3.0 DRAINAGE ANALYSIS AND RECOMMENDATIONS

3.1 Design Criteria

The design criteria for this project is based on City of Houston (COH) standards which can be found in the *COH Infrastructure Design Manual*, dated July 2009. Storm Sewer design criteria can be found in Section 9.05 C of the *COH Infrastructure Design Manual.*

In accordance with City design standards, the first objective in the analysis of the existing Kimberley Lane storm sewer system is to determine the location of the hydraulic grade line (HGL) in relation to the gutter line for the 2 year storm event.

The second objective is to ensure that flow from an extreme event (100-year storm) can be conveyed in the storm sewer and through street sheet flow. The following criteria was used to establish roadway cross-sections and then calculate the flow conveyed by the existing and proposed roadway cross-section:

- Streets shall be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet.
- The maximum depth of ponding at high points shall be 6" above top of curb.
- The maximum depth of ponding at low points shall be 18" above top of curb.
- The maximum ponding elevation for the 100-year event at any point along the street shall not be higher than the natural ground elevation at the right-of-way line.

Methods 1 through 3 from Section 9.05D of the *COH Infrastructure Design Manual* were used as guidance for analyzing the extreme event. Conduit flow (Q_c) was defined as the flow in the storm sewer for the 2 year design storm. The extreme event consideration requires that the flow from the 100 year event at the ultimate outlet (Q_T) can be carried by the capacity in the storm sewer (Q_C), the overland flow in the street (Q_O), and the change in storage with respect to time ($\Delta S/_T$). Methods 1 and 2 from the *COH Infrastructure Design Manual* remove the storage consideration by determining if the total flow (Q_T) can be conveyed only using conduit flow (Q_c) and overland flow (Q_O).

The City of Houston's version of TxDOT WinStorm software, HouStorm, was used to model the existing and proposed storm sewer networks. HouStorm utilizes the rational method to estimate peak run-off rates. The run-off coefficients were determined from the COH criteria shown in Table 3.1. The HouStorm output for this project can be found in **Appendix C.7**.

Table 3.1 - COH Run-off Coefficients

Land Use Type	Run-off Coefficient (C)
Residential Districts	
Lots more than 1/2 acre	0.35
Lots 1/4 - 1/2 acre	0.45
Lots less than 1/4 acre	0.55
Multi-Family area	
Less than 20 Service Units/Acre	0.65
20 Service Units/Acre or Greater	0.80
Business Districts	0.80
Industrial Districts	
Light Areas	0.65
Heavy Areas	0.75
Railroad Yard Areas	0.30
Parks/Open Areas	0.30

Time of concentration was computed using the following equation:

$$TC = 10A^{0.1761}+15$$

Where: TC = time of concentration (minutes)
A = subarea (acres)

The design criteria used for storm sewers in the Kimberley Lane Storm Sewer Project can be found in Section 9.05.C of the *COH Infrastructure Design Manual*.

3.2 Land Use and Development

The contributing drainage area for the Kimberley Lane Storm Sewer consists of commercial and private developments. The Town and Country Village Shopping Center comprises approximately sixty percent of the area that contributes to the Kimberley Lane storm sewer. The remainder of the contributing drainage area comes from the other private developments adjacent to Kimberley Lane. Bendwood Elementary School and Wildcat Way School drain to the existing Kimberley Lane storm sewer system and are located on the north side of Kimberley Lane and the east end of the contributing drainage area. On the south side of Kimberley Lane, a portion of the Pines Presbyterian Church property contributes to the Kimberley Lane Storm sewer while the remainder drains south via, the storm sewer system along Memorial Drive.

The Kimberley Lane storm sewer included in the project begins just east of West Bough Lane and drains west to the Beltway 8 Northbound Frontage Road. The Kimberley Lane storm sewer system begins at a manhole just east of West Bough Lane and north of Kimberley Lane. This manhole receives flow from a detention pond servicing Bendwood Elementary School and serves as an interconnector for two separate storm sewer systems. The storm sewer system to the east of the manhole serves the Fonn Villas subdivision and ultimately drains easterly to W153-00-00, a tributary to Buffalo Bayou. The storm sewer system to the west of the manhole is the system associated with this project referred to as the Kimberley Lane Storm Sewer System. For

modeling purposes, the drainage areas were divided at this manhole and the interconnector pipe between the two systems was ignored. The Beltway 8 Northbound Frontage Road defines the project western limit and has only an indirect impact on the project as it is serviced by its own storm sewer system.

