – This system drains approximately 190-acres from the seawall north to Harborside. The design 2-year flow for this system is approximately 304 cfs through the existing 5.5'x 3.5' box culvert outfall to the Ship Channel. Based on the storm sewer analysis, the HGL of this system is out of the ground with the worst locations between Ave I and K. Based on field investigations bridge blocks exist at Broadway within this drainage area at 17th, 18th, 20th and 21st Streets. Survey results are extensive within the drainage area of this system. From Post Office south to Broadway east of 19th only small 18-inch laterals exist. Due to the many complaints from these areas, these systems are likely to be clogged. South of Broadway the storm sewer system extends as far as Ave M, however, there are six additional blocks south to the seawall that have no evident storm sewer service. Outfall improvement is limited since the outfall extends under an existing building owned by UTMB. (Formerly known as the Lipton Tea Building.)

20th Street System – This system drains approximately 26-acres from Winnie north to the Ship Channel. The design 2-year flow for this system is approximately 54 cfs through an existing 40-inch elliptical pipe. At Harborside north to the Ship Channel the storm sewer has been upgraded, including a box culvert at Harborside to avoid a sanitary sewer conflict and an upgraded 54-inch elliptical pipe within one block north of Harborside through the Port of Galveston facilities. Heavy flooding is reported from Market to Mechanic Street where there is an existing trolley stop. Elevations around 4-ft. also contribute to flooding when tides are high. Survey results report the above problems as well as the Strand intersection where elevations are near 4-ft. The outfall for this system is under a dock area that is clear of existing buildings.

22nd and 24th Street System – This system drains approximately 240-acres from the seawall north to the Galveston Ship Channel, most of the system is along 23rd St. The

combined design flow for this system is approximately 439 cfs. This system is interconnected at Ave K and 22nd Street. Outfalls include a 72-inch pipe at 23rd Street and an 8'x 3' box culvert at 24th Street. Model results show that the HGL is primarily out of the ground for most of the system with 23rd from Ave K to P the most problematic. Survey reports from residents' point to a large flooding problem along 23rd from Ave P to Ave N just north of the seawall. Businesses have been flooded within this drainage system area. The current outfall pipes through the Port of Galveston and under existing buildings.

25th and 27th Street System – This system drains approximately 187-acres from the seawall north to the Ship Channel. The combined design flow is approximately 124 cfs with a diversion of approximately 68 cfs at Ave M. Outfalls include a 36-inch pipe at 25th Street (estimated 2-year flow of 36 cfs), a 6'x 2.25' box at 26th Street, (estimated 2-year flow of 78 cfs), and a 4.5'x 3.25' box at 27th Street (estimated 2-year flow of 10 cfs). This system is interconnected to the storm sewer on Ave M. At this location there is a 4'x 2.25' box in each direction, and a diversion was estimated to balance the hydraulic grade line in this location between systems. The outflows determined at 25th and 26th are beyond the capacity of the existing pipes, however, the 27th Street outfall has excess capacity. A portion of the 27th Street line was replaced recently with a section of 54-inch Hobas fiberglass pipe under a grain processing facility with a capacity of 137 cfs. Modeling shows that approximately 10 cfs is getting to this outfall location, and the 42-inch interconnection along Harborside to 26th Street is not very effective. Problem areas in this system are east of 26th Street, with the areas along 25th Street from Ave F to H the most problematic. Drainage survey reports indicate that flooding is a primary concern south of Broadway along 25th Street. There are currently no storm sewer systems at the intersection of Broadway and 25th Street. There was also one business that reported flooding at 25th and Market Street. The current outfalls go through the cruise terminal area and replacement of these storm sewers may be difficult.

29th Street System – This system drains approximately 104-acres from Broadway north to the Ship Channel and collects 28th and 30th Streets with laterals. Bridge blocks at Broadway are located at each one of these streets. The design flow at the 72-inch outfall is 182 cfs and is beyond the current capacity of 134 cfs. This storm sewer system does not extend to Broadway. Based on the resident drainage surveys most flooding reports are at or near Broadway where there are no storm sewers. Drainage in this area is via overland flow to the existing bridge blocks crossing Broadway. Clogging problems and the limited capacity of these existing bridge blocks contribute to ponding south of Broadway. Property flooding has been reported along 30th Street at Broadway and Ave I.

33rd to 41st Street System – This system drains approximately 911-acres and has two primary outfalls at 33rd Street via an 8'x 3' box, and 41st via a 6'x 3.5' box. Outfall capacity is limited. At 33rd Street the pipe capacity is estimated to be 91.6 cfs with a design flow of 522 cfs, and at 41st Street the pipe capacity is estimated to be 80.4 cfs with a design flow of 498.5 cfs. This system is also interconnected to the 45th Street outfall and Ave K outfall to Offats Bayou. Each of these systems also has capacity problems. As with most of the island this area is very flat and available pipe slopes are minimal. Earlier investigations have also found that there is a sediment problem in this system. In

addition, a 30-inch water transmission main along Ave G obstructs flow at 33rd Street. The manhole at Ave K and 43rd Street near a cemetery was found to be full of sand. Other problems include areas south of Ave M that have either small storm sewer laterals with minimal capacity, or no storm sewer coverage. Survey reports show that 39th Street south of Ave M is a prevalent problem with some property flooding, and hydraulic results verify that this system is undersized to serve this area. Other reports include problems on 29th Street south of Ave M after a roadway resurfacing project where some property flooding has also been reported. Due to the multiple interconnects with this system a balance of HGL between systems was made to best simulate existing diversion rates. The 33rd Street System also collects portions of the Port of Galveston. Existing French drain systems drain the rail yard areas from 36th to 31st Street.

37th Street System – This system drains approximately 188-acres and has design flow of approximately 253 cfs. The outfall is a 6'x 4.5' box culvert that extends under a few buildings and has a calculated capacity of 109 cfs. HGL's for this system are generally out of the ground with the storm sewer laterals on Ave H and F having the most problems. A 30-inch water main crosses this system along Ave G and obstructs the storm sewer at this location. Bridge blocks under Broadway are located under 36th, 38th and 39th Street, and storm inlets can be seen at Broadway and 37th and 40th Street. Drainage survey results show that most complaints are concentrated along Broadway and south to Ave L within this system.

45th Street System – This system drains approximately 142-acres of a 1,053-acre system that is interconnected with the 33rd - 41st Street System and extends from Broadway north to the Ship Channel. The 45th Street outfall is only one of three outfalls for this area. The West Ave K System is also interconnected just south of Broadway. Flow diversions were used to balance flows across these multiple outfalls by balancing the HGL across each system. The 45th Street System drainage area is considered downstream from the interconnect with the 33rd-41st Street System. Approximately 230 cfs is diverted into this system from the connection at 43rd and Ave J. This is a primarily an industrial and commercial area. Modeling results show a design flow of 390 cfs through the existing 5'x 3' box outfall that only has an approximate capacity of 52 cfs. The drainage survey results report flooding problems along 43rd Street at Ave F and G where no existing storm sewers has been found, however, this is downstream of the storm sewer diversion location and may be representative of storm sewer overflows at this location. No verification of this assessment has been made.

West Ave K System – This system drains approximately 295-acres and is interconnected with the 33rd and 41st Street systems as well as the upper portions of the 25th and 27th Street System. Drainage area coverage extends from Broadway south to Ave O and from near 45th Street to Offats Bayou to the west. The system has an estimated design flow of 450 cfs for an existing 9'x 4' box culvert that only has a capacity of 158 cfs. This storm sewer goes through a residential neighborhood and under existing homes. Upgrading this system through the neighborhood would be difficult at the current outfall locations. Hydraulic results show that the HGL will be above the ground for most of this system. Drainage survey reports include numerous flooding reports for this area. The primary storm sewer along Ave K has insufficient capacity, as well as the connecting system on

53rd and Ave O. Property ponding is mainly along Alamo and Ave K, with reports on Ave O and 45th, and Ave M and 50th. Areas along the north side of Broadway from 57th Street to 47th Street generally drain to the north. Some of this area has been included in the K System, however, if this area were taken from the system there would still be a capacity problem. Significant sediment build-up in the K System has been verified in field visits near the cemetery. Cleaning would help reduce the severity of the current problems, but would not solve the fundamental capacity problems found from the analysis of a clean system.

North Bayou Shore Area between System K and System P – This area drains to Offats Bayou, approximately 40-acres and has a small storm sewer system. There is some flooding reported in this area and a limited number of storm inlets. Capacities of the adjacent systems in this area are also insufficient and a diverting flow to these other outfalls is not recommended. Older master plans show that there is a 24-inch outfall at Lafitte, and possibly an 18-inch outfall at Stewart Road and Bayou Shore. There are not many drainage survey complaints from this area.

West Ave P System – This system drains approximately 394-acres from the seawall and 41st northwest to Ave P and Bayou Shore where there is a 9'x 4' box outfall under an existing home to Offats Bayou. An estimated design flow for this system is 492 cfs and the full flow outfall capacity is approximately 162 cfs. The HGL of this system is above the ground in most places with the worst areas along Ave P from 53rd to 45th and along a storm sewer lateral on 47th Street south of Ave P to Ave N1/2. Much of this area is not served by an existing storm sewer system, and most complaints are in these areas. Sheet flow must travel six blocks in some areas before being collected in a storm sewer system that may or may not have sufficient inlet capacity.

Bayou Shore System/57th Street - This system drains approximately 340-acres from Fort Crockett and the seawall north along 57th Street to Offats Bayou. The outfall for this system is a 3-6'x 6' box structure that is under an existing home at the corner of Bayou Shore (southeast corner of Offats Bayou) and has sufficient capacity for this system. This system outfall has an excess capacity that may be due to the incomplete run of 8'x 6' box along Ave Q that extends from 57th Street to 53rd Street. Earlier studies show that the extension of this lateral to 43rd Street has been proposed and would add a significant amount of drainage area to this system. Drainage survey results show numerous complaints around Heards Lane. Heards is very low in elevation and storm water ponding is likely due to tidal flooding in many cases, and not pipe capacity. Elevations are around 3-4-ft. at this location and flooding due to high tides is common in this area. Other survey results show that there are storm water ponding problems near Ave R1/2 and 57th Street as well as areas just north of Ft. Crockett at the extremity of the storm sewer system. Earlier studies indicate a potential connection to the Grover Street System via Ave R, however, this connection has not able to be confirmed with survey information.

59th Street System – This system drains approximately 32-acres of area along 59th Street from Ave R north. Much of this area is very low and subject to tidal flooding, especially south Heards Lane. The outfall is a 36-inch pipe to Offats Bayou and goes under Shore

Drive, which is relatively high, compared to Heards Lane, and existing homes. Shore Drive, therefore, blocks sheet flows to Offats Bayou and creates ponding problems on Heards Lane in addition to the tidal problems associated with this area. Hydraulic results show that the existing full pipe capacity is 21 cfs, which is 60% below the calculated design flow of 48 cfs. A general review of sheet flow conditions in this area shows that 61st is higher in elevation than areas north of Saladia/57th Street blocking flows to the west. Ponding would need to exceed 3-ft, at an elevation of approximately 5-ft, before sheet flows would be able to drain north to Offats Bayou. At this elevation large areas would be under water in this area. Resident survey reports verify flooding in the low-lying areas between 61st and 57th Streets.

61st Street System – This system drains approximately 8-acres near 61st Street and Heards Lane. The drainage area is small since 61st Street is relatively high compared to the surrounding area. The outfall is a 42-inch pipe that has excess capacity and a calculated flow of 11 cfs. This outfall has been updated with a pipe liner slightly reducing the inside diameter of the pipe and improving its roughness characteristics. Resident survey results identify drainage problems near 61st and Ave Q to Ave Q1/2. This may be due in part to both tidal effects in this area, and inlet capacity problems. At an elevation of 7-8-ft. this section of roadway is generally above the historical high tide elevations

West T1/2 System – This system drains approximately 58-acres along Ave T1/2 and 59th Street to the seawall area. Much of the drainage area is a cemetery. The calculated design flow is 82 cfs that drains via a 60-inch pipe to Greens Bayou (which drains to Grover Street). This system is at design capacity with no excess available. HGL elevations remain within the ground. Some drainage surveys report flooding problems at Maco and 59th Street and may be due to inlet problems or sediment from the seawall areas. The design tailwater for this area was checked since Greens Bayou drains to Offats Bayou via a storm sewer to verify if a 1.5-ft. tailwater was realistic. These results show that with the 2-year flows from other systems entering Greens Bayou the water levels in Greens Bayou will increase by approximately 1-ft. This increase in water surface elevation is sufficient to pass the 2-year design flows through the outlet at Grover Street (60 and 72-inch pipe) described in the Grover Street System section below.

Grover Street System - The Grover Street system is interconnected to the outlet for Greens Bayou that extends along Grover Street. The Grover Street system has a drainage area of approximately 118-acres, however, if you combine all the areas that drain into Greens Bayou the drainage area has an approximate total of 384-acres. The combined design flows from this drainage area and the outflow from Greens Bayou is approximately 237 cfs. The 72-inch and 60-inch outfalls along Grover Street for this system were constructed with no slope and as such do not have a design capacity using manning formulas. These pipes act as an equalizer between Greens Bayou and Offats Bayou. Systems draining into Greens Bayou include the West T1/2 System via a 60-inch pipe, and the Central City System via a 72-inch pipe. A 36-inch pipe extends towards the Bayou Shore System and does collect some overflow from this system. There is one 60-inch pipe out of Greens Bayou that acts as a restrictor. Using 2-yr estimated design flows upstream of the Grover Street System were modeled with a SWMM analysis and it was determined that there would be approximately a 1.5-foot rise in water surface elevations

in Greens Bayou for a 2-yr event. This elevation increase is factored into the tailwater conditions for systems draining into Greens Bayou. Within the Grover Street system the main storm sewer lines run along Heards and Stewart Road. Each of these storm sewer systems has insufficient capacity for their respective drainage areas. Model results indicate that the hydraulic grade line in the system would be above the ground for the portion of the system on Heards Lane between 66th Street and Grover Street. Furthermore, the Heards Lane area is low in elevation and subject to tidal flooding. Numerous resident survey complaints in this area indicate flooding along Heards Lane. Storm sewer capacity problems likely cause some troubles if tides are low, however the low ground elevations (less than 4-ft) in this area make this general area susceptible to tidal flooding. Areas south and along Heards Lane are generally lower than areas to the north of Heards in this area and generally cause flows to concentrate at Heards.

Central City System - The Central City System has a drainage area of approximately 88-acres and model results indicate that the design flow at the Central City outfall is 127 cfs. The outfall is a single 72-inch pipe. The model results indicate that this design flow is approximately equal to the design capacity for this outfall pipe with no excess. Furthermore, the model indicates that the hydraulic grade line in the system would be below the ground for the entire system. This system has at least 1.5 feet of freeboard. No survey complaints were identified in this area.

West Heards System – This system is split into two different outfalls. The westernmost outfall has a drainage area of about 30-acres and drains to an open channel at the west end of Heards Lane. Storm sewer is located along Heards Lane and extends south along 73rd St to Jones Road. Portions of this storm sewer are evident above ground during a field visit. Model results indicate that the design flow at the West Heards outfall is 46 cfs. The outfall is a set of two 36-inch pipes. The model results indicate that there is some excess capacity for this system. However, due to the ground elevations in the area the hydraulic grade line in the system would be above the ground for portions of the system along 73rd St. The second outfall is just northwest of the Wimcrest/Heards intersection, it has a drainage area of approximately 72-acres. Storm sewer is located along Heards Lane on either side of this channel and model results indicate that the design flow at the West Heards outfall is 115 cfs. The outfall is a set of two 36-inch pipes. The model results indicate that the outfall capacity is about 87% below the design flow for the pipe. Model results indicate that the hydraulic grade line in the system would be above the ground for the entire system. Generally the Heards Lane area is low in elevation and subject to tidal flooding. Survey reports show flooding problems along Heards Lane and around 69th Street near the school area. There is a general high area just north of Heards that tends to force water to drain east or west along Heards to Offatts Bayou. There are small storm sewer systems in these areas north of Heards and most collect small drainage areas and drain directly to Offats Bayou. Survey results report that there are limited inlets in this area along 72nd and 73rd Streets. Also, there is a sheet flow problem from the Turtle Lake Apartments to 74th Street residents.

Colony Park System - The Colony Park System has a drainage area of approximately 113-acres and model results indicate that the design flow of 148 cfs. This system collects areas near Stewart and Jones intersection and through the Colony Park Subdivision to

Lake Madeline. The outfall is a single 72-inch pipe. The model results indicate that the outfall capacity of this pipe is about 21% below the design flow for the pipe. However, the model indicates that the hydraulic grade line in the system would be below the ground for most of the system, with the exception of the portion of the system between the intersections of Poplar and Jones and Yucca and Stewart at the most upstream portion of the system. Earlier construction plans shows an open ditch just north of Fairway, however, this channel was filled in with the construction of homes off of Oleander. Survey reports indicate flooding problems on Fairway and around the Jones and Stewart Road intersection. Fairway residents identify clogged drains as the problem.

Colony Park South System - The East Stewart System has a drainage area of approximately 53-acres and model results indicate that the existing design flow at the East Stewart outfall is 85 cfs where there is pipe capacity of approximately 32 cfs. This system drains portions of Stewart Road and outfalls to a drainage channel that extends from Stewart Road north to Lake Madeline. The outfall is a single 42-inch pipe at the outfall to this open ditch. The model results indicate that the outfall capacity of this pipe is insufficient for conveyance of the calculated existing flows. Furthermore, the model indicates that the hydraulic grade line in the system would be above the ground for the entire system. Survey reports generally report trash and debris blocking inlets and ditch maintenance problems along Stewart Road.

Jones/Gerol System – This system is relatively small and serves a small portion of Jones Road from Pine west to the Lake Madeline channel. The drainage area is approximately 17-acres and model results indicate that the design flow at the East Jones outfall is 35 cfs. This system drains portions of Jones Road and 73rd Street to Lake Madeline. The outfall is a single 30-inch pipe. The model results indicate that the outfall capacity of this pipe is about 50% below the 19 cfs design flow for the pipe. Furthermore, the model indicates that the hydraulic grade line in the system would be above the ground for the entire system. Survey results report that there are limited inlets in this area along 72nd and 73rd Streets. Also, there is a sheet flow problem from the Turtle Lake Apartments to 74th Street residents. Survey complaints are mainly centered near the intersection of Jones and Pine Streets.

West Jones System - The West Jones System has a drainage area of approximately 18-acres and model results indicate that the design flow at the West Jones outfall is 27 cfs. This system drains portions of Jones Road near the Moody Gardens entrance to Lake Madeline. The outfall is a single 48-inch pipe. The model results indicate that the outfall capacity of this pipe is about 78% below the design flow for the pipe. However, the model indicates that the hydraulic grade line in the system would be below ground for the entire system. This system has at least 1.0 feet of freeboard. Surveys were obtained in this area, however, there are no specific complaints within this system.

Beluche System - The Beluche System has a drainage area of approximately 40-acres and model results indicate that the design flow at the Baudelare outfall is 61 cfs. This system is within the LaFitte Subdivision and drains areas along Beluche on the south side of Lake Madeline. The outfall is a single 24-inch pipe. The model results indicate that the outfall capacity of this pipe is about 85% below the design flow for the pipe.

Furthermore, the model indicates that the hydraulic grade line in the system would be above the ground for the portion of the system along Beluche Drive.

79th Street System - The 79th Street System has a drainage area of approximately 36-acres and model results indicate that the design flow at the 79th Street outfall is 54 cfs. This system drains a portion of Stewart Road from approximately 80th Street east to the same north/south drainage channel that the Colony Park South System drains to. The outfall is a single 48-inch pipe. The model results indicate the estimated outflows exceed the capacity of this outfall by approximately 9 cfs. Furthermore, the model indicates that the hydraulic grade line in the system would be above the ground for the most of this system. Survey results show that there are ponding problems at or near 80th and Stewart Road.

81st and 81st West Street System - The 81st Street System has a drainage area of approximately 32-acres and model results indicate that the design flow at the 81st Street outfall is 48 cfs. This system drains portions of Jones/81st Street from the seawall areas north to an extension of Lake Madeline. The outfall is a single 30-inch pipe. The model results indicate that the outfall capacity of this pipe is about 72% below the design flow for the pipe. Furthermore, the model indicates that the hydraulic grade line in the system would be above the ground for the entire system. Survey complaints of flooding are reported at the intersection of 81st and Beluche.

To the west of 81st Street there is a separate system that collects the open areas west of 81st Street and outfalls to Lake Madeline. This area has an area of approximately 41-acres. An estimate of the drainage area was made as it is possible for some areas also to drain west towards the airport area.

Lake Madeline Area – This area includes a number of small drainage systems that drain directly to Lake Madeline and do not tie to any major road system. These include the systems called Lakeview, Dominique Lebrun, Beluche and Pine. Most flooding reports within the Lake Madeline area are primarily limited to Beluche Drive and Lakeview Drive. No analysis was done on these systems due to their small size and limited drainage area. A drainage channel enters Lake Madeline from the southeast corner and includes run-off from Stewart Road as well as Pine Street. There is a remaining question regarding a connection to Greens Bayou near Lasker and 69th Street. The previous master plans have identified this connection as a 60-inch pipe, however, no direct evidence has been found in the field or on construction plans. The City has verified that this pipe is in place and is used as an overflow connection between the two lakes.

Harborside West of 51st Street – The drainage systems in this area are relatively small and each has a separate outfall to Galveston Bay to the north. This system was designed based on TxDOT drainage standards and considered a 150-ft. developed corridor. Due to the proximity of open water to the north and marsh areas to the south this estimate is reasonable. There is a significant ponding problem in areas immediately west of 51st Street. This appears to be a problem caused by excess sediment and other debris washing into the roadway from adjacent businesses. The City staff has verified this condition. Tidal flooding occurs in this area as well due to the low elevations in this area. Assuming a clean system this area has an adequate drainage system for the 2-year City guidelines.

However, sedimentation is evident at the outfalls of some of these systems. Depending on the outfall either ditch cleaning or dredging may be necessary along with a follow-up cleaning of the storm sewer system to wash out remaining debris.

B. Bridge Blocks

Bridge blocks are shallow culverts that have been used extensively on Galveston Island in the urban areas to allow water to pass under roadways where there are no storm sewer systems. These bridge blocks are located in numerous areas and are known to be easily clogged and difficult to maintain and clean. Much of the street ponding in areas south of Broadway is due to ponding upstream of these structures and limited gutter capacity. Some of the bridge blocks along Broadway are known to have false bottoms that are sand or mud. The following is a table of bridge block locations along Broadway Boulevard determined during field investigations. It is possible that some of these are tied in to underground storm sewer systems and these are noted.

BROADWAY BRIDGE BLOCK LOCATIONS	
LOCATION	**NOTES**
16th Street	
17th Street	
18th Street	
20th Street	
21st Street	
22nd Street	Possible inlets or bridge block
28th Street	Clogged not working well
29th Street	
30th Street	
33rd Street	Possible inlets or bridge block
35th Street	
36th Street	Clogged not working well
38th Street	
39th Street	

The elimination or plugging of these structures on Broadway and other areas is preferred due to maintenance problems. There are two different ways to eliminate these structures. First, in residential areas where vehicle speeds are slower it is possible to remove the bridge block and depress the gutter to allow water to pass through the intersection. This option has the benefit of being self cleaning, but may not be favorable in major roads where there is significant traffic. The second option is to extend storm sewer capacity to the upstream side of the structure and to remove or plug the existing bridge block. This will take more time and will not be possible until the additional storm sewer and inlet capacity is provided upstream of these existing structures. There are a large number of small bridge blocks in areas across the City, and these structures tend to create the majority of nuisance flooding problems within the City. In addition, some areas also have driveway culverts added by landowners to help cross either high curbs, or deep gutters without damage to their vehicles. Repairing existing curbs and eliminating these

small culverts from the roadways would improve gutter flow and would lessen maintenance costs.

C. Open Channel Systems

This section concerns the open channel drainage systems prevalent on the west end of the island and beyond the seawall. There are a few open channels within the eastern portions of Galveston Island, however, the majority of roadside ditches and open channels are in the west end where the main roadways are FM 3005 and Stewart Road. Ponding water is prevalent along FM 3005. However, roadway flooding is usually not a problem until you reach secondary roads in the area. Current City guidelines for development in this area require all new developments to drain north into Galveston Bay. Generally FM 3005 is high and restricts surface sheet flow from south to north towards the Bay. There are approximately 22-outlet channels from FM 3005 north to Galveston Bay over approximately 17-miles from the seawall west to San Louis Pass. Cross-culverts are spaced along FM 3005 to allow water to pass from south to north. Thirty crossings have been identified ranging in size from 24-inch to 2-36-inch pipes. There may be others that are not documented or found during site visits. Low lying areas between Stewart Road and FM 3005 are considered impoundment/storage areas based on previous studies of the west end of the island. These low-lying areas are generally tidally influenced. The environmental inventory maps should be referenced before development to determine where these areas have been mapped as potential wetland areas. These low areas provide run-off storage that reduces storm water peak flows north through Stewart Road. Roughly eight crossings have been identified along Stewart Road ranging in size from 15-inches to a 50-ft. bridge. North of Stewart Road there are other larger impoundment/low areas that generally shift storm water east or west towards either Sweetwater Lake, or Mensell Bayou near the Spanish Grant area. Areas north of Stewart Road are also generally low in elevation and impacted by tidal effects.

1. Pelican Island

Pelican Island has an area of about 3,400 acres. Created by the disposal of dredge material from the Galveston Ship Channel, it is essentially a man-made island. The U.S. Army Corps of Engineers and Port of Galveston still use large portions of the island to stockpile dredge material. In fact, the entire northern half (approximately 1,600 acres) of the island is used for this purpose and was not considered in this study. Access to the island is via the Pelican Island causeway extending north from 51st Street. The roadway name changes to Seawolf Parkway on Pelican Island and transverses the island from southwest to northeast. Development is primarily south of this road and along the Galveston Ship Channel.

Information on Exhibit 3 shows 1-foot contours for Pelican Island and the drainage areas considered for this study. The average elevation of the island is approximately 9 feet, mean sea level, with portions of the island having elevations greater than 20 feet, mean sea level. The total drainage area considered in the study is about 910 acres. Areas not considered in the study consist of privately maintained facilities directly adjacent to the Galveston Ship Channel, the Texas A&M campus, dredge containment areas, and areas draining directly to Galveston Bay without crossing Seawolf Parkway. The interior of the island is generally undeveloped.

The existing drainage system on Pelican Island consists of open ditches with culverts at roadway crossings. The ditches are irregular in size and slope. Standing water is present in some locations due to channel debris, silt, and minimal maintenance. Furthermore, some of the ditches do not have a recorded easement and other ditches have recorded easements that do not appear to match the existing channel limits.

The original Scope of Work for the Galveston Drainage Master Plan states that for Pelican Island, the work performed will include the identification of existing surface drainage systems on the island. A simple analysis of the performance of these systems will be made and problem areas will be identified along with recommendations. In October of 1990, the City of Galveston Department of Public Works published a report, *Outfall Drainage Plan for Pelican Island*. The information in this report (the City report) is relatively detailed in nature and it served as a guideline for the simple analysis performed for this study. In general, the improvements recommended in this study are similar to those mentioned in the City report, with the exception of a few additional considerations. In keeping with the purpose of the City report, this study will focus on the interior drainage of the island along Seawolf Parkway and the suggested improvements will reflect 100% development in the drainage areas shown on the exhibits.

a. Criteria And Methodology

The design criteria used in this study are similar to those used in the City report and are shown in the following table:

PELICAN ISLAND STUDY CRITERIA	
Run-off Calculations	2-Year Return Period – same as storm sewer
Culvert Sizes	Based on minimum 3-ft/s velocity
Ditch Sizes	Minimum 4-ft bottom width, 3:1 side slopes, 0.10% ditch slope minimum (except where explicitly mentioned, Manning's n-value of 0.04.

A computer spreadsheet was prepared that calculates recommended culvert sizes and normal depths in open ditches based on the criteria in the above table. As requested by the City, the analysis was done considering existing conditions and 100% developed conditions.

b. Results

Exhibit 3 presents the drainage areas and ditch/storm sewer alignments. Tables 3 through 8 provide a summary of the results and Tables in the Appendix present detailed cost estimates and quantities for the Pelican Island analysis. Drainage system boundaries generally are described from west to east across the island, with System "A" at the west end, and Systems "F" and "G" on the east side of the island. Detailed recommendations have been limited to the outfall channels, however, there is a need for deeper roadside channels to collect run-off from Seawolf Parkway. Within the drainage areas defined in this study it is necessary to provide a drainage swale along the road to the proposed

outfall channels. Recommended culvert sizes are generally based on a design velocity of 3-ft/s and sized to facilitate the addition of duplicate boxes in the future. Other pipe configurations are possible as long as the necessary flow area is provided for future flow conditions. An explanation of these proposed facilities are as follows:

i. System "A"

System "A" is on the southwest corner of the island just east of the Texas A&M facility. The total drainage area for this system is about 111 acres, not including Texas A&M which drains independently to the Galveston Ship Channel. Currently only about 7% of this area is currently developed. The estimated existing conditions 2-year discharge at the outlet of the main drainage ditch is 71.7 cfs. At 100% development this will increase to 149.4 cfs, see Table 3.

Future conditions improvements include a set of 2-36-inch culverts at Seawolf Parkway and a set of 4-42-inch culverts at the access road to the Western Geophysical facility, replacing the existing 36-inch and 24-inch culverts. Future conditions proposed ditches include an improved channel from Seawolf Parkway to the outfall as defined in the earlier study by the City. In addition a lateral ditch from the G.O.T (Galveston Oil Terminal) incorporated tank farm area to the main outfall ditch is proposed. These channels will have a minimum bottom width of 4-ft and 3:1 side slopes. Depth is approximately 4-ft. at Seawolf Parkway from the top of road and slope at 0.11% to the outfall location. The 1990 City study of Pelican Island should be referenced for detailed profiles of these channels. Based on the earlier study existing drainage easements are 70-ft. Future improvements will require a drainage easement from 70-ft. to 130-ft. as per the previous study. The drainage easement widths proposed in the earlier study were checked and are adequate for future open channel improvements. Storm sewer sizes have also been proposed as shown in Table 3.

There are separate drainage channels draining the properties near the Galveston Ship Channel, including the Todd Shipyards and Tenneco properties. No existing drainage easements are evident in this area, therefore, areas north of these properties, including Seawolf Parkway, have been diverted either west to "A" or east to "B".

ii. System "B"

System "B" is between System "A" and a dredge containment area just south of Seawolf Parkway. Bradner Road is the primary road intersection in this area. The total drainage area for this system is about 98 acres. Currently only about 13% of this area is developed. The estimated existing conditions 2-year discharge at the outlet of the main drainage ditch is 68.2 cfs. At 100% development this will increase to 133.6 cfs, see Table 4.

Future conditions proposed culverts include a 24-inch culvert at Seawolf Parkway just west of Bradner (Outfall B), a 24-inch culvert at Bradner just south of its intersection with Seawolf Parkway, and a set of 2-30-inch culverts at Bradner to drain the area east of Bradner (Outfall B-1). Future conditions proposed ditches include an improved channel (4-ft to 20-ft BW, 3:1 SS) from Seawolf Parkway to the outfall and two lateral ditches

from Bradner to the main outfall ditch. At Seawolf Parkway the depth is approximately 4-ft. from the top of road and slope from 0.17% to 0.10% near the outfall.

Currently there is only one section with a 70-ft. drainage easement adjacent to Seawolf Parkway and extending south to the G.O.T. However, the location of the drainage easement does not match the current ditch location. The remainder of the existing channel including Ditch B-1 is not within an existing drainage easement. The previous study outlined a range of easements from 70 to 130-ft. at the downstream end. Existing pipeline racks for the G.O.T. require the movement of the current outfall for System "B" east.

iii. System "C"

The outfall for System "C" is in the south central region of the island, just east of the Halliburton facility. The total drainage area for this system is about 287 acres. Currently only about 5% of this area is developed. Much of the area to the south and west below the dredge facility drains directly to the Galveston Ship Channel via separate and private facilities. The estimated existing conditions 2-year discharge at the outlet of the main drainage ditch is 158.6 cfs. At 100% development this will increase to 315.7 cfs, see Table 5.

Future conditions proposed culverts include a set of 2-24-inch culverts at Seawolf Parkway west of the Halliburton facility, a set of 5-36-inch culverts at Seawolf Parkway east of the Halliburton facility, a 30-inch culvert at Pennzoil Road, and 4-30-inch culverts at the road leading to the Halliburton facility. Future conditions proposed ditches include a series of lateral ditches to drain areas near Seawolf Parkway and an improved channel from Seawolf Parkway to the outfall. Bottom widths vary from 4-ft. to 20-ft. with easements from 40-ft. to 160-ft. at the outfall.

iv. System "D"

System "D" on the southeast side of the island, near the Shell facility. The total drainage area for this system is approximately 22 acres. Currently about 87% of this area is developed. The current Outfall "D" starts at Seawolf Parkway along the west side of Shell Road, then cuts underneath Shell Road to the eastern property boundary and outfalls at the Galveston Ship Channel. Existing culverts include a 42-inch at Shell Road and 2-42-inch pipes at approximately the halfway portion of the Shell property. The estimated existing conditions 2-year discharge at the outfall is 30.2 cfs. At 100% development this will increase to 32.6 cfs, see Table 6.

The City is currently working with the owner of the property to design a storm sewer outfall based on the previous study. Therefore, an effort was made to limit the drainage area for this outfall so that capacity would not be exceeded. Future conditions improvements include a 30-inch culvert under Seawolf Parkway, a 36-inch storm sewer between Seawolf Parkway and Shell Road and a 48/54-inch storm sewer from Shell Road to the outfall. By the time this study is issued portions of the 48/54-inch storm sewer will likely be complete.

v. Systems “F” and “G”

System “F” and “G” are on the east side of the island. The total drainage area for System “F” is approximately 119 acres and System “G” is approximately 12 acres for a total of 131 acres. This area was not included in the previous study and the outfall is generally along Seawolf Parkway at the point where the beach runs parallel with the roadway. Based on the contour information, it appears that area formerly thought to drain to System “D” may be draining along Seawolf Parkway east. Currently only about 6% of this area is developed. The estimated existing conditions 2-year discharge at the outlet of the main drainage ditch is 75.2 cfs. At 100% development this will increase to 158.8 cfs, see Table 7.

System “G” is an area nearest to Seawolf Park, and is only separated due to a proposed outfall to the beach area on the opposite side of Seawolf Parkway. It is also possible to drain this area towards the northeast and avoid the need for a culvert crossing.

Future conditions proposed culverts a series of culverts at Seawolf Parkway: a set of 4-36-inch culverts to drain area F3, a 24-inch culvert to drain area F2A, and a set of 3-24-inch culverts to drain area F1A. Future conditions proposed ditches includes an improved channel along Seawolf Parkway draining to the outfall.

The total drainage area for area G2 is approximately 12 acres. This area is completely undeveloped and drains toward Seawolf Parkway. The estimated existing conditions 2-year discharge for this drainage area is 7.7 cfs. At 100% development this will increase to 18.0 cfs.

Area G2 drains toward Seawolf Parkway. In order to prevent flooding of Seawolf Parkway at this location, a set of 2-24-inch culverts is proposed for the future condition.

vi. Pelican Island Industrial Park (PIP) System

The PIP System is on the northwest side of the study area. For the purposes of this study, it was assumed that at some future date the area east of Bradner and north of Seawolf Parkway will be developed into an industrial park and the City would provide a drainage outfall for this area. The total drainage area for the PIP System is approximately 269-acres. Currently this area is completely undeveloped. The estimated existing conditions 2-year discharge at the outlet of the main drainage ditch is 142.3 cfs. At 100% development this will increase to 302.1 cfs, see Table 8.

Future conditions improvements include a set of 6-48-inch culverts at Bradner, a lateral ditch along Bradner to improve runoff from Seawolf Parkway, and an improved channel from Bradner to the drainage area limit shown on the Exhibit 3. Further excavation beyond this point may be necessary to ensure positive drainage toward the outfall on the northwest side of the study area.

c. Construction Cost

The following table summarizes the construction costs for the future conditions proposed improvements. This cost includes the use of open ditch system plus a 20% contingency. Underground storm sewer system can be used on Pelican Island if the required drainage

easements cannot be acquired. A cost for obtaining easements has been added with an estimated cost of $10,000 per acre. However, the construction cost would be substantially higher. See the Appendix 4 for a detailed cost estimate.

FUTURE CONDITIONS PROPOSED IMPROVEMENTS CONSTRUCTION COSTS

System	Cost
A	$172,752
B	$165,110
C	$317,021
D	$299,181*
F,G	$100,560
PIP	$132,984
Total	$1,187,609

* Storm Sewer Only – System D

2. West End Problem Areas

The following subdivision areas were identified in the original scope of work. These areas have been known to have drainage problems. Also, included in this section is a brief synopsis of other drainage problems identified with the resident surveys, and a summary of possible causes. These areas can be located on Exhibit 3 under separate cover. Proposed improvements are presented in Section 9.C under the appropriate zones.

a. Bay Harbor – Bay Harbor is in far West Galveston, and is drained via roadside ditches and driveways are small culverts primarily 12-18-inches. The right-of-ways are very narrow (20-40-ft) and there is insufficient right-of-way for the ditches necessary to carry storm run-off. Based on conversations with persons in the area some drainage improvements were completed within the past 10-years. These improvements are evident by the existing grate inlets along 7th Street that outfall to Galveston Bay to the north. This area is very flat. Contours from the LIDAR data appear to accurately depict the ground topography and is evident in the field. There is a drainage channel along the western side of the subdivision that appears to collect areas from approximately 4th Street west. Other areas drain to the northwest towards 7th Street.

Based on LIDAR areas outside the subdivision east of 1st drain toward the subdivision. There is also an intermediate low area just northwest of the midpoint of 1st, 2nd, 3rd and 4th Street. This area can hold at least 1-ft. of water before spilling northwest to 7th. These low areas are very evident from the aerial photos. Many of the roadside ditches are silted in and need to be cleaned out. Silted culvert pipes and ditches decrease conveyance from south to north. With most of the homes elevated, flooding is primarily a health problem due to the use of septic tanks in this area in addition to a nuisance and access problem. Flow paths identified with LIDAR indicate that there is a large concentration of drainage area near the intersection of 1st and 7th. Another smaller concentrated area is at 4th and 7th. The remaining southwest corner of the subdivision drains to the ditch on the western side. There are drainage channels that collect this water within the subdivision just south

of the split of 6th and 7th Street on the west side of the subdivision. Some storm sewer systems have been added within the recent past and collect water at the northern ends of the street and pass this water onto the canal inlets at the north end of the subdivision. Streets extending into the canal areas have small drainage areas, however, there are limited outlets for storm water that create ponding problems during storm events. With low elevations in this area tidal flooding is a problem. No sanitary system exists in this area and residents rely on individual septic systems for sanitary waste. When these systems flood the flow from these systems drain into the yards, and eventually into the roadside ditch system that drains to Galveston Bay.

Other problems identified in resident survey:

- Corner of 4th and 6th Street heavy ponding for days
- Lack of ditch maintenance
- Heavy ponding at FM 3005

b. Terramar Beach - Many of the problem areas within Terramar Beach were identified with a memo from the Terramar Beach Community Improvement Association received March 14, 2002. This memo identified the following problem areas:

- Verano Drive east of Terramar Drive
- Verano Drive west of Terramar Drive
- West side of Terramar Drive

Based on the field visit, there is a significant amount of blown sand on Terramar Drive from the beach access point across FM 3005. The existing inlet on the east side of the intersection of Terramar Drive and Verano was not evident (probably covered by sand), and the inlet on the west side had a significant amount of sand at the entrance but was not full of sand. The drainage system along Terramar Drive collects run-off from the roadside ditches on FM 3005 as well as the drainage within the subdivision. A 36-inch extension crosses FM 3005 to pick-up drainage on the south side (beach side) of the FM 3005. The following is a list of specific problem areas identified in Terramar Beach and potential solutions:

Verano East of Terramar – Roadside ditches are not evident and may have completely silted in with sand. The storm sewer inlet noted on the memo is not evident and may be completely filled with sand. However, there is a drainage channel along the back of the properties between Verano and Buena. If access through the existing properties is possible, this channel is deep enough to provide drainage to Verano if shallow swales are extended along each existing property boundary and sloped north to the existing channel.

Verano West of Terramar Drive – The Improvement Association proposed the lowering of the existing inlet, and deepening the roadside ditch to the west along Verano to improve drainage from properties to the west of Terramar Drive.

Other problem areas identified in the resident survey:

- Residents mainly concerned with the lack of roadside ditch maintenance. A regular maintenance schedule for west end subdivisions is recommended. This should be a minimum of once a year and preferably done during the winter and spring when rainfall is generally less than during summer and fall.

c. Sea Isle – No specific problem areas were outlined in the original scope of work. Based on the LIDAR data the following areas have apparent drainage problems.

- Extensive ponding of roadside ditches along FM 3005
- Excessive ponding on streets within canal areas including Anticosta Key, Brewster Key and Guadalupe
- Ponding along Ector near FM 3005
- Low area along Grayson and Ft. Bend between Lampasis, and Shelby Ln. Overland sheet flow is trapped in this area and tends to follow Lampasis to outfall into a canal at the northeast end of the roadway once the area is full.
- Low area and drainage areas converge at Grayson between Mason and Navarro.
- Limited 50-ft right-of-way for road and roadside drainage channels.

d. Habla Road – This is a small subdivision with a T-intersection. There appears to be no conveyance system in place to drain water out of the area. The primary low spot is at the intersection of Habla and Glei. Based on the LIDAR data the lowest exit point is approximately the back of the 2nd lot west of this intersection. Water would have to pond approximately 2-ft. high to exit this location. This floods the roadway and driveways. LIDAR data shows that there is some area north of FM 3005 that tends to drain toward this subdivision along Habla Street. Culverts across FM 3005 in this area may cause additional problems. Elevations must reach 6-ft. before they can exit across the beach area. Existing townhomes along FM 3005 tend to channel the water to Habla at the entrance of the subdivision. A beach outfall is the obvious choice in this area, however, there are existing laws by the City and State General Land Office (GLO) that forbid this type of improvement. Neighboring subdivisions do have storm sewer outfalls to the beach but these outfalls were likely constructed before restrictions were enforced.

e. Bermuda Beach/Pabst Street – This subdivision did have improvements made within the past 10-years to improve drainage. Based on conversations with residents they say that the improvements did solve a number of the problems. West of Pabst Street storm water is directed north and west along FM 3005 via existing channels. Due to extensive beach erosion east of Pabst Street a number of these areas drain directly to the beach causing some additional beach erosion. There is only localized flooding within individual lots. Residents explained that there was utility work within the subdivision. The contractor patched the roads, however some settlement has occurred and there are low areas that cause ponding within Bermuda Beach and John Reynolds. At least one inlet on John Reynolds was impacted by the utility work and the concrete slope paving was not put back in the same condition. This slope paving is beginning to crack and break-up. Field visits confirm that there is a significant sheet flow drainage problem east of Pabst Street. Many of the dunes along the beach have been scoured by recent storms through the area. Therefore, there is no apparent block (sand dune) to run-off from

Bermuda Beach Road. Main problem reported by residents is ponding along John Reynolds.

Drainage survey information from residents indicates some ponding along Pabst Road. Elevated homes/land near Pabst is identified as a cause of the problem. Swales were not evident in this area during field visits.

f. Gulf Palms Drive – This roadway is located just east of Glei and off of 16-Mile Road. Properties along the beach are within the dune line and under control of the State of Texas open beaches policy. Existing homes are along the north side of the road. Gulf Palms Drive is now at the dune line and this roadway appears to have been abandoned. Low areas along Bristow collect water and there is little drainage conveyance toward 16-Mile Road, the only outfall in this area. Minimum elevations are 5-ft. on Bristow and on 16-Mile Road. Elevations along the dunes are from 6-8-ft, therefore, runoff must go to 16-Mile Road to leave the area. 16-Mile Road is a dirt road with some washout areas. Some ditch work can be done to help drain the area to 16-Mile Road, however, maintenance will be a continuous problem due to steady deposition of sand from the beach.

g. Palm/Pirates Beach - Survey reports identify ponding problems around Las Palmas and Oleander. Based on the LIDAR information there is a drainage channel between Surf and Sandpiper that drains north under FM 3005 towards the Galveston Country Club at Stewart Road. This area is very flat and in the 5-6-ft. range. With high tides ponding water will be evident in the drainage channels and along FM 3005. Storm water is directed north as per the current City guidelines. Existing roadside ditches within the subdivision are relatively small. Improved channels along Duncan Way from Oleander to the existing ditch just west of Sandpiper would improve drainage within an area that has complaints. Depths may be limited and driveway adjustments would be necessary. Also a channel and pipe is recommended along Duncan Way from Seagull west to the north/south channel. A section of 30-inch pipe is necessary to cross through the one row of homes adjacent to the north/south channel. Additional regular ditch maintenance would benefit local drainage in the area.

8. PROPOSED STORM SEWER SYSTEM IMPROVEMENT METHODOLOGY

Proposed storm sewer improvements within this Master Drainage Plan are focused on providing sufficient outfall capacity to drain the urbanized areas east of the airport area. This plan contains an outline of proposed major storm sewer trunk line improvements and existing systems that can remain in place. Minor storm sewer trunk lines and improved inlets are also necessary to convey storm water to the proposed trunk line system. However, these secondary systems must be phased in after the trunk line capacity is constructed. Along the primary trunk line routes, it is expected that storm sewer inlets and leads will be upgraded along with the roadway reconstruction necessary to restore the road surface after construction. The methodology for proposed improvements to the existing City of Galveston storm sewer system were based on the following concepts:

- Land development remains the same as the existing condition analysis since the storm sewer areas of the island are generally considered fully developed.
- Keep as much of the existing storm sewer system in place and functional as possible. However, data regarding existing storm sewer age and physical condition is not assessed in this study. Proposed storm sewer sizes in areas where there are existing systems are meant to represent the total conveyance area required. Flow areas of existing storm sewers that remain in place should be subtracted from these proposed sizes if considered to remain.
- Design frequency is the 2-year storm event as presented in the original TC&B drainage master plan. These curves account for rainfall depth reductions based on ground storage losses and losses due to evaporation and infiltration.
- Time of concentration is based on City of Houston method and 25-min. minimum from the current City of Galveston criteria. ($COH\text{-}TC = 15 + 10A^{(0.1761)}$)
- Desired design velocity is 3 ft/s, however, the system design is based on a pressure/surcharged system to minimize storm sewer sizes. This is generally 1-ft. below existing ground elevations where possible.
- The tailwater is at the mean low tide elevation of 1.6-ft.
- Storm sewer hydraulics based on Manning's roughness of 0.013 (concrete).
- Conflicts with major existing utilities shall be minimized or avoided if possible.
- Determine if there is sufficient right-of-way to construct the proposed improvements.

9. PROPOSED STORM SEWER SYSTEM IMPROVEMENTS

A. Storm Sewer Areas

Storm sewer sizes were developed based on the storm sewer design criteria outlined above. For all recommended storm sewer sizes in this report, the proposed storm sewer sizes can be modified as necessary to fit unexpected field conditions. Alternate storm sewer sizes should have an equivalent flow area and wetted perimeter. The recommendations in this report are considered minimal based on the design criteria and represent a surcharged pressure storm sewer system. In some cases there is minimal freeboard available, however, a minimum of 1-ft. below existing ground is considered desirable. Utility conflicts are inevitable and may require special structures to maintain the necessary flow areas. Adequate maintenance access is necessary upstream of these structures at a minimum to facilitate periodic cleaning of silt and debris that will likely clog the system over time. The Preliminary Environmental Assessment of Selected Storm Sewer Routes by Berg Oliver in separate cover should be referenced to review environmental and archeological conditions along some of the routes within the City of Galveston. The Environmental Baseline Exhibits, also under separate cover, should also be referenced as it shows approximate locations of potential environmental hazards in the City that may impact proposed construction.

Ferry Road System – The existing outfall capacity of the 2-54-inch storm sewers is adequate for the design storm event. Improvements to this system can be done in parallel with the existing system or the existing pipe can be removed and replaced with a larger pipe. For this system the storm sewer from Barracuda to Pompano, and existing 54-inch

from Whiting to the 2-54-inch outfall is undersized. The following improvements are necessary for the 2-year storm event:

- From Barracuda to Dolphin – upgrade 30-inch to a 42-inch
- From Dolphin to Bonita – upgrade 36-inch to a 48-inch
- From Bonita to Pompano – upgrade 42-inch to a 48-inch
- From Whiting to 2-54-inch – add a parallel 42-inch, or replace with 2-48-inch (equivalent box sewer is a 7'x 4')

The 4th Street System – No improvements necessary for this system.

9th Street System – There is adequate capacity on the portion of the system along 2nd Street. Flooding complaints east of this line are due to limited connections from San Marino. 2nd Street is relatively low in this area and existing overland flows go to drain to this street. Problem areas east of 2nd Street may be accommodated by additional inlets on 1st Street with connections of 24-inch to 30-inch to 2nd Street. However, flooding in this area is not significant and improvements are a low priority. Along 4th Street some upgrades are necessary to keep the hydraulic grade line under existing ground elevations. These improvements are as follows:

- Upgrade 5th Street from Sealy to Winnie from a 24-inch to a 30-inch
- Upgrade 4th Street from Post Office to San Jacinto from 36-inch to 42-inch
- Upgrade 4th Street from San Jacinto to Ave B from 42-inch to 54-inch

11th Street System – The primary trunk line extends along 11th Street to Ave K and outfalls via a 72-inch pipe. Based on information from the City there is limited space for additional storm sewer improvements along 11th Street. The improved 72-inch outfall for this system was built in 80's. Solutions to the flooding problems near the entrance to UTMB can be mitigated with a new storm sewer outfall. The proposed route outfalls to an existing boat slip just north of 13th Street. The proposed route is as follows:

- 60-inch from boat slip north of 13th Street south to Post Office
- 60-inch along Post Office from 13th Street to 11th Street
- At 11th Street connects to 36-inch and 60-inch from south, but only allows 60-inch to continue north
- 54-inch along Post Office from 11th to 8th Street
- 36-inch along 8th Street from Post Office north to Market
- 48-inch along 8th Street from Post Office south to Winnie
- 42-inch along 8th Street from Winnie to Sealy (connects to existing storm sewer from east but plugs existing 30-inch storm sewer to the west)
- 36-inch along 8th Street from Sealy to Broadway

At Broadway a 30-inch lateral east to 7th Street can be added. The remainder of the system stays in place. A portion of the existing system is disconnected at Ave K and 11th Street and diverted to a new 15th Street system described in the next section.

There are some major public utilities in this area including the following:

- 36-inch sanitary sewer at Harborside
- 30-inch sanitary sewer along 13th Street and Post Office
- 20-inch water line along Church Street

There is an existing 4'x 3' box that ties the 11th Street system with the 14th Street system. This existing line can be interconnected to the proposed 60-inch storm sewer. The drainage survey reports show that the worst flooding areas are along Ball Street south to Ave K as well as the UTMB area discussed above. The proposed 15th Street system is diverting drainage areas south of Broadway out of this system and will likely improve drainage along Ball Street. There is a 4-block area just south of Post Office between 14th and 11th Street that is unserved by storm sewer. If problems persist in these areas it may be necessary to extend laterals to the proposed 60-inch storm sewer along 12th and 13th Streets in a final phase of storm sewer improvements. Along Broadway there are only inlets at 9th Street with no bridge blocks evident within this area. Improvements to Ave K, as described in the 15th Street improvement section, will reduce ponding along the south side of Broadway in this area.

<u>14th Street System</u> – This system will remain in place with sections of the system bypassed into the proposed 15th Street storm sewer. Portions of the system south of Ave K and west of 15th Street are diverted to the proposed 15th Street storm sewer system. This reduces the drainage area of this system and improves performance of the downstream sections.

<u>Proposed 15th Street System</u> – This system is proposed to provide relief to the areas south of Broadway from the seawall area west to 16th Street. Portions of the 11th and 14th Street systems are collected south of Broadway. The intention is to connect laterals to Broadway. In most instances the lowest areas are midway between Broadway and Ave K. These existing inlets would need to be connected to the new storm sewer at Ave K. The existing system in place from Market north to the existing outfall can be removed since the capacity is replaced with the proposed storm sewer. If necessary it can remain in place to divert storm water away from construction of the new storm sewer. The proposed improvements as part of this system are as follows:

- From the boat slip just north of 15th Street extend an 8'x 5' box south to Ave K. Major existing utilities include a 36-inch sanitary sewer at Harborside and a 20-inch water line at Church Street.
- Along Ave K from 15th to 14th Street – 6'x 5' box
- Along Ave K from 14th to 11th Street – 5'x 5' box
- Along Ave K from 11th to 10th Street – 48-inch
- Along Ave K from 10th to 9th Street – 36-inch
- Along Ave K from 9th to 8th Street – 24-inch
- Upgrade exist 24-inch along Ave M1/2 from 16th to 14th Street to a 36-inch

Most of the drainage area for this system is south of Broadway. Along 15th Street inlets will be required at all intersections and will collect generally ½ block in east and west of 15th Street. Existing systems to the south and east of this proposed system shall be plugged in-place.

16th Street System – This system drains approximately 21-acres from Harborside north to Market Street. The existing analysis showed that this system was undersized. The following improvements consider that the existing pipes are to be removed and replaced:

- Upgrade existing outfall from a 24-inch to a 42-inch
- Upgrade existing system from just north of Harborside south to the Strand to a 36-inch
- Upgrade remaining portions south of the Strand to a minimum of 24-inch

It is recommended to remove and replace the existing system since a parallel system would double the existing system size. These smaller pipe diameters would take-up more right-of-way and also are more difficult to maintain. Ground elevations at Harborside at between 3 and 4-ft. indicate that this area is susceptible to tidal flooding when tides are 2-2.5-ft. higher than normal high tides.

18th Street System – This existing system drains approximately 32-acres from Market Street to Harborside. A new storm sewer system is proposed to drain areas south of Broadway from 16th Street west to 21st Street. This system was upgraded recently, however, due to the limited outfall locations available for new outfalls this route was chosen due to limited conflicts at the Port of Galveston. The existing outfall is relatively shallow and is within the shrimp boat fleet area near Pier 19. The proposed outlet is deeper and the harbor is deep enough to accommodate this. The proposed 18th Street system is as follows:

- Replace existing 48-inch outfall with a 9'x 5' box and extend south to Winnie, all existing systems east of this line are to be connected to the new storm sewer. Existing systems to the west will be plugged. A sanitary sewer crossing at Harborside and a 20-inch water line crossing at Church Street are necessary and special junction box structures will be required. Consideration of a water line adjustment at Church Street needs to be made during design.
- Along 18th Street from Winnie to Ball – 8'x 5' box
- Along 18th Street from Ball to Ave K – 7'x 5' box
- Along Ave K from 18th Street to 21st Street – 60-inch pipe
- Along 21st from Ave K to Ave M – Replace existing 4'x 2.5' box with 60-inch pipe
- Along 21st from Ave M to Ave N – Replace existing 4'x 2.5' box with 48-inch pipe
- Remaining storm sewer south along 21st to remain
- Along 18th Street from Ave K to Ave N – 48-inch pipe
- Along Ave N from 19th to 17th Street – 36-inch pipe draining to 18th Street
- Along 17th Street from Ave N to Ave O – 30-inch pipe

- Along 19th Street from Ave N to Ave O – 30-inch pipe
- Along 19th Street from Ave O to O1/2 – 24-inch pipe

The revised system along 21st Street south of Ave K is intended to upgrade the capacity of this line and disconnect it from the existing Ave K system to the west. This reduces the load on existing for the existing storm sewers between 24th Street and 19th Street to minimize the need for replacement. Existing bridge blocks at 17th and 18th Streets can be diverted to the new storm sewer.

