# LID 7

## Infrastructure Assessment
## During Hurricane Harvey
## Aug 25 – Sep 1, 2017


**V 1.12**

**Apr 25, 2018**

**Change Record**

| Date | Author | Version | Change Reference |
|---|---|---|---|
| 5-Sep-2017 | Jim Grotte | 1.0 | 1st draft |
| 7-Sep-2017 | Jim Grotte | 1.1 | Add rainfall totals (MP diagram) |
| 19-Sep-2017 | Jim Grotte | 1.2 | Commercial tract Brazos high water mark, RR track ballast. |
| 25-Sep-2017 | Jim Grotte | 1.3 | Brazos NW migration path to LID7 |
| 2-Oct-2017 | Jim Grotte | 1.4 | LIDAR |
| 13-Oct-2017 | Jim Grotte | 1.5 | Lakewind section (KA LW photos)<br>Optional detention, Storm sewer maps, Elevation X-ref |
| 27-Oct-2017 | Jim Grotte | 1.6 | Cumulative rainfall after PS gate closure. (J Hanig diagram section 1) |
| 16-Nov-2017 | Jim Grotte | 1.7 | 100 year events & Proposed Improvement Plan |
| 5-Dec-2017 | Jim Grotte | 1.8 | Pump Capacity & Rainfall (Sec 11)<br>RR track elevations |
| 10-Jan-2018 | Jim Grotte | 1.9 | GWL diagrams (Sec 5) |
| 5-Feb-2018 | Jim Grotte | 1.10 | NW RR track elevations |
| 3-Apr-2018 | Jim Grotte | 1.11 | Freeboard elevations (CP & NE) |
| 25-Apr-2018 | Jim Grotte | 1.12 | Updated North Levee & RR track map |

**Contributors**

| Date | Name | Version | Position |
|---|---|---|---|
| 6-Sep-2017 | Michael Pincomb | 1.1 | Crescent Ridge resident / Pres. NTRCA |
| 10-Oct-2017 | Khan Akmal | 1.5 | Greystone Place Resident |
| 27-Oct-2017 | Jeff Hanig | 1.6 | Greystone Place Resident |

# Table of Contents


1 OVERVIEW ..... 4
1.1 Timeline of Events ..... 4
1.2 Rainfall Totals ..... 5
1.3 100 Year Events ..... 6
1.4 Historical Brazos River Flood Levels (at Richmond Gauge) ..... 7
1.5 Brazos River Reservoirs ..... 8
2 NORTHERN BOUNDARY ..... 9
2.1 NE - Bull Head Slough at Montessori School ..... 9
2.2 90A / 99 Intersection ..... 14
2.3 NW – High Meadows ..... 20
2.4 Brazos Overflow Migration Path ..... 23
3 RAILROAD TRACK ..... 26
4 WEST SIDE ..... 27
4.1 Pump Station ..... 27
4.2 Chapel Bend / Crescent Ridge / Laurel Crest ..... 30
4.3 High Meadows / Autumn Ridge ..... 32
4.4 River Glen & Apartments ..... 33
5 EAST SIDE ..... 34
5.1 Greystone Place & Water Mill ..... 34
5.2 Lakewind ..... 39
6 SOUTH & WEST LEVEES ..... 43
7 ADDITIONAL DETENTION ..... 44
7.1 Convert Baseball Field (w optional new Pump Station) ..... 44
8 PUMP STATION CAPACITY, DETENTION & RAINFALL ..... 45
8.1 Detention & Portable Pump Impact on Ellis Creek ..... 45
8.2 Pump Station Capacity & Rainfall ..... 46
9 STAVINOHA BRIDGE ..... 47
10 LID 7 MAPS ..... 48
10.1 Levees (Actual & Proposed) ..... 48
10.2 Railroad Track Elevation ..... 49
10.3 Drainage ..... 50
10.4 LIDAR Full Ft. Bend County ..... 51
10.5 LIDAR LID 7 ..... 52
10.6 New Territory Storm Sewers (East) ..... 53
10.7 New Territory Storm Sewers (West) ..... 54
11 ELEVATION CROSS-REFERENCE ..... 55
11.1 Brazos River ..... 55
11.2 Rain Water ..... 55
12 INTERNAL FLOOD CONTROL ..... 56

# 1 Overview

This document describes first hand observations made in and around LID 7 during hurricane Harvey. LID 7 is comprised mostly of the New Territory community. Conclusions and recommendations have been drawn from these observations.

## 1.1 Timeline of Events

Aug 25-27 (F-Sun)

- Hurricane Harvey made landfall along the middle Texas coast near Rockport Aug 25.
- Harvey generally spared LID7 during its first few days, as Sugar Land fell between hurricane bands rotating through the Houston area.
- LID 7 also benefited from the Brazos river running at minimal levels prior to the storm.
- Richmond gauge river height projections were raised to 59.0 ft. Sunday (with an extended duration.)
- Mandatory evaluation was ordered Sunday (8-27) evening based on this prediction.



Aug 28-30 (M-W)

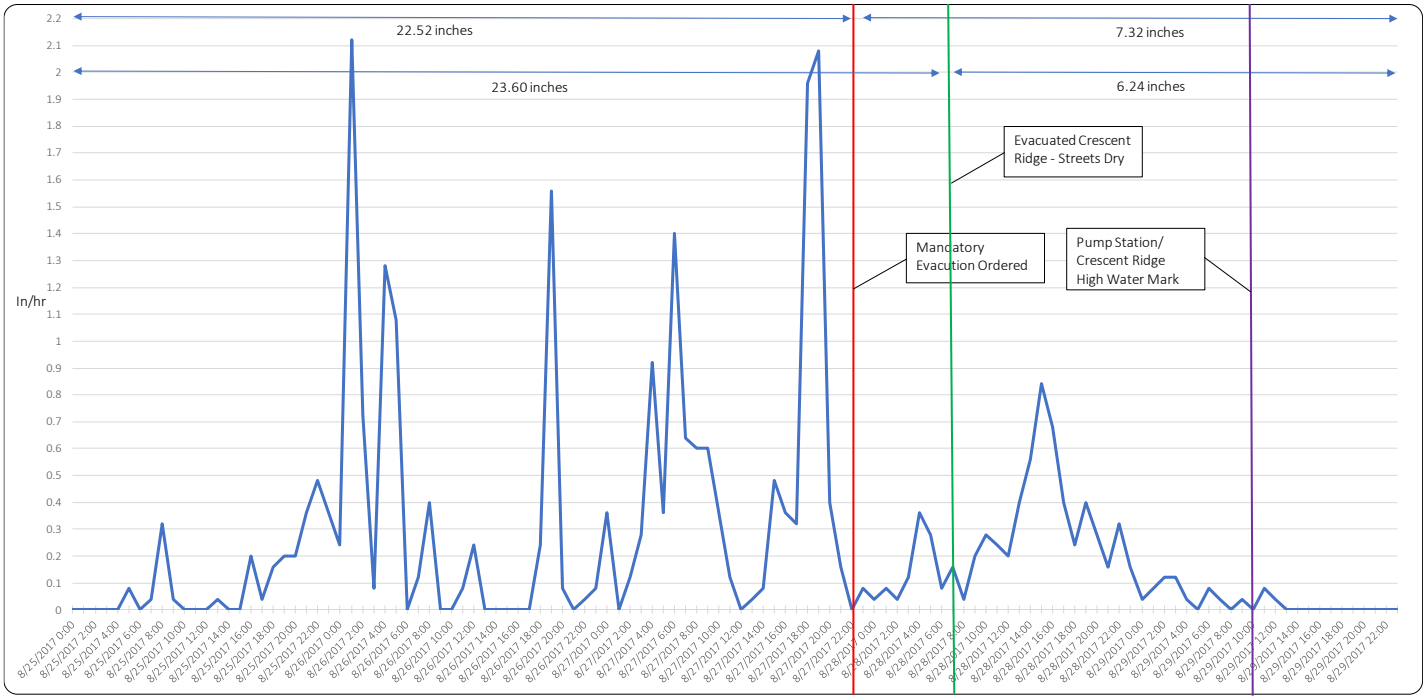
- Harvey dropped approximately 30 in. of rainfall on LID 7. Readings range from 30 in. on the Jodie Stavinoha bridge to 34 in. on the electronic gauge of a resident. The Costello engineers considers 30 in. to be the most likely.
- LID 7 was again fortunate as areas near Baytown and Dickenson records 52 in of rainfall.
- Harvey reentered the Gulf and made its third landfall near Cameron LA on Wed (8-30).
- Earlier predications had Harvey making its third landfall directly over Houston.

