Memorandum

DRAFT

To: Andy Yung, P.E. CFM; Lane Lease, P.E., CFM

CC: 

Subject: Rice University Floodplain Analysis for Letter of Map Revision (LOMR)

From: Jacob Torres, P.E.; Nick Fang, Ph.D., P.E.

Date: June 29, 2013

1. Introduction

The purpose of this technical memorandum is to concisely summarize the hydrologic and hydraulic analyses performed in support of a request to the Federal Emergency Management Agency (FEMA) for a Letter of Map Revision (LOMR) for the campus of Rice University, Houston, Texas, herein referred to as “Rice.”

1.1 Terminology

The use of the term “effective” is defined in this memorandum as the presently accepted FEMA hydrologic and hydraulic models and floodplain maps representing the existing conditions for Rice. The new models are referred to as “proposed effective,” because it is proposed in this analysis that they be accepted as representing existing conditions and substituted for the presently accepted “effective” models.

1.2. Background

At the request of Rice University Facilities Engineering and Planning, the Severe Storm Prediction Education and Evacuation from Disasters (SSPEED) Center at Rice, in conjunction with Water P. Moore and Associate, Inc., performed a hydrologic and hydraulic analysis in response to recent storm sewer upgrades along a major trunk line at Kirby Drive, located just west of Rice. The effective FEMA floodplain for Rice is depicted in the Flood Insurance Rate Map (FIRM), Panel ID – 0860L, for Harris County as provided in Attachment 1.

The effective FEMA models were adopted as the starting models for developing the proposed effective models and floodplain for Rice. The effective models were downloaded from the Harris County Model and Map Management (M3) System website (Harris county Flood Control District 2013).

2. Site Description

Rice University is located in Houston, Texas southwest of Downtown and is contained within the Harris Gully Watershed (D109-00-00), with an area of approximately 5 square miles. Harris Gully is a sub-watershed of the Brays Bayou Watershed (D100-00-00), which has an area of about 129 square miles.

The Harris Gully Watershed exists as an integrated dendritic network of storm sewers, varying in type and size, starting north of U.S. 59 and culminating with an outfall of dual 15 feet by 15 feet box culverts at the Brays Bayou confluence. The Harris Gully storm sewer network is illustrated in Figure 1. The landuse within the Harris Gully Watershed consists of commercial, residential, and
open green space, with major institutional and landmark features like Rice University, the Texas Medical Center (TMC), and Hermann Park.

Storm sewer improvements within the Harris Gully Watershed have been implemented in recent years. These improvements were analyzed in detail in the *Harris Gully Drainage Report, Volume 1* (City of Houston 2002), and included three storm sewer relief alternatives that have since been constructed.

Alternative 1 entailed storm sewer upgrades to the storm sewer trunk line along Kirby Drive, culminating with dual 12 feet by 12 feet box culverts south of Holcombe Road, just before outfalling into Brays Bayou. Alternative 2 included a 114-inch pipe along Fannin Street, with a tie-in connection at Sunset Boulevard, and a 12 feet by 10 feet box culvert along Hermann Drive. Alternative 3 included a 144-inch pipe along Cambridge Street and South MacGregor Way, with a Main Street tie-in connection.

Prior to construction of Alternative 1, the Kirby Road drainage area (i.e. TSARP Subbasin D109-01) constituted a substantial quantity of the contributing runoff into the main stem of Harris Gully through Rice and the TMC, as depicted in Attachment 2. Therefore, the Kirby storm sewer improvements have provided significant reductions in water surface elevation and floodplain area. This is the basis for proposing updates to the effective FEMA models.

![Figure 1. Existing Storm Sewer System for Harris Gully and Ongoing Projects](Source: Bedient et al. 2007)
3. Hydrology and Hydraulics

HEC-HMS Version 3.3 was utilized in this analysis. Version 3.3 was chosen because it is consistent with the version used to create the effective model. The hydrologic methodology adopted in the proposed effective model remained relatively consistent with the effective model, i.e. the use of Green and Ampt Infiltration, Clark Unit Hydrograph transform method, and Modified Puls for channel routing. The synthetic rainfalls were also the same in both effective and proposed effective models. However, the biggest change to the effective Harris Gully Watershed drainage system was a flow diversion for the Kirby Drive drainage area (Subbasin ID –D109-01), and the re-direction of flow away from Harris Gully towards Brays Bayou. This was a substantial improvement because Subbasin D109-01 accounts for approximately 1.7 square miles, or 34%, of the entire Harris Gully watershed, as depicted in Attachment 2. The effective HEC-HMS model was updated to reflect this change, and a comparison of the effective and proposed effective peak runoff calculations are provided in Table 1. Attachments 3 and 4 illustrate the full hydrograph comparisons upstream and downstream of Rice Campus.

In regards to the 1% Annual Exceedance Probability (AEP), a maximum peak flow reduction of 45% was computed at the upstream side of Rice near the football stadium. A minimum peak flow reduction of 13% was computed at the Harris Gully Outfall with Brays Bayou. A total of 1,106 acre-feet of runoff volume is reduced from the headwaters at Harris Gully. The remaining storm events (i.e. 10%, 2%, and 0.2%) and their peak flow reductions are summarized in Table 1. Overall, due to the significant reduction in contributing drainage area, significant runoff reductions were computed for all storm events through Harris Gully.