<u>19th Street System</u> – This system will remain in place with the existing portions south of Broadway diverted to the proposed 18th Street system. Some upgrades of the existing system near Broadway are necessary to divert additional storm water to 19th Street due to the additional capacity gained by diverting water to 18th Street. These improvements include a replacement of existing storm sewers along Ball (Ave H) as follows:

- Along Ball from 19th to 20th Street – remove existing 30-inch and replace with 5'x 3' box
- Along Ball from 20th to 21st Street – remove existing 24-inch and replace with 4'x 3' box
- Along Ball from 21st to 22nd Street - new 36-inch storm sewer
- Along 22nd from Ball to Broadway – Remove existing pipes and replace with a 36-inch pipe. The existing system on 22nd Street will be plugged just north of Ball
- The existing bridge blocks along Broadway can be diverted to Ave K once this system is upgraded. Due to the uncertainty of project timing these areas could also be drained south to the proposed Ball Street improvements if necessary

Area was diverted away from this system due to the limited ability to improve the outfall that extends under a building owned by UTMB and formerly known as the Lipton Tea Building.

<u>20th Street System</u> – This system has been upgraded since it was originally constructed. Some problems with the storm sewer through the rail yards within the Port of Galveston resulted in the reconstruction of a portion of this system to a 54-inch pipe north of Harborside. Additional improvements are limited to a small upgrade of existing systems from the Strand north to Market. These improvements include the replacement of the existing storm sewer south of the 54-inch pipe to a 48-inch pipe. At the Strand the existing 30-inch pipe can remain, however, an additional 30-inch pipe is proposed to extend along the west right-of-way and drain the portion of the roadway that is split by the trolley station. This lateral upgrades the existing 18-inch storm sewer pipes on the west side of the right-of-way to a minimum of a 24-inch pipe.

Heavy flooding has been reported from Market to Mechanic Street where there is an existing Trolley stop. Elevations around 4-ft. also contribute to flooding when tides are high. Survey results also report the above problems including the Strand intersection where elevations are near 4-ft. While the proposed improvements will help by diverting water away from this area it may also be necessary to upgrade the existing storm drains in this area.

22nd and 24th Street System – This system generally remains as-is. Portions of the existing system are diverted to either the 18th Street or 29th Street system. With these areas disconnected there is sufficient capacity for the remaining drainage area of this system.

25th and 27th Street System – This system has four (4) separate outfall pipes. The existing system along 25th Street is split into two lines on each side of the street. The west side is the smaller of the two and is 18-inches. A 24-inch minimum is preferable, however, if capacity of the storm sewer on each side of the street is combined it is adequate for the estimated design flows. Along the east side of 25th south of Ave F system is a 1.5'x 1.5' box and records show 21-inch pipes upstream of this section. Storm sewers that are a minimum of 24-inches deep are preferable but not necessary in this area.

On 26th Street diverting areas south of Ave M1/2 is helping the existing system. However, there remains a capacity problem on 26th between Ave E and Santa Fe. This is the location of the railroad museum. It is assumed that construction through this area should be avoided. For additional capacity the proposed improvements include doubling the capacity of the existing 5'x 2.5' box along 26th Street from Ave E to Santa Fe then diverting this extra line to the existing storm sewer at 27th Street that has excess capacity. Records show that this is currently a 4'x 3.5' box. Records in this area are not good and a check of this option should be made before starting design. Other improvements proposed for this area include the upgrade of existing storm sewer lateral of the 26th Street system along 27th Street and Ave E. The existing 18-inch lines are small for this area and 24-inch and 30-inch replacements would improve the hydraulic grade line significantly.

29th Street System – From 29th Street west a number of the existing storm sewer outfalls have limited capacity. To alleviate this and extend additional capacity to the Broadway Boulevard corridor a new drainage route was researched. Initially 30th Street looked to be a favorable route, however, there is limited right-of-way (approximately 40 ft.) between Ave M and N. The other potential conflict is the water pump station at 30th and Winnie. This pump station is supplied by two 30-inch water mains from the mainland and distributes water for most of Galveston east of this location. Due to these potential constraints, it was decided to upgrade the existing 29th Street storm sewer instead. The drainage area increases from 104 acres to 588 acres. This is a significant increase and there are limited avenues through the port area for improvements. Two options are available. First is to leave the existing 72-inch outfall in place just east of the grain elevators, and then extend the new storm sewer (2-9'x 6') around the west side of the grain elevators and under the existing port road. There is space through this area for construction. The second option is to keep all drainage facilities along 30th Street and remove and replace this storm sewer. The resulting outfall size would be approximately 3-8'x 6' or 2-10'x 7' boxes. The sanitary sewer along Harborside is reduced to a 24-inch force main through this area so sanitary conflicts can be minimized. Major water lines cross this area and will need to either be relocated to avoid conflicts or special structures could be constructed to keep the existing water lines in place. An environmental assessment by Berg Oliver resulted in the identification of potential archeological

artifacts at the proposed outfall. The Civil War era ship Zavalla was abandoned along the Galveston Ship Channel and is likely buried by fill in the approximate area of 29th and 30th Street. Additional details can be found in the Preliminary Environmental Assessment of Selected Storm Sewer Routes by Berg Oliver in a separate report. The following is a list of the major improvements assuming construction of the second option. Hydraulic calculations are based on 29th Street alignment and estimated storm sewer sizes on 30th Street are based on a combined flow and area to keep velocities within the same range.

- Starting at the current 72-inch outfall at 29th Street – Remove the current 72-inch pipe and replace with 2-10'x 7' box culverts north to Post Office
- Along 29th Street from Post Office to Broadway – Remove existing 5'x 2' box with a 9'x 6' box
- Along 29th Street from Broadway to Ave N – Construct new 7'x 6' box, and tie into 4'x 2.5' box to east at Ave M. Plug the remaining line west along Ave M.
- Along Ave N from 29th To 23rd Street – Construct 7'x 6' box and plug existing lines at 25th and 23rd to the north
- Upgrade existing storm sewer on 23rd Street from Ave N to Ave P from a 24-inch to a 48-inch
- Upgrade existing 15-inch storm sewer on Ave P from 21st to 23rd Street to a 36-inch pipe
- Upgrade existing 25th Street 3'x 2' box south of Ave N by doubling the existing 3'x 2' with an additional 3'x 2' box
- Upgrade existing 29th Street storm sewer from Ave N to Ave O1/2 from a 3.5'x 2.5' to a 7'x 4' box
- Upgrade existing 29th Street storm sewer from Ave O1/2 to Ave P1/2 from 3.5'x 2.5' to a 5'x 4' box
- Upgrade existing Ave P1/2 24-inch storm sewer from 29th to 27th Street to a 42-inch pipe

In addition, there is a secondary lateral to be constructed to this system that additional drainage area from the Ave M and 33rd Street lines. These improvements are as follows:

- Along Post Office from 29th Street to 30th Street – construct 2-8'x 5' box
- Along 30th from Post Office to Church – construct 2-8'x 5' box
- Along Church from 30th to 33rd Street – construct 2-8'x 5' box
- At 33rd Street and Church construct junction box and restrict flow north to half the existing 8'x 3' box
- Remove and replace existing 8'x 3' storm sewer along 33rd from Church to Ball to 2-6'x 5' boxes
- Remove and replace existing storm sewer from Ball to Ave M to 2-5'x 5' boxes. Plug existing box west of 33rd Street along Ave M
- Existing storm sewer along 33rd from Ave M to Ave O can remain. However, a parallel 48-inch pipe is required from Ave M to Ave O1/2
- Along 33rd from Ave O1/2 to Ave P – 42-inch pipe
- Along 33rd from Ave P to Ave R – 36-inch pipe

- Along Ave M from 33rd to 31st – remove existing 4.5'x 3.5' and replace with at 6'x 5' box and tie into existing 4'x 3' box from the east at 31st Street
- Along 31st from Ave M to Ave O – replace existing 2'x 2.5' box with a 5'x 5' box
- Along 31st from Ave O to Ave R – replace existing 2'x 2.5' box with a 42-inch pipe
- Along Ave R from 31st to 32nd – replace existing 1'x 1' box with a 30-inch pipe
- Along Broadway from 35th to 34th replace 24-inch with a 30-inch, from 34th to 33rd replace 24th with a 36-inch, from 33rd to 32nd replace 24-inch with 36-inch, from 32nd to 31st replace 24-inch with 30-inch
- Along Church from 33rd to 34th – replace existing pipe with a 54-inch pipe
- Along Church from 34th to 35th – replace existing pipe with a 48-inch pipe
- Along 35th from Church to Ball construct a 36-inch pipe

<u>37th Street System</u> – No improvements to this system are proposed. Drainage areas near Broadway are diverted to the proposed 51st Street outfall. The overall drainage area boundaries for this system are reduced from 188 acres to 124 acres.

<u>45th Street to 51st Street System</u> – The existing system is overburdened due to the large areas draining to this interconnected system. The primary relief route proposed for this area is the upgrade of the 51st Street outfall near the wastewater treatment plant. This proposed system improves performance of the drainage system from Ave O north and between 36th Street and 51st Street. Based on field observations the current 51st Street outfall is silted in significantly. This outfall is within a jurisdictional wetland area that will complicate the required permitting for construction. There is some storage available within these wetland areas for flood storage, however, the detailed analysis of this storage available for the 2-year design storm is beyond the scope of this study. Outfall size requirements are based on conveyance of the 2-year storm event without storage considerations. Protection of this outfall from future silting may require some non-traditional construction methods. One option is constructing a box culvert through the area and then allowing the wetland areas drain into the outfall via inlets that would restrict sediments. Another option may involve the construction of bulkheads and weirs facilitate periodic dredging operations to keep the outfall clear. Environmental regulations will require permits due to the wetland areas. This outfall also drains areas west of 51st Street that enters the wetland area. This includes areas west to the rail yard and 59th Street. The redevelopment of the old cotton warehouse into the Galveston County Detention Facility will also drain into this wetland area. The locations of all the outfalls to this area have not been identified, however, due to the ground contours of this area there is no other place for storm water to drain in this area. The outfall for the drainage inlets at 53rd just north of Ave G is assumed to go north, however, this was not verified.

The following is a listing of proposed improvements for the 51st Street outfall system:

- From the current outfall between the Pelican Island Causeway and the wastewater treatment plant dredge a deeper channel construct bulkheads and levies to prevent sedimentation of the outfall. Remove the existing 6-42-inch storm sewers and replace with an equivalent 10'x 10' box system.

- Dredge the areas south of Port Industrial along the current channel alignment. The channel will need to be dredged approximately 9-ft. deeper up to Post Office.
- Current railroad crossings need to be evaluated based on the required channel depth to determine if dredging operations will impact the structural integrity of the railroad base. An estimate of new railroad crossings is included in the cost estimates.
- At Post Office or parallel on the north side continue with a 10'x 10' box to 50th Street. Currently there is a culvert crossing under Post Office at this location.
- Along the existing ditch at 50th Street extend a 6'x 5' box south to Ave K. Tie existing systems into this new storm sewer. At Ave K plug the existing storm sewer to the west and maintain the connection to the south and east.
- Along Post Office from 50th to 48th Street construct a 2-8'x 6' box culvert. This size was selected to minimize construction depth, however continuation of a 10'x 10' may be desirable to minimize construction trench widths and if construction depth is not a problem in this area.
- Along the 48th Street corridor there is limited right-of-way and no paved roadways exist along the majority of this alignment. Construction of a 42-inch and 36-inch pipe up to Broadway is proposed to drain portions of Broadway currently not served by a storm sewer system. This will also facilitate drainage of the industrial area on each side of this right-of-way.
- Along Post Office from 48th to 45th Street – construct 2-8'x 6' or an equivalent 10'x 10' box. Connect to the existing storm sewer on 45th Street. Block 50% of the area for the existing storm sewer north of this location.
- Along Post Office from 45th to 43rd Street – construct a 9'x 6' box. This area is primarily abandoned railroads.
- Along 43rd Street from Post Office to Broadway – construct an 8'x 5' box and disconnect the existing storm sewers at Broadway going east and west.
- Along 43rd Street from Broadway to Ave M replace the existing 5'x 3.5' with a 7'x 5' box to provide additional depth. Disconnect the existing storm sewer west along Ave K.
- Along Ave M from 43rd to 39th replace the existing 5'x 3.5' box with a 5'x 5' box to provide additional depth.
- The remaining portions of the Ave M system can remain in place.

Another storm sewer lateral is proposed to drain portions of Ave K and remove drainage areas from the bridge blocks along Broadway from 35th Street to 39th Street. These improvements are as follows:

- Along 41st Street from Post Office to Winnie remove the existing storm sewer and replace with an 8'x 6' box culvert. The replacement option was chosen to reduce trench widths. Connect to the existing storm sewer south of Winnie.
- Along Winnie from 41st to 40th Street replace existing 18-inch pipe with a 7'x 5' box
- Along 40th Street from Winnie to Ball construct a 7'x 5' box
- Along 40th from Ball to Ave K construct a 5'x 4' box
- Along Ave K from 40th to 39th construct a 5'x 4' box
- Along Ave K from 39th to 37th construct a 42-inch pipe
- Along Ave K from 37th to 35th construct a 30-inch pipe

With improved inlets this will effectively remove the drainage area from the existing bridge blocks on Broadway so that they can be removed.

West Ave K System – This system is reduced from 295 acres to 142 acres and is cut-off at 50th Street alleviating the current capacity restrictions. The outfall for this system goes through many existing homes and adding additional capacity was not an option during this study. Most of this system is to remain in place except for the lateral along 53rd Street. The existing 2.5-ft. deep boxes are difficult to maintain and do not provide sufficient depth for inlet upgrades. These proposed improvements are as follows:

- Along 53rd from Ave K to Ave N1/2 - Remove and replace existing 4'x 2.5' box with a 48-inch pipe
- Along Ave N1/2 from 53rd to 50th – Remove existing 2'x 2.5' box and replace with a 42-inch pipe
- Along Ave N1/2 from 50th to 48th – Remove the existing 2'x 2.5' box and replace with a 36-inch pipe.
- The remaining portions of the line on Ave N1/2 are to remain in place.

Proposed Frazier/Ave. O System – This proposed system was initially outlined in the previous storm sewer master plan. The proposed outfall is at Offats Bayou and Fraiser. There is an opening here between two homes where there is adequate room to acquire easements and add storm sewer. This system drains areas from Offats Bayou east to an existing storm sewer at 35th Street and Ave O. This system is also draining portions of the Ave P and Q storm sewer system. Based on the current land use there are homes on top of the outfalls for the Ave P and Q storm sewer systems. A bypass for these systems is proposed along 53rd Street due to the higher elevation of the ground in this area. Another bypass route at 57th Street was looked at, however the ground elevations are so low in this area that it would be impossible to keep the hydraulic grade line within the ground based on the estimated design flows. Improvements based on this bypass construction are as follows:

- From Offats Bayou along Frazier and Ave O to 53rd Street – Construct a 10'x 7' box
- Along Ave O from 53rd to 49th construct a 8'x 7' box
- Along Ave O from 49th to 41st construct a 7'x 6' box
- Along Ave O from 41st to 39th construct a 6'x 6' box
- Along Ave O from 39th to 35th construct a 7'x 4' box and tie to existing storm sewer to the south (3'x 2.5')
- Along 37th south of Ave O at 2-block intervals extend a 48-inch, 42-inch and 30-inch pipe. Plug existing storm sewer to the north.
- Along 39th south of Ave O to Ave P remove and replace existing 3.5'x 2.5' box with a 48-inch pipe
- Bypass line along 53rd Street – construct an 8'x 7' box south to Ave Q – note that the Ave P crossing will be higher in elevation, however, both ends will need to remain open. The Ave P system will remain in place with no improvements.
- Along Ave Q from 53rd to 43rd Street construct a 7'x 6' box. The existing 8x6 stub out from 57th Street will remain but not connected to the new 7'x 6' box.

- Along Ave Q and 41st Street to Ave S construct a 60-inch pipe
- Along Ave S from 41st to 39th construct a 48-inch pipe
- Along Ave S from 39th to 37th construct a 36-inch pipe
- Along 43rd from Ave Q to Ave S1/2 construct a 48-inch pipe to relieve the 47th Street lateral. At Ave S1/2 disconnect the existing storm sewer to the west.
- Along Ave S1/2 from 43rd to 42nd remove existing 2'x 2.5' box with a 48-inch pipe
- Along Ave S1/2 from 42nd to 40th remove existing 2'x 2.5' box with a 36-inch pipe

Areas just south of Ave Q and west of 47th are currently unserved by storm sewer and future laterals to the Ave Q system can be completed as desired.

The original option to improve 57th Street included the addition of a second 9'x 6' box culvert north of Ave Q. However, the existing homes and swimming pool within the project path made this option less desirable. Construction of this segment would eliminate the need for the bypass line at 53rd Street and the remaining portions of the Frazier System would be reduced from a 10'x 7' to an 8'x 7' box.

<u>59th Street System</u> – Currently this system is undersized and heavily influenced by the tide elevations. Ground elevations are only 1-foot above the mean high tide elevation in a number of locations. The outfall is currently a 36-inch and goes through existing homes. Replacement of this line would be difficult without purchasing the properties and demolishing the structures. Proposed is a diversion to the existing storm sewer at 57th Street/Saladia and to upgrade the existing storm sewer along 59th Street.

- The existing line is small and should be replaced. Connection to the existing 9'x 6' box at 57th Street to 59th Street is via a 5'x 3'box.
- At 59th Street a junction box is required to tie into the existing 36-inch outfall to the north.
- To the south remove and replace the existing 24-inch pipe with a 7'x 3' box to Ave Q.
- From Ave Q to Ave R continue with a 6'x 3' box.
- From Ave R to R1/2 continue with a 5'x 3' box.
- From Ave R1/2 to Ave S continue with a 3'x 3' box. Remove the existing trunk system and update inlets at each intersection.
- The existing laterals from 57th Street and 61st can remain in place, and the additional storm sewer on 59th will take flows away from these laterals.

<u>Grover Street System</u> – Improvements to this system are limited to the existing storm sewers on Heards Lane. Based on field visits the current outfall structure just west of Grover and north of Heards contains two different outfalls. These outfalls differ from the pipes shown on previous studies and construction plans. The easternmost structure appears to be 2-5'x 4', and the westernmost is a 2-4'x 4'. Structure depths are difficult to determine due to silting but appear to be in the 4-5-foot range. Proposed improvements are based on the available data that shows a parallel 60-inch and 72-inch pipe along Grover and a 36-inch pipe along Heards from the west. The existing storm sewers along Grover are adequate and also provide an outfall for Greens Bayou. Improvements to Heards Lane include new box sewers to replace the existing storm sewer pipes. These include the following:

- Along Heards from Grover to Holleywood – replace existing 36-inch with a 6'x 4' box
- Along Heards from Holleywood to Victory – replace existing 36-inch with a 6'x 3' box
- Along Heards from Victory to Bayou Homes – replace existing pipe with a 5'x 3' box
- Along Heards from Bayou Homes to 67th Street – replace existing pipe with a 4'x 3' box

Not included in this list are improvements to the drainage systems just south of Heards. These areas are relatively low and subject to tidal flooding. Generally these areas drain via overland flow to Heards. Inlets at Heards may need to be upgraded to improve flow into the system during normal tide conditions.

West Heards System – This area generally drains to the open channel ditch between the intersection of 71st and Wimcrest. This channel is not adequate for the proposed design flows. With limited right-of-way improvements are based on a composite section with a 10-foot wide and 4-ft deep concrete low flow vertical wall section and 4:1 side slopes to match existing ground at each side of the existing right-of-way. At Ave P an access point can be constructed to allow a front-end loader or other device to enter the channel during low tides and clean out the concrete channel as needed. The proposed outfall to this channel is a 7x4 box from Heards Lane replacing the existing 2-36-inch pipes. All of this area is very low and subject to tidal flooding and storm sewer improvements will likely not improve this situation. Proposed improvements to this system include the following:

- Replace existing storm sewer from 71st to the 7'x 4' box outfall with a 5'x 3' box
- Replace existing storm sewer from 7'x 4' box outfall to 69th Street with a 5'x 4' box
- Replace existing storm sewer from 69th to 67th with a 4'x 3' box
- Along 69th Street from Heards to Jones Road a proposed 42-inch pipe to drain sections of Jones Road from 69th to Cypress Street. A 30-inch line is proposed along Jones from 69th to Cypress Street. Remaining connections from Jones Road to the Colony Park system would be disconnected and plugged.

Beluche Road System – This is a small subdivision storm sewer that is currently a 24-inch pipe. Improving this line to a 36-inch and upgrading the outfall to a 42-inch improves drainage in this area considerably based on the drainage areas determined for this system.

Colony Park South System – Drainage from a significant portion of Colony Park and the existing school drain to this system. The entire reach is undersized. The following improvements are necessary:

- Double the existing capacity of the outfall by installing a parallel 42-inch pipe from the outfall east to manhole draining the southern portion of the school property.
- From the above location east to South Street remove the existing pipe and construct a 4'x 3' box
- From South to Colony Park remove the existing pipe and construct a 3'x 3' box.

B. Bridge Blocks

There are a number of bridge blocks around the City. For this study they are too numerous to mention here in detail. Of primary concern are the existing bridge blocks

crossing Broadway Boulevard. These existing structures can be eliminated once adequate storm sewer improvements are made within the proximity of these bridge block locations. In some cases the existing large inlets may be able to remain in place, however, storm sewer laterals from adjacent storm sewer systems will be necessary to collect this runoff. The following table describes possible tie-in locations to the proposed trunk line system:

BROADWAY BRIDGE BLOCK LOCATIONS AND PROPOSED TIE-IN LOCATIONS FOR FUTURE BRIDGE BLOCK ABANDONMENT	
LOCATION	**NOTES**
16th Street	Drain east to proposed 15th Street system (6x5)
17th Street	Drain to west proposed 18th Street system (7'x 5')
18th Street	Drain to proposed 18th Street system (7'x 5')
20th Street	Drain south to Ave K system (60-inch)
21st Street	Drain south to Ave K system (60-inch)
22nd Street	Drain to upgraded 36-inch on 22nd Street
28th Street	Drain west to proposed 29th Street system (7'x 6')
29th Street	Drain to proposed 29th Street system
30th Street	Drain east to proposed 29th Street system
33rd Street	Drain to upgraded 33rd Street system
35th Street	Drain to upgraded lateral along Broadway to 33rd Street
36th Street	Drain south to Ave K system 30-inch
38th Street	Drain south to Ave K system 42-inch
39th Street	Drain south to Ave K system (5'x 4')

C. Open Channel Systems (West Galveston – Non – Seawall Areas)

Open channel systems are the primary drainage conveyance on Galveston Island from the Airport westward and beyond the existing seawall. As discussed in earlier sections the primary roadway is FM 3005. This road extends along the south side of Galveston Island. Stewart Road generally runs parallel between the airport and Galveston State Park. In the areas between the State Park and the Airport there are numerous low areas, wetlands, and tidally influenced areas. In previous studies these areas were referred to as impoundment areas. These areas are beneficial as they can provide rainfall storage and minimize rainfall peak flows from these large areas, and they are also important to maintaining a supply of fresh water for existing plant and wildlife. The purpose of this study is to define the existing primary drainage system, and determine needs based on LIDAR topography and reports from residents.

As outlined in the previous Pate Engineers study of Galveston County, a number of the same principals apply to drainage on the west end of Galveston Island. Since Galveston

Island is a barrier island it is a relatively new and transitional feature that changes with the movement of sand and sediment. The east end of the island is protected by a seawall and levies that protect this portion of the island. This does not eliminate beach erosion, but it does stabilize the location of the shoreline. The shoreline on the west side of the island is shifting and there is no feature other than the sand dunes to protect this portion of the island. Recent tropical storms have eroded significant portions of beach away from existing developments. These storms act to accelerate existing trends.

The island is composed of three primary areas. First the beach is the boundary between the Gulf of Mexico and the island. The beach contains intermediate sand bars that were the original building blocks for the island. The second feature is the dune areas. The dunes are built-up mounds of sand and sediment from the beach areas. Dunes are stabilized with the growth of vegetation on the dunes that help hold the sand in place and allow for the deposition of additional sediments. The remaining portion of the island is considered coastal bayshore. This is the area between the dunes and the bay and is generally the area that is available for development. This area is generally flat and drains to the bayside of the island. Along the bay coastline the areas below the high tide elevations are considered marshlands. The marsh areas are flooded intermittently based on the tide conditions in area. These areas are generally not desirable for development and are considered protected areas based on the documentation from the US Corps of Engineers provided in the environmental portion of this report. Dunes are also a protected feature of the island and breaches to the dune system are detrimental to the protection of the island from erosion during tropical storm events.

The LIDAR digital terrain map was used to estimate drainage areas and to determine flow patterns based on the ground contours. However, the numerous roads and small culverts allow water to pass areas that may not be evident with the LIDAR data. Drainage areas for the west end of Galveston Island were finalized based on a combination of LIDAR, previous studies and roadway alignments. The sizes of existing culvert crossings were based on previous studies. The most recent of which was done by Pate Engineers (date unknown). Culverts along FM 3005 are currently being studied separately for TxDOT. Each outfall and culvert structure along FM 3005 in this TxDOT study was given an ID#. These numbers are shown on the exhibit along with the culvert size for reference purposes. Drainage areas shown are intended to show general system boundaries and areas contributing to roadway right-of-ways. Drainage areas to a particular culvert are difficult in a number of areas due to multiple culverts acting as a manifold to allow storm water to pass through the roadway. The following is a summary of drainage conditions within different areas west of Galveston. Each area is designated on the drainage block map exhibits. Names are generally based on the name of drainage systems or subdivisions within the area.

Designated Drainage Zones in West Galveston:

Sweetwater Lake Area
Mensell Bayou Area
Eckers Bayou Area
Lake Como Area
Galveston State Park Area
Jamaica Beach Area
Indian Beach Area
Sea Isle/Terramar Area
Bay Harbor West Area

Sweetwater Lake Area – This area generally drains to either Sweetwater Lake or Sydor Bayou on the west side of the Airport. Development in this area is limited to small areas of residential communities. General limits include the area bounded by the Airport to the east and 9-mile Road to the west and the beach areas to the south. Areas draining to Sydnor Bayou are generally behind the seawall areas. This includes portions of the Airport, the Galveston Golf Club, and areas south of Stewart Road and east of Cove View. One of the lowest portions of this area is at the intersection of Stewart Road and 99th Street where there is an existing culvert (unknown size). Areas along 103rd Street and Pilot Lane are very low in elevation and high tide events can flood the roadways in these areas. Areas such as Campeche Cove and Cove View drain to excavated detention areas that drain to Sweetwater Lake. The exception to this area include the area south of FM 3005 called Hendersons Hole where there are two major dune breach points between 7-mile Road and 8-mile Road. These areas drain directly to the beach side. Hendersons Hole has been developed into a recreation area and the other breach point is within the City of Galveston Pocket Park #1. Other isolated areas include Anderson Ways, a small area at the north end of 8-mile Road and Sportsman Road on the bay side of the island. This area drains to the Bay directly. 8-mile Road north of Homrighaus Road to Anderson Ways is generally under an elevation of 4-ft. The majority of this area drains to a low area between Stewart Road and FM 3005 originating near 10-mile Road and FM 3005. There is a meandering low area that drains toward the intersection of Stewart Road and 8-mile Road. Existing crossings of Stewart Road include a 10'x4' box culvert and a small bridge near 8-mile Road. The area northwest of this intersection is a large low lying area that drains to through 8-mile Road to Sweetwater Lake. There are a number of crossings along 8-mile Road, however, previous studies only show a 36-inch culvert near Homrighaus. Proposed improvements in this area include:

(1) Raising existing roadways to a minimum of 5-ft. in elevation in areas that are escape routes. Galveston minimum is 8.2-ft and is representative of a 25-yr tidal elevation. Many areas can not meet this requirement and an elevation of approximately 5-ft is more appropriate which is between a 5 and 10-yr tidal frequency. This includes 8-mile Road, 9-mile Road, Stewart Road and the Ostermeyer/Zingleman/Homrigahaus Road routes. These roads cross a number of low areas that can flood during high tide events that can restrict access to

developments north of Stewart Road. Raising the roads will reduce the frequency of tidal flooding on these roadways.

(2) A 30-inch culvert crossing at the intersection of Ostermeyer Rd and Zingleman Road from north to south will allow the low area at this intersection to drain to the marsh areas south of the road. Limited drainage area will allow this area drain properly.

(3) 4-5'x 3' box culverts/ or 15-ft. bridge across 8-mile Road north of Stewart Road. Drainage area approximately 817 acres.

(4) Improved roadside ditch on south side of Stewart Rd from Silver Sand to 8-mile Road with a 5' x 3' box across Stewart Road to Sweetwater Lake.

(5) Minimum 2-36-inch draining approximately 88-acres crossing across Stewart Road just east of 7-mile Road near what appears to be Sweetwater Lake, the existing roadside channel on the south side will also require improvement to drain to the culvert location. Also need 2-24-inch culvert to drain 17 acre area from 7-mi Road to 71/8-mi Road.

Mensell Bayou Area – This area extends from a line defined by 9-mile Road and 10-mile Road west to roughly Pabst and Spanish Main Road as shown on Exhibit 3. To the north the area is bounded by a high area that runs along Ostermeyer and Jenkins Road. The south is bordered by the beach dune areas. The primary outfall for this area is a bridge that crosses Camino Real Road. Based on City reports this bridge is deteriorating and may need replaced or improved within the near future. There is a 2-30-inch culverts crossing of Pabst Road that allows portions of water to pass through. It is not clear if there is a culvert crossing of Stewart Road at Spanish Grant just west of Camino Real but this would be a good location for future drainage improvements. Just east of Camino Real there is a 50-ft. bridge that is adequate for the existing needs, however, the bridge on Camino Real must remain in place. Previous studies showed the construction of an additional channel to connect with the Mensel Bayou channel from Spanish Grant. As long as the outfall through Camino Real is in place this channel is not necessary. The following are recommended improvements for this area:

(1) Minimum culvert size under FM 3005 shall be 24-inch. Based on records there is an 18-inch near Pabst Rd and an 18-inch near Spanish Grant that should be upgraded to a 24-inch.

(2) Pabst Road just north of FM 3005 replace existing 2-30-inch pipes with 3-5'x 3' box culverts and raise the road above elevation 5-ft.

(3) Add a 24-inch culvert just south of Stewart Road to allow area to drain east to low area just east of Pabst Road. Some roadside ditch improvements will be necessary just upstream and downstream of this culvert.

(4) Review John Reynolds roadway condition and determine if an overlay project may help improve ponding on the roadway itself. Channels along the road with low-water crossings on the driveways are the norm in this area. Improvements to these swales would require the reconstruction of all driveways and is not recommended in this area due to the expense.

(5) Repair damaged inlet on John Reynolds.

Eckers Bayou Area – This area is generally bounded by 11-mile Road to the east and Buccaneer Blvd. to the west. The primary outfall channel extends from Pirates Beach north to Eckers Bayou and crosses under FM 3005 and Stewart Road near the location of Mutiny Circle. There are 3-30-inch culverts at FM 3005 (#26) along with two other 24-inch crossings west between the main channel and Buccaneer Blvd. Between FM 3005 and Stewart Road there is an east/west low area that is also connected to the Mensell Bayou area via a bridge under 11-mile Road. High areas just west of 11-mile Road tend to keep these areas separate unless there is ponding above an elevation of 4.5-ft. Pirates Beach is drained by roadside ditches that generally drain toward the intended outfall locations. However, there are low areas along Pirates Beach and Grand Terre that appear isolated from the outfall locations and cause nuisance ponding. Due to the number of outlets for drainage in this area it is not surprising that flooding reports within this area are limited. Suggesting that overall the existing drainage system in place is working. No improvements are outlined for this area.

Lake Como Area – This drains parts of Pirates Cove and Pirates Beach as shown on Exhibit 3. The Galveston Country Club and Golf Course are located along Stewart Road in this area. Five cross-culverts across FM 3005 have been located in this area with the largest near Pirates Beach Boulevard (4-24-inch), which is the primary outfall location for developments south of FM 3005. This channel continues north to Stewart Road where the previous master plan by Pate Engineers shows a proposed 48-inch cross-culvert. The existing culvert is a 2-30-inch. Drainage problems reported in this area are restricted to low areas away from outfall locations such as Oleander Drive and Vista Boulevard in Pirates Beach. There is a separate 24-inch outfall at the intersection of Swashbuckle and FM 3005 that drain this portion of the subdivision to a low area just north of FM 3005 that collects portions of the State Park. A channel has been constructed that takes this area north to Stewart Road where there is a 2-48-inch cross-culverts to Lake Como. The area between Buccaneer Blvd. and Pirates Drive south of FM 3005 drains to a 24-inch cross-culvert, however, there is no conveyance north of FM 3005 to Stewart Road. Crossings of Stewart Road are not evident, however, the area just south of Stewart Road is low and can store water. Another isolated area is between 12-mile Road and Cove north of Stewart Road. This area drains north via existing inlets and storm sewer via estimated 24-inch pipes north to Galveston Bay. Approximately 24-acres drains toward 12-mile Road and the golf course and the northern 25-acres drains north to a large low area. The following improvements are outlined on the exhibits:

(1) Proposed 5’ x 5’ box to replace existing 2-30-inch culverts at Stewart Road and Del Lago(at Channel outfall to Galveston Bay)
(2) Channel south side of FM 3005 from Buccaneer Blvd. west to the channel near Pirates Beach Blvd. where 2-30-inch cross-culverts are proposed.
(3) Channel south side of Stewart Road west from 12-mile Road to proposed 30-inch culvert crossing north to low area at golf course just east of Pirates Beach.

Galveston Island State Park Area – This area is bounded by Jamaica Beach and 13-mile Road. Most of this area drains directly to the north. There are a number of small culverts crossing FM 3005 that allow water to pass north through the roadway. Based on the LIDAR data many of the campground areas generally drain toward the beach side

(south). The park is maintained by the State of Texas. Portions of the park drain east and across 13-mile Road via a 36-inch culvert just north of FM 3005. Also there is a Lone Star Performing Arts Pavilion at the northeast corner of the property that collects portions of the State Park Drainage area as well. No improvements proposed for this area.

Jamaica Beach Area – This area is considered separate from the City of Galveston and has its own drainage system. This area is exempt from drainage fees and is not included in this Drainage Master Plan.

Indian Beach Area – This is a rather large area that extends from Sea Isle east to Jamaica Beach. The area has limited development that is confined primarily to the beach side of Galveston Island. The City has completed some drainage projects in 1996 that added additional outfalls for Kahala Beach, and The Dune's within this area. There are a total of six (6) outfall locations within this area, however, all of these are west of Indian Beach. The subdivisions south of FM 3005 within Indian Beach east to Jamaica Beach do not have any outfalls on the gulf side of Galveston Island. These developments drain south to the beach areas and were constructed before the current drainage regulations were put in place. The worst problem in this area is an area at Habla and Glei (Karankua Beach). New outlets are required to enable these areas to drain north and possibly abandon the current outfalls to the beach side of the island. The beach outfalls are a maintenance problem due to wave action and shifting dunes that block or dislocate the existing outfall locations. Exhibit 3 shows the proposed outfall channel locations. No easements exist in this area and the dedication of drainage easements will be required prior to ditch construction. Approximate drainage easements are determined based on maximum channel depth and a maintenance berm of 20-ft. on each side of the channel. An investigation of drainage through the dune areas was done by contacting the GLO. Based on these talks it was clear that there it would be very difficult to approve drainage outfalls to the beach areas. In addition the City regulations do not support this activity as well.

(1) Proposed Ditch IB-1 – This proposed drainage easement is located at an apparent road right-of-way and driveway to FM 3005. The existing easement does not go north to the bay and a minimum 100-ft. mixed use right-of-way will be required road access to the lots adjacent to this ditch alignment. Proposed channel, 6-ft. bottom width and 3:1 side slopes. The owner will need to provide a road to develop these existing empty lots and it is possible for the owner to dedicate right-of-way to the City for drainage and or roadway based on the current subdivision guidelines.

(2) East boundary of Indian Beach (IB-2) – 2-30-inch cross culvert, channel 6-ft. BW, 3:1 ss, 100-ft. ROW – This requires taking 100-ft. from back lots of east side properties of Indian Beach.

(3) Proposed ditch at boundary between Gulf Palms and Karankua Beach (IB-3) at Habla and Glei – 2-36-inch cross-culvert, channel 6-ft. BW, 3:1 ss, 100-ft. ROW – This cuts through the middle of a land parcel. As an alternate to this work for immediate results considers raising the roadways and driveways sufficiently to an elevation of 5-ft to improve vehicle access. 18-inch culverts are required under

each road at the T-intersection (Habla and Glei). This would not solve the existing flooding problems, but allows residents better access to their properties.

(4) Proposed ditch at current location of 36-inch culvert #11 (IB-4). This is generally located where there is an existing property boundary, however it cuts through a small business. Channel 6-ft. BW, 3:1 ss, 100-ft. ROW

(5) Proposed ditch approximately at Blue Heron Circle and at existing property boundary (IB-5). 36-inch cross culvert, channel 6-ft. BW, 3:1 ss, 100-ft. ROW

Sea Isle/Terramar Area – This area is covered in Section 7.C.2 which covers proposed improvements for each subdivision. The following is a summary of these recommendations.

- Along Verano West – Add a swale to drain roadway east to the existing inlet as recommended by the residents. The inlet appears to be set too high. Due to depth constraints it will be necessary to remove the inlet and use concrete slope paving around the existing 18-inch pipe entrance. There are no culverts under driveways in this area. If added to this area the ditches would need to be added and a minimum culvert size of 18-inches was used to facilitate cleaning. Based on the City policy the owners would be responsible for the cost of adding driveway culverts.
- Along Verano East – The existing inlet at the corner of Terramar is not evident and likely filled with sand. Plans show that there is a manhole under the dune area between FM 3005 and Verano. Low areas in the road are approximately 150-200-ft. east of the intersection. A 24-in storm sewer constructed from the existing 36-inch storm 400-ft. on the north side of Verano with Type A grate inlets on 200-ft. intervals including the connection to the existing 36-inch storm sewer. With this construction the low areas will be able to drain. The south side has a small sand dune that would likely fill an inlet with sand and is not suitable for inlets.
- Along Terramar – There is no swale or roadside ditch in the area just north of Verano. To provide some positive drainage a swale needs to be added along the west side of the road from Verano north to an existing pipe crossing under the southbound lanes of Terramar. This pipe will need to be cleaned out, as well as the other storm sewers and culverts in the subdivision. If the existing pipe is less than an 18-inch pipe then the removal and replacement of the existing pipe to the channel within Terramar is recommended along with the construction of a Type A inlet on the alignment of the existing pipe within the west right-of-way. Slope paving should be added within this area to help clean sand away from the inlet areas and to deter the spread of grass.
- Additional channels to drain FM 3005 are proposed on each side of Terramar Subdivision. TM-1 is along the west boundary and TM-2 is along the east boundary. TM-2 can be short due to the large excavated area as part of Isle Del Sol. A 60-ft. drainage easement is needed for both of these locations to maintain and reserve the outfall locations and to prevent future development that may block drainage from FM 3005.

For Sea Isle,

- Areas within canals such as Antascosta Key – The problems in these areas are both tidal and conveyance. Storm inlets are not located at low areas. This type of problem is due to the original construction grading. Solutions are limited. Check valves have been mentioned as a solution to prevent tidal flows from entering the storm sewer

system. This has the potential for trapping water in during high tides. If check valves are placed on the current outfall pipes a pump station is recommended to pump out run-off during rain events with higher than average tides. There does appear to be room to add a 24-inch outfall pipe and inlet to help get water out of this area.

- The existing storm sewer systems along Panola and around Ector need to be cleaned along with the roadside ditch system. No plans for the existing system were found and existing sizes are unknown. Due to this uncertainty a storm sewer is proposed as shown on Exhibit 3. The existing storm sewer system under Panola can be expanded to drain portions of FM 3005. There are some empty lots near along FM 3005 and it may be necessary to purchase a lot or split an easement between lots to gain additional access to FM 3005 roadside ditches.
- Fort Bend Drive is one of the lowest streets in the subdivision. Raising the road to a minimum elevation of 5-ft. would help mobility during high tide events. Preliminary sizes for a storm sewer system along this road are shown on Exhibit 3. Again extensions to FM 3005 would require a drainage easement (minimum 20-ft), or the purchase of an empty lot.
- Ponding along FM 3005 is due to lack of conveyance north. Proposals from the City include locating a storm sewer along Liberty and obtaining an easement between existing properties to get access to FM 3005. Drainage swales along FM 3005 would then need to be graded toward this outfall location. An estimated size for this storm sewer to collect water from Ector to San Jacinto at FM 3005 is a minimum of 24-inches. The area within Ector to Jackson is approximately 80-acres. The outfall pipe for the system should be a 2-48-inch pipe minimum.

Bay Harbor West Area – This area covers the western tip of Galveston Island to the eastern limit of Bay Harbor. There is a small tract of undeveloped land between Bay Harbor and Terramar Beach that represents the drainage divide. This area consists of a number of small bays and low areas. Drainage from FM 3005 outfalls to a number of these small bays via improved outfalls downstream of cross-culverts. Based on the terminology from the FM 3005 project these outfalls are numbered from #1 to #8A in this area. Only #8A is considered part of Bay Harbor, and there is an area approximately 4,000 feet long west of Bay Harbor where there are no defined outfall locations and limited developments along the beach side of FM 3005. Bay Harbor itself is drained via roadside ditches that drain north to 7th Street, or to Outfall #8A along the west side of the subdivision. At the end of 1st, 2nd and 3rd Streets storm sewer outfalls were constructed that outfall to the drainage channels just north of 7th Street. Each of these is estimated to be a 24-inch pipe. There are a number of low areas within Bay Harbor that are less than an elevation of 4-ft. These areas can be subject to occasional tidal flooding during storm events. Most flooding complaints are within the Bay Harbor subdivision. This area was outlined in Section 7. See Exhibit 3.

BH-1 Add an outfall (Channel 6-ft BW, 3:1 SS, 100-ft. ROW) for FM 3005 approximately 3,000-ft. west of Bay Harbor, and regrade roadside ditches to the existing channel along the west side of Bay Harbor.

- Clean out existing drainage swales to drain to the existing inlets and channels, obtain adequate drainage easements if necessary.

- Clean out or replace existing driveway culverts – replacement of culverts is the responsibility of the Owner under the current City rules.
- Many of the low areas are at an elevation of 2 and 3-ft. These areas would be heavily influenced by tidal fluctuations during storm events. Private property owners may fill their driveway to match the existing roadway elevation to improve accessibility. Homeowners must get approval from the City prior to implementing this work, and make sure that neighboring areas are not impacted by altering the existing sheet flow path as determined by existing contours.
- If additional easements are not possible then the construction of a storm sewer system as shown on Exhibit 3 is possible. This includes the construction of area inlets along the roadway that would limit ditch depths to a maximum of 2-ft. deep.

10. CONSTRUCTION COST ESTIMATES

Construction cost estimates for the Galveston Master Drainage Plan are computed using estimates of unit items in today's dollars (2003). Consideration for inflation and other factors over time are not considered in developing the raw construction cost estimates. Information for unit costs were obtained from local contractors familiar with the Galveston area, the City and the latest bid information available from TxDOT available on the Internet for the Houston Region. The cost estimates fit into two categories. Storm sewer improvements and general improvements. The east side of Galveston is primarily heavily developed and contains storm sewers. These costs include the storm sewer pipe, excavation and backfill, dewatering, outfall and bulkhead construction, pavement replacement and costs for intersection improvements to replace inlets and pipes to the proposed storm sewers. General improvements are smaller site specific projects that are typical of areas on the west side of the island where the existing infrastructure is scattered and improvements are limited and confined to smaller areas. See Table 9 for a breakdown of construction cost associated with the proposed capital improvement plan (CIP).

11. OPERATIONS AND MAINTENANCE

As discussed in Section 6, operations and maintenance constitute the general day-to-day activities to maintain the existing storm sewer infrastructure as well as responding to resident complaints on a day-to-day basis. This includes both storm sewer and open channel areas. For a number of years the City of Galveston has had limited resources to maintain the existing storm sewer system that has been filled with silt and debris in a number of areas. This general maintenance work is currently split between the Roadway Maintenance group and a group within the Sanitation Department. Under the direction of the Recycling Coordinator a team was developed that cleans the existing storm sewer system in specific areas that include street clean-up and a complete storm sewer clean out that is much more extensive than the usual inlet cleaning. These efforts have been very successful, however, this crew can not work on these items on a daily basis and based on the current rate of cleaning it would take a number of years to go through the existing system once. This effort is an example of work that would be expanded with additional revenue from an equitable storm water rate fee and development of a drainage utility.

Based on a review of the Galveston City Budget, the City currently spends about $1.2 million a year in the Street Department alone. For the purposes of this study, DEC reviewed the existing budget for drainage related activities. Based on this review, it was difficult to adequately itemize specific drainage related items from the general roadway items. However, based on the information provided by the City staff, the Public Works Department was significantly larger in the early 1980's. An estimate of the operations cost for a drainage utility was based on the current Street Department budget. Considering a portion of this budget is used for drainage, and some additional cost are within the Sanitation Department a total fee of $1.0 million was considered a reasonable estimate to get a drainage utility department started with a similar number of employees. In addition the cost for administering a minimum NPDES program was determined. This was estimated to cost approximately $200,000 a year. Total NPDES and general Drainage Utility cost is $1.2 million. This budget is used to determine projected revenue needs used to determine a preliminary assessment of an equitable storm water rate fees. The following section outlines the factors used to develop preliminary cost estimates for an equitable storm water rate fee for Galveston Island.

12. CAPITAL IMPROVEMENT PROGRAM AND EQUITABLE STORM WATER RATE FEE DETERMINATION

Based on the results of analysis of the existing drainage systems on Galveston Island a Capital Improvement Program can be developed. Due to the limited current funding sources the scope of work also provides for the development of alternative methods of funding. One of these methods is the development of a fee that will be proportional to runoff rates and variable over the years. However, the process to fully research and implement a citywide storm water rate fee is not considered part of this scope. An outline of the general CIP program is provided in Table 9 and shown as the proposed storm improvements on Exhibit 3 (under separate cover).

Equitable Storm Water Rate Fee Determination

Currently the City of Galveston is charging a drainage fee based on water meter sizes. While this is considered a means for generating revenue, it is not based on the quantity of run-off from a particular land parcel. Under this method the residential population pays the highest percentage of fees. Below is a summary of the current fee schedule:

Meter Size (inches)		Number of Meters		Current Fees		Revenue
5/8 & 3/4		19,702		$ 3.00		$ 59,106.00
1		432		$ 3.00		$ 1,296.00
1 1/2		197		$ 7.50		$ 1,477.50
2		240		$ 7.50		$ 1,800.00
3		54		$ 7.50		$ 405.00
4		38		$ 15.00		$ 570.00
6+		82		$ 15.00		$ 1,230.00
		20,745		Monthly Total		$ 65,884.50
				Annual Total		$ 790,614.00
Say a 95% Collection Rate						**$ 750,000.00**

The original public letter sent out to residents as part of the water bill had outlined a different set of rate charges. This is outlined as below:

Meter Size (inches)		Number of Meters		Letter Fees		Revenue
5/8 & 3/4		19702		$ 4.00		$ 78,808.00
1		432		$ 4.00		$ 1,728.00
1 1/2		197		$ 10.00		$ 1,970.00
2		240		$ 10.00		$ 2,400.00
3		54		$ 10.00		$ 540.00
4		38		$ 20.00		$ 760.00
6+		82		$ 20.00		$ 1,640.00
		20,745		Monthly Total		$ 87,846.00
				Annual Total		$1,054,152.00
Say a 95% Collection Rate						**$1,000,000.00**

As part of this study, DEC reviewed the development of equitable storm sewer rate fees in other cities across the country. The primary example for this study was Richland Hills, which is a suburb of Ft. Worth, Texas. For this city detailed information was available. Other examples were researched across the USA based on information on the Internet. The basic premise of the calculations was a determination of impervious area on each land parcel within the City. Collecting this information for all land parcels within the City is beyond the scope of this study. For an initial study it was determined that the data available from the Galveston County Appraisal District (GCAD) would be adequate for the land use analysis. GCAD collects information on each property for the estimation of appraised land values.

Each land parcel is given a land code as follows. Adjustments in this table are for Jamaica Beach only.

CAD - Code	Description	Number of Lots	Comments
A1	Real Residential Single Family	16,607	+487 from Pirates Beach that were undefined = 17,094 minus Jamaica Beach (1,088) = **16,006 lots**
A2	Real Residential Mobile Homes	22	Single Family
A3	Real Residential Condos	25	Multi-Family
A9	Exempt Residential Single Family	128	Single Family
B1	Real Residential Multifamily	869	Multi-Family minus 1 from Jamaica Beach = **868 lots**
B2	Real Commercial Multifamily	240	Multi-Family
B9	Exempt Commercial Multifamily	31	Multi-Family
C1	Real Vacant Plotted Lots/Tracts	4,787	Vacant No Charge – Minus 359 from Jamaica Beach = **4,428 lots**
C9	Exempt Vacant Lots/Tracts	402	Vacant No Charge – minus 27 from Jamaica Beach = **375 lots**
D1	Real Acreage Ranch Land	170	Undeveloped No Charge
D3	Farm Land	2	Undeveloped No Charge
D5	Non-Qualifying Ag Land	272	Undeveloped No Charge
D9	Exempt Farm & Ranch Land	3	Undeveloped No Charge
E1	Real Farm & Ranch Improvements	25	No Charge – Possible development
F1	Real Commercial	1,357	Commercial Rate minus 6 from Jamaica Beach = **1,351 lots**
F2	Real Industrial	45	Industrial Rate
F9	Exempt Commercial	392	Commercial Rate, however properties such as the State Park, and Federal facilities are considered Exempt Commercial – Minus 1 from Jamaica Beach = **391 lots**
J1	Real & Tang Personal Utilities, Water Systems	1	No Charge
J2	Gas Companies	1	Commercial
J3	Electric Companies	7	Commercial
J4	Telephone Companies	8	Commercial
J9	Exempt Personal Utilities, Water Systems	1	No Charge
O1	Inventory Vacant Land	290	No Charge

CAD - Code	Description	Number of Lots	Comments
	(C1, C2)		
	Undefined Property	1,636	Minus 487 lots from Pirates Beach = **1,149 lots**. Most of these remaining are likely vacant lots.

The means of determining equitable storm water rate fees (in this study) is by lot size and land use. All residential lots will keep being charged a fixed rate per month. For commercial, industrial and other lots the fees will be adjusted based on land use. For this study a simplified analysis is being done based on the land use type and the fully developed rational coefficient for that particular land use. The following rational coefficients are currently used in the City of Galveston storm sewer design criteria.

Land Use Type	**Rational Coefficient**	**Runoff Rate**
Commercial, Industrial and Multi-Family	0.7	2 cfs/ac
Residential – Single Family	0.5	1.5 cfs/ac
Undeveloped	0.3	0.8 cfs/ac

This structure is simplified over what is used in some cities. To determine an equitable fee rate for non-residential properties it is important to justify higher rates with the quantification of additional run-off from more developed impervious sites. In an ideal situation each property would be analyzed for the total area of impervious areas such as parking lots and buildings on the lot that contribute to increased run-off. Since rates on the residential areas will be fixed it is not necessary to determine the impervious cover for single family residential sites. There are fewer commercial and industrial sites, however, it is difficult to adequately determine impervious cover for each lot based on aerial photos that have limited resolution and the fact that many areas are covered by trees. Ground surveys are the best assessment if development plans are not available at the City of Galveston. This detailed land analysis is costly and beyond the scope of this preliminary equitable storm water rate fee analysis. Legal considerations should also be addressed prior to revising the existing rate fees. Public hearings are considered a good way to educate the community on proposed changes. The potential for litigation is high based on programs in other Cities. In these cases the City would be responsible for refunding all money plus interest to the residents/customers if unsuccessful in defeating the challenge.

For determination of an equitable storm water rate fee for the City of Galveston, a determination of storm water rate structures was done by evaluating the typical run-off rate for the average single family home on Galveston Island. This evaluation is based on an average lot size and the rational "C" value for a single family home of 0.5. This can be converted into an equivalent Rational "CA". Based on an analysis of single-family homes on Galveston Island the average lot size is 0.17 acres, or about 7,405 square feet. This lot is relatively small. These small lots are generally denser than residences that have more area. Other City's and drainage districts such as the City of Houston and Brazoria Drainage District #4 divide the Rational Coefficients based on residential tract size. The smaller tracts having a higher rational coefficient. For this study the single family standard C-value of 0.5 is used for all single-family residential units. While it may be advantageous to change the coefficients to various lot sizes it is generally arbitrary in this fee

analysis since all single family residence rates will be a fixed fee. If at some time different rates are charged to various single-family residence (SFR) lot sizes then it may be used as a factor in determining a rate fee structure based on residential lot size. The equivalent single family residential (ESFR) CA-value was determined to be 0.085 for the City of Galveston. This average City of Galveston home will then be factored into equations for determining the number of ESFR units per developed commercial or industrial tract on the island. This determines a factor of increased run-off from commercial and/or industrial tracts in comparison to an average single family home.

Land Use Type	Rational Coefficient	Number of Tracts	Total Area (acres)	CA	CA Per Lot
Residential < 5,000 sf	0.50	5,175	369.97	184.99	0.036
Residential 5,000-8,000 sf	0.50	8,909	1,226.50	613.25	0.069
Residential 8,000 – ¼ ac	0.50	496	108.66	54.33	0.110
Residential 1/4ac – 1/2ac	0.50	1,114	388.46	194.23	0.174
Residential > ½ ac	0.50	416	642.27	321.14	0.772
Average			**0.17**		**0.085**
Totals		**16,110**	**2,735.86**	**1,367.93**	

As described above, the ESFR for Galveston Island was determined to be 0.0849 (CA=0.0849). For comparison purposes a ½ acre developed commercial tract has a CA=0.7(0.5-acre) = 0.35. Determining the ESFR factor would be (CA = 0.35/ESFR = 0.0849 = 4.12) 4.12. Using this example this commercial site would contribute 4.12 times more run-off than an average 0.17-acre single-family home lot.

Based on the direction of the City, it was asked that DEC revise the rates for commercial, industrial and multi-family properties. Based on the GCAD records these categories are in some cases split into different categories. For example, the Galveston Island State Park is classified as Commercial Exempt. However, using a fully developed runoff factor of 0.70 would not be appropriate for this large undeveloped area. Therefore, an effort was made to quantify the properties that are considered exempt from fees, or difficult to collect. The City indicated that fees would be charged to churches, hospitals, private utilities, and the City wharves and airport. For the City facilities these charges would be passed along the vendors leasing space from the City. The following is a list of areas that have been exempted from the calculated equitable storm water rate fees and are reflected in the results presented in this study.

Owner	GCAD Code	Description	Number of Parcels	Total Area (acres)
State of Texas - Galveston State Park	F9	Commercial Exempt	2	1,903
City of Galveston	F9	Commercial Exempt	54	1,565
City of Galveston	F1	Real Commercial	4	0.96
City of Galveston	B9	Exempt Multi-Family	13	27.01
City of Galveston	A9	Exempt Single Family	46	9.49
Galveston ISD	F9	Commercial Exempt	25	145.82
US Coast Guard	F9	Commercial Exempt	1	376.77
State of Texas – Area on East Beach	F9	Commercial Exempt	1	133.56
Various – Jamaica Beach	A1	Single Family	1,088	224.79
Various – Jamaica Beach	F9	Commercial Exempt	6	4.61
Various – Jamaica Beach	F1	Commercial	6	3.79
Various – Jamaica Beach	B1	Multi Family	3	1.83

The City of Galveston asked for an analysis of different funding levels. From basic funding to a more robust comprehensive program. First is the minimal funding needed to maintain the required minimum NPDES program for the City of Galveston. The bare minimum collection rate would need to be approximately $1.2 million dollars a year to meet the needs of the NPDES program and provide basic operations and maintenance funding for the City of Galveston.