3.3 Existing Drainage System Analysis

3.3.1 Existing Storm Sewer – 2-Year Event Analysis

In accordance with City of Houston design criteria, the performance of the existing Kimberley Lane storm sewer system was determined under the 2-year event through the use of HouStorm. As required by City of Houston design criteria, the location of the hydraulic grade line (HGL) in relation to the gutter line was determined. **Appendix C.1** shows the profile plots of the main trunkline and HGL elevations for the existing conditions. It was ultimately determined that the HGL in all portions of the Kimberley Lane storm sewer system are located below the gutter line or critical elevation thus meeting the City of Houston requirements.

The existing conditions of the Kimberley Lane storm sewer system satisfies the drainage criteria defined in the *City of Houston Infrastructure Design Manual* Criteria 9.05.C.1.b. Criteria section 9.05.C.1.b which states the hydraulic grade line must be at or below the gutter line at all points in the storm sewer. See **Appendix C.2** for the detailed HouStorm calculations and output for the 2-year event analysis.

3.3.2 Existing Storm Sewer – Extreme Event Analysis

Methods 1 through 3 from Section 9.05D of the *COH Infrastructure Design Manual* were used as guidance for analyzing the extreme event. Conduit flow (Q_c) was defined as the flow in the storm sewer for the 2 year design storm. The extreme event consideration requires that the flow from the 100 year event at the ultimate outlet (Q_T) be carried by the flow in the storm sewer (Q_C), the overland flow in the street (Q_O), and the change in storage with respect to time ($\Delta S/T$).

Methods 1 and 2 from the *COH Infrastructure Design Manual* remove the storage consideration by determining if the total flow (Q_T) can be conveyed only using conduit flow (Q_c) and overland flow (Q_O).

It was determined that the required total flow (Q_T) under the extreme event is 97.9 cubic-feet-per-second (cfs). The conduit flow (Q_c) at the critical roadway section was determined to be 48.6 cfs and the required overland flow (Q_O) under the extreme event is 49.3 cfs. The overland flow capacity of the critical Kimberley Lane roadway sections at the intersection of Kimberley Lane and the Beltway 8 Northbound Frontage Road and Town and Country Boulevard were calculated to be 77.9 cfs. While the existing condition of the Kimberley Lane storm sewer system supplies the required drainage capacity defined in the *City of Houston Infrastructure Design Manual* Criteria 9.05.D, the roadway creates a hazardous ponding condition under the extreme event. The maximum ponding elevation for the 100-year event was found to exceed the natural ground elevation at the right-of-way line at multiple locations. **Therefore, the existing system does not satisfy the 100-year COH criteria.** The failure to meet the minimum COH criteria was considered the critical factor that warranted an improvement project for the

Kimberley Lane storm sewer. **Appendix C.3** summarizes the 100-year analysis for Kimberley Lane in greater detail.

3.4 Recommended Drainage Improvements

Complete pavement reconstruction and raising of the roadway profile approximately 6-inches higher than the existing roadway top of curb elevation is recommended based upon the findings from the *Kimberly Lane Drainage Improvements Preliminary Engineering Report*, dated May 2009, as well as findings concluded in this report. To mitigate the storage lost by raising the roadway, approximately 1,100-feet of 5' x 3' box culvert is also proposed to provide additional storage (in-line detention). This proposes to significantly decrease the Kimberley Lane flooding frequency and increase the capacity of the Kimberley Lane storm sewer system. The existing storm sewer along Kimberley Lane is anticipated to remain in place and interconnect to the proposed additional storage box culverts via lateral pipes. A condition assessment is recommended to be conducted in Phase II to confirm the existing storm sewer condition. The proposed improvements will provide a 10-year to 25-year level of service.

This recommendation is the most optimal solution based on benefit, cost and constructability. Raising the roadway and adding the 5' x 3' box culvert addresses both the sheetflow and ponding issues on Kimberley Lane as well as Kimberley Lane's need for pavement and infrastructure improvements. Other drainage improvement options were considered and can be referenced in **Appendix F**.