<table>
<thead>
<tr>
<th>HEC-HMS Element ID</th>
<th>Location Description</th>
<th>Plan</th>
<th>10% (cfs)</th>
<th>2% (cfs)</th>
<th>1% (cfs)</th>
<th>0.2% (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1090000_9904_J</td>
<td>Upstream of Rice Campus near Stadium</td>
<td>Effective</td>
<td>756</td>
<td>1,256</td>
<td>1,540</td>
<td>2,432</td>
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<td></td>
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<td>Proposed Effective</td>
<td>449</td>
<td>702</td>
<td>843</td>
<td>1,263</td>
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<tr>
<td></td>
<td></td>
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<td>48%</td>
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<tr>
<td>D1090000_9903_J</td>
<td>Downstream of Rice Campus near Main Street</td>
<td>Effective</td>
<td>1,299</td>
<td>2,010</td>
<td>2,407</td>
<td>3,583</td>
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<td>998</td>
<td>1,474</td>
<td>1,731</td>
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<td>23%</td>
<td>27%</td>
<td>28%</td>
<td>31%</td>
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<tr>
<td>D1090000_9902_J</td>
<td>Near Texas Medical Center at Fannin Street</td>
<td>Effective</td>
<td>2,108</td>
<td>3,124</td>
<td>3,689</td>
<td>5,291</td>
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<td>Proposed Effective</td>
<td>1,796</td>
<td>2,566</td>
<td>2,988</td>
<td>4,140</td>
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<td></td>
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<td>18%</td>
<td>19%</td>
<td>22%</td>
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<tr>
<td>D1090000_9901_J</td>
<td>at Texas Medical Center</td>
<td>Effective</td>
<td>2,251</td>
<td>3,342</td>
<td>3,667</td>
<td>4,164</td>
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<td>1,951</td>
<td>2,788</td>
<td>3,240</td>
<td>3,884</td>
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<td></td>
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<td>% Reduction</td>
<td>14%</td>
<td>17%</td>
<td>12%</td>
<td>7%</td>
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<tr>
<td>D1090000_0001_J</td>
<td>at Harris Gully outfall</td>
<td>Effective</td>
<td>2,451</td>
<td>3,615</td>
<td>4,066</td>
<td>5,990</td>
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<td></td>
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<td>Proposed Effective</td>
<td>2,141</td>
<td>3,061</td>
<td>3,555</td>
<td>4,786</td>
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<td>% Reduction</td>
<td>13%</td>
<td>15%</td>
<td>13%</td>
<td>20%</td>
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HEC-RAS 3.0.1 was utilized in this analysis because it is consistent with the version used to create the effective model. In short, flow change locations in the effective HEC-RAS model were updated to reflect the corresponding junction locations in the HEC-HMS model. Water surface profiles were computed for each storm event and the resulting reductions in water surface elevations (WSEL) along Harris Gully are summarized in Table 2.

In regards to the 1% AEP, a maximum WSEL reduction of 11% was computed at cross-section 7149.378 near Rice stadium. A minimum WSEL reduction of 3% was computed at cross-section 321.835 near the Harris Gully Outfall with Brays Bayou. The remaining storm events (i.e. 10%, 2%, and 0.2%) and their WSEL reductions are summarized in Table 2. Overall, it is of no surprise that the WSEL reductions are significant because of the major reductions in peak flows entering Harris Gully. Figure 2 shows a plot of all four water surface profiles along the Harris Gully main stem. Attachments 5 through 8 provide similar plots but for individual storm events such that changes in water surface reductions can be easily distinguished.

4. Mitigation of Adverse Impacts

The Harris Gully Drainage Report, Volume 1 (City of Houston 2002) states that the implementation of the Kirby Drive relief results in a slight hydraulic impact to Brays Bayou. This report investigated several mitigation measures to determine the most reasonable means of eliminating these impacts. The report recommended location options for constructing a detention basin. For this reason, the Harris County Flood Control District (HCFCD) construction detention basin D500-08-00 at the south west corner of IH-610 as shown in Figure 3. Because of this effort, it was assumed that no further mitigation analysis of adverse impacts was necessary for updating the effective FEMA models.