Aug 31 – Sep 2 (Th-Sat)

- Brazos river peaked at 55.2 ft. Thursday 8-31-17.
- Evacuation status lower to “voluntary” Saturday 9-2.

## 1.2 Rainfall Totals

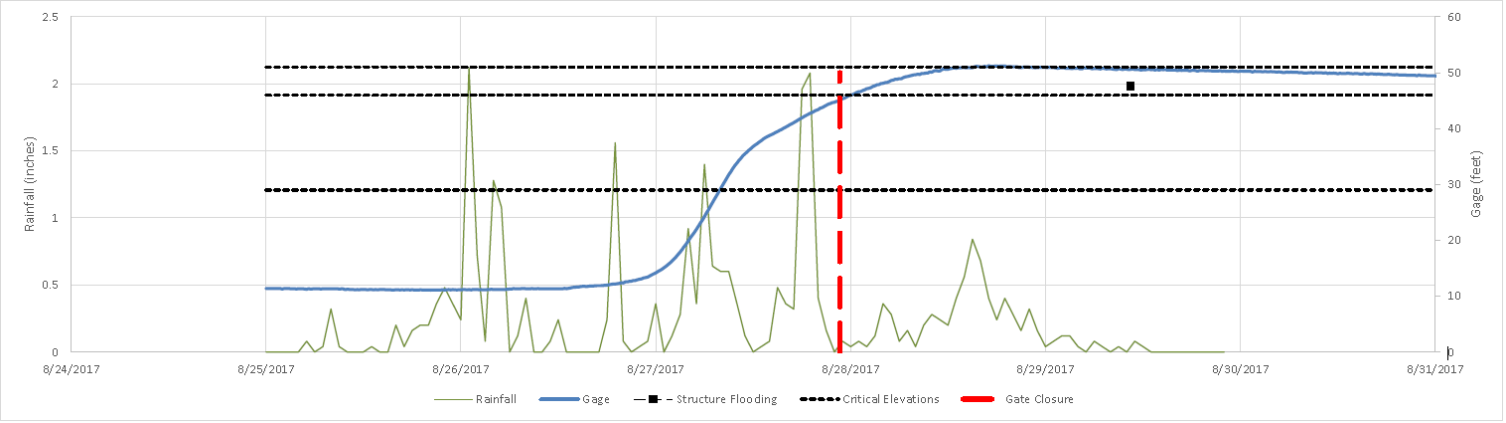
The following graph is based on rain amounts as measured by TxDOTs weather gauge on the Jodie Stavinoha Bridge.



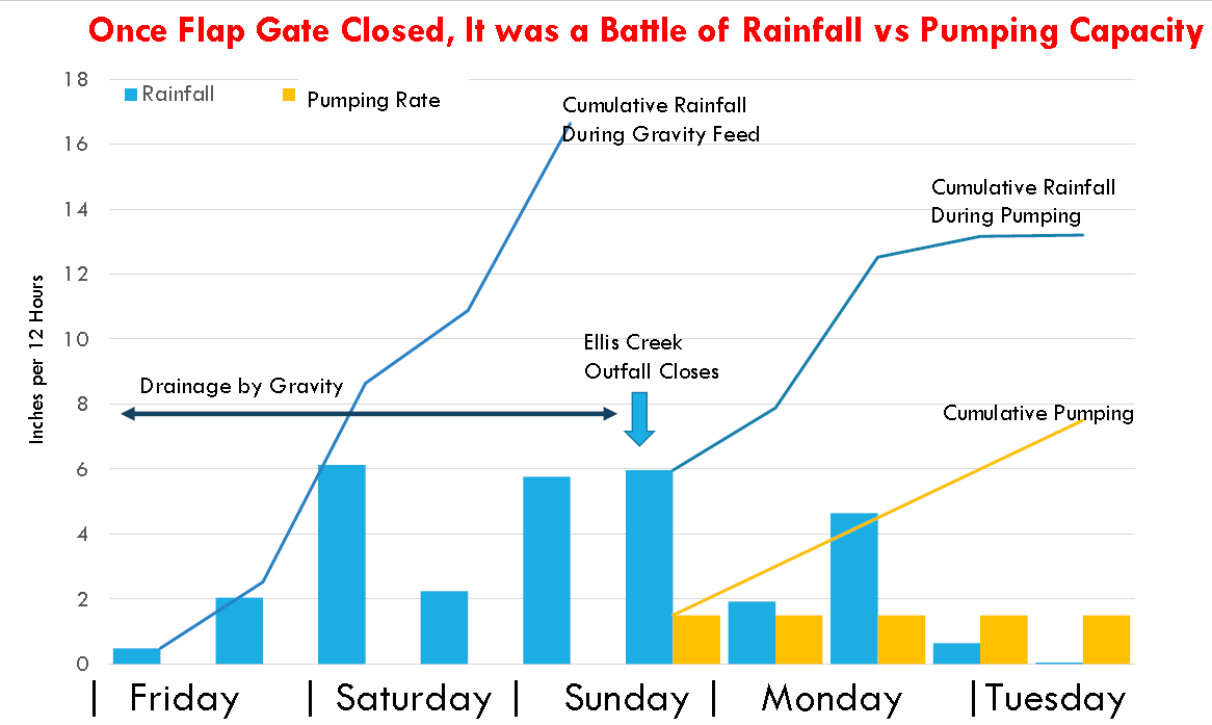

- Red line – mandatory evacuation ordered.
- Green line - Crescent Ridge resident observes the entrance and intersection as being dry.
- Purple line - high water mark as observed 28 hours later. (See photos in section 3.2)

While additional rain did fall over this timeperiod, the observations strongly suggest the high water was a result of Ellis Creek backing up into the Crescent Ridge neighborhood.

**Costello Diagram**



While a cumulative total of between 30-34 in of rain fell. Flooding within LID 7 was a result of 14 in (or possibly 20 in) of rain which fell after the Brazos river closed the pump stations flap gates.




## 1.3 100 Year Events

These are the Ft. Bend Country (FBC) criteria for 100-year event criteria:

**100 Rain Event**

12.5 in. of rain over 24 hrs where there is 0 in. of rain prior to and after the event.

**100 Flood Event**

56 ft reading at the Richmond Gauge (RG).

Rain Events

Heavy rains within LID 7 are normally not a flood concern so long as the Ellis Creek flap gates to the external channel remain open. These flap gates will only close when the Brazos river reaches 37 ft (RG).
At this height, the flap gates automatically close due to the weight of the river water against the gates.

Open flap gates allow for a flow of approximately 800,000 GPM. This compares to the 88,000 GPM combined capacity of the four pumps used when the gates are closed.

Hurricane Harvey (HH) demonstrated that 13 in. of rain over a 36 hr period will result in home flooding. This event also included heavy rain prior to the flap gates closing. These heavy rains probably resulted in Ellis Creek being filled to 50 % capacity at the time the gates closed.

Flood Events

The RG reading is not a true elevation. It is measured from a datum at approximately 27 ft above true elevation. There is some uncertainty as to the height of this datum. Flood models using Harvey data should clarify this.