Table 11 shows three different rate levels. All rate levels are based on the same criteria, however, as the monthly rate for each single family residence changes the corresponding rates for multi-family, commercial, and industrial also change. To make sure the fees are equitable, the multi-family, commercial, and industrial sites are charged according the factor determined by dividing the CA for the site by the ESFR CA determined above (0.0849). This rate will then be multiplied by the rate charged to each SFR. Using the example above with a 0.5 acre commercial site, the ESFR factor determined above was 4.12. If all residents are charged $3 a month then the monthly cost to this commercial site would be $3 * 4.12 = $12.36 a month or $148.32 a year. The following is a table that compares the required charges for the collection of these targeted funding levels:

Classification	Current Program	Rate 1	Rate 2	Rate 3
Revenue (95% collections)	$750,000	$1,907,313	$2,543,084	$5,086,169
Residential	$3/mo	$3/mo	$4/mo	$8/mo
Multi-Family	$7.5/mo (1-1/2-3”), or $15/mo	$25/developed acre/month	$33/developed acre/month	$66/developed acre/month

	(>3”) based on water meter size			
Commercial	$7.5/mo (1-1/2-3”), or $15/mo (>3”) based on water meter size	$25/developed acre/month	$33/developed acre/month	$66/developed acre/month
Industrial	$7.5/mo (1-1/2-3”), or $15/mo (>3”) based on water meter size	$25/developed acre/month	$33/developed acre/month	$66/developed acre/month

Equations:

Rate 1	$3 x ESFR
Rate 2	$4 x ESFR
Rate 3	$8 x ESFR

Based on this analysis Rate 1 is adequate for a Plan 2 60-year CIP plan and basic operations. Rate 2 is adequate for an 80-year complete (Plan 1) CIP plan and basic operations. Using Rate 3 will enable an approximate 30-year complete (Plan 1) CIP plan plus additional money for more maintenance operations. These estimates are considering a minimal operations and maintenance (O&M) budget. Increased cost in O&M would reduce the CIP budgets accordingly.

13. MASTER PLAN SUMMARY AND CONCLUSIONS

This study includes a comprehensive look at the current drainage conditions on Galveston Island. The primary objectives were to a) obtain good topographical information of the island to determine existing flow patterns; b) collect information on the existing storm sewer and culvert drainage systems and evaluate their performance; c) evaluate the current drainage criteria; d) determine the improvements necessary to bring the current drainage system into line with the existing drainage criteria; e) determine construction cost for a Capital Improvement Plan (CIP) program including priorities, and f) determine a equitable funding program for the City that could replace the current system and meet funding needs for a NPDES program, CIP, and ongoing maintenance of the existing storm drainage systems. The following is a general summary of the main points of the Master Drainage Plan for Galveston Island and some general conclusions.

This report is part of a team approach to the issues facing the City of Galveston. The primary goal was to assess the upcoming NPDES rules put in place by the EPA and administered by the Texas TCEQ (Texas Commission of Environmental Quality), by Dodson and Associates. Second was an evaluation of the existing storm sewers and surface drainage on Galveston Island and determine specific drainage improvements, a CIP, and determine funding levels necessary to implement the NPDES program, maintain the current drainage system and funding for a CIP, by Dannenbaum Inc. Other work included the development of elevation and contours for Galveston Island by TerraPoint, the assessment of environmental baseline conditions and route evaluations by Berg Oliver and Associates, Inc. and public relations and public meetings with Kathy Thomas Barr Communication.

The main goal of the Master Drainage Plan is to comply with the EPA mandate regarding the storm water quality or NPDES. With that in mind, the City of Galveston decided, in addition, to evaluate the existing drainage system (storm and surface drainage), identify flood prone problem areas and make recommendations that could be phased over the years. The Master Drainage Plan, in order to be comprehensive has several elements such as: storm sewer and surface drainage (this report), environmental, NPDES (in separate reports), and public involvement. Due to the age of the current system and the amount of sand blown from the Bay and deposited into the system, maintenance is a serious concern that affects the performance of the existing system. Factors including utility conflicts and other physical and/or political constraints while considered to some degree, the level of detail in this study is not to the level required for final design. However, the potential for improvements should be factored into the design of capital improvement projects around the City where funding is available. The following is a listing of general conclusions from this study report:

Review of Existing Drainage Criteria – Most of the existing drainage criteria for the City of Galveston is consistent with the information developed in the 1960 Galveston Master Plan by TC&B. This work determined the 2-year design storm rainfall frequency data based on rainfall observations from 1903 to 1951. The addition of new data from 1951 to present day does not significantly alter the original estimates. Therefore, no changes to these intensities are recommended. The minimum time of concentration of 25-minutes allows for the use of the intensity curves beyond the initial losses due to storage and infiltration. Some recommended items to add to the existing drainage criteria for development are as follows:

1. Include a formula for calculating the Rational Time of Concentration – $TC = 15+10xA^{0.1761}$. Use this formula for areas greater than or equal to 1-acre to calculate a time of concentration. Areas less than 1-acre shall have a time of concentration of 25-minutes.
2. Specify that proposed roadway centerline elevation shall be constructed a minimum of 1-ft. above the calculated HGL for the drainage system, minimum roadway elevation of 5-ft. MSL (roughly a 7.5-year Tidal Elevation of Galveston Bay), or as approved by the City Engineer.
3. Minimum roadway right-of-way for new developments 60-ft. This will provide room for drainage channels within the right-of-way.

Analysis of the Existing Drainage System – It was found that a significant portion of the existing drainage system is undersized for the existing drainage criteria. This evaluation was done using the assumption of a clean and debris free system. Factoring in the existing levels of sand and silt in the system and this situation gets worse. During the study period in 2002 a number of storm events caused flooding within the City of Galveston. The most significant of these was a storm on August 15, 2002 that was determined to be approximately a 100-year 6-hr. storm event. Based on reviews of old construction plans much of the system was constructed using monolithic box culverts and clay pipe inlet leads. Many of these inlet leads are smaller than 18-inches in diameter. These small pipes are easily blocked by debris and silt that limit conveyance capacity. Bridge blocks, or small pipes that connect roadside gutters across intersections are also a problem in the urbanized areas of Galveston. These structures are sometimes square, or small concrete pipes (<15-inch) and generally serve areas where there are no existing storm sewers.

Proposed Drainage System Improvements – Recommendations for proposed drainage system improvements were done for all of Galveston and Pelican Island and are shown on Exhibit 3 under separate cover, and working exhibits provided in the Appendix. Due to the numerous systems identified as having capacity problems with the existing criteria the City asked for the evaluation of proposed systems based on a surcharged system with a HGL that remains below the existing ground elevations. Areas on the west side of the island were evaluated based on existing drainage patterns. If there was an area that did not have an evident outfall location then a channel and culvert was proposed. These proposed improvements are based on the available information and represent the current conditions. The primary intent is to provide information regarding the required conveyance capacity of proposed systems. Improvements shown are an assessment based on the available information and can be modified to address changing conditions over time. The City did identify a number of specific subdivisions on the west side of Galveston Island to investigate and include, Habla Drive, Gulf Palms Drive, Bay Harbor, Terramar Beach , Sea Isle, Bermuda Beach area and Pabst Street. The assessment of these areas is included in Section 7.C.2. Many of the problems in these subdivisions and other areas of west Galveston are localized. Some of the areas are within low-lying areas that are susceptible to tidal flooding, or are impacted by the lack of outfalls and conveyance capacity. There are a number of outfalls proposed for FM 3005 to provide increased protection of this main traffic route for the west side of the island. There are also a number of arterial roads that are low and should be raised to a minimum of 5-ft. MSL to provide better access to properties and to allow more time for evacuation during tropical storm events.

Construction Cost Estimates – Construction cost data was compiled from area contractors and available data from TxDOT and other cities in the area. Included in the cost estimates are the cost for earthwork, storm sewer structures, pavement repairs, inlet and lateral improvements along proposed storm sewer routes, dewatering, and outfall and bulkhead construction. A compilation of cost data used for this project is included in the Appendix. The total of all capital improvements was determined to be approximately $94 million including improvements specified for Scholes Airport in a separate report.

Operations and Maintenance – Currently the City of Galveston performs storm sewer maintenance using primarily the roadway maintenance crews within the roadway portion of the Public Works Department. This work generally includes street clean up of inlets and street areas as necessary. Crews usually inspect inlets before island events such as Mardi Gras and then remove trash and other debris after the events to prevent clogging. These crews are also asked to fix drainage problems during storm events by clearing blocked storm drains. Street sweepers are used along seawall and downtown areas on a daily basis. Recently a newer group has started within the Recycling Group. This group does a more extensive clean-up effort that is geared to cleaning the entire drainage system starting with the roadway gutters and continuing to the inlets, storm sewer leads and main storm sewer trunk lines. These efforts have improved drainage in some areas considerably and are identifying structural problems within the existing drainage system. However, this process is slow and the work is only being done when time and personnel are available. Due to the limited maintenance of the past there has been a large accumulation of debris in the existing system. The addition of more crews dedicated to the extensive cleaning of the existing storm sewer is necessary to make progress and to provide evidence of improvements for the residents and businesses on the island. While this work is going on, specific drainage

problems such as inadequate driveway drains, structural problems or other drainage impediments can be identified and dealt with as part of the ongoing maintenance of the system. Enforcement of existing drainage regulations and the development of additional statutes may be necessary to provide incentive for property owners to correct problems identified with property owners, or give the City authority to correct problems within the public right-of-way if necessary.

Capital Improvement Program and Determination of Equitable Storm Water Rate Fee – As discussed the complete Capital Improvement Program including Scholes Airport is $94 million dollars. An evaluation of project priorities was done based on resident survey complaints and service area. Using these tools the 18th Street System has the highest density of complaints on the island. This project along with the 11th Street System near UTMB was selected as a high priority system due to the significant traffic in the area to this dense employment center.

- 18th Street and 11th Street Systems considered highest priority

The remaining projects are necessary to bring add enough capacity through the City drainage system to meet the current drainage criteria. These priorities were distributed based on the number and density of flooding complaints. Areas where elevations are low and where tidal flooding is more prevalent should also be given less priority. The cost of additional storm sewers in these areas would only provide minimal improvements due to the limited hydraulic head available. The cost for additional minor stems from the recommended major trunk line improvements is not included here, but will be necessary over time to extend the drainage system to unserved areas and replace bridge blocks where necessary.

The equitable storm water rate fee is based on determining the equivalent average run-off from an average Galveston single family home. For Galveston this typical home lot is 0.17 acres and has a CA = 0.0849. The City requested that the rates for single family homes remain constant (currently $3/month). Commercial, industrial and multi-family properties fees in Galveston are subject to change. Current City drainage criteria specify a rational coefficient of 0.70 to these properties. The equitable storm water rate fee for these properties is done by taking the CA determined for these properties and dividing it by the CA determined for the single family home (0.0849). This factor is then multiplied by the rate charged to single family homeowners. CIP plans are outlined in Table 9. These results are shown in the following table:

	Rate 1	Rate 2	Rate 3
Single Family Home Rate	$3/mo	$4/mo	$8/mo
Rate for Commercial, Industrial, and Multi-family	$25/developed acre/month	$33/developed acre/month	$66/developed acre/month
Estimated Revenue	$1,907,313	$2,543,084	$5,086,169
Estimated Plan	Plan 2 – 60-yr CIP	Plan 1 – 80-yr CIP	Plan 1 – approximately 30-yr CIP (between 20 and 40-yr)

