DAI Job No. 1898a

Document No. 2011/019

# INWOOD GOLF COURSE
# REGIONAL DETENTION ANALYSIS

**Harris County, Texas**

***Prepared for:***

HARRIS COUNTY FLOOD CONTROL DISTRICT

***Prepared by:***

**DODSON & ASSOCIATES, INC.**

**July 2011**

## EXECUTIVE SUMMARY

The purpose of this study is to determine the feasibility of converting the property once operated as the Inwood Golf Course into a regional detention basin. As shown on **Exhibit 1**, the Inwood Golf Course is located in central Harris County along Antoine Drive, north of Victory Drive and south of West Gulf Bank Road. White Oak Bayou (E100-00-00) and Vogel Creek (E121-00-00) converge just southeast of the golf course. The regional facility was designed with the following goals in mind (in order of importance):

- Maximize Flood Damage Reduction
- Neighborhood Enhancement (including environmental enhancements, aesthetics, and passive recreational features for the public)
- Water Quality
- Detention for Future City of Houston Capital Improvement Projects

The objectives of this study were to:

- Identify the Pre-Project conditions inundation limits along White Oak Bayou and Vogel Creek for the 10-year, 25-year, and 100-year flood events;
- Model several proposed regional detention scenarios based on different detention basin configurations within the golf course and identify any associated reductions in flooding along White Oak Bayou between Vogel Creek and IH 610;
- Determine the structural flood damage reductions associated with each of the proposed alternatives for the 10-year, 25-year, and 100-year flood events along White Oak Bayou and affected tributary reaches; and
- Produce a feasibility report which includes a recommended detention plan with control structures based on the results of the analysis.

A single configuration alternative for regional detention has been recommended based on the results of this analysis. The layout of the detention facility with its interconnected basins along White Oak Bayou and Vogel Creek is shown on **Exhibit 2**. The process used to identify the recommended plan was as follows:

1. A preliminary screening analysis of six detention basin alternatives was completed, which included a minimum, four intermediate, and a maximum detention volume scenario.
2. Since the four intermediate volume alternatives yielded very similar results, further model refinement and optimization was performed on all four in an alternative analysis phase of the study effort.

3. Based on the results of the better optimized alternatives a final recommended alternative was chosen and further model refinement and optimization were performed as a final phase.

Inundation maps were developed to visually illustrate the effectiveness of the recommended regional detention scenario. The inundation limits of the Pre-Project conditions models and proposed regional detention alternative were mapped and compared for storm events with a 1% (100-year), 4% (25-year), and 10% (10-year) annual exceedance probability (see **Exhibits 5 through 7**, respectively). **Exhibits 8 through 10** identify the structures which would no longer be inundated during each of these events.

Estimated construction costs of the Recommended Alternative were determined to be approximately $19.8 million. For a single 100-year event the estimated reduction in flood damages with the Recommended Alternative was computed to be approximately $23,700,000. The proposed regional detention within the golf course would also provide fairly significant benefits during the 25-year ($5,970,000) and 10-year events ($504,000).

As a part of this analysis, some revisions to the existing Harris County Flood Control District (HCFCD) regional detention basin E500-06 were also analyzed (see **Exhibit 12**). The lateral structure connecting E500-06 to White Oak Bayou was better optimized to function in harmony with the final Recommended Alternative and to maximize the reductions in flood damages.

*General Assumptions and Constraints*

The following general assumptions and constraints were applied to this study:

1. All elevations stated in this report are on the North American Vertical Datum of 1988 (NAVD 88), 2001 adjustment.

2. The Hydrologic Engineering Center's River Analysis System software (HEC-RAS) version 4.0 and Hydrologic Modeling System software (HEC-HMS) version 3.4 were used in this analysis.

3. A 50-foot maintenance berm was assumed around the perimeter of each detention cell for the Recommended Alternative except where noted on **Exhibit 2**.

4. For the Recommended Alternative the proposed dry-bottom detention basins have side slopes of 4(H):1(V) and the proposed lake-bottom detention basins have side slopes of 6(H):1(V), except where noted on **Exhibit 2**.

5. The Vogel Creek channel modification data was provided by HCFCD based on recently completed work on Vogel Creek. This "as-built" data was incorporated into the Pre-Project conditions model for this feasibility study in order to reflect the current conditions along Vogel Creek as closely as possible.

6. The flood damages were computed using data from the structural inventory database tool for the White Oak Bayou watershed provided by HCFCD.

*Hydrologic Methodology*

The hydrology for this analysis was based on the hydrologic model developed for the on-going Flood Event Modeling Program for the HCFCD. Some minor changes were made to better account for the inflows into the proposed detention facilities. Flow hydrographs were generated using HEC-HMS version 3.4.

*Hydraulic Methodology*

The Pre-Project conditions hydraulic models were developed using the HEC-RAS (version 4.0) software package. The unsteady simulation option of HEC-RAS was utilized for this analysis.

To evaluate the reasonableness of using the golf course as regional detention, the HEC-RAS model developed for the on-going Flood Event Modeling Program for HCFCD was used. The benefits of using this particular model are that it is a complete model of the Buffalo and White Oak Bayous system and all tributaries studied by FEMA. In addition, the use of an unsteady flow model provided the study team a reasonably good estimate of the time-based interactions of the White Oak Bayou and Vogel Creek hydrographs since the proposed detention is located at the confluence of these two streams.

*Pre-Project Conditions Model Results*

The Pre-Project conditions models were computed using the 10-year, 25-year, and 100-year events. Damages associated with each of the events were computed using the HCFCD structural database and damage curves.

The table below shows the number of structures identified as having sustained damage and the amount of damage in dollars associated with each flooding event. The damage assessment was performed using all of the structures in the HCFCD structural database for the White Oak Bayou watershed, approximately 36,000 structures.

**Table ES-1: Pre-Project Conditions Damage Summary**

| Condition | No. of Structures Inundated | Damages |
|---|---|---|
| *10% (10-Year) Event* | 302 | $ 8,516,701 |
| *4% (25-Year) Event* | 1177 | $ 37,404,143 |
| *1% (100-Year) Event* | 7322 | $ 256,660,166 |

*Recommended Alternative and Results*

The selection process was broken into three phases: 1) a preliminary screening analysis, 2) an alternative analysis, and 3) a recommended alternative analysis.

The preliminary screening process analyzed six detention basin configurations. The six configurations included a minimum, four intermediate, and a maximum detention volume scenario. Each configuration contained combinations of basins which differed in side slopes,

dry-bottom or lake-bottom features, shelf or off-line detention cells, maintenance berm widths, and whether the clubhouse would be demolished or not. Each of the alternatives was analyzed for the 25-year flood event to determine which would provide the most significant benefits to the White Oak Bayou system. The four intermediate volume alternatives were carried forward for the alternative analysis phase.

For the alternative analysis phase the 100-year and 10-year events were analyzed in addition to the 25-year. Further optimization of the detention basin outfall structures and interconnections was also performed along with a preliminary cost analysis.

The final Recommended Alternative was selected based on the results of the alternative analysis. The Recommended Alternative was chosen because it provided the most benefit or highest amount of flood damage reduction for the estimated cost. As a part of this final phase of the analysis, detailed optimization was performed on this alternative.

A check was performed to ensure that flood risks were not increased anywhere within the system when compared to Pre-Project conditions. A comparison of the maximum ponded water surface elevations for the 100-year, 25-year, and 10-year events in the storage areas has been included in **Appendix E**. **Table ES-2** provides a summary of the benefits for the recommended plan.

**Table ES-2: Benefits for Recommended Alternative**

| Condition | Volume of Storage (ac-ft) | No. of Structures Inundated | Damages | Benefit (No. of Structures No Longer in Floodplain) | Benefit (Reduced Damages) |
|---|---|---|---|---|---|
| **10% (10-Year) Event** | | | | | |
| *Pre-Project* | | 302 | $ 8,516,701 | | |
| *Recommended Alternative* | 819 | 284 | $ 8,012,484 | 18 | $ 504,217 |
| **4% (25-Year) Event** | | | | | |
| *Pre-Project* | | 1177 | $ 37,404,143 | | |
| *Recommended Alternative* | 1123 | 1039 | $ 31,434,653 | 138 | $ 5,969,490 |
| **1% (100-Year) Event** | | | | | |
| *Pre-Project* | | 7322 | $ 256,660,166 | | |
| *Recommended Alternative* | 1332 | 6937 | $ 232,972,674 | 385 | $ 23,687,493 |

For the 100-Year (1% AEP) event 385 structures originally identified in the Pre-Project model as flooded are no longer shown as being inundated. For the 25-Year (4% AEP) and 10-Year (10% AEP) events, the number of structures no longer shown as being inundated is 138 and 18, respectively.

Approximate construction costs were refined for the Recommended Alternative. The final cost for the Recommended Alternative was estimated at approximately $19,800,000. This final cost is subject to change based on the final design. A breakdown of all of the costs excluding land acquisition and any anticipated demolition of the existing clubhouse is included in **Appendix B**.

The proposed Recommended Alternative for this project and the results shown for the final analysis include an adjustment to raise the spillway at the HCFCD E500-06 regional detention

basin. This regional facility was originally constructed for the purpose of mitigating the Vogel Creek channel modifications between Victory and Arncliff. The raising of the spillway crest provided some additional benefit to damage reduction while maintaining its effectiveness in mitigating the Vogel Creek channel modifications.

*Conclusion*

This feasibility study indicates that the Inwood Golf Course could be converted to regional detention to provide effective flood damage reduction in the reach along White Oak Bayou between the site and the mouth of White Oak. As shown on **Exhibit 2**, this can be accomplished through the use of interconnected basins created by excavating the fairways and driving range and by drawing water from several sources. Lateral spillways are proposed to divert water from White Oak Bayou and Vogel Creek into the storage basins, which will also be fed by inflows from E121-02-00, Antoine Drive, and E140-00-00.

STATE OF TEXAS
ANDREW C. YUNG
79810
REGISTERED
PROFESSIONAL ENGINEER

07-01-2011

**Andrew C. Yung, P.E., CFM**
Vice President and Chief Hydrologist
Dodson & Associates, Inc.
(Registration F-000397)

# TABLE OF CONTENTS

**SECTION 1 - INTRODUCTION.....1**

*1.1 SITE DESCRIPTION.....1*
*1.2 ENVIRONMENTAL CONCERNS.....2*
*1.3 GEOTECHNICAL ISSUES.....2*
*1.4 PIPELINE CONSIDERATIONS.....2*

**SECTION 2 - HYDROLOGY.....3**

*2.1 DRAINAGE AREAS.....3*
*2.2 LOCATION OF INFLOW HYDROGRAPHS IN HEC-RAS MODEL.....4*

**SECTION 3 - HYDRAULICS.....5**

*3.1 MODEL BASIS.....5*
*3.2 BOUNDARY CONDITIONS AND ASSUMPTIONS.....5*
*3.3 PRE-PROJECT CONDITIONS RESULTS.....7*
3.4 OPTIMIZATION OF ALTERNATIVES.....9

**SECTION 4 – PLAN FORMULATION.....10**

*4.1 BENEFITS AND COSTS.....10*
*4.2 PRELIMINARY SCREENING ANALYSIS.....10*
*4.3 ALTERNATIVES ANALYSIS.....11*
*4.4 RECOMMENDED ALTERNATIVE ANALYSIS.....13*

**SECTION 5 – FINAL RECOMMENDATION.....14**

*5.1 REVISED PRE-PROJECT CONDITIONS.....14*
*5.2 CONFIGURATION.....14*
*5.3 RESULTS.....15*
*5.4 LAST-ADDED ANALYSIS.....17*
*5.5 FINAL RECOMMENDATION COSTS.....18*

**SECTION 6 – CONCLUSIONS.....19**

## EXHIBITS


| | |
|---|---|
| Exhibit 1: | Vicinity Map |
| Exhibit 2: | Recommended Alternative Layout |
| Exhibit 3: | Drainage Subarea Map |
| Exhibit 4: | Schematic Layout of Hydraulic Model |
| Exhibit 5: | 100-Year (1%) Inundation Limits Comparison |
| Exhibit 6: | 25-Year (4%) Inundation Limits Comparison |
| Exhibit 7: | 10-Year (10%) Inundation Limits Comparison |
| Exhibit 8: | 100-Year (1%) Structural Flooding Comparison |
| Exhibit 9: | 25-year (4%) Structural Flooding Comparison |
| Exhibit 10: | 10-Year (10%) Structural Flooding Comparison |
| Exhibits 11a through 11j: | Basin Details |
| Exhibit 12: | E500-06 Proposed Weir Detail |


## APPENDICES


| | |
|---|---|
| Appendix A: | DVD with Supporting Data |
| Appendix B: | Recommended Alternative Construction Costs |
| Appendix C: | Time of Concentration and Storage Coefficient Calculations |
| Appendix D: | Preliminary Environmental Evaluation of Site |
| Appendix E: | Summary of Detention Storage for Recommended Alternative |
| Appendix F: | Results of “Last-Added” Analysis |

# SECTION 1 - INTRODUCTION

The purpose of this document is to provide technical background information for a feasibility study which considers the conversion of the Inwood Golf Course into a series of interconnected flood storage areas which will potentially serve as a regional detention facility for the White Oak Bayou watershed. This regional facility was designed with the following goals in mind (in order of importance):

- To maximize flood damage reduction;
- To promote neighborhood enhancement through environmental enhancements, aesthetics, and passive recreational features for the public;
- To promote water quality; and
- To provide detention for future City of Houston capital improvement projects.

In order to meet the goal of flood control, the detention system is being designed to draw water off of White Oak Bayou and Vogel Creek through a series of lateral spillways (side-weirs) and discharge the excess water into storage areas which will be constructed by excavating and hydraulically connecting the open areas of the golf course. **Exhibit 2** provides a layout of the detention system on the golf course property.

To satisfy the goal of enhancing water quality, three inflows (not including White Oak Bayou and Vogel Creek) will be designed to discharge directly or partially into the detention system. HCFC Unit E121-02-00 will discharge directly into what is being referred to as “Basin I” (**Exhibit 2**). The Antoine Drive storm sewer system will discharge directly into “Basin L.” Additionally, low flows from HCFC Unit E140-00-00 will be partially diverted into “Basin A.” Each of these basins provides roughly a 2-day drain time. This should provide beneficial residence time for discharges into these basins. In addition, each of these basins contain lake-bottom storage which will also enhance the pollutant removal for some time following a storm.

With regard to neighborhood enhancement, possibilities include use of the clubhouse as a community center as well as recreational facilities which might include hike-and-bike trails and park-like features surrounding the individual detention basins. Also, it is possible that the lake-bottom detention cells could provide an amenity to the community.

Lastly, with respect to detention for future capital improvement projects, the estimated 1,000 acre-feet of excavated storage may be able to provide some detention to City projects in the local area, such as roadway improvements. Details of such an agreement would need to be negotiated between the City and HCFCD.

## *1.1 Site Description*

As shown on **Exhibit 1**, the Inwood Golf Course is a 27-hole golf course with a driving range and clubhouse and is located along Antoine Drive in central Harris County, north of Victory Drive and south of West Gulf Bank Road. White Oak Bayou (E100-00-00) and Vogel Creek (E121-00-00) converge just southeast of the golf course.

Much of the site is shown on the effective Flood Insurance Rate Map as inundated by the 100-year flood event (FIRM Panels 48201C0465L and 48201C0655L). The eastern portion of the site drains toward E121-00-00 and the FIRM has not yet been updated to reflect the presence of the Vogel Creek channel modifications.

### *1.2 Environmental Concerns*

A select number of trees were identified to be preserved if possible. The trees were generally old growth of a favorable species. The locations of the trees have been identified on **Exhibit 2**.

In a few locations, permanent pools of water exist which could potentially be wetland areas. Where possible the potential wetland areas were preserved, albeit lowered to a depth consistent with the bottom of the basin(s). Additionally, in each of the alternatives examined there was an increase in overall wetted surface area due to proposed lake-bottom basins.

Additional information related to environmental issues is provided in **Appendix D**, which is a Preliminary Environmental Evaluation report (dated July 28, 2009) produced by the Harris County Flood Control District regarding the Inwood site.

### *1.3 Geotechnical Issues*

According to soil tests performed November 2008 and May 2009 by Geotech Engineering and Testing (from reports dated December 2008 and June 2009, respectively), the groundwater table is estimated to be at a depth of approximately 10-15 feet below ground surface in the vicinity of the golf course. This should aid in maintaining a static water level in the lake-bottom detention basins, all of which range from 13.5 to 19.5 feet deep on average.

### *1.4 Pipeline Considerations*

Two gas pipelines traverse the Inwood property running generally southwest to northeast (see **Exhibit 2**). The Exxon liquid propane pipeline is located to the north and runs from the south bank of E140-00-00 toward West Gulf Bank Road near Vogel Creek. This pipeline crosses the detention areas at one location ("Basins B") and may need to be relocated to a deeper elevation to allow for excavation of the detention facility. It is likely that a relocation of the pipeline in the vicinity of "Basin A" will not be necessary. Any loss of storage due to <u>not</u> relocating the pipeline in this area will be minimal and likely not affect the results of this study.

The NATCO natural gas pipeline is located to the south and runs from Alabonson Road near White Oak Bayou toward West Gulf Bank near Bluestem Drive. This pipeline crosses the detention areas at five locations (twice at "Basin D," and once each at "Basins C, H and I") and may need to be relocated to a deeper elevation to allow for excavation of the detention facility.

## SECTION 2 - HYDROLOGY

The hydrology for this analysis was based on the hydrologic model developed for the on-going Flood Event Modeling Program for the HCFCD. Some minor changes to drainage boundaries were made to account for local drainage components which will drain directly to the proposed detention facilities. Flow hydrographs were generated using the Hydrologic Engineering Center's Hydrologic Modeling System software (HEC-HMS) version 3.4 for use in the hydraulic analysis.

### *2.1 Drainage Areas*

Two of the existing drainage areas in the hydrologic model, E100H and E121B, were subdivided into smaller drainage subareas. A total of five new drainage subareas were delineated from the original two. The new drainage subareas were defined by considering the results of a hydrologic drainage analysis of the local topography in ArcGIS, using the ArcHydro extension, in combination with the existing storm sewer drainage network. **Exhibit 3** illustrates the boundaries and areas of each of the newly defined drainage subareas. **Table 1** below shows the existing and revised subarea parameters used in the analysis.

**Table 1: Subarea Parameters**

| Original Subarea | Area (acres) | Time of Concentration (hours) | Storage Coefficient (hours) |
|---|---|---|---|
| *E100H* | 1267.1 | 0.43 | 3.44 |
| *E121B* | 2398.2 | 0.91 | 4.63 |
| **Revised Subarea** | **Area (acres)** | **Time of Concentration (hours)** | **Storage Coefficient (hours)** |
| *E100H* | 1211.8 | 0.43 | 3.44 |
| *E121B1* | 811.5 | 0.53 | 2.99 |
| *E121B2* | 474.2 | 0.51 | 2.55 |
| *E121B3* | 1043.2 | 0.67 | 4.37 |
| *E121B4* | 123.6 | 0.25 | 1.57 |

The times of concentration (TC) and storage coefficients (R) were determined using the standard Harris County TC and R methodology. For areas less than one square mile the TC and R values were calculated as stated; however, the storage coefficient was adjusted by trial-and-error so that the peak runoff matched the Harris County site runoff curves. The percent impervious was not adjusted for the subdivided drainage areas, the original impervious values were used. Details of the TC and R calculations have been included in **Appendix C**.

### *2.2 Location of Inflow Hydrographs in HEC-RAS Model*

Flow hydrographs for the hydraulic model were directly imported from the HEC-HMS model using the data storage system (DSS) file created by HEC-HMS. Some minor changes in the flow input locations from those used in the Flood Event Modeling Program models were necessary to account for the Post-Project conditions. In the Pre-Project model Subarea E121B2 and Subarea E121B4 contribute to E121-00-00 as lateral flow hydrographs. However, in the proposed conditions models Subarea E121B2 is input directly into detention Basin I and Subarea E121B4 into detention Basin L, **Exhibits 2 and 3**.

**Table 2** shows the locations for inflow hydrographs in the HEC-RAS unsteady flow model in the vicinity of the Inwood site. For each inflow hydrograph, this table includes the contributing subbasin name, the percentage of flow contributing from the subbasin at the given location, the type of inflow (lateral or uniform), and the cross sections or storage area inflow locations.

**Table 2: Inflow Hydrograph Locations[1]**

| Stream Designation | Subarea | Contribution (%) | Distribution Type | Input Location | D/S Uniform Ditribution Location |
|---|---|---|---|---|---|
| *E100-00-00* | E100H | 40% | uniform | 71493 | 64218 |
| | E100I | 100% | uniform | 62890 | 56239 |
| *E121-00-00* | E121A | 10% | lateral | 34188 | ---- |
| | E121A | 90% | uniform | 33899 | 13814 |
| | 121B1 | 100% | lateral | 9455 | ---- |
| | E121B3 | 100% | lateral | 1568 | ---- |
| | E121B2 | 100% | lateral | Basin I | ---- |
| | E121B4 | 100% | lateral | Basin L | ---- |
| *E140-00-00* | E100H | 10% | lateral | 11232.33 | |
| | E100H | 50% | uniform | 10313.91 | 2108.919 |

[1] It is noted that under Pre-Project conditions Subareas E121B2 and E121B4 were inserted at cross section 5529 and 3576 along E121-00-00, respectively. It is further noted that in the Preliminary Screening and Alternative Analyses that 100% of E100H was inserted along E140-00-00. This was altered for the better definition of impacts in the Final Recommended Alternative Analysis, and as stated in Section 5.1 of this report was reflective of this table in which 40% of E100H was inserted into E100-00-00 (see **Exhibit 3**).

## SECTION 3 - HYDRAULICS

To evaluate the reasonableness of using the golf course as regional detention, the Hydrologic Engineering Center's River Analysis System model (HEC-RAS) version 4.0 developed for the on-going Flood Event Modeling Program for HCFCD was used. This is an unsteady flow model which allowed the study team to determine how the flows and stages would react in time and provided a reasonable estimate of the interactions of White Oak Bayou and Vogel Creek together since the proposed detention is located at the confluence of these two streams.

### *3.1 Model Basis*

The Flood Event Modeling Program system was developed to be representative of the current White Oak Bayou watershed characteristics. This model was originally based on the "E100_PH3E_US" models developed as part of the federal project on White Oak Bayou. The Flood Event Modeling Program then added Buffalo Bayou and all of the FEMA studied tributaries for both Buffalo and White Oak to create a comprehensive dendritic network for the two watersheds. The model includes HCFCD flood control projects constructed up to the time of this study (August 2009).

As a part of this project, flows from White Oak Bayou, Vogel Creek, and E140-00-00 are proposed to be diverted into the network of detention basins. A hydraulic model of E140-00-00 did not exist prior to the beginning of this feasibility study, but was necessary to account for the hydraulic connection with the proposed regional facility. E140-00-00 was, therefore, added to the overall hydraulic model. Field reconnaissance was performed for the two bridge crossings on E140-00-00, West Gulf Bank Road and Alabonson Road, and Light Detection and Ranging (LiDAR) data was used to develop cross-section data. A schematic of the hydraulic model in the vicinity of the site is shown as **Exhibit 4**.

### *3.2 Boundary Conditions and Assumptions*

Several boundary conditions and assumptions associated with this feasibility study are noted below.

- All elevations stated in this report are on the North American Vertical Datum of 1988 (NAVD 88), 2001 adjustment.

- Since the White Oak Bayou main stem has about a 10-year capacity, the 25-year flood event was used as a design event to estimate initial benefits. The 10-year and 100-year events were also analyzed to determine the effectiveness of the 25-year design on those two storm events.

- As stated in Section 2.2 of this report, hydrographs were developed using the HEC-HMS model and were inserted into the HEC-RAS model at various locations along White Oak Bayou, Buffalo Bayou, and their tributaries, using either the lateral inflow option or the uniform inflow option. **Table 2** shows the subarea, type of hydrograph input, and HEC-RAS location for the inflows around the Inwood site.

- Only about 60% of Subarea E100H actually drains to E140-00-00. The remainder drains directly to White Oak Bayou. Therefore, 60% was added to E140-00-00 as a uniform

inflow along the entire length. The remaining 40% was added as a uniform inflow to White Oak throughout the lower reach of the subarea.

- With the exception of Antoine Drive, it is assumed that existing local storm sewer infrastructure will not drain directly to the proposed Inwood regional facility. However, this may need additional consideration during final design.

- E240-00-00 and the subsequent 84" (approx.) pipe were not analyzed as separate drainage features since the drainage area appeared to be small. However, this may need additional consideration.

- The downstream boundary of the overall model begins with a rating curve at the Houston Ship Channel, which was developed for the Flood Event Modeling Program.

- The E500-06 regional detention basin has two drains which both have flapgates attached to their outfalls. These drains are separated by about 1200 feet along White Oak Bayou. However, for modeling purposes, they were placed together for ease of analysis and the flapgates were included to prevent water from entering the storage area prior to water engaging the spillway. It is unlikely that the assumption of placing these two outfalls together will have a significant effect on the results.