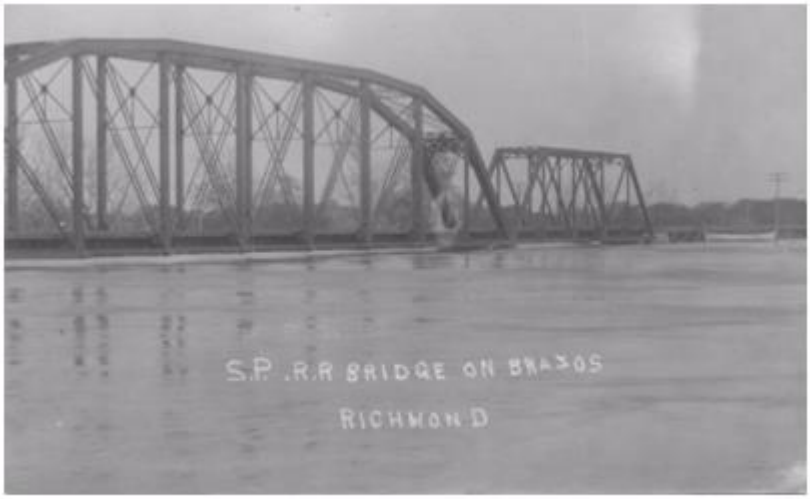
FEMA requires levees to exceed the 100-year level by 3 ft. FBC requires an additional 1 ft. Consequently, for a levee to be FEMA certified it must be of sufficient height to protect a RG reading of 60 ft.

## 1.4 Historical Brazos River Flood Levels (at Richmond Gauge)

Below are the five highest record levels of the Brazos River at the Richmond Gauge (RG).

| | |
|---|---|
| 61.2 ft | 12/10/1913 |
| 58.6 ft | July 1899 |
| 55.2 ft | 08/31/2017 |
| 54.7 ft | 06/02/2016 |
| 50.3 ft | 10/21/1994 |

The following photo shows the Richmond railroad bridge during the 1899 flood. This bridge, still in use today, was constructed in the 1860s to replace a bridge washed out in the flood of 1859.




Railroad Bridge at Richmond, 1899 (Crest at 58.6 ft)

Compare this to the 2017 photo take at a gauge reading of 55.2 ft. The height of the water shown in these photos strongly suggests that the 61.2 ft 1913 flood level was an accurate reading.

Railroad Bridge at Richmond 8-31-2017 (Crest at 55.2 ft)

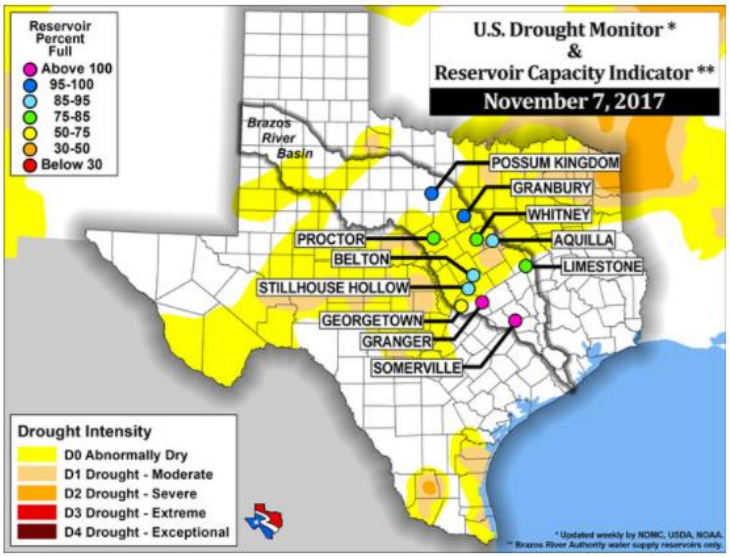
## 1.5 Brazos River Reservoirs

In 1929 the Texas Legislature creates the Brazos River Authority (BRA) to develop a master plan for managing both river flooding and water supply during droughts. The master plan proposed the creation of 13 dams on the Brazos and its tributaries. The first dam is completed in 1941 creating Possum Kingdom Lake. To date, 11 reservoirs have been created.

These reservoirs are designed to maintain minimum water levels to be used during drought conditions. The also keep a reserve capacity to detain water during flood conditions. These reservoirs we instrumental in limiting the height of the Brazos during the 2016 Memorial Day flood. The question is whether they place an upper limit on the height the Brazos can reach at the Richmond Gauge.

Information regarding the Brazos reservoirs can be found on the BRA web site: http://www.brazos.org/

### Current Reservoir Capacity




### Current Reservoir Levels

| Reservoir | Elevation | +/- ft | Date/Time | Release |
|---|---|---|---|---|
| Possum Kingdom* | 998.17 | -0.83 | 11/15/17 10:30 PM | 55 cfs |
| Granbury* | 692.45 | -0.25 | 11/15/17 11:30 PM | 16 avg. cfs |
| Proctor | 1159.47 | -2.53 | 11/15/17 11:30 PM | |
| Whitney | 528.54 | -4.46 | 11/15/17 11:15 PM | |
| Aquilla | 535.54 | -1.92 | 11/15/17 11:30 PM | |
| Limestone* | 359.48 | -3.52 | 11/15/17 11:45 PM | 6 cfs |
| Belton | 591.67 | -2.32 | 11/15/17 11:00 PM | |
| Stillhouse | 619.65 | -2.35 | 11/15/17 11:00 PM | |
| Granger | 504.51 | 0.67 | 11/15/17 11:00 PM | |
| Georgetown | 778.69 | -12.28 | 11/15/17 11:00 PM | |
| Somerville | 238.52 | 0.53 | 11/15/17 11:00 PM | |

*Brazos River Authority reservoir.

DROUGHT CONDITIONS

BOAT RAMP AVAILABILITY

CURRENT TEXAS OUTDOOR BURN BANS

# 2 Northern Boundary

## 2.1 NE - Bull Head Slough at Montessori School

Observations

Tuesday (8-29)

- Water in the slough moved very quickly and the slough was effective in removing water in areas north of 90A. Current only fell after Richmond Gauge exceeded 54 ft. A slight rise in water (1.5 in.), due to Brazos river backwash, was seen at RG 54.96.
- All water in slough came from rain. Brazos river water did not enter slough.
- The initial effort to place tiger dams failed (photo #1). A small tornado was identified as a possible reason, though it is also possible that moving water from Robinsons Landing neighborhood behind levee caused the failure. A subsequent effort successfully placed a 3-tube dam.
- Bull Head Slough quickly overflowed its banks late Monday after heavy rain arrived.
- Commercial Tract businesses were at material risk from flooding. Water rose to a few inches from the doors. The Montessori school was not threatened due to it higher elevation.
- At no point, did flood water cover 90A or the school bridge.

Conclusions

- Tiger dams were ineffective. The added height provided no protection to the school or the businesses. They also appear susceptible to fast moving water.
- Flood waters threatening the Commercial Tract businesses came from the section between 90A and the school bridge (where no dams were placed).
- The railroad track creates a constriction point which regulates the volume of water reaching Bullhead slough south of 90A. It is possible that higher rainfalls would simply result in increased water levels north of 90A, while flow rates south of the track would be relatively unchanged.

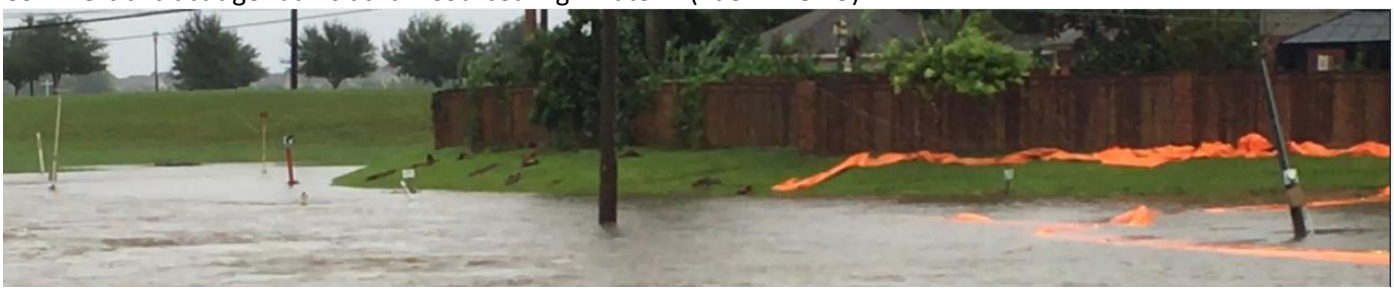
Recommendations

- Build an earthen berm/flood running from either:
    - the corner house (Robinsons Landing) to 90A.
    - the Telfair levee to 90A.
    - elevation should equal the height of the railroad tracks plus one ft.
- Deepen Bull Head Slough channel to Ditch H.