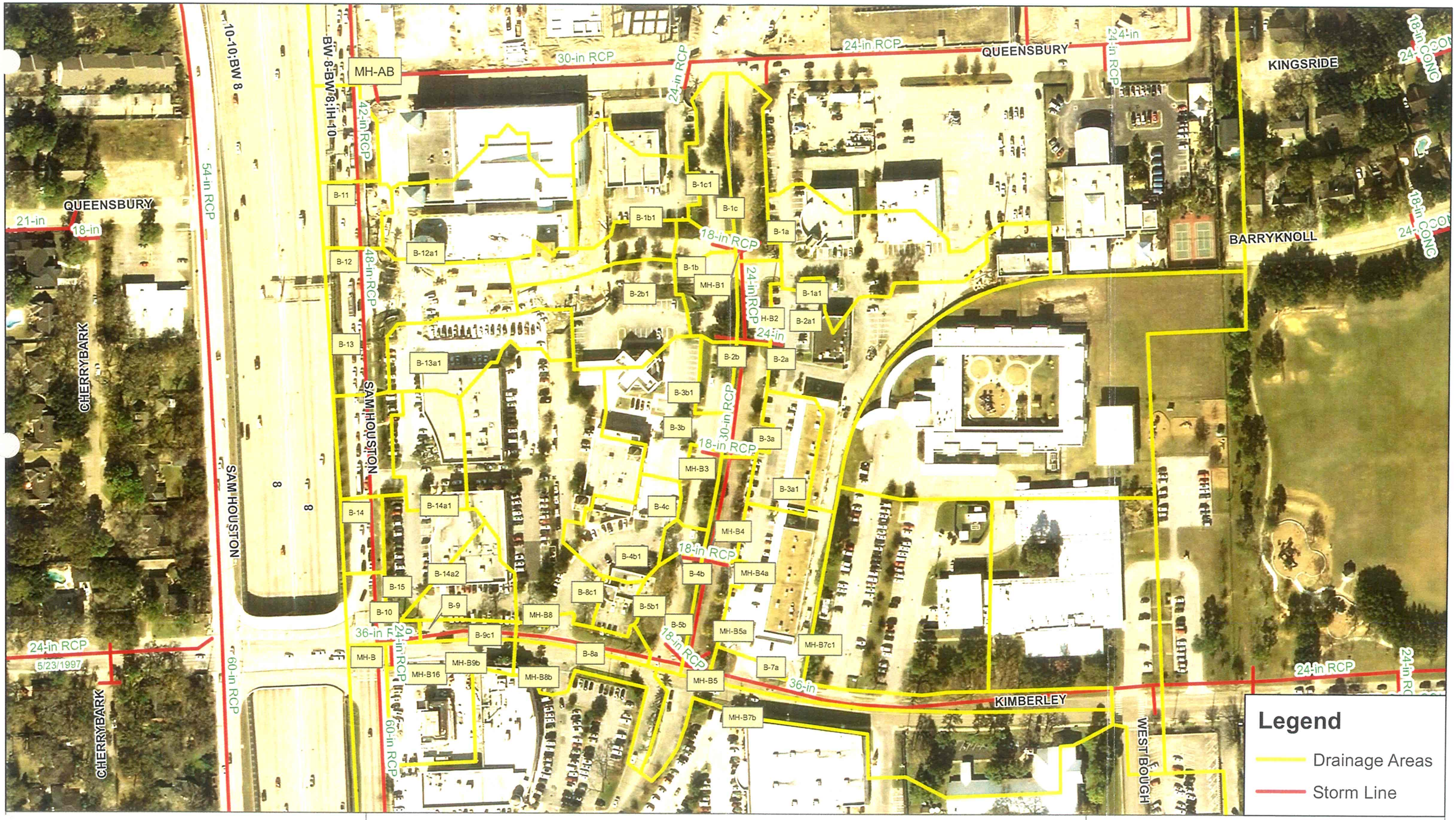

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EXHIBIT 3.1 EXISTING DRAINAGE AREA MAP

N

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Feet

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EXHIBIT 3.2 SHEET FLOW AND PONDING

N

0 75 150 300

Feet

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