- A 50-foot maintenance berm was assumed around the perimeter of each detention cell for the Recommended Alternative except where noted on **Exhibit 2**.

- For the Recommended Alternative the proposed dry-bottom detention basins have side slopes of 4(H):1(V) and the proposed lake-bottom detention basins have side slopes of 6(H):1(V), except where noted on **Exhibit 2**.

- Bank elevations for each storage basin on the golf course were derived from taking LiDAR points around the perimeter of each storage area and choosing the lowest point. If there were areas that appeared to be localized low spots, they were ignored in favor of generalized low elevations. Some judgment was used in determining these elevations.

- Allowable maximum pond elevations were set equal to the Pre-Project 100-year flood elevation in the vicinity of each basin, or the bank elevation of the basin, whichever was higher. This would keep any adverse flooding conditions from occurring on adjacent properties.

- Due to the limits of one-dimensional modeling, potential flood risk remains for residents near Basins C, D, and E. This is due to the fact that an average maximum ponding elevation for these three basins was taken from cross section 69789.51; however, White Oak Bayou has a sloping water surface profile across this area. Additional considerations such as emergency overflow paths and/or berms may need to be considered in final design to prevent adverse conditions.

- Basins I and L are assumed to have flat ponding elevations. Because of this, the banks of the basins will need to be examined more closely during final design to determine if

berms are required to prevent flooding of properties adjacent to the lower ends of these storage areas.

- To avoid double-counting storage between the basins and the floodplain, volumes for the storage areas were calculated up to the estimated bank elevations. Above that, an elevation of 99 with an increase of storage equal to 0.01 acre-feet was added. In addition, the storage basins were not shown in the cross sections. As a result, the cross sections account for floodplain storage only, and the basins account for detention storage only. It is likely that excavation of the basins will yield slightly more storage available in the floodplain; however, this was not considered to have significant effect on the results of the analysis.

- The excavation of Basins C and D in the recommended plan shows constrictions which would make it difficult to drain completely (see **Exhibit 2**). Positive drainage in these constricted areas will need to be addressed in the final design. Some possible solutions to these problem areas might be pipes, waterways with bulkheads, or altering the side slopes of the basins in this area.

- Excavation volumes used in the cost estimate included areas such as tee boxes and greens which may be above the proposed bank elevations and would need to be removed.

- Spillways for the lateral structures drawing water off of White Oak and Vogel Creek were assumed to have side slopes of approximately 6(H):1(V) or flatter to allow for vehicular access.

- All pipe sizes draining storage areas were assumed to have a minimum allowable size of 24 inches. Except where design calls for reinforced boxes, culverts entering the streams were assumed to be CMP and pipes between storage areas were assumed to be RCP.

- It is noted that under Pre-Project conditions that the Vogel Creek channel modifications were considered in-place at the beginning of this study. Therefore, it is likely that significant flood damage reduction has already been realized along Vogel Creek. Any additional flood reduction identified in this study will not likely contribute to flood damage reduction along Vogel Creek itself.

### *3.3 Pre-Project Conditions Results*

The Pre-Project conditions models were analyzed using the 10-year, 25-year, and 100-year events. Damages associated with each of the events were computed using the HCFCD structural database and damage curves.

The inundation limits for each event were exported and processed in GIS to determine the associated monetary structural damages. **Figure 1** below shows the damage versus depth relationship used to determine the damages.

**Figure 1: Depth vs. Damage Relationship**

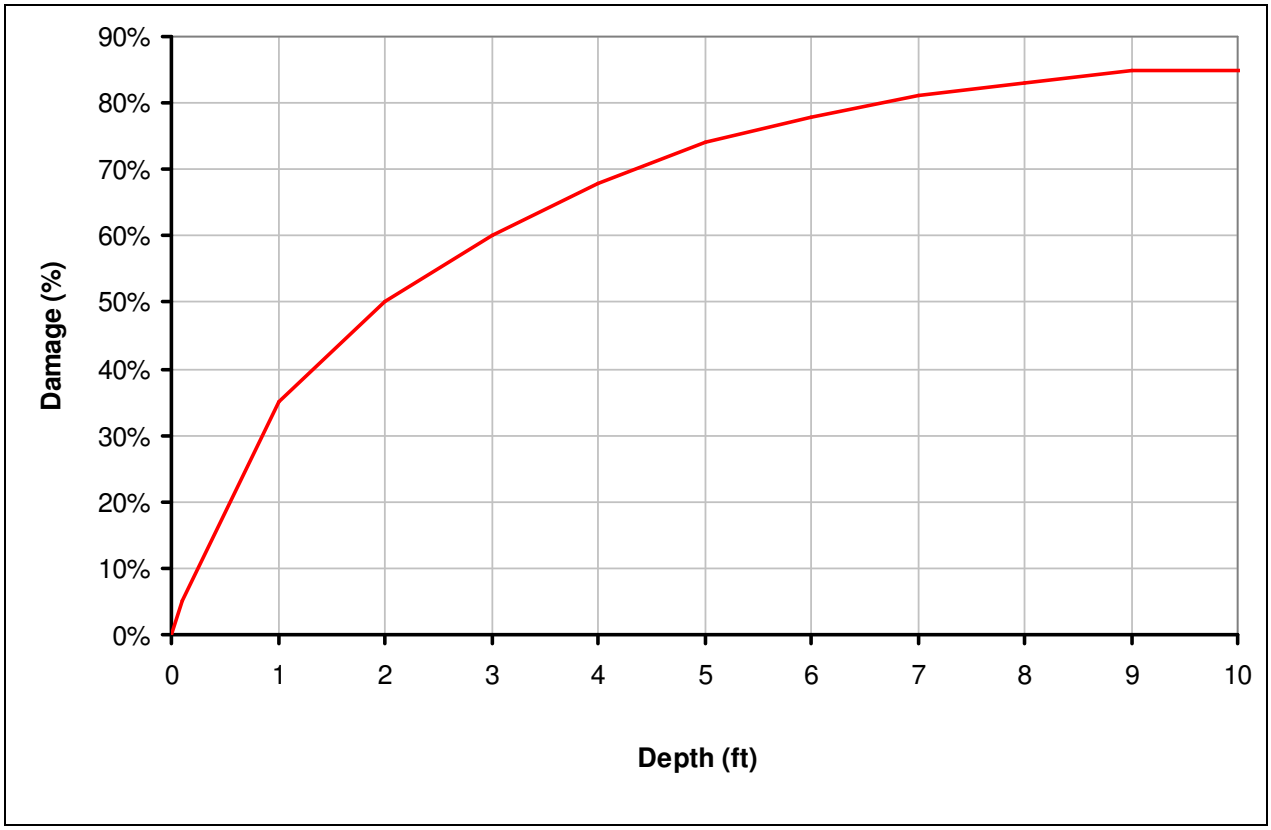



**Table 3** below shows the number of structures identified as having sustained damage and the amount of damage in dollars associated with each flooding event. The damage assessment was performed using all of the structures in the HCFCD structural database for the White Oak Bayou watershed, or approximately 36,000 structures.

**Table 3: Pre-Project Conditions Inundated Structures and Damage Summary[2]**

| Flood Event | Pre-Project Conditions | |
|---|---|---|
| | Structures Inundated | Damages |
| *10% (10-Year Event)* | 298 | $ 8,353,784 |
| *4% (25-Year Event)* | 1162 | $ 36,712,717 |
| *1% (100-Year Event)* | 7407 | $ 257,596,595 |

[2] Please note that this table does not match Table ES-1. This table is reflective of the original Pre-Project conditions results. Table ES-1 matches Tables ES-2 and 9, which are reflective of the change to Pre-Project conditions noted in Section 5.1 of this report.

### 3.4 Optimization of Alternatives

Optimization of control structures (i.e., spillways and drain pipes) was used to maximize the benefits of each of the alternatives. Briefly, the optimization process is described as follows:

1. Starting with a 25-year event, the lateral spillways were sized to cut off the peak of the hydrograph passing down White Oak Bayou or Vogel Creek, depending on the location of the spillway. Crest lengths and elevations of the spillways were adjusted through an iterative process so that water levels would equalize between the storage area and the stream under peak conditions

2. Connecting pipes linking storage areas were sized so that headloss between the storage basins was minimal and so that interconnected basins would rise and fall together achieving approximately the same peak elevation to maximize the use of reservoir storage capacity.

3. At the upper end of Basin I, a culvert system was used to provide the transfer of flow between Vogel Creek and the basin, instead of a spillway. This was done so that Streamside Drive could remain intact and continue to provide transportation access throughout the community.

4. Low flow outlets were then designed to allow water to fully drain out of the detention basin system.

5. The 25-year benefits in terms of water surface reductions, number of structures inundated, and monetary damages reduced were reviewed to determine if subsequent optimization could provide additional benefit.

6. The 10-year and 100-year events were then analyzed to determine benefits of the design to these flood events.

7. Where critical issues developed with the computed 100-year water surface exceeding allowable elevations, spillways were further optimized.

## SECTION 4 – PLAN FORMULATION

In initial discussions with HCFCD staff, it was decided that six alternatives would be analyzed. This would limit the effort of alternative formulation to a manageable scope. The first two alternatives identified were a maximum volume alternative and a minimum volume alternative. Then on October 19, 2009, a planning meeting (which included representatives from the City of Houston, HCFCD, and Dodson and Associates, Inc.) was called to brainstorm and select three alternatives to be analyzed as part of this study. The last of the six alternatives was decided upon by the study team and the project managers from HCFCD and the City of Houston.

### *4.1 Benefits and Costs*

To aid in determining which of the alternatives should be carried forward to ultimately define a recommended plan, the costs and benefits were taken into consideration starting during the Alternative Analysis phase of this project. The Preliminary Screening Analysis only looked at the benefits in terms of damage reduction for the 25-year event.

### *4.2 Preliminary Screening Analysis*

The preliminary screening process analyzed the six identified detention basin configurations. Details of the six configurations are provided in **Table 4** below. Each configuration contained combinations of basins which differed in side slopes, dry-bottom or lake-bottom features, shelf or off-line detention cells, maintenance berm widths, and whether the clubhouse would be demolished or not. Each of the alternatives was analyzed for the 25-year flood event to determine which would provide the most significant benefits to the White Oak Bayou system. The four intermediate volume alternatives were carried forward for optimization and analysis of the 100-year and 10-year flood events in the alternative analysis phase.

**Table 4: Alternative Plan Volumes for Plan Screening**

| Detention Cell | Min Volume | Alt 1 | Alt 2 | Alt 3 | Alt 4 | Max Volume |
|---|---|---|---|---|---|---|
| A (north) | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 6.1 |
| A (south) | 28.2 | 87.7 | 67.5 | 67.5 | 67.5 | 87.7 |
| B | 19.9 | 40.0 | 40.0 | 40.0 | 40.0 | 104.9 |
| C | 111.7 | 306.4 | 250.5 | 235.2 | 321.9 | 537.1 |
| D | 51.9 | 184.2 | 184.2 | 184.2 | 184.2 | 184.2 |
| E | 25.7 | 52.1 | 25.7 | 52.1 | 52.1 | 45.1 |
| F | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 28.9 |
| G | 15.7 | 17.3 | 17.3 | 17.3 | 17.3 | 64.8 |
| H | 48.8 | 66.5 | 36.3 | 36.3 | 66.5 | 103.6 |
| I | 147.4 | 241.6 | 146.8 | 127.7 | 183.6 | 241.6 |
| J (east) | 8.8 | 9.7 | 9.7 | 9.7 | 9.7 | 13.1 |
| J (west) | 3.4 | 3.7 | 3.7 | 3.7 | 3.7 | 5.6 |
| K | 29.2 | 29.2 | 32.1 | 32.1 | 29.2 | 59.3 |
| L | 33.8 | 80.4 | 106.4 | 80.4 | 80.4 | 80.4 |
| | | | | | | |
| **Total Volume (acre-feet)** | **543.8** | **1138.1** | **939.5** | **905.5** | **1075.4** | **1562.4** |
| *% of Maximum* | *35%* | *73%* | *60%* | *58%* | *69%* | *100%* |

Note: Volumes exclude E500-06 (298.7 acre-feet)

26 acre-feet in "H" south of pipeline is connected to "L"

**Table 5** below lists the results from the preliminary screening phase for each of the six scenarios analyzed for the 25-year rainfall event. The damage assessment was performed by taking into consideration only the structures adjacent to White Oak Bayou from the project site downstream to the mouth (approximately 8,100 structures).

**Table 5: Preliminary Analysis Results**

| Alternative | Maximum Volume (acre-feet) | Structures Inundated | Estimated Damages | Damage Reduction |
|---|---|---|---|---|
| *Pre-Project* | | 366 | $ 14,900,917 | |
| *Minimum* | 770 | 317 | $ 12,782,288 | $ 2,118,629 |
| *Alternative 1* | 1283 | 246 | $ 10,282,192 | $ 4,618,725 |
| *Alternative 2* | 1072 | 247 | $ 10,451,452 | $ 4,449,465 |
| *Alternative 3* | 1074 | 247 | $ 10,606,237 | $ 4,294,680 |
| *Alternative 4* | 1231 | 241 | $ 10,408,742 | $ 4,492,175 |
| *Maximum* | 1656 | 233 | $ 9,246,924 | $ 5,653,993 |

In reviewing the results, it was determined that the four intermediate alternatives would be carried forward to the next phase. From **Table 3**, it is apparent that the minimum volume alternative also produces the minimum benefit in terms of damage reduction. And, while the maximum volume alternative resulted in the highest reduction in flood damages, it would require significant exceptions to current HCFCD criteria for regional detention facilities. Therefore, since it was unlikely that this alternative would be selected for construction, it was not carried forward. The remaining four alternatives produced very similar benefits and so it was determined that all four alternatives should be analyzed in more depth during the next phase of analysis.

### *4.3 Alternatives Analysis*

During this second phase of analysis (Alternative Analysis), the 100-year and 10-year events were analyzed in addition to the 25-year. These other events were analyzed to a) determine the benefits for varying flood events associated with the 25-year design, and b) to identify any potential adverse flooding impacts which might occur as a result of the design. This step of the feasibility study included further optimization of the detention basin outfall structures and interconnections. A preliminary cost analysis was also performed.

**Table 6** below lists the results of the Alternative Analysis. The damage assessment was performed using all of the structures in the HCFCD structural database (approximately 36,000

structures). **Table 7** provides a comparison of the total cost for each of the alternatives contained in **Table 6**.

**Table 6: Alternatives Analysis Results**

| Alternative | Maximum Volume (acre-feet) | Structures Inundated | Estimated Damages | Damage Reduction |
|---|---|---|---|---|
| **10% (10-Year) Event** | | | | |
| *Pre-Project* | | 298 | $ 8,353,784 | |
| *Alternative 1* | 878 | 287 | $ 7,848,267 | $ 505,517 |
| *Alternative 2* | 694 | 286 | $ 7,971,565 | $ 382,219 |
| *Alternative 3* | 732 | 287 | $ 7,978,991 | $ 374,793 |
| *Alternative 4* | 833 | 286 | $ 7,887,309 | $ 466,475 |
| **4% (25-Year) Event** | | | | |
| *Pre-Project* | | 1162 | $ 36,712,717 | |
| *Alternative 1* | 1098 | 1061 | $ 32,065,545 | $ 4,647,172 |
| *Alternative 2* | 880 | 1074 | $ 32,819,741 | $ 3,892,976 |
| *Alternative 3* | 905 | 1075 | $ 33,015,367 | $ 3,697,350 |
| *Alternative 4* | 1038 | 1063 | $ 32,324,505 | $ 4,388,212 |
| **1% (100-Year) Event** | | | | |
| *Pre-Project* | | 7407 | $ 257,596,595 | |
| *Alternative 1* | 1465 | 7042 | $ 234,360,199 | $ 23,236,397 |
| *Alternative 2* | 1221 | 7107 | $ 238,482,810 | $ 19,113,785 |
| *Alternative 3* | 1222 | 7126 | $ 239,513,622 | $ 18,082,973 |
| *Alternative 4* | 1384 | 7068 | $ 235,903,826 | $ 21,692,770 |

**Table 7: Alternative Plan Costs**

| Alternative | Estimated Cost |
|---|---|
| Alternative 1 | $ 22,517,939.70 |
| Alternative 2 | $ 18,786,789.17 |
| Alternative 3 | $ 19,087,063.92 |
| Alternative 4 | $ 21,349,377.11 |

### *4.4 Recommended Alternative Analysis*

The final Recommended Alternative (Alternative 1 in **Table 6**) was selected based on the results of the alternative analysis. Although Alternative 1 had the highest cost of the four remaining alternatives, it was chosen as the Recommended Alternative because it provided the most benefit (highest amount of flood damage reduction) for all three flood events analyzed. In addition, since costs were relatively close, Alternative 1 was chosen to allow some room for modifications in final design (i.e., since it has the largest volume of the four remaining, if the storage volume should be reduced during final design, significant benefits will still be derived and can be compared to the previous unselected alternatives).

As a part of this final analysis phase, a thorough optimization was performed and costs were examined in greater detail. A full description of the Recommended Alternative is contained in the following section of this report.

## SECTION 5 – FINAL RECOMMENDATION

The final recommended plan (Alternative 1) provides significant damage reduction to downstream properties along White Oak Bayou. The plan calls for a chain of linked storage areas on the Inwood Golf Course site near the confluence of White Oak Bayou and Vogel Creek, which will provide regional detention for flood reduction purposes. The configuration of the final alternative and the results of the final analysis are described below.

### *5.1 Revised Pre-Project Conditions*

In the process of performing the final analysis, it was determined that approximately 40% of Subarea E100H should actually inflow directly into White Oak Bayou instead of E140-00-00 (see **Exhibit 3**). Therefore, this inflow hydrograph was relocated to be consistent with **Table 2** above. This change produced slight differences in the damage estimates for both the Pre-Project and Recommended Alternative conditions. These changes are reflected in **Tables 8 and 9** below.

### *5.2 Configuration*

The Recommended Alternative includes a series of interconnected reservoirs within the property that will receive flow from White Oak Bayou, Vogel Creek, and E140-00-00. The reservoirs are labeled "Basin A" through "Basin L" on **Exhibit 2**. A brief description of the various components follows. Detailed information for each basin is provided on **Exhibits 11a through 11j**.

1. Basin A: This storage area will be a lake-bottom basin capable of storing 87.7 acre-feet. Water will be diverted off of E140-00-00 into the basin and will drain to Basin C. It is noted that in the Preliminary Screening and Alternative Analysis phases of this study, Basin A was divided into Basins A-North and A-South and were connected by a pipe. However, Basin A-North was eliminated due to the small amount of storage that this area contributes to the entire regional detention system at this site. Therefore, it is recommended that this A-North area be reserved for greenspace or other uses not associated with detention. Also, the western edge of Basin A will have 3(H):1(V) side slopes with no maintenance berm, which is the current configuration of the E240-00-00 ditch, which runs southward adjacent to the townhome complex south of E140-00-00.

2. Basin B: This storage area will be a dry-bottom basin capable of storing 40.0 acre-feet. This basin will fill and drain by water backing up from and exiting to Basin C.

3. Basin C: This storage area will be a lake-bottom basin capable of storing 306.4 acre-feet. This basin will be filled from two sources (Basin A and water backing up through Basin E) and drain to Basin E. The forested areas surrounding the driving range will remain to provide recreational and park features. In addition, the clubhouse will be removed and the remaining land used as part of the detention area.

4. Basin D: This storage area will be a lake-bottom basin capable of storing 184.2 acre-feet. This basin will fill by diverting water from White Oak Bayou into the basin near Alabonson Road and will drain back to White Oak downstream near Victory Drive. The western edge of Basin D (along Alabonson Road) will have side slopes of 3(H):1(V) and 30-foot maintenance berms.

5. Basin E: This storage area will be a lake- or wetland-bottom basin capable of storing 52.1 acre-feet. This basin will be filled primarily by water backing up from Basin D. It will also drain to Basin D. Due to the narrow configuration of this basin, side slopes were set to 3(H):1(V) and maintentance berms to 30 feet. Without these exceptions to the basin criteria, Basin C will not drain effectively and an extremely long pipe would be required to connect Basins E and D.

6. Basin F: This storage area will be a dry-bottom basin capable of storing 74.5 acre-feet. This basin will fill and drain by diverting from and exiting to White Oak Bayou.

7. Basin G: This storage area will be a dry shelf expansion which will add storage volume directly to the White Oak floodplain. The western edge of Basin G (along Alabonson Road) will have side slopes of 3(H):1(V) and 30-foot maintenance berms.

8. Basin H: This storage area will be a partial lake-bottom/partial dry bottom basin capable of storing 66.5 acre-feet. This basin will be filled by diverting water from Vogel Creek and will drain to Basin L. Side slopes of 6(H):1(V) were maintained around the entire perimeter of Basin H.

9. Basin I: This storage area will be a lake-bottom basin capable of storing 241.6 acre-feet. Water will be diverted off of Vogel Creek into the basin near Arncliffe Drive. Additionally, E121-02-00 will outfall directly into Basin I. Basin I will then drain to Vogel Creek near Maple Tree Drive. Also, the southeastern edge of Basin I will have 3(H):1(V) side slopes with no maintenance berm, which is the current configuration of the existing E121-02-00 ditch. To continue traffic flow patterns along Streamside Drive through the adjacent neighborhood, the intake structure for Basin I near Arncliffe will be a culvert structure without a spillway overflow.

10. Basin J: This storage area will be a dry shelf expansion which will add storage volume directly to the Vogel Creek floodplain. Basin J straddles either side of Maple Tree Drive.

11. Basin K: This storage area will be a dry-bottom basin capable of storing 29.2 acre-feet. This basin will fill and drain by diverting from and exiting to Vogel Creek.

12. Basin L: This storage area will be a lake-bottom basin capable of storing 80.4 acre-feet. This basin will be filled by water from the Antoine Drive drainage system and from Basin H. It will drain to Vogel Creek.

13. Regional Detention Basin E500-06: This storage area will remain unmodified from its current configuration in terms of available storage. However, the spillway crest will be raised and widened (see **Exhibit 12**) to divert water from White Oak Bayou later in time during a flood event, creating a more efficient use of the available storage volume in the basin.

### *5.3 Results*

As shown in **Tables 8 and 9**, the results from the analysis of the final recommended plan (as described in the previous section of this report) indicate reductions in White Oak Bayou flood elevations of 0.3 to 0.5 feet for all events along significant portions of the reach between the Inwood site and the mouth of White Oak (**Table 8**). In addition, flood damages appear to be significantly reduced based on implementation of the recommended plan (**Table 9**). **Appendix**

**E** provides a summary of storage and pond elevations from the Recommended Alternative for each flood event analyzed under Post-Project conditions.

It is noted in both **Appendix E** and in examination of the detailed output of the HEC-RAS model for the Recommended Alternative that two issues will need to be addressed in the final design. First, 100-year ponding levels in Basins B and C were found to be 0.1 foot higher than allowable. Given the location of these two basins, it would seem that this can be easily addressed by grading the banks of the storage areas to a slightly higher elevation in order to contain the volumes within the detention areas. This should be adequate since both basins are on the extreme fringe of the floodplain of White Oak Bayou. As an alternative, slight changes in the interconnecting pipes in this part of the system may effectively reduce ponding elevations below the allowable maximum. Secondly, it is also noted that slight impacts of 0.01 foot occur several miles upstream of the site. It would appear to be unreasonable to expect any impacts that far upstream.