Failed tiger dams (1st attempt)

Reset tiger dams - Tue AM (8-29)

Commercial tract tiger dams at rain sourced high water – (Tue AM 8-29)



View West from school bridge - Tue AM (8-29)

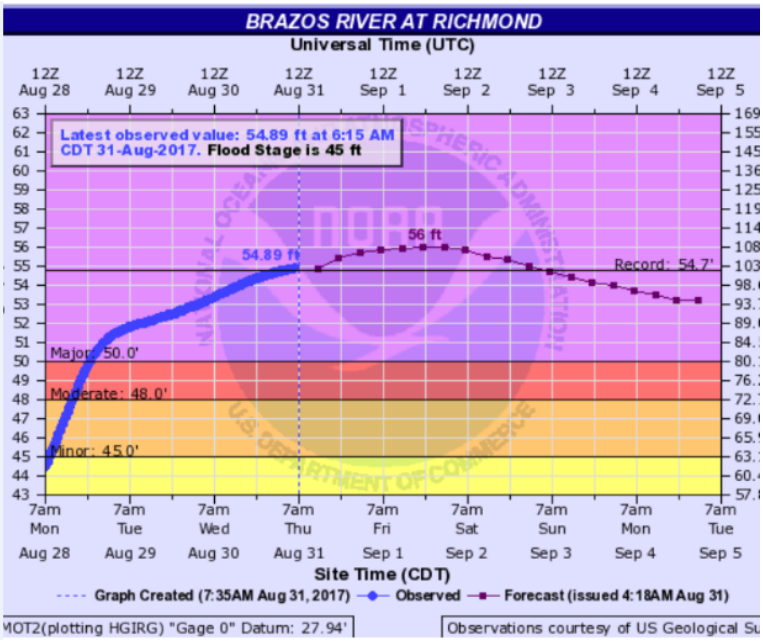
View South showing 90A & Commercial Tract

View of school from school bridge - Tue AM (8-29)

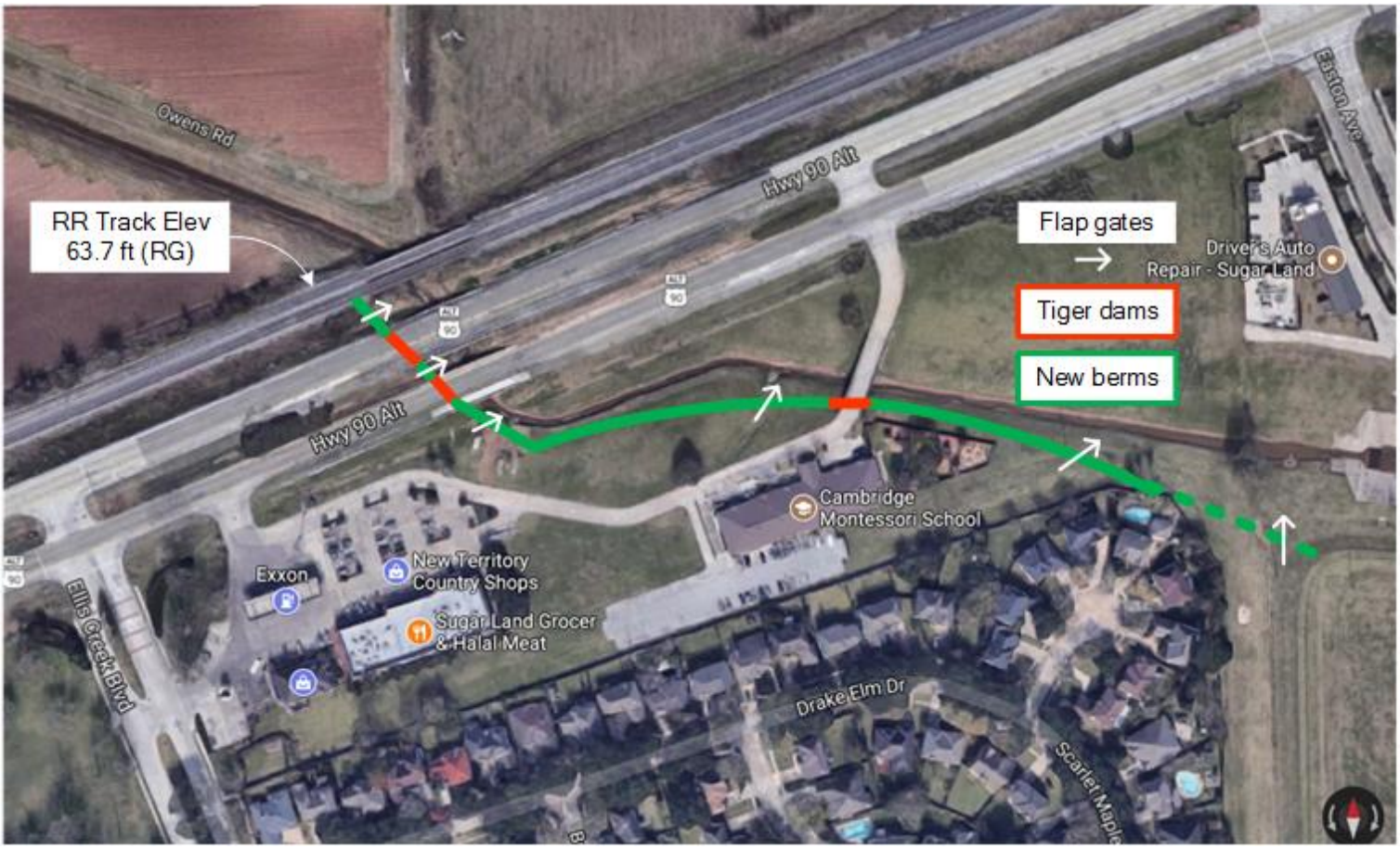
View South showing 90A & Commercial Tract



View of Commercial Tract south from 90A - Tue AM (8-29)




Commercial tract at (near) Brazos high water mark (Aug 31)




Proposed New Berms

Laser level used to measure 8.5 ft elevation difference between Harvey HWM (55.2 ft) and track bed (63.7 ft).

## 2.2 90A / 99 Intersection

Observations

Monday (8-28),

- Tiger dams are placed across 99 frontage road. County trucked in street grade material to create barrier under 99 overpass.

Tuesday AM (8-29)

- Water levels rose to approximately 17 ft. in the intersection. At highest point, water rose several inches up tiger dams placed across frontage road near Sandhill.
- Water source was entirely rain water from Bull Head Slough north of 90A.

Tuesday PM

- Tiger dam placement was extended around 90A-99 corners and up 90A on both east & west sides. SLFD assisted till Wed morning with filling tiger tubes where extra hoses were needed.
- Existing TXDOT pumps lowered water levels by several feet by late Tue evening.

Thursday (8-31)

- Intersection passable to traffic.

Friday (9-1)

- Tiger dams across 90A & 99 frontage road removed.

Conclusions

- Brazos river did not threaten intersection. Water from river never entered intersection.
- Bull Head Slough quickly flooded the intersection under this extreme rain event. The maximum upstream elevation for Bull Head Slough was approximately 75 ft. This indicates that the water in the 90/99 interchange reached its maximum possible elevation at 76.5 ft. Bull Head Slough, at the Commercial Tract / NE LID 7, experienced very heavy runoff. The fact that this heavy runoff did not increase the 90/99 interchange water height, above 76.5 ft, supports the conclusion that this interchange maxed out for a BHS event.
- The 99/90A intersection served as a capacity overflow which probably reduced the water transported by Bullhead slough to the Commercial tract (NE LID 7), though the impact may not have been material.
- Tiger dams were effective on 99 frontage road, but the ultimately the water level would not have entered LID 7 up the frontage road.
- Tiger dams proved to be unnecessary on 90A.
- TXDOT pumps eventually caught up with flood waters, but took 2-3 days and only after heavy rain stopped.
- Tremendous effort and cost required to lay tubes around corners and up/down 90A.