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
11th Street System	12I	4.55	0.50	7.68	12I-11I	2.28	25.00	3.35	7.68	24 inch	365	4	3.8	0.00055	2.45	1.71	5.3	-2.39	0.00115	7.92	11.67	3.75
11th Street System	11M	6.31	0.50	10.65	11M-11K	3.16	25.00	3.35	10.65	24 inch	676	4.86	4.35	0.00075	3.39	2.00	6.21	-4.44	0.00222	9.25	9.85	0.60
11th Street System	10D	5.14	0.70	12.15	10D-10B	3.60	25.00	3.35	12.15	2.5 X 2.5	647	1.91	1.59	0.00050	1.94	1.87	11.61	-0.54	0.00054	6.35	8.40	2.05
11th Street System	10I	7.48	0.50	12.63	10I-11I	3.74	25.00	3.35	12.63	24 inch	397	3.6	3.28	0.00081	4.02	2.07	6.42	-6.21	0.00312	8.74	6.68	-2.06
11th Street System	9K	8.76	0.50	14.79	9K-10K	4.38	25.00	3.35	14.79	24 inch	381	4.9	4.6	0.00079	4.71	2.05	6.35	-8.44	0.00428	9.92	9.02	-0.90
11th Street System	8I	11	0.50	18.57	8I-9I	5.50	25.00	3.35	18.57	18 inch	401	4.62	4.21	0.00100	10.51	1.84	3.32	-15.25	0.03127	19.59	6.50	-13.09
11th Street System	7G	12.13	0.50	20.48	7G-8G	6.06	25.00	3.35	20.48	24 inch	387	4.16	3.58	0.00150	6.52	2.83	8.76	-11.72	0.00819	9.62	7.00	-2.62
11th Street System	8E	13.78	0.50	23.27	8E-8D	6.89	25.00	3.35	23.27	2.5 X 2.5	328	2.46	2.29	0.00052	3.72	1.92	11.89	-11.38	0.00198	6.65	6.34	-0.31
11th Street System	13B2	14.1	0.70	33.33	13B2-11B1	9.87	25.00	3.35	33.33	4 X 3	710	0.61	0.13	0.00068	2.78	2.68	32.18	-1.15	0.00073	6.81	5.50	-1.31
11th Street System	9I	11.82	0.50	19.96	9I-9G	11.41	25.64	3.31	38.02	24 inch	664	3.71	3.05	0.00100	12.10	2.31	7.15	-30.86	0.02824	25.25	7.05	-18.20
11th Street System	8G	6.8	0.50	11.48	8G-9G	9.46	25.99	3.28	31.3	30 inch	353	3.08	2.55	0.00150	6.38	3.24	15.88	-15.42	0.00584	8.56	6.45	-2.11
11th Street System	10K	10.03	0.50	16.93	10K-11K	9.40	26.35	3.26	30.83	24 inch	403	4.6	4.3	0.00074	9.81	1.99	6.17	-24.66	0.01859	15.24	8.29	-6.95
11th Street System	8D	6.27	0.70	14.82	8D-9D	11.28	26.47	3.25	36.92	2.5 X 2.5	386	2.29	2.1	0.00049	5.91	1.87	11.59	-25.33	0.00500	7.93	6.00	-1.93
11th Street System	9F	2.77	0.50	4.68	9F-10F	3.75	26.91	3.22	12.15	24 inch	366	2.87	2.32	0.00150	3.87	2.83	8.77	-3.38	0.00287	9.75	6.80	-2.95
11th Street System	9G	5.53	0.50	9.34	9G-10G	21.28	26.91	3.22	68.97	42 inch	373	1.55	0.99	0.00150	7.17	4.06	38.98	-29.99	0.00469	8.44	6.50	-1.94
11th Street System	9D	9.61	0.70	22.72	9D-9B	18.01	27.56	3.17	57.55	2.5 X 2.5	654	2.1	1.77	0.00051	9.21	1.89	11.73	-45.82	0.01214	15.01	6.00	-9.01
11th Street System	10G	6.31	0.50	10.65	10G-11G2	24.43	27.78	3.16	77.71	48 inch	372	0.49	-0.07	0.00150	6.18	4.42	55.63	-22.08	0.00290	7.71	6.69	-1.02
11th Street System	11K	7.51	0.50	12.68	11K-11J	16.30	28.32	3.12	51.24	30 inch	317	4.35	3.11	0.00391	10.44	5.23	25.65	-25.58	0.01562	12.79	7.75	-5.04
11th Street System	10F	4.81	0.50	8.12	10F-11F	6.15	28.49	3.11	19.27	24 inch	372	2.32	1.76	0.00151	6.13	2.83	8.78	-10.49	0.00726	8.70	11.97	3.27
11th Street System	9B	2.11	0.70	4.99	9B-10B	19.48	28.74	3.09	60.65	Box 2.5 X 4.5	359	1.27	1.09	0.00050	5.39	2.22	24.89	-35.76	0.00298	7.07	9.00	1.93
11th Street System	11G2	5.64	0.50	9.52	11G2-11F2	27.25	28.78	3.09	84.75	54 inch	337	-0.57	-0.67	0.00030	5.33	2.14	34.04	-50.71	0.00187	6.63	7.60	0.97
11th Street System	11J	16.71	0.50	28.21	11J-11I	24.66	28.83	3.08	76.61	36 inch	334	2.61	2.28	0.00099	10.84	2.95	20.96	-55.65	0.01320	11.91	7.84	-4.07
11th Street System	11I	4.4	0.50	7.43	11I-11G1	32.87	29.34	3.05	100.94	36 inch	664	2.28	1.68	0.00090	14.28	2.82	20.05	-80.89	0.02291	21.71	7.50	-14.21
11th Street System	11G1	3	0.50	5.07	11G1-11F1	34.37	30.12	3.00	103.79	36 inch	341	1.68	1.32	0.00106	14.68	3.05	21.67	-82.12	0.02422	14.76	6.50	-8.26
11th Street System	11F1	2.27	0.50	3.83	11F1-11D1	12.43	30.50	2.98	37.33	36 inch	658	1.32	0.73	0.00090	5.28	2.81	19.97	-17.36	0.00313	8.06	6.50	-1.56
11th Street System	11F2	1.93	0.50	3.26	11F2-11D2	57.45	30.50	2.98	172.57	60 inch	651	-1.17	-1.56	0.00060	8.79	3.26	63.82	-108.74	0.00439	8.86	6.00	-2.86
11th Street System	10B	4.81	0.70	11.37	10B-11B2	26.45	30.55	2.98	79.4	Box 2.5 X 4.5	361	1.09	0.91	0.00050	7.06	2.22	24.82	-54.58	0.00510	7.97	6.00	-1.97
11th Street System	11D2	1.11	0.50	1.87	11D2-11C2	58.01	31.74	2.93	171.35	66 inch	325	-2.06	-2.52	0.00140	7.21	5.28	125.64	-45.7	0.00262	6.85	6.00	-0.85
11th Street System	11C2	1.8	0.70	4.25	11C2-11B2	59.27	32.49	2.90	173.27	66 inch	345	-2.52	-3	0.00140	7.29	5.28	125.64	-47.63	0.00267	7.05	6.00	-1.05
11th Street System	11D1	1.6	0.50	2.70	11D1-11C1	13.23	32.58	2.90	38.63	36 inch	323	0.73	0.44	0.00090	5.47	2.81	19.98	-18.64	0.00334	7.58	6.00	-1.58
11th Street System	11C1	2.04	0.70	4.82	11C1-11B1	14.66	33.57	2.86	42.21	36 inch	342	0.44	0.13	0.00091	5.97	2.83	20.08	-22.13	0.00401	7.66	6.50	-1.16
11th Street System	11B1	1.8	0.50	3.04	11B1-11B2	25.43	34.52	2.82	72.26	4 X 3	48	0.13	0.12	0.00021	6.02	1.49	17.86	-54.39	0.00333	6.29	6.50	0.21
11th Street System	11B2	1.76	0.50	2.97	11B2-11A	112.02	34.65	2.81	317.74	72 inch	421	-3.51	-3.79	0.00067	11.24	3.86	109.21	-208.52	0.00565	8.84	6.13	-2.71
11th Street System	11A	5.58	0.50	9.42	11A-9(1/2)A	114.81	35.28	2.79	322.76	72 inch	593	-3.79	-4.64	0.00143	11.42	5.67	160.33	-162.43	0.00580	6.46	8.26	1.80
11th Street System	9(1/2)A	6.94	0.50	11.72	9(1/2)A-Harborside_Out	118.28	36.14	2.75	328.39	72 inch	252	-4.64	-5	0.00143	11.62	5.66	160.06	-168.33	0.00603	3.02	7.54	4.52
Total Area/Average C		218.21	0.55																			
14th Street System	13B1	3.14	0.70	7.42	13B1-14B	2.20	25.00	3.35	7.42	4 X 3	347	0.61	0.56	0.00014	0.62	1.24	14.86	7.43	0.00003	4.77	5.50	0.73
14th Street System	13I	4.9	0.50	8.27	13I-14I	2.45	25.00	3.35	8.27	24 inch	375	3.23	3.2	0.00008	2.63	0.65	2.02	-6.25	0.00133	7.50	7.00	-0.50
14th Street System	16K1	8.18	0.50	13.81	16K1-15K	4.09	25.00	3.35	13.81	24 inch	388	4.01	3.98	0.00008	4.40	0.64	1.99	-11.82	0.00374	8.87	7.12	-1.75
14th Street System	15I	8.51	0.50	14.37	15I-14I	4.26	25.00	3.35	14.37	24 inch	383	3.24	3.2	0.00010	4.57	0.75	2.31	-12.06	0.00405	8.55	7.00	-1.55
14th Street System	16M(1/2)	18.6	0.50	31.40	16M(1/2)-14M(1/2)	9.30	25.00	3.35	31.4	24 inch	756	4.15	3.54	0.00081	10.00	2.07	6.43	-24.98	0.01927	22.99	8.28	-14.71
14th Street System	13K	25.83	0.50	43.61	13K-14K	12.92	25.00	3.35	43.61	24 inch	382	4.48	4.44	0.00011	13.88	0.75	2.31	-41.3	0.03717	21.27	7.81	-13.46
14th Street System	14M1/2	15.61	0.50	26.36	14M(1/2)-14K	17.10	26.26	3.26	56.24	4 x 3 ft	990	3.54	2.94	0.00061	4.69	2.54	30.47	-25.77	0.00206	9.11	8.42	-0.69
14th Street System	15K	8.28	0.50	13.98	15K-14K	8.23	26.47	3.25	26.94	30 inch	371	3.73	3.69	0.00011	5.49	0.87	4.26	-22.68	0.00431	8.67	7.42	-1.25
14th Street System	14K	8.07	0.50	13.63	14K-14J	42.28	29.78	3.02	128.52	4 x 3 ft	380	2.94	2.56	0.00100	10.71	3.26	39.14	-89.38	0.01079	11.60	7.07	-4.53
14th Street System	14J	3.35	0.50	5.66	14J-14I	43.96	30.37	2.99	132.27	6 x 3 ft	362	2.56	2.2	0.00099	7.35	3.60	64.88	-67.39	0.00414	8.50	7.50	-1.00
14th Street System	14I	6.59	0.50	11.13	14I-14H	53.96	31.19	2.95	160.58	6 x 3 ft	348	2.2	1.85	0.00101	8.92	3.63	65.25	-95.33	0.00609	8.12	7.00	-1.12
14th Street System	14H	10.74	0.50	18.13	14H-14F	59.33	31.84	2.93	175	6 x 3 ft	660	1.85	1.52	0.00050	9.72	2.56	46.01	-129	0.00724	10.78	6.00	-4.78
14th Street System	14F	20.4	0.50	34.44	14F-14D	69.53	32.97	2.88	201.92	6 x 3 ft	660	1.52	1.12	0.00061	11.22	2.81	50.65	-151.27	0.00964	12.36	6.00	-6.36
14th Street System	14D	13.7	0.50	23.13	14D-14B	76.38	33.96	2.84	218.79	BOX 8 X3	658	1.12	0.56	0.00085	9.12	3.53	84.81	-133.98	0.00567	8.49	6.00	-2.49
14th Street System	14B	5.55	0.70	13.12	14B-14A	82.46	35.16	2.79	232.22	BOX 8 X3	332	0.56	0.39	0.00051	9.68	2.74	65.78	-166.44	0.00639	7.90	4.76	-3.14
14th Street System	14A	10.1	0.50	17.05	14A-Outfall	87.51	35.73	2.77	244.42	BOX 8 X3	700	0.39	-0.49	0.00126	10.19	4.29	103.07	-141.35	0.00707	7.46	5.78	-1.68
Total Area/Average C		171.55	0.53																			
15th Street System	15B	10.49	0.70	24.80	15B-15Out	4.94	25.00	3.35	16.69	30 inch	865	-0.34	-0.43	0.00010	3.75	0.85	4.18	-12.51	0.00171	2.98	3.16	0.18
16th Street System	16D	2.89	0.70	6.83	16D-16A1/2	2.02	25.00	3.35	6.83	18 inch	843	-0.49	-1.75	0.00150	3.87	2.26	4.07	-2.76	0.00423	6.57	5.00	-1.57
16th Street System	16A1/2	12.15	0.70	28.72	16A1/2-16Wharf	10.53	28.63	3.10	32.85	24 inch	728	-2.25	-3.34	0.00150	10.46	2.83	8.76	-24.09	0.02109	20.35	3.00	-17.35
16th Street System	16Wharf	6.32	0.70	14.94	16Wharf-16Out	14.95	29.79	3.01	45.43	24 inch	530	-3.34	-4.14	0.00150	14.46	2.83	8.76	-36.67	0.04034	22.88	5.00	-17.88
Total Area/Average C		21.36	0.70																			
18th Street System	18D	2.72	0.70	6.43	18D-18C	1.90	25.00	3.35	6.43	24 inch	332	0.51	-0.32	0.00250	2.05	3.65	11.31	4.88	0.00201	4.71	4.51	-0.20
18th Street System	17B	2.9	0.70	6.85	17B-17_(1/2)A	2.03	25.00	3.35	6.85	24 inch	535	0.24	-0.3	0.00100	2.18	2.31	7.15	0.3	0.00092	6.18	4.00	-2.18
18th Street System	17C	5.99	0.50	10.11	17C-18C	2.99	25.00	3.35	10.11	24 inch	394	0.57	0.18	0.00100	3.22	2.31	7.15	-2.96	0.00081	4.19	4.00	-0.19
18th Street System	18C	2.86	0.70	6.76	18C-18A(1/2)	6.90	27.70	3.16	21.99	36 inch	508	-0.82	-1.33	0.00100	3.11	2.97	21.09	-0.9	0.00108	5.07	3.92	-1.15
18th Street System	17_(1/2)A	4.49	0.70	10.61	18_(1/2)A-17_(1/2)A	5.17	29.09	3.06	15.98	24 inch	392	-0.3	-0.69	0.00100	5.09	2.31	7.15	-8.82	0.00500	5.69	6.20	0.51
18th Street System	18A(1/2)	5.7	0.70	13.47	18A(1/2)-18_(1/2)A	10.35	30.43	2.98	31.11	36 inch	361	-1.33	-1.69	0.00100	4.40	2.97	21.09	-10.02	0.00219	4.52	4.92	0.40
18th Street System	18_(1/2)A	7.09	0.70	16.76	18_(1/2)A-18Out	20.48	31.79	2.93	60.46	36 inch	340	-1.69	-2.03	0.00100	8.55	2.97	21.09	-39.37	0.00821	4.29	3.73	-0.56
18th Street System	J-1	#N/A	#N/A	#N/A	18-A(1/2) - 19A(1/2)	#N/A	#N/A	#N/A	1.84	30 inch	320	-0.07	-0.59	0.00163	0.37	3.37	16.53	14.69	0.00003	3.32	4.92	1.60
Total Area/Average C		31.75	0.67																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
19th Street System	20-E	0.85	0.70	2.01	20-E-19E	0.60	25.00	3.35	2.01	24 inch	354	1.79	1.05	0.00209	0.64	3.34	10.34	8.33	0.00008	4.39	5.37	0.98
19th Street System	17I	6.57	0.50	11.09	17I-19I	3.28	25.00	3.35	11.09	3 X 1.67	785	2.62	1.83	0.00100	2.22	2.38	11.92	0.83	0.00087	5.84	9.48	3.64
19th Street System	18K	8.49	0.50	14.33	18K-19K	4.24	25.00	3.35	14.33	24 inch	365	3.17	2.8	0.00101	4.56	2.32	7.2	-7.13	0.00403	8.94	7.00	-1.94
19th Street System	20I	6.66	0.70	15.74	20I-20H	4.66	25.00	3.35	15.74	24 inch	327	2.06	1.73	0.00101	5.01	2.32	7.19	-8.56	0.00483	7.10	5.30	-1.80
19th Street System	21H	7.45	0.70	17.61	20H-21H	5.21	25.00	3.35	17.61	24 inch	372	2.1	1.73	0.00100	5.61	2.30	7.13	-10.48	0.00605	7.77	5.33	-2.44
19th Street System	19M	23.16	0.50	39.10	19M-19K	11.58	25.00	3.35	39.1	24 inch	660	3.17	2.61	0.00085	12.45	2.13	6.59	-32.51	0.02988	27.19	7.05	-20.14
19th Street System	17K	25.1	0.50	42.38	17K-19K	12.55	25.00	3.35	42.38	24 inch	782	2.88	2.8	0.00010	13.49	0.74	2.29	-40.09	0.03510	34.92	7.38	-27.54
19th Street System	20H	3.02	0.70	7.14	20H-19H	11.99	26.11	3.27	39.56	30 inch	360	1.23	0.87	0.00100	8.06	2.65	12.97	-26.59	0.00931	8.35	5.52	-2.83
19th Street System	19K	32.11	0.50	54.21	19K-19J	44.43	26.33	3.26	145.85	24 inch	380	2.51	2.19	0.00084	46.43	2.12	6.56	-139.29	0.41571	164.97	7.47	-157.50
19th Street System	19I	13.12	0.70	31.01	19I-19H	56.90	30.90	2.96	170	5.5 X 3.5	330	1.37	1.09	0.00085	8.83	3.49	67.03	-102.98	0.00545	6.80	5.16	-1.64
19th Street System	19H	8.62	0.70	20.38	19H-19G	74.92	31.52	2.94	221.98	5.5 X 3.5	309	1.09	0.83	0.00084	11.53	3.48	66.75	-155.23	0.00932	8.88	5.00	-3.88
19th Street System	19G	16.8	0.70	39.71	19G-19F	86.68	31.97	2.92	255.26	5.5 X 3.5	351	0.83	0.53	0.00086	13.26	3.50	67.27	-187.99	0.01231	9.79	6.00	-3.79
19th Street System	19F	14.6	0.70	34.51	19F-19E	96.90	32.41	2.90	283.63	5.5 X 3.5	314	0.53	0.26	0.00086	14.73	3.51	67.47	-216.16	0.01519	9.13	5.47	-3.66
19th Street System	19E	11.28	0.70	26.66	19E-19D	105.39	34.23	2.83	300.76	5.5 X 3.5	346	0.26	-0.03	0.00084	15.62	3.47	66.62	-234.14	0.01708	10.41	4.36	-6.05
19th Street System	19D	2.61	0.70	6.17	19D-19A(1/2)	107.22	34.59	2.82	304.38	5.5 X 3.5	990	-0.03	-1.15	0.00113	15.81	4.03	77.39	-226.98	0.01749	20.63	4.50	-16.13
19th Street System	19A(1/2)	8.19	0.70	19.36	19A(1/2)-19Wharf	113.50	39.24	2.63	300.95	5.5 X 3.5	436	-1.15	-1.95	0.00184	15.63	5.13	98.57	-202.39	0.01711	11.46	3.31	-8.15
19th Street System	19Wharf	1.81	0.70	4.28	19Wharf-O-2	114.77	39.70	2.61	302.16	5.5 X 3.5	154	-1.95	-2.23	0.00182	15.70	5.11	98.12	-204.04	0.01727	4.16	4.00	-0.16
19th Street System	19J	#N/A	#N/A	#N/A	19J-19I	#N/A	#N/A	#N/A	145.42	30 inch	380	1.69	1.37	0.00084	29.63	2.43	11.9	-133.52	0.12571	52.93	7.00	-45.93
Total Area/Average C		190.44	0.64																			
20th Street System	20D	2.1	0.70	4.96	20D-20C2	1.47	25.00	3.35	4.96	15 inch	332	2.33	2	0.00099	4.04	1.70	2.04	-2.93	0.00590	6.46	5.00	-1.46
20th Street System	20E	5.91	0.70	13.97	20E-20C	4.14	25.00	3.35	13.97	24 inch	624	1.73	1.17	0.00090	4.45	2.19	6.78	-7.19	0.00381	6.88	5.50	-1.38
20th Street System	20C2	2.66	0.70	6.29	20C2-20JB	3.33	26.37	3.25	10.93	18 inch	312	1.75	1.44	0.00099	6.19	1.84	3.31	-7.62	0.01083	7.88	4.50	-3.38
20th Street System	20C	4	0.70	9.46	20C-20B	6.94	27.34	3.19	22.28	30 inch	333	0.67	0.38	0.00087	4.54	2.47	12.1	-10.18	0.00294	5.48	4.50	-0.98
20th Street System	20B	2.83	0.70	6.69	20B-20A1/2	12.25	28.56	3.10	38.29	30 inch	169	0.38	0.23	0.00089	7.80	2.49	12.22	-26.07	0.00876	5.30	4.50	-0.80
20th Street System	20A1/2	1.78	0.70	4.21	20A1/2-20A1	13.50	28.92	3.08	41.84	40 in.	130	-0.6	-0.71	0.00085	4.79	2.95	25.69	-16.14	0.00223	3.82	4.50	0.68
20th Street System	20A2	3.52	0.70	8.32	20A2-20JA1	15.96	29.57	3.03	48.75	54 inch	134	-1.94	-2.06	0.00090	3.07	3.70	58.84	10.1	0.00060	3.28	4.00	0.72
20th Street System	20Wharf	3.1	0.70	7.33	20Wharf-20-OUT	18.13	31.04	2.96	54.06	40 in.	241	-1.1	-1.34	0.00100	6.51	3.20	27.87	-26.19	0.00402	2.47	5.00	2.53
20th Street System	20JB	#N/A	#N/A	#N/A	20JB-20B	#N/A	#N/A	#N/A	10.73	18 inch	60	1.44	1.38	0.00100	6.07	1.84	3.32	-7.41	0.01050	5.13	4.50	-0.63
20th Street System	20JA	#N/A	#N/A	#N/A	20A1-20A2	#N/A	#N/A	#N/A	41.41	3 X 2.5	65	0.13	0.06	0.00108	5.52	2.91	21.79	-19.61	0.00385	3.53	4.00	0.47
20th Street System	20JA1	#N/A	#N/A	#N/A	20JA1-20Wharf	#N/A	#N/A	#N/A	48.07	40 in.	245	-0.89	-1.1	0.00086	5.51	2.97	25.86	-22.21	0.00298	3.20	4.00	0.80
Total Area/Average C		25.9	0.7																			
22nd-24th Street System	22A(1/2)	1.32	0.70	3.12	22A(1/2)-22Out2	0.92	25.00	3.35	3.12	Box 2.5 X 4.5	388	-0.25	-0.64	0.00101	0.65	3.15	35.24	32.12	0.00886	14.81	5.26	-9.55
22nd-24th Street System	22J	5.91	0.70	13.97	22J-22G	4.14	25.00	3.35	13.97	24 inch	952	1.19	0.9	0.00031	4.45	1.27	3.95	-10.02	0.00199	11.66	7.40	-4.26
22nd-24th Street System	21P	7.59	0.70	17.94	21P-23P	5.31	25.00	3.35	17.94	15 inch	680	6.39	5.75	0.00094	14.62	1.65	1.98	-15.96	0.00005	1.52	9.10	7.58
22nd-24th Street System	23Q	9.01	0.70	21.30	23Q-23P	6.31	25.00	3.35	21.3	24 inch	633	6.03	4.95	0.00171	6.78	3.01	9.34	-11.95	0.00381	9.31	13.62	4.31
22nd-24th Street System	21P(1/2)	18.1	0.70	42.78	21P(1/2)-21N(1/2)	12.67	25.00	3.35	42.78	4' X 2.5'	1589	6.05	4.66	0.00088	4.28	2.84	28.38	-14.4	0.07715	61.66	13.89	-47.77
22nd-24th Street System	24K	10.39	0.50	17.54	24K-24J	39.48	25.80	3.29	131.11	6 X 2.5	380	2.65	2.18	0.00124	8.74	3.70	55.47	-75.64	0.00692	11.29	9.99	-1.30
22nd-24th Street System	23P	13.91	0.70	32.88	23P-23N(1/2)	21.36	26.56	3.24	69.77	24 inch	1285	4.95	2.8	0.00167	22.21	2.98	9.25	-60.52	0.09514	129.85	9.20	-120.65
22nd-24th Street System	24I	4.1	0.70	9.69	24I-24H	42.35	27.40	3.18	135.84	6 X 3	319	1.21	0.81	0.00125	7.55	4.05	72.85	-62.98	0.00436	7.39	7.80	0.41
22nd-24th Street System	23N(1/2)	18.43	0.70	43.56	23N(1/2)-23K	34.26	27.52	3.17	109.59	24 inch	1356	2.8	0.75	0.00151	34.88	2.84	8.8	-100.79	0.23470	325.37	7.60	-317.77
22nd-24th Street System	24H	2.57	0.70	6.07	24H-24G	44.15	28.11	3.13	139.41	6 X 3	341	0.81	0.39	0.00123	7.75	4.01	72.21	-67.2	0.00460	7.75	6.00	-1.75
22nd-24th Street System	22G	6.72	0.70	15.88	22G-22F(1/2)	8.84	28.57	3.10	27.63	24 inch	173	0.9	0.85	0.00029	8.79	1.24	3.85	-23.78	0.01491	8.36	5.68	-2.68
22nd-24th Street System	24G	2.6	0.70	6.15	24G-24D	45.97	28.84	3.08	142.78	7 x 3 ft	990	0.39	-0.84	0.00124	6.80	4.16	87.4	-55.37	0.00331	7.53	6.18	-1.35
22nd-24th Street System	22E	7.28	0.70	17.21	22E-22D(1/2)	13.94	29.86	3.01	42.28	36 inch	165	-0.3	-0.35	0.00030	5.98	1.64	11.61	-30.67	0.00400	5.30	4.83	-0.47
22nd-24th Street System	22D1/2	2.68	0.70	6.33	22D(1/2)-22C(1/2)	15.81	30.32	2.99	47.61	36 inch	327	-0.35	-0.45	0.00031	6.74	1.64	11.66	-35.95	0.00511	5.68	4.64	-1.04
22nd-24th Street System	22C(1/2)	5.45	0.70	12.88	22C(1/2)-22B(1/2)	19.63	31.13	2.95	58.46	36 inch	328	-0.45	-0.55	0.00031	8.27	1.64	11.65	-46.82	0.00768	6.47	4.01	-2.46
22nd-24th Street System	21N(1/2)	21.86	0.70	51.67	21N1/2-21M1/2	27.97	31.19	2.95	83.25	4' X 2.5'	335	4.66	4.5	0.00048	8.32	2.10	20.97	-62.27	0.00752	10.02	8.50	-1.52
22nd-24th Street System	24D	9.93	0.70	23.47	24D-24A	52.92	31.27	2.95	157.33	8 X 3	990	-0.84	-2.07	0.00124	6.56	4.27	102.47	-54.86	0.00293	5.52	4.25	-1.27
22nd-24th Street System	21M1/2	10.15	0.70	23.99	21M1/2-21K	35.08	31.86	2.93	103.44	4' X 2.5'	985	4.5	4.05	0.00046	10.34	2.05	20.51	-82.93	0.01162	18.67	7.50	-11.17
22nd-24th Street System	21K	8.99	0.70	21.25	21K-22K	41.37	33.45	2.86	119.35	6 X 2.5	382	4.05	3.58	0.00123	7.96	3.69	55.33	-64.03	0.00573	9.19	7.22	-1.97
22nd-24th Street System	24A	3.8	0.70	8.98	24A-O24	55.58	33.79	2.85	159.6	8 X 3	480	-2.07	-2.67	0.00125	6.65	4.28	102.78	-56.82	0.00302	2.95	2.62	-0.33
22nd-24th Street System	22K	6.87	0.70	16.24	22K-23K	46.18	34.25	2.83	131.74	6 X 2.5	376	3.58	3.11	0.00125	8.78	3.72	55.76	-75.97	0.00697	9.74	7.00	-2.74
22nd-24th Street System	23K	17.48	0.70	41.32	23K-23I	58.38	34.96	2.80	164.87	60 inch	743	-2.25	-2.7	0.00061	8.40	3.27	64.09	-100.78	0.00401	9.98	7.12	-2.86
22nd-24th Street System	23I	10.22	0.70	24.16	23I-23F	65.54	36.44	2.74	181.18	60 inch	996	-2.7	-3.3	0.00060	9.23	3.26	63.92	-117.26	0.00484	10.39	7.00	-3.39
22nd-24th Street System	23F	3.97	0.70	9.38	23F-23E	68.32	38.23	2.67	183.91	60 inch	308	-3.3	-3.5	0.00065	9.37	3.39	66.36	-117.55	0.00500	6.07	5.57	-0.50
22nd-24th Street System	23E	6.56	0.70	15.51	23E-23C	72.91	38.78	2.65	194.66	66 inch	687	-4	-4.4	0.00058	8.20	3.40	81.03	-113.63	0.00336	5.87	4.53	-1.34
22nd-24th Street System	23C	6.71	0.70	15.86	23C-23B	77.61	40.18	2.60	203.11	66 inch	327	-4.4	-4.58	0.00055	8.55	3.31	78.78	-124.33	0.00367	5.08	3.56	-1.52
22nd-24th Street System	23B	4.01	0.70	9.48	23B-22B2	80.41	40.82	2.58	209.42	66 inch	371	-4.58	-4.8	0.00059	8.82	3.44	81.77	-127.65	0.00388	5.61	3.88	-1.73
22nd-24th Street System	22B2	4.24	0.70	10.02	22B2-22_(1/2)A	103.01	41.52	2.57	266.82	72 inch	482	-3.6	-3.74	0.00029	9.44	2.55	72.17	-194.64	0.00398	4.25	4.17	-0.08
22nd-24th Street System	22_(1/2)A	6.26	0.70	14.80	22_(1/2)A - 22Out1	107.39	42.37	2.55	276.32	72 inch	159	-3.74	-3.79	0.00031	10.13	2.65	75.1	-201.23	0.00522	2.33	6.04	3.71
22nd-24th Street System	22B(1/2)	#N/A	#N/A	#N/A	22B(1/2)-22B2	#N/A	#N/A	#N/A	57.94	36 inch	168	-0.55	-0.6	0.00030	8.20	1.62	11.51	-46.43	0.00756	5.44	3.95	-1.49
22nd-24th Street System	24J	#N/A	#N/A	#N/A	24J-24I	#N/A	#N/A	#N/A	129.09	6 x 3 ft	380	1.68	1.21	0.00124	7.17	4.02	72.36	-56.73	0.00395	8.89	8.66	-0.23
22nd-24th Street System	22E(1/2)	#N/A	#N/A	#N/A	22E(1/2)-22E	#N/A	#N/A	#N/A	27.02	24 inch	166	0.75	0.7	0.00030	8.60	1.27	3.93	-23.1	0.01428	7.20	5.29	-1.91
22nd-24th Street System	22F(1/2)	#N/A	#N/A	#N/A	22F(1/2)-22F	#N/A	#N/A	#N/A	27.42	24 inch	167	0.85	0.8	0.00030	8.73	1.26	3.91	-23.51	0.01467	8.19	5.78	-2.41
22nd-24th Street System	22F	#N/A	#N/A	#N/A	22F-22E(1/2)	#N/A	#N/A	#N/A	27.22	24 inch	169	0.8	0.75	0.00030	8.67	1.25	3.89	-23.33	0.01450	7.74	5.74	-2.00
22nd-24th Street System	J23K	#N/A	#N/A	#N/A	23K-24K	#N/A	#N/A	#N/A	115.79	6 X 2.5	369	3.11	2.65	0.00125	7.72	3.71	55.69	-60.1	0.00539	11.98	7.12	-4.86
Total Area/Average C		237.11	0.69																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
25th-27th Street System	26(1/2)B	1.46	0.50	2.47	26(1/2)B - 27A1	0.73	25.00	3.35	2.47	36 inch	243	-0.42	-0.56	0.00058	0.35	2.25	16.01	13.54	0.00004	3.31	4.63	1.32
25th-27th Street System	27A2	1.27	0.50	2.14	27A2 - 27_(1/2)A	1.33	25.00	3.35	4.49	4 X 3.25	164	-1.47	-1.57	0.00061	0.37	2.62	34.12	29.63	0.00000	1.52	5.00	3.48
25th-27th Street System	27C2	5.85	0.50	9.88	27C2-27B(1/2)	2.92	25.00	3.35	9.88	24 inch	191	1.09	0.9	0.00100	1.57	4.60	14.27	4.39	0.00052	3.44	4.09	0.65
25th-27th Street System	25K	8.5	0.50	14.35	25M-26K	4.25	25.00	3.35	14.35	2 X 2.25	626	5.1	4.5	0.00096	3.19	2.32	10.42	-3.93	0.00182	8.50	7.67	-0.83
25th-27th Street System	27J	6.15	0.70	14.54	27J-26J	4.30	25.00	3.35	14.54	24 inch	382	4.67	4.29	0.00100	4.63	2.30	7.13	-7.4	0.00414	9.54	7.90	-1.64
25th-27th Street System	27K	9.3	0.50	15.70	27K-26K	4.65	25.00	3.35	15.7	24 inch	389	4.67	4.28	0.00100	5.00	2.31	7.16	-8.54	0.00481	9.94	6.97	-2.97
25th-27th Street System	25Q	11.69	0.50	19.74	25Q-25O	5.84	25.00	3.35	19.74	2 X 2.5	1284	6.85	5.57	0.00100	3.95	2.44	12.19	-7.54	0.00261	11.85	9.87	-1.98
25th-27th Street System	25H	9.73	0.70	23.00	25H-J25G	6.81	25.00	3.35	23	21 Inch	328	2.61	2.28	0.00101	9.56	2.10	5.03	-17.97	0.02107	12.64	6.18	-6.46
25th-27th Street System	27E	16.22	0.70	38.34	27E-26E	11.35	25.00	3.35	38.34	18 in.	384	3.38	3	0.00099	21.70	1.83	3.3	-35.04	0.13323	56.04	5.00	-51.04
25th-27th Street System	27B(1/2)	2.07	0.50	3.49	27B(1/2) - J-507	3.96	27.03	3.21	12.81	4 X 3.25	478	-0.35	-0.83	0.00100	0.99	3.37	43.78	30.97	0.00008	3.34	4.07	0.73
25th-27th Street System	25E2	9.02	0.70	21.32	25E2-25C	13.12	28.03	3.14	41.52	36 inch	657	0.35	-0.9	0.00190	5.87	4.10	29.09	-12.42	0.00388	5.90	4.35	-1.55
25th-27th Street System	25C	7.78	0.70	18.39	25C-25B	18.57	29.89	3.01	56.3	36 inch	333	-0.9	-1.4	0.00150	7.97	3.64	25.84	-30.46	0.00712	5.35	3.35	-2.00
25th-27th Street System	25O	21.18	0.50	35.76	25O-25M	16.43	30.42	2.98	49.42	3 X 2.5	1324	5.57	4.25	0.00100	6.59	2.80	20.97	-28.45	0.00554	14.69	8.50	-6.19
25th-27th Street System	25B	3.83	0.70	9.05	25B-25A2	21.25	30.59	2.98	63.76	36 inch	331	-1.4	-1.9	0.00151	9.02	3.65	25.92	-37.84	0.00912	5.97	2.98	-2.99
25th-27th Street System	25A2	4.04	0.70	9.55	25A2-25Out1	12.04	31.20	2.95	35.83	36 inch	502	-1.9	-2.65	0.00149	5.07	3.63	25.78	-10.05	0.00289	2.95	4.70	1.75
25th-27th Street System	27_(1/2)A	4.48	0.50	7.56	27_(1/2)A - 27Out	3.57	32.41	2.90	10.44	4.5 X 3.25	554	-1.57	-6	0.00800	0.73	9.85	143.84	133.39	0.00004	1.52	5.31	3.79
25th-27th Street System	25M	17.66	0.50	29.82	25M-26M	29.52	33.77	2.85	84.77	4 X 2.25	393	4.5	4.3	0.00051	9.42	2.07	18.64	-66.12	0.01053	11.73	7.36	-4.37
25th-27th Street System	26M	11.54	0.50	19.48	26M-26K	15.17	34.47	2.82	43.15	4' X 2.5'	664	4.05	3.2	0.00128	4.32	3.43	34.33	-8.82	0.00202	9.41	7.59	-1.82
25th-27th Street System	26J	7.6	0.70	17.96	26J-26H	29.45	38.07	2.68	79.47	5 X 2.5	745	2.59	1.47	0.00150	6.36	3.92	48.99	-30.48	0.00395	8.94	7.96	-0.98
25th-27th Street System	26H	7.9	0.70	18.67	26H-26G	34.98	40.02	2.60	91.65	5 X 2.5	328	1.47	0.98	0.00150	7.33	3.92	49	-42.65	0.00524	7.32	6.00	-1.32
25th-27th Street System	26E	7.75	0.70	18.32	26E-26C	51.76	42.38	2.55	133.16	6 X 2.25	666	0.26	-0.74	0.00150	9.86	3.87	52.28	-80.88	0.00973	11.18	4.88	-6.30
25th-27th Street System	26C	5.62	0.70	13.28	26C-25-B	55.69	43.50	2.53	142.02	6 X 2.25	352	-0.74	-1.27	0.00150	10.52	3.87	52.28	-89.74	0.01108	8.90	4.70	-4.20
25th-27th Street System	25-B	1.81	0.70	4.28	25-B-26A2	56.96	44.06	2.52	144.61	6 X 2.25	320	-1.27	-1.76	0.00153	10.71	3.91	52.82	-91.79	0.01147	6.97	5.00	-1.97
25th-27th Street System	26A2	4.84	0.70	11.44	26A-Outfall	76.38	178.04	1.01	77.75	6 X 2.25	542	-1.76	-2.57	0.00150	5.76	3.87	52.28	-25.47	0.00332	3.30	4.32	1.02
25th-27th Street System	27A1	#N/A	#N/A	#N/A	27A1-J-507	#N/A	#N/A	#N/A	0.1	42 inch	82	-1.47	-1.53	0.00073	0.01	2.83	27.21	27.11	0.00000	3.30	5.11	1.81
25th-27th Street System	J26K	#N/A	#N/A	#N/A	26K-26J	#N/A	#N/A	#N/A	54.32	4' X 2.5'	339	3.2	2.59	0.00180	5.43	4.07	40.71	-13.62	0.00322	9.05	8.07	-0.98
25th-27th Street System	26F	#N/A	#N/A	#N/A	26F-26E	#N/A	#N/A	#N/A	90.56	6 X 2.25	325	0.74	0.26	0.00150	6.71	3.87	52.31	-38.26	0.00449	6.34	5.40	-0.94
25th-27th Street System	25F2	#N/A	#N/A	#N/A	25F2-25F1	#N/A	#N/A	#N/A	22.46	1.5 X 1.5	71	2.22	2.15	0.00099	9.98	1.91	4.2	-18.26	0.02817	6.66	5.30	-1.36
25th-27th Street System	J-507	#N/A	#N/A	#N/A	J-507-26A2	#N/A	#N/A	#N/A	4.29	42 inch	288	-1.53	-1.76	0.00080	0.45	2.96	28.43	24.15	0.00000	3.30	5.00	1.70
25th-27th Street System	J26M	diversion out to 33rd-41st system			J26M-27M	#N/A	#N/A	#N/A	67.92	4' X 2.5'	375	4.05	3.86	0.00051	6.79	2.16	21.6	-46.32	0.00501	8.88	7.59	-1.29
25th-27th Street System	25F1	#N/A	#N/A	#N/A	25F1-25E2	#N/A	#N/A	#N/A	22.4	4 X 2	301	1.65	1.35	0.00100	2.80	2.75	22.03	-0.37	0.00103	4.66	5.30	0.64
25th-27th Street System	26G	#N/A	#N/A	#N/A	26G-26F	#N/A	#N/A	#N/A	91.13	6 X 2.25	324	1.23	0.74	0.00150	6.75	3.87	52.28	-38.85	0.00457	6.88	5.60	-1.28
25th-27th Street System	J25G	#N/A	#N/A	#N/A	J25G-25F2	#N/A	#N/A	#N/A	22.72	21 Inch	310	2.28	1.97	0.00100	9.45	2.09	5.01	-17.71	0.02058	11.68	5.73	-5.95
25th-27th Street System	J25A2	#N/A	#N/A	#N/A	25A2-26A2	#N/A	#N/A	#N/A	40.66	42 inch	407	-1.36	-1.76	0.00098	4.23	3.29	31.54	-9.12	0.00162	3.96	4.70	0.74
Total Area/Average C		187.29	0.61																			
29th Street System	31B	2.67	0.70	6.31	31B-30B	1.87	25.00	3.35	6.31	30 inch	334	0.63	0.3	0.00099	1.29	2.63	12.89	6.58	0.00024	4.01	5.00	0.99
29th Street System	28B	6.75	0.70	15.96	28B-29B	4.72	25.00	3.35	15.96	36 inch	377	-0.19	-0.57	0.00101	2.26	2.98	21.17	5.22	0.00058	3.55	4.50	0.95
29th Street System	29H	13.03	0.50	22.00	29H-29E	6.52	25.00	3.35	22	5 X 3	994	1.57	0.57	0.00101	1.47	3.47	52.09	30.09	0.00018	5.18	5.00	-0.18
29th Street System	28D1/2	16.18	0.70	38.25	28D1/2-J29D1/2	11.33	25.00	3.35	38.25	4.5 X 2	377	1.75	1.37	0.00101	4.25	2.84	25.56	-12.69	0.00225	5.85	4.00	-1.85
29th Street System	30B	9.76	0.70	23.07	30B-29B	8.70	29.33	3.05	26.72	36 inch	375	-0.2	-0.57	0.00099	3.78	2.95	20.95	-5.77	0.00160	3.93	5.00	1.07
29th Street System	29E	15.61	0.70	36.90	29E-J29D1/2	17.44	36.30	2.75	48.32	5 X 3	167	0.57	0.37	0.00120	3.22	3.79	56.83	8.52	0.00084	5.14	5.00	-0.14
29th Street System	29B	28.65	0.70	67.72	29B-29Wharf	62.25	39.79	2.61	163.66	72 inch	626	-3.57	-4.2	0.00101	5.79	4.75	134.34	-29.32	0.00149	3.33	5.00	1.67
29th Street System	29Wharf	11.29	0.70	26.69	29Wharf-29Out	70.15	41.60	2.57	181.6	72 inch	488	-4.2	-4.69	0.00100	6.42	4.74	134.19	-47.41	0.00184	2.40	5.00	2.60
29th Street System	J29D1/2	#N/A	#N/A	#N/A	J29D1/2-29B	#N/A	#N/A	#N/A	78.69	5 X 3	829	0.37	-0.57	0.00113	5.25	3.69	55.3	-23.39	0.00230	5.24	5.00	-0.24
Total Area/Average C		103.94	0.68																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
33rd-41st Street System	32N(1/2)	2.63	0.50	4.44	33N(1/2)-32N(1/2)	1.32	25.00	3.35	4.44	30 inch	323	4.04	3.7	0.00105	0.90	2.72	13.31	8.87	0.00012	8.22	8.10	-0.12
33rd-41st Street System	34F	2.07	0.70	4.89	34F-33F	1.45	25.00	3.35	4.89	15 inch	334	2.83	2.56	0.00081	3.99	1.53	1.84	-3.06	0.00575	6.14	4.10	-2.04
33rd-41st Street System	39G	3.19	0.50	5.39	39G-41G	1.60	25.00	3.35	5.39	18 inch	736	2.03	1.66	0.00050	3.05	1.31	2.36	-3.03	0.00264	7.84	4.32	-3.52
33rd-41st Street System	42H	3.45	0.50	5.82	42H-41H	1.72	25.00	3.35	5.82	15 inch	343	0.5	0.16	0.00099	4.75	1.69	2.03	-3.79	0.00813	8.97	6.10	-2.87
33rd-41st Street System	32B	3.68	0.70	8.70	32B-33B	2.58	25.00	3.35	8.7	30 inch	388	0.4	0.21	0.00049	1.77	1.85	9.08	0.38	0.00044	4.65	4.48	-0.17
33rd-41st Street System	29R	5.6	0.50	9.46	29R - 29P(1/2)	2.80	25.00	3.35	9.46	3 X 2.5	1001	6.78	5.78	0.00100	1.26	2.80	20.99	11.53	0.00020	9.73	10.00	0.27
33rd-41st Street System	40F	5.68	0.50	9.59	40F-41F	2.84	25.00	3.35	9.59	24 inch	395	1.56	1.16	0.00101	3.05	2.32	7.2	-2.39	0.00180	7.20	6.81	-0.39
33rd-41st Street System	41O	9.04	0.50	15.26	Q41-M41	4.52	25.00	3.35	15.26	36 inch	1290	2	0.71	0.00100	2.16	2.97	21.09	5.83	0.00053	8.04	7.63	-0.41
33rd-41st Street System	31C	6.87	0.70	16.24	31C - 33C	4.81	25.00	3.35	16.24	4' X 2.5'	750	0.9	0.53	0.00049	1.62	2.13	21.31	5.07	0.00028	4.40	4.31	-0.09
33rd-41st Street System	34G	9.74	0.50	16.45	34G-J33G	4.87	25.00	3.35	16.45	2 X 1.5	376	2.39	2	0.00104	5.48	2.09	6.28	-10.17	0.00713	6.68	4.00	-2.68
33rd-41st Street System	27O(1/2)	10.52	0.50	17.76	27O(1/2) - 29O(1/2)	5.26	25.00	3.35	17.76	24 inch	762	6.39	5.63	0.00100	5.65	2.30	7.14	-10.62	0.00617	13.93	8.86	-5.07
33rd-41st Street System	32D	7.61	0.70	17.99	32D-33D	5.33	25.00	3.35	17.99	3 X 2.5	383	0.97	0.78	0.00050	2.40	1.97	14.79	-3.2	0.00073	4.69	4.62	-0.07
33rd-41st Street System	31J	7.65	0.70	18.08	32J-31J	5.36	25.00	3.35	18.08	24 inch	326	3.46	3.2	0.00080	5.76	2.06	6.39	-11.69	0.00638	9.98	8.38	-1.60
33rd-41st Street System	32R	11.07	0.50	18.69	32R - 31R	5.53	25.00	3.35	18.69	1 X 1	377	8.28	7.9	0.00101	18.69	1.44	1.44	-17.25	0.16979	73.97	9.86	-64.11
33rd-41st Street System	35E	8.44	0.70	19.95	35E-33E	5.91	25.00	3.35	19.95	2.5 X 1.5	755	2.63	2.03	0.00080	5.32	1.92	7.29	-12.66	0.00595	8.74	4.39	-4.35
33rd-41st Street System	35J	8.58	0.70	20.28	35J-34J	6.01	25.00	3.35	20.28	24 inch	368	3.08	2.9	0.00049	6.46	1.61	5	-15.28	0.00804	10.96	8.28	-2.68
33rd-41st Street System	43O	12.23	0.50	20.65	43O-43M	6.11	25.00	3.35	20.65	2.5 X 2.5	1296	2.13	0.83	0.00100	3.30	2.67	16.54	-4.11	0.00157	9.28	8.10	-1.18
33rd-41st Street System	35S	16.1	0.50	27.18	35S - 35P(1/2)	8.05	25.00	3.35	27.18	3.5 X 2.5	1623	6.28	4.66	0.00100	3.11	2.91	25.6	-1.59	0.00113	10.83	10.08	-0.75
33rd-41st Street System	33Q1/2	18.27	0.50	30.85	33Q1/2-33P1/2	9.14	25.00	3.35	30.85	4 X 2	645	6.08	5.43	0.00101	3.86	2.77	22.15	-8.69	0.00195	9.75	10.00	0.25
33rd-41st Street System	27P(1/2)	21.41	0.50	36.15	27P(1/2) - 29P(1/2)	10.70	25.00	3.35	36.15	24 inch	753	7.03	6.28	0.00100	11.51	2.30	7.14	-29.01	0.02554	28.76	9.32	-19.44
33rd-41st Street System	37O	44.83	0.50	75.69	37O-37M	22.42	25.00	3.35	75.69	36 inch	1286	2.76	1.47	0.00100	10.71	2.97	21.12	-54.57	0.01288	24.21	8.32	-15.89
33rd-41st Street System	39R	54.47	0.50	91.97	39R-39P	27.24	25.00	3.35	91.97	3.5 X 2.5	1331	4.86	3.56	0.00098	10.51	2.88	25.32	-66.65	0.01289	24.65	9.42	-15.23
33rd-41st Street System	31R	4.65	0.50	7.85	31R - 31O	7.86	25.34	3.33	26.36	2 X 2.5	1980	6.4	4.42	0.00100	5.27	2.44	12.21	-14.14	0.00466	17.22	9.96	-7.26
33rd-41st Street System	41J	7.44	0.70	17.59	P-237	122.64	25.64	3.30	408.57	6 X 3.5	372	-1.16	-1.53	0.00100	19.46	3.85	80.92	-327.65	0.02535	16.23	7.76	-8.47
33rd-41st Street System	27M	31.37	0.50	52.97	27M-29M	35.80	25.92	3.29	118.56	4' X 2.5'	761	3.86	3.48	0.00050	11.86	2.14	21.44	-97.11	0.01527	19.72	7.00	-12.72
33rd-41st Street System	32J	7.9	0.70	18.67	33J-32J	10.88	25.94	3.28	36.03	24 inch	388	3.2	2.89	0.00080	11.47	2.06	6.39	-29.64	0.02536	18.19	7.90	-10.29
33rd-41st Street System	34J	7.58	0.70	17.92	34J-33J	11.31	25.95	3.28	37.44	24 inch	375	2.9	2.71	0.00051	11.92	1.64	5.09	-32.35	0.02739	18.62	8.00	-10.62
33rd-41st Street System	41I	5.26	0.70	12.43	P-236	126.32	25.96	3.28	418	6 X 3.5	322	-1.53	-1.85	0.00099	19.90	3.85	80.89	-337.11	0.02652	14.72	6.80	-7.92
33rd-41st Street System	41H	3.42	0.50	5.77	41H-41G	129.76	26.23	3.26	426.89	6 X 3.5	327	-1.85	-2.18	0.00101	20.33	3.88	81.51	-345.38	0.02768	14.95	6.18	-8.77
33rd-41st Street System	39P	19.24	0.50	32.48	P-238	36.85	27.11	3.20	118.96	3.5 X 2.5	1972	3.56	1.59	0.00100	13.60	2.91	25.61	-93.35	0.02156	50.30	7.50	-42.80
33rd-41st Street System	41G	5.13	0.50	8.66	41G-41F	133.92	29.02	3.07	414.19	6 X 3.5	343	-2.18	-2.52	0.00099	19.72	3.85	80.79	-333.4	0.02606	15.43	5.90	-9.53
33rd-41st Street System	41F	5	0.50	8.44	41F-41PI	139.26	29.31	3.05	427.86	6 X 3.5	1191	-2.52	-3.71	0.00100	20.37	3.86	81.11	-346.75	0.02780	37.61	6.49	-31.12
33rd-41st Street System	41PI	37.3	0.50	62.98	41PI-41Out2	157.91	30.29	2.99	475.68	6 X 3.5	1194	-3.71	-4.91	0.00101	22.65	3.87	81.35	-394.33	0.03436	48.38	4.50	-43.88
33rd-41st Street System	33N(1/2)	4.37	0.50	7.38	33N(1/2) - 33N	3.50	30.95	2.96	10.45	30 inch	328	3.7	3.37	0.00101	2.13	2.66	13.01	2.56	0.00064	8.37	8.18	-0.19
33rd-41st Street System	41Out2	19.06	0.50	32.18	41Out2 - 41Out1	167.44	31.17	2.95	498.46	6 X 3.5	346	-4.91	-5.25	0.00098	23.74	3.83	80.44	-418.02	0.03775	14.56	7.35	-7.21
33rd-41st Street System	31O	57.58	0.50	97.22	31O-31M	36.65	31.60	2.94	108.47	3 X 2.5	1315	4.42	3.1	0.00100	14.46	2.81	21.04	-87.43	0.02668	42.65	8.00	-34.65
33rd-41st Street System	33O1/2	19.5	0.50	32.92	33O1/2-J33N1/2	18.88	32.12	2.92	55.5	6 X 2.5	653	4.3	3.68	0.00095	3.70	3.24	48.6	-6.9	0.00124	8.99	8.00	-0.99
33rd-41st Street System	33N	6.99	0.50	11.80	33N - 33M	6.99	33.52	2.86	20.16	36 inch	656	2.87	2.22	0.00099	2.85	2.96	20.99	0.83	0.00091	8.44	8.16	-0.28
33rd-41st Street System	35P(1/2)	28.73	0.50	48.51	35P(1/2) - 35O	22.42	33.71	2.85	64.43	3.5 X 2.5	998	4.66	3.66	0.00100	7.36	2.91	25.65	-38.79	0.00632	14.28	9.00	-5.28
33rd-41st Street System	35O	15.25	0.50	25.75	35O-35M	30.04	35.97	2.76	83.61	3.5 X 2.5	1309	3.66	2.35	0.00100	9.56	2.91	25.63	-57.98	0.01065	21.59	7.97	-13.62
33rd-41st Street System	29P(1/2)	21.41	0.50	36.15	29P(1/2) - 29O(1/2)	24.21	38.23	2.67	65.17	3 X 2.5	649	5.78	5.13	0.00100	8.69	2.80	21.02	-44.16	0.00963	15.48	9.53	-5.95
33rd-41st Street System	35M	23.03	0.50	38.88	35M-37M	115.32	38.25	2.67	310.37	6.5 X 3.75	760	1.1	0.72	0.00050	12.74	2.87	69.92	-240.45	0.00986	15.14	7.65	-7.49
33rd-41st Street System	37M	23.25	0.50	39.26	37M-39M	149.36	39.24	2.63	396	8 X 3.5	762	0.97	0.59	0.00050	14.15	2.91	81.48	-314.51	0.01178	16.77	7.65	-9.12
33rd-41st Street System	29O(1/2)	11.56	0.50	19.52	29O(1/2) - 29M	35.25	39.48	2.62	93.12	3.5 X 2.5	1648	5.13	3.48	0.00100	10.64	2.91	25.64	-67.49	0.01321	29.87	9.23	-20.64
33rd-41st Street System	39M	40.47	0.50	68.33	39M-41M	206.45	40.14	2.60	540.48	8 X 3.5	761	0.59	0.21	0.00050	19.31	2.91	81.54	-458.94	0.02194	24.06	7.79	-16.27
33rd-41st Street System	41M	17.92	0.50	30.26	41M-43M	219.93	40.80	2.58	572.85	8 X 3.5	764	0.21	-0.17	0.00050	20.47	2.91	81.38	-491.48	0.02466	26.09	7.36	-18.73
33rd-41st Street System	43M	21.69	0.50	36.62	43M-43K	236.89	41.42	2.57	614.06	8 X 3.5	653	-0.17	-0.49	0.00049	21.94	2.89	80.78	-533.28	0.02835	25.76	7.25	-18.51
33rd-41st Street System	43K	17.99	0.50	30.37	43K-43J	209.00	41.92	2.56	539.68	8 X 3.5	390	-0.49	-0.72	0.00059	19.28	3.16	88.61	-451.07	0.02190	16.35	7.25	-9.10
33rd-41st Street System	29M	23.67	0.50	39.96	29M - 31M	82.88	42.06	2.56	213.78	4 x 3 ft	754	2.98	2.6	0.00050	17.82	2.32	27.78	-185.99	0.02984	30.07	8.10	-21.97
33rd-41st Street System	43J	6.45	0.70	15.25	43J-44J	96.08	42.25	2.55	247.45	4 x 3 ft	386	-0.22	-0.5	0.00073	20.63	2.78	33.33	-214.11	0.04000	23.19	7.81	-15.38
33rd-41st Street System	31M	22.78	0.50	38.46	31M-33M	130.92	42.76	2.54	335.82	4.5 X 3.5	750	2.1	1.72	0.00051	21.32	2.54	40.1	-295.73	0.03555	34.50	7.57	-26.93
33rd-41st Street System	33M	14.24	0.50	24.04	33M-33L	90.16	43.35	2.53	230.19	6 x 3 ft	334	2.22	2	0.00066	12.79	2.93	52.8	-177.39	0.01251	12.18	7.84	-4.34
33rd-41st Street System	33L	8.09	0.50	13.66	33L-33J	94.20	43.79	2.52	239.7	6 x 3 ft	691	2	1.5	0.00072	13.32	3.07	55.34	-184.35	0.01357	17.73	8.00	-9.73
33rd-41st Street System	33H	17.17	0.70	40.59	P-325	128.42	45.51	2.49	322.3	7 X 3	317	0.8	0.51	0.00092	15.35	3.57	75	-247.3	0.01691	9.36	5.00	-4.36
33rd-41st Street System	33F	28.49	0.70	67.34	33F-33E	154.68	46.20	2.48	386.04	7 x 3 ft	318	0.2	-0.12	0.00101	18.39	3.75	78.66	-307.38	0.02425	11.96	4.22	-7.74
33rd-41st Street System	33E	2.68	0.70	6.33	33E-33D	162.46	46.49	2.47	404.52	7 x 3 ft	340	-0.12	-0.41	0.00085	19.27	3.45	72.42	-332.1	0.02665	13.47	4.25	-9.22
33rd-41st Street System	33D	3.79	0.70	8.96	33D-33C	170.44	46.79	2.46	423.38	7 x 3 ft	340	-0.41	-0.74	0.00097	20.17	3.68	77.25	-346.13	0.02918	14.11	4.41	-9.70
33rd-41st Street System	33C	13.88	0.70	32.81	33C-33B	184.97	47.07	2.46	458.42	7 x 3 ft	344	-0.74	-1.08	0.00099	21.84	3.71	77.96	-380.46	0.03422	16.25	4.19	-12.06
33rd-41st Street System	33B	5.04	0.70	11.91	33B-33A	191.07	47.33	2.45	472.53	BOX 8 X3	306	-1.08	-1.38	0.00098	19.70	3.79	91.02	-381.51	0.02644	12.09	4.48	-7.61
33rd-41st Street System	33A	29.29	0.70	69.23	33A-33OUt	211.58	47.59	2.45	522.13	BOX 8 X3	1269	-1.38	-2.64	0.00099	21.77	3.82	91.6	-430.53	0.03229	42.48	4.00	-38.48
33rd-41st Street System	J33N1/2	#N/A	#N/A	#N/A	J33N1/2-J33M1	#N/A	#N/A	#N/A	53.26	6 X 3	945	3.18	2.28	0.00095	2.96	3.53	63.49	10.24	0.00067	8.47	8.18	-0.29
33rd-41st Street System	J33M1	#N/A	#N/A	#N/A	J33M1-33M	#N/A	#N/A	#N/A	49.35	6 X 3	63	2.28	2.22	0.00095	2.74	3.53	63.49	14.14	0.00063	7.88	7.84	-0.04
33rd-41st Street System	J33G	#N/A	#N/A	#N/A	P-326	#N/A	#N/A	#N/A	333.6	7 X 3	337	0.51	0.2	0.00092	15.89	3.58	75.21	-258.39	0.01810	10.32	4.00	-6.32
33rd-41st Street System	J33M	#N/A	#N/A	#N/A	J33M-35M	#N/A	#N/A	#N/A	249.09	6 X 3.5	734	1.72	1.35	0.00050	11.86	2.74	57.61	-191.48	0.00943	14.57	7.84	-6.73
33rd-41st Street System	33P1/2	#N/A	#N/A	#N/A	33P1/2-33P	#N/A	#N/A	#N/A	29.05	5 X 2	328	5.43	5.11	0.00098	2.91	2.85	28.53	-0.52	0.00101	8.49	9.00	0.51
33rd-41st Street System	33J	#N/A	#N/A	#N/A	33J-33H	#N/A	#N/A	#N/A	294.15	7 x 3 ft	719	1.5	0.8	0.00097	14.01	3.68	77.37	-216.77	0.01408	15.12	8.35	-6.77
33rd-41st Street System	J43J	#N/A	#N/A	#N/A	J43J-41J	#N/A	#N/A	#N/A	396.55	6 X 3.5	729	-0.72	-1.16	0.00060	18.88	3.00	63.04	-333.51	0.02388	25.17	7.81	-17.36
33rd-41st Street System	33P	#N/A	#N/A	#N/A	33P-33O1/2	#N/A	#N/A	#N/A	27.84	5 X 2.5	327	4.61	4.3	0.00095	2.23	3.12	38.96	11.12	0.00049	8.16	8.50	0.34
33rd-41st Street System	J43K	diversion out to west K system			J43K - 45K	#N/A	#N/A	#N/A	124.55	6 X 2	725	5.04	4.63	0.00057	10.38	2.24	26.93	-97.62	0.01210	15.94	7.25	-8.69
Total Area/Average C		911.79	0.56																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
37th Street System	35H	5.92	0.50	10.00	35H-36H	2.96	25.00	3.35	10	30 inch	373	0.97	0.78	0.00051	2.04	1.89	9.26	-0.74	0.00059	4.72	4.31	-0.41
37th Street System	35F	5.24	0.70	12.39	35F-37F	3.67	25.00	3.35	12.39	15 inch	765	2	1.94	0.00008	10.09	0.48	0.57	-11.81	0.03677	31.74	3.34	-28.40
37th Street System	38F	5.28	0.70	12.48	38F-37F	3.70	25.00	3.35	12.48	24 inch	368	1.56	1.19	0.00101	3.97	2.31	7.17	-5.31	0.00304	4.73	4.71	-0.02
37th Street System	38B	7.85	0.70	18.56	38B-37B	5.49	25.00	3.35	18.56	30 inch	375	-0.12	-0.49	0.00099	3.78	2.63	12.88	-5.67	0.00205	4.40	4.29	-0.11
37th Street System	37J(1/2)	14.87	0.50	25.11	37J(1/2)-37H	7.44	25.00	3.35	25.11	30 inch	670	1.95	1.28	0.00100	5.11	2.65	12.97	-12.14	0.00375	6.98	6.84	-0.14
37th Street System	40H1	21.15	0.50	35.71	40H1-39H	10.58	25.00	3.35	35.71	24 inch	367	2.92	2.3	0.00169	11.37	3.00	9.3	-26.41	0.02493	13.57	7.43	-6.14
37th Street System	39H	25.27	0.50	42.67	39H-38H	23.21	25.54	3.31	77.49	30 inch	399	1.8	1.63	0.00043	15.79	1.73	8.47	-69.03	0.03569	18.54	4.42	-14.12
37th Street System	38H	7.22	0.50	12.19	38H-37H	26.82	25.96	3.28	88.75	36 inch	351	1.13	0.78	0.00100	12.56	2.97	21.06	-67.69	0.01772	10.69	4.30	-6.39
37th Street System	36H	8.07	0.50	13.63	36H-37H	6.99	28.05	3.14	22.11	30 inch	395	0.28	0.08	0.00051	4.50	1.88	9.23	-12.88	0.00291	5.62	4.50	-1.12
37th Street System	37H	7.58	0.50	12.80	37H-37F	45.04	29.51	3.03	137.74	6 X 3.67	660	0.11	-0.48	0.00089	6.26	3.73	81.95	-55.8	0.00253	5.28	4.47	-0.81
37th Street System	37F	13.23	0.70	31.27	37F-37D	61.66	31.27	2.95	183.31	6 X 3.67	660	-0.48	-1.07	0.00089	8.33	3.73	81.95	-101.37	0.00447	6.45	3.61	-2.84
37th Street System	37D	40.97	0.70	96.84	37D-37B	90.34	32.59	2.90	263.76	6 X 3.67	660	-1.07	-1.66	0.00089	11.99	3.73	81.95	-181.81	0.00926	9.74	3.50	-6.24
37th Street System	37B	10.49	0.70	24.80	37B-37A	103.18	33.51	2.86	297.43	6 X 3.67	330	-1.66	-1.96	0.00091	13.52	3.76	82.64	-214.79	0.01179	7.78	3.63	-4.15
37th Street System	37A	15.21	0.70	35.95	37A-37Out	113.83	33.92	2.84	326.25	6 X 4.5	700	-2.79	-3.42	0.00090	12.09	4.05	109.47	-216.78	0.00800	7.10	3.89	-3.21
Total Area/Average C		188.35	0.60																			
45th Street System	45B1	2.96	0.70	7.00	45B1-45B2	2.07	25.00	3.35	7	24 inch	91	-1.1	-1.19	0.00099	2.23	2.29	7.11	0.12	0.00099	4.03	4.46	0.43
45th Street System	45(1/2)F	4.15	0.70	9.81	45(1/2)F-45F	2.90	25.00	3.35	9.81	18 inch	190	0.08	-0.11	0.00100	5.55	1.84	3.32	-6.49	0.00874	6.89	5.24	-1.65
45th Street System	44F	5.55	0.70	13.12	44F-45F	3.88	25.00	3.35	13.12	24 inch	379	0.5	-1.13	0.00430	4.18	4.79	14.84	1.72	0.00335	6.50	6.27	-0.23
45th Street System	44B	5.72	0.70	13.52	44B-45B2	4.00	25.00	3.35	13.52	30 inch	413	-0.78	-1.19	0.00099	2.75	2.64	12.92	-0.6	0.00109	4.39	4.49	0.10
45th Street System	43H	12.42	0.70	29.36	42H-44H	8.69	25.00	3.35	29.36	24 inch	718	0.98	-0.46	0.00201	9.34	3.27	10.13	-19.23	0.01684	18.32	6.30	-12.02
45th Street System	46H	17.5	0.70	41.37	46H-45H	12.25	25.00	3.35	41.37	30 inch	338	0.7	0.22	0.00142	8.43	3.16	15.46	-25.91	0.01018	9.67	5.42	-4.25
45th Street System	44J	6.05	0.70	14.30	44J-45J	100.32	42.57	2.55	257.72	4 x 3 ft	371	-0.5	-0.78	0.00076	21.49	2.83	34	-223.72	0.04340	23.48	7.75	-15.73
45th Street System	45J	6.21	0.70	14.68	45J-45H	104.66	42.85	2.54	268.29	4 x 3 ft	681	-0.78	-1.46	0.00100	22.37	3.26	39.11	-229.18	0.04703	38.26	7.38	-30.88
45th Street System	45H	6.17	0.70	23.29	45H-45F	129.93	43.36	2.53	331.71	5 x 3 ft	665	-1.46	-2.13	0.00101	22.13	3.48	52.13	-279.58	0.04084	32.39	6.23	-26.16
45th Street System	45F	4.17	0.70	15.74	45F-45D	139.64	43.86	2.52	355.09	5 X 3	721	-2.13	-2.85	0.00100	23.69	3.46	51.9	-303.19	0.04681	38.75	5.23	-33.52
45th Street System	45D	32.76	0.70	77.44	45D-45B2	162.57	44.37	2.51	411.74	5 X 3	435	-2.85	-3.29	0.00101	27.47	3.48	52.23	-359.51	0.06294	31.32	5.00	-26.32
45th Street System	45A	38	0.70	89.82	45A-45Out	195.24	45.08	2.50	491.7	5 x 3 ft	1243	-4.05	-5.29	0.00100	32.81	3.46	51.87	-439.83	0.08978	113.10	4.38	-108.72
45th Street System	45B2	#N/A	#N/A	#N/A	45B2-45A	#N/A	#N/A	#N/A	426.23	5 X 3	764	-3.29	-4.05	0.00100	28.44	3.45	51.8	-374.44	0.06746	55.92	3.94	-51.98
Total Area/Average C		141.66	0.70																			
4th Street System	5A	2.29	0.50	3.87	5A-4A	1.14	25.00	3.35	3.87	24 inch	340	6.14	5.97	0.00050	1.29	1.63	5.06	1.19	0.00024	7.91	9.15	1.24
4th Street System	3A	2.49	0.50	4.20	3A-4A	1.24	25.00	3.35	4.2	24 inch	379	6.15	5.97	0.00048	1.40	1.59	4.93	0.73	0.00029	7.94	9.00	1.06
4th Street System	4A	4.81	0.50	8.12	4A-4Tuna	4.80	29.51	3.03	14.67	36 inch	427	5.97	5.54	0.00100	3.17	2.97	21.09	6.43	0.00096	7.83	10.17	2.34
4th Street System	4Tuna	4.05	0.50	6.84	5.04	6.82	31.76	2.93	20.14	42 inch	954	5.04	4.09	0.00100	2.62	3.31	31.81	11.67	0.00044	7.42	10.29	2.87
4th Street System	4Bonita	17.53	0.50	29.60	4Bonita-4Out	15.58	37.82	2.69	42.22	42 inch	344	4.09	3.75	0.00099	6.14	3.29	31.63	-10.59	0.00358	7.00	10.22	3.22
Total Area/Average C		31.17	0.50																			
59th Street System	59R	7.23	0.50	12.21	59R-59Q	3.62	25.00	3.35	12.21	18 inch	681	1	0.32	0.00100	6.91	1.84	3.32	-8.89	0.01351	11.70	3.00	-8.70
59th Street System	59Q	17.8	0.50	30.05	59Q-59Shr	12.51	26.64	3.23	40.81	24 inch	491	-0.18	-0.67	0.00100	12.99	2.31	7.15	-33.66	0.03255	18.87	2.50	-16.37
59th Street System	59Shr	7.46	0.50	12.60	59Shr-59Out	16.24	27.27	3.19	52.25	36 inch	226	-1.67	-1.9	0.00100	7.39	2.97	21.09	-31.16	0.00615	2.89	5.00	2.11
60th Street System	J61P	#N/A	#N/A	#N/A	J61P-61Out	#N/A	#N/A	#N/A	10.73	42 inch	282	-1.34	-1.62	0.00100	1.23	3.31	31.81	21.09	0.00011	1.53	6.50	4.97
Total Area/Average C		32.49	0.50																			
61st Street System	61P1/2_2	0.44	0.50	0.74	61P1/2_2-61P1/2	0.22	25.00	3.35	0.74	24 inch	297	0.78	0.48	0.00100	0.53	2.31	7.15	6.41	0.00003	1.58	5.00	3.42
61st Street System	61Q1/2	3.71	0.50	6.26	61Q1/2-J61Q	1.86	25.00	3.35	6.26	36 inch	320	0.15	-0.17	0.00100	1.62	2.97	21.09	14.83	0.00022	1.65	6.00	4.35
61st Street System	61P1/2	3.92	0.50	6.62	61P1/2-J61P	4.04	35.29	2.79	11.34	42 inch	322	-1.02	-1.34	0.00100	1.42	3.31	31.81	20.47	0.00012	1.57	7.00	5.43
61st Street System	J61Q	#N/A	#N/A	#N/A	J61Q-61P1/2	#N/A	#N/A	#N/A	5.83	42 inch	348	-0.67	-1.02	0.00100	0.83	3.31	31.81	25.98	0.00003	1.58	7.50	5.92
Total Area/Average C		8.07	0.50																			
81st Street System	81Stwrt	28.26	0.50	47.71	81Stwrt-J81_1	14.13	25.00	3.35	47.71	24 inch	1769	2.6	0.83	0.00100	15.19	2.31	7.15	-40.56	0.04449	82.70	6.00	-76.70
81st Street System	J81_1	#N/A	#N/A	#N/A	J81_1-LMOut2	#N/A	#N/A	#N/A	45.78	30 inch	379	0.33	-0.05	0.00100	9.60	2.65	12.97	-32.81	0.01285	7.06	4.00	-3.06
9th Street System	6A	4.52	0.50	7.63	6A-7A	2.26	25.00	3.35	7.63	30 inch	465	1.08	0.61	0.00100	2.67	2.65	12.97	5.34	0.00092	2.47	8.40	5.93
9th Street System	5H	12.14	0.50	20.50	5H-5G	6.07	25.00	3.35	20.5	24 inch	258	7.72	5.81	0.00740	6.52	6.28	19.46	-1.03	0.00822	13.50	12.12	-1.38
9th Street System	2E	15.79	0.50	26.66	2E-2D	7.90	25.00	3.35	26.66	36 inch	344	3.35	3.01	0.00099	3.77	2.95	20.97	-5.69	0.00160	8.11	8.08	-0.03
9th Street System	2A	18.37	0.50	31.02	2B-2A	9.18	25.00	3.35	31.02	48 inch	314	1.75	1.38	0.00119	2.47	3.93	49.57	18.56	0.00048	7.32	7.68	0.36
9th Street System	5G	4.57	0.50	7.72	5G-5F	8.35	25.66	3.30	27.82	30 inch	491	5.31	4.54	0.00157	5.67	3.31	16.24	-11.58	0.00460	12.87	11.38	-1.49
9th Street System	2D	13.69	0.50	23.11	2D-2B	14.74	26.52	3.24	48.19	48 inch	572	2.01	1.44	0.00100	3.84	3.60	45.42	-2.77	0.00114	7.82	7.56	-0.26
9th Street System	5F	4.67	0.50	7.88	5F-5E	10.69	27.10	3.20	34.51	36 inch	248	4.04	3.64	0.00161	4.88	3.77	26.79	-7.73	0.00266	11.41	10.61	-0.80
9th Street System	7A	3.26	0.50	5.50	7A-9_1/2A	3.89	27.91	3.15	12.34	36 inch	164	0.11	-0.05	0.00100	2.51	2.97	21.09	8.75	0.00049	2.04	8.64	6.60
9th Street System	5E	4.57	0.50	7.72	5E-4E	12.97	27.95	3.14	41.11	36 inch	380	3.64	3.04	0.00158	5.82	3.73	26.5	-14.61	0.00379	11.25	10.75	-0.50
9th Street System	2B	22.91	0.50	38.68	4B-2B	35.38	29.01	3.07	109.47	60 inch	736	0.99	-0.19	0.00160	5.58	5.32	104.28	-5.19	0.00177	7.17	7.73	0.56
9th Street System	4E	14.26	0.50	24.08	4E-4D	20.10	29.04	3.07	62.16	36 inch	281	3.04	2.59	0.00160	8.79	3.76	26.69	-35.47	0.00868	11.85	9.81	-2.04
9th Street System	4D	7.84	0.50	13.24	4D-4C	24.02	29.57	3.03	73.38	42 inch	332	2.09	1.79	0.00090	7.63	3.15	30.24	-43.14	0.00533	11.60	9.41	-2.19
9th Street System	4C	9.07	0.50	15.31	P-205	28.56	30.30	2.99	86.02	42 inch	330	1.79	1.32	0.00141	8.94	3.93	37.76	-48.26	0.00730	11.30	9.83	-1.47
9th Street System	4B	5.36	0.50	9.05	4B - 6B	38.06	31.21	2.95	113.24	60 inch	765	-0.19	-0.96	0.00101	5.77	4.22	82.62	-30.62	0.00188	5.87	8.89	3.02
9th Street System	6B	9.85	0.50	16.63	7B-6B	71.54	33.42	2.86	206.5	72 inch	374	-0.96	-1.33	0.00100	8.32	4.72	133.56	-72.94	0.00316	4.43	11.30	6.87
9th Street System	7B	3.55	0.50	5.99	7B-9_1/2A	73.32	34.17	2.83	209.4	7 X 5	720	-1.33	-2.05	0.00099	7.00	4.64	162.24	-47.17	0.00179	3.25	14.50	11.25
9th Street System	9_1/2A	2.48	0.50	4.19	9(1/2)A-O-10	78.45	35.88	2.76	218.63	7 X 5	122	-2.05	-2.17	0.00098	8.15	4.61	161.35	-57.28	0.00377	1.96	7.54	5.58
9th Street System	J4B	#N/A	#N/A	#N/A	I-25 - 6B	#N/A	#N/A	#N/A	85.32	42 inch	758	1.32	0.54	0.00103	8.87	3.36	32.27	-53.04	0.00719	9.88	8.89	-0.99
Total Area/Average C		156.90	0.50																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
Baudelare System	75In1	5.36	0.50	9.05	75In1-75Blch	2.68	25.00	3.35	9.05	24 inch	437	1.72	1.06	0.00150	2.88	2.83	8.76	-0.29	0.00160	5.70	6.00	0.30
Baudelare System	80Blch	16.69	0.50	28.18	80Blch-75Blch	8.34	25.00	3.35	28.18	24 inch	1644	3.53	1.06	0.00150	8.97	2.83	8.76	-19.42	0.01552	30.51	7.00	-23.51
Baudelare System	75Blch	16.65	0.50	28.11	75Blch-LMOut3	19.35	28.05	3.14	61.17	24 inch	181	1.06	0.79	0.00150	19.48	2.83	8.77	-52.4	0.07315	16.02	5.00	-11.02
Total Area/Average C		38.70	0.50																			
Bayou Shore System	48S1/2	2.8	0.50	4.73	48S1/2-49S1/2	1.40	25.00	3.35	4.73	24 inch	574	6.3	5.39	0.00159	1.50	2.91	9.01	4.28	0.00044	9.78	11.00	1.22
Bayou Shore System	56S	4.17	0.50	7.04	56S-56R1/2	2.08	25.00	3.35	7.04	30 inch	333	0.25	-0.08	0.00099	1.43	2.63	12.91	5.87	0.00027	3.59	4.00	0.41
Bayou Shore System	WestW	5.37	0.50	9.07	WestW-53U	2.68	25.00	3.35	9.07	24 inch	495	7.14	6.64	0.00101	4.17	2.32	7.19	-1.88	0.00242	8.92	12.00	3.08
Bayou Shore System	FCB1	6.33	0.50	10.69	FCB1-JFCB1	3.16	25.00	3.35	10.69	36 inch	109	6.85	6.74	0.00101	2.03	2.98	21.19	10.5	0.00037	8.91	13.50	4.59
Bayou Shore System	55S	7.77	0.50	13.12	55S-55R1/2	3.88	25.00	3.35	13.12	30 inch	332	0.86	0.53	0.00099	2.67	2.64	12.93	-0.19	0.00102	4.27	6.50	2.23
Bayou Shore System	52S1/2	8.9	0.50	15.03	52S1/2-51S1/2	4.45	25.00	3.35	15.03	24 inch	382	4.87	4.49	0.00100	4.78	2.30	7.13	-7.89	0.00442	9.21	10.00	0.79
Bayou Shore System	59S	19.62	0.50	33.13	59S-BShrS	4.90	25.00	3.35	16.56	30 inch	678	0.43	-0.25	0.00100	3.37	2.65	12.97	-3.59	0.00164	4.61	3.00	-1.61
Bayou Shore System	48T1/2	9.91	0.50	16.73	48T1/2-49T1/2	4.95	25.00	3.35	16.73	24 inch	566	6.44	5.87	0.00101	5.33	2.32	7.18	-9.55	0.00548	14.10	11.00	-3.10
Bayou Shore System	59R1/2	10.31	0.50	17.41	59R1/2-JBShrR1/2	5.15	25.00	3.35	17.41	24 inch	688	0.46	-0.22	0.00100	5.54	2.31	7.15	-10.25	0.00592	7.25	3.00	-4.25
Bayou Shore System	BShrHeron	10.4	0.50	17.56	BShrHeron-BShrIbis	5.20	25.00	3.35	17.56	36 inch	521	3.14	2.32	0.00157	2.59	3.73	26.46	8.9	0.00063	5.75	8.00	2.25
Bayou Shore System	53S	11.72	0.50	19.79	53S-53R1/2	5.86	25.00	3.35	19.79	30 inch	330	2.06	1.73	0.00100	4.03	2.65	12.97	-6.82	0.00230	5.34	9.50	4.16
Bayou Shore System	Adler	12.22	0.50	20.63	Adler-UNrAdler	6.11	25.00	3.35	20.63	24 inch	169	4.92	4.75	0.00101	7.05	2.31	7.17	-13.46	0.00947	7.98	11.00	3.02
Bayou Shore System	55Q	25.89	0.50	43.71	55Q-BShrQ	12.94	25.00	3.35	43.71	8 X 6	1059	-5.17	-5.7	0.00050	0.91	3.66	175.81	132.1	0.00004	1.87	7.00	5.13
Bayou Shore System	49T1/2	8.59	0.50	14.50	49T1/2-JWOOD	9.25	26.77	3.23	30.08	30 inch	303	5.37	5.07	0.00099	6.13	2.63	12.91	-17.17	0.00538	11.52	11.00	-0.52
Bayou Shore System	BShrIbis	13.19	0.50	22.27	BShrIbis-BShrU	11.79	28.35	3.12	37.04	42 inch	696	1.82	0.72	0.00158	3.85	4.17	40	2.96	0.00135	5.42	6.00	0.58
Bayou Shore System	49S1/2	5.49	0.50	9.27	49S1/2	13.40	31.36	2.95	39.77	36 inch	566	4.39	3.49	0.00159	5.63	3.75	26.6	-13.18	0.00355	9.53	10.00	0.47
Bayou Shore System	FCB2	8.3	0.50	14.01	FCB2-JFCB6	7.32	33.03	2.88	21.23	42 inch	80	5.58	5.5	0.00100	2.31	3.31	31.81	10.59	0.00037	8.74	13.50	4.76
Bayou Shore System	51S1/2	10.73	0.50	18.12	51S1/2-J51S	23.21	33.03	2.88	67.35	42 inch	322	2.99	2.48	0.00158	7.00	4.17	40.04	-27.31	0.00447	7.52	10.00	2.48
Bayou Shore System	51R1/2	5.74	0.50	9.69	51R1/2-J52R1/2	26.08	34.85	2.81	73.76	54 inch	375	0.95	0.34	0.00163	4.65	4.99	79.31	5.54	0.00136	5.38	9.00	3.62
Bayou Shore System	FCB3	4.07	0.50	6.87	FCB3-JFCB9	9.35	36.49	2.74	25.83	48 inch	93	4.62	4.53	0.00097	2.06	3.55	44.68	18.86	0.00022	8.57	14.00	5.43
Bayou Shore System	53R1/2	8.89	0.50	15.01	53R1/2-55R1/2	36.38	37.92	2.68	98.4	66 inch	757	-1.27	-2.47	0.00159	4.14	5.62	133.69	35.29	0.00086	4.58	9.00	4.42
Bayou Shore System	FCB4	21.21	0.50	35.81	FCB4-49U	19.95	39.04	2.64	53.07	54 inch	345	3.81	3.67	0.00041	3.34	2.49	39.61	-13.46	0.00072	8.48	12.50	4.02
Bayou Shore System	49U	7.62	0.50	12.87	49U-51U	23.76	40.76	2.58	61.92	54 inch	572	3.67	3.45	0.00039	3.94	2.43	38.56	-23.35	0.00093	8.23	12.00	3.77
Bayou Shore System	55R1/2	5.86	0.50	9.89	55R1/2-56R1/2	43.20	40.97	2.58	112.37	66 inch	384	-2.47	-3.08	0.00159	4.73	5.62	133.83	21.46	0.00112	3.93	7.50	3.57
Bayou Shore System	51U	7.6	0.50	12.83	51U-52U	27.56	43.18	2.54	70.47	54 inch	366	3.45	3.3	0.00041	4.65	2.50	39.81	-30.66	0.00123	7.70	12.00	4.30
Bayou Shore System	56R1/2	3.84	0.50	6.48	56R1/2-57R1/2	47.20	42.32	2.55	121.5	66 inch	379	-3.08	-3.68	0.00158	5.11	5.61	133.61	12.1	0.00132	3.50	4.00	0.50
Bayou Shore System	52U	6.34	0.50	10.70	52U-53U	30.74	44.50	2.51	77.76	54 inch	384	3.3	3.14	0.00042	5.70	2.52	40.14	-37.63	0.00201	7.25	12.00	4.75
Bayou Shore System	57R1/2	1.88	0.50	3.17	57R1/2-BShrR1/2	48.14	43.56	2.53	122.72	66 inch	147	-3.68	-3.91	0.00157	5.17	5.58	132.82	10.1	0.00136	3.20	3.00	-0.20
Bayou Shore System	53U	4.1	0.50	6.92	53U-UNrAdler	35.47	45.62	2.49	88.94	60 inch	572	2.64	1.75	0.00156	5.36	5.24	102.73	13.79	0.00119	6.48	11.00	4.52
Bayou Shore System	UNrAdler	6.98	0.50	11.79	UNrAdler-BShrU	45.07	47.40	2.45	111.4	60 inch	856	1.74	-0.78	0.00295	6.10	7.22	141.44	30.05	0.00154	5.80	10.00	4.20
Bayou Shore System	BShrU	11.06	0.50	18.67	BShrU-BShrS	62.40	49.74	2.41	151.27	6 X 6	1247	-1.78	-3.75	0.00158	4.20	5.95	214.31	63.04	0.00079	4.48	6.00	1.52
Bayou Shore System	BShrS	37.66	0.50	63.59	BShrS-JBShrR1/2	86.13	54.68	2.28	198.2	6 X 6	301	-3.75	-4.22	0.00158	5.51	5.94	213.97	15.77	0.00133	3.58	3.50	-0.08
Bayou Shore System	BShrR1/2	1.79	0.50	3.02	BShrR1/2-BShrR	140.33	55.94	2.25	318.48	9 X 6	334	-4.41	-4.78	0.00111	5.90	5.63	303.99	-14.5	0.00123	3.07	3.00	-0.07
Bayou Shore System	BShrR	5.7	0.50	9.62	BShrR-BShrQ	143.18	56.88	2.23	321.55	9 X 6	669	-4.78	-5.7	0.00138	5.95	6.27	338.69	17.15	0.00124	2.66	3.00	0.34
Bayou Shore System	BShrQ	11.87	0.50	20.04	BShrQ-BShrP1/2	162.06	58.75	2.18	356.3	6 X 6	429	-5.7	-6.29	0.00138	3.30	16.66	599.88	243.58	0.00047	1.83	3.00	1.17
Bayou Shore System	BShrP1/2	2.8	0.50	4.73	BShrP1/2-Bshor-Out	163.46	60.92	2.13	351.59	6 X 6	266	-6.29	-6.65	0.00135	3.26	16.53	595.09	243.5	0.00049	1.63	4.00	2.37
Bayou Shore System	JFCB8	#N/A	#N/A	#N/A	JFCB8-FCB3	#N/A	#N/A	#N/A	20.55	42 inch	150	5.27	5.12	0.00100	2.15	3.31	31.81	11.27	0.00040	8.63	14.00	5.37
Bayou Shore System	J59S	#N/A	#N/A	#N/A	J59S-J61S	#N/A	#N/A	#N/A	16.56	36 inch	650	-0.43	-0.44	0.00002	2.34	0.37	2.62	-13.95	0.00062	2.94	3.00	0.06
Bayou Shore System	JBShrR1/2	#N/A	#N/A	#N/A	JBShrR1/2-BShrR1/2	#N/A	#N/A	#N/A	207.96	6 X 6	118	-4.22	-4.41	0.00158	5.78	5.95	214.07	6.11	0.00153	3.18	3.50	0.32
Bayou Shore System	JFCB9	#N/A	#N/A	#N/A	JFCB9-FCB4	#N/A	#N/A	#N/A	25.54	48 inch	219	4.53	4.31	0.00101	2.03	3.61	45.53	19.98	0.00032	8.55	13.00	4.45
Bayou Shore System	JFCB2	#N/A	#N/A	#N/A	JFCB2-JFCB3	#N/A	#N/A	#N/A	10.34	36 inch	98	6.66	6.56	0.00102	1.84	3.00	21.3	10.97	0.00020	8.85	14.00	5.15
Bayou Shore System	JFCB3	#N/A	#N/A	#N/A	JFCB3-JFCB4	#N/A	#N/A	#N/A	10.14	36 inch	184	6.56	6.38	0.00098	1.72	2.94	20.86	10.72	0.00027	8.83	14.00	5.17
Bayou Shore System	JFCB4	#N/A	#N/A	#N/A	JFCB4-JFCB5	#N/A	#N/A	#N/A	9.74	36 inch	194	6.38	6.19	0.00098	1.56	2.94	20.87	11.13	0.00015	8.78	14.00	5.22
Bayou Shore System	JWOOD	#N/A	#N/A	#N/A	JWOOD-49S1/2	#N/A	#N/A	#N/A	29.54	36 inch	183	4.57	4.39	0.00098	4.18	2.95	20.92	-8.62	0.00197	9.89	10.50	0.61
Bayou Shore System	JFCB7	#N/A	#N/A	#N/A	JFCB7-JFCB8	#N/A	#N/A	#N/A	20.86	42 inch	140	5.41	5.27	0.00100	2.21	3.31	31.81	10.95	0.00036	8.68	14.00	5.32
Bayou Shore System	JFCB6	#N/A	#N/A	#N/A	JFCB6-JFCB7	#N/A	#N/A	#N/A	21.06	42 inch	91	5.5	5.41	0.00099	2.27	3.30	31.64	10.58	0.00033	8.71	14.00	5.29
Bayou Shore System	JFCB1	#N/A	#N/A	#N/A	JFCB1-JFCB2	#N/A	#N/A	#N/A	10.49	36 inch	78	6.74	6.66	0.00103	1.92	3.01	21.36	10.87	0.00026	8.87	14.00	5.13
Bayou Shore System	J52R1/2	#N/A	#N/A	#N/A	J52R1/2-53R1/2	#N/A	#N/A	#N/A	72.35	60 inch	382	-0.16	-0.77	0.00160	3.68	5.31	104.07	31.72	0.00076	4.87	9.50	4.63
Bayou Shore System	J51S	#N/A	#N/A	#N/A	J51S-51R1/2	#N/A	#N/A	#N/A	66.63	48 inch	335	1.98	1.45	0.00158	5.31	4.53	57.13	-9.5	0.00209	6.08	10.00	3.92
Bayou Shore System	JFCB5	#N/A	#N/A	#N/A	JFCB5-FCB2	#N/A	#N/A	#N/A	9.4	42 inch	107	5.69	5.58	0.00103	1.04	3.36	32.26	22.85	0.00009	8.75	14.00	5.25
Total Area/Average C		336.72	0.50																			
Central City System	GBIn3	6.17	0.50	10.42	GBIn3-GBIn2	3.08	25.00	3.35	10.42	36 inch	359	1.32	0.96	0.00100	1.49	2.97	21.12	10.7	0.00022	4.15	7.50	3.35
Central City System	GBIn5	23.18	0.50	39.14	GBIn5-GBJ4	11.59	25.00	3.35	39.14	48 inch	319	-0.1	-0.41	0.00097	3.11	3.55	44.78	5.64	0.00075	4.18	9.00	4.82
Central City System	GBIn4	26.02	0.50	43.93	GBIn4-GBIn2	13.01	25.00	3.35	43.93	42 inch	964	1.42	0.46	0.00100	4.57	3.31	31.75	-12.18	0.00191	5.91	7.50	1.59
Central City System	GBIn2	13.38	0.50	22.59	GBJ1-GBIn2	22.78	29.01	3.07	70.49	60 inch	535	-1.04	-1.57	0.00099	3.59	4.18	81.97	11.48	0.00073	4.07	7.50	3.43
Central City System	GBIn1	21.62	0.50	36.50	GBIn1-GBOut	45.18	35.16	2.79	127.23	72 inch	406	-3.2	-3.6	0.00099	4.50	4.70	132.92	5.69	0.00091	3.43	8.00	4.57
Central City System	GBJ4	#N/A	#N/A	#N/A	GBJ4-GBJ3	#N/A	#N/A	#N/A	37.74	48 inch	101	-0.41	-0.51	0.00099	3.00	3.59	45.2	7.46	0.00069	3.94	10.00	6.06
Central City System	GBJ3	#N/A	#N/A	#N/A	GBJ3-GBJ2	#N/A	#N/A	#N/A	37.28	48 inch	370	-0.51	-0.88	0.00100	2.97	3.60	45.42	8.14	0.00068	3.87	10.00	6.13
Central City System	GBJ1	#N/A	#N/A	#N/A	GBJ1-GBIn1	#N/A	#N/A	#N/A	67.52	66 inch	625	-2.07	-2.7	0.00101	2.84	4.48	106.61	39.09	0.00040	3.68	8.00	4.32
Central City System	GBJ2	#N/A	#N/A	#N/A	GBJ2-GBIn1	#N/A	#N/A	#N/A	35.58	48 inch	320	-0.88	-1.2	0.00100	2.83	3.60	45.42	9.84	0.00059	3.62	9.00	5.38
Total Area/Average C		90.37	0.50																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
Colony Park System	PopStwrt	16.4	0.50	27.69	PopStwrt-69Stwrt	8.20	25.00	3.35	27.69	18 in.	384	3.5	3.4	0.00025	15.67	0.92	1.66	-26.03	0.06951	31.69	5.50	-26.19
Colony Park System	69Stwrt	17.28	0.50	29.18	69Stwrt-69CD	16.84	25.41	3.32	56.38	24 inch	264	2.9	2.83	0.00025	17.95	1.15	3.58	-52.8	0.06212	22.40	5.00	-17.40
Colony Park System	CDFrwy	15.1	0.50	25.49	CDFrwy-CDGC	24.39	26.33	3.26	80.08	42 inch	301	1.12	0.88	0.00080	8.32	2.96	28.41	-51.67	0.00631	8.64	7.00	-1.64
Colony Park System	CDGC	11.16	0.50	18.84	CDGC-LMNIn1	29.97	26.93	3.22	97.12	48 inch	587	0.38	-0.1	0.00082	7.73	3.26	41.07	-56.05	0.00458	6.74	7.00	0.26
Colony Park System	LMNIn1	7.13	0.50	12.04	LMNIN1-JLM1	33.53	28.19	3.13	105.68	54 inch	289	-0.6	-0.77	0.00059	6.89	3.00	47.69	-57.99	0.00301	4.05	8.00	3.95
Colony Park System	LMNrDby	11.05	0.50	18.66	LMNrDby-JLMPne	39.06	30.12	3.00	117.93	66 inch	277	-2.11	-2.38	0.00098	5.65	4.41	104.84	-13.1	0.00130	2.45	9.00	6.55
Colony Park System	LMBlch	21.3	0.50	35.96	LMBlch-LMOut1	49.71	31.40	2.94	147.52	72 inch	323	-2.95	-3.12	0.00053	6.12	3.43	97.15	-50.37	0.00152	1.99	7.50	5.51
Colony Park System	JLMPne	#N/A	#N/A	#N/A	JLMPne-LMBlch	#N/A	#N/A	#N/A	116.64	72 inch	130	-2.88	-2.95	0.00054	4.67	3.47	98.27	-18.38	0.00077	2.09	6.00	3.91
Colony Park System	CDYuc	#N/A	#N/A	#N/A	CDYuc-CDFrwy	#N/A	#N/A	#N/A	55.67	36 inch	153	1.74	1.62	0.00080	7.88	2.65	18.83	-36.84	0.00699	8.07	6.00	-2.07
Colony Park System	69CD	#N/A	#N/A	#N/A	69CD-CDYuc	#N/A	#N/A	#N/A	56.09	24 inch	373	2.83	2.74	0.00024	17.85	1.13	3.51	-52.57	0.06147	28.93	6.00	-22.93
Colony Park System	JLM1	#N/A	#N/A	#N/A	JLM1-LMNrDby	#N/A	#N/A	#N/A	104.03	60 inch	431	-1.27	-1.61	0.00079	5.86	3.73	73.15	-30.88	0.00169	3.18	7.00	3.82
Total Area/Average C		99.42	0.50																			
East Heards System	61R	2.89	0.50	4.88	61R-61R1/2	1.44	25.00	3.35	4.88	36 inch	337	0.17	-0.17	0.00100	0.77	2.97	21.09	16.21	0.00003	2.56	7.00	4.44
East Heards System	61S1/2	22.18	0.50	37.45	61S1/2-61S	11.09	25.00	3.35	37.45	36 inch	335	-0.16	-0.5	0.00100	5.30	2.97	21.09	-16.36	0.00316	3.59	6.00	2.41
East Heards System	66Hrd1	22.34	0.50	37.72	66Hrd1-JHrd1	11.17	25.00	3.35	37.72	24 inch	207	0.9	0.49	0.00200	12.01	3.26	10.12	-27.6	0.02783	9.76	3.00	-6.76
East Heards System	ByuHmHrd	16.18	0.50	27.32	ByuHmHrd-VictHrd	19.26	25.68	3.30	64.11	36 inch	321	-1.08	-1.09	0.00003	4.53	1.05	7.45	-56.66	0.00231	3.74	4.00	0.26
East Heards System	VictHrd	7.4	0.50	12.49	P-93	22.96	26.86	3.22	74.51	36 inch	382	-1.09	-1.1	0.00003	5.27	0.96	6.82	-67.69	0.00312	4.19	3.00	-1.19
East Heards System	64Hrd	35.27	0.50	59.55	64Hrd-J62Hrd	40.60	28.07	3.13	128.28	36 inch	384	-1.1	-1.11	0.00003	9.13	0.96	6.81	-121.48	0.00930	5.35	3.00	-2.35
East Heards System	61R1/2	2.06	0.50	3.48	61R1/2-J61S	2.47	32.33	2.91	7.25	42 inch	274	-0.67	-0.94	0.00100	0.77	3.31	31.81	24.56	0.00004	2.55	6.50	3.95
East Heards System	61S	5.62	0.50	9.49	P-97	21.28	39.21	2.63	56.45	60 inch	511	-2.5	-3.01	0.00100	2.87	4.20	82.35	25.9	0.00047	2.53	7.00	4.47
East Heards System	62CalvCm	15.57	0.50	26.29	62CalvCm-J62R1/2	29.06	42.17	2.56	74.9	72 inch	309	-4.01	-4.03	0.00006	2.65	1.17	33.21	-41.69	0.00029	2.29	4.50	2.21
East Heards System	62R	2.8	0.50	4.73	62R-62Q	30.46	46.16	2.48	76.06	72 inch	640	-4.05	-4.09	0.00006	2.69	1.15	32.63	-43.42	0.00033	2.10	4.50	2.40
East Heards System	62Q	6.94	0.50	11.72	62Q-J62Hrd	33.93	50.13	2.40	81.98	72 inch	336	-4.09	-4.11	0.00006	2.91	1.15	32.67	-49.31	0.00033	1.89	4.00	2.11
East Heards System	J62Hrd	#N/A	#N/A	#N/A	J62Hrd-62Out	#N/A	#N/A	#N/A	176.44	72 inch	163	-4.11	-4.12	0.00006	6.34	1.17	33.17	-143.27	0.00172	1.78	3.50	1.72
East Heards System	JHrd1	#N/A	#N/A	#N/A	JHrd1-ByuHmHrd	#N/A	#N/A	#N/A	37.49	24 inch	284	0.49	-0.08	0.00201	11.93	3.27	10.13	-27.36	0.02746	11.54	4.00	-7.54
East Heards System	J62R1/2	#N/A	#N/A	#N/A	J62R1/2-62R	#N/A	#N/A	#N/A	73.76	72 inch	321	-4.03	-4.05	0.00006	2.61	1.15	32.58	-41.18	0.00031	2.20	4.50	2.30
East Heards System	J61S	#N/A	#N/A	#N/A	J61S-61S	#N/A	#N/A	#N/A	19.86	60 inch	57	-2.44	-2.5	0.00100	1.01	4.20	82.35	62.5	0.00018	2.54	7.00	4.46
Total Area/Average C		139.25	0.50																			
East Jones System	72JD	7.42	0.50	12.53	72JD-73JD	3.71	25.00	3.35	12.53	24 inch	383	-0.17	-0.5	0.00085	3.99	2.13	6.6	-5.93	0.00305	5.67	5.00	-0.67
East Jones System	74Q	15.16	0.50	25.60	74Q-J73Q	7.58	25.00	3.35	25.6	30 inch	196	0	-0.17	0.00088	5.21	2.48	12.15	-13.45	0.00388	4.26	3.00	-1.26
East Jones System	73R	8.42	0.50	14.22	73R-73JD	11.79	27.68	3.16	37.58	30 inch	338	-0.71	-1	0.00085	7.66	2.44	11.95	-25.63	0.00840	7.34	3.00	-4.34
East Jones System	73JD	8.55	0.50	14.44	73JD-JDGrl	19.77	28.42	3.11	62.01	30 inch	666	-1	-1.56	0.00085	12.63	2.44	11.96	-50.05	0.02285	22.22	4.50	-17.72
East Jones System	JDGrl	20.53	0.50	34.66	JDGrl-J_JDOut	30.04	29.29	3.05	92.34	30 inch	379	-1.56	-1.89	0.00085	18.81	2.44	11.96	-80.38	0.05069	27.40	7.00	-20.40
East Jones System	J73Q	#N/A	#N/A	#N/A	J73Q-73R	#N/A	#N/A	#N/A	25.26	30 inch	634	-0.17	-0.71	0.00085	5.15	2.44	11.96	-13.3	0.00379	5.40	3.50	-1.90
East Jones System	J_JDOut	#N/A	#N/A	#N/A	J_JDOut-JDOut1	#N/A	#N/A	#N/A	91.63	30 inch	134	-1.89	-2	0.00085	18.67	2.44	11.96	-79.66	0.04993	8.19	10.00	1.81
Total Area/Average C		60.08	0.50																			
East Stewart System	ColStwrt	11.78	0.50	19.89	ColStwrt-StwrtIn2	5.89	25.00	3.35	19.89	21 Inch	626	5.24	4.62	0.00100	8.27	2.09	5.01	-14.88	0.01575	16.86	7.50	-9.36
East Stewart System	StwrtIn2	10.81	0.50	18.25	StwrtIn2-JSoStwrt	11.29	26.26	3.26	37.14	21 Inch	211	4.62	4.4	0.00100	15.44	2.09	5.01	-32.13	0.05493	18.59	7.00	-11.59
East Stewart System	SoStwrt	11.19	0.50	18.89	SoStwrt-JStwrt2	16.89	26.70	3.23	55.01	24 inch	312	4.01	3.7	0.00100	17.51	2.31	7.15	-47.86	0.05913	25.45	7.00	-18.45
East Stewart System	IStwrtPn	39	0.70	92.19	IStwrtPn-JStwrtPn	44.19	28.00	3.14	139.86	36 inch	423	2.23	1.8	0.00100	19.79	2.97	21.09	-118.76	0.04397	25.60	7.00	-18.60
East Stewart System	JStwrt2	#N/A	#N/A	#N/A	JStwrt2-IStwrtPn	#N/A	#N/A	#N/A	54.66	36 inch	468	2.7	2.23	0.00100	7.73	2.97	21.09	-33.57	0.00671	10.14	7.00	-3.14
East Stewart System	JStwrtPn	#N/A	#N/A	#N/A	JStwrtPn-StwrtOut2	#N/A	#N/A	#N/A	138.74	42 inch	235	1.3	1.07	0.00100	14.53	3.31	31.81	-106.93	0.01940	8.98	7.00	-1.98
East Stewart System	JSoStwrt	#N/A	#N/A	#N/A	JSoStwrt-SoStwrt	#N/A	#N/A	#N/A	36.95	24 inch	147	4.16	4.01	0.00100	11.76	2.31	7.15	-29.8	0.02667	10.92	7.00	-3.92
Total Area/Average C		72.78	0.55																			
Ferry Road System	Ferry_Barracuda	22.03	0.50	37.20	Ferry_Barracuda - Ferry_Dolphin	11.01	25.00	3.35	37.2	30 inch	237	3.69	3.38	0.00131	7.58	3.03	14.83	-22.36	0.00823	10.95	9.00	-1.95
Ferry Road System	Ferry-Bonita	18.72	0.50	31.61	Ferry_Bonita - Ferry_Tarpon	20.38	26.41	3.25	66.78	48 inch	774	2.42	1.77	0.00084	5.31	3.30	41.62	-25.16	0.00217	9.87	8.35	-1.52
Ferry Road System	Ferry_Whiting	30.6	0.50	51.67	Ferry_Whiting- Ferry_next	35.67	30.52	2.98	107.13	54 inch	1010	0.54	-0.47	0.00100	6.74	3.91	62.18	-44.95	0.00297	10.00	7.20	-2.80
Ferry Road System	Ferry_next	27.76	0.50	46.87	Ferry_next - I8	49.55	33.02	2.88	143.82	54 inch	459	-0.47	-0.93	0.00100	9.04	3.91	62.18	-81.63	0.00536	10.34	7.00	-3.34
Ferry Road System	I-9	44.5	0.50	75.13	I9 - Ferry_out	71.80	34.40	2.82	204.41	54 inch	575	-1.21	-1.79	0.00100	13.19	3.91	62.18	-142.23	0.01125	8.75	7.20	-1.55
Ferry Road System	Ferry_Pompano	#N/A	#N/A	#N/A	Ferry_Tarpon - Ferry_Avalon	#N/A	#N/A	#N/A	63.29	48 inch	511	1.41	0.92	0.00096	5.04	3.53	44.48	-18.81	0.00194	8.19	8.20	0.01
Ferry Road System	Ferry_Dolphin	#N/A	#N/A	#N/A	Ferry_Dolphin - Ferry_Bonita	#N/A	#N/A	#N/A	36.79	36 inch	276	3.16	2.72	0.00159	5.20	3.75	26.63	-10.16	0.00304	9.19	9.00	-0.19
Ferry Road System	I-8	#N/A	#N/A	#N/A	I8-I9	#N/A	#N/A	#N/A	142.13	54 inch	283	-0.93	-1.21	0.00100	8.94	3.91	62.18	-79.94	0.00523	8.68	7.88	-0.80
Total Area/Average C		143.61	0.50																			
West Heards System	66Hrd2	19.48	0.50	32.89	66Hrd2-JHrd2	9.74	25.00	3.35	32.89	30 inch	296	0	-0.01	0.00003	6.70	0.49	2.38	-30.51	0.00642	5.90	3.00	-2.90
West Heards System	70Hrd	31.94	0.50	53.93	70Hrd-JHrdOut	15.97	25.00	3.35	53.93	36 inch	265	-0.52	-0.53	0.00004	7.63	0.58	4.1	-49.83	0.00653	4.51	4.00	-0.51
West Heards System	68Hrd	21.21	0.50	35.81	68Hrd-JHrdOut	20.34	27.17	3.20	65.58	36 inch	383	-0.52	-0.53	0.00003	9.28	0.48	3.41	-62.17	0.00966	6.48	3.50	-2.98
West Heards System	JHrd2	#N/A	#N/A	#N/A	JHrd2-68Hrd	#N/A	#N/A	#N/A	32.38	36 inch	395	-0.51	-0.52	0.00003	4.58	0.47	3.36	-29.03	0.00235	4.43	4.00	-0.43
West Heards System	JHrdOut	#N/A	#N/A	#N/A	JHrdOut-HrdOut	#N/A	#N/A	#N/A	115.3	36 inch	77	-0.53	-0.54	0.00013	8.73	2.14	15.2	-100.1	0.01117	2.78	4.00	1.22
Total Area/Average C		72.63	0.50																			
West Jones System	JDIn2	3.66	0.50	6.18	JDIn2-JDIn1	1.83	25.00	3.35	6.18	24 inch	480	0.18	-0.06	0.00050	2.08	1.63	5.06	-1.12	0.00067	2.01	4.00	1.99
West Jones System	JDIn3	3.73	0.50	6.30	JDIn3-J_JD2	1.86	25.00	3.35	6.3	24 inch	187	0.22	0.13	0.00050	2.10	1.63	5.06	-1.24	0.00070	2.06	4.00	1.94
West Jones System	JDIn1	10.17	0.50	17.17	JDIn1-JDOut2	8.78	29.51	3.03	26.85	48 inch	614	-2.06	-2.07	0.00002	2.23	0.46	5.8	-21.06	0.00031	1.69	3.00	1.31
West Jones System	J_JD2	#N/A	#N/A	#N/A	J_JD2-J_JD1	#N/A	#N/A	#N/A	6.1	24 inch	315	0.13	-0.03	0.00050	2.06	1.63	5.06	-1.04	0.00063	1.93	3.00	1.07
West Jones System	J_JD1	#N/A	#N/A	#N/A	J_JD1-JDIn1	#N/A	#N/A	#N/A	5.77	24 inch	57	-0.03	-0.06	0.00050	1.97	1.63	5.06	-0.71	0.00070	1.73	4.00	2.27
Total Area/Average C		17.56	0.50																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
West K System	46M	5.06	0.50	8.54	46M-45(1/2)L	2.53	25.00	3.35	8.54	1.5' X 2.25'	168	4.6	4.5	0.00060	2.53	1.63	5.53	-3.02	0.00143	7.24	7.00	-0.24
West K System	54M	5.73	0.50	9.67	54M-54K	2.86	25.00	3.35	9.67	3 X 3	649	2.35	1.73	0.00096	1.07	2.92	26.25	16.57	0.00012	6.47	6.21	-0.26
West K System	53O	6.13	0.50	10.35	53O-53N(1/2)	3.06	25.00	3.35	10.35	4' X 2.5'	329	3.42	3.26	0.00049	1.03	2.12	21.16	10.81	0.00012	7.86	7.92	0.06
West K System	47(1/2)L1	7.1	0.50	11.99	47(1/2)L1 - 47(1/2)L2	3.55	25.00	3.35	11.99	24 inch	71	4.3	4.2	0.00141	3.82	3.56	11.04	-0.95	0.00169	7.12	7.00	-0.12
West K System	55M(1/2)	7.52	0.50	12.70	55M(1/2)-55K	3.76	25.00	3.35	12.7	3 X 3	988	2.51	1.52	0.00100	1.41	2.99	26.88	14.18	0.00022	6.91	6.20	-0.71
West K System	50_(1/2)M(1/2)	9.1	0.50	15.36	50_(1/2)M(1/2) - 50K	4.55	25.00	3.35	15.36	24 inch	830	4.39	3.56	0.00100	4.89	2.31	7.15	-8.21	0.00461	10.13	6.90	-3.23
West K System	56M	9.25	0.50	15.62	56M-56K	4.62	25.00	3.35	15.62	3 X 3	666	1.98	1.31	0.00101	1.74	2.99	26.93	11.32	0.00035	6.59	6.52	-0.07
West K System	57J	7.13	0.70	16.85	57J-57K	4.99	25.00	3.35	16.85	3 X 3	444	1.48	1.04	0.00099	1.87	2.97	26.73	9.88	0.00038	6.76	7.50	0.74
West K System	45M	11.96	0.50	20.19	45M-45L	5.98	25.00	3.35	20.19	1.5' X 2.25'	572	4.5	4.4	0.00018	5.98	0.88	3	-17.2	0.00795	11.55	7.04	-4.51
West K System	55J	8.68	0.70	20.52	55J-55K	6.08	25.00	3.35	20.52	3 X 3	445	1.97	1.52	0.00101	2.28	3.00	27	6.49	0.00058	6.95	6.69	-0.26
West K System	45N(1/2)	12.54	0.50	21.17	45N(1/2)-46N(1/2)	6.27	25.00	3.35	21.17	2 X 2.5	358	4.77	4.59	0.00050	4.23	1.73	8.66	-12.51	0.00302	8.87	7.88	-0.99
West K System	48Wharton	13.45	0.50	22.71	48Wharton-48L	6.72	25.00	3.35	22.71	24 inch	465	4.2	4.1	0.00022	7.23	1.39	4.31	-18.4	0.00596	9.77	7.23	-2.54
West K System	56J	11.49	0.70	27.16	56J-56K	8.04	25.00	3.35	27.16	3 X 3	297	1.61	1.31	0.00101	3.02	3.00	26.99	-0.17	0.00101	6.66	5.73	-0.93
West K System	50K1	0	0.00	0.00	J50K - Ditch	8.55	25.00	3.35	28.87	36 inch	419	2.56	2.14	0.00100	4.08	2.97	21.12	-7.75	0.00186	5.92	6.30	0.38
West K System	54J	12.28	0.70	29.03	54J-54K	8.60	25.00	3.35	29.03	3 X 3	445	2.18	1.73	0.00101	3.23	3.00	27	-2.02	0.00117	6.91	6.48	-0.43
West K System	48L	2	0.50	3.38	48L-48K	11.27	26.09	3.27	37.2	30 inch	332	3.6	3.5	0.00030	7.58	1.45	7.12	-30.09	0.00822	9.23	7.00	-2.23
West K System	45(1/2)L(1/2)	2.59	0.50	4.37	45(1/2)L(1/2)-45(1/2)L	3.82	26.11	3.27	12.62	1.5' X 2.25'	109	4.6	4.5	0.00092	3.74	2.02	6.86	-5.76	0.00312	7.34	7.00	-0.34
West K System	46N(1/2)	8.34	0.50	14.08	46N(1/2)-47N(1/2)	10.44	26.41	3.25	34.22	2 X 2.5	403	4.59	4.39	0.00050	6.84	1.72	8.6	-25.61	0.00784	11.55	7.79	-3.76
West K System	45L	4	0.50	6.75	45L-45K	11.80	27.39	3.18	37.87	1.5' X 2.25'	324	4.4	4.38	0.00006	11.22	0.52	1.78	-36.09	0.02793	16.22	7.00	-9.22
West K System	47N(1/2)	8.4	0.50	14.18	47N(1/2)-48N(1/2)	14.64	27.39	3.18	46.97	2 X 2.5	365	4.39	4.21	0.00049	9.39	1.72	8.58	-38.39	0.01479	13.50	8.39	-5.11
West K System	45K	7.54	0.50	12.73	45K-48K	52.46	27.88	3.15	166.5	6 X 2	1123	4.63	4	0.00056	13.87	2.24	26.82	-139.68	0.02162	30.78	7.17	-23.61
West K System	48N(1/2)	9.13	0.50	15.42	48N(1/2)-49N(1/2)	19.20	28.04	3.14	60.73	2 X 2.5	371	4.21	4.02	0.00051	12.15	1.75	8.74	-51.99	0.02472	17.62	8.10	-9.52
West K System	49N(1/2)	8.48	0.50	14.32	49N(1/2)-50N(1/2)	23.44	28.55	3.10	73.3	2 X 2.5	389	4.02	3.83	0.00049	14.66	1.71	8.54	-64.77	0.03602	21.91	8.45	-13.46
West K System	50N(1/2)	8.59	0.50	14.50	50N(1/2)-51N(1/2)	27.74	28.99	3.07	85.86	2 X 2.5	411	3.83	3.62	0.00051	17.17	1.75	8.73	-77.13	0.04944	27.88	7.90	-19.98
West K System	48K	9.7	0.50	16.38	48K-50K	68.58	29.22	3.05	211.15	8 X 3	784	3	2.56	0.00056	8.80	2.87	68.87	-142.28	0.00528	10.44	6.50	-3.94
West K System	51N(1/2)	8.66	0.50	14.62	51N(1/2)-52N(1/2)	32.07	29.39	3.04	98.36	2 X 2.5	344	3.62	3.45	0.00049	19.67	1.72	8.59	-89.78	0.06488	30.14	7.56	-22.58
West K System	52N(1/2)	8.95	0.50	15.11	52N(1/2)-53N(1/2)	36.54	29.68	3.02	111.34	2 X 2.5	382	3.45	3.26	0.00050	22.27	1.72	8.61	-102.72	0.08312	39.57	7.82	-31.75
West K System	53N(1/2)	2.75	0.50	4.64	53N(1/2)-53N	40.98	30.30	2.99	123.45	4' X 2.5'	308	3.26	3.11	0.00049	12.34	2.12	21.18	-102.27	0.01656	12.84	7.82	-5.02
West K System	50K	24.7	0.50	41.70	50K-51K	76.93	30.71	2.97	230.45	8 X 3	362	2.56	2.36	0.00055	9.60	2.85	68.33	-162.12	0.00630	9.28	6.30	-2.98
West K System	53N	2.73	0.50	4.61	53N-53M(1/2)	42.35	30.71	2.97	126.85	4' X 2.5'	376	3.11	2.92	0.00051	12.68	2.16	21.57	-105.28	0.01747	13.84	7.74	-6.10
West K System	53M(1/2)	3.15	0.50	5.32	53M(1/2)-53M	43.92	31.21	2.95	130.69	4' X 2.5'	318	2.92	2.76	0.00050	13.07	2.15	21.52	-109.17	0.01855	12.97	7.27	-5.70
West K System	51K	32.71	0.50	55.23	51K-53K	93.29	31.34	2.95	277.08	8 X 3	758	2.36	1.94	0.00055	11.55	2.85	68.43	-208.65	0.00909	13.82	7.00	-6.82
West K System	53M	2.97	0.50	5.01	53M-53L	45.41	31.61	2.94	134.37	4' X 2.5'	323	2.76	2.6	0.00050	13.44	2.14	21.36	-113.01	0.01960	13.39	7.07	-6.32
West K System	53L	2.95	0.50	4.98	53L-53K	46.88	32.01	2.92	137.97	4' X 2.5'	327	2.6	2.44	0.00049	13.80	2.12	21.23	-116.75	0.02067	13.69	7.06	-6.63
West K System	53K	4.72	0.50	7.97	53K-54K	142.53	32.43	2.90	417.05	9 X 4	383	0.94	0.73	0.00055	11.59	3.33	119.7	-297.35	0.00666	8.94	6.93	-2.01
West K System	54K	6.4	0.50	10.81	54K-55K	157.20	35.06	2.80	443.27	9 X 4	381	0.73	0.52	0.00055	12.31	3.33	120.01	-323.26	0.00751	9.55	6.39	-3.16
West K System	55K	7.02	0.50	11.85	55K-56K	170.54	36.67	2.73	469.84	9 X 4	383	0.52	0.31	0.00055	13.05	3.33	119.7	-350.14	0.00846	9.60	6.69	-2.91
West K System	56K	5.6	0.50	9.46	56K-57K	186.01	37.16	2.71	508.78	9 X 4	380	0.31	0.04	0.00071	14.13	3.79	136.26	-372.52	0.00989	10.35	6.36	-3.99
West K System	57K	18.48	0.50	31.20	57K-KOut	200.24	37.61	2.70	544.09	9 X 4	1129	0.04	-1.03	0.00095	15.11	4.37	157.37	-386.72	0.01133	15.76	6.59	-9.17
West K System	45(1/2)L	#N/A	#N/A	#N/A	45(1/2)-45L	#N/A	#N/A	#N/A	12.49	1.5' X 2.25'	178	4.5	4.4	0.00056	3.70	1.58	5.37	-7.12	0.00303	7.54	7.00	-0.54
West K System	47(1/2)L2	#N/A	#N/A	#N/A	47(1/2)L2-48L	#N/A	#N/A	#N/A	11.91	24 inch	178	4.2	4.1	0.00056	3.79	1.73	5.36	-6.55	0.00275	7.49	7.00	-0.49
Total Area/Average C		327.98	0.51																			
West P System	40P	6.07	0.50	10.25	40P-41P	3.03	25.00	3.35	10.25	6 X 2	383	5.93	5.74	0.00050	0.85	2.10	25.22	14.97	0.00008	8.53	8.50	-0.03
West P System	45R1/2	6.52	0.50	11.01	46R1/2-45R1/2	3.26	25.00	3.35	11.01	18 inch	375	7.01	6.63	0.00101	6.23	1.86	3.34	-7.66	0.01099	14.12	10.00	-4.12
West P System	56O	9.31	0.50	15.72	56O-56O1/2	4.65	25.00	3.35	15.72	24 inch	332	2.9	2.61	0.00087	5.00	2.16	6.69	-9.03	0.00482	6.60	5.00	-1.60
West P System	45Q1/2	10.98	0.50	18.54	45Q1/2-46Q1/2	5.49	25.00	3.35	18.54	18 inch	375	6.86	6.48	0.00101	10.49	1.86	3.34	-15.19	0.03115	21.68	10.00	-11.68
West P System	47T	14.6	0.50	24.65	47T-47S1/2	7.30	25.00	3.35	24.65	2 X 2.5	331	6.75	6.42	0.00100	4.93	2.44	12.2	-12.46	0.00408	11.35	11.00	-0.35
West P System	40S1/2	19.7	0.50	33.26	40S1/2-42S1/2	9.85	25.00	3.35	33.26	2.5 X 2.5	768	8.02	7.56	0.00060	5.32	2.06	12.78	-20.48	0.00406	14.12	11.00	-3.12
West P System	46Q1/2	3.25	0.50	5.49	46Q1/2-47Q1/2	7.11	25.60	3.31	23.73	24 inch	383	5.98	5.6	0.00099	7.55	2.30	7.13	-16.6	0.01099	13.21	10.00	-3.21
West P System	46R1/2	5.71	0.50	9.64	46R1/2	6.12	26.00	3.28	20.22	24 inch	382	6.63	6.25	0.00100	6.44	2.30	7.13	-13.08	0.00798	13.05	10.00	-3.05
West P System	56O1/2	8.78	0.50	14.82	56O1/2-J56P	9.04	26.11	3.27	29.84	24 inch	325	2.61	2.33	0.00086	9.50	2.14	6.64	-23.2	0.01738	11.15	5.00	-6.15
West P System	42S1/2	11.43	0.50	19.30	42S1/2-43S1/2	15.56	27.41	3.18	49.92	2.5 X 2.5	370	7.56	7.34	0.00060	7.99	2.05	12.73	-37.18	0.00914	14.38	11.00	-3.38
West P System	43S1/2	23.43	0.50	39.56	43S1/2-46S1/2	27.28	28.18	3.13	86	2.5 X 2.5	1144	7.34	6.65	0.00060	13.76	2.07	12.83	-73.18	0.02712	41.03	11.00	-30.03
West P System	46S1/2	20.71	0.50	34.97	46S1/2-47S1/2	37.64	29.56	3.03	114.97	2.5 X 2.5	385	6.65	6.42	0.00060	18.40	2.06	12.76	-102.21	0.04847	28.66	10.00	-18.66
West P System	47S1/2	3.41	0.50	5.76	47S1/2-47R1/2	46.64	29.91	3.01	141.33	4' X 2.5'	651	6.42	5.75	0.00103	14.13	3.08	30.78	-110.55	0.02169	24.12	10.00	-14.12
West P System	47R1/2	5.55	0.50	9.37	47R1/2-47R	55.53	30.68	2.97	166.4	4' X 2.5'	335	5.75	5.43	0.00096	16.64	2.97	29.66	-136.74	0.03006	20.07	10.00	-10.07
West P System	47R	6.02	0.50	10.16	47R-47Q1/2	58.54	31.01	2.96	174.63	4' X 2.5'	333	5.43	5.1	0.00099	17.46	3.02	30.21	-144.42	0.03312	20.03	10.00	-10.03
West P System	47Q1/2	2.74	0.50	4.63	47Q1/2-47Q	67.02	31.33	2.95	199.08	4' X 2.5'	336	5.1	4.76	0.00101	19.91	3.05	30.53	-168.56	0.04304	23.46	9.00	-14.46
West P System	47Q	2.79	0.50	4.71	47Q-47P1/2	68.42	31.61	2.94	202.45	4' X 2.5'	325	4.76	4.43	0.00102	20.25	3.06	30.58	-171.87	0.04452	23.47	9.00	-14.47
West P System	47P1/2	2.77	0.50	4.68	47P1/2-47P	69.80	31.88	2.92	205.79	4' X 2.5'	327	4.43	4.1	0.00101	20.58	3.05	30.48	-175.31	0.04599	23.04	9.00	-14.04
West P System	41P	45.68	0.50	77.13	41P-43P	25.88	32.47	2.90	75.66	6 X 2	750	5.74	5.36	0.00051	6.31	2.12	25.49	-50.18	0.00447	11.85	8.50	-3.35
West P System	43P	23.21	0.50	39.19	43P-45P	37.48	34.46	2.82	106.6	6 X 2	770	5.36	4.98	0.00049	8.88	2.10	25.15	-81.45	0.00887	14.83	8.50	-6.33
West P System	45P	28.73	0.50	48.51	45P-47P	51.84	35.90	2.76	144.44	6 X 2	752	4.98	4.6	0.00051	12.04	2.12	25.45	-118.99	0.01628	20.24	8.00	-12.24
West P System	47P	2.76	0.50	4.66	47P-48P	123.03	36.94	2.72	337.6	8 X 3	384	3.6	3.41	0.00050	14.07	2.69	64.66	-272.94	0.01349	13.18	8.00	-5.18
West P System	48P	21.16	0.50	35.73	48P-49P	133.61	37.40	2.70	364.19	8 X 3	379	3.41	3.22	0.00050	15.18	2.71	65.09	-299.1	0.01570	14.45	8.00	-6.45
West P System	49P	19.64	0.50	33.16	49P-50P	143.43	37.81	2.69	388.55	8 X 3	379	3.22	3.03	0.00050	16.19	2.71	65.09	-323.46	0.01786	15.77	8.50	-7.27
West P System	50P	19.89	0.50	33.58	50P-51P	153.37	38.20	2.67	413.08	8 X 3	384	3.03	2.84	0.00050	17.22	2.69	64.66	-348.41	0.02021	16.26	9.00	-7.26
West P System	51P	14.32	0.50	24.18	51P-52P	160.53	38.58	2.66	429.95	8 X 3	389	2.84	2.65	0.00049	17.92	2.68	64.25	-365.71	0.02190	16.52	8.50	-8.02
West P System	52P	14.78	0.50	24.95	53P-52P	167.92	38.94	2.64	447.3	8 X 3	363	2.65	2.47	0.00050	18.65	2.70	64.73	-382.56	0.02369	16.60	8.00	-8.60
West P System	53P	14.66	0.50	24.75	53P-55P	175.25	39.26	2.63	464.53	9 X 4	771	1.47	0.7	0.00100	12.91	4.49	161.54	-302.98	0.00826	12.37	8.00	-4.37
West P System	55P	17.13	0.50	28.92	55P-J56P	183.82	40.26	2.59	480.8	9 X 4	371	0.7	0.33	0.00100	13.36	4.48	161.43	-319.37	0.00887	8.79	6.00	-2.79
West P System	57P	8.29	0.50	14.00	57P-O-WestP	197.01	41.16	2.58	511.7	9 X 4	595	-0.04	-0.64	0.00101	14.22	4.51	162.33	-349.37	0.01003	9.33	5.00	-4.33
West P System	J56P	#N/A	#N/A	#N/A	J56P-57P	#N/A	#N/A	#N/A	502.66	9 X 4	373	0.33	-0.04	0.00099	13.97	4.47	161	-341.67	0.00968	8.61	5.50	-3.11
Total Area/Average C		394.02	0.50																			