**Table 8: Hydrologic & Hydraulic Benefits for Recommended Alternative**

**10-Year Recommended Alternative**

| Station | Location | Flow (cfs) | | | W.S. Elev. | | |
|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Difference | Existing | Proposed | Difference |
| 61936 | D/S of E500-06 | 11,096 | 10,112 | -984 | 69.19 | 68.47 | -0.72 |
| 56811 | U/S Tidwell | 11,702 | 10,767 | -935 | 67.52 | 66.83 | -0.69 |
| 55757 | D/S of E117-00-00 | 14,674 | 13,830 | -844 | 66.15 | 65.59 | -0.56 |
| 46827 | D/S of E115-00-00 | 20,344 | 19,791 | -553 | 60.43 | 59.87 | -0.56 |
| 39419 | U/S Loop 610 | 20,530 | 20,004 | -526 | 54.13 | 53.81 | -0.32 |
| 17756 | U/S Heights | 22,607 | 22,102 | -505 | 35.28 | 34.91 | -0.37 |
| 6775 | D/S E101-00-00 | 29,636 | 29,144 | -492 | 30.68 | 30.45 | -0.23 |
| **Location of Maximum Hydraulic Benefit** | | | | | | | |
| *70347* | *Site* | | | | *76.29* | *75.50* | *-0.79* |

**25-Year Recommended Alternative**

| Station | Location | Flow (cfs) | | | W.S. Elev. | | |
|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Difference | Existing | Proposed | Difference |
| 61936 | D/S of E500-06 | 12,840 | 12,373 | -467 | 70.49 | 70.06 | -0.43 |
| 56811 | U/S Tidwell | 13,584 | 12,948 | -636 | 68.78 | 68.34 | -0.44 |
| 55757 | D/S of E117-00-00 | 17,388 | 16,396 | -992 | 67.20 | 66.81 | -0.39 |
| 46827 | D/S of E115-00-00 | 23,811 | 22,764 | -1047 | 62.96 | 62.30 | -0.66 |
| 39419 | U/S Loop 610 | 24,008 | 22,963 | -1045 | 56.09 | 55.69 | -0.40 |
| 17756 | U/S Heights | 26,173 | 25,382 | -791 | 38.54 | 38.01 | -0.53 |
| 6775 | D/S E101-00-00 | 33,672 | 32,851 | -821 | 33.54 | 33.20 | -0.34 |
| **Location of Maximum Hydraulic Benefit** | | | | | | | |
| *70347* | *Site* | | | | *77.50* | *76.74* | *-0.76* |

**100-Year Recommended Alternative**

| Station | Location | Flow (cfs) | | | W.S. Elev. | | |
|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Difference | Existing | Proposed | Difference |
| 61936 | D/S of E500-06 | 15,665 | 15,751 | 86 | 72.21 | 72.07 | -0.14 |
| 56811 | U/S Tidwell | 16,305 | 16,072 | -233 | 70.69 | 70.45 | -0.24 |
| 55757 | D/S of E117-00-00 | 20,773 | 20,209 | -564 | 69.39 | 69.02 | -0.37 |
| 46827 | D/S of E115-00-00 | 27,548 | 26,705 | -843 | 65.90 | 65.55 | -0.35 |
| 39419 | U/S Loop 610 | 27,521 | 26,740 | -781 | 58.92 | 58.46 | -0.46 |
| 17756 | U/S Heights | 28,980 | 28,592 | -388 | 40.73 | 40.52 | -0.21 |
| 6775 | D/S E101-00-00 | 37,558 | 37,296 | -262 | 36.00 | 35.92 | -0.08 |
| **Location of Maximum Hydraulic Benefit** | | | | | | | |
| *70239.59* | *Site* | | | | *78.62* | *78.03* | *-0.59* |

**Table 9: Benefits for Recommended Alternative**

| Condition | Volume of Storage (ac-ft) | No. of Structures Inundated | Damages | Benefit (No. of Structures No Longer in Floodplain) | Benefit (Reduced Damages) |
|---|---|---|---|---|---|
| **10% (10-Year) Event** | | | | | |
| *Pre-Project* | | 302 | $ 8,516,701 | | |
| *Recommended Alternative* | 819 | 284 | $ 8,012,484 | 18 | $ 504,217 |
| **4% (25-Year) Event** | | | | | |
| *Pre-Project* | | 1177 | $ 37,404,143 | | |
| *Recommended Alternative* | 1123 | 1039 | $ 31,434,653 | 138 | $ 5,969,490 |
| **1% (100-Year) Event** | | | | | |
| *Pre-Project* | | 7322 | $ 256,660,166 | | |
| *Recommended Alternative* | 1332 | 6937 | $ 232,972,674 | 385 | $ 23,687,493 |

**Exhibits 5 through 7** illustrate the reduction in floodplain areas as a result of the Recommended Alternative. **Exhibits 8 through 10** serve to identify those structures which would no longer be inundated by the 1%, 4%, and 10% exceedance probability flood events, respectively, as a result of the Recommended Alternative construction on the Inwood site.

### *5.4 Last-Added Analysis*

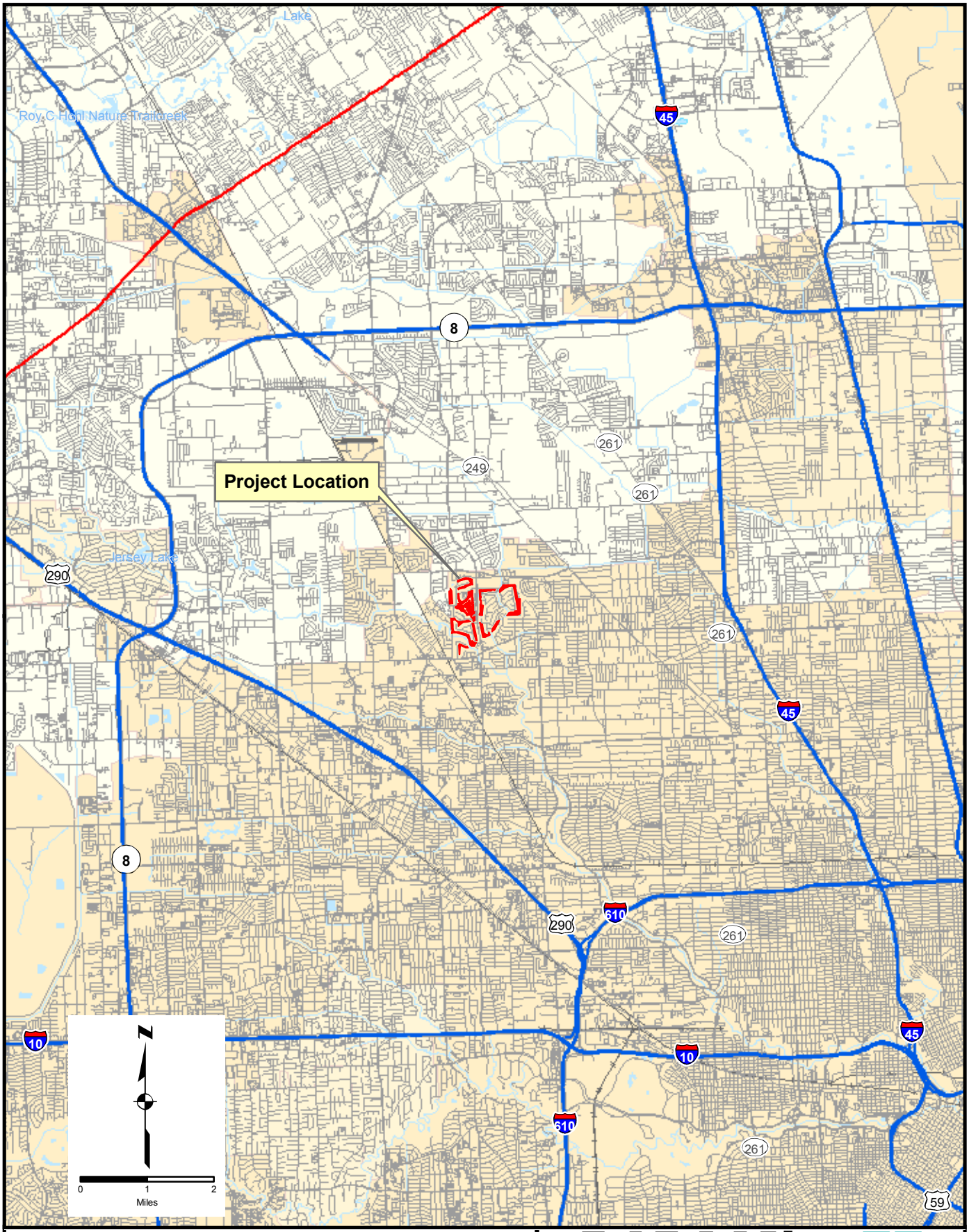
Additionally, to isolate the benefits of the proposed detention within the Inwood Golf Course, a separate "last-added" analysis was performed by leaving the E500-06 regional detention basin spillway as it currently exists in the field. This allowed the study team to determine how much of the reductions could be attributed to the Inwood detention alone. The results of this analysis have been included in **Appendix F** and indicate that the modification of the spillway crest (see **Exhibit 12**) from 200 feet long at an elevation of 62.25 to 300 feet long at elevation 68.00 creates an incremental benefit to the 25-year event of about $688,000. In other words, if the spillway is left unmodified, total benefits for the 25-year flood event would be roughly $5,280,000 instead of the approximately $5,970,000 shown in **Table 9**.

### *5.5 Final Recommendation Costs*

Based on the detailed cost data for the Recommended Alternative contained in **Appendix B**, the overall cost for this plan is $19,800,000. The unit costs contained in **Appendix B** were provided by HCFCD, and verified with HCFCD personnel. All costs are subject to change based on final design.

## SECTION 6 – CONCLUSIONS

The Pre-Project conditions models developed for this study show that there is a significant amount of flooding within the project limits. In all three rainfall events analyzed (the 100-year, 25-year, and 10-year events), there are significant flood damages. As a result, the 25-year event was chosen as the target flood event to provide the most benefit. The final analysis of the recommended plan yields benefits to all events and based on this analysis will provide significant flood damage reduction to downstream properties along White Oak Bayou. Therefore, based on this study it appears that utilizing the Inwood Golf Course for regional detention purposes is feasible and effective.




Inwood Detention Analysis

Vicinity Map

DODSON & ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 1 |
|---|---|---|---|

Note:
This portion of the golf course to remain open space.

Note:
This Edge 3:1 S.S., No Maintenace Berm within HCFCD R.O.W.

Note:
6:1 S.S.

Note:
This Edge 3:1 S.S., No Maintenace Berm within HCFCD R.O.W.

Note:
This Edge 3:1 S.S., 30' Maintenance Berm.

Note:
3:1 S.S., 30' Maintenance Berm so pond can drain south.

Note:
30' Maintenance Berm.

A B C D E F G H I J K L

Clubhouse Pond

Tree Preserves
Outfall Pipes
Spillways
Flow Direction
Pipeline R.O.W.
Shelf Lines
Dry Bottom
Permanent Pool
Top of Bank
Property Boundaries
Stream Centerlines

Assumptions (unless otherwise noted):
1. Maintainance berms of 50 ft., with exceptions along stream corridors.
2. Side Slopes of 6:1 (Lake) & 4:1 (Dry)
3. Min. Pond Elev = Channel Bottom + 3 ft.
4. Difference between pond levels are about 1 ft.

N

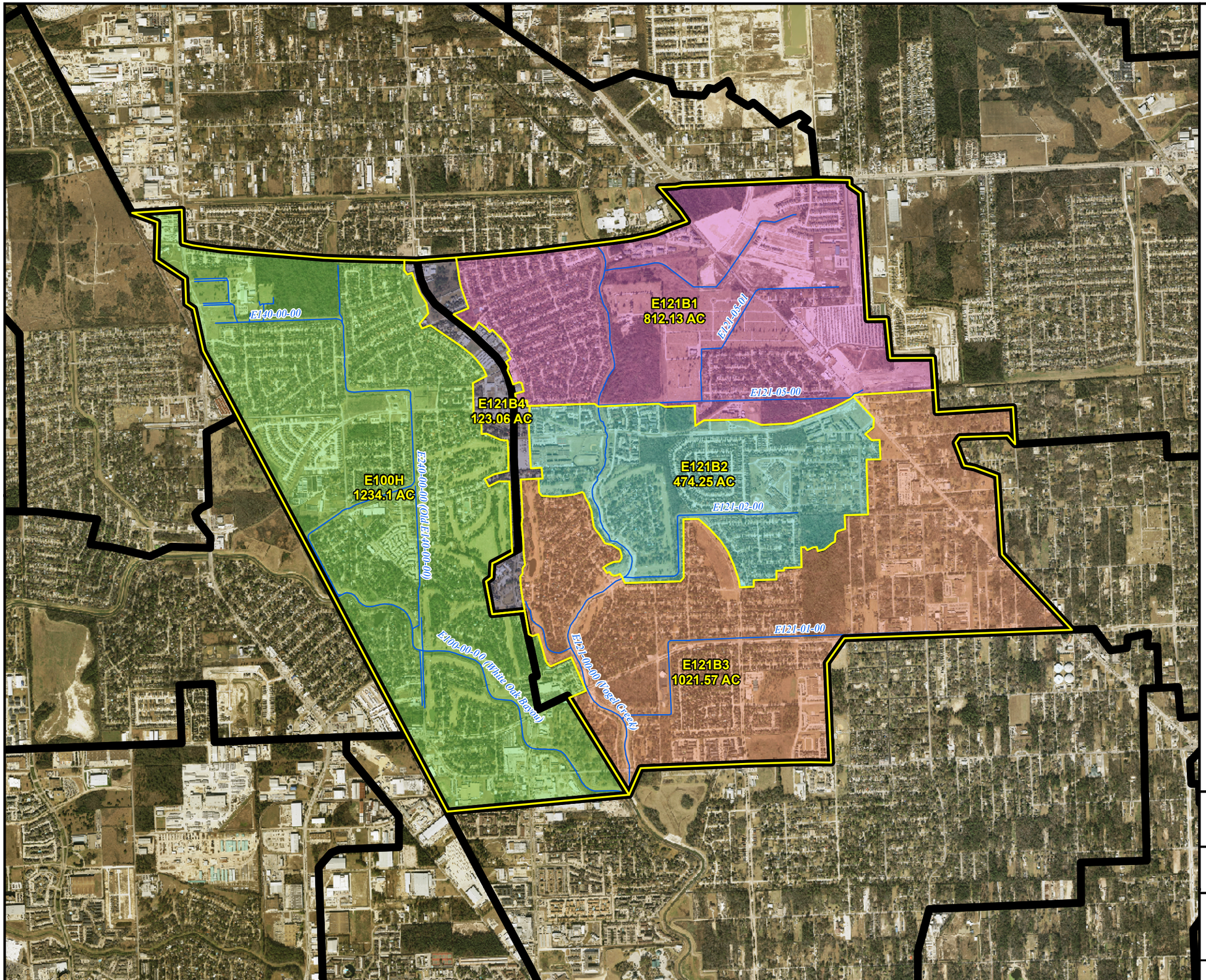
0 100 200 400
Feet

DODSON & ASSOCIATES, INC.
Hydrologists and Civil Engineers

Inwood Detention Analysis

Recommended Alternative Layout
Storage - 1132.0 acre-feet

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 2 |
|---|---|---|---|




**Legend**

- Revised Subarea
- Effective Subbasin
- Channel

N

2,000 1,000 0 2,000

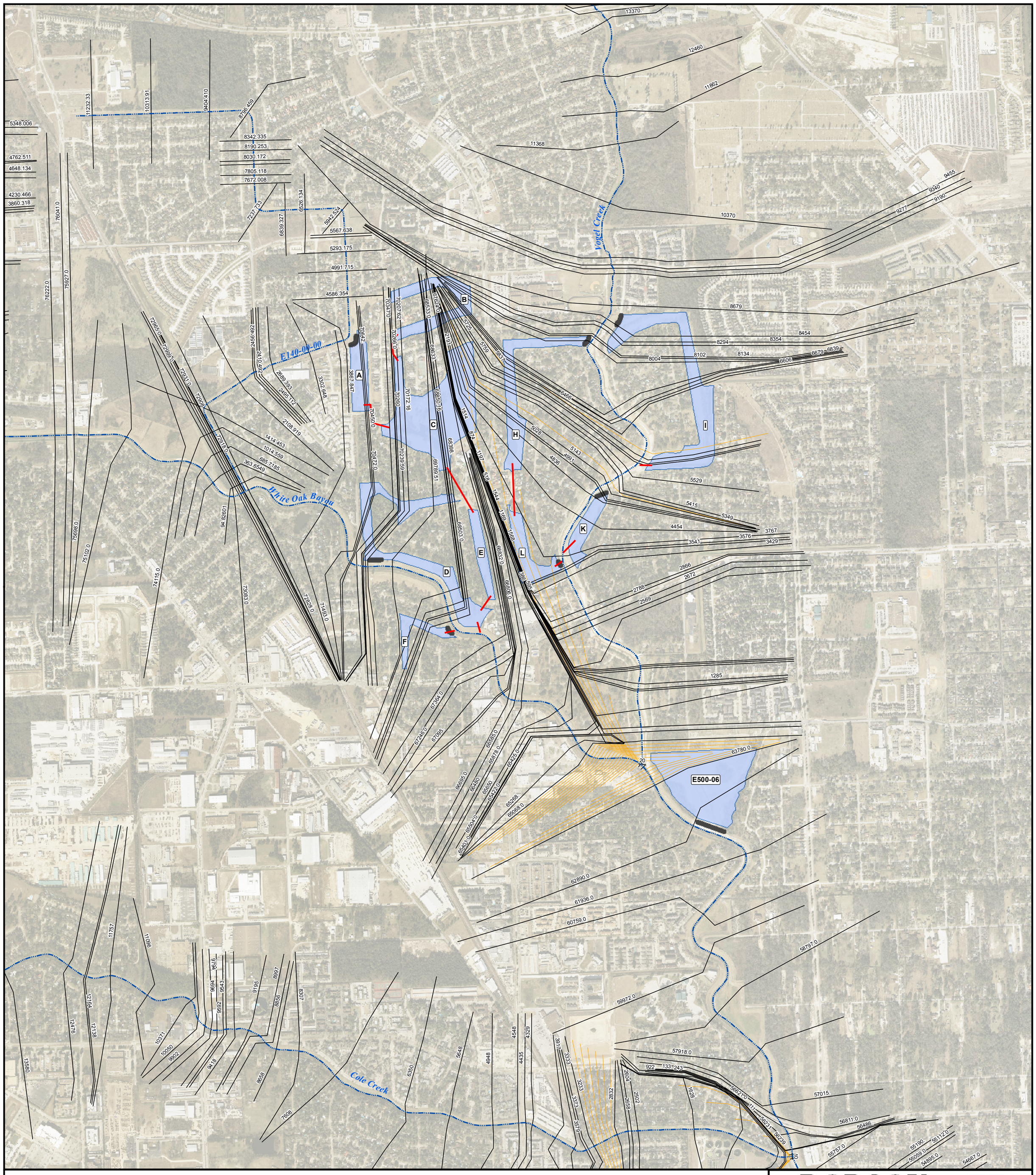
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

**Inwood Detention Analysis**

**Drainage Subarea Map**

| Job 1898 | July 2011 | By MWH | Exhibit 3 |
|---|---|---|---|




**Legend**

- Stream Centerlines
- Storage Connections
- HEC-RAS User Defined Cross-Sections
- HEC-RAS Interpolated Cross-Sections
- Spillways
- Storage Areas

N

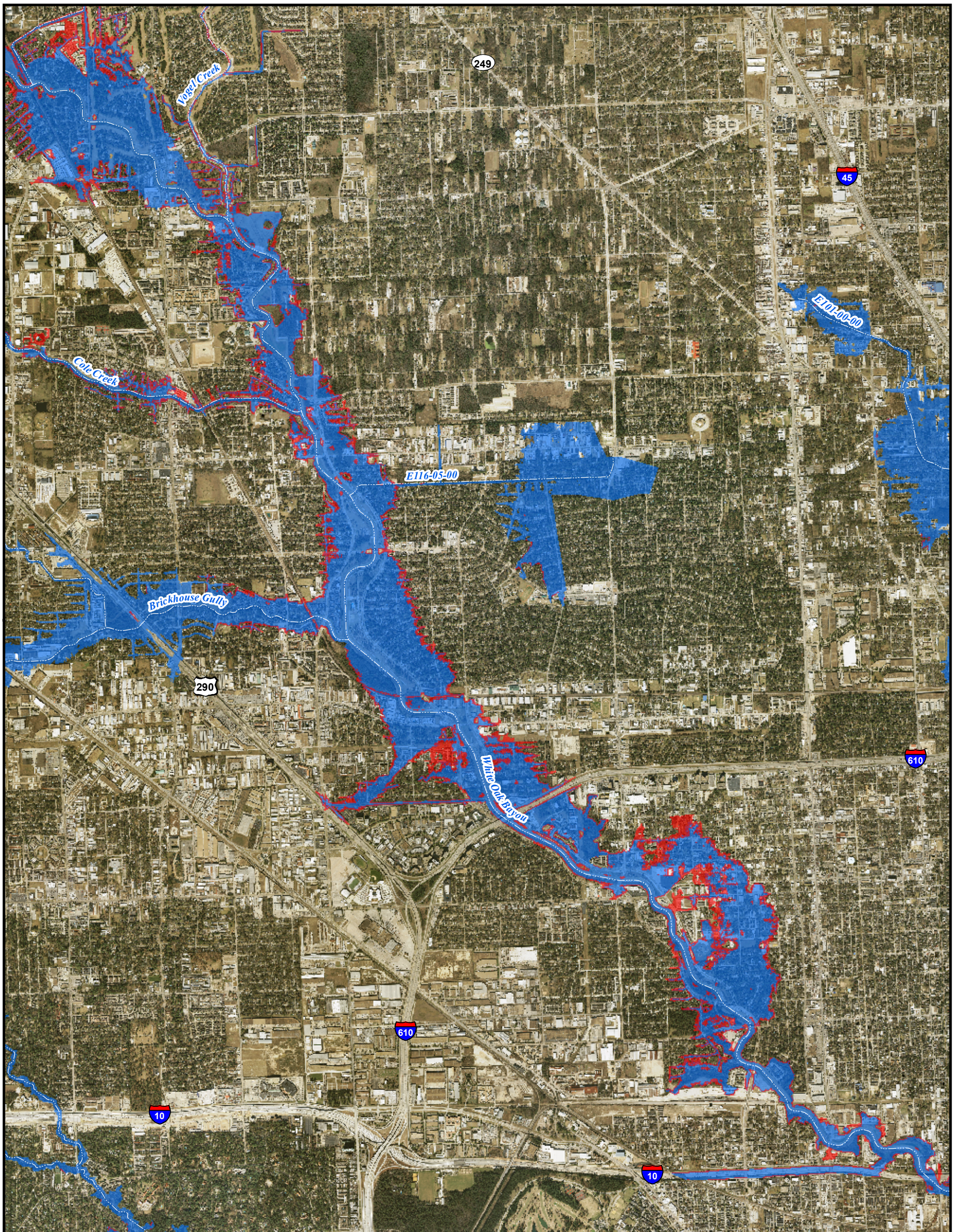
0 500 1,000 2,000
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Schematic Layout of Hydraulic Model

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 4 |
|---|---|---|---|




**Legend**

- Pre Project - 1% Exceedance Probability Floodplain
- Recommended Alternative - 1% Exceedance Probability Floodplain

Note:
The Pre-Project 1% floodplain
does not represent the Effective 1% floodplain
as shown on the Flood Insurance Rate Map.