Recommendations

Non-LID 7 Improvements

- Close gap in Brazos levee at Rivers Edge / Rio Vista (see Section 2.4).
- Work with County on possibly raising Pitts or Harlem roads to prevent migration or river water from west.

Option 1

- Place earthen berms along 99 frontage road and 90A so that tiger dams are only required on roadways.
- Place earthen dam underneath 99 overpass just north of Sandhill.

Option 2

- Install new levee north of RR tracks along both sides of 99.
- Install new levee under 99 just south of 1462.
- Install swing gates on 99 frontage road.
- Work with County on shared funding.

Option 3

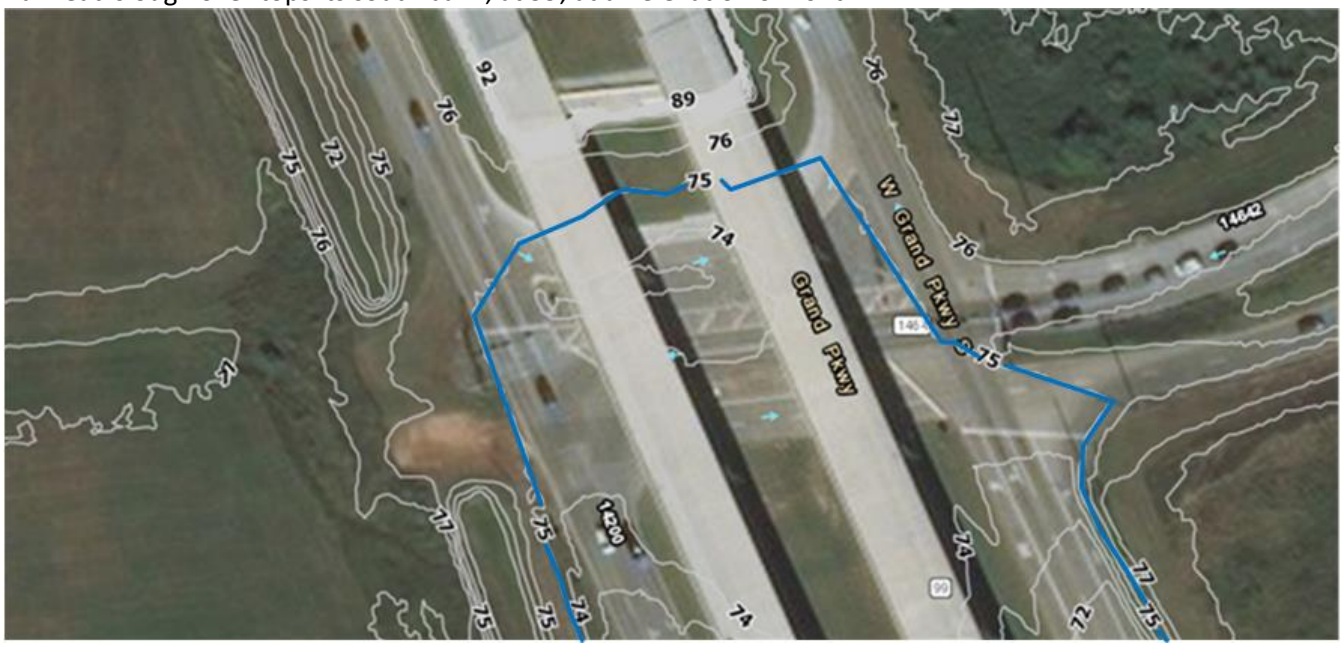
- Expand Option 2 by extending levee west along north side of RR tracks.
- RR track east of 99 appear to be sufficiently high to divert water down to Telfair without the need of a levee.


99 south bound frontage road (facing north) - Tue Aug 29


99 south bound frontage road (facing east) - Tue Aug 29


99 north bound frontage road (facing north) - Tue Aug 29


Bullhead slough over tops its south bank, at 99, at an elevation of 70 ft.




Traveling south, the southern bank peaks at 75 ft.

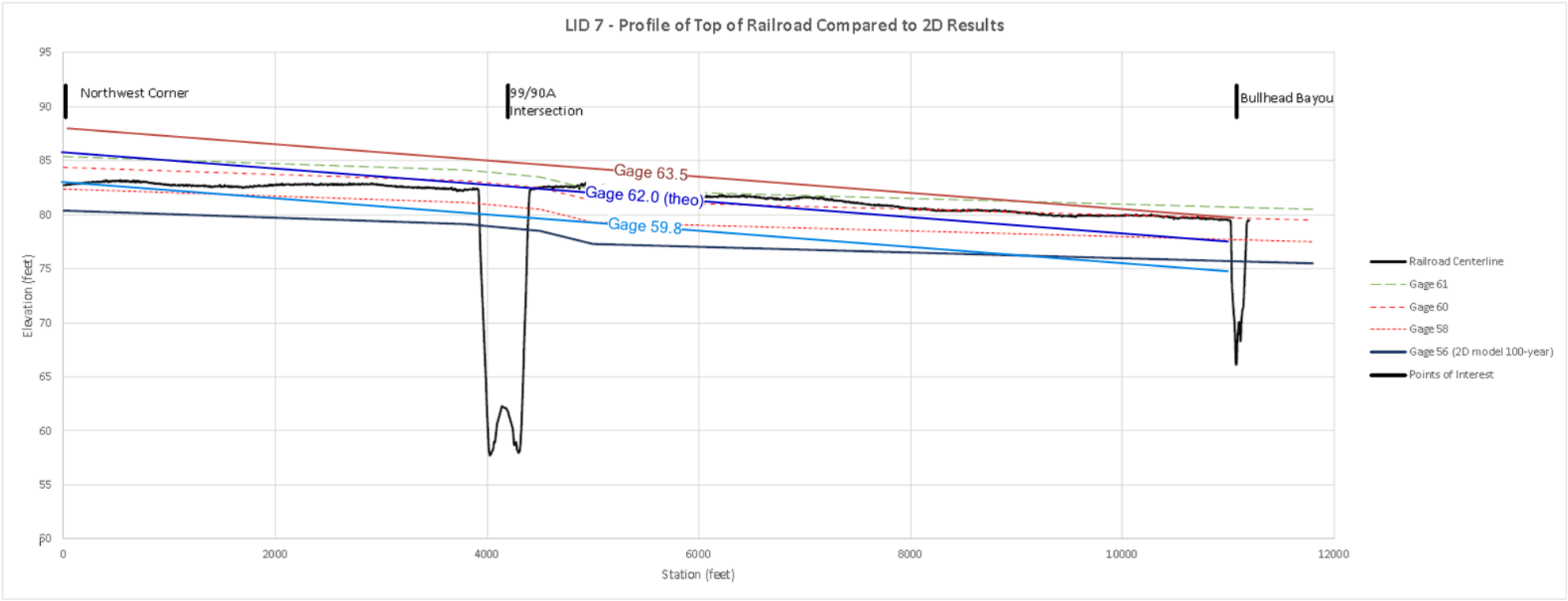

Max rain water height reached 76.5 ft at tiger dams.

Option 1 - New Berms

Option 2 – Option 2 with levee extended west.

## Updated North Levee Option (Apr – 2018)

Railroad Track Protection



## 2.3 NW – High Meadows

Observations

Monday (8-28)

- Tiger dam placed in channel between RR track on 90A west bound.

Thursday (8-31)

- Highest Brazos river levels reached (RG 55.2 ft.).
- LID 7 levee at 90A/external channel maintained 43 in. freeboard at max water level.
- 90A east bound flooded and was closed. 90A west bound remained open during event.
- HWM analysis indicates railroad tracks at NW corner of LID 7 protect to a height of 60.8 ft.

Recommendations

- Add flap gate closed between RR track on 90A west bound to eliminate need for tiger dam.
- Railroad tracks provide effective flood protection to between 59.5 – 60.0 ft. The provide additional production up to 60.8 ft. Top foot of railroad track bed is subjected to seepage, but this should be controllable with adequate pumpage.