City of Galveston Master Drainage Plan
Existing System Model Output

TABLE 1

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
West Stewart System	87Stwrt	8.58	0.50	14.49	87Stwrt-JStwrt1	4.29	25.00	3.35	14.49	24 inch	369	5.11	4.74	0.00100	5.35	2.31	7.15	-7.33	0.00472	7.90	8.00	0.10
West Stewart System	78Stwrt	19.94	0.50	33.67	78Stwrt-StwrtIn1	14.26	29.92	3.01	43.21	42 inch	463	2.74	2.28	0.00099	4.96	3.30	31.68	-11.53	0.00192	5.96	8.00	2.04
West Stewart System	StwrtIn1	7.89	0.50	13.32	StwrtIn1-J75Stwrt	18.20	31.47	2.94	53.97	48 inch	291	1.78	1.49	0.00100	5.02	3.60	45.42	-8.55	0.00162	5.07	8.00	2.93
West Stewart System	JStwrt1	#N/A	#N/A	#N/A	JStwrt1-78Stwrt	#N/A	#N/A	#N/A	14.14	36 inch	499	3.74	3.24	0.00100	2.21	2.97	21.09	6.95	0.00040	6.16	7.50	1.34
West Stewart System	J75Stwrt	#N/A	#N/A	#N/A	J75Stwrt-StwrtOut1	#N/A	#N/A	#N/A	53.26	48 inch	423	1.49	1.07	0.00100	6.32	3.60	45.42	-7.84	0.00317	4.60	8.00	3.40
Total Area/Average C		36.41	0.50																			
West T1/2 System	61T	4.76	0.50	8.04	61T-J61T1/2_1	2.38	25.00	3.35	8.04	36 inch	343	0.92	0.58	0.00100	1.14	2.97	21.09	13.05	0.00015	5.21	6.00	0.79
West T1/2 System	59SW	9.63	0.50	16.26	59SW-59Weber	4.81	25.00	3.35	16.26	30 inch	805	1.73	0.93	0.00099	3.31	2.64	12.93	-3.33	0.00158	6.77	9.00	2.23
West T1/2 System	61U	10.13	0.50	17.10	61U-J61T1/2	5.06	25.00	3.35	17.1	42 inch	253	0.33	0.08	0.00100	1.78	3.31	31.81	14.71	0.00028	5.76	6.50	0.74
West T1/2 System	59T1/2	33.5	0.50	56.56	59T1/2-J61T1/2	21.56	38.19	2.67	58.1	36 inch	655	-0.72	-1.38	0.00101	8.22	2.98	21.17	-36.92	0.00759	10.66	5.00	-5.66
West T1/2 System	ICalvCm1	4.76	0.50	8.04	ICalvCm1-JCalvCm1	31.39	40.79	2.58	81.76	54 inch	294	-3.37	-3.66	0.00099	5.14	3.88	61.76	-20.01	0.00173	3.92	6.50	2.58
West T1/2 System	JCalvCm1	#N/A	#N/A	#N/A	JCalvCm1-T1/2Out	#N/A	#N/A	#N/A	81.16	60 inch	358	-4.16	-4.52	0.00101	4.14	4.21	82.58	1.42	0.00098	3.41	7.00	3.59
West T1/2 System	59Weber	#N/A	#N/A	#N/A	59Weber-59T1/2	#N/A	#N/A	#N/A	14.88	36 inch	1154	0.43	-0.72	0.00100	2.11	2.96	21.05	6.17	0.00049	5.57	5.50	-0.07
West T1/2 System	J61T1/2	#N/A	#N/A	#N/A	j61T1/2-J61T1/2_1	#N/A	#N/A	#N/A	70.31	36 inch	47	-1.38	-1.43	0.00106	9.95	3.06	21.75	-48.56	0.01128	5.69	6.00	0.31
West T1/2 System	J61T1/2_1	#N/A	#N/A	#N/A	J61T1/2_1-ICalvCm1	#N/A	#N/A	#N/A	76.51	48 inch	439	-2.43	-2.87	0.00100	6.09	3.61	45.47	-31.03	0.00282	5.16	6.00	0.84
Total Area/Average C		62.78	0.50																			

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

CITY OF GALVESTON - MASTER DRAINAGE PLAN
EXISTING CONDITIONS RESULTS SUMMARY - From StormCAD

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
11th-13th Street System	11D1	1.6	0.50	2.65	11D1-11C1	0.80	25.86	3.29	2.65	1	36 inch	323	0.73	0.44	0.00090	0.48	2.81	19.98	17.33	0.00000	2.79	6.00	3.21
11th-13th Street System	9F	2.77	0.50	4.48	9F-10F	1.38	26.97	3.21	4.48	1	24 inch	366	2.87	2.32	0.00150	1.53	2.83	8.77	4.28	0.00036	4.51	6.80	2.29
11th-13th Street System	10D	2.1	0.70	4.82	10D-10B	1.47	26.40	3.25	4.82	1	2.5 X 2.5	647	1.91	1.59	0.00050	0.91	1.87	11.61	6.79	0.00008	3.91	8.40	4.49
11th-13th Street System	9I	4.2	0.50	6.67	9I-9G	2.10	27.88	3.15	6.67	1	24 inch	664	3.71	3.05	0.00100	3.54	2.31	7.15	0.49	0.00173	5.18	7.05	1.87
11th-13th Street System	13B1	3.14	0.70	7.08	13B1-14B	2.20	27.23	3.19	7.08	1	4 X 3	347	0.61	0.56	0.00014	0.78	1.24	14.86	7.78	0.00003	2.86	5.50	2.64
11th-13th Street System	11C1	2.04	0.70	4.69	11C1-11B1	2.23	37.08	2.72	6.1	1	36 inch	342	0.44	0.13	0.00091	0.98	2.83	20.08	13.98	0.00009	2.79	6.50	3.71
11th-13th Street System	12I	4.55	0.50	7.19	12I-11I	2.28	28.06	3.14	7.19	1	24 inch	365	4	3.8	0.00055	2.29	1.71	5.3	-1.9	0.00101	7.09	11.67	4.58
11th-13th Street System	10I	5.2	0.50	8.16	10I-11I	2.60	28.37	3.11	8.16	1	24 inch	397	3.6	3.28	0.00081	2.60	2.07	6.42	-1.74	0.00131	7.24	6.68	-0.56
11th-13th Street System	10F	4.81	0.50	7.58	10F-11F	3.79	30.96	2.96	11.31	1	24 inch	372	2.32	1.76	0.00151	3.75	2.83	8.78	-2.54	0.00237	4.38	11.97	7.59
11th-13th Street System	13B2	5.44	0.70	11.93	13B2-11B1	3.81	28.47	3.11	11.93	1	4 X 3	710	0.61	0.13	0.00068	1.24	2.68	32.18	20.25	0.00010	2.83	5.50	2.67
11th-13th Street System	9D	5.5	0.70	12.05	9D-9B	3.85	28.50	3.10	12.05	1	2.5 X 2.5	654	2.1	1.77	0.00051	2.13	1.89	11.73	-0.32	0.00055	4.38	6.00	1.62
11th-13th Street System	8G	6.8	0.50	10.52	8G-9G	4.29	34.81	2.81	12.14	1	30 inch	353	3.08	2.55	0.00150	3.83	3.24	15.88	3.73	0.00184	4.68	6.45	1.77
11th-13th Street System	9B	2.11	0.70	4.84	9B-10B	5.33	33.63	2.85	15.33	1	Box 2.5 X 4.5	359	1.27	1.09	0.00050	2.22	2.22	24.89	9.56	0.00045	4.02	9.00	4.98
11th-13th Street System	7G	12.13	0.50	18.21	7G-8G	6.06	30.52	2.98	18.21	1	36 inch	387	2.25	1.86	0.00100	2.69	2.97	21.09	2.88	0.00065	4.93	7.00	2.07
11th-13th Street System	8D	9.77	0.70	20.71	8D-8E	6.84	29.94	3.00	20.71	1	36 inch	328	0.71	0.38	0.00100	2.93	2.97	21.09	0.38	0.00098	5.42	6.00	0.58
11th-13th Street System	11B1	1.8	0.50	2.97	11B1-11B2	6.94	42.90	2.54	17.77	1	4 X 3	48	0.13	0.12	0.00021	1.69	1.49	17.86	0.09	0.00021	2.76	6.50	3.74
11th-13th Street System	8I	11	0.70	23.21	J8I-8G	7.70	30.25	2.99	23.21	1	42 inch	660	1.19	0.86	0.00050	2.41	2.34	22.5	-0.71	0.00053	5.03	6.50	1.47
11th-13th Street System	11I	4.4	0.50	6.97	11I-11G1	8.88	34.37	2.83	25.28	1	36 inch	664	2.28	1.68	0.00090	3.58	2.82	20.05	-5.23	0.00143	6.72	7.50	0.78
11th-13th Street System	9G	5.53	0.50	8.65	9G-10G	9.16	36.35	2.75	25.34	1	42 inch	373	1.55	0.99	0.00150	3.28	4.06	38.98	13.64	0.00067	4.03	6.50	2.47
11th-13th Street System	10B	4.81	0.70	10.61	10B-11B2	10.16	38.29	2.67	27.34	1	Box 2.5 X 4.5	361	1.09	0.91	0.00050	4.94	2.22	24.82	-2.52	0.00307	3.86	6.00	2.14
11th-13th Street System	11G1	3	0.50	4.84	11G1-11F1	10.38	37.46	2.70	28.25	1	42 inch	341	1.68	1.32	0.00106	2.94	3.41	32.69	4.43	0.00079	5.77	6.50	0.73
11th-13th Street System	11F1	2.27	0.5	3.71	11F-11E	11.51	39.4	2.62	30.45	#N/A	42 inch	327	1.32	1.02	0.000917	3.16	3.173958333	30.47	0.03	0.000917431	5.5	6.5	1
11th-13th Street System	10G	6.31	0.50	9.80	10G-11G2	12.31	38.24	2.67	33.14	1	48 inch	372	0.49	-0.07	0.00150	2.86	4.42	55.63	22.49	0.00043	3.78	6.69	2.91
11th-13th Street System	11G2	5.64	0.50	8.81	11G2-11F2	15.13	40.41	2.59	39.53	1	54 inch	337	-0.57	-0.67	0.00030	2.57	2.14	34.04	-5.49	0.00036	3.62	7.60	3.98
11th-13th Street System	11F2	1.93	0.50	3.18	11F2-J11E	19.89	42.60	2.55	51.08	1	60 inch	320	-1.17	-1.36	0.00060	2.66	3.25	63.68	12.6	0.00031	3.50	6.00	2.50
11th-13th Street System	8E	13.78	0.50	20.59	8E-9E	26.60	38.52	2.66	71.31	1	54 inch	363	-0.62	-0.8	0.00050	4.48	2.77	44.03	-27.28	0.00132	5.10	6.34	1.24
11th-13th Street System	9E	4.2	0.70	9.33	9E-10E	29.54	39.87	2.61	77.58	1	54 inch	381	-0.8	-1.09	0.00075	4.88	3.39	53.88	-23.71	0.00155	4.62	6.00	1.38
11th-13th Street System	11D2	1.11	0.50	1.87	11D2-11C2	31.47	45.99	2.48	78.68	1	66 inch	325	-2.06	-2.52	0.00140	3.36	5.28	125.64	46.96	0.00046	3.10	6.00	2.90
11th-13th Street System	10E	3	0.70	6.78	10E-J11E	31.64	41.17	2.58	82.18	1	54 inch	362	-1.09	-1.36	0.00075	5.17	3.38	53.8	-28.38	0.00174	4.03	6.00	1.97
11th-13th Street System	11C2	1.8	0.70	4.16	11C2-11B2	32.73	47.60	2.45	80.77	1	66 inch	345	-2.52	-3	0.00140	3.40	5.28	125.64	44.87	0.00058	2.95	6.00	3.05
11th-13th Street System	13E	6	0.50	9.35	13E-13C	35.12	44.04	2.52	89.18	1	60 inch	658	-2.11	-2.76	0.00099	4.54	4.18	81.85	-7.33	0.00117	4.43	6.00	1.57
11th-13th Street System	13C	3.09	0.70	6.97	13C-13B	37.28	46.46	2.47	92.86	1	60 inch	370	-2.76	-3.13	0.00100	4.73	4.20	82.35	-10.51	0.00127	3.66	6.00	2.34
11th-13th Street System	13B3	3.09	0.7	6.97	13B-13A	39.45	47.76	2.44	97.21	#N/A	60 inch	300	-3.13	-3.43	0.001	4.95	4.201530612	82.35	-14.86	0.0014	3.19	5	1.81
11th-13th Street System	13A	7.91	0.5	12.13	13A-13OUT	43.4	48.77	2.42	106.07	#N/A	60 inch	706	-3.43	-4.14	0.001006	5.4	4.21377551	82.59	-23.49	0.001657224	2.77	4.5	1.73
11th-13th Street System	11B2	1.76	0.50	2.91	11B2-11A	50.71	49.29	2.41	123.41	1	72 inch	421	-3.73	-4.16	0.00100	4.36	4.73	133.92	10.51	0.00086	2.75	6.13	3.38
11th-13th Street System	11A	5.58	0.50	8.73	11A-9(1/2)A	53.50	50.90	2.38	128.22	1	72 inch	593	-4.16	-4.75	0.00100	4.53	4.73	133.92	5.7	0.00091	2.39	8.26	5.87
11th-13th Street System	9(1/2)A	6.94	0.50	10.72	9(1/2)A-Harborside_Out	56.97	53.08	2.32	133.41	1	72 inch	252	-4.75	-5	0.00100	4.72	4.73	133.92	0.51	0.00099	1.85	7.54	5.69
11th-13th Street System	J8G	#N/A	#N/A	#N/A	J8G-8E	#N/A	#N/A	#N/A	36.43	1	48 inch	644	0.36	-0.12	0.00075	2.90	3.12	39.34	2.91	0.00065	5.52	6.45	0.93
11th-13th Street System	J11E	#N/A	#N/A	#N/A	J11E-11D2	#N/A	#N/A	#N/A	78.16	1	60 inch	331	-1.86	-2.06	0.00060	3.98	3.27	64	-14.16	0.00091	3.40	7.00	3.60
11th-13th Street System	J11E-3	#N/A	#N/A	#N/A	11E-13E	#N/A	#N/A	#N/A	83.46	#N/A	60 inch	746	-1.36	-2.11	0.001005	4.25	4.213265306	82.58	-0.89	0.001032172	5.2	7	1.8
Total Area/Average C		177.11	0.58																				
14th Street System	14J	3.35	0.50	5.38	14J-14I	1.67	27.37	3.18	5.38	1	6 x 3 ft	362	2.56	2.2	0.00099	0.51	3.60	64.88	59.51	0.00000	4.15	7.50	3.35
14th Street System	13I	4.9	0.50	7.71	13I-14I	2.45	28.23	3.12	7.71	1	24 inch	375	3.23	3.2	0.00008	3.79	0.65	2.02	-5.69	0.00227	5.04	7.00	1.96
14th Street System	14I	6.59	0.50	10.21	14I-14H	7.42	39.19	2.63	19.69	1	6 x 3 ft	348	2.2	1.85	0.00101	1.57	3.63	65.25	45.56	0.00011	4.15	7.00	2.85
14th Street System	14H	10.74	0.50	16.20	14H-14F	12.79	42.89	2.54	32.78	1	6 x 3 ft	660	1.85	1.52	0.00050	2.34	2.56	46.01	13.23	0.00027	4.11	6.00	1.89
14th Street System	14F	20.32	0.50	29.91	14F-14D	22.95	47.59	2.45	56.64	1	6 x 3 ft	660	1.52	1.12	0.00061	4.18	2.81	50.65	-5.99	0.00103	3.93	6.00	2.07
14th Street System	14D	7.74	0.50	11.89	14D-14B	26.82	50.22	2.39	64.74	1	BOX 8 X3	658	1.12	0.56	0.00085	3.67	3.53	84.81	20.07	0.00061	3.25	6.00	2.75
14th Street System	14B	5.55	0.60	10.42	14B-14A	32.35	53.21	2.32	75.64	1	BOX 8 X3	332	0.56	0.39	0.00051	4.29	2.74	65.78	-9.86	0.00099	2.85	4.76	1.91
14th Street System	14A	10.1	0.50	15.27	14A-Outfall	37.40	54.50	2.29	86.24	1	BOX 8 X3	700	0.39	-0.49	0.00126	5.11	4.29	103.07	16.84	0.00131	2.52	5.78	3.26
Total Area/Average C		69.29	0.51																				
15th Street System	11J	3.6	0.50	5.76	11J-11I	1.80	27.53	3.17	5.76	1	36 inch	334	2.61	2.28	0.00099	0.81	2.95	20.96	15.21	0.00006	6.74	7.84	1.10
15th Street System	8K	6	0.50	9.35	8K-9K	3.00	28.71	3.09	9.35	1	24 inch	375	3.58	3.21	0.00100	2.97	2.31	7.15	-2.19	0.00171	8.21	13.50	5.29
15th Street System	11M	6.31	0.50	9.80	11M-11K	3.16	28.83	3.08	9.8	1	24 inch	676	3.93	3.25	0.00100	3.12	2.31	7.15	-2.65	0.00188	7.99	9.85	1.86
15th Street System	16K1	8.18	0.50	12.52	16K1-15K	4.09	29.48	3.04	12.52	1	24 inch	388	2.62	2.23	0.00100	3.98	2.31	7.15	-5.37	0.00307	6.01	7.12	1.11
15th Street System	9K	10.4	0.50	15.70	9K-10K	8.20	30.81	2.97	24.53	1	36 inch	381	2.21	1.82	0.00100	3.47	2.97	21.09	-3.44	0.00134	7.57	9.02	1.45
15th Street System	16M(1/2)	18.6	0.50	27.47	16M(1/2)-14M(1/2)	9.30	31.73	2.93	27.47	1	36 inch	756	2.78	2.02	0.00101	3.89	2.98	21.15	-6.33	0.00169	8.16	8.28	0.12
15th Street System	10K	12.2	0.50	18.31	10K-11K	14.30	32.64	2.89	41.72	1	48 inch	403	0.82	0.42	0.00100	3.32	3.60	45.42	3.7	0.00084	7.06	8.29	1.23
15th Street System	14M1/2	15.61	0.50	23.22	14M(1/2)-14K	17.10	34.97	2.80	48.29	1	4 X 3	990	0.29	-0.7	0.00100	4.02	3.26	39.14	-9.16	0.00153	6.88	8.42	1.54
15th Street System	11K	7.51	0.50	11.55	11K-12K	21.21	34.66	2.81	60.15	1	5 X 4	362	0.42	0.06	0.00100	3.01	3.88	77.55	17.4	0.00061	6.72	7.75	1.03
15th Street System	12K	13.1	0.50	19.61	12K-13K	27.76	36.67	2.73	76.48	1	BOX 5X4	375	0.06	-0.32	0.00100	3.82	3.88	77.55	1.07	0.00099	6.50	8.00	1.50
15th Street System	13K	25.83	0.50	37.63	13K-14K	40.67	38.30	2.67	109.38	1	BOX 5X4	382	-0.32	-0.7	0.00100	5.47	3.88	77.55	-31.83	0.00199	6.13	7.81	1.68
15th Street System	14K	8.07	0.50	12.36	15K-14K	61.81	39.47	2.62	163.33	1	6 x 5 ft	371	-0.7	-1.07	0.00100	5.44	4.44	133.16	-30.17	0.00148	5.37	7.07	1.70
15th Street System	15K	8.28	0.50	12.66	15K-15I	70.04	40.60	2.59	182.72	1	8 x 5 ft	736	-1.07	-1.44	0.00050	4.57	3.42	136.61	-46.11	0.00090	4.82	7.42	2.60
15th Street System	15E	4.8	0.50	7.57	15E-15D	76.70	47.95	2.44	188.72	1	8 x 5 ft	334	-2.1	-2.27	0.00050	4.74	3.41	136.25	-52.47	0.00060	2.89	6.00	3.11
15th Street System	15D	2.1	0.50	3.44	15D-15C	77.75	49.13	2.42	189.46	1	8 x 5 ft	332	-2.27	-2.44	0.00050	4.80	3.41	136.25	-53.22	0.00063	2.69	6.00	3.31
15th Street System	15I	8.51	0.50	12.99	15I-15E	74.30	43.29	2.53	189.8	1	8 x 5 ft	1329	-1.44	-2.1	0.00050	4.75	3.41	136.25	-53.55	0.00096	4.16	7.00	2.84
15th Street System	15C	2.9	0.50	4.69	15C-15B	79.20	50.28	2.39	191.04	1	8 x 5 ft	334	-2.44	-2.61	0.00050	4.88	3.41	136.25	-54.8	0.00066	2.48	4.00	1.52
15th Street System	15B	5.5	0.50	8.61	15B-15Out	81.67	51.42	2.36	194.67	1	8 x 5 ft	865	-2.6	-3.03	0.00050	5.13	3.41	136.38	-58.29	0.00076	2.26	3.16	0.90
Total Area/Average C		167.5	0.50																				
16th Street System	16D	2.89	0.50	4.67	16D-16A1/2	1.44	27.05	3.21	4.67	1	24 inch	843	-0.66	-1.5	0.00100	1.49	2.31	7.15	2.48	0.00043	3.17	5.00	1.83
16th Street System	16A1/2	12.15	0.50	18.24	16A1/2-16Wharf	7.52	36.51	2.74	20.77	1	36 inch	728	-3	-3.73	0.00100	2.94	2.97	21.09	0.32	0.00096	2.81	3.00	0.19
16th Street System	16Wharf	6.32	0.70	13.74	16Wharf-16Out	11.94	40.64	2.59	31.15	1	42 inch	530	-3.73	-4.34	0.00116	3.24	3.56	34.19	3.04	0.00096	2.11	5.00	2.89
Total Area/Average C		21.36	0.57																				
18th Street System	17B	2.9	0.70	6.56	17B-17_(1/2)A	2.03	27.06	3.21	6.56	1	24 inch	535	0.24	-0.3	0.00100	2.09	2.31	7.15	0.59	0.00084	2.66	4.00	1.34
18th Street System	17C	5.99	0.50	9.33	17C-18C	2.99	28.71	3.09	9.33	1	24 inch	394	0.57	0.18	0.00100	2.97	2.31	7.15	-2.18	0.00170	3.55	4.00	0.45
18th Street System	19M	6.13	0.50	9.54	19M-19K	3.06	28.76	3.09	9.54	1	54 inch	660	1.04	0.38	0.00100	0.60	3.91	62.18	52.65	0.00002	6.24	7.05	0.81
18th Street System	17I	6.57	0.50	10.18	P-742	3.28	28.93	3.07	10.18	1	3 X 1.67	380	2.62	2.2	0.00109	2.04	2.49	12.46	2.28	0.00074	5.13	9.48	4.35
18th Street System	17_(1/2)A	4.49	0.70	9.94	18_(1/2)A-17_(1/2)A	5.17	31.33	2.95	15.37	1	36 inch	392	-1.3	-1.69	0.00100	2.17	2.97	21.09	5.73	0.00054	2.21	6.20	3.99
18th Street System	17K	12.1	0.50	18.17	P-740	6.05	30.51	2.98	18.17	1	24 inch	376	2.16	-1.33	0.00929	5.78	7.03	21.8	3.63	0.00646	8.12	7.38	-0.74
18th Street System	17N	13	0.50	19.47	17N-18N	6.50	30.71	2.97	19.47	1	36 inch	381	3.51	3.13	0.00100	2.75	2.97	21.09	1.62	0.00087	8.62	9.00	0.38
18th Street System	21P(1/2)	16.08	0.50	23.89	21P(1/2)-21N(1/2)	8.04	31.31	2.95	23.89	1	3 X 2.5	1589	6.05	4.66	0.00088	3.19	2.62	19.64	-4.25	0.00130	9.89	13.89	4.00
18th Street System	19N	17	0.50	25.20	P-739	8.50	31.47	2.94	25.2	1	36 inch	403	2.75	0.24	0.00623	3.57	7.41	52.64	27.43	0.00144	8.87	9.00	0.13