N

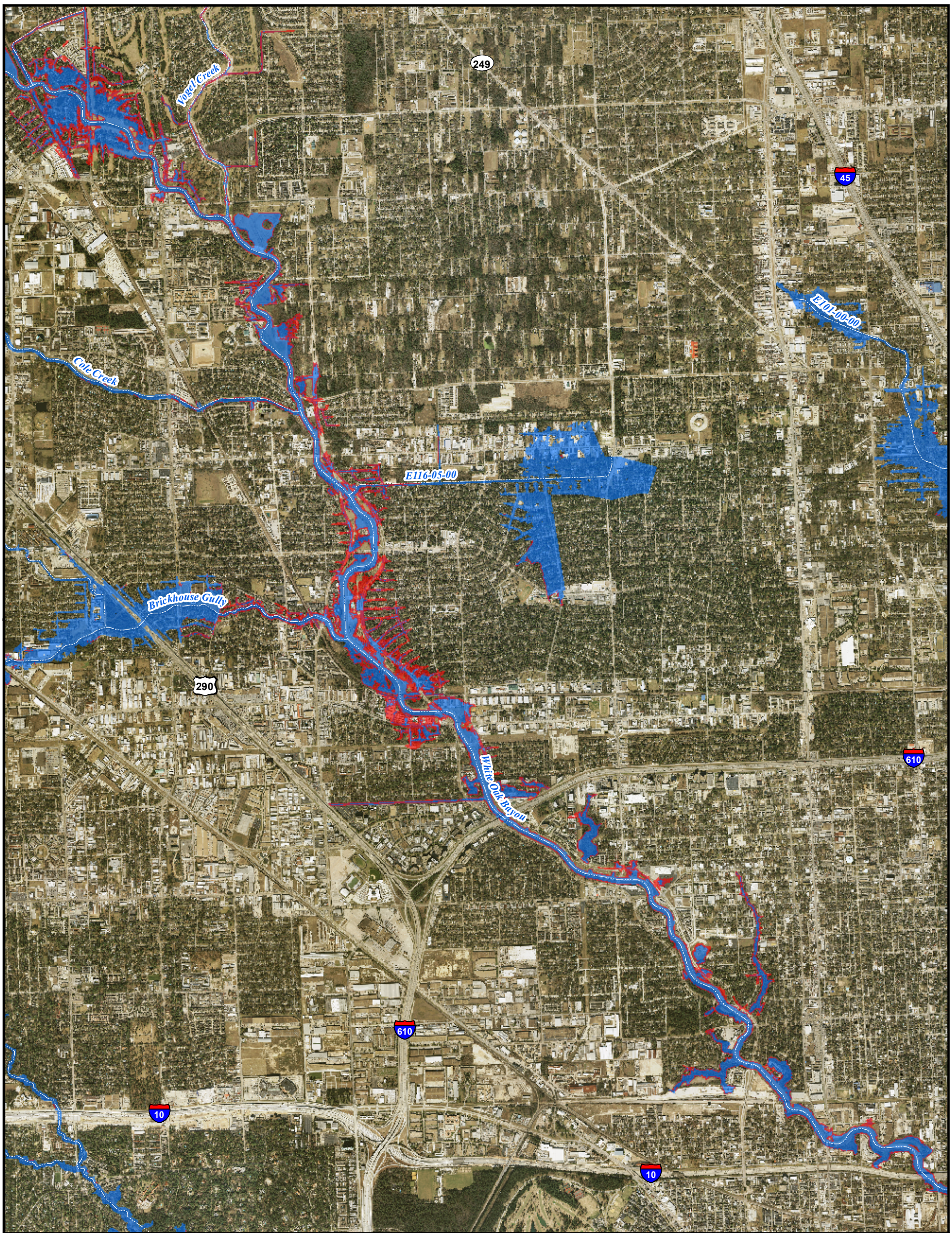
0 1,500 3,000 6,000
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

1% Inundation Limits Comparison
Pre-Project and Recommended Alternative

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 5 |
|---|---|---|---|




**Legend**

- Pre Project - 4% Exceedance Probability Floodplain
- Recommended Alternative - 4% Exceedance Probability Floodplain

N

0 1,500 3,000 6,000
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

4% Inundation Limits Comparison
Pre-Project and Recommended Alternative

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 6 |
|---|---|---|---|

**Legend**

- Pre Project - 10% Exceedance Probability Floodplain
- Recommended Alternative - 10% Exceedance Probability Floodplain

N

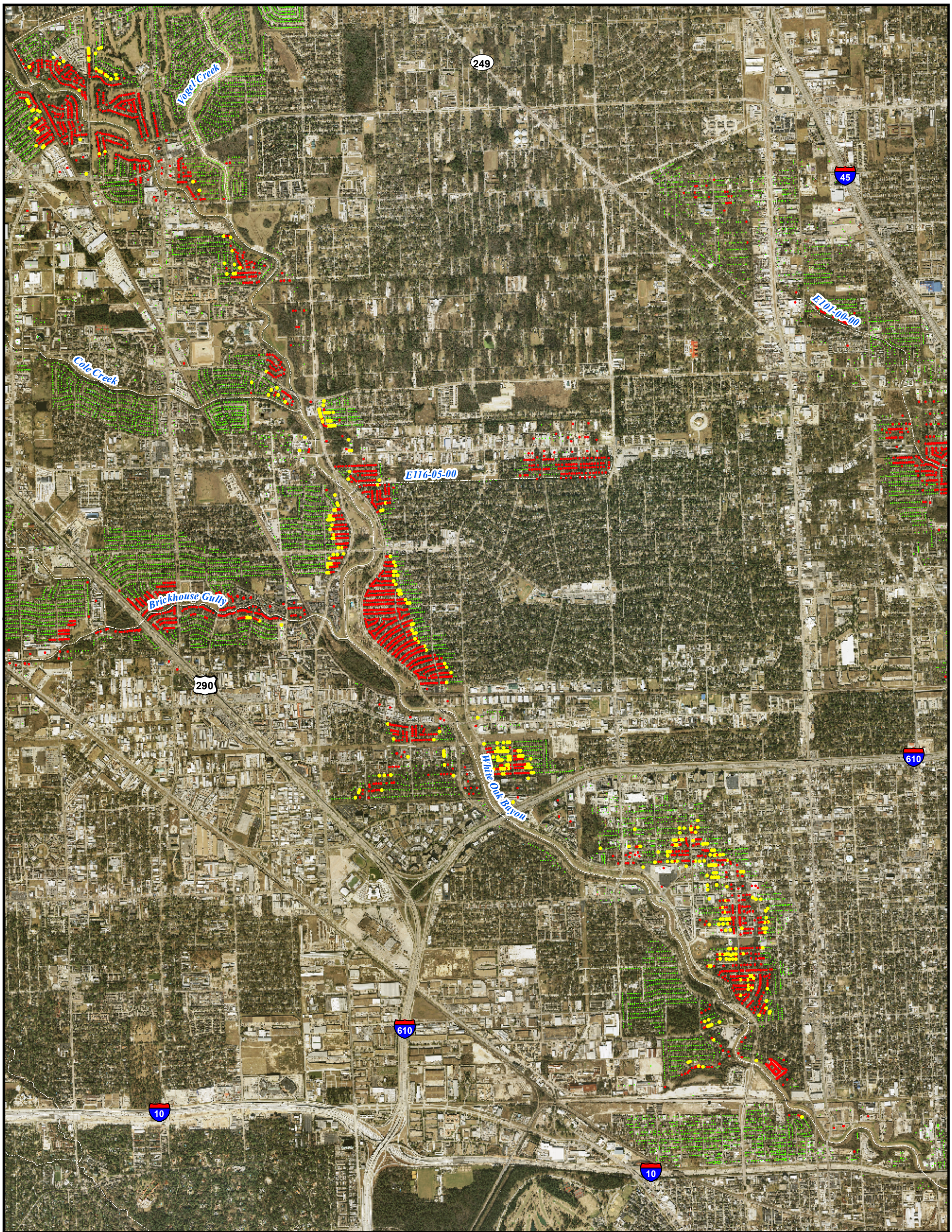
0 1,500 3,000 6,000
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

10% Inundation Limits Comparison
Pre-Project and Recommended Alternative

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 7 |
|---|---|---|---|




**Legend**

**Structure Inventory**

- Not Inundated
- No Longer Inundated Under Recommended Plan
- Inundated

N

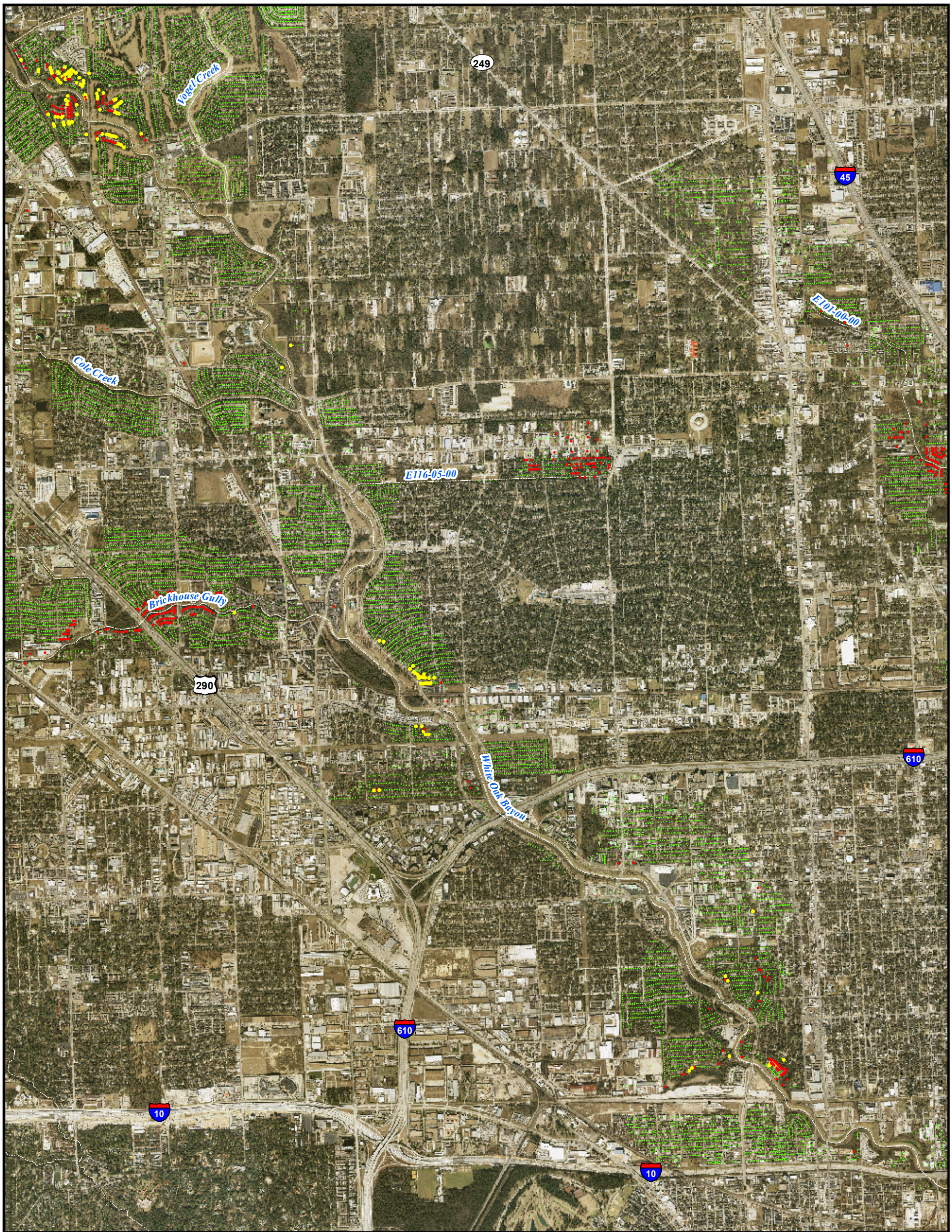
0 1,500 3,000 6,000
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

1% Structural Flooding Comparison
Pre-Project and Recommended Alternative

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 8 |
|---|---|---|---|




**Legend**

**Structure Inventory**

- Not Inundated
- No Longer Inundated Under Recommended Plan
- Inundated

N

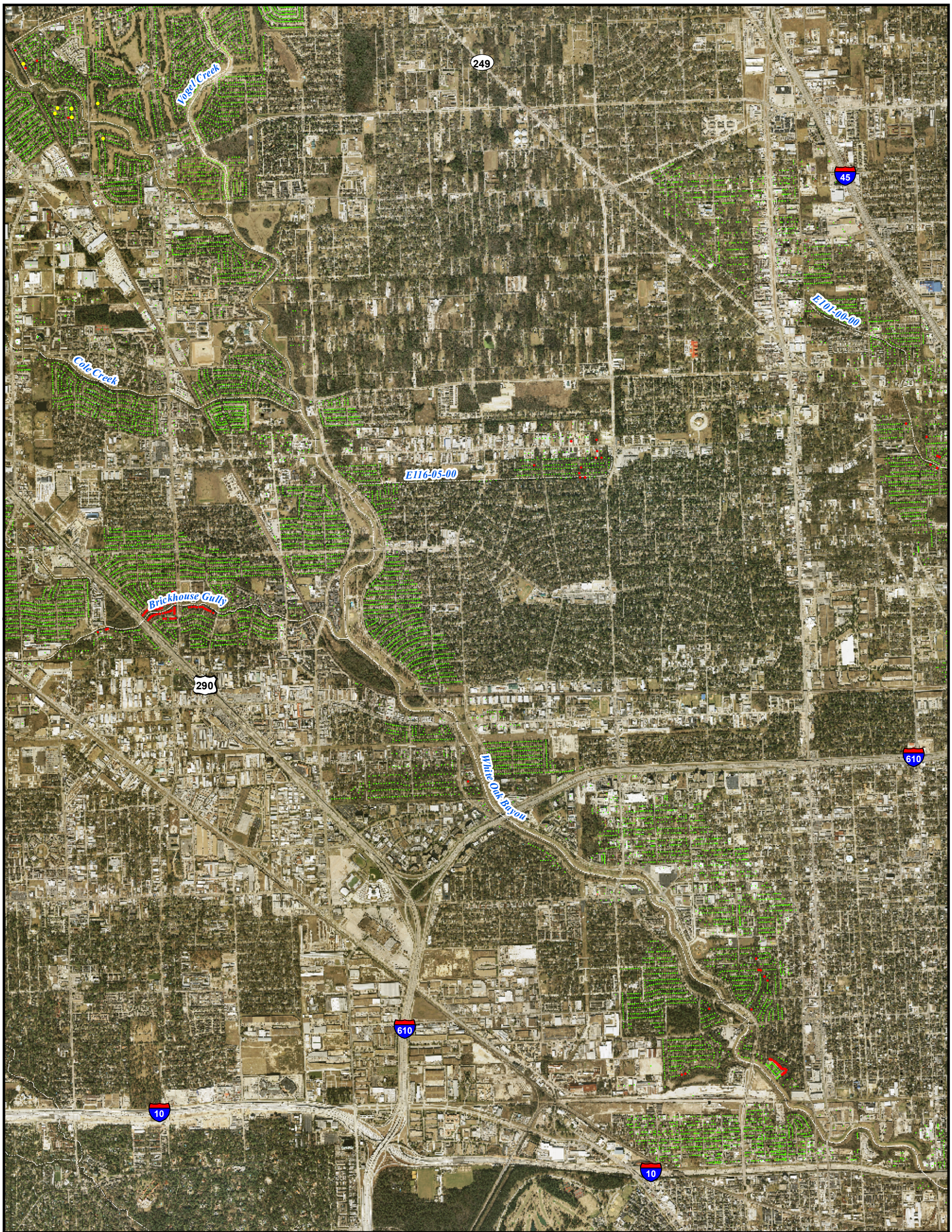
0 1,500 3,000 6,000
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

4% Structural Flooding Comparison
Pre-Project and Recommended Alternative

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 9 |
|---|---|---|---|




**Legend**

**Structure Inventory**

- Not Inundated
- No Longer Inundated Under Recommended Plan
- Inundated

N

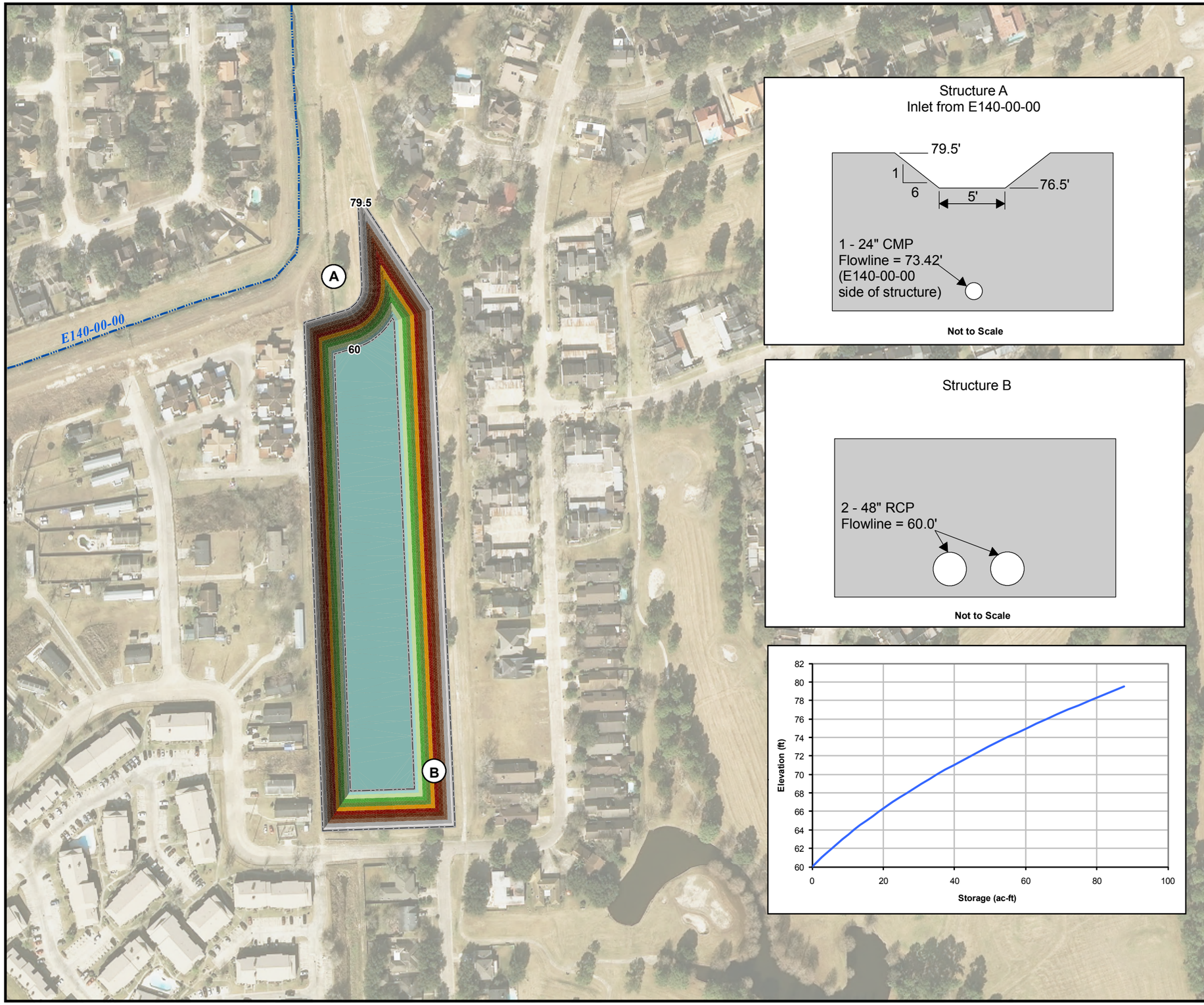
0 1,500 3,000 6,000
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

10% Structural Flooding Comparison
Pre-Project and Recommended Alternative

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 10 |
|---|---|---|---|













**Legend**

- Stream Centerlines
- Pool
- TOB

**Pond Elevation (ft.)**

- 78 - 79.5
- 76 - 78
- 74 - 76
- 72 - 74
- 70 - 72
- 68 - 70
- 66 - 68
- 64 - 66
- 62 - 64
- 60 - 62

N

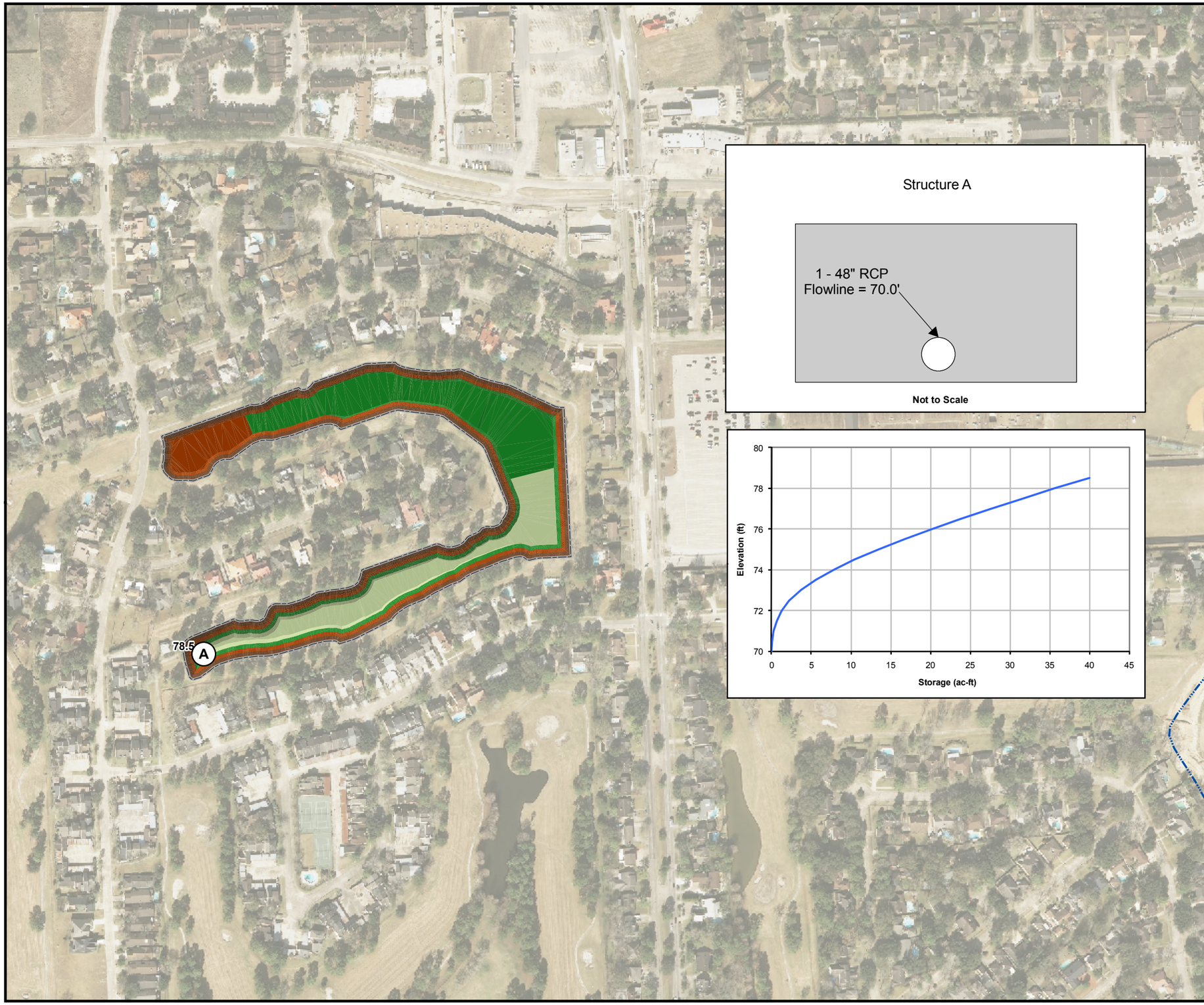
0 100 200 400
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin A Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11a |
|---|---|---|---|




**Legend**

- Stream Centerlines
- TOB

**Pond Elevation (ft.)**

- 78 - 78.5
- 76 - 78
- 74 - 76
- 72 - 74
- 70 - 72

N

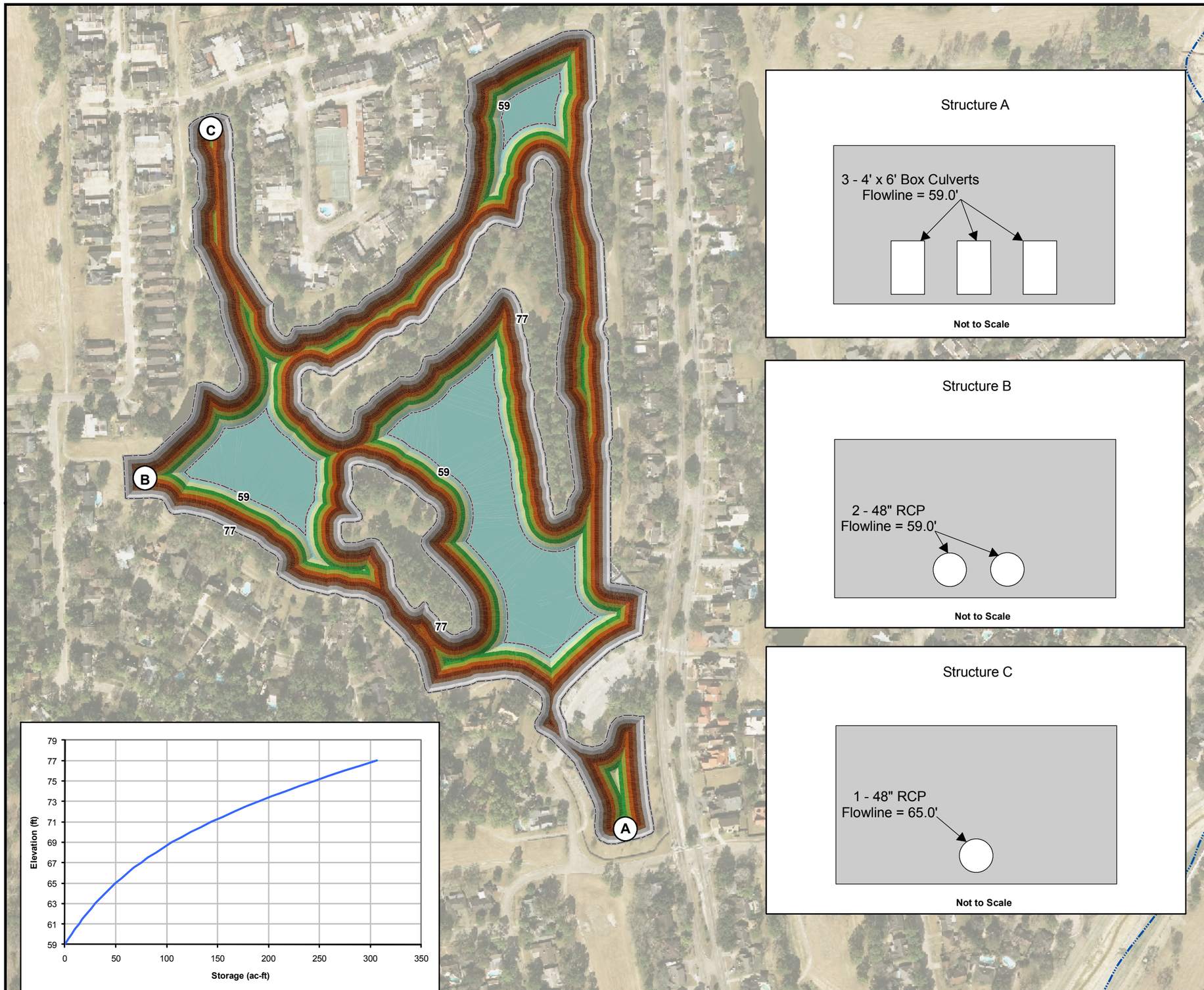
0 150 300 600
Feet

DODSON
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin B Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11b |
|---|---|---|---|




Structure A




Not to Scale

Structure B




Not to Scale

Structure C




Not to Scale

**Legend**

- Stream Centerlines
- Pool
- TOB

**Pond Elevation (ft.)**

- 75 - 77
- 73 - 75
- 71 - 73
- 69 - 71
- 67 - 69
- 65 - 67
- 63 - 65
- 61 - 63
- 59 - 61