Table 2. Effective and Proposed Effective WSEL Reductions at Select Locations along Harris Gully resulting from Kirby Drive Stormsewer Diversion

<table>
<thead>
<tr>
<th>HEC-RAS Cross Section</th>
<th>Location Description</th>
<th>Plan</th>
<th>10% (ft)</th>
<th>2% (ft)</th>
<th>1% (ft)</th>
<th>0.2% (ft)</th>
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<tr>
<td>7149.378</td>
<td>Upstream of Rice Campus near Stadium</td>
<td>Effective</td>
<td>36.33</td>
<td>41.42</td>
<td>46.21</td>
<td>47.2</td>
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<tr>
<td></td>
<td></td>
<td>Proposed Effective</td>
<td>35.16</td>
<td>38.46</td>
<td>41.09</td>
<td>46.49</td>
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<tr>
<td></td>
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<td>% Reduction</td>
<td>3%</td>
<td>7%</td>
<td>11%</td>
<td>2%</td>
</tr>
<tr>
<td>4441.798</td>
<td>Downstream of Rice Campus near Main Street</td>
<td>Effective</td>
<td>36.16</td>
<td>40.93</td>
<td>44.26</td>
<td>46.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proposed Effective</td>
<td>34.93</td>
<td>38.09</td>
<td>40.53</td>
<td>45.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% Reduction</td>
<td>3%</td>
<td>7%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>2954.708</td>
<td>Near Texas Medical Center at Fannin Street</td>
<td>Effective</td>
<td>35.32</td>
<td>39.3</td>
<td>42.46</td>
<td>44.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proposed Effective</td>
<td>34.07</td>
<td>36.99</td>
<td>39.06</td>
<td>43.02</td>
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<td></td>
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<td>% Reduction</td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>976.751</td>
<td>at Texas Medical Center</td>
<td>Effective</td>
<td>34.67</td>
<td>38.09</td>
<td>39.44</td>
<td>42.31</td>
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<td>Proposed Effective</td>
<td>33.58</td>
<td>36.4</td>
<td>37.96</td>
<td>39.01</td>
</tr>
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<td></td>
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<td>4%</td>
<td>8%</td>
</tr>
<tr>
<td>321.835</td>
<td>at Harris Gully outfall</td>
<td>Effective</td>
<td>34.37</td>
<td>37.56</td>
<td>38.7</td>
<td>41.7</td>
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<td></td>
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<td>Proposed Effective</td>
<td>33.29</td>
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<td>37.83</td>
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<td></td>
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<td>% Reduction</td>
<td>3%</td>
<td>4%</td>
<td>3%</td>
<td>9%</td>
</tr>
</tbody>
</table>
Figure 2. Harris Gully Water Surface Profiles

![Water Surface Profiles by AEP along Harris Gully at Rice for Effective and Proposed Effective Floodplains](image)

Figure 3. Constructed Detention Basin for Mitigating Adverse Impacts from Kirby Drive Stormsewer Relief (source: Google Earth)

![constructed detention basin image](image)

Brays Bayou
Downstream
HCFCD Basin ID: D500-08-00
5. Floodplain mapping

Floodplain mapping was achieved using HEC-GeoRAS and raster processing in ArcGIS version 10.1. A preliminary floodplain map was generated for the 1% AEP at Rice. Attachment 9 shows an overlapping comparison of the effective and proposed effective floodplains. The reduction in floodplain extent is quite significant. It is evident that the Kirby Drive storm sewer diversion provides much flood relief to Rice campus for the 1% AEP, and consequently reduces the Rice floodplain, leaving only small pockets of 1% AEP inundation at the downstream ends of Rice. Further work is needed to post-process the calculated floodplain raster and refine the proposed effective floodplain. It is not surprising that a 34% reduction in contributing drainage area can lead to significant flood control benefits for the Rice campus.

6. Conclusions

A new hydrologic and hydraulic analysis was performed in accordance with standard engineering practice. Preliminary results indicate a maximum peak runoff reduction of 45% for Harris Gully at the Rice campus and a maximum water surface elevation reduction of 11%. It is recommended that, following secondary review of this analysis, the design flows developed in this study be adopted for the proposed effective hydrologic and hydraulic models.

7. References


Harris County Flood Control District. 2013. http://www.hcfcd.org/m3/


8. Attachments:

1. Effective FEMA FIRM for Panel ID – 0860L
2. Effective Kirby Drive Drainage Area
3. FEMA Effective and Proposed Effective Hydrographs Upstream of Rice near Stadium
4. FEMA Effective and Proposed Effective Hydrographs Downstream of Rice near Main Street
5. 0.2% Annual Exceedance Probability Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains
6. 1% Annual Exceedance Probability Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains
7. 2% Annual Exceedance Probability Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains
8. 10% Annual Exceedance Probability Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains
9. Comparison of Effective and Proposed Effective 1% AEP Floodplain at Rice
FEMA Effective and Proposed Effective Hydrographs
Upstream of Rice near Stadium
FEMA Effective and Proposed Effective Hydrographs
Downstream of Rice near Main Street
0.2% Annual Exceedance Probability
Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains

(Draft)
Attachment 5

0.2 % - Effective
0.2 % - Proposed
Channel Invert

Water Surface Elevation (ft)
Station (ft)
(← Downstream Towards Brays Bayou)
1% Annual Exceedance Probability
Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains

Water Surface Elevation (ft)

Station (ft)
(← Downstream Towards Brays Bayou)
2% Annual Exceedance Probability
Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains

Water Surface Elevation (ft)

Station (ft)
(← Downstream Towards Brays Bayou)
10% Annual Exceedance Probability
Water Surface Profiles along Harris Gully for Effective and Proposed Effective FEMA Floodplains

(← Downstream towards Brays Bayou)