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
18th Street System	21N(1/2)	21.86	0.50	32.08	21N1/2-21M1/2	18.97	39.62	2.62	50	1	48 inch	335	3	2.66	0.00100	3.98	3.60	45.42	-4.58	0.00122	7.83	8.50	0.67
18th Street System	18N	14.1	0.50	21.05	P-737	22.05	33.35	2.87	63.7	1	48 inch	1321	-0.01	-1.33	0.00100	5.07	3.60	45.4	-18.29	0.00197	8.29	9.00	0.71
18th Street System	21M1/2	10.15	0.50	15.34	21M1/2-21K	24.04	41.03	2.58	62.52	1	60 inch	985	1.66	1.09	0.00058	3.18	3.20	62.76	0.24	0.00057	7.42	7.50	0.08
18th Street System	21K	8.99	0.50	13.68	21K-18K	28.54	46.18	2.48	71.24	1	60 inch	374	1.09	0.74	0.00091	3.63	4.02	78.71	7.47	0.00075	6.86	7.22	0.36
18th Street System	18K	8.49	0.50	12.96	18K-19K	32.78	47.90	2.44	80.7	1	60 inch	365	0.74	0.38	0.00100	4.11	4.20	82.35	1.65	0.00096	6.58	7.00	0.42
18th Street System	19K	5.71	0.50	8.92	P-741	38.71	49.38	2.41	94.12	1	60 inch	406	0.03	-1.33	0.00336	4.79	7.70	150.95	56.83	0.00133	6.23	7.47	1.24
18th Street System	I-491	12.34	0.50	18.52	P-738	72.98	50.79	2.38	175.08	1	7 X 5	726	-1.33	-1.76	0.00059	5.00	3.58	125.21	-49.88	0.00116	5.69	7.00	1.31
18th Street System	I-490	7.28	0.50	11.22	P-736	79.90	53.21	2.32	186.83	1	7 X 5	338	-1.76	-1.97	0.00062	5.34	3.66	127.93	-58.9	0.00130	4.85	5.20	0.35
18th Street System	18H	6.1	0.50	9.49	18H-18G	82.95	54.27	2.29	191.75	1	8 x 5 ft	329	-1.97	-2.17	0.00061	4.79	3.77	150.6	-41.15	0.00100	4.41	6.00	1.59
18th Street System	18G	12	0.50	18.03	18G-18F	88.95	55.41	2.26	203.06	1	9 x 5 ft	336	-2.17	-2.42	0.00075	4.51	4.29	193.27	-9.79	0.00083	4.08	6.00	1.92
18th Street System	18F	8.8	0.50	13.41	18F-18E	93.35	56.65	2.23	210.18	1	9 x 5 ft	334	-2.42	-2.69	0.00079	4.67	4.42	198.79	-11.4	0.00087	3.80	6.00	2.20
18th Street System	18E	8.6	0.50	13.12	18E-18D	97.65	57.84	2.20	216.93	1	9 x 5 ft	336	-2.69	-2.97	0.00085	4.82	4.58	205.9	-11.04	0.00095	3.51	5.00	1.49
18th Street System	18D	2.72	0.50	4.41	18D-18C	99.01	59.01	2.17	217.06	1	9 x 5 ft	332	-2.97	-3.25	0.00085	4.82	4.57	205.68	-11.38	0.00093	3.19	4.51	1.32
18th Street System	18C	2.86	0.50	4.62	18C-18A(1/2)	103.44	60.15	2.15	223.89	1	9 x 5 ft	508	-3.25	-3.71	0.00090	4.98	4.70	211.67	-12.22	0.00102	2.88	3.92	1.04
18th Street System	18A(1/2)	5.7	0.70	12.46	18A(1/2)-18_(1/2)A	104.74	61.85	2.12	223.57	1	9 x 5 ft	361	-3.71	-4.03	0.00090	4.97	4.71	211.75	-11.82	0.00100	2.36	4.92	2.56
18th Street System	18_(1/2)A	7.09	0.70	15.32	18_(1/2)A-18Out	114.88	63.07	2.10	242.75	1	9 x 5 ft	340	-4.03	-4.37	0.00100	5.40	4.96	223.17	-19.58	0.00118	2.00	3.73	1.73
18th Street System	J-1	#N/A	#N/A	#N/A	18-A(1/2) - 19A(1/2)	#N/A	#N/A	#N/A	7.88	1	30 inch	320	-0.07	-0.59	0.00163	1.61	3.37	16.53	8.65	0.00038	2.69	4.92	2.23
Total Area/Average C		227.05	0.532																				
19th Street System	20-E	0.85	0.70	2.01	20-E-19E	0.60	25.00	3.35	2.01	1	24 inch	354	1.79	1.05	0.00209	0.64	3.34	10.34	8.33	0.00008	4.06	5.37	1.31
19th Street System	19J	2.93	0.70	6.62	19J-19I	2.05	27.08	3.20	6.62	1	30 inch	380	1.35	1.16	0.00050	1.35	1.87	9.17	2.55	0.00026	4.84	7.00	2.16
19th Street System	19I	2.93	0.50	4.73	19I-19H	3.52	31.77	2.93	10.38	1	5.5 X 3.5	330	1.16	0.99	0.00052	0.54	2.72	52.23	41.85	0.00003	4.74	5.16	0.42
19th Street System	22J	5.91	0.70	12.90	22J-J22H	4.14	28.67	3.09	12.9	1	36 inch	626	1.86	1.55	0.00050	1.82	2.09	14.84	1.94	0.00037	5.43	7.00	1.57
19th Street System	20I	6.66	0.70	14.44	20I-20H	4.66	28.96	3.07	14.44	1	36 inch	327	1.06	0.73	0.00100	2.04	2.97	21.09	6.65	0.00046	5.12	5.30	0.18
19th Street System	21H	7.45	0.70	16.05	20H-21H	9.35	38.28	2.67	25.16	1	4 X 3	372	1.35	1.17	0.00048	2.10	2.27	27.22	2.07	0.00040	5.12	5.33	0.21
19th Street System	20H	3.02	0.70	6.82	20H-19H	16.13	41.24	2.58	41.87	1	5 x 3 ft	360	1.17	0.99	0.00050	2.79	2.45	36.72	-5.14	0.00067	4.97	5.52	0.55
19th Street System	19H	2.5	0.7	5.69	P-734	21.39	43.39	2.53	54.61	#N/A	5.5 X 3.5	316	0.99	0.83	0.0005	2.84	2.6796875	51.45	-3.15	0.00056962	4.73	5.4	0.67
19th Street System	19G	4.4	0.70	9.75	19G-19F	24.47	45.25	2.50	61.55	1	5.5 X 3.5	351	0.83	0.53	0.00086	3.20	3.50	67.27	5.72	0.00071	4.55	5.50	0.95
19th Street System	19F	4.3	0.70	9.54	19F-19E	27.48	47.08	2.46	68.11	1	5.5 X 3.5	314	0.53	0.26	0.00086	3.54	3.51	67.47	-0.64	0.00086	4.30	5.47	1.17
19th Street System	19E	2.7	0.70	6.13	19E-19D	29.97	48.55	2.43	73.37	1	5.5 X 3.5	346	0.26	-0.03	0.00084	3.81	3.47	66.62	-6.76	0.00101	4.03	4.36	0.33
19th Street System	19D	2.6	0.70	5.91	19D-19A(1/2)	31.79	50.07	2.40	76.85	1	5.5 X 3.5	990	-0.03	-1.15	0.00113	3.99	4.03	77.39	0.55	0.00112	3.68	4.50	0.82
19th Street System	19A(1/2)	8.19	0.70	17.55	19A(1/2)-19Wharf	40.21	54.20	2.29	93.01	1	5.5 X 3.5	436	-1.15	-1.95	0.00184	4.83	5.13	98.57	5.55	0.00163	2.57	3.31	0.74
19th Street System	19Wharf	1.81	0.70	4.18	19Wharf-O-2	41.47	55.70	2.26	94.37	1	5.5 X 3.5	154	-1.95	-2.23	0.00182	4.90	5.11	98.12	3.74	0.00169	1.86	4.00	2.14
Total Area/Average C		56.25	0.69																				
20th Street System	20D	2.1	0.70	4.82	20D-20C2	1.47	26.40	3.25	4.82	1	24 inch	332	1.63	1.3	0.00100	2.05	2.31	7.15	2.33	0.00060	2.97	5.00	2.03
20th Street System	20C2	2.66	0.70	6.04	20C2-20JB	3.33	29.09	3.06	10.29	1	30 inch	312	0.8	0.49	0.00100	2.42	2.65	12.97	2.68	0.00061	2.77	4.50	1.73
20th Street System	20E	5.91	0.70	12.90	20E-20C	4.14	28.67	3.09	12.9	1	24 inch	624	0.88	0.26	0.00100	4.11	2.31	7.15	-5.74	0.00325	5.42	5.50	0.08
20th Street System	20C	4	0.70	8.91	20C-20B	6.94	31.21	2.95	20.64	1	30 inch	333	-0.24	-0.57	0.00100	4.20	2.65	12.97	-7.67	0.00252	3.39	4.50	1.11
20th Street System	20B	2.83	0.70	6.41	20B-20A1/2	12.25	32.53	2.90	35.8	1	48 inch	169	-1.07	-1.24	0.00100	2.97	3.60	45.42	9.63	0.00053	2.55	4.50	1.95
20th Street System	20A1/2	1.78	0.70	4.11	20A1/2-20A1	13.50	33.47	2.86	38.92	1	48 inch	130	-1.24	-1.37	0.00100	3.19	3.60	45.42	6.5	0.00062	2.46	4.50	2.04
20th Street System	20A2	3.52	0.70	7.89	20A2-20JA1	15.96	34.32	2.83	45.48	1	54 inch	134	-1.94	-2.06	0.00090	3.13	3.70	58.84	13.36	0.00045	1.90	4.00	2.10
20th Street System	20Wharf	3.1	0.70	6.99	20Wharf-20-OUT	18.13	36.38	2.74	50.16	1	54 inch	241	-2.31	-2.55	0.00100	3.30	3.91	62.18	12.02	0.00054	1.73	5.00	3.27
20th Street System	20JB	#N/A	#N/A	#N/A	20JB-20B	#N/A	#N/A	#N/A	9.91	1	30 inch	60	0.49	0.43	0.00100	2.25	2.65	12.97	3.06	0.00050	2.58	4.50	1.92
20th Street System	20JA	#N/A	#N/A	#N/A	20A1-20A2	#N/A	#N/A	#N/A	38.55	1	3 X 2.5	65	0.13	0.06	0.00108	6.35	2.91	21.79	-16.76	0.00738	2.38	4.00	1.62
20th Street System	20JA1	#N/A	#N/A	#N/A	20JA1-20Wharf	#N/A	#N/A	#N/A	45.02	1	54 inch	245	-2.06	-2.31	0.00100	3.03	3.91	62.18	17.16	0.00045	1.84	4.00	2.16
Total Area/Average C		25.9	0.7																				
22nd-24th Street System	22A(1/2)	1.32	0.70	3.09	22A(1/2)-22Out2	3.49	32.73	2.89	10.16	1	Box 2.5 X 4.5	388	-0.25	-0.64	0.00101	1.93	3.15	35.24	25.08	0.00036	1.74	5.26	3.52
22nd-24th Street System	22G	6.72	0.70	14.56	22G-22F(1/2)	4.70	28.99	3.07	14.56	1	30 inch	173	1.32	1.06	0.00150	3.74	3.24	15.89	1.32	0.00162	3.18	5.68	2.50
22nd-24th Street System	22K	6.87	0.70	14.87	22K-23K	4.81	29.04	3.07	14.87	1	6 X 2.5	376	3.58	3.11	0.00125	3.66	3.72	55.76	40.9	0.00189	4.40	7.00	2.60
22nd-24th Street System	22E	7.28	0.70	15.70	22E-22D(1/2)	9.80	32.05	2.92	28.83	1	54 inch	165	-1.69	-1.77	0.00050	1.98	2.76	43.84	15.01	0.00018	2.15	4.83	2.68
22nd-24th Street System	23K	17.48	0.70	36.24	23K-23I	10.74	31.55	2.94	31.8	1	60 inch	743	-2.25	-2.7	0.00061	1.62	3.27	64.09	32.29	0.00015	3.14	7.12	3.98
22nd-24th Street System	24K	10.39	0.50	15.69	24K-24J	11.50	33.96	2.84	32.95	1	6 X 2.5	380	2.65	2.18	0.00124	4.62	3.70	55.47	22.52	0.00208	4.02	9.99	5.97
22nd-24th Street System	22D1/2	2.68	0.70	6.08	22D(1/2)-22C(1/2)	11.68	33.43	2.86	33.69	1	60 inch	327	-2.27	-2.4	0.00040	1.83	2.66	52.13	18.43	0.00015	2.12	4.64	2.52
22nd-24th Street System	24I	4.1	0.70	9.12	24I-24H	14.37	37.27	2.71	39.25	1	6 X 3	319	1.21	0.81	0.00125	3.51	4.05	72.85	33.61	0.00066	2.98	7.80	4.82
22nd-24th Street System	22C(1/2)	5.45	0.70	11.95	22C(1/2)-22B(1/2)	15.49	36.41	2.74	42.84	1	66 inch	328	-2.9	-3.03	0.00040	1.89	2.82	67.11	24.26	0.00012	2.07	4.01	1.94
22nd-24th Street System	24H	2.57	0.70	5.85	24H-24G	16.17	38.78	2.65	43.17	1	6 X 3	341	0.81	0.39	0.00123	3.49	4.01	72.21	29.03	0.00059	2.77	6.00	3.23
22nd-24th Street System	23I	10.22	0.70	21.62	23I-23F	17.89	39.20	2.63	47.47	1	60 inch	996	-2.7	-3.3	0.00060	2.42	3.26	63.92	16.45	0.00034	3.03	7.00	3.97
22nd-24th Street System	24G	2.6	0.70	5.91	24G-24D	17.99	40.41	2.59	47	1	7 x 3 ft	990	0.39	-0.84	0.00124	2.66	4.16	87.4	40.4	0.00028	2.57	6.18	3.61
22nd-24th Street System	23F	3.97	0.70	8.85	23F-23E	20.67	46.06	2.48	51.65	1	60 inch	308	-3.3	-3.5	0.00065	2.63	3.39	66.36	14.71	0.00039	2.69	5.57	2.88
22nd-24th Street System	24D	9.93	0.70	21.03	24D-24A	24.94	46.61	2.47	62.04	1	8 X 3	990	-0.84	-2.07	0.00124	2.58	4.27	102.47	40.43	0.00045	2.29	4.25	1.96
22nd-24th Street System	23E	6.56	0.70	14.23	23E-23C	25.26	48.01	2.44	62.13	1	66 inch	687	-4	-4.4	0.00058	2.62	3.40	81.03	18.9	0.00033	2.57	4.53	1.96
22nd-24th Street System	24A	3.8	0.70	8.48	24A-O24	27.60	53.00	2.33	64.69	1	8 X 3	480	-2.07	-2.67	0.00125	2.69	4.28	102.78	38.09	0.00050	1.84	2.62	0.78
22nd-24th Street System	23C	6.71	0.70	14.54	23C-23B	29.96	52.39	2.34	70.67	1	66 inch	327	-4.4	-4.58	0.00055	2.97	3.31	78.78	8.11	0.00046	2.34	3.56	1.22
22nd-24th Street System	23B	4.01	0.70	8.93	23B-22B2	32.77	54.22	2.29	75.78	1	66 inch	371	-4.58	-4.8	0.00059	3.19	3.44	81.77	5.99	0.00051	2.19	3.88	1.69
22nd-24th Street System	22B2	4.24	0.70	9.42	22B2-22_(1/2)A	48.67	56.16	2.25	110.17	1	72 inch	482	-3.6	-3.74	0.00029	4.05	2.55	72.17	-38	0.00060	2.00	4.17	2.17
22nd-24th Street System	22_(1/2)A	6.26	0.70	13.62	22_(1/2)A - 22Out1	53.05	58.15	2.20	117.44	1	72 inch	159	-3.74	-3.79	0.00031	4.37	2.65	75.1	-42.34	0.00069	1.71	6.04	4.33
22nd-24th Street System	J22B	#N/A	#N/A	#N/A	J22B-22A(1/2)	#N/A	#N/A	#N/A	7.59	1	30 inch	254	1	0.75	0.00100	3.59	2.65	12.97	5.38	0.00217	2.29	4.17	1.88
22nd-24th Street System	J22H	#N/A	#N/A	#N/A	J22H-21H	#N/A	#N/A	#N/A	11.78	1	36 inch	389	1.55	1.35	0.00051	1.67	2.13	15.12	3.35	0.00031	5.24	5.20	-0.04
22nd-24th Street System	22E(1/2)	#N/A	#N/A	#N/A	22E(1/2)-22E	#N/A	#N/A	#N/A	13.98	1	30 inch	166	0.56	0.31	0.00150	3.62	3.24	15.89	1.9	0.00145	2.39	5.29	2.90
22nd-24th Street System	22F	#N/A	#N/A	#N/A	22F-22E(1/2)	#N/A	#N/A	#N/A	14.13	1	30 inch	169	0.81	0.56	0.00150	3.66	3.24	15.89	1.76	0.00154	2.65	5.74	3.09
22nd-24th Street System	22F(1/2)	#N/A	#N/A	#N/A	22F(1/2)-22F	#N/A	#N/A	#N/A	14.31	1	30 inch	167	1.06	0.81	0.00150	3.69	3.24	15.89	1.58	0.00150	2.90	5.78	2.88
22nd-24th Street System	J23K	#N/A	#N/A	#N/A	23K-24K	#N/A	#N/A	#N/A	18.68	1	6 X 2.5	369	3.11	2.65	0.00125	2.56	3.71	55.69	37.01	0.00049	4.20	7.12	2.92
22nd-24th Street System	24J	#N/A	#N/A	#N/A	24J-24I	#N/A	#N/A	#N/A	32.31	1	6 x 3 ft	380	1.68	1.21	0.00124	3.26	4.02	72.36	40.05	0.00066	3.23	8.66	5.43
22nd-24th Street System	22B(1/2)	#N/A	#N/A	#N/A	22B(1/2)-22B2	#N/A	#N/A	#N/A	41.03	1	66 inch	168	-3.03	-3.1	0.00040	1.79	2.82	67.06	26.03	0.00018	2.03	3.95	1.92
Total Area/Average C		123.16	0.69																				
25th-27th Street System	26(1/2)B	1.46	0.50	2.43	26(1/2)B - 27A1	0.73	25.69	3.30	2.43	1	36 inch	243	-0.42	-0.56	0.00058	0.35	2.25	16.01	13.58	0.00000	2.31	4.63	2.32
25th-27th Street System	27A2	1.27	0.50	2.13	27A2 - 27_(1/2)A	1.33	25.69	3.30	4.42	1	4 X 3.25	164	-1.47	-1.57	0.00061	0.35	2.62	34.12	29.69	0.00000	1.62	5.00	3.38
25th-27th Street System	27C2	5.85	0.50	9.12	27C2-27B(1/2)	2.92	28.65	3.09	9.12	2	24 inch	191	1.09	0.9	0.00100	1.91	4.60	14.27	5.15	0.00052	2.47	4.09	1.62
25th-27th Street System	27J	6.15	0.50	9.57	27J-26J	3.08	28.77	3.09	9.57	1	24 inch	382	4.67	4.29	0.00100	3.04	2.30	7.13	-2.43	0.00178	7.21	7.50	0.29
25th-27th Street System	27_(1/2)A	4.48	0.50	7.09	27_(1/2)A - 27Out	3.57	33.46	2.86	10.29	1	4.5 X 3.25	554	-1.57	-6	0.00800	0.71	9.85	143.84	133.54	0.00004	1.62	5.31	3.69
25th-27th Street System	25K	8.5	0.50	12.98	25M-26K	4.25	29.58	3.03	12.98	1	3 X 3	626	3.05	2.74	0.00050	1.44	2.11	18.99	6.01	0.00024	7.04	7.67	0.63
25th-27th Street System	27K	9.3	0.50	14.12	27K-26K	4.65	29.81	3.01	14.12	1	24 inch	389	4.67	4.28	0.00100	4.50	2.31	7.16	-6.96	0.00391	8.12	7.20	-0.92
25th-27th Street System	25H	9.73	0.7	20.63	P-732	6.81	29.93	3.01	20.63	#N/A	36 inch	1007	2.19	1.1	0.001082	2.92	3.090140845	21.94	1.31	0.000953327	5.31	6.18	0.87
25th-27th Street System	27B(1/2)	2.07	0.50	3.40	27B(1/2) - J-507	7.56	47.82	2.44	18.63	1	4 X 3.25	478	-0.35	-0.83	0.00100	1.60	3.37	43.78	25.15	0.00013	2.37	4.07	1.70
25th-27th Street System	27E	16.22	0.50	24.09	27E-26E	8.11	31.33	2.95	24.09	1	18 inch	384	-0.29	-0.67	0.00100	13.63	1.84	3.32	-20.77	0.05260	24.71	5.00	-19.71
25th-27th Street System	25M	10.3	0.50	15.56	25M-26M	9.40	36.81	2.73	25.84	1	5 X 3	393	2.74	2.54	0.00050	1.72	2.45	36.77	10.93	0.00025	6.89	7.36	0.47

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
25th-27th Street System	26M	6.7	0.50	10.37	26M-27M	12.75	40.61	2.59	33.26	1	4 X 4	390	1.54	1.35	0.00050	2.08	2.56	40.89	7.64	0.00031	6.79	7.59	0.80
25th-27th Street System	26J	7.6	0.70	16.35	26J-26H	13.04	35.34	2.79	36.64	1	4' X 2.5'	745	2.59	1.47	0.00150	3.66	3.72	37.21	0.57	0.00146	6.53	7.50	0.97
25th-27th Street System	25E2	9.02	0.70	19.21	25E2-25C	13.12	35.68	2.77	36.68	1	3 X 3	657	0.35	-0.9	0.00190	4.08	4.12	37.04	0.36	0.00187	4.36	4.35	-0.01
25th-27th Street System	25A2	4.04	0.70	8.99	25A2-25Out1	14.45	41.52	2.57	37.42	1	5 X 2	502	-1.9	-2.65	0.00149	3.74	3.53	35.3	-2.12	0.00167	2.44	4.70	2.26
25th-27th Street System	26H	7.9	0.70	16.96	26H-26G	18.57	38.73	2.65	49.63	1	6 X 2.5	328	0.3	-0.03	0.00100	3.31	3.33	49.88	0.24	0.00098	5.44	6.00	0.56
25th-27th Street System	25C	7.78	0.70	16.72	25C-25B	18.57	38.36	2.67	49.9	1	5 x 3 ft	333	-0.9	-1.4	0.00150	3.33	4.24	63.64	13.74	0.00093	3.13	3.35	0.22
25th-27th Street System	25B	3.83	0.70	8.55	25B-25A2	21.25	40.03	2.60	55.68	1	5 x 3 ft	331	-1.4	-1.9	0.00151	3.71	4.26	63.83	8.15	0.00115	2.82	2.98	0.16
25th-27th Street System	26E	7.75	0.70	16.66	26E-26C	32.11	43.74	2.53	81.73	2	6 X 2.5	666	-0.67	-1.5	0.00125	2.72	7.44	111.53	29.8	0.00068	4.51	4.88	0.37
25th-27th Street System	26C	5.62	0.70	12.30	26C-25-B	32.44	47.82	2.44	79.9	1	6 X 2.5	352	-1.5	-2.03	0.00150	5.33	4.07	61.09	-18.82	0.00256	4.06	4.70	0.64
25th-27th Street System	25-B	1.81	0.70	4.18	25-B-26A2	33.71	48.92	2.42	82.28	1	6 X 2.5	320	-2.03	-2.51	0.00150	5.49	4.07	61.09	-21.19	0.00272	3.16	5.00	1.84
25th-27th Street System	26A2	4.84	0.70	10.68	26A-Outfall	54.33	174.42	1.03	56.29	1	6 X 2.5	542	-1.76	-2.57	0.00150	3.75	4.07	61.09	4.8	0.00127	2.29	4.32	2.03
25th-27th Street System	27A1	#N/A	#N/A	#N/A	27A1-J-507	#N/A	#N/A	#N/A	0.1	1	42 inch	82	-1.47	-1.53	0.00073	0.01	2.83	27.21	27.11	0.00000	2.31	5.11	2.80
25th-27th Street System	J-507	#N/A	#N/A	#N/A	J-507-26A2	#N/A	#N/A	#N/A	8.09	1	42 inch	288	-1.53	-1.76	0.00080	0.84	2.96	28.43	20.34	0.00007	2.31	5.00	2.69
25th-27th Street System	J26K	#N/A	#N/A	#N/A	26K-26J	#N/A	#N/A	#N/A	13.83	1	4' X 2.5'	339	3.2	2.59	0.00180	1.38	4.07	40.71	26.88	0.00021	6.60	7.20	0.60
25th-27th Street System	J25A2	#N/A	#N/A	#N/A	25A2-26A2	#N/A	#N/A	#N/A	29.18	1	42 inch	407	-1.36	-1.76	0.00098	3.03	3.29	31.54	2.36	0.00084	2.63	4.70	2.07
25th-27th Street System	26F	#N/A	#N/A	#N/A	26F-26E	#N/A	#N/A	#N/A	47.91	1	6 X 2.5	325	-0.34	-0.67	0.00100	3.19	3.33	49.88	1.96	0.00092	4.81	5.40	0.59
25th-27th Street System	26G	#N/A	#N/A	#N/A	26G-26F	#N/A	#N/A	#N/A	48.54	1	6 X 2.5	324	-0.03	-0.35	0.00100	3.24	3.33	49.88	1.34	0.00096	5.12	5.60	0.48
Total Area/Average C		142.22	0.6																				
29th-30th Street System	34G	9.74	0.50	14.75	34G-J33G	0.50	29.93	3.00	1.52	1	2 X 1.5	376	0	-0.38	0.00100	0.51	2.05	6.16	4.65	0.00005	4.02	4.00	-0.02
29th-30th Street System	35J	2.5	0.50	4.07	35J-34J	1.25	26.75	3.23	4.07	1	30 inch	368	3.46	3.09	0.00100	1.03	2.65	12.97	8.9	0.00011	5.19	7.00	1.81
29th-30th Street System	32N(1/2)	2.63	0.50	4.27	33N(1/2)-32N(1/2)	1.32	26.86	3.22	4.27	1	30 inch	323	4.04	3.7	0.00105	0.87	2.72	13.31	9.04	0.00012	6.61	8.10	1.49
29th-30th Street System	31B	2.67	0.70	6.06	31B-30B	1.87	26.89	3.22	6.06	1	30 inch	334	0.63	0.3	0.00099	1.41	2.63	12.89	6.83	0.00018	2.56	5.00	2.44
29th-30th Street System	29R	5.6	0.50	8.75	29R - 29P(1/2)	2.80	28.54	3.10	8.75	1	3 X 2.5	1001	6.78	5.78	0.00100	1.53	2.80	20.99	12.24	0.00019	8.36	10.00	1.64
29th-30th Street System	35H	5.92	0.50	9.23	35H-35F	2.96	28.68	3.09	9.23	1	36 inch	669	-0.94	-1.66	0.00107	1.31	3.08	21.86	12.63	0.00019	3.63	4.00	0.37
29th-30th Street System	33N(1/2)	4.37	0.50	6.92	33N(1/2) - 33N	3.50	33.05	2.88	10.15	1	30 inch	328	3.7	3.37	0.00101	2.07	2.66	13.01	2.86	0.00061	6.57	8.18	1.61
29th-30th Street System	21P	7.59	0.50	11.67	21P-23P	3.80	29.29	3.05	11.67	1	36 inch	680	5.51	5.17	0.00050	1.65	2.10	14.91	3.25	0.00031	8.96	9.10	0.14
29th-30th Street System	31J	7.65	0.50	11.75	32J-31J	3.82	29.31	3.05	11.75	1	30 inch	326	3.61	3.28	0.00100	2.65	2.65	12.97	1.22	0.00074	5.68	7.00	1.32
29th-30th Street System	23Q	9.01	0.50	13.71	23Q-23P	4.50	29.73	3.02	13.71	1	24 inch	633	6.03	4.95	0.00171	4.36	3.01	9.34	-4.37	0.00367	11.07	13.62	2.55
29th-30th Street System	29H	9.4	0.50	14.27	29H-29E	4.70	29.84	3.01	14.27	1	5 X 3	994	1.57	0.57	0.00101	1.56	3.47	52.09	37.82	0.00013	3.06	5.00	1.94
29th-30th Street System	28B	6.75	0.70	14.62	28B-29B	4.72	29.00	3.07	14.62	1	36 inch	377	-0.19	-0.57	0.00101	2.30	2.98	21.17	6.55	0.00042	2.24	4.50	2.26
29th-30th Street System	34J	7.58	0.50	11.65	34J-33J	5.04	32.71	2.89	14.69	1	36 inch	375	2.09	1.71	0.00101	2.08	2.99	21.23	6.54	0.00048	5.15	7.00	1.85
29th-30th Street System	27O(1/2)	10.52	0.50	15.88	27O(1/2) - 29O(1/2)	5.26	30.13	2.99	15.88	1	36 inch	762	4.62	3.86	0.00100	2.25	2.97	21.09	5.21	0.00058	8.16	8.86	0.70
29th-30th Street System	32R	11.07	0.50	16.68	32R - 31R	5.53	30.27	2.99	16.68	1	30 inch	377	4.94	4.37	0.00150	3.40	3.24	15.89	-0.79	0.00164	9.03	9.86	0.83
29th-30th Street System	35F	5.24	0.50	8.22	35F-34F	5.58	37.22	2.71	15.25	1	48 inch	426	-1.66	-1.83	0.00040	1.21	2.28	28.73	13.48	0.00012	3.55	3.50	-0.05
29th-30th Street System	25Q	11.69	0.50	17.58	25Q-25O	5.84	30.42	2.98	17.58	1	3 x 2 ft	1284	5.18	3.9	0.00100	2.93	2.57	15.43	-2.15	0.00129	9.85	9.87	0.02
29th-30th Street System	33N	6.99	0.50	10.79	33N - 33M	6.99	35.69	2.77	19.55	1	36 inch	656	2.87	2.22	0.00099	2.77	2.96	20.99	1.45	0.00085	6.37	8.16	1.79
29th-30th Street System	32J	7.9	0.50	12.11	33J-32J	7.78	31.36	2.95	23.09	1	36 inch	388	2.28	1.89	0.00101	3.27	2.98	21.15	-1.94	0.00121	5.44	7.00	1.56
29th-30th Street System	31R	4.65	0.50	7.34	31R - 31O	7.86	32.12	2.92	23.1	1	42 inch	1980	3.37	2.38	0.00050	2.40	2.34	22.5	-0.6	0.00053	8.41	9.96	1.55
29th-30th Street System	33Q1/2	18.27	0.50	27.01	33Q1/2-33P1/2	9.14	31.68	2.93	27.01	1	36 inch	645	6.08	5.43	0.00101	3.82	2.98	21.17	-5.83	0.00164	9.55	10.00	0.45
29th-30th Street System	29E	10.4	0.50	15.70	29E-J29D1/2	9.90	40.44	2.59	25.86	1	5 X 3	167	0.57	0.37	0.00120	2.12	3.79	56.83	30.98	0.00024	2.93	5.00	2.07
29th-30th Street System	27P(1/2)	21.41	0.50	31.44	27P(1/2) - 29P(1/2)	10.70	32.15	2.91	31.44	1	42 inch	753	4.57	3.82	0.00100	3.27	3.31	31.81	0.37	0.00097	8.90	9.32	0.42
29th-30th Street System	28D1/2	16.18	0.70	33.64	28D1/2-J29D1/2	11.33	31.33	2.95	33.64	1	4.5 X 2	377	1.75	1.37	0.00101	4.50	2.84	25.56	-8.08	0.00183	3.58	4.00	0.42
29th-30th Street System	34F	2.07	0.70	19.08	34F-33F	11.40	43.07	2.54	29.17	1	54 inch	334	-2.83	-2.96	0.00040	1.83	2.47	39.33	10.16	0.00021	3.87	3.50	-0.37
29th-30th Street System	23P	13.91	0.50	20.78	23P-23N(1/2)	15.26	36.16	2.75	42.34	1	48 inch	1322	3.17	2.51	0.00050	3.37	2.55	32.12	-10.23	0.00087	8.75	9.20	0.45
29th-30th Street System	25O	21.18	0.50	31.12	25O-J25N	16.43	37.72	2.69	44.58	2	3.5 X 2.5	665	2.9	2.24	0.00100	2.55	5.82	51.24	6.66	0.00077	8.19	8.50	0.31
29th-30th Street System	33O1/2	19.5	0.50	28.75	33O1/2-J33N1/2	18.88	38.04	2.68	50.99	1	48 inch	653	2.8	2.18	0.00095	4.06	3.51	44.26	-6.73	0.00126	7.81	8.00	0.19
29th-30th Street System	27M	13.3	0.50	19.90	27M-29M	19.40	43.74	2.53	49.38	1	6 X 4	761	1.35	0.97	0.00050	2.06	2.89	69.27	19.89	0.00026	6.67	7.00	0.33
29th-30th Street System	29P(1/2)	21.41	0.50	31.44	29P(1/2) - 29O(1/2)	24.21	39.42	2.62	64.02	1	5 X 4	649	3.11	2.46	0.00100	3.20	3.87	77.37	13.36	0.00069	8.17	9.53	1.36
29th-30th Street System	23N(1/2)	18.43	0.50	27.23	23N(1/2)-25N	24.47	42.69	2.55	62.8	1	BOX 5X4	786	1.51	1.2	0.00040	3.14	2.45	49.05	-13.75	0.00066	8.20	7.60	-0.60
29th-30th Street System	29M	13.3	0.50	19.90	29M-J30M	26.05	49.91	2.40	63.07	1	7 X 4	351	0.97	0.79	0.00050	2.25	3.00	84.05	20.98	0.00028	6.47	8.10	1.63
29th-30th Street System	29B	15.4	0.50	22.92	29B-29Wharf	33.65	45.00	2.50	84.8	1	72 inch	626	-3.57	-4.2	0.00101	3.04	4.75	134.34	49.55	0.00037	2.08	5.00	2.92
29th-30th Street System	29O(1/2)	11.56	0.50	17.39	29O(1/2)-29N	35.25	42.80	2.54	90.39	1	7 X 4	991	2.46	1.47	0.00100	3.23	4.25	118.86	28.47	0.00058	7.72	9.23	1.51
29th-30th Street System	31O	57.58	0.50	80.77	31O-31M	36.65	45.87	2.48	91.72	1	5 x 5 ft	1315	1.38	0.6	0.00060	3.67	3.25	81.22	-10.5	0.00076	7.36	8.00	0.64
29th-30th Street System	29Wharf	11.29	0.50	17.00	29Wharf-29Out	39.30	48.44	2.43	96.3	1	72 inch	488	-4.2	-4.69	0.00100	3.41	4.74	134.19	37.89	0.00051	1.85	5.00	3.15
29th-30th Street System	25N	7.4	0.50	11.39	25N-26N	44.60	46.87	2.46	110.73	1	7 x 6 ft	392	0.2	0.04	0.00040	2.64	3.15	132.18	21.46	0.00028	7.68	8.00	0.32
29th-30th Street System	26N	4.8	0.50	7.57	26N-27N	47.00	49.34	2.41	114.34	1	7 x 6 ft	383	0.04	-0.15	0.00050	2.72	3.52	147.98	33.64	0.00029	7.57	8.00	0.43
29th-30th Street System	31M	22.78	0.50	33.37	31M-33M	48.04	51.84	2.35	113.99	1	6 x 5 ft	750	0.6	0.22	0.00050	3.80	3.14	94.29	-19.7	0.00073	6.36	7.57	1.21
29th-30th Street System	27N	18.1	0.50	26.76	27N-29N	56.06	51.69	2.36	133.22	1	7 x 6 ft	760	-0.15	-0.53	0.00050	3.17	3.52	147.79	14.57	0.00041	7.46	8.00	0.54
29th-30th Street System	33M	14.24	0.50	21.25	33M-33L	81.04	55.13	2.27	185.57	2	5 x 5 ft	334	0.22	-0.2	0.00126	3.71	9.41	235.17	49.6	0.00078	5.81	7.84	2.03
29th-30th Street System	33L	8.09	0.50	12.39	33L-33J	85.08	56.63	2.23	191.62	2	5 x 5 ft	691	-0.2	-1.1	0.00130	3.83	9.57	239.34	47.72	0.00084	5.55	7.50	1.95
29th-30th Street System	29N	10.3	0.50	15.56	29N-J30N	96.46	55.68	2.26	219.53	1	8 X 6	360	-0.53	-0.71	0.00050	4.57	3.66	175.72	-43.81	0.00078	7.15	8.00	0.85
29th-30th Street System	33H	17.17	0.50	25.44	33H-J33G	106.48	62.45	2.11	226.18	2	6 X 5	317	-2.68	-3	0.00100	3.77	8.89	266.69	40.51	0.00073	4.23	4.50	0.27
29th-30th Street System	33F	18.8	0.50	27.76	33F-30F	118.79	65.35	2.06	246.22	2	8 x 5 ft	1142	-3.96	-4.59	0.00055	3.08	7.14	285.79	39.57	0.00040	3.94	3.80	-0.14
29th-30th Street System	30L	5.8	0.70	12.67	30L-30H	126.57	60.43	2.14	273.33	1	8 x 6 ft	1401	-1.55	-2.95	0.00100	5.69	5.18	248.51	-24.81	0.00121	5.98	8.00	2.02
29th-30th Street System	30H	10.6	0.50	15.99	P-668	131.86	64.53	2.07	275.24	1	8 x 6 ft	660	-2.95	-3.61	0.00100	5.74	5.18	248.51	-26.72	0.00123	4.29	6.00	1.71
29th-30th Street System	30E	10.9	0.50	16.43	30E-30B	256.10	72.75	1.93	497.42	2	9 X 6	995	-5.87	-6.77	0.00090	4.61	10.15	548	50.58	0.00074	3.24	5.00	1.76
29th-30th Street System	30B	6.8	0.50	10.52	30B-30A	261.37	76.35	1.86	491.06	2	9 X 6	337	-6.77	-7.07	0.00090	4.55	10.15	548	56.94	0.00074	2.50	5.00	2.50
29th-30th Street System	30A	13.2	0.50	19.76	30A-30OUT	267.97	77.58	1.84	497.62	2	9 X 6	879	-7.07	-7.86	0.00090	4.61	10.15	548	50.37	0.00074	2.25	5.00	2.75
29th-30th Street System	33P	#N/A	#N/A	#N/A	33P-33O1/2	#N/A	#N/A	#N/A	25.42	1	42 inch	327	3.61	3.3	0.00095	2.64	3.23	30.98	5.55	0.00064	8.02	8.50	0.48
29th-30th Street System	33P1/2	#N/A	#N/A	#N/A	33P1/2-33P	#N/A	#N/A	#N/A	25.97	1	36 inch	328	5.43	5.11	0.00098	3.69	2.93	20.83	-5.14	0.00143	8.49	9.00	0.51
29th-30th Street System	J33M1	#N/A	#N/A	#N/A	J33M1-33M	#N/A	#N/A	#N/A	47.69	1	48 inch	63	1.28	1.22	0.00095	3.79	3.52	44.33	-3.36	0.00111	5.88	7.84	1.96
29th-30th Street System	J33N1/2	#N/A	#N/A	#N/A	J33N1/2-J33M1	#N/A	#N/A	#N/A	49.22	1	48 inch	945	2.18	1.28	0.00095	3.92	3.52	44.33	-4.89	0.00117	6.99	8.18	1.19
29th-30th Street System	J29D1/2	#N/A	#N/A	#N/A	J29D1/2-29B	#N/A	#N/A	#N/A	54.88	1	5 X 3	829	0.37	-0.57	0.00113	4.25	3.69	55.3	0.42	0.00098	2.89	5.00	2.11
29th-30th Street System	33J	#N/A	#N/A	#N/A	33J-33H	#N/A	#N/A	#N/A	213.07	2	5 X 5	719	-1.96	-2.68	0.00100	4.26	8.39	209.71	-3.35	0.00103	4.97	7.00	2.03
29th-30th Street System	J30N	#N/A	#N/A	#N/A	J30N-J30M	#N/A	#N/A	#N/A	216.34	1	8 X 6	656	-0.71	-1.2	0.00075	4.51	4.48	215.22	-1.12	0.00076	6.87	8.00	1.13
29th-30th Street System	J33G	#N/A	#N/A	#N/A	J33G-33F	#N/A	#N/A	#N/A	224.6	2	6 X 5	337	-3	-3.34	0.00100	3.74	8.89	266.69	42.09	0.00071	4.04	4.00	-0.04
29th-30th Street System	J30M	#N/A	#N/A	#N/A	J30M-30L	#N/A	#N/A	#N/A	267.28	1	8 X 6	338	-1.2	-1.55	0.00102	5.57	5.22	250.34	-16.94	0.00115	6.37	8.00	1.63
29th-30th Street System	30F	#N/A	#N/A	#N/A	30F-30E	#N/A	#N/A	#N/A	492.22	2	9 X 6	333	-5.59	-5.87	0.00085	4.56	9.86	532.56	40.34	0.00072	3.48	4.50	1.02
Total Area/Average C		593.64	0.52																				
33rd Street System	32B	3.68	0.50	5.88	32B-33B	1.84	27.58	3.17	5.88	1	30 inch	388	0.4	0.21	0.00049	1.20	1.85	9.08	3.2	0.00021	2.83	4.48	1.65
33rd Street System	31C	6.87	0.50	10.62	31C - 33C	3.43	29.04	3.07	10.62	1	4' X 2.5'	750	0.9	0.53	0.00049	1.07	2.13	21.31	10.69	0.00012	3.35	4.31	0.96
33rd Street System	35E	8.44	0.60	15.47	35E-33E	5.06	29.56	3.03	15.47	1	2.5 X 1.5	755	0.64	-0.12	0.00100	4.13	2.15	8.18	-7.29	0.00359	6.38	4.39	-1.99
33rd Street System	32D	7.61	0.70	16.37	32D-33D	5.33	29.30	3.05	16.37	1	3 X 2.5	383	0.97	0.78	0.00050	2.18	1.97	14.79	-1.58	0.00063	3.77	4.62	0.85
33rd Street System	33E	2.68	0.70	6.08	33E-33D	18.04	35.42	2.78	50.61	1	7 x 3 ft	340	-0.12	-0.41	0.00085	2.41	3.45	72.42	21.81	0.00041	3.67	4.25	0.58
33rd Street System	33D	3.79	0.70	8.46	33D-33C	26.02	37.77	2.69	70.53	1	7 x 3 ft	340	-0.41	-0.74	0.00097	3.36	3.68	77.25	6.73	0.00079	3.53	4.41	0.88
33rd Street System	33C	13.88	0.50	20.74	33C-33B	36.39	40.68	2.59	94.88	1	7 x 3 ft	344	-0.74	-1.08	0.00099	4.52	3.71	77.96	-16.92	0.00148	3.26	4.19	0.93
33rd Street System	33B	5.04	0.50	7.92	33B-33A	40.75	41.95	2.56	105.2	1	BOX 8 X3	306	-1.08	-1.38	0.00098	4.38	3.79	91.02	-14.18	0.00131	2.75	4.48	1.73

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
33rd Street System	33A	29.29	0.50	42.44	33A-33OUt	55.40	43.11	2.54	141.71	2	BOX 8 X3	1269	-1.38	-2.64	0.00099	2.95	7.63	183.21	41.5	0.00059	2.35	4.00	1.65
Total Area/Average C		81.28	0.58																				
37th Street System	38F	5.28	0.60	9.94	38F-37F	3.17	28.40	3.11	9.94	1	24 inch	368	1.56	1.19	0.00101	4.07	2.31	7.17	-2.76	0.00261	3.39	4.71	1.32
37th Street System	38H	7.22	0.50	11.13	38H-37H	3.61	29.16	3.06	11.13	1	36 inch	351	1.13	0.78	0.00100	2.67	2.97	21.06	9.93	0.00068	2.79	4.30	1.51
37th Street System	38B	7.85	0.50	12.04	38B-37B	3.92	29.37	3.04	12.04	1	30 inch	375	-0.12	-0.49	0.00099	2.48	2.63	12.88	0.84	0.00077	2.26	4.29	2.03
37th Street System	36H	8.07	0.5	12.36	P-731	4.03	29.44	3.04	12.36	#N/A	30 inch	395	0.5	0.11	0.000987	2.55	2.630612245	12.89	0.53	0.00078481	2.86	4.5	1.64
37th Street System	39H	8.1	0.50	12.40	39H-40H1	4.05	29.45	3.04	12.4	1	36 inch	367	-0.58	-0.95	0.00100	1.75	2.97	21.09	8.69	0.00035	4.27	4.42	0.15
37th Street System	37H	7.58	0.50	11.65	37H-37F	11.43	32.02	2.92	33.65	1	6 X 3.67	660	0.11	-0.48	0.00089	2.11	3.73	81.95	48.3	0.00018	2.55	4.47	1.92
37th Street System	37F	13.23	0.50	19.80	37F-37D	21.22	37.23	2.71	57.98	1	6 x 4 ft	660	-0.48	-1.07	0.00089	3.15	3.86	92.62	34.64	0.00038	2.43	3.61	1.18
37th Street System	37D	40.97	0.50	58.45	37D-37B	41.70	40.72	2.59	108.69	2	6 x 4 ft	660	-2.5	-2.83	0.00050	2.26	5.77	138.54	29.85	0.00032	2.18	3.50	1.32
37th Street System	37B	10.49	0.50	15.83	37B-37A	50.87	45.58	2.49	127.6	2	6 X 4.5	330	-2.83	-3	0.00050	2.36	6.04	163.19	35.59	0.00030	1.97	3.63	1.66
37th Street System	37A	15.21	0.50	22.64	37A-37Out	58.48	47.91	2.44	143.93	2	6 X 4.5	700	-3	-3.34	0.00050	2.67	6.04	163.19	19.26	0.00039	1.87	3.89	2.02
Total Area/Average C		124	0.51																				
41st Street. System	41PI	37.3	0.50	53.45	41PI-41Out2	22.96	33.91	2.84	65.81	1	6 X 3.5	1194	-3.71	-4.91	0.00101	3.13	3.87	81.35	15.54	0.00065	2.76	4.50	1.74
41st Street. System	41Out2	19.06	0.50	28.13	41Out2 - 41Out1	32.49	40.26	2.59	84.98	1	6 X 3.5	346	-4.91	-5.25	0.00098	4.05	3.83	80.44	-4.54	0.00110	1.98	7.35	5.37
Total Area/Average C		56.36	0.50																				
45th St. System	45B1	2.96	0.50	4.78	45B1-45B2	1.48	27.11	3.20	4.78	1	24 inch	91	-1.1	-1.19	0.00099	1.52	2.29	7.11	2.34	0.00044	2.62	4.46	1.84
45th St. System	44B	5.72	0.50	8.93	44B-45B2	2.86	28.59	3.10	8.93	1	30 inch	413	-0.78	-1.19	0.00099	1.82	2.64	12.92	3.99	0.00046	2.77	4.49	1.72
45th St. System	45D	34.18	0.50	49.18	45D-45B2	23.29	33.63	2.85	67.02	1	5 X 3	435	-2.85	-3.29	0.00101	4.47	3.48	52.23	-14.79	0.00166	3.30	5.00	1.70
45th St. System	45A	38	0.50	54.41	45A-45Out	46.63	40.17	2.60	122.05	2	8 X 3	1243	-4.05	-5.29	0.00100	2.54	7.66	183.86	61.81	0.00044	2.15	4.38	2.23
45th St. System	45B2	#N/A	#N/A	#N/A	45B2-45A	#N/A	#N/A	#N/A	77.7	2	5 X 3	764	-3.29	-4.05	0.00100	2.59	6.92	103.87	26.17	0.00056	2.58	3.94	1.36
Total Area/Average C		80.86	0.50																				
4th Street System	5A	2.29	0.50	3.74	5A-4A	1.14	26.57	3.24	3.74	1	24 inch	340	6.14	5.97	0.00050	1.27	1.63	5.06	1.32	0.00024	7.86	9.15	1.29
4th Street System	3A	2.49	0.50	4.05	3A-4A	1.24	26.74	3.23	4.05	1	24 inch	379	6.15	5.97	0.00048	1.38	1.59	4.93	0.88	0.00029	7.89	9.00	1.11
4th Street System	4A	4.81	0.50	7.58	4A-4Tuna	4.80	31.34	2.95	14.24	1	36 inch	427	5.97	5.54	0.00100	3.17	2.97	21.09	6.85	0.00096	7.78	10.17	2.39
4th Street System	4Tuna	4.05	0.50	6.44	5.04	6.82	33.58	2.86	19.64	1	42 inch	954	5.04	4.09	0.00100	2.61	3.31	31.81	12.17	0.00045	7.37	10.29	2.92
4th Street System	4Bonita	17.53	0.50	25.95	4Bonita-4Out	15.58	39.66	2.61	41.06	1	42 inch	344	4.09	3.75	0.00099	6.07	3.29	31.63	-9.43	0.00349	6.94	10.22	3.28
Total Area/Average C		31.17	0.50																				
51st Street System	45(1/2)F	2.29	0.70	5.24	45(1/2)F-45F	1.60	26.57	3.24	5.24	1	18 inch	190	0.7	0.51	0.00100	2.96	1.84	3.32	-1.91	0.00253	4.40	5.24	0.84
51st Street System	39G	3.19	0.60	6.16	39G-J40G	1.91	27.27	3.19	6.16	1	24 inch	346	-0.4	-0.75	0.00100	1.96	2.31	7.15	1	0.00075	4.32	4.32	0.00
51st Street System	42H	3.45	0.60	6.63	42H-41H	2.07	27.44	3.18	6.63	1	24 inch	343	2	1.66	0.00100	2.11	2.31	7.15	0.52	0.00085	4.27	6.10	1.83
51st Street System	46M	5.06	0.50	7.95	46M-45(1/2)L	2.53	28.30	3.12	7.95	1	24 inch	168	3	2.75	0.00150	2.53	2.83	8.76	0.81	0.00119	7.03	7.00	-0.03
51st Street System	44F	5.55	0.50	8.68	44F-45F	2.78	28.52	3.10	8.68	1	24 inch	379	0.5	-1.13	0.00430	2.76	4.79	14.84	6.15	0.00148	4.48	6.27	1.79
51st Street System	40F	5.68	0.50	8.87	40F-41F	2.84	28.58	3.10	8.87	1	24 inch	395	1.56	1.16	0.00101	2.82	2.32	7.2	-1.67	0.00152	4.48	6.81	2.33
51st Street System	35K	6	0.50	9.35	35K-37K	3.00	28.71	3.09	9.35	1	30 inch	761	2.04	1.62	0.00055	1.90	1.96	9.62	0.27	0.00053	6.18	8.00	1.82
51st Street System	44J	6.05	0.50	9.42	44J-45J	3.02	28.73	3.09	9.42	1	4 X 3	371	-1.91	-2.19	0.00076	0.78	2.83	34	24.58	0.00005	5.15	7.75	2.60
51st Street System	47(1/2)L1	7.1	0.50	10.96	47(1/2)L1 - 47(1/2)L2	3.55	29.12	3.06	10.96	1	30 inch	71	2.5	2.39	0.00150	2.23	3.24	15.89	4.93	0.00070	6.26	7.00	0.74
51st Street System	41J	7.44	0.50	11.45	41J-41I	3.72	29.24	3.05	11.45	1	6 X 3.5	372	-1.59	-1.96	0.00100	0.55	3.85	80.94	69.49	0.00003	4.00	7.76	3.76
51st Street System	45(1/2)L(1/2)	2.59	0.50	4.21	45(1/2)L(1/2)-45(1/2)L	3.82	29.41	3.04	11.73	1	30 inch	109	1.92	1.81	0.00100	2.39	2.65	12.97	1.24	0.00083	6.83	7.00	0.17
51st Street System	50_(1/2)M(1/2)	9.1	0.50	13.84	50_(1/2)M(1/2) - 50K	4.55	29.75	3.02	13.84	1	24 inch	830	1.03	-0.21	0.00150	4.40	2.83	8.76	-5.08	0.00373	7.76	6.90	-0.86
51st Street System	45M	11.96	0.50	17.97	45M-45L	5.98	30.48	2.98	17.97	1	36 inch	572	1.9	1.04	0.00150	2.54	3.64	25.83	7.86	0.00072	7.01	7.04	0.03
51st Street System	45J	6.21	0.50	9.65	45J-45H	6.13	36.61	2.74	16.9	1	4 x 3 ft	681	-2.19	-2.87	0.00100	1.41	3.26	39.11	22.21	0.00019	5.13	7.38	2.25
51st Street System	41I	5.26	0.50	8.25	41I-41H	6.35	40.61	2.59	16.56	1	6 X 3.5	322	-1.96	-2.28	0.00099	0.79	3.85	80.9	64.33	0.00003	3.99	6.80	2.81
51st Street System	48Wharton	13.45	0.50	20.12	48Wharton-48L	6.72	30.80	2.97	20.12	1	36 inch	465	0.91	0.21	0.00150	2.85	3.64	25.83	5.71	0.00090	6.51	7.23	0.72
51st Street System	59po	19.92	0.5	29.34	59po-59rr	9.96	31.94	2.92	29.34	#N/A	36 inch	1126	-0.33	-1.44	0.000986	4.15	2.949295775	20.94	-8.4	0.001936057	4.61	4	-0.61
51st Street System	41H	3.42	0.50	5.48	41H-41G	10.13	47.42	2.45	25.03	1	6 X 3.5	327	-3.28	-3.61	0.00100	1.19	3.86	81.14	56.11	0.00009	3.98	6.18	2.20
51st Street System	37K	14.9	0.50	22.20	37K-39K	10.45	35.37	2.79	29.34	1	42 inch	760	0.62	0.2	0.00055	3.05	2.46	23.59	-5.74	0.00084	5.78	7.00	1.22
51st Street System	46H	17.5	0.60	31.09	46H-45H	10.50	31.55	2.94	31.09	1	36 inch	338	0.42	-0.09	0.00150	4.40	3.64	25.83	-5.26	0.00219	5.74	5.42	-0.32
51st Street System	48L	2	0.50	3.29	48L-48K	11.27	33.53	2.86	32.49	1	4 X 3	332	0.21	-0.12	0.00100	2.71	3.26	39.14	6.65	0.00069	6.09	7.00	0.91
51st Street System	35M	23.03	0.50	33.72	35M-37M	11.51	32.37	2.91	33.72	1	6.5 X 3.75	760	1.1	0.72	0.00050	1.38	2.87	69.92	36.2	0.00012	7.26	7.65	0.39
51st Street System	45L	4	0.50	6.36	45L-45K	11.80	34.23	2.83	33.68	1	4 X 3	324	1.04	0.72	0.00100	2.81	3.26	39.14	5.45	0.00074	6.60	7.00	0.40
51st Street System	45K	7.54	0.50	11.59	45K-48K	15.58	36.15	2.75	43.23	1	6 x 3 ft	1123	-0.28	-1.12	0.00075	2.40	3.13	56.34	13.11	0.00045	6.36	7.17	0.81
51st Street System	39K	17.2	0.50	25.49	39K-40K	19.05	39.53	2.62	50.29	1	BOX 5X4	379	0.2	-0.01	0.00055	2.51	2.88	57.51	7.22	0.00042	5.14	6.50	1.36
51st Street System	45H	6.17	0.50	9.60	45H-45F	19.72	44.67	2.51	49.81	1	4 x 3 ft	665	-3.87	-4.54	0.00100	4.15	3.26	39.14	-10.68	0.00162	5.00	6.23	1.23
51st Street System	59-rr	19.92	0.5	29.34	P-718	19.92	36.46	2.74	55.05	#N/A	36 inch	122	-1.44	-1.5	0.000492	7.79	2.083098592	14.79	-40.26	0.006803279	2.43	4	1.57
51st Street System	37M	23.25	0.50	34.03	37M-39M	23.14	41.53	2.57	59.93	1	8 X 3.5	762	0.97	0.59	0.00050	2.14	2.91	81.48	21.55	0.00026	7.17	7.65	0.48
51st Street System	45F	2.29	0.70	5.24	45F-J45E	25.70	47.34	2.45	63.54	1	4 x 3 ft	321	-4.54	-4.86	0.00100	5.30	3.26	39.14	-24.41	0.00262	3.92	5.23	1.31
51st Street System	40K	15.4	0.50	22.92	40K-J40J	26.75	42.04	2.56	69.01	1	BOX 5X4	360	-0.01	-0.21	0.00055	3.45	2.88	57.51	-11.49	0.00081	4.98	6.30	1.32
51st Street System	48K	9.7	0.50	14.69	48K-50K	31.70	43.95	2.52	80.56	1	6 x 3 ft	784	-1.12	-1.71	0.00075	4.48	3.13	56.34	-24.21	0.00153	5.86	6.50	0.64
51st Street System	40H1	5.7	0.50	8.90	40H1-J40G	33.65	47.30	2.45	83.24	1	7 x 5 ft	308	-1.95	-2.11	0.00052	2.38	3.35	117.26	34.02	0.00026	4.14	4.50	0.36
51st Street System	39M	26.9	0.50	39.12	39M-41M	36.59	47.46	2.45	90.39	1	5 x 5 ft	761	-0.35	-0.73	0.00050	3.62	2.96	74.1	-16.29	0.00075	6.97	7.79	0.82
51st Street System	41M	17.92	0.50	26.51	41M-43M	45.55	50.97	2.38	109.08	1	5 x 5 ft	764	-0.73	-1.11	0.00050	4.36	2.96	73.95	-35.13	0.00109	6.40	7.36	0.96
51st Street System	41G	5.13	0.50	8.06	41G-41F	48.26	52.09	2.35	114.21	1	8 x 6 ft	343	-3.61	-3.95	0.00100	2.38	5.18	248.51	134.3	0.00020	3.95	5.90	1.95
51st Street System	50K	24.7	0.50	36.06	50K-50J	48.60	46.87	2.46	120.64	1	6 x 5 ft	420	-2.71	-2.92	0.00050	4.02	3.14	94.29	-26.35	0.00083	4.66	6.30	1.64
51st Street System	50J	4	0.7	8.91	50J-50I	51.4	48.61	2.43	125.79	#N/A	6 x 5 ft	384	-2.92	-3.11	0.000495	4.19	3.126666667	93.8	-31.99	0.000885417	4.31	6.7	2.39
51st Street System	41F	5	0.60	9.44	41F-J41E	54.10	54.49	2.29	124.75	1	8 x 6 ft	313	-3.95	-4.26	0.00100	2.60	5.18	248.51	123.76	0.00026	3.88	6.49	2.61
51st Street System	43M	21.69	0.50	31.84	43M-43K	56.40	53.89	2.30	130.9	1	7 X 5	653	-1.11	-1.44	0.00050	3.74	3.28	114.95	-15.95	0.00064	5.57	7.25	1.68
51st Street System	50I	12.64	0.50	18.95	50I-50G	57.72	50.13	2.40	139.44	1	6 x 5 ft	603	-3.11	-3.41	0.00050	4.65	3.14	94.05	-45.39	0.00109	3.97	5.50	1.53
51st Street System	43K	17.99	0.50	26.61	P-709	65.39	56.80	2.23	146.99	1	7 x 5 ft	384	-1.44	-1.63	0.00050	4.20	3.27	114.44	-32.55	0.00081	5.15	7.25	2.10
51st Street System	50G	17	0.50	25.20	50G-50E	66.22	52.30	2.34	156.37	1	6 x 5 ft	669	-3.41	-3.75	0.00051	5.21	3.17	95.06	-61.31	0.00138	3.31	5.50	2.19
51st Street System	43J	6.45	0.70	14.01	43J-43H	69.90	58.32	2.19	154.45	1	8 x 5 ft	688	-1.63	-2.63	0.00145	3.86	5.81	232.3	77.85	0.00064	4.84	7.81	2.97
51st Street System	43H	12.42	0.5	18.63	43H-43F	76.11	61.29	2.13	163.22	#N/A	8 x 5 ft	991	-2.63	-3.87	0.001251	4.08	5.38825	215.53	52.31	0.000726539	4.4	6.5	2.1
51st Street System	43F	0	0.00	0.00	43F-J45	124.91	65.34	2.06	258.94	1	9 X 6	754	-4.65	-5.03	0.00050	4.80	3.80	205.04	-53.9	0.00080	3.68	6.00	2.32
51st Street System	48E	28.37	0.50	41.17	48E-50E	158.13	74.12	1.90	303.32	2	8 x 6 ft	804	-5.59	-5.99	0.00050	3.16	7.30	350.57	47.25	0.00037	2.69	5.70	3.01
51st Street System	51E	0.01	0.50	0.02	51E-J51B	233.45	79.79	1.80	424.43	1	10 x 10 ft	712	-6.77	-7.1	0.00046	4.69	4.50	450.09	25.66	0.00035	2.23	6.00	3.77
51st Street System	50E	18.2	0.5	26.91	50E-51E	233.45	78.36	1.83	430.34	#N/A	8 x 7 ft	331	-6.64	-6.77	0.0004	3.84	6.931428571	388.16	-42.18	0.000483384	2.39	5.5	3.11
51st Street System	51B	144	0.20	62.42	J51B-51A	262.25	82.32	1.77	468.16	1	10 x 10 ft	659	-7.1	-7.4	0.00045	5.16	4.47	446.63	-21.53	0.00047	1.98	4.00	2.02
51st Street System	51A	59.91	0.20	25.97	51A-50-OUT	274.24	84.45	1.74	482.19	2	9 X 8	223	-8.4	-8.5	0.00045	3.35	7.98	574.77	92.58	0.00031	1.67	4.00	2.33
51st Street System	47(1/2)L2	#N/A	#N/A	#N/A	47(1/2)L2-48L	#N/A	#N/A	#N/A	10.82	1	30 inch	178	0.98	0.71	0.00150	2.20	3.24	15.89	5.06	0.00067	6.21	7.00	0.79
51st Street System	45(1/2)L	#N/A	#N/A	#N/A	45(1/2)-45L	#N/A	#N/A	#N/A	11.54	1	30 inch	178	1.81	1.54	0.00150	2.35	3.24	15.89	4.34	0.00079	6.74	7.00	0.26
51st Street System	J40J	#N/A	#N/A	#N/A	J40J-40H	#N/A	#N/A	#N/A	68.07	1	BOX 5X4	719	-0.21	-1.75	0.00214	3.40	5.68	113.5	45.43	0.00076	4.69	7.00	2.31
51st Street System	J40G	#N/A	#N/A	#N/A	J40G-41G	#N/A	#N/A	#N/A	86.43	1	7 x 5 ft	390	-2.1	-2.3	0.00051	2.47	3.33	116.5	30.08	0.00028	4.06	5.00	0.94
51st Street System	J41E	#N/A	#N/A	#N/A	J41-43F	#N/A	#N/A	#N/A	110.06	#N/A	9 X 6	776	-4.26	-4.65	0.000505	2.04	3.801481481	205.28	95.22	0.000154639	3.8	6	2.2
51st Street System	J45E	#N/A	#N/A	#N/A	J45-48E	#N/A	#N/A	#N/A	291.74	2	8 x 6 ft	1122	-5.03	-5.59	0.00050	3.04	7.32	351.14	59.4	0.00035	3.08	6.00	2.92