N

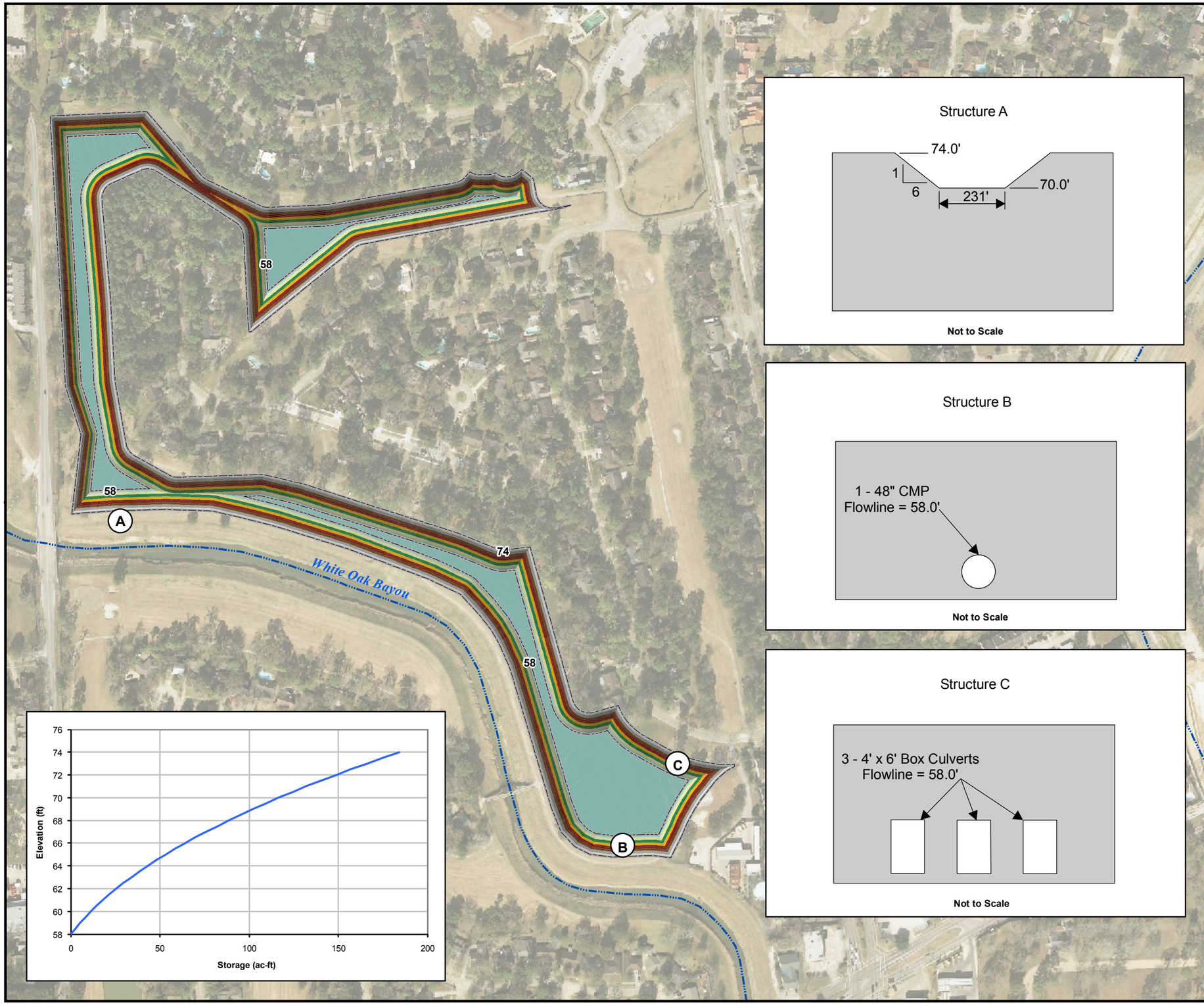
0 150 300 600
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin C Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11c |
|---|---|---|---|













**Legend**

- Stream Centerlines
- Pool
- TOB

**Pond Elevation (ft.)**

- 72 - 74
- 70 - 72
- 68 - 70
- 66 - 68
- 64 - 66
- 62 - 64
- 60 - 62
- 58 - 60

N

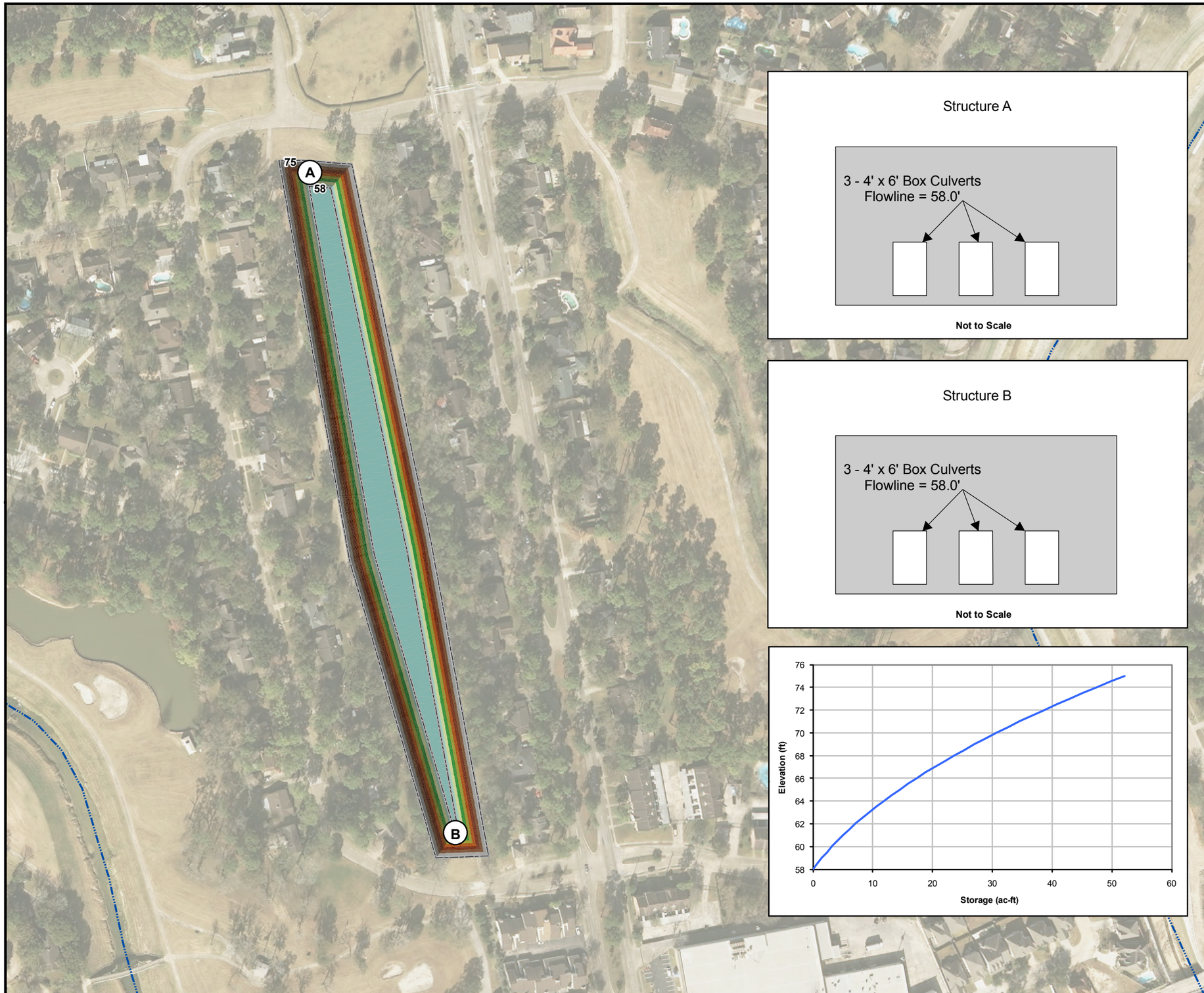
0 150 300 600
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin D Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11d |
|---|---|---|---|




Structure A




Not to Scale

Structure B




Not to Scale




**Legend**

- Stream Centerlines
- Pool
- TOB

**Pond Elevation (ft.)**

- 74 - 75
- 72 - 74
- 70 - 72
- 68 - 70
- 66 - 68
- 64 - 66
- 62 - 64
- 60 - 62
- 58 - 60

N

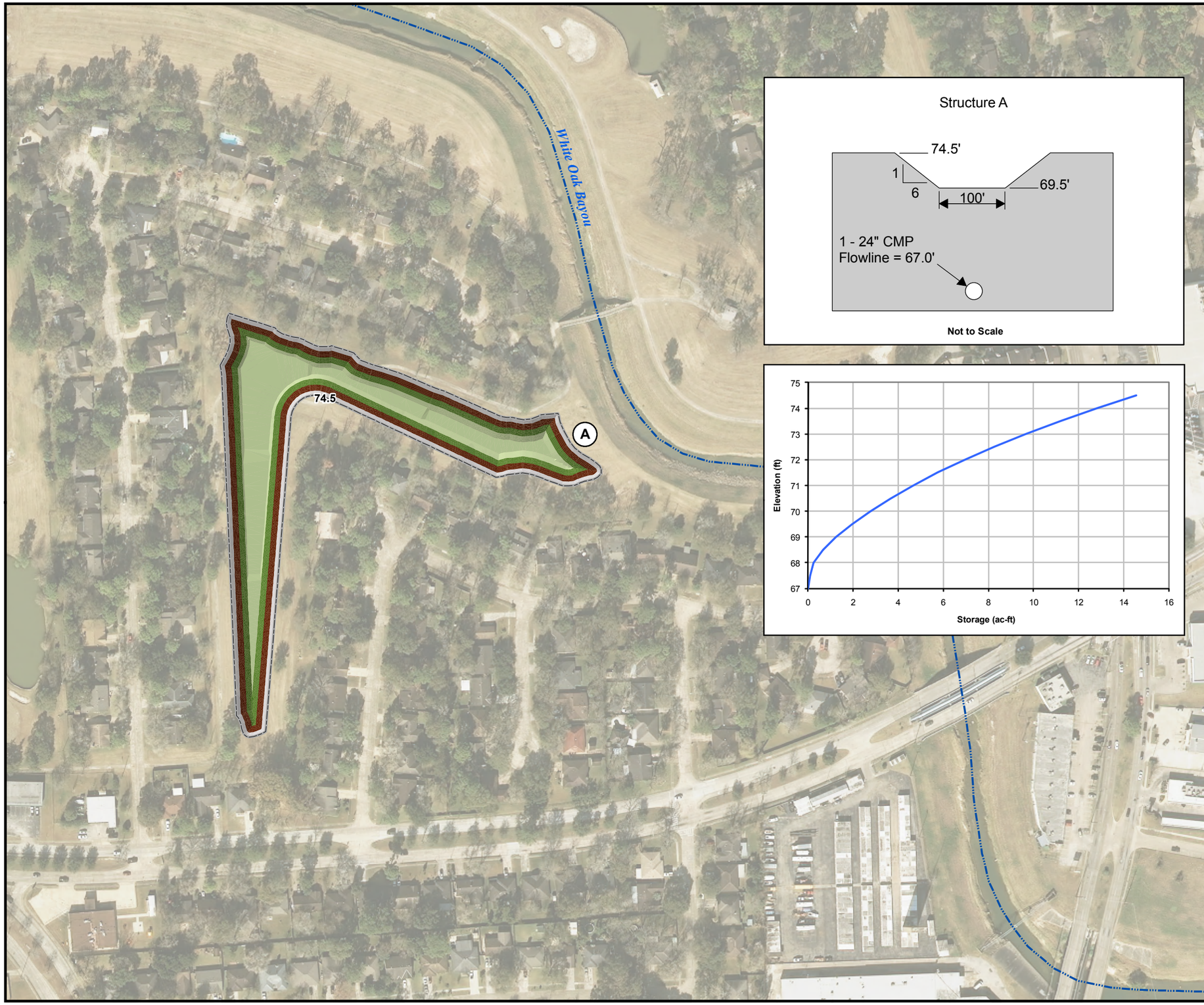
0 100 200 400
Feet

DODSON
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin E Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11e |
|---|---|---|---|




**Legend**

- Stream Centerlines
- TOB

**Pond Elevation (ft.)**

- 73 - 74.5
- 71 - 73
- 69 - 71
- 67 - 69

N

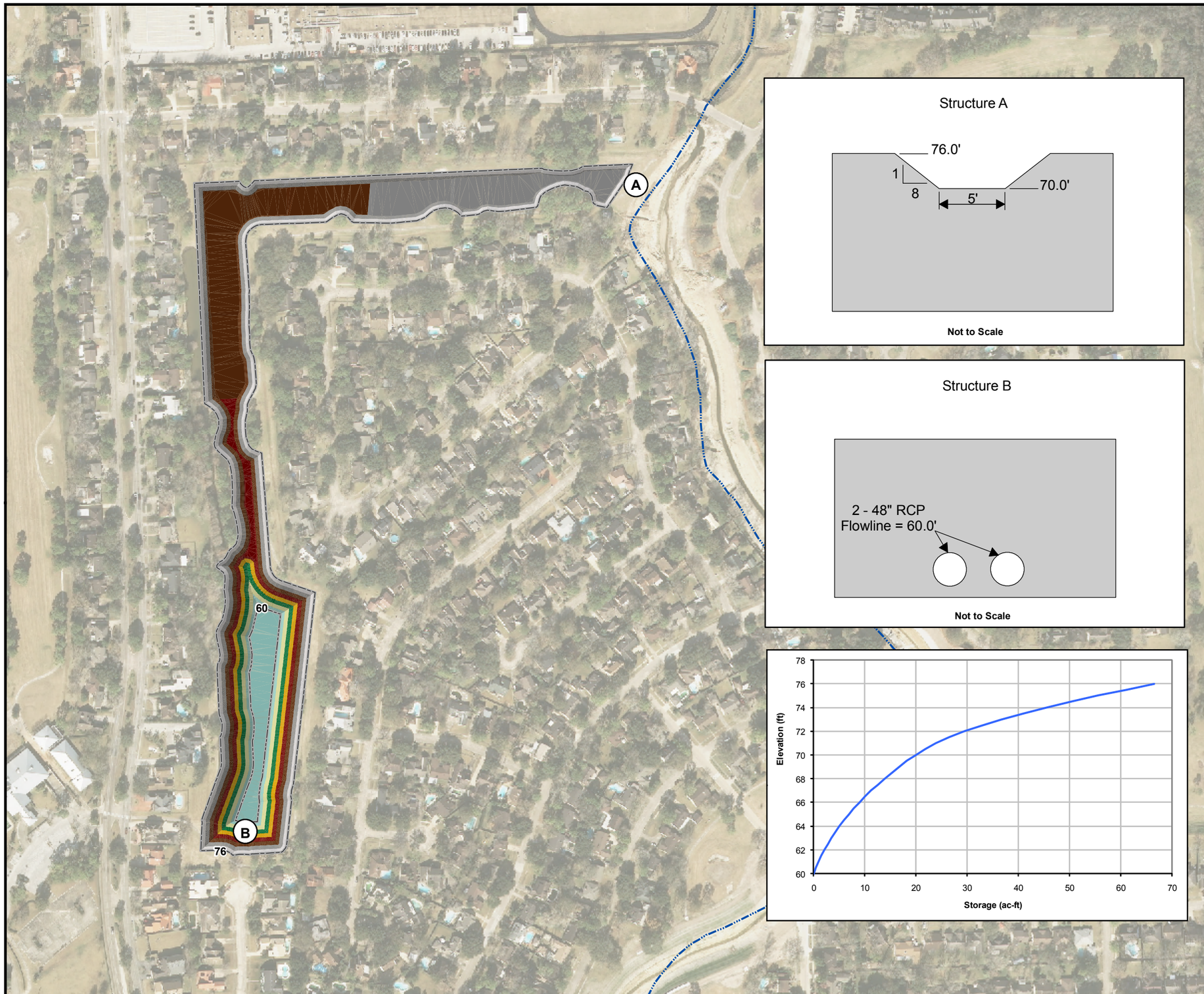
0 100 200 400
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin F Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11f |
|---|---|---|---|













**Legend**

- Stream Centerlines
- Pool
- TOB

**Pond Elevation (ft.)**

- 74 - 76
- 72 - 74
- 70 - 72
- 68 - 70
- 66 - 68
- 64 - 66
- 62 - 64
- 60 - 62

N

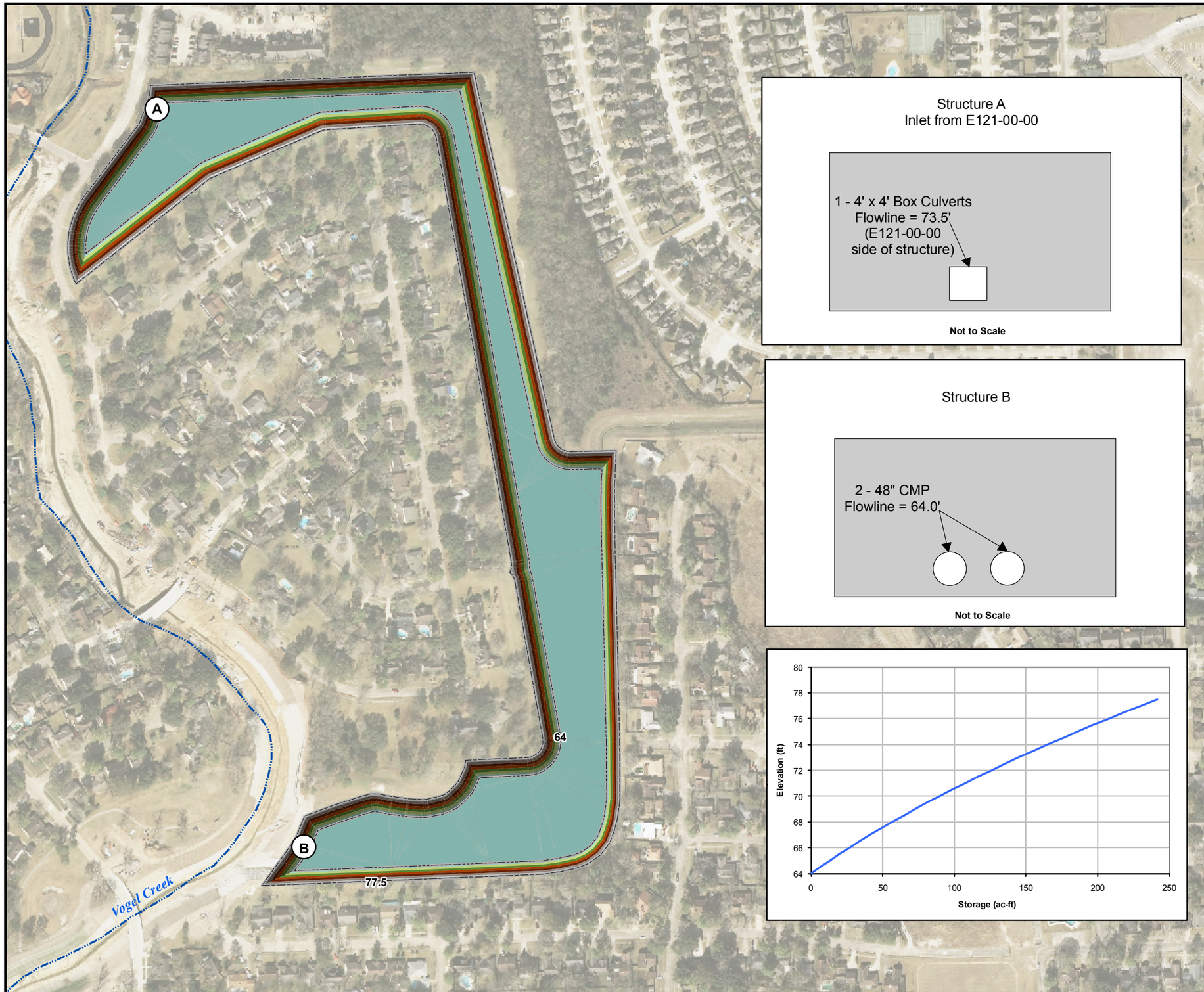
0 150 300 600
Feet

**DODSON**
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin H Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11g |
|---|---|---|---|




Structure A
Inlet from E121-00-00




Not to Scale

Structure B




Not to Scale

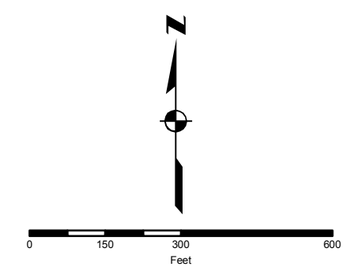



**Legend**

- Stream Centerlines
- Pool
- TOB

**Pond Elevation (ft.)**

- 76 - 77.5
- 74 - 76
- 72 - 74
- 70 - 72
- 68 - 70
- 66 - 68
- 64 - 66

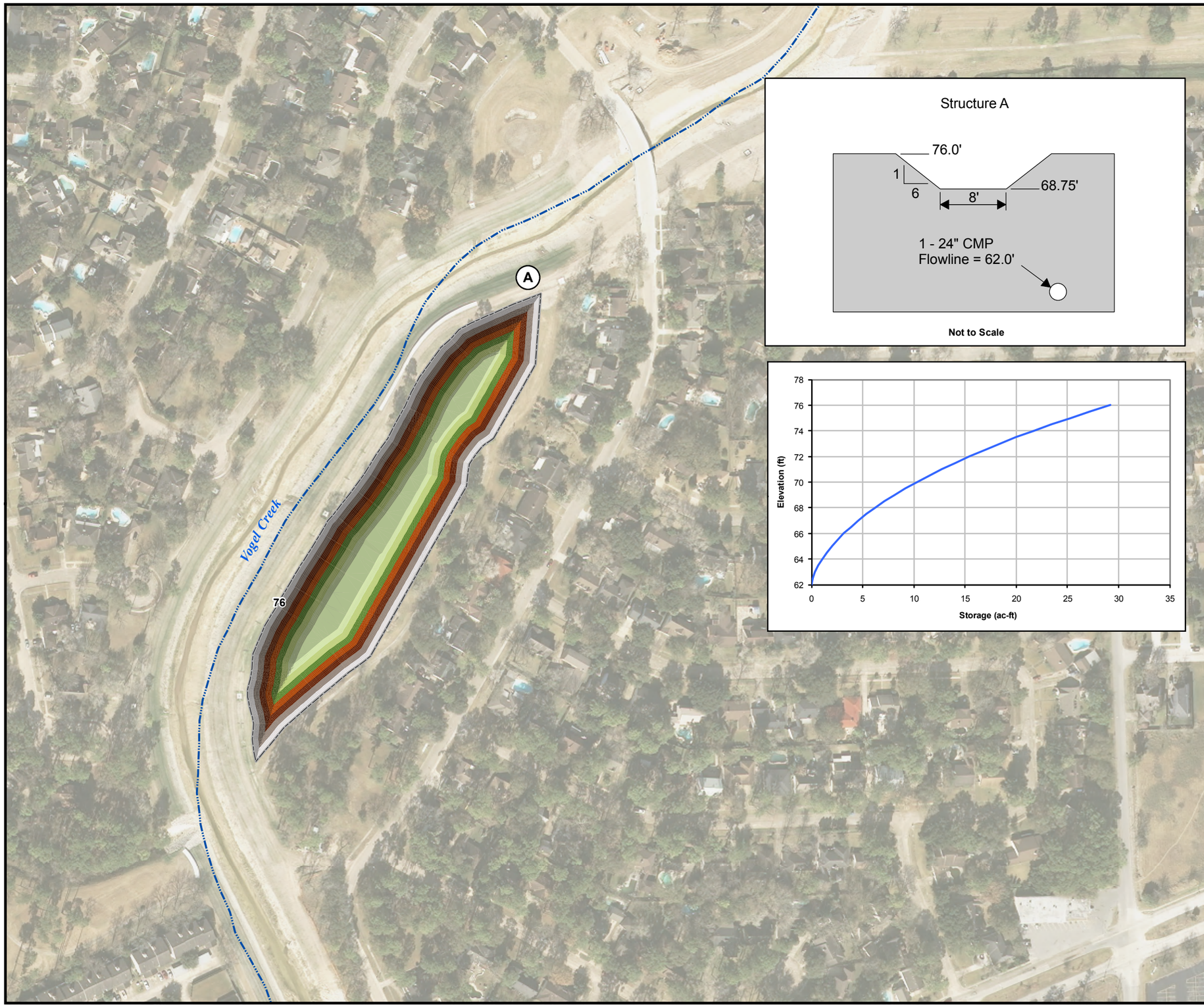



DODSON
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin I Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11h |
|---|---|---|---|