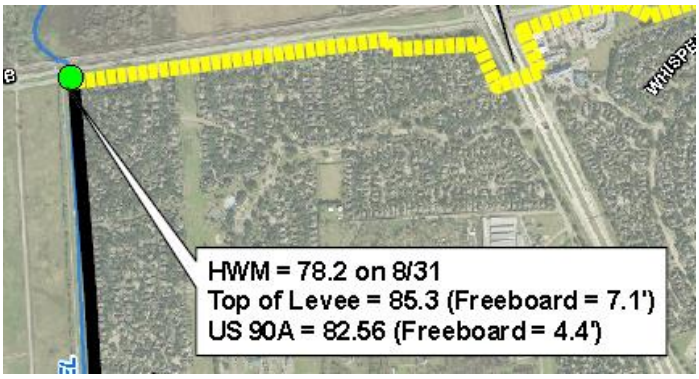

External Channel at 90A (Brazos river high water mark)

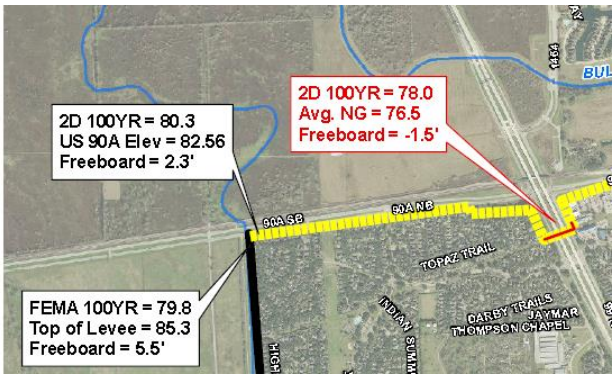

61.7 ft


61.7 ft
level with top of flood wall
22 in (1.9 ft)
59.8 ft
elev South RR track bed


Level with top of flood wall
(22 in / 1.9 ft
above RR track bed)


| Laser level elevations (Richmond Gauge basis) | Description |
|---|---|
| 55.2 ft | Brazos High Water Mark (HWM) |
| 61.7 ft | Top of flood wall |
| 59.8 ft | Top of RR track bed |




FEMA 100 YR Elevation 79.8 ft / 2D 100 YR Elevation 80.3 ft

## 2.4 Brazos Overflow Migration Path

Observations

Monday (8-28)

- Harlem road remained open, but one south bound lane and shoulder flooded.
- Bull Head Slough overflows its banks, but did not cross Harlem roadway.
- Tiger dam placed in channel between RR track on 90A west bound.

Thursday (8-31)

- Highest Brazos river levels reached (RG 55.2 ft.).
- 359 closed at Pecan Grove levee.
- Pitts road closed at 90 A. Moving water crossed Pitts road (west to east). Pitts may have been closed earlier.
- 90A east bound flooded and was closed. 90A west bound remained open during event.
- Harlem remains open though water extended half way across intersection at 90A. BHS back within banks.

90A & Pitts (facing south) 8-31

90A & Harlem (facing east) 8-31


90A & Pitts 8-31-17 (elev 80 ft at cross over)

90A & Harlem 8-31-17 (elev 79 ft at cross over)

**Discussion (Stephen Wilcox) 9/26/2017**

1. How much protection does the Rio Vista and Rivers Edge levee provide LID 7?

   A levee connecting the higher fill in Rivers Edge behind Rio Vista and to Pecan Lakes does physically cut-off the overflow for a 100-year event. This would not provide the additional freeboard to be certified by FEMA. The extended levee in the PER connecting to Pecan Grove would be a FEMA certifiable levee with plus 4 feet of freeboard.

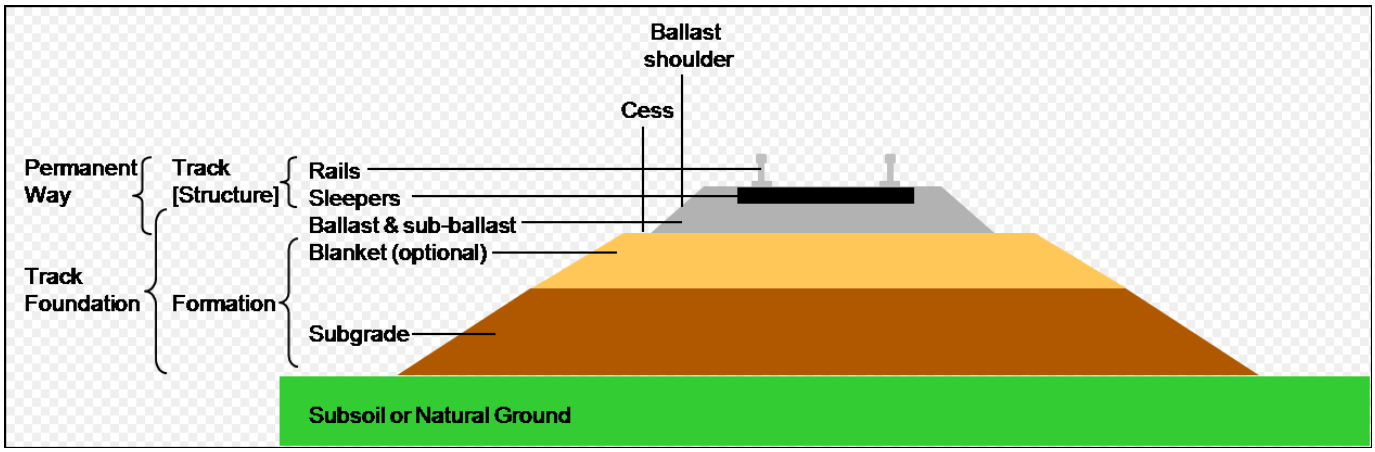
2. Does raising Pitts road fix our problem on the north side?

   Raising Pitts could physically cut-off the overflow but would not be FEMA certifiable (unless we raised it 4 plus feet) and would impound water on the upstream side necessitating complex and expensive mitigation upstream of Pitts. We have looked at the Pitts options extensively and determined the more cost effective methods are a cutoff levee through Smith to Pecan Grove or working with the regional levee group to construct a fully FEMA certifiable levee from LID 7 to Pecan Lakes.

   I have not presented to you the full regional option yet due to waiting on major land owners to provide certain commitments. None of these options fully protect the day care area.

Brazos river overflow path from Rivers Edge/Rio Vista to LID 7

# 3 Railroad Track




**Track ballast**

From Wikipedia, the free encyclopedia

Track ballast forms the track bed upon which railroad ties (sleepers) are laid. It is packed between, below, and around the ties. It is used to bear the load from the railroad ties, to facilitate drainage of water, and to keep down vegetation that might interfere with the track structure. This also serves to hold the track in place as the trains roll by. It is typically made of crushed stone, although ballast has sometimes consisted of other, less suitable materials, for example burnt clay.

The term "ballast" comes from a nautical term for the stones used to stabilize a ship.

The appropriate thickness of a layer of track ballast depends on the size and spacing of the ties, the amount of traffic on the line, and various other factors.

Track ballast should never be laid down less than 150 mm **(5.9 inches)** thick;

High-speed railway lines may require ballast up to ½ meter **(19.7 inches)** thick.

Ballast less than 300 mm (**11.8 inches**) thick can lead to vibrations that damage nearby structures.

However, increasing the depth beyond 300 mm (**11.8 inches**) adds no extra benefit in reducing vibration.[6]

In turn, track ballast typically rests on a layer of small crushed stones: the sub-ballast. The sub-ballast layer gives a solid support for the top ballast, and reduces the seepage of water from the underlying ground.[1] Sometimes an elastic mat is placed on the layer of sub-ballast and beneath the ballast, thereby significantly reducing vibration.[6]

# 4 West Side

## 4.1 Pump Station

Observations

Tuesday AM (8-29)

- Ellis Creek levels peak at pump station. Only top section of gates remain above water. Only top horizontal bars exposed at pump inlet.
- Water touches bottom of West Meadow bridge.
- 4 ft. of water at Crescent Ridge entrance. This is the deepest level of water in neighborhood, though many streets impassible.