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
Total Area/Average C		714.65	0.502																				
61st Street System	61P1/2_2	0.44	0.50	0.74	61P1/2_2-61P1/2	0.22	25.00	3.35	0.74	1	24 inch	297	0.78	0.48	0.00100	0.47	2.31	7.15	6.41	0.00003	1.67	5.00	3.33
61st Street System	61Q1/2	3.71	0.50	5.92	61Q1/2-J61Q	1.86	27.60	3.17	5.92	1	36 inch	320	0.15	-0.17	0.00100	1.44	2.97	21.09	15.17	0.00016	1.72	6.00	4.28
61st Street System	61P1/2	3.92	0.50	6.24	61P1/2-J61P	4.04	38.99	2.64	10.74	1	42 inch	322	-1.02	-1.34	0.00100	1.30	3.31	31.81	21.08	0.00012	1.66	7.00	5.34
61st Street System	J61Q	#N/A	#N/A	#N/A	J61Q-61P1/2	#N/A	#N/A	#N/A	5.51	1	42 inch	348	-0.67	-1.02	0.00100	0.75	3.31	31.81	26.3	0.00003	1.67	7.50	5.83
0	J61P	#N/A	#N/A	#N/A	J61P-61Out	#N/A	#N/A	#N/A	10.32	1	42 inch	282	-1.34	-1.62	0.00100	1.15	3.31	31.81	21.49	0.00007	1.62	6.50	4.88
Total Area/Average C		8.07	0.5																				
79th St. System	87Stwrt	8.13	0.50	12.45	87Stwrt-JStwrt1	4.07	29.46	3.04	12.45	1	24 inch	369	5.11	4.74	0.00100	4.94	2.31	7.15	-5.29	0.00385	7.43	8.00	0.57
79th St. System	78Stwrt	19.94	0.50	29.37	78Stwrt-StwrtIn1	14.04	34.71	2.81	39.78	1	42 inch	463	2.74	2.28	0.00099	4.84	3.30	31.68	-8.1	0.00184	5.75	8.00	2.25
79th St. System	StwrtIn1	7.89	0.50	12.10	StwrtIn1-J75Stwrt	17.98	36.30	2.75	49.8	1	48 inch	291	1.78	1.49	0.00100	4.87	3.60	45.42	-4.38	0.00155	4.90	8.00	3.10
79th St. System	JStwrt1	#N/A	#N/A	#N/A	JStwrt1-78Stwrt	#N/A	#N/A	#N/A	12.18	1	36 inch	499	3.74	3.24	0.00100	2.08	2.97	21.09	8.91	0.00032	5.91	7.50	1.59
79th St. System	J75Stwrt	#N/A	#N/A	#N/A	J75Stwrt-StwrtOut1	#N/A	#N/A	#N/A	49.08	1	48 inch	423	1.49	1.07	0.00100	6.13	3.60	45.42	-3.66	0.00303	4.45	8.00	3.55
Total Area/Average C																							
81st System	81Stwrt	15.25	0.50	22.70	81Stwrt-J81_1	7.62	31.16	2.95	22.7	1	4 X 3	1769	0.41	-1.62	0.00115	1.43	7.00	83.94	61.24	0.00012	1.90	6.00	4.10
81st System	81beluche	17.1	0.50	25.34	J81_1-LMOut2	16.18	51.78	2.36	38.4	2	4 X 3	379	-1.62	-2	0.00100	1.60	6.52	78.28	39.87	0.00024	1.69	4.00	2.31
Total Area/Average C		32.35	0.50																				
81st West System	81-can-n	0	0.00	0.00	81cann-81canw	0.00	31.80	0.00	0	#DIV/0!	30 inch	372	-0.51	-1	0.00132	0.00	3.04	14.89	14.89	0.00000	1.60	3.25	1.65
81st West System	81can-w	0	0	0	81canw-81canal	0	34.25	0	0	#N/A	36 inch	135	-1	-1.35	0.002593	0	14.34929577	101.88	101.88	0	1.6	4.25	2.65
81st West System	81-school	0	0	0	81sch-81canw	0	34.25	0	0	#N/A	30 inch	338	-0.34	-1	0.001953	0	7.397959184	36.25	36.25	0	1.6	3.56	1.96
Total Area/Average C																							
9th Street System	6A	4.52	0.50	7.15	6A-7A	2.26	28.04	3.14	7.15	1	30 inch	465	1.08	0.61	0.00100	2.57	2.65	12.97	5.82	0.00084	2.42	8.40	5.98
9th Street System	7A	3.26	0.50	5.24	7A-9_1/2A	3.89	31.06	2.96	11.6	1	36 inch	164	0.11	-0.05	0.00100	2.38	2.97	21.09	9.49	0.00049	2.03	8.64	6.61
9th Street System	5H	12.14	0.50	18.23	5H-5G	6.07	30.52	2.98	18.23	1	30 inch	258	7.72	5.81	0.00740	3.71	7.20	35.29	17.06	0.00198	10.34	12.12	1.78
9th Street System	2E	15.79	0.50	23.47	2E-2D	7.90	31.26	2.95	23.47	1	36 inch	344	3.35	3.01	0.00099	3.32	2.95	20.97	-2.51	0.00125	7.67	8.08	0.41
9th Street System	5G	4.57	0.50	7.22	5G-5F	8.35	31.68	2.93	24.7	1	36 inch	491	5.31	4.54	0.00157	3.49	3.72	26.41	1.71	0.00136	9.83	11.38	1.55
9th Street System	2A	18.37	0.50	27.15	2B-2A	9.18	31.70	2.93	27.15	1	48 inch	314	1.75	1.38	0.00119	2.16	3.93	49.57	22.42	0.00035	6.85	7.68	0.83
9th Street System	5F	4.67	0.50	7.37	5F-5E	10.69	34.02	2.84	30.59	1	36 inch	248	3.93	3.68	0.00100	4.33	2.97	21.09	-9.5	0.00210	9.16	10.61	1.45
9th Street System	5E	4.57	0.50	7.22	5E-4E	12.97	34.98	2.80	36.63	1	36 inch	380	3.68	3.3	0.00100	5.18	2.97	21.09	-15.54	0.00303	8.64	10.75	2.11
9th Street System	2D	13.69	0.50	20.46	2D-2B	14.74	32.98	2.88	42.8	1	48 inch	572	2.01	1.44	0.00100	3.41	3.60	45.42	2.62	0.00087	7.24	7.56	0.32
9th Street System	4E	14.26	0.50	21.28	4E-4D	20.10	36.20	2.75	55.77	1	42 inch	281	2.3	2.02	0.00100	5.80	3.31	31.81	-23.96	0.00306	7.49	9.81	2.32
9th Street System	4D	7.84	0.50	12.03	4D-4C	24.02	37.01	2.72	65.86	1	54 inch	332	1.52	1.19	0.00100	4.14	3.91	62.18	-3.68	0.00111	6.63	9.41	2.78
9th Street System	4C	9.07	0.50	13.80	4C-4B	28.56	38.34	2.67	76.76	1	54 inch	379	1.19	0.81	0.00100	4.83	3.91	62.18	-14.58	0.00153	6.26	9.83	3.57
9th Street System	2B	22.91	0.50	33.55	4B-2B	35.38	35.78	2.77	98.74	1	60 inch	736	0.99	-0.19	0.00160	5.03	5.32	104.28	5.54	0.00144	6.74	7.73	0.99
9th Street System	4B	5.36	0.70	11.76	4B - 6B	67.69	39.65	2.61	178.36	1	6 x 5 ft	765	0.8	0.04	0.00100	6.36	4.44	133.34	-45.02	0.00150	5.68	8.89	3.21
9th Street System	6B	9.85	0.70	20.87	7B-6B	74.59	41.66	2.57	192.99	1	6 x 5 ft	374	0.04	-0.33	0.00100	8.24	4.44	133.34	-59.64	0.00374	4.53	11.30	6.77
9th Street System	7B	3.55	0.70	7.95	7B-9_1/2A	77.07	42.41	2.55	198.24	1	7 X 5	720	-1.33	-2.05	0.00099	6.72	4.64	162.24	-36.01	0.00164	3.13	14.50	11.37
9th Street System	9_1/2A	2.48	0.50	4.04	9(1/2)A-O-10	82.20	44.20	2.52	208.48	1	7 X 5	122	-2.05	-2.17	0.00098	7.67	4.61	161.35	-47.13	0.00287	1.95	7.54	5.59
Total Area/Average C		156.9	0.54																				
Bayou Shore System	48S1/2	2.8	0.50	4.53	48S1/2-49S1/2	1.40	26.99	3.21	4.53	1	24 inch	574	6.3	5.39	0.00159	1.64	2.91	9.01	4.48	0.00037	7.76	11.00	3.24
Bayou Shore System	56S	4.17	0.50	6.62	56S-56R1/2	2.08	27.86	3.15	6.62	1	30 inch	333	0.25	-0.08	0.00099	1.35	2.63	12.91	6.29	0.00024	3.53	4.00	0.47
Bayou Shore System	WestW	5.37	0.50	8.41	WestW-53U	2.68	28.44	3.11	8.41	1	24 inch	495	7.14	6.64	0.00101	4.06	2.32	7.19	-1.22	0.00232	8.82	12.00	3.18
Bayou Shore System	FCB1	6.33	0.50	9.83	FCB1-JFCB1	3.16	28.84	3.08	9.83	1	36 inch	109	6.85	6.74	0.00101	2.14	2.98	21.19	11.36	0.00037	8.67	13.50	4.83
Bayou Shore System	55S	7.77	0.50	11.93	55S-55R1/2	3.88	29.35	3.05	11.93	1	30 inch	332	0.86	0.53	0.00099	2.43	2.64	12.93	1	0.00087	4.12	6.50	2.38
Bayou Shore System	52S1/2	8.9	0.50	13.55	52S1/2-51S1/2	4.45	29.70	3.02	13.55	1	24 inch	382	4.87	4.49	0.00100	4.31	2.30	7.13	-6.42	0.00361	8.16	10.00	1.84
Bayou Shore System	48T1/2	9.91	0.50	14.99	48T1/2-49T1/2	4.95	29.98	3.00	14.99	1	36 inch	566	6	5.43	0.00100	2.57	2.97	21.09	6.1	0.00055	8.19	11.00	2.81
Bayou Shore System	BShrHeron	10.4	0.50	15.70	BShrHeron-BShrIbis	5.20	30.10	3.00	15.7	1	36 inch	521	3.14	2.32	0.00157	2.54	3.73	26.46	10.76	0.00048	5.37	8.00	2.63
Bayou Shore System	53S	11.72	0.50	17.62	53S-53R1/2	5.86	30.43	2.98	17.62	1	30 inch	330	2.06	1.73	0.00100	3.59	2.65	12.97	-4.65	0.00182	5.01	9.50	4.49
Bayou Shore System	Adler	12.22	0.50	18.34	Adler-UNrAdler	6.11	30.54	2.98	18.34	1	24 inch	169	4.92	4.75	0.00101	6.45	2.31	7.17	-11.17	0.00787	7.62	11.00	3.38
Bayou Shore System	FCB2	8.3	0.50	12.69	FCB2-JFCB6	7.32	36.52	2.74	20.2	1	42 inch	80	5.58	5.5	0.00100	2.35	3.31	31.81	11.62	0.00038	8.48	13.50	5.02
Bayou Shore System	49T1/2	8.59	0.50	13.11	49T1/2-JWOOD	9.25	33.64	2.85	26.61	1	42 inch	303	4.37	4.07	0.00100	2.77	3.31	31.81	5.2	0.00069	7.88	11.00	3.12
Bayou Shore System	FCB3	4.07	0.50	6.47	FCB3-JFCB9	9.35	39.96	2.60	24.52	1	48 inch	93	4.62	4.53	0.00097	2.01	3.55	44.68	20.16	0.00022	8.33	14.00	5.67
Bayou Shore System	59Shr	7.46	0.50	11.48	59Shr-59Out	9.36	41.84	2.56	24.19	1	36 inch	226	-4.24	-4.35	0.00050	3.42	2.10	14.91	-9.28	0.00133	1.90	5.00	3.10
Bayou Shore System	59S	19.62	0.50	28.92	59S-59R1/2	9.81	31.89	2.92	28.92	1	3 X 3	321	-2	-2.48	0.00150	3.21	3.66	32.91	3.99	0.00115	3.36	3.00	-0.36
Bayou Shore System	BShrIbis	13.19	0.50	19.74	BShrIbis-BShrU	11.79	33.53	2.86	33.99	1	42 inch	696	1.82	0.72	0.00158	3.57	4.17	40	6	0.00108	5.12	6.00	0.88
Bayou Shore System	49S1/2	5.49	0.50	8.59	49S1/2	13.40	36.60	2.74	36.94	1	42 inch	566	3.89	2.99	0.00159	3.84	4.18	40.12	3.17	0.00136	7.55	10.00	2.45
Bayou Shore System	59R1/2	10.31	0.50	15.57	59R1/2-59R	14.96	33.56	2.86	43.11	1	5 X 3	343	-3.48	-3.65	0.00050	2.87	2.45	36.72	-6.39	0.00070	2.99	3.00	0.01
Bayou Shore System	59R	7.23	0.50	11.14	59R-59Q	18.58	35.54	2.78	52.03	1	6 x 3 ft	681	-3.65	-3.99	0.00050	2.89	2.56	46.01	-6.03	0.00063	2.75	3.00	0.25
Bayou Shore System	FCB4	21.21	0.50	31.16	FCB4-49U	19.95	42.59	2.55	51.26	1	54 inch	345	3.81	3.67	0.00041	3.24	2.49	39.61	-11.64	0.00061	8.25	12.50	4.25
Bayou Shore System	51S1/2	10.73	0.50	16.18	51S1/2-J51S	23.21	39.06	2.64	61.71	1	42 inch	322	2.99	2.48	0.00158	6.66	4.17	40.04	-21.67	0.00382	6.78	10.00	3.22
Bayou Shore System	49U	7.62	0.50	11.71	49U-51U	23.76	44.37	2.51	60.19	1	54 inch	572	3.67	3.45	0.00039	3.88	2.43	38.56	-21.63	0.00084	8.04	12.00	3.96
Bayou Shore System	51R1/2	5.74	0.50	8.96	51R1/2-J52R1/2	26.08	40.95	2.58	67.85	1	54 inch	375	0.95	0.34	0.00163	4.41	4.99	79.31	11.46	0.00096	5.01	9.00	3.99
Bayou Shore System	59Q	17.8	0.50	26.34	59Q-59Shr	27.48	39.47	2.62	72.61	1	7 X 3	491	-3.99	-4.24	0.00050	3.46	2.64	55.45	-17.16	0.00086	2.32	2.50	0.18
Bayou Shore System	51U	7.6	0.50	11.68	51U-52U	27.56	46.82	2.46	68.45	1	54 inch	366	3.45	3.3	0.00041	4.63	2.50	39.81	-28.64	0.00120	7.56	12.00	4.44
Bayou Shore System	52U	6.34	0.50	9.84	52U-53U	30.74	48.14	2.44	75.51	1	54 inch	384	3.3	3.14	0.00042	5.80	2.52	40.14	-35.37	0.00216	7.12	12.00	4.88
Bayou Shore System	53U	4.1	0.50	6.51	53U-UNrAdler	35.47	49.24	2.42	86.35	1	60 inch	572	2.64	1.75	0.00156	5.50	5.24	102.73	16.38	0.00128	6.29	11.00	4.71
Bayou Shore System	53R1/2	8.89	0.50	13.54	53R1/2-55R1/2	36.38	44.21	2.52	92.27	1	66 inch	757	-1.27	-2.47	0.00159	3.88	5.62	133.69	41.43	0.00077	4.41	9.00	4.59
Bayou Shore System	55R1/2	5.86	0.50	9.14	55R1/2-56R1/2	43.20	47.46	2.45	106.72	1	66 inch	384	-2.47	-3.08	0.00159	4.49	5.62	133.83	27.12	0.00099	3.83	7.50	3.67
Bayou Shore System	UNrAdler	6.98	0.50	10.78	UNrAdler-BShrU	45.07	50.98	2.38	107.92	1	60 inch	856	1.74	-0.78	0.00295	6.10	7.22	141.44	33.52	0.00139	5.56	10.00	4.44
Bayou Shore System	56R1/2	3.84	0.50	6.12	56R1/2-57R1/2	47.20	48.89	2.42	115.26	1	66 inch	379	-3.08	-3.68	0.00158	4.85	5.61	133.61	18.35	0.00119	3.45	4.00	0.55
Bayou Shore System	57R1/2	1.88	0.50	3.10	57R1/2-BShrR1/2	48.14	50.19	2.40	116.24	1	66 inch	147	-3.68	-3.91	0.00157	4.89	5.58	132.82	16.58	0.00122	3.18	3.00	-0.18
Bayou Shore System	55Q	25.89	0.50	37.72	55Q-BShrQ	59.08	75.59	1.88	111.78	1	8 X 6	1059	-2.82	-3.88	0.00100	2.46	5.18	248.51	136.73	0.00015	2.56	6.00	3.44
Bayou Shore System	BShrU	11.06	0.50	16.66	BShrU-BShrS	62.40	53.32	2.32	145.73	1	6 X 6	1247	-1.78	-3.75	0.00158	4.05	5.95	214.31	68.58	0.00073	4.37	6.00	1.63
Bayou Shore System	BShrS	37.66	0.50	53.95	BShrS-JBShrR1/2	81.22	58.45	2.19	179.21	1	6 X 6	301	-3.75	-4.22	0.00158	4.98	5.94	213.97	34.77	0.00110	3.46	3.50	0.04
Bayou Shore System	BShrR1/2	1.79	0.50	2.95	BShrR1/2-BShrR	130.27	59.86	2.15	282.78	1	9 X 6	334	-4.41	-4.78	0.00111	5.24	5.63	303.99	21.2	0.00096	3.32	3.00	-0.32
Bayou Shore System	BShrR	5.7	0.50	8.90	BShrR-BShrQ	133.12	60.92	2.13	286.33	1	9 X 6	669	-4.78	-5.7	0.00138	5.30	6.27	338.69	52.37	0.00097	3.05	3.00	-0.05
Bayou Shore System	BShrQ	11.87	0.50	17.84	BShrQ-BShrP1/2	198.13	82.76	1.77	352.59	1	9 X 6	429	-5.7	-6.29	0.00138	6.53	6.27	338.71	-13.88	0.00149	2.40	3.00	0.60
Bayou Shore System	BShrP1/2	2.8	0.50	4.53	BShrP1/2-Bshor-Out	221.37	83.86	1.75	390.9	3	6 X 6	266	-6.29	-6.65	0.00135	3.62	16.53	595.09	204.18	0.00060	1.76	4.00	2.24
Bayou Shore System	JFCB5	#N/A	#N/A	#N/A	JFCB5-FCB2	#N/A	#N/A	#N/A	8.95	1	42 inch	107	5.69	5.58	0.00103	1.07	3.36	32.26	23.3	0.00009	8.49	14.00	5.51
Bayou Shore System	JFCB4	#N/A	#N/A	#N/A	JFCB4-JFCB5	#N/A	#N/A	#N/A	9.2	1	36 inch	194	6.38	6.19	0.00098	1.64	2.94	20.87	11.67	0.00021	8.53	14.00	5.47
Bayou Shore System	JFCB3	#N/A	#N/A	#N/A	JFCB3-JFCB4	#N/A	#N/A	#N/A	9.42	1	36 inch	184	6.56	6.38	0.00098	1.80	2.94	20.86	11.44	0.00022	8.57	14.00	5.43
Bayou Shore System	JFCB2	#N/A	#N/A	#N/A	JFCB2-JFCB3	#N/A	#N/A	#N/A	9.53	1	36 inch	98	6.66	6.56	0.00102	1.93	3.00	21.3	11.78	0.00031	8.60	14.00	5.40
Bayou Shore System	JFCB1	#N/A	#N/A	#N/A	JFCB1-JFCB2	#N/A	#N/A	#N/A	9.64	1	36 inch	78	6.74	6.66	0.00103	2.02	3.01	21.36	11.72	0.00038	8.63	14.00	5.37
Bayou Shore System	JFCB8	#N/A	#N/A	#N/A	JFCB8-FCB3	#N/A	#N/A	#N/A	19.53	1	42 inch	150	5.27	5.12	0.00100	2.14	3.31	31.81	12.29	0.00027	8.37	14.00	5.63

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
Bayou Shore System	JFCB7	#N/A	#N/A	#N/A	JFCB7-JFCB8	#N/A	#N/A	#N/A	19.84	1	42 inch	140	5.41	5.27	0.00100	2.23	3.31	31.81	11.98	0.00036	8.42	14.00	5.58
Bayou Shore System	JFCB6	#N/A	#N/A	#N/A	JFCB6-JFCB7	#N/A	#N/A	#N/A	20.03	1	42 inch	91	5.5	5.41	0.00099	2.29	3.30	31.64	11.61	0.00033	8.45	14.00	5.55
Bayou Shore System	JFCB9	#N/A	#N/A	#N/A	JFCB9-FCB4	#N/A	#N/A	#N/A	24.37	1	48 inch	219	4.53	4.31	0.00101	1.96	3.61	45.53	21.16	0.00027	8.31	13.00	4.69
Bayou Shore System	JWOOD	#N/A	#N/A	#N/A	JWOOD-49S1/2	#N/A	#N/A	#N/A	25.93	1	42 inch	183	4.07	3.89	0.00100	2.70	3.31	31.81	5.88	0.00066	7.67	10.50	2.83
Bayou Shore System	J51S	#N/A	#N/A	#N/A	J51S-51R1/2	#N/A	#N/A	#N/A	60.96	1	48 inch	335	1.98	1.45	0.00158	5.15	4.53	57.13	-3.83	0.00161	5.55	10.00	4.45
Bayou Shore System	J52R1/2	#N/A	#N/A	#N/A	J52R1/2-53R1/2	#N/A	#N/A	#N/A	67.11	1	60 inch	382	-0.16	-0.77	0.00160	3.44	5.31	104.07	36.96	0.00063	4.65	9.50	4.85
Bayou Shore System	JBShrR1/2	#N/A	#N/A	#N/A	JBShrR1/2-BShrR1/2	#N/A	#N/A	#N/A	177.14	1	6 X 6	118	-4.22	-4.41	0.00158	4.92	5.95	214.07	36.93	0.00110	3.13	3.50	0.37
Total Area/Average C		369.21	0.5																				
Beluche System	75In1	5.36	0.50	8.40	75In1-75Blch	2.68	28.44	3.11	8.4	1	24 inch	437	1.44	1	0.00100	2.72	2.31	7.15	-1.25	0.00121	3.40	6.00	2.60
Beluche System	80Blch	18.25	0.50	26.98	80Blch-75Blch	9.12	31.68	2.93	26.98	1	36 inch	1644	2.64	1	0.00100	4.82	2.97	21.09	-5.89	0.00184	5.90	7.00	1.10
Beluche System	75Blch	16.65	0.50	24.70	75Blch-LMOut3	20.13	37.37	2.71	54.89	1	36 inch	181	-1	-1.18	0.00100	7.90	2.97	21.09	-33.8	0.00702	2.87	5.00	2.13
Total Area/Average C		40.26	0.50																				
Central City System	GBIn3	6.17	0.50	9.60	GBIn3-GBIn2	3.08	28.78	3.09	9.6	1	36 inch	359	1.32	0.96	0.00100	1.63	2.97	21.12	11.52	0.00022	3.52	7.50	3.98
Central City System	GBIn4	6.42	0.50	9.96	GBIn4-GBIn2	3.21	28.87	3.08	9.96	1	42 inch	964	1.42	0.46	0.00100	1.38	3.31	31.75	21.78	0.00011	3.55	7.50	3.95
Central City System	GBIn2	14.42	0.50	21.51	GBJ1-GBIn2	13.50	40.51	2.59	35.26	1	60 inch	535	-1.04	-1.57	0.00099	1.85	4.18	81.97	46.71	0.00015	3.44	7.50	4.06
Central City System	GBIn5	40.43	0.50	57.72	GBIn5-GBJ4	20.22	34.18	2.83	57.72	1	48 inch	319	-0.1	-0.41	0.00097	4.59	3.55	44.78	-12.95	0.00160	5.02	9.00	3.98
Central City System	GBIn1	20.16	0.50	29.68	GBIn1-GBOut	43.80	52.61	2.33	103.08	1	72 inch	406	-3.2	-3.6	0.00099	3.64	4.70	132.92	29.85	0.00059	3.30	8.00	4.70
Central City System	GBJ1	#N/A	#N/A	#N/A	GBJ1-GBIn1	#N/A	#N/A	#N/A	33.94	1	66 inch	625	-2.07	-2.7	0.00101	1.43	4.48	106.61	72.67	0.00010	3.36	8.00	4.64
Central City System	GBJ2	#N/A	#N/A	#N/A	GBJ2-GBIn1	#N/A	#N/A	#N/A	55.36	1	48 inch	320	-0.88	-1.2	0.00100	4.41	3.60	45.42	-9.94	0.00150	3.78	9.00	5.22
Central City System	GBJ3	#N/A	#N/A	#N/A	GBJ3-GBJ2	#N/A	#N/A	#N/A	56.48	1	48 inch	370	-0.51	-0.88	0.00100	4.49	3.60	45.42	-11.05	0.00154	4.35	10.00	5.65
Central City System	GBJ4	#N/A	#N/A	#N/A	GBJ4-GBJ3	#N/A	#N/A	#N/A	56.78	1	48 inch	101	-0.41	-0.51	0.00099	4.52	3.59	45.2	-11.58	0.00158	4.51	10.00	5.49
Total Area/Average C		87.6	0.5																				
Colony Park South System	ColStwrt	19.47	0.50	28.70	ColStwrt-StwrtIn2	9.74	31.87	2.93	28.7	1	3 X 3	626	2.5	1.87	0.00101	3.19	2.99	26.94	-1.77	0.00113	7.44	7.50	0.06
Colony Park South System	StwrtIn2	3.12	0.50	5.02	StwrtIn2-JSoStwrt	11.30	35.14	2.79	31.81	1	3 X 3	211	1.87	1.66	0.00100	3.53	2.98	26.79	-5.02	0.00142	6.73	7.00	0.27
Colony Park South System	SoStwrt	11.19	0.50	16.85	SoStwrt-JStwrt2	16.89	36.84	2.73	46.42	1	4 x 3 ft	312	1.51	1.2	0.00100	3.87	3.26	39.14	-7.28	0.00141	6.23	7.00	0.77
Colony Park South System	IStwrtPn	39	0.70	78.08	IStwrtPn-JStwrtPn	44.19	40.24	2.60	115.6	2	42 inch	423	-0.27	-0.69	0.00100	6.01	6.63	63.63	-51.97	0.00331	5.16	7.00	1.84
Pine System	JStwrtPn	#N/A	#N/A	#N/A	JStwrtPn-StwrtOut2	#N/A	#N/A	#N/A	114.55	2	42 inch	235	-0.69	-0.93	0.00100	5.95	6.63	63.63	-50.93	0.00323	3.76	#N/A	#N/A
Colony Park South System	JSoStwrt	#N/A	#N/A	#N/A	JSoStwrt-SoStwrt	#N/A	#N/A	#N/A	31.36	1	3 X 3	147	1.66	1.51	0.00102	3.48	3.01	27.13	-4.24	0.00136	6.43	7.00	0.57
Colony Park South System	JStwrt2	#N/A	#N/A	#N/A	JStwrt2-IStwrtPn	#N/A	#N/A	#N/A	45.5	1	4 x 3 ft	468	1.2	0.73	0.00100	3.79	3.26	39.14	-6.36	0.00135	5.79	#N/A	#N/A
Total Area/Average C		72.78	0.55																				
Colony Park System	CDFrwy	26.09	0.50	38.00	CDFrwy-CDGC	13.04	32.76	2.89	38	1	42 inch	301	0.62	0.33	0.00096	3.95	3.25	31.23	-6.77	0.00143	4.33	6.00	1.67
Colony Park System	CDGC	8.2	0.50	12.55	CDGC-LMNIn1	17.14	34.03	2.84	49.06	1	48 inch	587	0.38	-0.1	0.00082	4.29	3.26	41.07	-7.99	0.00114	3.90	6.50	2.60
Colony Park System	LMNIn1	21.25	0.50	31.22	LMNIN1-JLM1	27.77	36.31	2.75	76.91	1	54 inch	289	-0.6	-0.77	0.00059	5.60	3.00	47.69	-29.22	0.00187	3.23	8.00	4.77
Colony Park System	LMNrDby	21.04	0.50	30.92	LMNrDby-JLMPne	38.29	38.74	2.65	102.3	1	66 inch	277	-2.11	-2.38	0.00098	5.03	4.41	104.84	2.53	0.00097	2.28	9.00	6.72
Colony Park System	LMBlch	20.53	0.50	30.20	LMBlch-LMOut1	48.56	40.18	2.60	127.07	1	72 inch	323	-2.95	-3.12	0.00053	5.24	3.43	97.15	-29.92	0.00102	1.93	7.50	5.57
Colony Park System	JLM1	#N/A	#N/A	#N/A	JLM1-LMNrDby	#N/A	#N/A	#N/A	75.94	1	60 inch	431	-1.27	-1.61	0.00079	4.60	3.73	73.15	-2.8	0.00095	2.69	7.00	4.31
Colony Park System	JLMPne	#N/A	#N/A	#N/A	JLMPne-LMBlch	#N/A	#N/A	#N/A	100.89	1	72 inch	130	-2.88	-2.95	0.00054	4.09	3.47	98.27	-2.62	0.00062	2.01	6.00	3.99
Total Area/Average C		97.11	0.5																				
East Heards System	61R	2.89	0.50	4.67	61R-61R1/2	1.44	27.05	3.21	4.67	1	36 inch	337	0.17	-0.17	0.00100	0.68	2.97	21.09	16.42	0.00003	2.89	7.00	4.11
East Heards System	61R1/2	2.06	0.50	3.38	61R1/2-J61S	2.47	35.35	2.79	6.95	1	42 inch	274	-0.67	-0.94	0.00100	0.72	3.31	31.81	24.86	0.00007	2.88	6.50	3.62
East Heards System	61S1/2	22.18	0.50	32.53	61S1/2-61S	11.09	32.26	2.91	32.53	1	36 inch	335	-0.16	-0.5	0.00100	4.60	2.97	21.09	-11.44	0.00239	3.66	6.00	2.34
East Heards System	66Hrd1	22.34	0.50	32.75	66Hrd1-JHrd1	11.17	32.28	2.91	32.75	1	4 x 3 ft	207	-1	-1.08	0.00040	2.73	2.06	24.75	-8	0.00068	3.36	3.00	-0.36
East Heards System	61S	5.62	0.50	8.78	P-97	16.38	44.59	2.51	41.4	1	60 inch	511	-2.5	-3.01	0.00100	2.11	4.20	82.35	40.95	0.00025	2.86	7.00	4.14
East Heards System	ByuHmHrd	16.18	0.50	24.03	ByuHmHrd-VictHrd	19.26	35.31	2.79	54.12	1	5 X 3	321	-2.19	-2.32	0.00040	3.61	2.19	32.85	-21.27	0.00109	3.02	4.00	0.98
East Heards System	VictHrd	7.4	0.50	11.39	P-93	22.96	36.79	2.73	63.14	1	6 X 3	382	-2.32	-2.47	0.00040	3.51	2.29	41.15	-21.99	0.00094	2.67	3.00	0.33
East Heards System	GrnBayIn	0	0.00	0.00	GrnBayIn-J62Hrd2	24.18	39.72	2.61	99.43	1	60 inch	1607	-4.11	-4.01	-0.00006	5.06	-1.05	-20.54	-119.97	0.00146	4.22	4.50	0.28
East Heards System	62CalvCm	15.57	0.50	23.16	62CalvCm-J62R1/2	35.80	48.63	2.43	95.61	1	72 inch	309	-4.01	-4.03	0.00006	3.38	1.17	33.21	-62.4	0.00049	2.73	4.50	1.77
East Heards System	62R	2.8	0.50	4.53	62R-62Q	37.20	51.75	2.36	96.36	1	72 inch	640	-4.05	-4.09	0.00006	3.41	1.15	32.63	-63.73	0.00052	2.42	4.50	2.08
East Heards System	64Hrd	35.27	0.50	50.68	64Hrd-J62Hrd2	40.60	38.61	2.66	108.67	1	6 X 4	357	-3.61	-3.75	0.00040	4.53	2.58	61.96	-46.71	0.00120	2.31	3.00	0.69
East Heards System	62Q	6.94	0.50	10.72	62Q-J62Hrd	40.67	54.88	2.28	101.39	1	72 inch	336	-4.09	-4.11	0.00006	3.59	1.15	32.67	-68.72	0.00060	2.09	4.00	1.91
East Heards System	J61S	#N/A	#N/A	#N/A	J61S-61S	#N/A	#N/A	#N/A	6.4	1	60 inch	57	-2.44	-2.5	0.00100	0.33	4.20	82.35	75.95	0.00000	2.86	7.00	4.14
East Heards System	JHrd1	#N/A	#N/A	#N/A	JHrd1-ByuHmHrd	#N/A	#N/A	#N/A	32.18	1	4 X 3	284	-1.08	-1.19	0.00040	2.68	2.06	24.75	-7.43	0.00070	3.22	4.00	0.78
East Heards System	J62R1/2	#N/A	#N/A	#N/A	J62R1/2-62R	#N/A	#N/A	#N/A	94.48	1	72 inch	321	-4.03	-4.05	0.00006	3.34	1.15	32.58	-61.9	0.00050	2.58	4.50	1.92
East Heards System	J62Hrd2	#N/A	#N/A	#N/A	J62Hrd2-62Out2	#N/A	#N/A	#N/A	109.45	1	60 inch	156	-4.11	-4.12	0.00006	5.57	1.06	20.85	-88.6	0.00179	1.88	3.50	1.62
East Heards System	J62Hrd	#N/A	#N/A	#N/A	J62Hrd-62Out	#N/A	#N/A	#N/A	181.67	1	72 inch	163	-4.11	-4.12	0.00006	6.48	1.17	33.17	-148.5	0.00178	1.89	3.50	1.61
Total Area/Average C		139.25	0.4583																				
Ferry Road System	Ferry_Barracuda	22.03	0.50	32.32	Ferry_Barracuda - Ferry_Dolphin	11.01	32.24	2.91	32.32	1	42 inch	237	2.94	2.7	0.00100	3.36	3.31	31.81	-0.5	0.00101	7.38	7.10	-0.28
Ferry Road System	Ferry-Bonita	18.72	0.50	27.64	Ferry_Bonita - Ferry_Tarpon	20.38	35.23	2.79	57.32	1	48 inch	774	2.42	1.77	0.00084	4.56	3.30	41.62	-15.69	0.00160	7.16	7.00	-0.16
Ferry Road System	Ferry_Whiting	30.6	0.50	44.25	Ferry_Whiting- Ferry_next	35.67	40.01	2.60	93.49	2	48 inch	1010	0.92	-0.09	0.00100	3.72	7.21	90.84	-2.65	0.00106	5.18	7.00	1.82
Ferry Road System	Ferry_next	27.76	0.50	40.32	Ferry_next - I8	49.55	44.53	2.51	125.35	2	48 inch	459	-0.09	-0.55	0.00100	5.03	7.21	90.84	-34.5	0.00185	4.11	7.00	2.89
Ferry Road System	I-9	44.5	0.50	63.24	I9 - Ferry_out	71.80	46.98	2.46	178.09	2	54 inch	575	-2.28	-3	0.00125	5.60	8.75	139.16	-38.93	0.00205	2.78	7.20	4.42
Ferry Road System	Ferry_Dolphin	#N/A	#N/A	#N/A	Ferry_Dolphin - Ferry_Bonita	#N/A	#N/A	#N/A	31.79	1	48 inch	276	2.7	2.42	0.00100	2.53	3.60	45.42	13.63	0.00051	7.14	7.20	0.06
Ferry Road System	Ferry_Pompano	#N/A	#N/A	#N/A	Ferry_Tarpon - Ferry_Avalon	#N/A	#N/A	#N/A	54.99	1	48 inch	511	1.41	0.92	0.00096	4.38	3.53	44.48	-10.51	0.00145	5.92	7.20	1.28
Ferry Road System	I-8	#N/A	#N/A	#N/A	I8-I9	#N/A	#N/A	#N/A	123.83	2	48 inch	283	-0.55	-0.83	0.00100	5.10	7.21	90.84	-32.98	0.00170	3.26	7.88	4.62
Total Area/Average C		143.61	0.5																				
Greens Bayou System	JCalvCm1	#N/A	#N/A	#N/A	JCalvCm1-T1/2Out	#N/A	#N/A	#N/A	69.74	1	60 inch	358	-4.16	-4.52	0.00101	3.55	4.21	82.58	12.84	0.00073	3.32	7.00	3.68
Greens Bayou System	greensbayou	119.42	0.3	96.46	greens	35.83	38.22	2.67	96.46	#N/A	60 inch	441	-3.9	-4.01	0.000249	4.91	2.098469388	41.13	-55.33	0.001360544	4.82	7	2.18
Total Area/Average C		119.42	0.3																				
Jones/Gerol System	I-478	3.38	0.5	5.42	P-713	1.69	27.39	3.18	5.42	#N/A	24 inch	444	1.56	0.49	0.00241	1.73	3.580645161	11.1	5.68	0.000585586	3.68	5.73	2.05
Jones/Gerol System	JDGrl	13.11	0.50	19.63	JDGrl-J_JDOut	8.24	31.68	2.93	24.38	1	30 inch	379	0.29	-0.09	0.00100	5.20	2.65	12.99	-11.39	0.00359	3.42	6.57	3.15
Jones/Gerol System	J_JDOut	#N/A	#N/A	#N/A	J_JDOut-JDOut1	#N/A	#N/A	#N/A	23.97	1	30 inch	134	-2.57	-2.77	0.00150	4.88	3.24	15.89	-8.09	0.00343	2.06	10.00	7.94
Total Area/Average C		16.49	0.5																				
West Heards System	72JD	3.05	0.50	4.92	72JD-73JD	1.52	27.17	3.20	4.92	1	24 inch	381	3.44	2.35	0.00286	1.73	3.90	12.1	7.18	0.00042	4.98	5.46	0.48
West Heards System	73JD	7.13	0.50	11.00	73R-73JD	5.09	30.84	2.97	15.22	1	36 inch	343	2.1	1.76	0.00099	2.22	2.96	21	5.78	0.00044	4.82	6.00	1.18
West Heards System	PopStwrt	10.28	0.5	15.53	P-720	5.14	30.07	3	15.53	#N/A	30 inch	384	1.71	1.51	0.000521	3.16	1.910204082	9.36	-6.17	0.001432292	4.72	5	0.28
West Heards System	73R	4.62	0.5	7.3	J73Q-73R	7.4	33.42	2.86	21.36	#N/A	36 inch	634	1.76	1.12	0.001009	3.04	2.984507042	21.19	-0.17	0.000914826	4.67	4.77	0.1
West Heards System	69Stwrt	5.96	0.50	9.29	P-721	8.12	32.09	2.92	23.87	1	42 inch	1366	1	-2.28	0.00240	2.54	5.14	49.3	25.43	0.00055	4.17	5.00	0.83
West Heards System	66Hrd2	19.48	0.50	28.72	66Hrd2-JHrd2	9.74	31.87	2.93	28.72	1	4 x 3 ft	296	-1	-1.12	0.00040	2.39	2.06	24.75	-3.97	0.00054	3.78	3.00	-0.78
West Heards System	I-477	12.62	0.5	18.92	P-714	13.71	38.68	2.65	36.66	#N/A	36 inch	221	1	0.78	0.000995	6.37	2.963380282	21.04	-15.62	0.004932127	3.84	6	2.16
West Heards System	74hrd	2.46	0.50	4.01	P-646	14.94	39.25	2.63	39.61	1	36 inch	234	0.78	0.5	0.00120	5.05	6.50	46.14	6.54	0.00329	2.70	5.50	2.80

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
West Heards System	70Hrd	31.94	0.50	46.10	70Hrd-JHrdOut	15.97	33.40	2.86	46.1	1	5 X 3	265	-2.32	-2.43	0.00040	3.07	2.19	32.85	-13.26	0.00079	3.28	4.00	0.72
West Heards System	68Hrd	21.21	0.50	31.16	68Hrd-JHrdOut	28.46	41.04	2.58	74	1	BOX 5X4	383	-2.28	-2.43	0.00040	3.70	2.45	49.05	-24.95	0.00091	3.42	3.50	0.08
West Heards System	J73Q	#N/A	#N/A	#N/A	P-716	#N/A	#N/A	#N/A	20.32	1	36 inch	318	1.37	1	0.00116	2.98	3.20	22.75	2.43	0.00079	4.09	4.50	0.41
West Heards System	JHrd2	#N/A	#N/A	#N/A	JHrd2-68Hrd	#N/A	#N/A	#N/A	27.91	1	4 x 3 ft	395	-1.12	-1.28	0.00040	2.33	2.06	24.75	-3.16	0.00051	3.62	4.00	0.38
West Heards System	JHrdOut	#N/A	#N/A	#N/A	JHrdOut-HrdOut	#N/A	#N/A	#N/A	113.97	1	7 X 4	77	-3.43	-3.46	0.00039	4.07	2.65	74.19	-39.78	0.00091	3.07	4.00	0.93
Total Area/Average C		118.75	0.5																				
West Jones System	J_JD1	#N/A	#N/A	#N/A	J_JD1-JDIn1	#N/A	#N/A	#N/A	5.49	1	24 inch	57	-0.03	-0.06	0.00050	1.82	1.63	5.06	-0.43	0.00053	1.80	4.00	2.20
West Jones System	J_JD2	#N/A	#N/A	#N/A	J_JD2-J_JD1	#N/A	#N/A	#N/A	5.74	1	24 inch	315	0.13	-0.03	0.00050	1.90	1.63	5.06	-0.69	0.00057	1.98	3.00	1.02
West Jones System	JDIn2	3.66	0.50	5.85	JDIn2-JDIn1	1.83	27.57	3.17	5.85	1	24 inch	480	0.18	-0.06	0.00050	1.93	1.63	5.06	-0.79	0.00058	2.05	4.00	1.95
West Jones System	JDIn3	3.73	0.50	5.95	JDIn3-J_JD2	1.86	27.61	3.17	5.95	1	24 inch	187	0.22	0.13	0.00050	1.96	1.63	5.06	-0.9	0.00059	2.09	4.00	1.91
West Jones System	JDIn1	10.17	0.50	15.37	JDIn1-JDOut2	8.78	32.49	2.90	25.67	1	48 inch	614	-2.06	-2.07	0.00002	2.10	0.46	5.8	-19.87	0.00028	1.77	3.00	1.23
Total Area/Average C		17.56	0.50																				
West K System	57J	1.14	0.70	2.68	57J-57K	0.80	25.23	3.33	2.68	1	24 inch	295	1.48	1.04	0.00149	0.90	2.82	8.74	6.05	0.00010	3.15	7.50	4.35
West K System	55J	1.47	0.70	3.42	55J-55K	1.03	25.70	3.30	3.42	1	24 inch	294	1.97	1.52	0.00153	1.14	2.85	8.85	5.43	0.00020	3.70	6.69	2.99
West K System	56J	1.92	0.70	4.42	56J-56K	1.34	26.22	3.26	4.42	1	24 inch	297	1.61	1.31	0.00101	1.42	2.32	7.19	2.77	0.00037	3.52	5.73	2.21
West K System	54J	2.48	0.70	5.65	54J-54K	1.74	26.73	3.23	5.65	1	24 inch	297	2.18	1.73	0.00152	1.85	2.84	8.81	3.16	0.00057	3.96	6.48	2.52
West K System	45N(1/2)	4.2	0.50	6.67	45N(1/2)-46N(1/2)	2.10	27.88	3.15	6.67	1	2 X 2.5	358	3.87	3.73	0.00040	1.33	1.54	7.72	1.06	0.00028	7.15	7.88	0.73
West K System	54M	5.73	0.50	8.95	54M-54K	2.86	28.60	3.10	8.95	1	3 X 3	649	2.35	1.73	0.00096	1.65	2.92	26.25	17.3	0.00025	3.95	6.21	2.26
West K System	46N(1/2)	2.7	0.50	4.38	46N(1/2)-47N(1/2)	3.45	32.35	2.91	10.11	1	2 X 2.5	403	3.73	3.57	0.00040	2.02	1.54	7.72	-2.38	0.00069	7.05	7.79	0.74
West K System	55M(1/2)	7.52	0.50	11.56	55M(1/2)-55K	3.76	29.27	3.05	11.56	1	3 X 3	988	2.51	1.52	0.00100	2.15	2.99	26.88	15.32	0.00043	4.06	6.20	2.14
West K System	47N(1/2)	2.7	0.50	4.38	47N(1/2)-48N(1/2)	4.80	35.67	2.77	13.42	1	2 X 2.5	365	3.57	3.42	0.00040	2.68	1.54	7.72	-5.69	0.00121	6.77	8.39	1.62
West K System	56M	9.25	0.50	14.05	56M-56K	4.62	29.80	3.01	14.05	1	3 X 3	666	1.98	1.31	0.00101	2.42	2.99	26.93	12.88	0.00053	3.76	6.52	2.76
West K System	48N(1/2)	2.9	0.50	4.69	48N(1/2)-49N(1/2)	6.25	37.94	2.68	16.9	1	36 inch	371	3.42	3.27	0.00040	2.42	1.88	13.34	-3.56	0.00057	6.33	8.10	1.77
West K System	49N(1/2)	2.7	0.50	4.38	49N(1/2)-50N(1/2)	7.60	40.49	2.59	19.84	1	36 inch	389	3.27	3.11	0.00040	2.91	1.88	13.34	-6.5	0.00080	6.12	8.45	2.33
West K System	50N(1/2)	2.7	0.50	4.38	50N(1/2)-51N(1/2)	8.95	42.72	2.55	22.97	1	42 inch	411	2.61	2.45	0.00039	2.50	2.07	19.85	-3.12	0.00046	5.81	7.90	2.09
West K System	51N(1/2)	2.7	0.50	4.38	51N(1/2)-52N(1/2)	10.30	45.47	2.49	25.86	1	42 inch	344	2.45	2.31	0.00041	2.84	2.11	20.3	-5.56	0.00058	5.62	7.56	1.94
West K System	52N(1/2)	2.8	0.50	4.53	52N(1/2)-53N(1/2)	11.70	47.48	2.45	28.9	1	42 inch	382	2.31	2.16	0.00039	3.27	2.08	19.94	-8.96	0.00079	5.42	7.82	2.40
West K System	53N(1/2)	2.75	0.50	4.45	53N(1/2)-53N	13.08	49.43	2.41	31.78	1	48 inch	308	1.66	1.54	0.00039	2.76	2.25	28.35	-3.43	0.00045	5.12	7.82	2.70
West K System	53N	2.73	0.50	4.42	53N-53M(1/2)	14.44	51.29	2.37	34.46	1	48 inch	376	1.54	1.39	0.00040	3.02	2.28	28.69	-5.77	0.00056	4.98	7.74	2.76
West K System	53M(1/2)	3.15	0.50	5.07	53M(1/2)-53M	16.02	53.37	2.32	37.38	1	48 inch	318	1.39	1.26	0.00041	3.34	2.30	29.04	-8.34	0.00069	4.77	7.27	2.50
West K System	53M	2.97	0.50	4.79	53M-53L	17.50	54.96	2.28	40.15	1	48 inch	323	1.26	1.1	0.00050	3.69	2.54	31.97	-8.18	0.00084	4.55	7.07	2.52
West K System	53L	2.95	0.50	4.76	53L-53K	18.98	56.42	2.24	42.84	1	48 inch	327	1.1	0.94	0.00049	4.14	2.52	31.77	-11.06	0.00113	4.28	7.06	2.78
West K System	51K	32.71	0.50	47.16	51K-53K	16.35	33.48	2.86	47.16	1	8 X 3	758	2.36	1.94	0.00055	3.03	2.85	68.43	21.27	0.00049	4.28	7.00	2.72
West K System	53K	4.72	0.50	7.45	53K-54K	37.69	57.73	2.21	83.84	1	9 X 4	383	0.94	0.73	0.00055	3.09	3.33	119.7	35.86	0.00031	3.91	6.93	3.02
West K System	54K	6.4	0.50	9.93	54K-55K	45.49	59.80	2.15	98.82	1	9 X 4	381	0.73	0.52	0.00055	3.55	3.33	120.01	21.19	0.00039	3.79	6.39	2.60
West K System	55K	7.02	0.50	10.84	55K-56K	53.79	61.59	2.12	115.07	1	9 X 4	383	0.52	0.31	0.00055	4.11	3.33	119.7	4.63	0.00060	3.64	6.69	3.05
West K System	56K	5.6	0.50	8.75	56K-57K	62.56	63.14	2.10	132.11	1	9 X 4	380	0.31	0.04	0.00071	4.75	3.79	136.26	4.15	0.00076	3.41	6.36	2.95
West K System	57K	18.48	0.50	27.30	57K-KOut	72.60	64.47	2.07	151.6	1	9 X 4	1129	0.04	-1.03	0.00095	5.94	4.37	157.37	5.77	0.00135	3.12	6.59	3.47
Total Area/Average C		142.39	0.53																				
West P/Frazier System	47P1/2	2.77	0.50	4.48	47P1/2-47P	1.38	26.97	3.21	4.48	1	4' X 2.5'	327	4.43	4.1	0.00101	0.66	3.05	30.48	26	0.00003	5.98	9.00	3.02
West P/Frazier System	40P	6.07	0.50	9.45	40P-41P	3.03	28.74	3.09	9.45	1	6 X 2	383	5.93	5.74	0.00050	0.79	2.10	25.22	15.77	0.00008	8.37	8.50	0.13
West P/Frazier System	45R1/2	6.52	0.50	10.11	46R1/2-45R1/2	3.26	28.91	3.08	10.11	1	36 inch	375	4.65	4.08	0.00150	1.43	3.64	25.83	15.72	0.00024	8.82	10.00	1.18
West P/Frazier System	37R	7.3	0.50	11.25	37R-37Q	3.65	29.19	3.06	11.25	1	30 inch	662	4.5	3.84	0.00100	2.29	2.64	12.95	1.7	0.00076	8.08	10.00	1.92
West P/Frazier System	56O1/2	8.78	0.50	13.38	56O1/2-J56P	4.39	29.66	3.02	13.38	1	24 inch	325	2.61	2.33	0.00086	5.18	2.14	6.64	-6.74	0.00437	5.07	5.00	-0.07
West P/Frazier System	43S1/2	23.43	0.50	34.28	43S1/2-46S1/2	5.46	37.94	2.68	14.75	2	2.5 X 2.5	1144	4.15	3.29	0.00075	1.18	4.61	28.6	13.85	0.00020	9.72	11.00	1.28
West P/Frazier System	45Q1/2	10.98	0.50	16.55	45Q1/2-46Q1/2	5.49	30.25	2.99	16.55	1	36 inch	375	4.14	3.58	0.00150	2.34	3.64	25.83	9.28	0.00061	8.02	10.00	1.98
West P/Frazier System	46R1/2	5.71	0.50	8.92	46R1/2	6.12	33.28	2.87	17.68	1	36 inch	382	4.08	3.51	0.00150	2.50	3.64	25.83	8.15	0.00071	8.73	10.00	1.27
West P/Frazier System	46Q1/2	3.25	0.50	5.22	46Q1/2-47Q1/2	7.11	32.92	2.88	20.68	1	36 inch	383	3.58	3.01	0.00150	2.93	3.64	25.83	5.15	0.00097	7.79	10.00	2.21
West P/Frazier System	47T	14.6	0.50	21.77	47T-47S1/2	7.30	31.03	2.96	21.77	1	4' X 2.5'	331	6.75	6.42	0.00100	2.21	3.03	30.3	8.53	0.00045	9.17	11.00	1.83
West P/Frazier System	35S	16.1	0.50	23.92	35S - 35P(1/2)	8.05	31.31	2.95	23.92	2	3 X 2.5	1623	4.88	4.07	0.00050	1.59	3.96	29.7	5.78	0.00032	9.20	10.08	0.88
West P/Frazier System	39R	16.2	0.50	24.06	39R-39P	8.10	31.33	2.95	24.06	1	36 inch	1331	4.86	3.56	0.00098	3.40	2.94	20.84	-3.22	0.00130	8.75	9.42	0.67
West P/Frazier System	41P	10.7	0.50	16.14	41P-43P	8.38	36.85	2.73	23.04	1	6 X 2	750	5.74	5.36	0.00051	1.92	2.12	25.49	2.44	0.00041	8.34	8.50	0.16
West P/Frazier System	37Q	11.9	0.50	17.88	37Q-37P	9.60	34.01	2.84	27.48	1	42 inch	661	3.84	3.45	0.00059	2.86	2.55	24.44	-3.04	0.00074	7.58	9.00	1.42
West P/Frazier System	40S1/2	19.7	0.50	29.03	40S1/2-42S1/2	9.85	31.90	2.92	29.03	1	42 inch	768	6	5.42	0.00075	3.02	2.87	27.55	-1.48	0.00083	10.69	11.00	0.31
West P/Frazier System	43P	7.6	0.50	11.68	43P-45P	12.18	43.36	2.53	31.11	1	6 X 2	770	5.36	4.98	0.00049	2.59	2.10	25.15	-5.96	0.00075	8.03	8.50	0.47
West P/Frazier System	37P	11.7	0.50	17.59	37P-37O	15.45	37.86	2.69	41.82	1	48 inch	661	3.45	3.12	0.00050	3.56	2.55	32.12	-9.7	0.00079	7.09	8.50	1.41
West P/Frazier System	42S1/2	11.43	0.50	17.20	42S1/2-43S1/2	15.56	36.14	2.75	43.21	1	48 inch	370	5.42	5.15	0.00075	3.44	3.12	39.3	-3.91	0.00089	10.05	11.00	0.95
West P/Frazier System	46S1/2	20.71	0.50	30.46	46S1/2-47S1/2	15.81	54.09	2.30	36.62	2	2.5 X 2.5	385	3.29	3	0.00075	2.93	4.62	28.66	-7.95	0.00122	9.49	10.00	0.51
West P/Frazier System	39P	19.24	0.50	28.38	39P-39O	17.72	37.85	2.69	47.98	1	48 inch	657	2.42	1.66	0.00116	3.82	3.88	48.94	0.96	0.00113	7.02	7.50	0.48
West P/Frazier System	39S	38.3	0.50	54.82	39S-J41S	19.15	34.00	2.84	54.82	1	5 X 3	760	3	2.54	0.00060	3.65	2.68	40.23	-14.59	0.00112	9.01	10.00	0.99
West P/Frazier System	45P	16.6	0.50	24.63	45P-47P	20.48	48.31	2.43	50.26	1	6 X 2	752	3.98	3.6	0.00050	4.19	2.11	25.32	-24.94	0.00197	7.45	8.00	0.55
West P/Frazier System	43S1/2-B	0	0	0	P-700	21.82	37.94	2.68	59.01	#N/A	48 inch	1562	3.9	0.29	0.002308	4.7	5.476984127	69.01	10	0.001683739	10.12	11	0.88
West P/Frazier System	35P(1/2)	28.73	0.50	41.67	35P(1/2) - 35O	22.42	48.28	2.43	55	2	3 X 2.5	998	4.07	3.07	0.00100	3.67	5.60	42	-13	0.00172	8.68	9.00	0.32
West P/Frazier System	47P	2.76	0.50	4.47	47P-48P	23.25	51.30	2.37	55.49	1	8 X 3	384	3.6	3.41	0.00050	2.90	2.69	64.66	9.18	0.00036	5.97	8.00	2.03
West P/Frazier System	47S1/2	3.41	0.50	5.47	47S1/2-47R1/2	24.82	56.28	2.24	56.11	2	4' X 2.5'	651	3	2.51	0.00075	2.81	5.26	52.55	-3.56	0.00086	9.02	10.00	0.98
West P/Frazier System	48P	6	0.50	9.35	48P-49P	26.25	53.51	2.31	61.19	1	8 X 3	379	3.41	3.22	0.00050	3.14	2.71	65.09	3.9	0.00042	5.83	8.00	2.17
West P/Frazier System	49P	5.6	0.50	8.75	49P-50P	29.05	55.51	2.26	66.24	1	8 X 3	379	3.22	3.03	0.00050	3.39	2.71	65.09	-1.15	0.00050	5.67	8.50	2.83
West P/Frazier System	35O	15.25	0.50	22.70	35O-370	30.04	52.81	2.33	70.54	1	6 x 4 ft	760	2.57	2.12	0.00060	2.94	3.16	75.88	5.34	0.00051	6.96	7.97	1.01
West P/Frazier System	50P	5.7	0.50	8.90	50P-51P	31.90	57.38	2.22	71.24	1	8 X 3	384	3.03	2.84	0.00050	3.68	2.69	64.66	-6.58	0.00063	5.48	9.00	3.52
West P/Frazier System	47R1/2	5.55	0.50	8.68	47R1/2-47R	33.71	60.15	2.15	72.96	2	4' X 2.5'	335	2.51	2.26	0.00075	3.65	5.25	52.53	-20.42	0.00143	8.46	10.00	1.54
West P/Frazier System	51P	5.7	0.50	8.90	51P-52P	34.75	59.12	2.17	76.08	1	8 X 3	389	2.84	2.65	0.00049	4.08	2.68	64.25	-11.83	0.00085	5.24	8.50	3.26
West P/Frazier System	41Q	35	0.50	50.31	41Q-43Q	36.65	48.02	2.44	90.13	1	6 X 5	763	0.75	0.29	0.00060	3.00	3.44	103.29	13.16	0.00046	7.84	9.00	1.16
West P/Frazier System	47R	6.02	0.50	9.37	47R-47Q1/2	36.72	61.68	2.12	78.48	2	4' X 2.5'	333	2.26	2.01	0.00075	3.92	5.26	52.59	-25.9	0.00168	7.98	10.00	2.02
West P/Frazier System	52P	5.9	0.50	9.20	53P-52P	37.70	60.71	2.14	81.23	1	8 X 3	363	2.65	2.47	0.00050	5.02	2.70	64.73	-16.5	0.00168	4.91	8.00	3.09
West P/Frazier System	47Q1/2	2.74	0.50	4.44	47Q1/2-47Q	45.20	63.10	2.10	95.49	2	4' X 2.5'	336	2.01	1.76	0.00075	4.77	5.26	52.56	-42.93	0.00247	7.42	9.00	1.58
West P/Frazier System	53Q	17.7	0.50	26.20	53Q-55Q	46.13	69.94	1.98	91.89	1	8 X 6	764	-2.21	-2.82	0.00080	2.25	4.63	222.24	130.35	0.00012	2.65	8.00	5.35
West P/Frazier System	37O	13.8	0.50	20.62	37O-39O	52.39	57.12	2.22	117.34	1	6 X 6	759	1.12	0.66	0.00060	3.53	3.67	132.02	14.68	0.00038	6.57	8.32	1.75
West P/Frazier System	53P	5.8	0.50	9.05	53P-55P	59.30	61.91	2.12	126.5	1	9 X 4	771	1.47	0.7	0.00100	4.83	4.49	161.54	35.04	0.00079	4.30	7.70	3.40
West P/Frazier System	43Q	15.6	0.50	23.20	43Q-45Q	66.27	52.25	2.34	156.57	1	7 x 6 ft	761	0.29	-0.16	0.00060	3.73	3.85	161.89	5.32	0.00057	7.49	9.00	1.51
West P/Frazier System	55P	17.13	0.50	25.39	55P-J56P	67.86	64.57	2.07	141.59	1	9 X 4	371	0.7	0.33	0.00100	5.25	4.48	161.43	19.84	0.00094	3.69	6.00	2.31
West P/Frazier System	45Q	12.1	0.50	18.17	45Q-47Q	72.32	55.65	2.26	164.67	1	7 x 6 ft	760	-0.16	-0.62	0.00060	3.92	3.85	161.89	-2.77	0.00062	7.06	9.00	1.94
West P/Frazier System	57P	8.29	0.50	12.68	57P-O-WestP	76.40	66.87	2.03	156.31	1	9 X 4	595	-0.04	-0.64	0.00101	6.81	4.51	162.33	6.02	0.00222	2.92	4.00	1.08
West P/Frazier System	39O	13.5	0.50	20.19	39O-41O	76.86	60.70	2.14	165.62	1	6 X 6	763	0.66	0.2	0.00060	4.98	3.67	132.1	-33.51	0.00081	6.28	8.00	1.72
West P/Frazier System	41O	9.04	0.50	13.75	41O-43O	81.38	63.25	2.09	171.69	1	7 x 6 ft	764	0.21	-0.25	0.00060	4.51	3.85	161.89	-9.8	0.00063	5.66	7.63	1.97
West P/Frazier System	43O	12.23	0.50	18.36	43O-45O	87.49	66.08	2.04	180.24	1	7 x 6 ft	753	-0.25	-0.7	0.00060	4.75	3.86	161.93	-18.31	0.00064	5.18	8.10	2.92
West P/Frazier System	I-484	0	0.00	0.00	P-723	88.94	34.00	2.84	254.61	1	8 x 7 ft	602	-2.87	-3.54	0.00111	4.98	5.78	323.74	69.12	0.00050	3.35	7.70	4.35