**Legend**

- Stream Centerlines
- TOB

**Pond Elevation (ft.)**

- 74 - 76
- 72 - 74
- 70 - 72
- 68 - 70
- 66 - 68
- 64 - 66
- 62 - 64

N

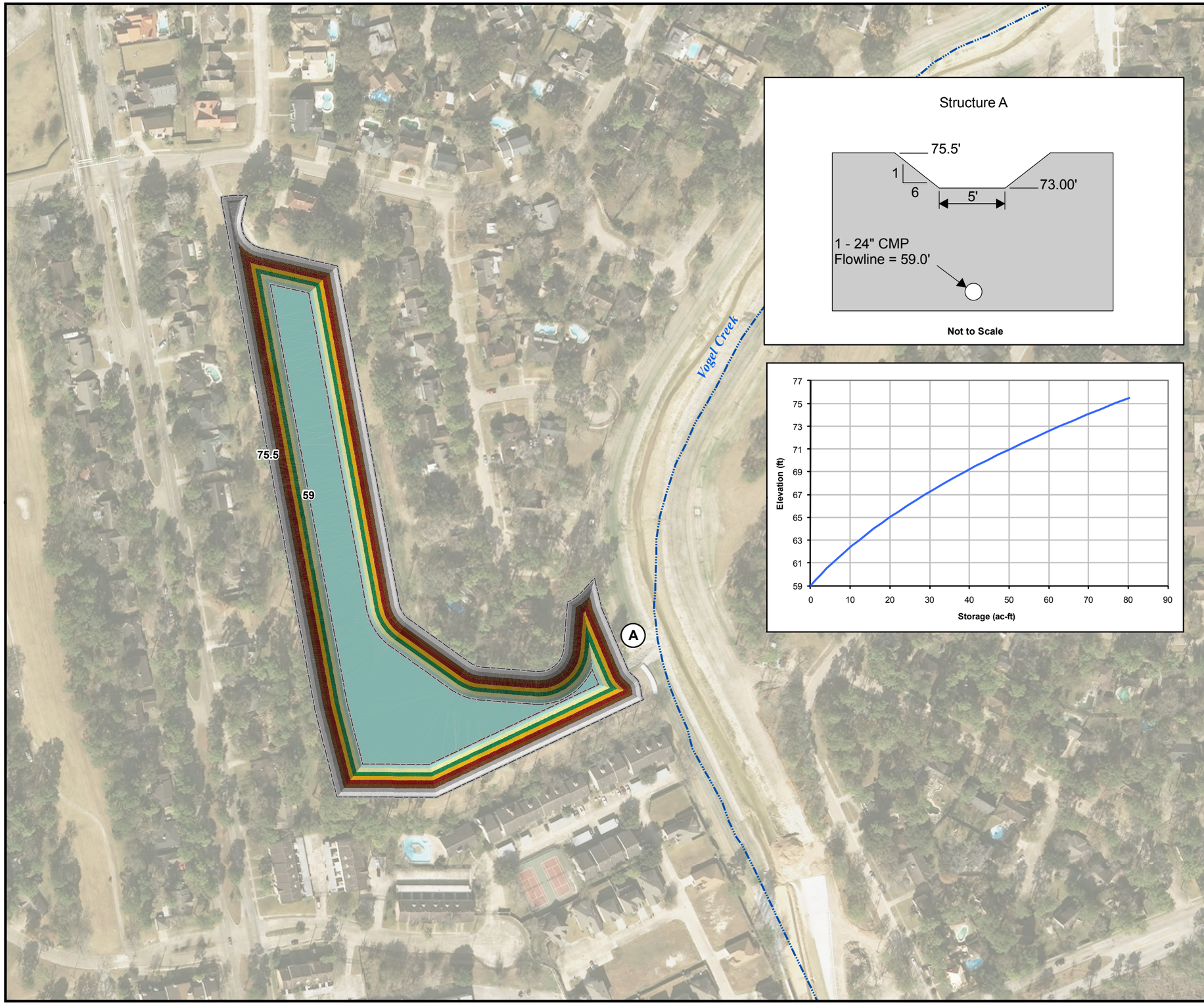
0 100 200 400
Feet

DODSON
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin K Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11i |
|---|---|---|---|










**Legend**

- Stream Centerlines
- TOB
- Pool

**Pond Elevation (ft.)**

- 73 - 75.5
- 71 - 73
- 69 - 71
- 67 - 69
- 65 - 67
- 63 - 65
- 61 - 63
- 59 - 61

N

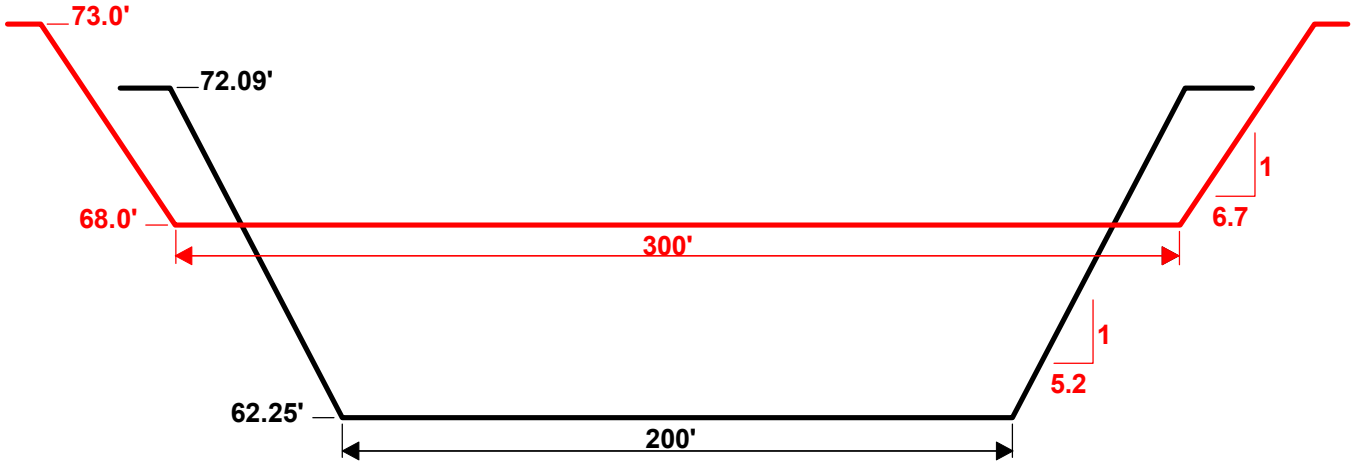
0 100 200 400
Feet

DODSON
& ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

Inwood Detention Analysis

Basin L Details

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 11j |
|---|---|---|---|




**Legend**

Existing Weir

Proposed Weir

Note: Drawing Not to Scale

Inwood Detention Analysis

E500-06 Proposed Weir Detail

DODSON & ASSOCIATES, INC.
*Hydrologists and Civil Engineers*

| Job No. 1898 | July 2011 | Drawn By: ams | Exhibit 12 |
|---|---|---|---|

# APPENDIX A

## (CD with Models and Supporting Data)

# APPENDIX B

**Recommended Alternative (Alternative - 1) Construction Costs**

| Site Prep | | | Unit | | Unit Cost | Total Unit | Total Cost |
|---|---|---|---|---|---|---|---|
| Site Preparation | | | LS | | | | $20,000.00 |
| Land Clearing and grubbing | | | AC | | $500.00 | 123.02 | $61,510.00 |
| Pipe Crossing | | | EA | | $218,280.00 | 6 | $1,309,680.00 |
| E-500-06 LS demolition | | | SY | | $20.00 | 5750 | $115,000.00 |
| **Excavation** | | | | | | | |
| **Basin** | | **Volume, cu.yd** | **Unit** | | **Unit Cost, $/cu.yd** | **Total Unit, cu.yd** | **Total Cost** |
| A South | | 152887 | | | | | |
| B | | 95481 | | | | | |
| C | | 608730 | | | | | |
| D | | 394393 | | | | | |
| E | | 100098 | | | | | |
| F | | 30752 | CY | | $6.00 | 2419945 | $14,519,672.47 |
| G | | 117441 | | | | | |
| H | | 148908 | | | | | |
| I | | 513727 | | | | | |
| J East | | 45410 | | | | | |
| J West | | 21192 | | | | | |
| K | | 51911 | | | | | |
| L | | 139015 | | | | | |
| **Structures** | | | | | | | |
| **From** | **To** | **Type** | **Length, ft** | **Unit** | **Unit Cost** | **Total Unit** | **Total Cost** |
| E140-00-00 | A-South | 5 ft Weir, 6:1 Side slope | 110 | SY (8" thick) | $65.00 | 800 | $52,000.00 |
| E100-00-00 | Basin D | 300 ft Weir, 6:1 Side slope | 90 | SY (8" thick) | $65.00 | 3700 | $240,500.00 |
| E100-00-00 | Basin F | 100 ft Weir, 6:1 Side slope | 120 | SY (8" thick) | $65.00 | 1400 | $91,000.00 |
| E100-00-00 | Basin E-500-06 | 300 ft Weir, 6:1 Side slope | 100 | SY (8" thick) | $65.00 | 3760 | $244,400.00 |
| E121-00-00 | Basin H | 5 ft Weir, 6:1 Side slope | 100 | SY (8" thick) | $65.00 | 1400 | $91,000.00 |
| E121-00-00 | Basin K | 12 ft Weir, 6:1 Side slope | 100 | SY (8" thick) | $65.00 | 1245 | $80,925.00 |
| E121-02-00 | Basin I | 100 ft Weir, 6:1 Side slope | 100 | SY (8" thick) | $65.00 | 3200 | $208,000.00 |
| E121-00-00 | Basin L | 5 ft Weir, 6:1 Side slope | 100 | SY (8" thick) | $65.00 | 560 | $36,400.00 |
| | | | | | | | |
| E100-00-00 | Basin F | 2.0 ft RCP | 90 | LF | $68.56 | 90 | $6,170.40 |
| E121-00-00 | Basin K | 2.0 ft RCP | 70 | LF | $68.56 | 70 | $4,799.20 |
| E121-00-00 | Basin L | 2.0 ft RCP | 110 | LF | $68.56 | 110 | $7,541.60 |
| | | | | | | | |
| Basin C | Basin A-South | One 4.0 ft RCP | 420 | LF | $187.21 | 420 | $78,628.20 |
| Basin C | Basin B | One 4.0 ft RCP | 400 | LF | $187.21 | 400 | $74,884.00 |
| Basin H | Basin L | Two 4.0 ft RCP | 600 | LF | $187.21 | 1200 | $224,652.00 |
| E100-00-00 | Basin D | One 4.0 ft RCP | 90 | LF | $187.21 | 90 | $16,848.90 |
| E121-00-00 | Basin I | Two 4.0 ft RCP | 100 | LF | $187.21 | 200 | $37,442.00 |
| | | | | | | | |
| E121-00-00 | Basin I | One 4X4 ft RCB | 200 | LF | $200.00 | 200 | $40,000.00 |
| | | | | | | | |
| Basin C | Basin E | Three 4X6 ft RCB | 180 | LF | $396.00 | 540 | $213,840.00 |
| Basin D | Basin E | Three 4X6 ft RCB | 180 | LF | $396.00 | 540 | $213,840.00 |
| **Road Cut for Pipe Connections between Basins** | | | | | | | |
| Basin C | Basin B | One 4.0 ft RCP | | EA | $5,000.00 | 1 | $5,000.00 |
| Basin C | Basin A-South | One 4.0 ft RCP | | EA | $5,000.00 | 1 | $5,000.00 |
| Basin H | Basin L | Two 4.0 ft RCP | | EA | $5,000.00 | 2 | $10,000.00 |
| E121-00-00 | Basin I | One 4X4 ft RCB | | EA | $8,000.00 | 1 | $8,000.00 |
| Basin C | Basin E | Three 4X6 ft RCB | | EA | $10,000.00 | 3 | $30,000.00 |
| Basin D | Basin E | Three 4X6 ft RCB | | EA | $10,000.00 | 3 | $30,000.00 |
| **Wingwalls** | | | | | | | |
| Lateral structure E100 to Basin D | | | | | | | |
| Lateral structure E100 to Basin F | | | | | | | |
| Connector C to A-South | | | | | | | |
| Connector C to B | | | | | | | |
| Connector C to E | | | | | | | |
| Connector D to E | | | | EA | $20,000.00 | 22 | $440,000.00 |
| Lateral Structure E121 to I | | | | | | | |
| Lateral Structure E121 to H | | | | | | | |
| Lateral Structure E121 to I | | | | | | | |
| Lateral Structure E121 to K | | | | | | | |
| Lateral Structure E121 to L | | | | | | | |
| **Landscaping and Liners** | | | Area, ac | Unit | Unit Cost | Total Unit | Total Cost |
| Hydroseed | | | | AC | $3,000.00 | 125 | $374,880.00 |
| Plantings (20 per ac, $140 per tree)) | | | 124.96 | AC | $2,800.00 | 125 | $349,888.00 |
| | | | | | | | |
| Total | | | | | | | $19,241,501.77 |
| Engineering, Permitting, Construction Management (Lump Sum) | | | | | | | $600,000.00 |
| Total | | | | | | | **$19,841,501.77** |

**Note:** This cost estimate does not include bulkheads or architectural landscaping features. All costs subject to change based on final design.

# APPENDIX C

***Original TC&R***

| Subwatershed | Drainage Area (acres) | Drainage Area (sq.mi.) | Watershed Length (mi.) L | Length to Centroid(mi.) Lca | Channel Slope(ft./mi) S | Overland Slope(ft./mi.) So | D | Percent Urban Development 2002 DLU | Percent Channel Improvement DCI | Percent Channel Conveyance DCC | Percent Ponding DPP | DLU affected by Detention DET | Percent Impervious 2002 | (TC+R)" | TC" | R" | DLU Minimum | DLU *(Detention)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E121B | 2398.2 | 3.75 | 3.49 | 1.67 | 5.50 | 10.00 | 2.46 | 66.60 | 80 | 70 | 0 | 2.18 | 21.90 | 5.54 | 0.91 | 4.63 | 29.03 | 64.42 |

***Revised TC & R***

| Subwatershed | Drainage Area (acres) | Drainage Area (sq.mi.) | Watershed Length (mi.) L | Length to Centroid(mi.) Lca | Channel Slope(ft./mi) S | Overland Slope(ft./mi.) So | D | Percent Urban Development 2002 DLU | Percent Channel Improvement DCI | Percent Channel Conveyance DCC | Percent Ponding DPP | DLU affected by Detention DET | Percent Impervious 2002 | (TC+R)" | TC" | R" | DLU Minimum | DLU *(Detention)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E121B1 | 812.2 | 1.27 | 1.84 | 1.00 | 5.50 | 10.00 | 2.46 | 66.60 | 80 | 70 | 0 | 2.18 | 21.90 | 3.53 | 0.53 | 2.99 | 29.03 | 64.42 |
| E121B2 | 474.2 | 0.74 | 1.89 | 0.96 | 5.50 | 10.00 | 2.46 | 66.60 | 80 | 70 | 0 | 2.18 | 21.90 | 3.60 | 0.51 | | 29.03 | 64.42 |
| E121B3 | 1021.4 | 1.60 | 3.05 | 1.25 | 5.50 | 10.00 | 2.46 | 66.60 | 80 | 70 | 0 | 2.18 | 21.90 | 5.04 | 0.67 | 4.37 | 29.03 | 64.42 |
| E121B4 | 123.6 | 0.19 | 1.70 | 0.81 | 5.50 | 10.00 | 2.46 | 66.60 | 80 | 70 | 0 | 2.18 | 21.90 | 3.34 | 0.43 | 2.92 | 29.03 | 64.42 |

*Note: For drainage areas E121B2 and E121B4 (less than one square mile) the storage coeficient was adjusted so that the peak runoff for the 100-year event matched the Harris County site runoff curves.*

# APPENDIX D

**Harris County Flood Control District**

**Inwood Forest Golf Club**

**Project ID No. E121-00-00**

**Watershed Environmental Baseline (WEB) Map**
**Preliminary Environmental Evaluation Report**

**7/28/2009**

## Introduction

Harris County Flood Control District (HCFCD) is conducting a feasibility study on the former Inwood Forest Golf Club golf course. The project area is located in Harris County within the White Oak Bayou watershed, in between White Oak Bayou and Vogel Creek, and is approximately 208.73 acres.

## Purpose

The purpose of the District's Watershed Environmental Baseline (WEB) Map Data Summary Tool (DST) is to provide a comprehensive synthesis of environmental considerations that should be evaluated during HCFCD project development. This Preliminary Environmental Evaluation Report (PEER) provides the user with a summary of available spatial information contained in the District's WEB Map database. This data can be used in the project planning process to assess potential environmental impacts associated with various project alternatives, avoid and minimize potential environmental impacts, and develop alternative flood mitigation options.

Because spatial information is constantly changing and often incomplete, it is important that this information only be used as a preliminary starting point in the evaluation process. The state and federal databases used by the WEB Map DST are updated periodically to add new environmental features as updated information becomes available. Therefore, this PEER is not a comprehensive assessment of project impacts. It may be necessary to conduct literature searches and/or field reconnaissance surveys for resources with potential impacts, and in some cases, a resource may require an in-depth field survey (i.e. wetland delineation, endangered species survey, archeological survey, Phase I Environmental Site Assessment, etc.) to determine potential impacts.

## Vegetation

The project area contains the following vegetation types:

Non-Forested Wetland
Other

The WEB Map vegetation data layer was last updated: 10/29/2003.

## Soils

The project area encompasses/crosses the following soil map units:

Katy-aris-clodine (tx248)
Clodine-addicks-gessner (tx100)

The WEB Map soils data layer was last updated: 1/1/1994.

## Geology

The project area lies within the following geology formation(s):

Lissie

The geology data was last updated: 1/1/1982.

## Faults

The project area does contain a geologic fault.

The geologic structures data was last updated: N/A.

## Water Quality

The project area contains or is adjacent to the following channel(s):

| HCFCD Channel | TCEQ Segment ID | 303d Status |
|---|---|---|
| E100-00-00 | 1017 | Yes |
| E240-00-00 | | No |
| E140-00-00 | | No |
| E121-00-00 | | No |

The WEB Map water quality data layer was last updated: 10/1/2002.

## Special Biological Resources

The following known rare or protected species locations and/or other special biological resources areas (bird rookeries, rare habitats, etc.) are located inside or within one mile of the proposed project area.

| Common Name | Fed Status | State Status | Distance |
|---|---|---|---|
| Texas Prairie Dawn | E | E | 3,307' |

Note: Results with distances of 0' are inside (or intersect) the project area.

E – Endangered
T – Threatened
R – Rare
SOC – Species of Concern
NL / Blank – Not Listed

The WEB Map Special Biological Resources data layer was last updated: 6/4/2003.

## Wetlands

The project area contains the following approximate acreages and types of wetlands from remote sensing sources:

| Wetland Type | Acreage |
|---|---|
| Forested | 0.00 |
| Non-Forested | 0.00 |
| Other | 8.16 |
| Total | 8.16 |

Forested wetlands are made up of the palustrine (fresh-water) forested (PFO) wetland type. Non-forested wetlands include palustrine emergent (PEM) and scrub-shrub (PSS), palustrine aquatic bed (PAB), lacustrine (lake fringe) and estuarine (salt-water) wetland types. Other includes lakes, ponds, rivers, and similar bodies of open water.

These approximate acreages combine both National Wetland Inventory (NWI) data and additional wetlands interpreted from more recent aerial photography. A wetland delineation is necessary to confirm actual wetland types, acreages, and boundaries present within the project area.

The NWI Wetlands data layer was last updated: 3/2/2007.
The WEB Map potential wetland layer was last updated: 3/2/2007.

Stream Habitat

The project area contains/is adjacent to HCFCD channels. Approximately 0 feet of these channels are designated high quality habitat, 0 feet medium quality habitat, and 5,872 feet low quality habitat within the project area.

The WEB Map stream habitat data layer was last updated: 3/2/2007.

Cultural Resources

All or portions of the project area have been previously surveyed for cultural resources. The results of this/these survey(s) can be found in the following reports:

| **Project Name** | **Author** |
|---|---|
| DRAFT: A Cultural Resource Survey for the Proposed Vogel Creek Improvement Project, Harris County, Texas | Driver |
| Archeological Survey of White Oak Bayou from Cole Creek to West Road, Harris County, Texas | Beck, Sanchez, Moore |
| Upper White Oak Bayou and Cole and Vogel Creeks, Harris County, Texas: Archeological and Historical Resource Inventory and Evaluation | Payne |
| Upper White Oak Bayou and Cole and Vogel Creeks, Harris County, Texas: Archeological and Historical Resource Inventory and Evaluation | Payne |
| Cultural Resources Investigations Along Whiteoak Bayou, Harris County, Texas | Fields |
| Archaeological Resources Survey Report: WTC Jester: From Victory Drive to SH 249 | TXDOT |
| Archaeological Resources Survey Report: WTC Jester: From Victory Drive to SH 249 | TXDOT |

The WEB Map cultural resource survey data layer was last updated: 8/15/2008.

Hazardous Locations

There are 424 hazardous material locations located inside or within one mile of the proposed project area.

| Site Name | Address | Database | Distance |
|---|---|---|---|
| | | PW | 0' |
| | ANTONIE & VICTORY | PW | 0' |
| | ANTONIE & VICTORY | PW | 0' |
| | ANTONIE & VICTORY | PW | 0' |
| | ANTONIE & VICTORY | PW | 0' |
| | | PW | 0' |
| 7399 ANTOINE | 7399 ANTOINE DRIVE, BEHIND THE BUIDING BY THE TRASH DUMPSTERS | SP | 4' |
| BEHIND THE BUILDING BY THE TRASH DUMPSTERS | 7399 ANTOINE DRIVE | ER | 30' |
| WHITEOAK BAYOU AT ALABONSON RD AT | | FE | 74' |
| | | PW | 79' |
| SUPER K C FOOD STORE | 6100 W LITTLE YORK RD | US | 165' |
| STOP N GO STORE 3666 | 6100 W LITTLE YORK | LU | 165' |
| NORTHWEST MATHEMATICS SCIENCE | 6031 VICTORY DR | FI | 189' |
| | | PW | 208' |
| EISENHOWER H S | 7922 ANTOINE DR | FI | 223' |
| SAFEWAY 1034 | 7320 ANTOINE | US | 250' |
| DRYCLEAN USA | 7342 ANTOINE | OT | 263' |
| DRY CLEAN USA | 7342 ANTOINE | GE | 263' |
| DRYCLEAN USA | 7342 ANTOINE | NR | 263' |
| DRY CLEAN USA | 7342 ANTOINE | FI | 263' |
| DRYCLEAN USA | 7342 ANTOINE | FI | 263' |
| BOSS CLEANERS | 7342 ANTOINE DR | OT | 269' |
| RANDALLS FUEL CENTER #1034 | 7320 ANTOINE DR | LU | 333' |
| RANDALL S GROCERY STORE/GAS STATI | 7316 ANTONE ST | ER | 343' |
| TIP TOP CLEANERS | 7301 ANTOINE DR | OT | 358' |
| TIP TOP CLEANERS | 7301 ANTOINE DRIVE | OT | 358' |
| TIP TOP CLEANERS | 7301 ANTOINE DRIVE | GE | 358' |
| TIP TOP CLEANERS | 7301 ANTOINE | FI | 358' |
| TIP TOP CLEANERS | 7301 ANTOINE DRIVE | FI | 358' |
| TIP TOP CLEANERS | 7301 ANTOINE DRIVE | NR | 358' |
| LJ-65-05-726 | | FE | 428' |
| | | TO | 435' |
| EISENHOWER HIGH SCHOOL | | FI | 438' |
| | 7979 ANTOINE DR. | PW | 457' |
| DRY CLEAN USA | 5833 W GULFBANK | OT | 483' |
| DRYCLEAN USA 111 | 5833 W GULFBANK | GE | 483' |
| USA CLEANERS | 5833 W GULFBANK | NR | 483' |
| DRY CLEAN USA #111 | 5833 W GULFBANK | FI | 483' |
| USA CLEANERS | 5833 W GULFBANK | FI | 483' |
| EXXON CO USA #60533 | 7979 ANTOINE | NR | 487' |
| EXXON CO USA #60533 | 7979 ANTOINE | FI | 487' |
| EXXON CO USA #60533 | 7979 ANTOINE | FI | 487' |
| EXXON RS 60533 | 7979 ANTOINE | US | 487' |
| EXXON STATION 60533 | 7979 ANTOINE | LU | 487' |
| EXXON 6 0533 | 7979 ANTOINE DR | LU | 487' |
| | | PW | 524' |
| CHEVRON USA INC INC #156071 | 8003 ANTOINE & GULFBANK | GE | 576' |
| CHEVRON USA INC INC #156071 | 8003 ANTOINE & GULFBANK | FI | 576' |
| CHEVRON HP 333 | 8003 ANTOINE DR | US | 576' |
| | | PW | 583' |
| PRIME 1.19 CLEANERS | 7250 ANTOINE DR | OT | 584' |