Wednesday AM (8-29)

- Pump station water level down about 12 in.
- All four pumps (25,000 GPH) ran for at least 7 hours, but eventually they tripped and went off line. Operators waited 20 minutes and then brought up 2 pumps. They continue to rotate running 2 pumps at a time.
- Power was never lost at the pump station.

Conclusions

- The pump station pumps were just able to keep up. Additional rainfall would probably have resulted in addition East side homes flooding.
- All four pumps cannot be run reliably for extended periods.

Recommendations

- Perform following pump station upgrades are recommended in Schrader study. Including,
    - Update wiring so that all 4 pumps can be run by generator. There still may be a restriction that only 3 pumps can run concurrently by generator.
    - Resolve issues preventing all four pumps from running simultaneously using grid power.
    - Install solid state control system.
- Build second pump station to increase capacity.
- Replace/refurbish existing station to increase capacity to approximately 300,000 GPM.

Peak water levels - Tue 8-29 10:45 AM

Approx. 5 ft freeboard within concrete pump box
4 x 22,000 GPM pumps

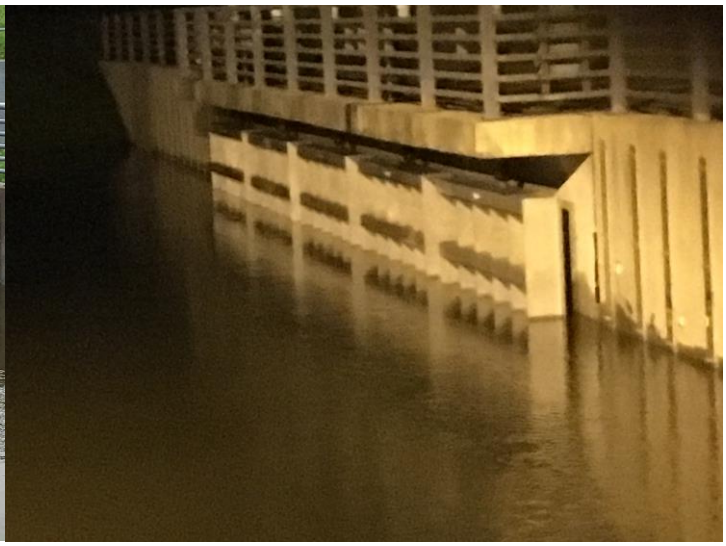
External channel (behind pump station facing S)

External channel (behind pump station facing N)

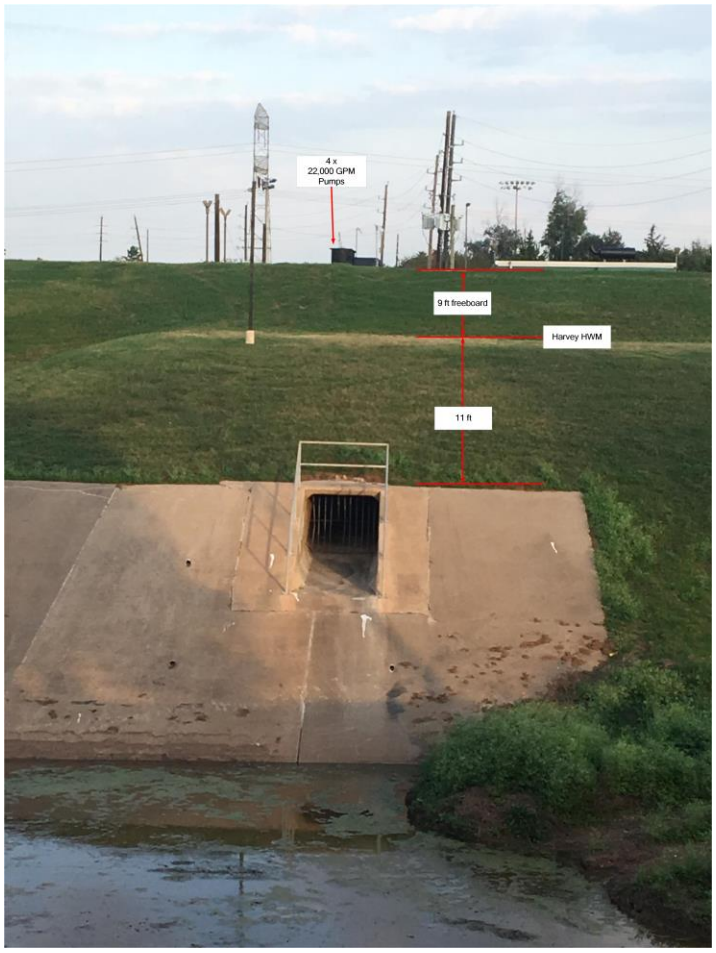
Pumps station inlet (facing east) – Tue 8-29 10:45 AM

West Meadow bridge at recycled water plant.

Peak water levels - Tue 8-29 10:45 AM



Dropped water levels – Wed 8-30 5:30 AM
(16 hr 45 min of pumping – approx. 12 in.)




Pump outflow culvert was approximately 11 ft under water at the Harvey HWM.

## 4.2 Chapel Bend / Crescent Ridge / Laurel Crest

Observations

Monday (7:00 AM)

- Crescent Ridge entrance and first intersection dry.

Tuesday AM (8-29 11:00 AM)

- Cunningham Creek / Sandhill intersection dry.
- Cunningham Creek open to Brazos Bend Elementary.
- Cunningham Creek closed at intersection to Laurel Crest.
- Cunningham Creek closed at Chapel Bend. Water above sidewalks in parts of Chapel Bend.
- Crescent Ridge entrance flooded. 4 ft. of water in first intersection. This is the deepest level of water in neighborhood, though many streets impassible.

Conclusions

- Standing water in Crescent Ridge is most likely a result of backup from Ellis Creek. High water marks occurred approximately 36 hours after the heaviest rain falls.
- These sections of MUD 68 drain into Ellis Creek. Flood levels probably match water levels in Ellis Creek.
- Only effective way to lower water is to lower water in Ellis Creek.

Recommendations

- No changes


Chapel Bend entrance – Tue 8/29 11:00 AM


Crescent Ridge entrance.


Crescent Ridge – 1st intersection (Tue 8/29 11:00 AM)
LIDAR 70.5 ft street elevation in intersection.

Crescent Ridge just inside entrance (Tue 8/29 11:00 AM)

HWM approx. 73 ft per LIDAR

## 4.3 High Meadows / Autumn Ridge

Observations

Tuesday AM (8-29)

- Cunningham Creek / Sandhill intersection dry.
- Two portable pumps set up. One in High Meadows and the other in Autumn Ridge.
- Both pumps rated at 4,000 GPM.
- Streets mostly dry throughout neighborhoods.
- Autumn Ridge portable pump shut off to conserve fuel. Street still passable, but water is high at pump.

Conclusions

- These sections of MUD 68 drain into the external channel.
- If this section drained into Ellis Creek as has been proposed, then, in all likelihood, homes in Lakewind, Greystone Place and other East side neighborhoods would have flooded.

Recommendations

- No changes

High Meadows portable pump – Tue 8-29 noon

## 4.4 River Glen & Apartments

Observations

Tuesday AM (8-29)

- NT blvd flooded and impassible at apartments. Water in street is level with Ellis Creek.
- Ellis Creek 6-12 in below bank overflow level.
- River Glen streets flooding as water in neighborhood reaches equilibrium with Ellis Creek.
- 3-4 ft. of water at Ellis Creek - River Glen lift station.
- No flooding in Brandon's Pointe or Cambridge Park.

Wednesday (8-30)

- NT blvd open

Conclusions

- River Glen flooding a result of Ellis Creek. Draining Ellis Creek alleviates flooding in neighborhood.

Recommendations

- See Pump Station improvements.

NT bridge at Sport Complex

River Glen at Ellis Creek lift station – Tue 8-29 11:30AM and just inside neighborhood

# 5 East Side

## 5.1 Greystone Place & Water Mill

Observations

Tuesday AM (8-29)

- Homeward Way flooded and impassible at NT blvd (by Randall's).
- Ellis Creek 6-12 in. from overflowing banks near Sartartia MS.