City of Galveston Master Drainage Plan
City of Galveston Proposed System Model Output

Table 2

System Name	US Node	Drainage Area (ac)	C	Q Inlet (cfs)	Pipe Name	Cumulative CA (ac)	Cumulative TC (min)	Cumulative i (in/hr)	Q Pipe (cfs)	Number of Barrels	Size	Length (ft)	US Inv. El.	DS Inv. El.	Slope (ft/ft)	Avg. V (fps)	Full Flow V (fps)	Full Flow Pipe Cap. (cfs)	Excess Cap. (cfs)	Friction Slope (ft/ft)	US HGL	US Ground El.	Freeboard (ft)
West P/Frazier System	45O	8.4	0.50	12.84	45O-47O	91.69	68.72	2.00	184.62	1	7 x 6 ft	767	-0.7	-1.16	0.00060	4.91	3.85	161.86	-22.76	0.00069	4.70	8.00	3.30
West P/Frazier System	47O	11.1	0.50	16.72	47O-59O	97.24	71.32	1.95	191.33	1	7 x 6 ft	758	-1.16	-1.62	0.00060	5.20	3.86	161.93	-29.4	0.00080	4.17	8.00	3.83
West P/Frazier System	59O	12	0.50	18.03	49O-51O	103.24	73.75	1.91	198.71	1	8 x 7 ft	758	-2.62	-3.08	0.00061	3.95	4.27	239.05	40.35	0.00034	3.56	8.00	4.44
West P/Frazier System	I-483	0	0.00	0.00	P-722	107.64	34.00	2.84	308.13	1	8 x 7 ft	612	-2.21	-2.87	0.00108	5.50	5.69	318.67	10.54	0.00101	4.92	8.00	3.08
West P/Frazier System	51O	11.8	0.50	17.74	51O-53O	109.14	76.95	1.85	203.91	1	8 x 7 ft	762	-3.08	-3.54	0.00060	3.93	4.26	238.43	34.51	0.00033	3.30	8.00	4.70
West P/Frazier System	47Q	2.79	0.50	4.52	47Q-49Q	118.92	64.27	2.08	248.77	1	7 x 6 ft	758	-0.62	-1.07	0.00060	5.92	3.85	161.89	-86.88	0.00142	6.59	9.00	2.41
West P/Frazier System	49Q	29.2	0.50	42.32	49Q-51Q	133.52	66.40	2.04	274.29	1	7 x 6 ft	760	-1.08	-1.64	0.00074	6.58	4.29	180.21	-94.08	0.00163	5.51	9.00	3.49
West P/Frazier System	51Q	22.8	0.50	33.40	51Q-53Q	144.92	68.33	2.00	292.79	1	7 x 6 ft	758	-1.64	-2.21	0.00075	7.85	4.31	181.08	-111.7	0.00214	4.27	9.00	4.73
West P/Frazier System	53O	12.3	0.50	18.46	53O-56O	204.24	80.18	1.80	370.12	1	10 x 7 ft	1141	-3.54	-4.22	0.00060	5.62	4.52	316.11	-54	0.00060	3.05	7.50	4.45
West P/Frazier System	56O	18	0.50	26.62	56O-J56O	213.24	83.56	1.76	377.34	1	10 x 7 ft	188	-4.22	-4.33	0.00059	5.74	4.47	313.22	-64.12	0.00064	2.36	4.50	2.14
West P/Frazier System	57FRAZ	19.1	0.50	28.18	57FRAZ-O_OUT	222.79	85.16	1.74	389.73	1	10 x 7 ft	598	-4.55	-4.91	0.00060	5.96	4.54	317.71	-72.02	0.00069	2.01	4.30	2.29
West P/Frazier System	J41S	#N/A	#N/A	#N/A	J41S-41Q	#N/A	#N/A	#N/A	52.14	1	5 X 5	1320	1.54	0.75	0.00060	2.09	3.25	81.22	29.08	0.00024	8.16	10.00	1.84
West P/Frazier System	J56P	#N/A	#N/A	#N/A	J56P-57P	#N/A	#N/A	#N/A	149.25	1	9 X 4	373	0.33	-0.04	0.00099	5.56	4.47	161	11.75	0.00113	3.34	5.50	2.16
West P/Frazier System	J56O	#N/A	#N/A	#N/A	J56O-57FRAZ	#N/A	#N/A	#N/A	375.87	1	10 x 7 ft	363	-4.33	-4.55	0.00061	5.72	4.55	318.78	-57.09	0.00063	2.24	5.00	2.76
Total Area/Average C		690.63	0.4741																				
West T1/2 System	61T	4.76	0.50	7.51	61T-J61T1/2_1	2.38	28.16	3.13	7.51	1	36 inch	343	0.92	0.58	0.00100	1.06	2.97	21.09	13.58	0.00012	3.91	6.00	2.09
West T1/2 System	59SW	9.63	0.50	14.59	59SW-59Weber	4.81	29.90	3.01	14.59	1	30 inch	805	1.73	0.93	0.00099	2.97	2.64	12.93	-1.66	0.00127	5.91	9.00	3.09
West T1/2 System	61U	10.43	0.50	15.75	61U-J61T1/2	5.22	30.11	3.00	15.75	1	42 inch	253	0.33	0.08	0.00100	1.64	3.31	31.81	16.07	0.00024	3.96	6.50	2.54
West T1/2 System	59T1/2	33.5	0.50	48.25	59T1/2-J61T1/2	21.56	44.33	2.51	54.63	1	54 inch	655	-2.22	-2.88	0.00100	3.44	3.91	62.18	7.55	0.00076	4.40	5.00	0.60
West T1/2 System	ICalvCm1	0.01	0.50	0.02	ICalvCm1-JCalvCm1	29.16	49.74	2.41	70.71	1	60 inch	294	-3.87	-4.16	0.00100	3.60	4.20	82.35	11.65	0.00071	3.53	6.50	2.97
West T1/2 System	59Weber	#N/A	#N/A	#N/A	59Weber-59T1/2	#N/A	#N/A	#N/A	13.7	1	36 inch	1154	0.43	-0.72	0.00100	1.94	2.96	21.05	7.35	0.00042	4.89	5.50	0.61
West T1/2 System	J61T1/2	#N/A	#N/A	#N/A	j61T1/2-J61T1/2_1	#N/A	#N/A	#N/A	66.13	1	60 inch	47	-3.38	-3.43	0.00100	3.37	4.20	82.35	16.23	0.00064	3.90	6.00	2.10
West T1/2 System	J61T1/2_1	#N/A	#N/A	#N/A	J61T1/2_1-ICalvCm1	#N/A	#N/A	#N/A	71.87	1	60 inch	439	-3.43	-3.87	0.00100	3.66	4.20	82.35	10.49	0.00077	3.87	6.00	2.13
Total Area/Average C		58.33	0.5																				

TABLE 3
PELICAN ISLAND SUMMARY
SYSTEM "A"

SUMMARY OF SYSTEM "A" DESIGN FLOWS

Analysis Point	Location	Sub-Area Area (ac)	Sub-Area Developed Area (ac)	Cumulative Area Area (ac)	Cumulative Area Developed Area (ac)	Cumulative Area Percent Developed (%)	Design Flow Rates Undev (cfs)	Design Flow Rates Future (cfs)	Design Flow Rates Interpolated Current* (cfs)
Approximate study areas									
A3	Culverts Under Seawolf Pkwy	34.1	0.00	34.10	0.00	0.0%	21.3	49.6	21.3
A2A	Culverts At RR Spur	18.8	0.00	52.90	0.00	0.0%	32.6	75.5	32.6
A5	Lateral Ditch and Culverts At RR Spur	19.8	0.00	19.80	0.00	0.0%	12.5	29.2	12.5
A2B	Culverts At Western Geophysical	22.6	0.00	95.30	0.00	0.0%	57.1	130.3	57.1
A1	Ditch to Outfall	15.7	7.85	111.00	7.85	7.1%	65.8	149.4	71.7

* Interpolated Current is a linearly interpolated value between Undev and Future and is based on Percent Developed

SUMMARY OF SYSTEM "A" STORM SEWER SIZES

Analysis Point	Location	Using Future Flows for Pipe: Req Area @ 3fps (sf)	Using Future Flows for Pipe: Required Area Per Barrel (sf)	Using Future Flows for Pipe: Raw Diameter (ft)	Using Future Flows for Pipe: Number of Barrels (No.)	Using Future Flows for Pipe: Use (in)	Using Current Flows for Pipe: Req Area @ 3fps (sf)	Using Current Flows for Pipe: Required Area Per Barrel (sf)	Using Current Flows for Pipe: Raw Diameter (ft)	Using Current Flows for Pipe: Number of Barrels (No.)	Using Current Flows for Pipe: Use (in)
Approximate study areas											
A3	Culverts Under Seawolf Pkwy	16.52	8.26	3.24	2	36.0	7.09	7.09	3.01	1	36.0
A2A	Culverts At RR Spur	25.16	12.58	4.00	2	48.0	10.87	10.87	3.72	1	42.0
A5	Lateral Ditch and Culverts At RR Spur	9.72	4.86	2.49	2	30.0	4.15	4.15	2.30	1	30.0
A2B	Culverts At Western Geophysical	43.44	10.86	3.72	4	42.0	19.04	9.52	3.48	2	42.0
A1	Ditch to Outfall	49.78	12.45	3.98	4	48.0	23.91	11.96	3.90	2	48.0

SUMMARY OF SYSTEM "A" OPEN CHANNEL CHARACTERISTICS USING SECTION FACTORS (n=.04, s=0.10%)

Point	Location	Using Future Flows: $(Qn)/(1.49s^{1/2})$ (A)	Using Future Flows: BW (ft)	Using Future Flows: Normal Depth (ft)	Using Future Flows: $AR^{2/3}$ (B)	Using Future Flows: Diff (A)-(B)	Using Current Flows: $(Qn)/(1.49s^{1/2})$ (A)	Using Current Flows: BW (ft)	Using Current Flows: Flow Depth (ft)	Using Current Flows: $AR^{2/3}$ (B)	Using Current Flows: Diff (A)-(B)
Approximate study areas - Depths determined by balancing both sides of the Manning's equation using iterative depths											
A3	Culverts Under Seawolf Pkwy	42.1	4.00	2.72	42.1	0.0	18.1	4.00	1.80	18.1	0.0
A2A	Culverts At RR Spur	64.1	4.00	3.31	64.1	0.0	27.7	4.00	2.22	27.7	0.0
A5	Lateral Ditch and Culverts At RR Spur	24.8	4.00	2.10	24.8	0.0	10.6	4.00	1.37	10.6	0.0
A2B	Culverts At Western Geophysical	110.6	10.00	3.52	110.6	0.0	48.5	4.00	2.90	48.5	0.0
A1	Ditch to Outfall	126.8	15.00	3.31	126.8	0.0	55.9	4.00	3.10	55.9	0.0

TABLE 4
PELICAN ISLAND SUMMARY
SYSTEM "B"

SUMMARY OF SYSTEM "B" DESIGN FLOWS

Analysis Point	Location	Sub-Area Area (ac)	Sub-Area Developed Area (ac)	Cumulative Area Area (ac)	Cumulative Area Developed Area (ac)	Cumulative Area Percent Developed (%)	Design Flow Rates Undev (cfs)	Design Flow Rates Future (cfs)	Design Flow Rates Interpolated Current* (cfs)
Approximate study areas									
B4	Culverts Under Bradner	3.60	0.00	3.60	0.00	0.0%	2.3	5.4	2.3
B3A	Culverts Under Seawolf Pkwy	2.10	0.00	2.10	0.00	0.0%	1.3	3.1	1.3
B3B	Lateral Ditch	16.90	0.00	22.60	0.00	0.0%	14.2	33.2	14.2
B2B	Culverts Under Bradner	24.10	0.00	24.10	0.00	0.0%	15.1	35.4	15.1
B2A	Lateral Ditch	23.90	5.98	48.00	5.98	12.4%	29.7	68.8	34.5
B2	Culverts Under Access Road @ Tank Farm	10.90	6.54	81.50	12.52	15.4%	49.3	113.0	59.1
B1	Ditch to Outfall	16.50	0.00	98.00	12.52	12.8%	58.6	133.6	68.2

* Interpolated Current is a linearly interpolated value between Undev and Future and is based on Percent Developed

SUMMARY OF SYSTEM "B" STORM SEWER SIZES

Analysis Point	Location	Using Future Flows for Pipe: Req Area @ 3fps (sf)	Using Future Flows for Pipe: Required Area Per Barrel (sf)	Using Future Flows for Pipe: Raw Diameter (ft)	Using Future Flows for Pipe: Number of Barrels (No.)	Using Future Flows for Pipe: Use (in)	Using Current Flows for Pipe: Req Area @ 3fps (sf)	Using Current Flows for Pipe: Required Area Per Barrel (sf)	Using Current Flows for Pipe: Raw Diameter (ft)	Using Current Flows for Pipe: Number of Barrels (No.)	Using Current Flows for Pipe: Use (in)
	Approximate study areas										
B4	Culverts Under Bradner	1.80	1.80	1.51	1	24.0	0.76	0.76	0.99	1	24.0
B3A	Culverts Under Seawolf Pkwy	1.05	1.05	1.16	1	24.0	0.45	0.45	0.75	1	24.0
B3B	Lateral Ditch	11.07	5.53	2.66	2	30.0	4.73	4.73	2.46	1	30.0
B2B	Culverts Under Bradner	11.79	5.89	2.74	2	30.0	5.04	5.04	2.53	1	30.0
B2A	Lateral Ditch	22.94	11.47	3.82	2	48.0	11.52	11.52	3.83	1	48.0
B2	Culverts Under Access Road @ Tank Farm	37.67	9.42	3.46	4	42.0	19.69	9.85	3.54	2	42.0
B1	Ditch to Outfall	44.55	11.14	3.77	4	48.0	22.73	11.37	3.81	2	48.0

SUMMARY OF SYSTEM "B" OPEN CHANNEL CHARACTERISTICS USING SECTION FACTORS (n=.04, s=0.10%)

Analysis Point	Location	Using Future Flows: $(Qn)/(1.49s^{1/2})$ (A)	Using Future Flows: BW (ft)	Using Future Flows: Normal Depth (ft)	Using Future Flows: $AR^{2/3}$ (B)	Using Future Flows: Diff (A)-(B)	Using Current Flows: $(Qn)/(1.49s^{1/2})$ (A)	Using Current Flows: BW (ft)	Using Current Flows: Flow Depth (ft)	Using Current Flows: $AR^{2/3}$ (B)	Using Current Flows: Diff (A)-(B)
Approximate study areas - Depths determined by balancing both sides of the Manning's equation using iterative depths											
B4	Culverts Under Bradner	4.6	4.00	0.87	4.6	0.0	1.9	4.00	0.54	1.9	0.0
B3A	Culverts Under Seawolf Pkwy	2.7	4.00	0.65	2.7	0.0	1.1	4.00	0.39	1.1	0.0
B3B	Lateral Ditch	28.2	4.00	2.24	28.2	0.0	12.1	4.00	1.46	12.1	0.0
B2B	Culverts Under Bradner	30.0	4.00	2.31	30.0	0.0	12.8	4.00	1.51	12.8	0.0
B2A	Lateral Ditch	58.4	4.00	3.17	58.4	0.0	29.3	4.00	2.28	29.3	0.0
B2	Culverts Under Access Road @ Tank Farm	96.0	12.00	3.08	96.0	0.0	50.2	4.00	2.95	50.2	0.0
B1	Ditch to Outfall	113.5	15.00	3.11	113.5	0.0	57.9	4.00	3.16	57.9	0.0

TABLE 5
PELICAN ISLAND SUMMARY
SYSTEM "C"

SUMMARY OF SYSTEM "C" DESIGN FLOWS

Analysis Point	Location	Sub-Area		Cumulative Area			Design Flow Rates		
		Area	Developed Area	Area	Developed Area	Percent Developed	Undev	Future	Interpolated Current*
		(ac)	(ac)	(ac)	(ac)	(%)	(cfs)	(cfs)	(cfs)
Approximate study areas									
C7	Culverts Under Penzoil Rd	8.60	0.00	8.60	0.00	0.0%	5.5	12.8	5.5
C6	Roadside Ditch on Seawolf Pkwy	77.20	0.00	85.80	0.00	0.0%	51.7	118.5	51.7
C4	Culverts Under Seawolf Pkwy	90.30	0.00	90.30	0.00	0.0%	54.3	124.1	54.3
C3C	Culverts Under Seawolf Pkwy	10.90	0.00	10.90	0.00	0.0%	6.9	16.2	6.9
C3B	Lateral Ditch	17.90	0.00	28.80	0.00	0.0%	18.0	42.1	18.0
C3A	Lateral Ditch	13.70	2.74	13.70	2.74	20.0%	8.7	20.3	11.0
C5	Lateral Ditch	4.70	0.00	47.20	2.74	5.8%	29.2	67.7	31.4
C2	Ditch Nr Halliburton Property	39.70	7.94	263.00	10.68	4.1%	140.0	297.9	146.4
C1	Ditch to Outfall	24.40	4.07	287.40	14.75	5.1%	150.1	315.7	158.6

* Interpolated Current is a linearly interpolated value between Undev and Future and is based on Percent Developed

SUMMARY OF SYSTEM "C" STORM SEWER SIZES

Analysis Point	Location	Using Future Flows for Pipe					Using Current Flows for Pipe				
		Req Area @ 3fps	Required Area Per Barrel	Raw Diameter	Number of Barrels	Use	Req Area @ 3fps	Required Area Per Barrel	Raw Diameter	Number of Barrels	Use
		(sf)	(sf)	(ft)	(No.)	(in)	(sf)	(sf)	(ft)	(No.)	(in)
Approximate study areas											
C7	Culverts Under Penzoil Rd	4.27	4.27	2.33	1	30.0	1.82	1.82	1.52	1	24.0
C6	Roadside Ditch on Seawolf Pkwy	39.49	9.87	3.55	4	42.0	17.25	8.62	3.31	2	42.0
C4	Culverts Under Seawolf Pkwy	41.37	8.27	3.25	5	36.0	18.10	6.03	2.77	3	36.0
C3C	Culverts Under Seawolf Pkwy	5.40	2.70	1.85	2	24.0	2.30	2.30	1.71	1	24.0
C3B	Lateral Ditch	14.02	7.01	2.99	2	36.0	6.01	6.01	2.77	1	36.0
C3A	Lateral Ditch	6.77	3.38	2.08	2	24.0	3.66	3.66	2.16	1	24.0
C5	Lateral Ditch	22.57	5.64	2.68	4	30.0	10.48	5.24	2.58	2	30.0
C2	Ditch Nr Halliburton Property	99.30	16.55	4.59	6	54.0	48.79	16.26	4.55	3	54.0
C1	Ditch to Outfall	105.24	17.54	4.73	6	54.0	52.88	17.63	4.74	3	54.0

SUMMARY OF SYSTEM "C" OPEN CHANNEL CHARACTERISTICS USING SECTION FACTORS (n=0.04, s=0.10%)

Analysis Point	Location	Using Future Flows					Using Current Flows				
		$(Qn)/(1.49s^{1/2})$	BW	Flow Depth	$AR^{2/3}$	Diff	$(Qn)/(1.49s^{1/2})$	BW	Flow Depth	$AR^{2/3}$	Diff
		(A)	(ft)	(ft)	(B)	(A)-(B)	(A)	(ft)	(ft)	(B)	(A)-(B)
Approximate study areas - Depths determined by balancing both sides of the Manning's equation using iterative depths											
C7	Culverts Under Penzoil Rd	10.9	4.00	1.39	10.9	0.0	4.6	4.00	0.88	4.6	0.0
C6	Roadside Ditch on Seawolf Pkwy	100.6	4.00	4.07	100.6	0.0	43.9	4.00	2.77	43.9	0.0
C4	Culverts Under Seawolf Pkwy	105.4	4.00	4.16	105.4	0.0	46.1	4.00	2.84	46.1	0.0
C3C	Culverts Under Seawolf Pkwy	13.7	4.00	1.57	13.7	0.0	5.9	4.00	1.00	5.9	0.0
C3B	Lateral Ditch	35.7	4.00	2.51	35.7	0.0	15.3	4.00	1.65	15.3	0.0
C3A	Lateral Ditch	17.2	4.00	1.76	17.2	0.0	9.3	4.00	1.28	9.3	0.0
C5	Lateral Ditch	57.5	4.00	3.15	57.5	0.0	26.7	4.00	2.18	26.7	0.0
C2	Ditch Nr Halliburton Property	252.9	25.00	3.96	252.9	0.0	124.3	15.00	3.27	124.3	0.0
C1	Ditch to Outfall	268.0	25.00	4.10	268.0	0.0	134.7	15.00	3.42	134.7	0.0

TABLE 6
PELICAN ISLAND SUMMARY
SYSTEM "D"

SUMMARY OF SYSTEM "D" DESIGN FLOWS

Analysis Point	Location	Sub-Area		Cumulative Area			Design Flow Rates		
		Area	Developed Area	Area	Developed Area	Percent Developed	Undev	Future	Interpolated Current
		(ac)	(ac)	(ac)	(ac)	(%)	(cfs)	(cfs)	(cfs)
Approximate study areas									
D3B	Culverts Under Seawolf Pkwy	5.80	0.00	5.80	0.00	0.0%	3.7	8.7	3.7
D3A	Culverts Under Penzoil Rd	2.40	0.00	8.20	0.00	0.0%	5.2	12.2	5.2
D2	Ditch Along Shell Road	8.20	6.15	16.40	6.15	37.5%	10.3	24.2	15.6
D1	Ditch to Outfall	5.80	5.80	22.20	11.95	53.8%	14.0	32.6	24.0

* Interpolated Current is a linearly interpolated value between Undev and Future and is based on Percent Developed

SUMMARY OF SYSTEM "D" STORM SEWER SIZES

Analysis Point	Location	Using Future Flows for Pipe					Using Current Flows for Pipe				
		Req Area @ 3fps	Required Area Per Barrel	Raw Diameter	Number of Barrels	Use*	Req Area @ 3fps	Required Area Per Barrel	Raw Diameter	Number of Barrels	Use*
		(sf)	(sf)	(ft)	(No.)	(in)	(sf)	(sf)	(ft)	(No.)	(in)
Approximate study areas											
D3B	Culverts Under Seawolf Pkwy	2.89	2.89	1.92	1	30.0	1.23	1.23	1.25	1	30.0
D3A	Culverts Under Penzoil Rd	4.07	4.07	2.28	1	36.0	1.73	1.73	1.49	1	36.0
D2	Ditch Along Shell Road	8.08	8.08	3.21	1	48.0	5.19	5.19	2.57	1	48.0
D1	Ditch to Outfall	10.88	10.88	3.72	1	54.0	8.00	8.00	3.19	1	54.0

* Raw diameters based on revised areas are less than previous Pelican Island study of 1990, since work to old study has been implemented will keep previous sizes.

SUMMARY OF SYSTEM "D" OPEN CHANNEL CHARACTERISTICS USING SECTION FACTORS (n=.04, s=0.10%)

Analysis Point	Location	Using Future Flows					Using Current Flows				
		$(Qn)/(1.49s^{1/2})$	BW	Flow Depth	$AR^{2/3}$	Diff	$(Qn)/(1.49s^{1/2})$	BW	Flow Depth	$AR^{2/3}$	Diff
		(A)	(ft)	(ft)	(B)	(A)-(B)	(A)	(ft)	(ft)	(B)	(A)-(B)
Approximate study areas - Depths determined by balancing both sides of the Manning's equation using iterative depths											
D3B	Culverts Under Seawolf Pkwy	7.4	4.00	1.13	7.4	0.0	3.1	4.00	0.71	3.1	0.0
D3A	Culverts Under Penzoil Rd	10.4	4.00	1.35	10.4	0.0	4.4	4.00	0.86	4.4	0.0
D2	Ditch Along Shell Road	20.6	4.00	1.92	20.6	0.0	13.2	4.00	1.53	13.2	0.0
D1	Ditch to Outfall	27.7	4.00	2.22	27.7	0.0	20.4	4.00	1.91	20.4	0.0

TABLE 7
PELICAN ISLAND SUMMARY
SYSTEM "F&G"

SUMMARY OF SYSTEM "F&G" DESIGN FLOWS

Analysis Point	Location	Sub-Area Area (ac)	Sub-Area Developed Area (ac)	Cumulative Area Area (ac)	Cumulative Area Developed Area (ac)	Cumulative Area Percent Developed (%)	Design Flow Rates Undev (cfs)	Design Flow Rates Future (cfs)	Design Flow Rates Interpolated Current* (cfs)
Approximate study areas									
F3	Culverts Under Seawolf Pkwy	60.20	0.00	60.20	0.00	0.0%	36.9	85.3	36.9
F4	Lateral Ditch	17.00	6.80	77.20	6.80	8.8%	46.8	107.5	52.2
F2A	Culverts Under Seawolf Pkwy	6.20	0.00	6.20	6.80	109.7%	3.9	9.3	9.8
F2B	Ditch Along Seawolf Pkwy	7.00	0.00	90.40	6.80	7.5%	54.4	124.2	59.6
F1A	Culverts Under Seawolf Pkwy	22.50	0.00	22.50	6.80	30.2%	14.1	33.1	19.9
F1B	Ditch to Outfall	6.10	0.00	119.00	6.80	5.7%	70.2	158.8	75.2
		119.00							
G1	Culverts Under Seawolf Pkwy	12.10	0.00	12.10	0.00	0.0%	7.7	18.0	7.7
		131.10							

* Interpolated Current is a linearly interpolated value between Undev and Future and is based on Percent Developed

SUMMARY OF SYSTEM "F&G" STORM SEWER SIZES

Analysis Point	Location	Using Future Flows for Pipe: Req Area @ 3fps (sf)	Required Area Per Barrel (sf)	Raw Diameter (ft)	Number of Barrels (No.)	Use (in)	Using Current Flows for Pipe: Req Area @ 3fps (sf)	Required Area Per Barrel (sf)	Raw Diameter (ft)	Number of Barrels (No.)	Use (in)
Approximate study areas											
F3	Culverts Under Seawolf Pkwy	28.43	7.11	3.01	4	36.0	12.31	6.15	2.80	2	36.0
F4	Lateral Ditch	35.84	8.96	3.38	4	42.0	17.39	8.70	3.33	2	42.0
F2A	Culverts Under Seawolf Pkwy	3.08	3.08	1.98	1	24.0	3.26	3.26	2.04	1	24.0
F2B	Ditch Along Seawolf Pkwy	41.41	10.35	3.63	4	42.0	19.87	9.93	3.56	2	42.0
F1A	Culverts Under Seawolf Pkwy	11.02	3.67	2.16	3	24.0	6.62	3.31	2.05	2	24.0
F1B	Ditch to Outfall	52.93	10.59	3.67	5	42.0	25.08	8.36	3.26	3	42.0
G1	Culverts Under Seawolf Pkwy	5.99	2.99	1.95	2	24.0	2.55	2.55	1.80	1	24.0

SUMMARY OF SYSTEM "F&G" OPEN CHANNEL CHARACTERISTICS USING SECTION FACTORS (n=0.04, s=0.10%)

Analysis Point	Location	Using Future Flows: $(Qn)/(1.49s^{1/2})$ (A)	BW (ft)	Flow Depth (ft)	$AR^{2/3}$ (B)	Diff (A)-(B)	Using Current Flows: $(Qn)/(1.49s^{1/2})$ (A)	BW (ft)	Flow Depth (ft)	$AR^{2/3}$ (B)	Diff (A)-(B)
Approximate study areas - Depths determined by balancing both sides of the Manning's equation using iterative depths											
F3	Culverts Under Seawolf Pkwy	72.4	4.00	3.50	72.4	0.0	31.3	4.00	2.36	31.3	0.0
F4	Lateral Ditch	91.3	10.00	3.19	91.3	0.0	44.3	4.00	2.78	44.3	0.0
F2A	Culverts Under Seawolf Pkwy	7.9	4.00	1.17	7.9	0.0	8.3	4.00	1.20	8.3	0.0
F2B	Ditch Along Seawolf Pkwy	105.5	12.00	3.24	105.5	0.0	50.6	4.00	2.96	50.6	0.0
F1A	Culverts Under Seawolf Pkwy	28.1	4.00	2.24	28.1	0.0	16.9	4.00	1.74	16.9	0.0
F1B	Ditch to Outfall	134.8	15.00	3.42	134.8	0.0	63.9	4.00	3.30	63.9	0.0
G1	Culverts Under Seawolf Pkwy	15.2	4.00	1.65	15.2	0.0	6.5	4.00	1.06	6.5	0.0

TABLE 8
PELICAN ISLAND SUMMARY
SYSTEM "PIP"

SUMMARY OF SYSTEM "PIP" DESIGN FLOWS

Analysis Point	Location	Sub-Area		Cumulative Area			Design Flow Rates		
		Area	Developed Area	Area	Developed Area	Percent Developed	Undev	Future	Interpolated Current*
		(ac)	(ac)	(ac)	(ac)	(%)	(cfs)	(cfs)	(cfs)
Approximate study areas									
PIP4	Ditch Along Bradner	27.60	0.00	27.60	0.00	0.0%	17.3	40.4	17.3
PIP3	Culverts Under Bradner	152.80	0.00	180.40	0.00	0.0%	102.0	225.2	102.0
PIP2	PIP Improved Ditch	39.50	0.00	219.90	0.00	0.0%	120.8	262.3	120.8
PIP1	PIP Improved Ditch	48.70	0.00	268.60	0.00	0.0%	142.3	302.1	142.3

* Interpolated Current is a linearly interpolated value between Undev and Future and is based on Percent Developed

SUMMARY OF SYSTEM "PIP" STORM SEWER SIZES

Analysis Point	Location	Using Future Flows for Pipe					Using Current Flows for Pipe				
		Req Area @ 3fps	Required Area Per Barrel	Raw Diameter	Number of Barrels	Use	Req Area @ 3fps	Required Area Per Barrel	Raw Diameter	Number of Barrels	Use
		(sf)	(sf)	(ft)	(No.)	(in)	(sf)	(sf)	(ft)	(No.)	(in)
Approximate study areas											
PIP4	Ditch Along Bradner	13.45	13.45	4.14	1	48.0	5.76	5.76	2.71	1	30.0
PIP3	Culverts Under Bradner	75.07	12.51	3.99	6	48.0	33.99	11.33	3.80	3	48.0
PIP2	PIP Improved Ditch	87.45	12.49	3.99	7	48.0	40.27	13.42	4.14	3	48.0
PIP1	PIP Improved Ditch	100.71	16.79	4.62	6	54.0	47.45	15.82	4.49	3	54.0

SUMMARY OF SYSTEM "PIP" OPEN CHANNEL CHARACTERISTICS USING SECTION FACTORS (n=.04, s=0.10%)

Analysis Point	Location	Using Future Flows					Using Current Flows				
		$(Qn)/(1.49s^{1/2})$	BW	Flow Depth	$AR^{2/3}$	Diff	$(Qn)/(1.49s^{1/2})$	BW	Flow Depth	$AR^{2/3}$	Diff
		(A)	(ft)	(ft)	(B)	(A)-(B)	(A)	(ft)	(ft)	(B)	(A)-(B)
Approximate study areas - Depths determined by balancing both sides of the Manning's equation using iterative depths											
PIP4	Ditch Along Bradner	34.3	4.00	2.46	34.3	0.0	14.7	4.00	1.62	14.7	0.0
PIP3	Culverts Under Bradner	191.2	12.00	4.43	191.2	0.0	86.6	8.00	3.31	86.6	0.0
PIP2	PIP Improved Ditch*	315.0	25.00	4.49	315.0	0.0	145.1	8.00	4.28	145.1	0.0
PIP1	PIP Improved Ditch*	362.7	30.00	4.50	362.7	0.0	170.9	12.00	4.18	170.9	0.0

* Designed at 0.05% slope.

CAPITAL IMPROVEMENT PLAN SUMMARY

MASTER DRAINAGE ESTIMATED CAPITAL IMPROVEMENT PLAN COST ANALYSIS

Project	System	Total Cost	Construction Cost Contingency (20%)	Total Cost + 35% (Const. and Eng.)	Total Structural Complaints	Total Complaints	Total Area (acre)	Complaint/Acre
E	18th Street System	$4,112,000	$822,400	$6,661,440	*12*	133	227	0.59
B	West P/Frazier System	$10,800,000	$2,160,000	$17,496,000	*18*	406	694	0.59
K	West K System	$1,451,000	$290,200	$2,350,620	*3*	64	142	0.45
J	19th Street System	$867,000	$173,400	$1,404,540	*4*	22	56	0.39
H	15th Street System	$3,131,000	$626,200	$5,072,220	*4*	61	180	0.34
F	Grover Street System	$519,000	$103,800	$840,780	*8*	44	133	0.33
C	29th-30th Street System	$14,395,000	$2,879,000	$23,319,900	*15*	188	588	0.32
L	11th-13th Street System	$2,577,000	$515,400	$4,174,740	*1*	56	183	0.31
I	West Heards System	$487,000	$97,400	$788,940	*4*	36	118	0.31
D	Bayou Shore System	$762,000	$152,400	$1,234,440	*13*	99	373	0.27
G	25th-27th Street System	$840,000	$168,000	$1,360,800	*5*	35	142	0.25
A	51st Street System	$7,223,000	$1,444,600	$11,701,260	*29*	162	763	0.21
M	9th Street System	$470,000	$94,000	$761,400	*1*	16	157	0.10
N	37th Street System	$962,000	$192,400	$1,558,440	*1*	5	124	0.04

Prioritized						at 6% interest over 20yrs Annual Debt Service	Monthly Revenue Req'd	Monthly Cumulative
High Priority (L,E) - Medical Center - 18th Street	$6,689,000		$10,836,180	30	539	$944,748	$78,729	$78,729
Mid Priority (B,K,J,H) - West P, West K, 19th, and 15th Street	$16,249,000		$26,323,380	11	147	$2,294,992	$191,249	$269,978
Low Priority (A,C) - 51st and 29th/30th Streets - Large Projects	$21,618,000		$35,021,160	41	423	$3,053,304	$254,442	$524,420
Remaining Projects - Tidal areas and other smaller jobs	$4,040,000		$6,544,800	31	183	$570,605	$47,550	$571,971
Airport Systems (new storm sewer system cost only)	$9,077,200	$0	$9,077,200		2	$791,392	$65,949	$637,920
Pelican Island	$999,904	$199,981	$1,619,844		1	$141,225	$11,769	$649,689
West Galveston Projects - Many small projects	$2,659,050	$531,810	$4,307,661			$375,562	$31,297	$680,986

GRAND TOTAL CIP (Proj. A thru N)	**$78,725,520**	$6,863,650	$571,971	$571,971
GRAND TOTAL With Airport, Pelican and West Galveston	$93,730,225	$8,171,828	$680,986	$680,986
PLAN 1 - GRAND TOTAL Without Airport Project (Use in CIP Estimate)	**$84,653,025**	$7,380,437	$615,036	$615,036
PLAN 2 - High Priority + Mid Priority	$37,159,560			
PLAN 3 - Plan 2 + Low Priority	$72,180,720			

City of Galveston
Master Drainage Plan

Table 10

GALVESTON MASTER DRAINAGE PLAN SUMMARY

MASTER DRAINAGE PLAN COST ANALYSIS
(Does not include inflation - Rates will need adjustment at periodic intervals to maintain level of service.)

COST ITEM	TOTAL	ANNUAL COST BASED ON VARIOUS CIP PLANS				
		20yr CIP	40yr CIP	60yr CIP	80yr CIP	100yr CIP
Total CIP - Plan 1 - All Projects	$93,730,225	$4,686,511	$2,343,256	$1,562,170	$1,171,628	$937,302
CIP - Plan 2 - (High Priority + Mid Priority)	$37,200,000	$1,860,000	$930,000	$620,000	$465,000	$372,000
CIP - Plan 3 - (Plan 2 + Low Priority)	$72,200,000	$3,610,000	$1,805,000	$1,203,333	$902,500	$722,000
Operations and Maintenance (O&M)	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Storm Water Management (EPA) - Admin	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
TOTAL REQUIRED ANNUAL DRAINAGE FEE (CIP Plan 1)		$5,886,511	$3,543,256	$2,762,170	$2,371,628	$2,137,302
TOTAL REQUIRED ANNUAL DRAINAGE FEE (CIP Plan 2)		$3,060,000	$2,130,000	$1,820,000	$1,665,000	$1,572,000
TOTAL REQUIRED ANNUAL DRAINAGE FEE (CIP Plan 3)		$4,810,000	$3,005,000	$2,403,333	$2,102,500	$1,922,000

LIST OF GENERAL O&M EXPENSES
1. ADMINISTRATION
2. SPECIAL PROGRAMS (GIS, Mapping, Public Involvement)
3. BILLING AND FINANCE (includes Customer Service)
4. INDIRECT COST (Overhead, Cost Control)
5. ENGINEERING AND PLANNING (Criteria, Data Collection, Master Planning, Design, Field and Ops Engineer)
6. OPERATIONS (General Maintenance, Emergency Response, Public Assistance)
7. REGULATION AND ENFORCEMENT (Permits Adm, Code Enforcement, Inspections)

LIST OF GENERAL STORM WATER MANAGEMENT EXPENSES
1. PUBLIC EDUCATION (Bill inserts, Public Meeting)
2. PUBLIC INVOLVEMENT (Stenciling, Adopt a Stream)
3. ILLICIT DISCHARGE DETECTION AND ELIMINATION (Mapping, Ordinance Development, Detection, Business Education)
4. POLLUTION PREVENTION/GOOD HOUSEKEEPING (For City Facilities)
5. CONSTRUCTION SITE RUN-OFF CONTROL (Construction Ordinance, Site Plan Review, Hotline)
6. POST-CONSTRUCTION STORM WATER MANAGEMENT (Research Pollutants, Post Construction Ordinance)

GALVESTON MASTER DRAINAGE PLAN SUMMARY

MASTER DRAINAGE PLAN EQUITABLE STORM WATER FEE ANALYSIS

Proposed Drainage Fee Collection Estimates
Minimal Annual Funding Goal $1,200,000

Land Use	Area (sf)	Area (ac)	Parcels	Percent Acerage	Rate 1 Average Monthly charge per parcel $3*(SFR)	Rate 1 Average Annual charge per parcel (x12)	Rate 1 Charge per Acre per Month	Rate 1 Annual Total Collections	Rate 2 Average Monthly Charge $4*(SFR)	Rate 2 Average Annual charge per parcel (x12)	Rate 2 Charge per Acre per Month	Rate 2 Annual Total Collections	Rate 3 Average Monthly Charge $8*(SFR)	Rate 3 Average Annual charge per parcel (x12)	Rate 3 Charge per Acre per Month	Rate 3 Annual Total Collections
SFR, < 5000 sf	16,115,975	369.97	5,175	4.90%	$3	$36	$42	$186,300	$4	$48	$56	$248,400	$8	$96	$112	$496,800
SFR, 5000-8000 sf	53,426,381	1,226.50	8,909	16.25%	$3	$36	$22	$320,724	$4	$48	$29	$427,632	$8	$96	$58	$855,264
SFR, 8000 sf -1/4 ac	4,733,182	108.66	496	1.44%	$3	$36	$14	$17,856	$4	$48	$18	$23,808	$8	$96	$37	$47,616
SFR, 1/4 -1/2 ac	16,921,150	388.46	1,114	5.15%	$3	$36	$9	$40,104	$4	$48	$11	$53,472	$8	$96	$23	$106,944
SFR, >1/2 ac	27,977,175	642.27	416	8.51%	$3	$36	$2	$14,976	$4	$48	$3	$19,968	$8	$96	$5	$39,936
MFR	19,864,257	456.02	1,149	6.04%	$10	$118	$25	$135,395	$13	$157	$33	$180,527	$26	$314	$66	$361,054
Commercial	169,812,156	3,898.35	1,654	51.66%	$58	$700	$25	$1,157,145	$78	$933	$33	$1,542,861	$155	$1,866	$66	$3,085,721
Industrial	19,841,456	455.50	61	6.04%	$185	$2,216	$25	$135,198	$246	$2,955	$33	$180,263	$493	$5,910	$66	$360,527
	Total Area	7,545.73		100.00%				**$2,007,698**				**$2,676,931**				**$5,353,862**
						Say 95% Collections		**$1,907,313**		Say 95% Collections		**$2,543,084**		Say 95% Collections		**$5,086,169**
						Residential	30%			Residential	30%			Residential	30%	
						Commercial	61%			Commercial	61%			Commercial	61%	
						Others	9%			Others	9%			Others	9%	

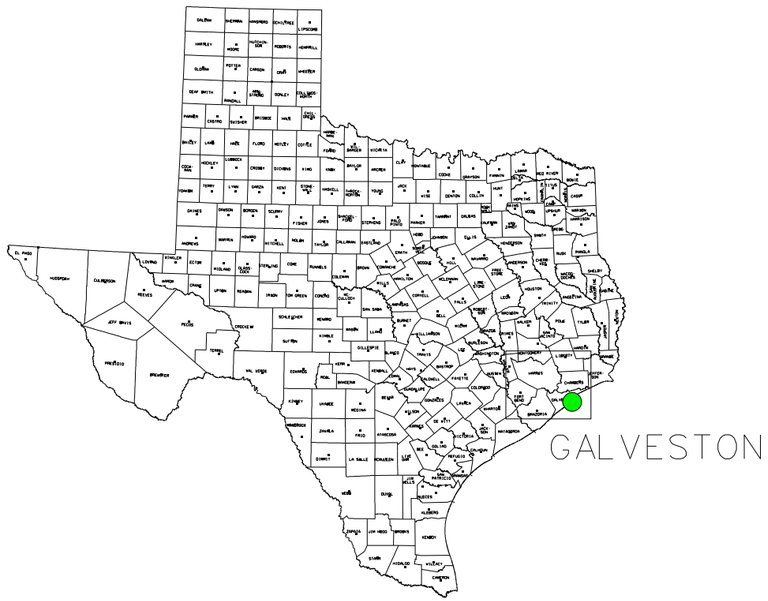
DETERMINE EQUIVALENT SINGLE FAMILY RESIDENCE (SFR)
SFR Land Use Analysis

	Area (sf)	Area (ac)	Parcels	Avg Parcel Size (ac)	C from COG	C*A Per Parcel	C*A
SFR, < 5000 sf	16,115,975	369.97	5,175	0.071	0.50	0.04	184.99
SFR, 5000-8000 sf	53,426,381	1,226.50	8,909	0.138	0.50	0.07	613.25
SFR, 8000 sf -1/4 ac	4,733,182	108.66	496	0.219	0.50	0.11	54.33
SFR, 1/4 -1/2 ac	16,921,150	388.46	1,114	0.349	0.50	0.17	194.23
SFR, >1/2 ac	27,977,175	642.27	416	1.544	0.50	0.77	321.14
Totals	119,173,863	2,735.86	16,110	0.170			1,367.93

Avg C*A Per Parcel (ESFR) = 0.0849 equivalent SFR (Total CA/Parcels)

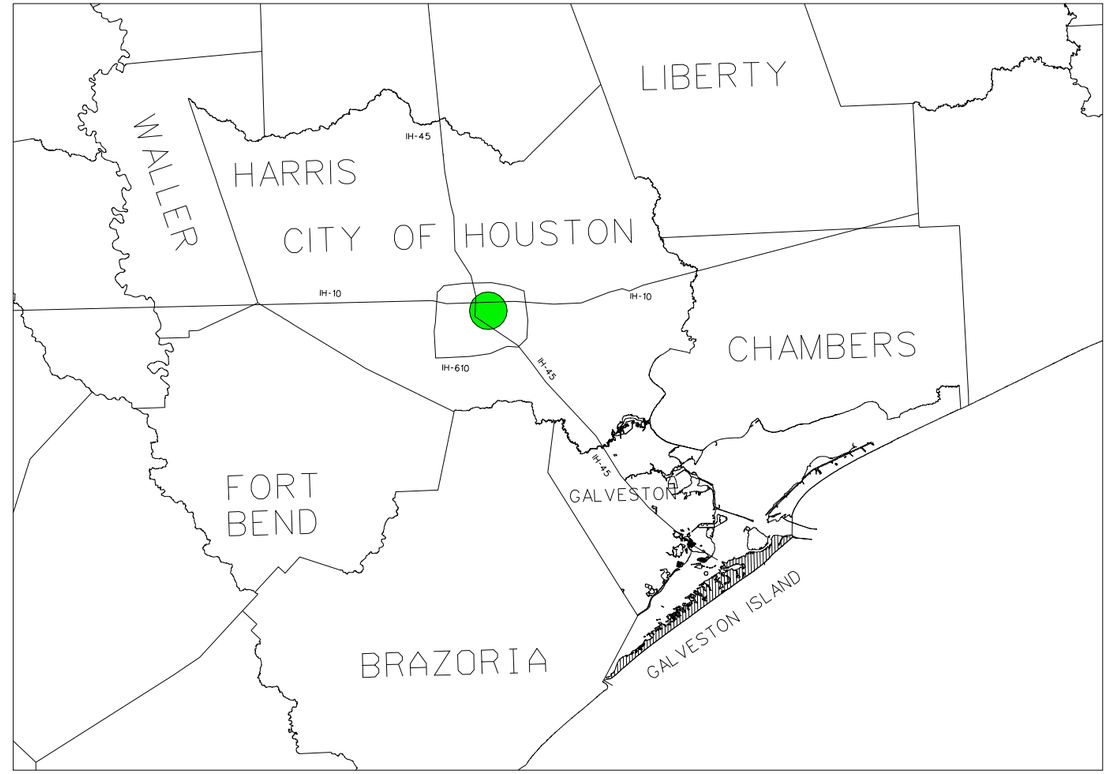
DETERMINE EQUIVALENT SFR FOR OTHER PROPERTIES

	Area (sf)	Area (ac)	Parcels	Avg Parcel Size	C from COG	C*A Per Parcel	Equiv. SFR (CA/SFR)	**Average Charge Per Parcel Per Month** Rate 1 Charge $3*(SFR)	Rate 2 Charge $4*(SFR)	Rate 3 Charge $8*(SFR)
MFR	19,864,257	456.02	1,149	0.397	0.70	0.28	3.27	$9.82	$13.09	$26.19
Commercial	169,812,156	3,898.35	1,654	2.357	0.70	1.65	19.43	$58.30	$77.73	$155.47
Industrial	19,841,456	455.50	61	7.467	0.70	5.23	61.57	$184.70	$246.26	$492.52



STATE OF TEXAS

AREA MAP



DEC DANNENBAUM ENGINEERING CORPORATION
3100 WEST ALABAMA
HOUSTON, TEXAS 77098
(713) 520-9570

CITY OF GALVESTON
MASTER DRAINAGE PLAN
VICINITY MAP

SCALE: NTS | DATE: MAY 2003

EXHIBIT 1

DESIGN FILE: W:\DrainHENG\35x43\graphics\drainmap.dgn
PLOTTED BY: Wolfe, J. DATE: 03/26/04 AM
STATUS: Plan Review Submittal DATE: 11/04/2004

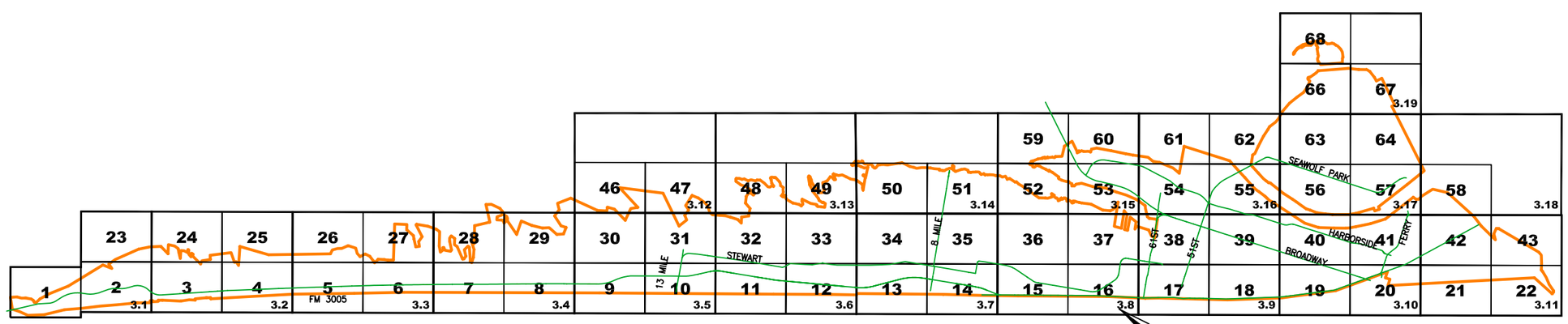


EXHIBIT NUMBER (TYPICAL)

DRAINAGE SYSTEM NAME (ALPHABETICAL ORDER)	EXHIBIT #
11TH STREET SYSTEM	3.10
14TH STREET SYSTEM	3.10
15TH STREET SYSTEM	3.10
16TH STREET SYSTEM	3.10
18TH STREET SYSTEM	3.10
19TH STREET SYSTEM	3.10
20TH STREET SYSTEM	3.10
22ND–24TH STREET SYSTEM	3.10
25TH–27TH STREET SYSTEM	3.10
29TH STREET SYSTEM	3.9
33RD–41ST STREET SYSTEM	3.9
37TH STREET SYSTEM	3.9
45TH STREET SYSTEM	3.9
4TH STREET SYSTEM	3.10
51ST STREET SYSTEM	3.9
59TH STREET SYSTEM	3.9
61ST STREET SYSTEM	3.9
79TH STREET SYSTEM	3.8
81ST STREET SYSTEM	3.8
81ST STREET WEST SYSTEM	3.8
9TH STREET SYSTEM	3.10
BAY HARBOR WEST AREA	3.1, 3.2
BAYOU SHORE/57TH STREET SYSTEM	3.9
BERMUDA BEACH	3.6
CENTRAL CITY SYSTEM	3.8
COLONY PARK SYSTEM	3.8
COLONY PARK SOUTH SYSTEM	3.8
ECKERS BAYOU AREA	3.6
FERRY ROAD SYSTEM	3.10

DRAINAGE SYSTEM NAME (ALPHABETICAL ORDER)	EXHIBIT #
GALVESTON STATE PARK AREA	3.5
GREENS BAYOU SYSTEM	3.8
GROVER STREET SYSTEM	3.8
GULF PALMS DRIVE	3.4
HABLA ROAD	3.4
HARBORSIDE DRIVE WEST OF 51 STREET	3.12, 3.13
INDIAN BEACH AREA	3.3, 3.4
JAMAICA BEACH AREA	3.4, 3.5
JONES/GEROL SYSTEM	3.8
LAKE COMO AREA	3.5, 3.6
LAKE MADELINE AREA	3.8
BELUCHE SYSTEM	3.8
DOMINIQUE LEBRUM SYSTEM	3.8
LAKEVIEW SYSTEM	3.8
PINE SYSTEM	3.8
MENSELL BAYOU AREA	3.9
NORTH BAYOU SHORE SYSTEM	3.8
PALM/PIRATES BEACH	3.5
SCHOLES AIRPORT AREA	3.2, 3.3
SEA ISLE/TERRAMAR AREA	3.7, 3.8
SWEETWATER LAKE AREA	3.7, 3.8
SYDNOR BAYOU AREA	3.8
WEST HEARDS SYSTEM	3.8
WEST JONES SYSTEM	3.9
WEST AVE K SYSTEM	3.9
WEST AVE P SYSTEM	3.9
WEST T1/2 SYSTEM	3.9
PELICAN ISLAND DRAINAGE SYSTEMS	3.14, 3.15

STREET KEY

AVENUE A	HARBORSIDE
AVENUE B	STRAND/TEXAS
AVENUE C	MECHANIC
AVENUE D	MARKET
AVENUE E	POST OFFICE
AVENUE F	CHURCH
AVENUE G	WINNIE
AVENUE H	BALL
AVENUE I	SEALY
AVENUE J	BROADWAY
AVENUE N	URSALINE AVE.
AVENUE O	MIKE GAIDO BLVD.
AVENUE P	BERNADO DE GALVEZ
25TH STREET	ROSENBERG
23RD STREET	TREMONT
21ST STREET	CENTER

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GALVESTON
MASTER DRAINAGE PLAN

SCALE: NA

DATE: 07/03

EXHIBIT 2