| | | | |
|---|---|---|---|
| | | PW | 586' |
| HOUSTON CELLULAR TELEPHONE COMPANY, L.P. | 7827 A BAYOU FOREST | TO | 620' |
| STOP N GO 2616 | 5750 W GULF BANK RD | US | 695' |
| STOP N GO 2616 | 5750 W GULF BANK RD | LU | 695' |
| ATT WIRELESS PCS LLC | 6231 WEST LITTLE YORK | TO | 702' |
| | 7270 ANTOINE DRIVE | PW | 763' |
| | 7270 ANTOINE DR. | PW | 763' |
| | 7270 ANTOINE DR. | PW | 763' |
| | 7270 ANTOINE DR. | PW | 763' |
| CHEVRON HP NO 333 | 8003 ANTOINE DR | OT | 764' |
| JMC ENTERPRICE | 8003 ANTOINE DR | NR | 764' |
| JMC ENTERPRICE | 8003 ANTOINE DR | FI | 764' |
| CHEVRON FACILITY 156071 | 8003 ANTOINE | LU | 764' |
| LJ-65-13-111 | | FE | 765' |
| | | PW | 774' |
| | | PW | 776' |
| | | PW | 776' |
| | 5750 WEST GULF BANK | PW | 796' |
| | 5750 WEST GULF BANK | PW | 796' |
| DRY CLEAN USA | 5833 W GULF BANK RD | OT | 874' |
| | 28077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 8077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 328077 ANTONIE | PW | 882' |
| | 15328077 ANTONIE | PW | 882' |
| | | PW | 910' |
| EXPRESS FOOD | 7355 ALABONSON | US | 935' |
| TIMBERS OF INWOOD FOREST APARTME | 5850 WEST GULF BANK R | BF | 951' |
| TIMBERS OF INWOOD FOREST APARTME | 5850 WEST GULF BANK RO | VC | 951' |
| TIMBERS OF INWOOD FOREST APARTME | 5850 WEST GULF BANK RO | IC | 951' |
| THE OAKS OF INWOOD SHOPPING CENTE | 6600 ANTOINE DRIVE | VC | 961' |
| L. B. FOSTER COMPANY | 6500 LANGFIELD ROAD | VC | 961' |
| HOFFMAN MIDDLE | 6101 W LITTLE YORK RD | FI | 999' |
| J RUTH SMITH ACADEMY | 5815 W LITTLE YORK RD | FI | 1,045' |
| HOFFMAN MIDDLE SCHOOL | | FI | 1,157' |
| BELL CLEANERS | 8193 ANTOINE | OT | 1,182' |
| BELL CLEANERS 4 | 8193 ANTOINE DR | OT | 1,182' |
| BELL CLEANERS | 8193 ANTOINE | GE | 1,182' |
| BELL CLEANERS | 8193 ANTOINE | NR | 1,182' |
| BELL CLEANERS | 8193 ANTOINE | FI | 1,182' |
| BELL CLEANERS | 8193 ANTOINE | FI | 1,182' |
| BELL DRY CLEANERS | 8193 ANTOINE DR | OT | 1,182' |
| 1.25 ANTOINE CLEANER | 8124 ANTOINE DR | OT | 1,187' |
| 1.25 ANTOINE CLEANERS | 8124 ANTOINE DR | GE | 1,187' |
| EQUUS POWER SYSTEMS | 7514 ALABONSON RD | NR | 1,188' |
| INTL SWITCH BOARD CORP | 7514 ALABONSON RD | FI | 1,188' |
| EQUUS POWER SYSTEMS | 7514 ALABONSON RD | FI | 1,188' |
| EQUUS POWER SYSTEMS | 7514 ALABONSON RD | OT | 1,188' |
| | 8077 ANTOINE | PW | 1,225' |
| | 8077 ANTOINE | PW | 1,229' |

| | | | |
|---|---|---|---|
| | 8077 ANTOINE | PW | 1,229' |
| | GULF BANK/ANTOINE | PW | 1,229' |
| | GULF BANK/ANTOINE | PW | 1,229' |
| | GULF BANK/ANTOINE | PW | 1,229' |
| | GULF BANK/ANTOINE | PW | 1,229' |
| | GULF BANK/ANTOINE | PW | 1,229' |
| INWOOD CENTRAL SHOPPING CENTER | 8077 ANTOINE DRIVE | BF | 1,233' |
| INWOOD CENTRAL SHOPPING CENTER | 8077 ANTOINE DRIVE | VC | 1,233' |
| JERRYS AUTOMOTIVE | 8080 ANTOINE | US | 1,246' |
| INWOOD TEXACO | 8080 ANTOINE | LU | 1,246' |
| MCS TRANSPORTATION INC | 3818 BLACK LOCUST | GE | 1,311' |
| MCS TRANSPORTATION INC | 3818 BLACK LOCUST | FI | 1,311' |
| MCS TRANSP INC | JONES TOWN AT BICKLEY | FI | 1,311' |
| | 8077 ANTOINE | PW | 1,314' |
| | | PW | 1,328' |
| | | PW | 1,330' |
| | 6923 ANTOINE | PW | 1,349' |
| | 8077 ANTOINE | PW | 1,364' |
| LJ-65-13-110 | | FE | 1,383' |
| MCS TRANSPORTATION | 3818 BLACK LOCUST | OT | 1,393' |
| KIM S CLEANERS | 5758 WEST LITTLE YORK STREET | AI | 1,398' |
| WALGREEN 3369 | 8105 ANTOINE | OT | 1,414' |
| WALGREEN 3369 | 8105 ANTOINE | GE | 1,414' |
| WALGREENS NO 1203 | 8105 ANTOINE | FI | 1,414' |
| WALGREEN 3369 | 8105 ANTOINE | FI | 1,414' |
| KIMS CLEANERS | 5758 WEST LITTLE YORK ST | DO | 1,415' |
| KIMS CLEANERS | 5758 W LITTLE YORK RD | OT | 1,415' |
| HEIGHTS MARTINIZING | 5758 W LITTLE YORK | GE | 1,415' |
| HEIGHTS MARTINIZING | 5758 W LITTLE YORK | NR | 1,415' |
| HEIGHTS MARTINIZING | 5758 W LITTLE YORK | FI | 1,415' |
| KIMS DRY CLEANER | 5758 W LITTLE YORK | FI | 1,415' |
| HEIGHTS MARTINIZING | 5758 W LITTLE YORK | FI | 1,415' |
| KIMS CLEANERS | 5758 WEST LITTLE YORK ST | FI | 1,415' |
| HEIGHTS MARTINIZING | 5758 W LITTLE YORK | OT | 1,415' |
| KIM S CLEANERS | 5758 WEST LITTLE YORK ST | FD | 1,415' |
| PWI 309 | 7304 VOGEL | LU | 1,451' |
| MISTER COPY CENTER | 5730 W LITTLE YORK | NR | 1,507' |
| MISTER COPY CTR | 5730 W LITTLE YORK | FI | 1,507' |
| MISTER COPY CENTER | 5730 W LITTLE YORK | FI | 1,507' |
| MISTER COPY CENTER | 5730 W LITTLE YORK | OT | 1,507' |
| FIRESTONE SERVICE CENTER | 5620 LITTLE YORK RD | US | 1,537' |
| FIRESTONE MASTER CARE CENTER | 5620 LITTLE YORK RD | LU | 1,537' |
| AAA COOPER TRANSPORTATION | 5735 W LITTLE YORK RD | HM | 1,547' |
| | | PW | 1,609' |
| | | PW | 1,623' |
| MRS BAIRDS BAKERIES BUSINESS TRUST | 6650 NORTH HOUSTON ROS | FI | 1,657' |
| MRS BAIRDS BAKERIES | 6650 N HOUSTON ROSSLYN | FI | 1,657' |
| MRS BAIRDS BAKERY HOUSTON PLANT | 6650 N HOUSTON ROSSLYN | OT | 1,657' |
| MRS BAIRDS BAKERIES | 6659 N HOUSTON ROSSLYN | US | 1,671' |
| MRS BAIRDS BAKERIES INC | 6650 N HOUSTON ROSSLYN | GE | 1,690' |
| THE STEEL CORPORATION OF TEXAS | 6605 N HOUSTON ROSSLYN | US | 1,728' |
| CARAWAY INTERMEDIATE SCHOOL | | FI | 1,747' |
| YOUR FABRICARE CLEANERS | 6464 W LITTLE YORK RD STE | OT | 1,762' |
| VIP CLEANERS | 6464 W LITTLE YORK RD STE | NR | 1,762' |
| SHELL SERVICE STATION SAP 101115 | 6923 ANTOINE DR | OT | 1,768' |
| SHELL OIL PRODUCTS US | 6923 ANTOINE DR | GE | 1,768' |
| STAR ENTERPRISE | 6923 ANTOINE | FI | 1,768' |
| SHELL OIL PRODUCTS US | 6923 ANTOINE DR | FI | 1,768' |
| TEXACO 4204913 | 6923 ANTOINE | LU | 1,768' |
| | 4540 WEST LITTLE YORK | PW | 1,816' |
| SHELL SVC STATION | 4540 W LITTLE YORK | GE | 1,860' |

| | | | |
|---|---|---|---|
| SHELL SVC STATION | 4540 W LITTLE YORK | NR | 1,860' |
| SHELL SVC STA | 4540 W LITTLE YORK | FI | 1,860' |
| SHELL SVC STATION | 4540 W LITTLE YORK | FI | 1,860' |
| SHELL | 4540 W LITTLE YORK | US | 1,860' |
| SHELL FUEL FAC | 4540 W LITTLE YORK | LU | 1,860' |
| FORGED PRODUCTS INC | 6505 N HOUSTON ROSSLYN | NR | 1,912' |
| GULF AND WESTERN FORGED PRODUCT | 6505 N HOUSTON ROSSLYN | FI | 1,912' |
| PWI 309 | 7304 VOGEL | US | 1,930' |
| TEXACO 42 049 1353 | 6923 ANTOINE DR | US | 1,938' |
| FORGED PRODUCTS INC | 6505 N HOUSTON ROSSLYN | GE | 1,996' |
| FORGED PRODUCTS INC | 6505 N HOUSTON ROSSLYN | FI | 1,996' |
| FORGED PRODUCTS INC | 6505 N HOUSTON ROSSLYN | US | 1,996' |
| FORGED PRODUCTS INC | 6505 N HOUSTON ROSSLYN | LU | 1,996' |
| FORGED PRODUCTS | 6505 N HOUSTON ROSSLYN | OT | 1,996' |
| G & W FORGED PRODUCTS | 6505 N HOUSTON ROSSLYN | OT | 1,996' |
| FORGED PRODUCTS INC | 6505 N HOUSTON-ROSSLYN | TR | 2,017' |
| INWOOD STORAGE | 8235 ANTOINE | BF | 2,071' |
| INWOOD STORAGE | 8235 ANTOINE | IC | 2,071' |
| INWOOD STORAGE | 8235 ANTOINE | VC | 2,071' |
| | | PW | 2,113' |
| | | PW | 2,121' |
| | 20242 LAKEVIEW WAY | PW | 2,122' |
| DIAMOND SHAMROCK 0571 | 8383 N HOUSTON ROSSLYN | US | 2,141' |
| CAMERON RESEARCH CENTER | 6750 BINGLE ROAD | OT | 2,176' |
| COOPER CAMERON CORPORATION | 6750 BINGLE ROAD | GE | 2,176' |
| COOPER CAMERON CORPORATION | 6750 BINGLE ROAD | FI | 2,176' |
| OLD WAREHOUSE | 6711 BINGLE RD | US | 2,244' |
| EISENHOWER NINTH GRADE SCHOOL | 3550 W GULFBANK | FI | 2,246' |
| JOHNSTON PUMP SERVICE CENTER | 6455 BURLINGTON N | NR | 2,381' |
| JOHNSTON PUMP SERVICE CENTER | 6455 BURLINGTON N | FI | 2,381' |
| JOHNSTON PUMP SERVICE CENTER | 6455 BURLINGTON N | OT | 2,381' |
| FIRE STATION 4 | 6530 W LITTLE YORK | US | 2,391' |
| STEP N GO | 8398 N HOUSTON ROSSLYN | US | 2,429' |
| PRICE BUSTER STORE (RICE FOOD MKT) | 6620 ANTOINE ROAD | FD | 2,439' |
| PRICE BUSTER STORE (RICE FOOD MKT) | 6620 ANTOINE ROAD | FI | 2,439' |
| PRICE BUSTER STORE (RICE FOOD MKT) | 6620 ANTOINE ROAD | AI | 2,439' |
| STOP N GO MKTS 564 64 | 8402 N HOUSTON ROSSLYN | US | 2,460' |
| PILGRIM CLEANERS #2 | 6600 ANTOINE | GE | 2,461' |
| PILGRIM CLEANERS INC | 6600 ANTOINE | NR | 2,461' |
| PILGRIM CLEANERS #2 | 6600 ANTOINE | FI | 2,461' |
| PILGRIM CLEANERS INC | 6600 ANTOINE | FI | 2,461' |
| PILGRIM CLEANERS 2 | 6600 ANTOINE | OT | 2,461' |
| THE OAKS OF INWOOD SHOPPING CEN | 6600 ANTOINE DRIVE | BF | 2,461' |
| INGRAM CACTUS | 6445 BURLINGTON N | NR | 2,622' |
| FOSTER OILFIELD EQUIPMENT CO | 6445 BURLINGTON N | FI | 2,622' |
| INGRAM CACTUS | 6445 BURLINGTON N | FI | 2,622' |
| INGRAM CACTUS | 6445 BURLINGTON N | OT | 2,622' |
| JOHNSTON PUMP/GENERAL VALVE | 6455 BURLINGTON ST | FI | 2,623' |
| SEVEN DAYS FOOD STORE | 8244 ANTOINE DR | US | 2,631' |
| PACIFIC CLEANERS | 6405 ANTOINE DR | OT | 2,725' |
| PACIFIC CLEANERS | 6405 ANTOINE | OT | 2,725' |
| PACIFIC CLEANERS | 6405 ANTOINE | GE | 2,725' |
| PACIFIC CLEANERS | 6405 ANTOINE | NR | 2,725' |
| PACIFIC CLEANERS | 6405 ANTOINE | FI | 2,725' |
| PACIFIC CLEANERS | 6405 ANTOINE | FI | 2,725' |
| PACIFIC CLEANERS | 6405 ANTOINE #1 | FD | 2,725' |
| NIROOS AUTO CLINIC | 5767 WINDSOR FOREST DR | GE | 2,741' |
| NIROOS AUTO CLINIC | 5767 WINDSOR FOREST DR | NR | 2,741' |
| NIROO S AUTO CLINIC | 5767 WINDSOR FOREST DR | FI | 2,741' |
| NIROOS AUTO CLINIC | 5767 WINDSOR FOREST DR | FI | 2,741' |
| NIROOS AUTO CLINIC | 5767 WINDSOR FOREST DR | US | 2,741' |
| CARAWAY INT | 3031 ELLINGTON | FI | 2,753' |

| | | | |
|---|---|---|---|
| JIFFY LUBE 698 | 6440 ANTOINE DR | OT | 2,755' |
| JIFFY LUBE | 6440 ANTOINE | GE | 2,755' |
| JIFFY LUBE INTERNATIONAL INC | 6440 ANTOINE DR | NR | 2,755' |
| JIFFY LUBE | 6440 ANTOINE | FI | 2,755' |
| JIFFY LUBE INTERNATIONAL INC | 6440 ANTOINE DR | FI | 2,755' |
| JIFFY LUBE 698 | 6440 ANTOINE DR | US | 2,755' |
| STOVALL ACADEMY | 3025 ELLINGTON | FI | 2,765' |
| GAYLA INDUSTRIES | 6401 ANTOINE | GE | 2,809' |
| GAYLA INDUSTRIES INC | 6401 ANTOINE | NR | 2,809' |
| GAYLA INDUSTRIES | 6401 ANTOINE | FI | 2,809' |
| GAYLA INDUSTRIES INC | 6401 ANTOINE | FI | 2,809' |
| GAYLA INDUSTRIES | 6401 ANTOINE | OT | 2,809' |
| GAYLA INDUSTRIES | 6401 ANTOINE | NC | 2,809' |
| | | PW | 2,876' |
| WEST LITTLE YORK SHELL | 4540 W LITTLE YORK RD | US | 2,881' |
| LJ-65-05-728 | | FE | 2,952' |
| | | PW | 2,968' |
| | LOT 5, BLOCK # 11 UNIT # 2 | PW | 3,051' |
| LEW DOUGLAS HODGE | 100002 COE COURT | CE | 3,081' |
| LEW DOUGLAS HODGE | 100002 COE COURT | FI | 3,081' |
| | | PW | 3,108' |
| TOTAL BUILDING SYSTEMS | 6250 N HOUSTON ROSSLYN | OT | 3,112' |
| TOTAL BUILDING SYSTEMS | 6250 N HOUSTON ROSSLYN | NR | 3,112' |
| RICHMOND STEEL INC | 6250 N HOUSTON ROSSLYN | FI | 3,112' |
| TOTAL BUILDING SYSTEMS | 6250 N HOUSTON ROSSLYN | FI | 3,112' |
| RICHARD STEEL | 6250 N HOUSTON ROSSLYN | LU | 3,112' |
| | 6619 BARBADOS | ER | 3,121' |
| | | PW | 3,127' |
| MAASS FLANGE CORP HOUSTON | 6202 LUMBERDALE RD | FI | 3,150' |
| MAASS FLANGE CORP HOUSTON | 6202 LUMBERDALE RD | TR | 3,150' |
| MAASS FLANGE CORPORATION | 6202 LUMBERDALE RD | NR | 3,150' |
| RICHMOND EQUIPMENT | 6240 N HOUSTON ROSSLYN | US | 3,158' |
| RUSSELL STEEL DIV VAN PELT CORP | 6202 LUMBERDALE | US | 3,162' |
| HIGHLAND COORS DIST INC | 6550 BINGLE RD | US | 3,175' |
| HIGHLAND DISTRIBUTING CO | 6550 BINGLE | LU | 3,175' |
| EMPIRE COACH | 6311 ANTOINE DR | OT | 3,181' |
| EMPIRE COACH INC | 6311 ANTOINE | GE | 3,181' |
| EMPIRE COACH INC | 6311 ANTOINE DR | NR | 3,181' |
| EMPIRE COACHES INC | 6311 ANTOINE DR | FI | 3,181' |
| EMPIRE COACH INC | 6311 ANTOINE DR | FI | 3,181' |
| CARBON & ALLOY METALS INC | 6201 LUMBERDALE | US | 3,201' |
| BINGLE RD STORM SEWER AT HOUSTON, | | FE | 3,211' |
| SAFETY KLEEN CORP | 6307 ANTOINE | ER | 3,241' |
| DESOTO SHOPPING CENTER | 6307 ANTOINE | US | 3,241' |
| SAFETY KLEEN CORP | 6307 ANTOINE | HM | 3,241' |
| COTTMAN TRANSMISSIONS | 6305 ANTOINE | OT | 3,285' |
| A M CASTLE & CO | 6501 BINGLE RD | US | 3,542' |
| CASTLE A M & CO | 6501 BINGLE | LU | 3,542' |
| IN THE CALLER S YARD | 5426 WINDING WAY | ER | 3,650' |
| SCREEN GRAPHICS INC | 6450 BINGLE RD | GE | 3,753' |
| SCREEN GRAPHICS INC | 6450 BINGLE | NR | 3,753' |
| SCREEN GRAPHICS INC | 6450 BINGLE RD | FI | 3,753' |
| SCREEN GRAPHICS INC | 6450 BINGLE | FI | 3,753' |
| SCREEN GRAPHICS | 6450 BINGLE | OT | 3,753' |
| GOODYEAR TIRE CENTER | 8610 ANTOINE DR | US | 3,793' |
| MARMON KEYSTONE CORP | 6441 BINGLE RD | US | 3,824' |
| LJ-65-05-826 | | FE | 3,850' |
| | | PW | 3,865' |
| NEXTEL OF TEXAS INC | | TO | 3,875' |
| RAINBOW QUICK STOP | 8670 ANTOINE DR | US | 3,883' |
| RAINBOW QUICK STOP | 8670 ANTOINE DR | LU | 3,883' |
| RJ TRUCKING | 3207 HOLDER FOREST DRI | OT | 3,895' |

| | | | |
|---|---|---|---|
| | | PW | 3,907' |
| | | PW | 3,913' |
| CROWN CASTLE WEST AREA | 6308 DEIHL STREET | TO | 3,931' |
| CROWN CASTLE USA INC | | TO | 3,931' |
| CROWN CASTLE WEST AREA | | TO | 3,931' |
| GTE MOBILNET OF SOUTH TEXAS | | TO | 3,931' |
| LUBE KING | 6210 ANTOINE DR | US | 3,932' |
| VINES EC/PRE-K CENTER | 7220 INWOOD PARK DR | FI | 3,987' |
| LUCKY STOP & SAVE | 8795 ANTOINE DR | US | 4,009' |
| | | PW | 4,013' |
| GTE MOBILNET OF SOUTH TEXAS LP | | TO | 4,032' |
| | | PW | 4,037' |
| ATT WIRELESS PCS LLC | | TO | 4,055' |
| HARRIS ACADEMY | 3130 HOLDER FOREST DR | FI | 4,072' |
| | | PW | 4,097' |
| | 6923 ANTOINE | PW | 4,110' |
| LJ-65-05-813 | | FE | 4,168' |
| | | PW | 4,182' |
| | | PW | 4,187' |
| DIAMOND SHAMROCK 2627 | 3400 W LITTLE YORK | US | 4,191' |
| STOP N GO 2627 | 3400 W LITTLE YORK | LU | 4,191' |
| HANDI PLUS 40 | 3405 W LITTLE YORK | US | 4,229' |
| | 3006 JORENT DR. | PW | 4,288' |
| | | PW | 4,296' |
| | | PW | 4,355' |
| | 9601 WEST MONTGOMERY A | RL | 4,361' |
| A + TRANSMISSION SPECIALISTS | 9239 N HOUSTON ROSSLYN | US | 4,368' |
| LJ-65-05-729 | | FE | 4,369' |
| | | PW | 4,375' |
| | | PW | 4,380' |
| | | PW | 4,380' |
| DRESSER FLOW CONTROL TOM WHEATLEY OPERAT | 3131 W LITTLE YORK | OT | 4,402' |
| DRESSER INC | 3131 W LITTLE YORK | GE | 4,402' |
| TOM WHEATLEY VALVE CO | 3131 W LITTLE YORK RD | FI | 4,402' |
| DRESSER INC | 3131 W LITTLE YORK | FI | 4,402' |
| ALMEDA/PEARLAND WAREHOUSES, LTD. | 8421 INDUSTRIAL ROAD | VC | 4,459' |
| ALMEDA/PEARLAND WAREHOUSES, LTD. | 8421 INDUSTRIAL ROAD | IC | 4,459' |
| SUPERMERCADO GIGANTE 2 | 9436 N HOUSTON ROSSLYN | US | 4,507' |
| BUILDING SPECIALITIES | 6230 BINGLE RD | US | 4,511' |
| DRY CLEAN EXPRESS | 6002 ANTOINE DR STE M | OT | 4,512' |
| DRY CLEAN EXPRESS #304 | 6002-M ANTOINE | GE | 4,512' |
| DRY CLEAN EXPRESS #304 | 6002-M ANTOINE | FI | 4,512' |
| DRY CLEAN EXPRESS | 6002 ANTIONE DR STE M | FI | 4,512' |
| FRIENDLY MART 3 | 6002 ANTOINE DR | US | 4,512' |
| DRY CLEAN EXPRESS 304 | 6002 ANTIONE DR | OT | 4,512' |
| BELL CLEANERS | 7006 W GULFBANK | OT | 4,517' |
| BELL CLEANERS USA | 7006 W GULFBANK | GE | 4,517' |
| BELL CLEANERS | 7006 W GULFBANK | NR | 4,517' |
| BELL CLEANERS USA | 7006 W GULFBANK | FI | 4,517' |
| BELL CLEANERS | 7006 W GULFBANK | FI | 4,517' |
| | | PW | 4,522' |
| INTERNATIONAL PAINT INCORPORATED | 6001 ANTOINE DRIVE | DO | 4,535' |
| INTERNATIONAL PAINT LLC | 6001 ANTOINE DR | GE | 4,535' |
| COURTAULDS COATINGS INC | 6001 ANTOINE DR | FI | 4,535' |
| MATCOTE CO, INC | 6001 ANTOINE | FI | 4,535' |
| INTL PAINT CO INC | 6001 ANTOINE | FI | 4,535' |
| INTERNATIONAL PAINT INCORPORATED | 6001 ANTOINE DRIVE | FI | 4,535' |
| COURTAULDS COATINGS INC. | 6001 ANTOINE DR. | TR | 4,535' |
| INTERNATIONAL PAINT LLC | 6001 ANTOINE DR | TR | 4,535' |
| INTERNATIONAL PAINT | 6001 ANTOINE | US | 4,535' |
| FORMER COURTAULDS COATINGS | 6001 ANTOINE DR | LU | 4,535' |

| | | | |
|---|---|---|---|
| INTERNATIONAL PAINT | 6001 ANTOINE DR | OT | 4,535' |
| INTERNATIONAL PAINT, INC. | 6001 ANTOINE DRIVE | NC | 4,535' |
| FLEET TRANSPORT CO INC | 6001 ANTOINE | HM | 4,535' |
| INTL PAINT LLC | 6001 ANTOINE | FD | 4,535' |
| INTERNATIONAL PAINT | 6001 ANTOINE DR | FD | 4,535' |
| | | PW | 4,540' |
| LJ-65-05-737 | | FE | 4,540' |
| | | PW | 4,555' |
| CIRCLE K 2227 | 9822 N HOUSTON ROSSLYN | US | 4,572' |
| CITGO FOOD STORE | 6000 ANTOINE DR | US | 4,584' |
| DIAMOND SHAMROCK 575 | 6000 ANTOINE DR | LU | 4,584' |
| TEXACO STATION | 9875 N HOUSTON ROSSLY | GE | 4,619' |
| TEXACO STATION | 9875 N HOUSTON ROSSLY | NR | 4,619' |
| TEXACO STA | 9875 N HOUSTON ROSSLYN | FI | 4,619' |
| TEXACO STATION | 9875 N HOUSTON ROSSLYN | FI | 4,619' |
| TOOR TEXACO FOOD MART | 9875 N HOUSTON ROSSLYN | US | 4,619' |
| E-Z-7 | 9903 N HOUSTON ROSSLYN | US | 4,631' |
| BELL CLEANERS | 7006 W GULF BANK RD | OT | 4,635' |
| | 2819 JORENT | PW | 4,636' |
| CHEVRON FAC 157997 | 9435 HOUSTON ROSSLYN | OT | 4,676' |
| CHEVRON USA INC #157997 | 9435 HOUSTON ROSSLYN | GE | 4,676' |
| CHEVRON USA INC | 9435 HOUSTON ROSSLYN | NR | 4,676' |
| CHEVRON USA INC #157997 | 9435 HOUSTON ROSSLYN | FI | 4,676' |
| CHEVRON USA INC | 9435 HOUSTON ROSSLYN | FI | 4,676' |
| HANDI PLUS 4442 | 9435 N HOUSTON ROSSLYN | US | 4,676' |
| CHEVRON FAC 157997 | 9435 HOUSTON ROSSLYN | LU | 4,676' |
| | | PW | 4,702' |
| | CARNARVON DRIVE | PW | 4,737' |
| MIDWAY GROCERY | 9632 W MONTGOMERY | US | 4,739' |
| WEYERHAEUSER CO | 6800 PINE VISTA LN | US | 4,765' |
| | | PW | 4,862' |
| CRS POWER FLOW | 6989 W LITTLE YORK RD | OT | 4,872' |
| TUBESALES | 6161 BINGLE RD | US | 4,878' |
| | | PW | 4,881' |
| | | PW | 4,889' |
| | | PW | 4,891' |
| LJ-65-13-223 | | FE | 4,892' |
| | | PW | 4,895' |
| | | PW | 4,932' |
| | | PW | 4,954' |
| NEXTEL COMMUNICATIONS | | TO | 4,990' |
| BETHUNE ACAD | 2500 S VICTORY DR | FI | 4,990' |
| DRY CLEAN EXPRESS | 6002 ANTIONE DR STE M | NR | 5,011' |
| | 3131 WEST LITTLE YORK | PW | 5,052' |
| | 3131 WEST LITTLE YORK | PW | 5,052' |
| | 3131 WEST LITTLE YORK | PW | 5,052' |
| | 3131 WEST LITTLE YORK | PW | 5,052' |
| BLANK | | TO | 5,058' |
| KLEIN INTERMEDIATE SCHOOL | | FI | 5,086' |
| LJ-65-05-730 | | FE | 5,111' |
| LABATT FOODS FREEZER WAREHOUSE | 6650 PINE VISTA LN | US | 5,149' |
| | | PW | 5,155' |
| | | PW | 5,174' |
| | | PW | 5,174' |
| ERMEL ELEMENTARY SCHOOL | | FI | 5,181' |
| | 3131 WEST LITTLE YORK | PW | 5,189' |
| | 3131 WEST LITTLE YORK | PW | 5,189' |
| | | PW | 5,193' |
| | | PW | 5,193' |
| KLEIN INT | 4710 W MOUNT HOUSTON | FI | 5,211' |
| ERMEL EL | 7103 WOODSMAN TRL | FI | 5,219' |
| NITSCH ELEMENTARY SCHOOL | | FI | 5,222' |

| | | | |
|---|---|---|---|
| PERFECT USA DRY CLEAN | 9006 WEYBURN GROVE DR | OT | 5,225' |
| | 3131 WEST LITTLE YORK | PW | 5,234' |
| LJ-65-05-723 | | FE | 5,260' |
| | | PW | 5,268' |

Note: Results with distances of 0' are inside (or intersect) the project area.

Database:
AI - Current Emission Inventory Data (AIRS)
BF – TX BROWNFIELDS
CA – Corrective Action Report (CORRACTS)
CE – CERCLIS No Further Remedial Action Planned (CERCLIS-NFRAP)
CE – Comprehensive Environmental Response, Compensation, & Liability Information System (CERCLIS)
CG – GASIFICATION
DN – National Priority List Deletions (DELISTED NPL)
DO – Integrated Compliance Information System (ICIS)
ER – Emergency Response Notification System (ERNS)
FB/BF – Brownfield Management System (BMS - FED EC/IC)
FD – Section 7 Tracking Systems (SSTS)
FI – Facility Index System/Facility Identification Initiative Program Summary Report (FINDS)
GE – Resource Conservation and Recovery Information System (RCRIS-LQG)
GE – Resource Conservation and Recovery Information System (RCRIS-SQG)
HI – National Registry of Historic Places Database (HIST LANDMARKS)
HM – Hazardous Materials Information Reporting System (HMIRS)
IC – INSTITUTIONAL
LA – Department of Defense Sites (DOD)
LU – Leaking Petroleum Storage Tank Database (LUST)
N/A – Commercial Hazardous & Solid Waste Management Facilities (TX_COMMERCIAL)
N/A – Closed Landfill Inventory (CLI)
N/A – Records of Decision (RODS)
N/A – RCRA Administrative Action Tracking System (RAATS)
NC – FIFRA* / TSCA** Tracking System – FIFRA (FTTS)
NC – Toxic Substances Control Act (TSCA)
NL – National Priority List (NPL)
NP – National Pollution Discharge Elimination System (NPDES)
NR – RCRA-NLR
NU – Material Licensing Tracking System (MLTS)
OT – Industrial & Hazardous Waste Database (IHW 3)
PA – PCB Activity Database System (PADS)
PE – PERMITS
PR – Potentially Responsible Parties (SETS PRP)
PW – Public Water Supply Wells (STATE WELLS)
RL – Air and Surface Water Releases (RELEASES)
SP – Spills Database (TX_SPILL)
ST – State Equivalent to CERCLIS (STATE SITES)
SW – Texas Solid Waste Lanfills (SWL)
TO – FAA/FTC Towers (TOWERS)
TR – Toxic Chemical Release Inventory System (TRIS)
TS – Resource Conservation and Recovery Information System (RCRIS-TSDF)
VC – Voluntary Cleanup Program Database (VCP***)
US – Petroleum Storage Tank Database (AST)
US – Petroleum Storage Tank Database (UST)

** FIFRA – Federal Insecticide, Fungicide, Rodenticide Act*
*** TSCA – Toxic Substances Control Act*
**** Also known as VCP BROWNFIELDS*

The WEB Map hazardous materials locations data layer was last updated: 4/22/2009.

## Oil & Gas Wells

There are 10 oil & gas well locations located inside or within one mile of the proposed project area.

| Lease Name | Operator | Permit # | Distance |
|---|---|---|---|
| | | 0 | 0' |
| | | 0 | 827' |
| | | 0 | 1,373' |
| | | 0 | 1,871' |
| | | 0 | 2,104' |
| | | 0 | 3,376' |
| | | 0 | 3,743' |
| SETTEGAST HEIRS | KILROY COMPANY OF TEXAS, INC. | 182065 | 4,137' |
| | NORTH HOUSTON OPER. COMM. AGENTS | 0 | 4,728' |
| | | 0 | 4,983' |

Note: Results with distances of 0' are inside (or intersect) the project area.

The WEB Map oil & gas well locations data layer was last updated: 4/17/2009.

## Pipelines

There are 6 pipelines located inside or within one mile of the proposed project area.

| ID No. | Operator Name | Distance |
|---|---|---|
| 604720 | NETCO PIPELINE, L.L.C. | 0' |
| 463345 | KINDER MORGAN TEXAS PIPELINE LLC | 537' |
| 141061 | CENTERPOINT ENERGY INTRA P/L,INC | 1,670' |
| 85368 | BP PIPELINES (NORTH AMERICA),INC | 2,420' |
| 257129 | EXXONMOBIL PIPELINE COMPANY | 3,686' |
| 521318 | MAGELLAN PIPELINE COMPANY, L.P. | 3,718' |

Note: Results with distances of 0' are inside (or intersect) the project area.

The WEB Map pipeline data layer was last updated: 4/17/2009.

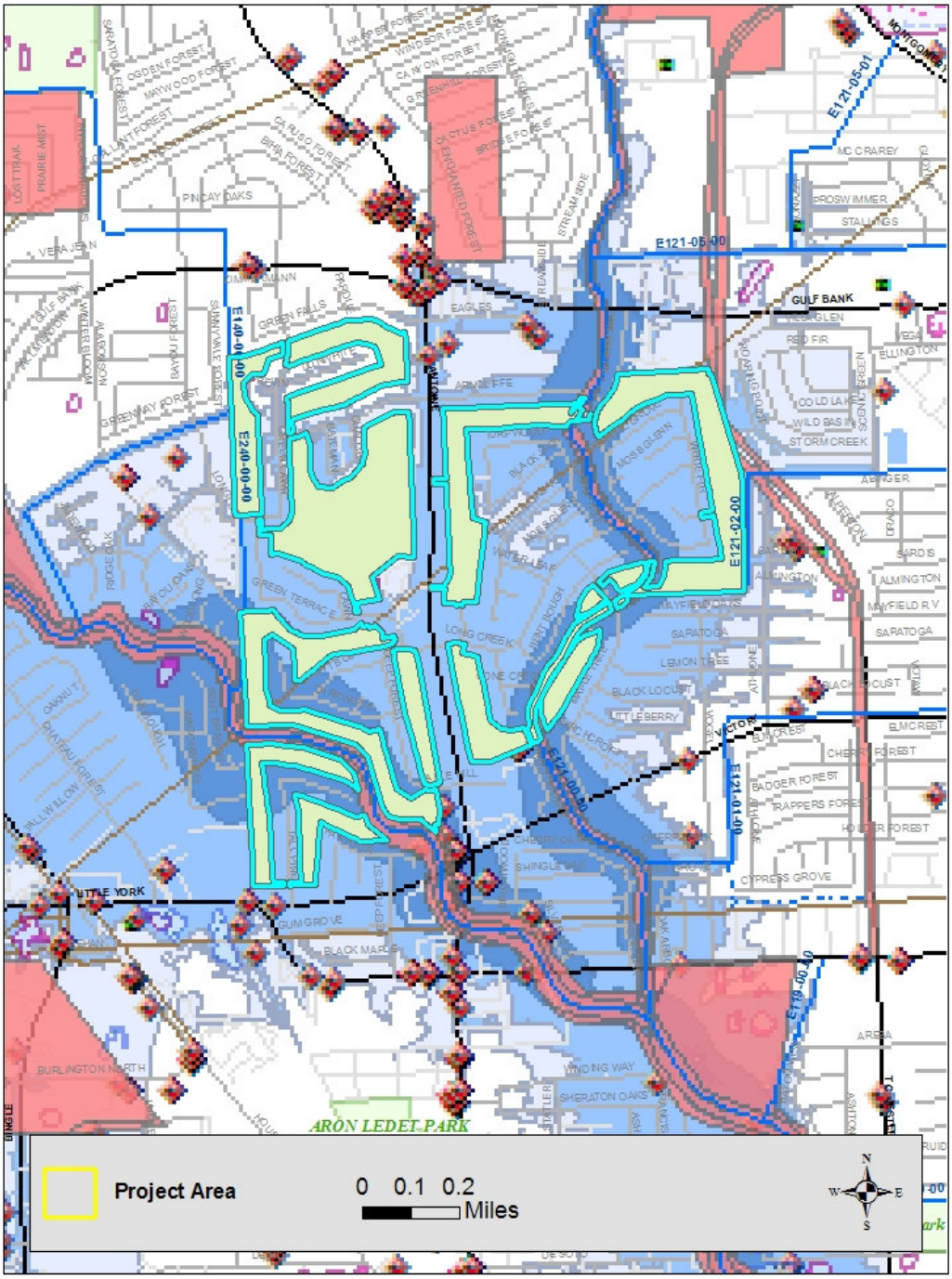
## Land Use

The project area is located within/encompasses the following land use type(s):

Residential

The WEB Map land use data layer was last updated: 11/1/2004.

**Inwood Forest Golf Club golf course**
**7/28/2009**



## MAP LEGEND

Watershed Boundary

**Stream Wildlife Habitat**

- High Potential for Wildlife Habitat
- Medium Potential for Wildlife Habitat
- Low Potential for Wildlife Habitat

**Water Quality**

- Stream Segments
- 303d Waterways

**Wetlands**

- Potential Wetlands
- NWI Wetlands

**Geologic Structures**

- Fault Line
- Growth Fault

**Floodplain - 2000**

- 500-Year-Floodplain
- 100-Year-Floodplain
- Floodway

**Vegetation Assemblages**

- Cropland
- Forested Wetland
- Hardwood Forest
- Hardwood-Pine Forest
- Non-Forested Wetland
- Other
- Pasture / Grassland
- Pine Forest
- Pine-Hardwood Forest
- Scrub-Shrub
- Tidal Marsh

- Threatened & Endangered Species
- Threatened & Endangered Species Areas
- Cultural Resource Surveys
- Hazardous Materials
- Oil & Gas Well Locations
- Oil & Gas Pipelines

**Land Use**

- Agriculture Land Use
- Commercial Land Use
- Industrial Land Use
- Institutional Land Use
- Mixed Use - Both Residential & Commercial Land Use
- Recreational Land Use
- Residential Land Use
- Undeveloped Land Use

**Geology**

- Alluvium
- Beaumont
- Deweyville
- Fill and Spoil
- Fluviatile Terrace Deposites - Undivided
- Lissie
- Tertiary Rocks on Hockley Salt Dome
- Willis Formation

# APPENDIX E

# Summary of Detention Storage for Recommended Alternative

| Detention Cell | Max Stage Allowable | 10% Flood Event Alternative 1 Storage | |
|---|---|---|---|
| | | Max. Stage | Max. Vol. |
| A (north) | 80.50 | | |
| A (south) | 79.50 | 74.65 | 58.33 |
| B | 78.00 | 74.55 | 10.76 |
| C | 78.00 | 74.59 | 232.51 |
| D | 78.00 | 74.91 | 184.17 |
| E | 78.00 | 74.65 | 50.44 |
| F | 77.35 | 73.15 | 10.14 |
| G | 78.39 | | |
| H | 76.00 | 71.05 | 24.14 |
| I | 77.50 | 71.68 | 119.74 |
| J (east) | 73.16 | | |
| J (west) | 73.13 | | |
| K | 76.00 | 69.55 | 9.28 |
| L | 75.50 | 71.05 | 50.51 |
| E500-06 | 72.39 | 62.32 | 69.19 |
| **Total** | | | **819.22** |

| Detention Cell | Max Stage Allowable | 4% Flood Event Alternative 1 Storage | |
|---|---|---|---|
| | | Max. Stage | Max. Vol. |
| A (north) | 80.50 | | |
| A (south) | 79.50 | 76.71 | 70.14 |
| B | 78.00 | 76.04 | 20.42 |
| C | 78.00 | 76.08 | 276.85 |
| D | 78.00 | 76.03 | 184.17 |
| E | 78.00 | 76.02 | 52.11 |
| F | 77.35 | 74.75 | 14.55 |
| G | 78.39 | | |
| H | 76.00 | 72.56 | 33.27 |
| I | 77.50 | 73.98 | 164.63 |
| J (east) | 73.16 | | |
| J (west) | 73.13 | | |
| K | 76.00 | 71.18 | 13.18 |
| L | 75.50 | 72.63 | 60.36 |
| E500-06 | 72.39 | 70.26 | 233.61 |
| **Total** | | | **1123.28** |

| Detention Cell | Max Stage Allowable | 1% Flood Event Alternative 1 Storage | |
|---|---|---|---|
| | | Max. Stage | Max. Vol. |
| A (north) | 80.50 | | |
| A (south) | 79.50 | 79.42 | 87.18 |
| B | 78.00 | 78.12 | 36.72 |
| C | 78.00 | 78.13 | 306.42 |
| D | 78.00 | 77.91 | 184.17 |
| E | 78.00 | 77.98 | 52.11 |
| F | 77.35 | 77.24 | 14.56 |
| G | 78.39 | | |
| H | 76.00 | 74.17 | 47.20 |
| I | 77.50 | 77.18 | 234.19 |
| J (east) | 73.16 | | |
| J (west) | 73.13 | | |
| K | 76.00 | 73.06 | 18.60 |
| L | 75.50 | 74.12 | 70.40 |
| E500-06 | 72.39 | 72.25 | 280.35 |
| **Total** | | | **1331.88** |

**E500-06 spillway is 300 feet at Elevation 68.00**

**Note:** E500-06 is included in the Pre-Project Conditions.

# APPENDIX F

# Hydraulic Benefits for Last-Added Analysis (E500-06)

## 10-Year Last-Added Analysis

| Station | Location | Flow (cfs) | | | W.S. Elev. | | |
|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Difference | Existing | Proposed | Difference |
| 61936 | D/S of E500-06 | 11,096 | 10,358 | -738 | 69.19 | 68.48 | -0.71 |
| 56811 | U/S Tidwell | 11,702 | 10,909 | -793 | 67.52 | 66.76 | -0.76 |
| 55757 | D/S of E117-00-00 | 14,674 | 13,831 | -843 | 66.15 | 65.50 | -0.65 |
| 46827 | D/S of E115-00-00 | 20,344 | 19,584 | -760 | 60.43 | 59.69 | -0.74 |
| 39419 | U/S Loop 610 | 20,530 | 19,774 | -756 | 54.13 | 53.64 | -0.49 |
| 17756 | U/S Heights | 22,607 | 21,823 | -784 | 35.28 | 34.71 | -0.57 |
| 6775 | D/S E101-00-00 | 29,636 | 28,779 | -857 | 30.68 | 30.31 | -0.37 |
| **Location of Maximum Hydraulic Benefit** | | | | | | | |
| *43420* | *TC Jester near 34th* | | | | *57.90* | *57.02* | *-0.88* |

## 25-Year Last-Added Analysis

| Station | Location | Flow (cfs) | | | W.S. Elev. | | |
|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Difference | Existing | Proposed | Difference |
| 61936 | D/S of E500-06 | 12,840 | 12,386 | -454 | 70.49 | 70.17 | -0.32 |
| 56811 | U/S Tidwell | 13,584 | 12,982 | -602 | 68.78 | 68.46 | -0.32 |
| 55757 | D/S of E117-00-00 | 17,388 | 16,691 | -697 | 67.20 | 66.93 | -0.27 |
| 46827 | D/S of E115-00-00 | 23,811 | 23,104 | -707 | 62.96 | 62.48 | -0.48 |
| 39419 | U/S Loop 610 | 24,008 | 23,311 | -697 | 56.09 | 55.74 | -0.35 |
| 17756 | U/S Heights | 26,173 | 25,503 | -670 | 38.54 | 38.07 | -0.47 |
| 6775 | D/S E101-00-00 | 33,672 | 32,919 | -753 | 33.54 | 33.23 | -0.31 |
| **Location of Maximum Hydraulic Benefit** | | | | | | | |
| *70347* | *Site* | | | | *77.50* | *76.76* | *-0.74* |

## 100-Year Last-Added Analysis

| Station | Location | Flow (cfs) | | | W.S. Elev. | | |
|---|---|---|---|---|---|---|---|
| | | Existing | Proposed | Difference | Existing | Proposed | Difference |
| 61936 | D/S of E500-06 | 15,665 | 15,756 | 91 | 72.21 | 72.09 | -0.12 |
| 56811 | U/S Tidwell | 16,305 | 16,082 | -223 | 70.69 | 70.47 | -0.22 |
| 55757 | D/S of E117-00-00 | 20,773 | 20,263 | -510 | 69.39 | 69.05 | -0.34 |
| 46827 | D/S of E115-00-00 | 27,548 | 26,793 | -755 | 65.90 | 65.59 | -0.31 |
| 39419 | U/S Loop 610 | 27,521 | 26,821 | -700 | 58.92 | 58.49 | -0.43 |
| 17756 | U/S Heights | 28,980 | 28,599 | -381 | 40.73 | 40.52 | -0.21 |
| 6775 | D/S E101-00-00 | 37,558 | 37,279 | -279 | 36.00 | 35.92 | -0.08 |
| **Location of Maximum Hydraulic Benefit** | | | | | | | |
| *70239.59* | *Site* | | | | *78.62* | *78.03* | *-0.59* |

# Summary of Detention Storage for "Last-Added" Analysis

| Detention Cell | Max Stage Allowable | 10% Flood Event Alternative 1 Storage | |
|---|---|---|---|
| | | Max. Stage | Max. Vol. |
| A (north) | 80.50 | | |
| A (south) | 79.50 | 74.65 | 58.33 |
| B | 78.00 | 74.55 | 10.76 |
| C | 78.00 | 74.59 | 232.51 |
| D | 78.00 | 74.90 | 184.17 |
| E | 78.00 | 74.65 | 50.44 |
| F | 77.35 | 73.15 | 10.14 |
| G | 78.39 | | |
| H | 76.00 | 71.01 | 23.94 |
| I | 77.50 | 71.59 | 118.06 |
| J (east) | 73.16 | | |
| J (west) | 73.13 | | |
| K | 76.00 | 69.57 | 9.32 |
| L | 75.50 | 71.00 | 50.21 |
| E500-06 | 72.39 | 68.68 | 198.36 |
| **Total** | | | **946.24** |

| Detention Cell | Max Stage Allowable | 4% Flood Event Alternative 1 Storage | |
|---|---|---|---|
| | | Max. Stage | Max. Vol. |
| A (north) | 80.50 | | |
| A (south) | 79.50 | 76.73 | 70.26 |
| B | 78.00 | 76.06 | 20.56 |
| C | 78.00 | 76.09 | 277.16 |
| D | 78.00 | 76.04 | 184.17 |
| E | 78.00 | 76.04 | 52.11 |
| F | 77.35 | 74.78 | 14.55 |
| G | 78.39 | | |
| H | 76.00 | 72.68 | 34.18 |
| I | 77.50 | 74.00 | 165.03 |
| J (east) | 73.16 | | |
| J (west) | 73.13 | | |
| K | 76.00 | 71.29 | 13.47 |
| L | 75.50 | 72.79 | 61.40 |
| E500-06 | 72.39 | 70.37 | 236.13 |
| **Total** | | | **1129.04** |

| Detention Cell | Max Stage Allowable | 1% Flood Event Alternative 1 Storage | |
|---|---|---|---|
| | | Max. Stage | Max. Vol. |
| A (north) | 80.50 | | |
| A (south) | 79.50 | 79.42 | 87.18 |
| B | 78.00 | 78.12 | 36.72 |
| C | 78.00 | 78.13 | 306.42 |
| D | 78.00 | 77.91 | 184.17 |
| E | 78.00 | 77.98 | 52.11 |
| F | 77.35 | 77.24 | 14.56 |
| G | 78.39 | | |
| H | 76.00 | 74.19 | 47.39 |
| I | 77.50 | 77.19 | 234.42 |
| J (east) | 73.16 | | |
| J (west) | 73.13 | | |
| K | 76.00 | 73.08 | 18.66 |
| L | 75.50 | 74.17 | 70.75 |
| E500-06 | 72.39 | 72.27 | 280.84 |
| **Total** | | | **1333.21** |

**E500-06 spillway is 200 feet at Elevation 62.25**

## Benefit Analysis for Last-Added Alternative (Current E500-06 Configuration)

| Condition | Volume of Storage (ac-ft) | No. of Structures Inundated | Damages | Benefit (No. of Structures No Longer in Floodplain) | Benefit (Reduced Damages) |
|---|---|---|---|---|---|
| **10% (10-Year) Event** | | | | | |
| *Pre-Project* | | 302 | $ 8,516,701 | | |
| *Last-Added Alternative* | 946 | 284 | $ 7,844,430 | 18 | $ 672,271 |
| **4% (25-Year) Event** | | | | | |
| *Pre-Project* | | 1177 | $ 37,404,143 | | |
| *Last-Added Alternative* | 1129 | 1049 | $ 32,122,830 | 128 | $ 5,281,313 |
| **1% (100-Year) Event** | | | | | |
| *Pre-Project* | | 7322 | $ 256,660,166 | | |
| *Last-Added Alternative* | 1333 | 6954 | $ 234,509,832 | 368 | $ 22,150,334 |

| Incremental Benefit of E500-06 Modification | |
|---|---|
| **Structures** | **Damages** |
| **10% (10-Year) Event** | |
| | |
| 0 | $ (168,054.02) |
| **4% (25-Year) Event** | |
| | |
| 10 | $ 688,176.42 |
| **1% (100-Year) Event** | |
| | |
| 17 | $ 1,537,158.39 |

| | | |
|---|---|---|
| **Cost (excluding land acquisition and demolition of clubhouse)** | | **$ 19,597,102** |