Tuesday PM (8-29)

- Homeward Way floods and is impassible at Greystone Place.
- Homeward Way floods and is impassible at Watermill
- Homeward Way floods and is impassible at Lakewind.
- One Greystone house floods (1-3 in water inside home).
- 8-10 Greystone houses within 1-3 in of flooding. Several garages flood.

Conclusions

- Grey Stone & Water Mill neighborhood have the lowest elevation in New Territory.
- At its maximum capacity, Ellis Creek completely prevents drainage from these neighborhoods.
- At its maximum capacity, Ellis Creek probably backs up into the lakes.
- It may also backup into the neighborhoods and be the source of home flooding.
- It is probable that water from Lake Wind drains into the GS/WM storm sewer network via the storm drain at Homeward Way & Kendall Creek.
- The LW storm sewer network drains into Ellis Creek at a higher elevation that the GS/WM network. This means that LW equilibrium with Ellis Creek will be approximately 12 inches higher than GS/WM equilibrium with Ellis Creek. Consequently, water draining from LW to GS/WM will be coming from a higher water table.
- Streets in Tessa Lakes and other nearby neighborhoods, not within the GS/WM storm sewer network, did not experience the same high water levels. While their elevations were a bit higher, the backup from Ellis Creek into those neighborhoods did not result in water levels commensurate with GS/WM.
- Additional pumps in this area would have been ineffective. The quantity of water entering GS/WM from both Ellis Creek and LW would have overwhelmed any portable pumps placed in GS/WM.
- The most effective solution, by far, is to drop elevation of Ellis Creek.

Recommendations

- See 4.1 Pump Station improvements.
- See 5.3 Drainage Map.
- See 7 Optional Detention Capacity.
- See 10.4 LIDAR Map LID 7
- Consider sluice gates and backflow preventers at the Greystone lake culvert.

Homeward Way at Sartartia MS – Tue 7:30 PM

Greystone Place entrance– Tue 7:30 PM

Greystone Place (1st intersection at Amberstone drive facing each direction)


Colton Trails (HWM)

House, very close, but did not flood (12 Amberstone Dr.)

8 Amberstone Dr. (did not flood)

11 Amberstone Dr. (did not flood)


Flooded home
Photo of people on bridge
High water elev = 71.5 ft
Homeward Way
Colton Trails Dr
Stone Ter
Amberstone Dr


Ellis Creek high water mark (HWM) is unknown. Anecdotal reports indicate that it did not overflow its banks. No photos are available. A HWM of 71.5 ft is consistent with the water level in Greystone.

## 5.2 Lakewind

Observations

Tuesday AM (8-29)

- Lakewind lake overruns its banks and covers Homeward Way.
- Several homes very closed to flooding.
- Homeward Way flooded and impassible at Greystone Place.
- Homeward Way flooded and impassible at Watermill
- Homeward Way flooded and impassible at Lakewind.

Conclusions

- Overflow from Kendall Creek (Lakewind drainage) appears to migrate into Watermill / Greystone Place drainage.
- The only effective way to remove water from Lakewind is to lower Ellis Creek. The levees behind LW back up to Telfair so portable pumps are not an option as there is nowhere to pump the water.

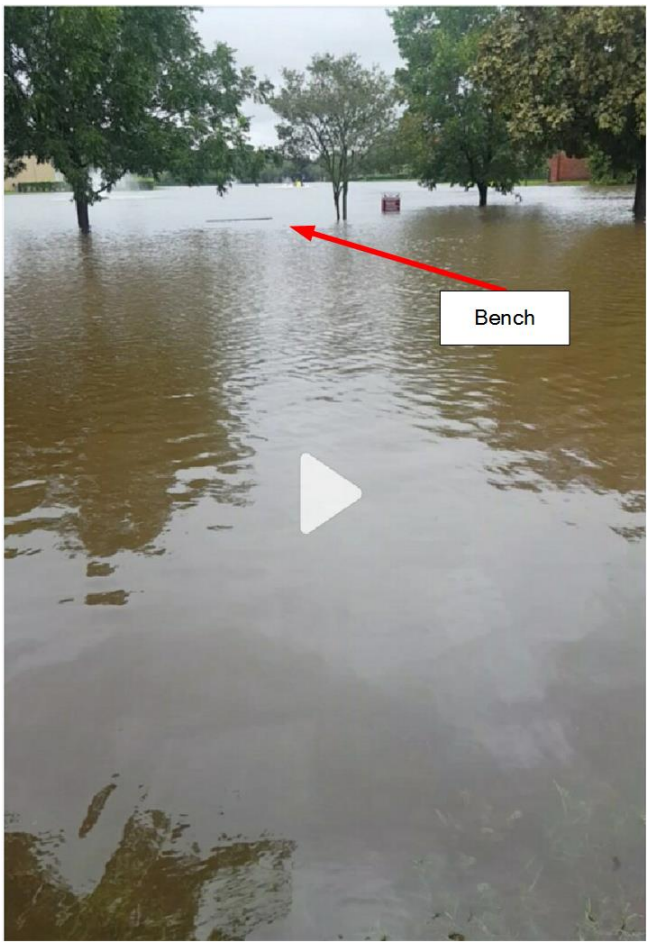
Recommendations

- No recommended changes.

Lower edge of Lakewind lake on Homeward Way.
(LIDAR elev of street at blue car = 71.0 ft) (Tue 8/29/2017)


Kendall Creek at Homeward Way. (see drainage map)
(LIDAR elev of sidewalk = 72.0 ft) (Tue 8/29/2017)

LIDAR elevation of Watermill drain, adjacent to Kendall Creek, 72.0 ft.





A. View of Lakewind lake from Homeward Way. Horizontal line, between two trees, is top of bench.
B. **Debris line** marks max water level (Lakewind house backing up to lake) -Thu 8-31 10:00 AM



A. Lakewind bench (normal conditions) – (LIDAR elev at bench = 70.5 ft)
B. Lakewind home with debris line (note drain).

Drainage Map – Lakewind (yellow) / Grey Stone & Water Mill (blue)Drainage Map


The Harvey high water mark (HWM) at the Lake Wind bench is approximately 1.5 ft. above the inlet drain to the Greystone / Watermill drainage system. This indicates significant amounts of water migrated into the Greystone area from Lakewind. This is a possible cause for home flooding. While it is probable that Ellis Creek water did flow back in the Greystone lakes, the elevation of the Ellis Creek waters may not have been high enough to reach home levels.

# 6 South & West Levees

Observations

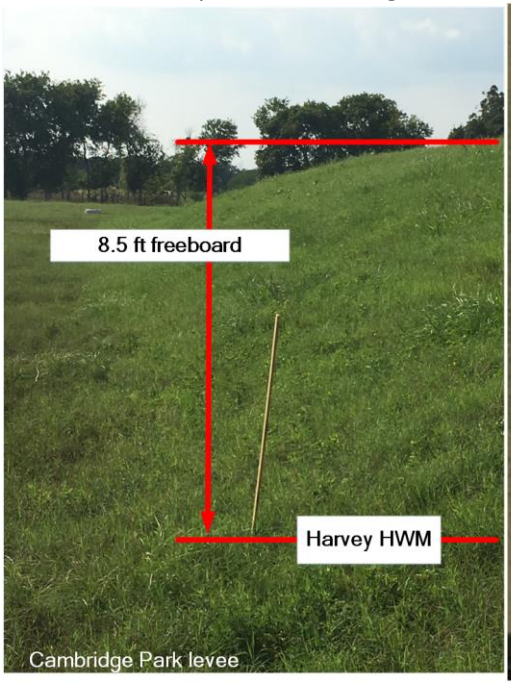
- Levee at 90A maintained approximately 4 ft. freeboard at max river height.
- Levee at Cambridge Park (SW corner of LID 7) had 9 ft. freeboard at max river height.
- Brazos river peaked at 55.2 ft. at Richmond gauge.
- WWTP closure statement released 8-28. (Plant never shut down)

Conclusions

- South and west earthen and wall levees were never at risk of breach.
- South and west levees are secure to approximately 62 ft. Richmond gauge height.

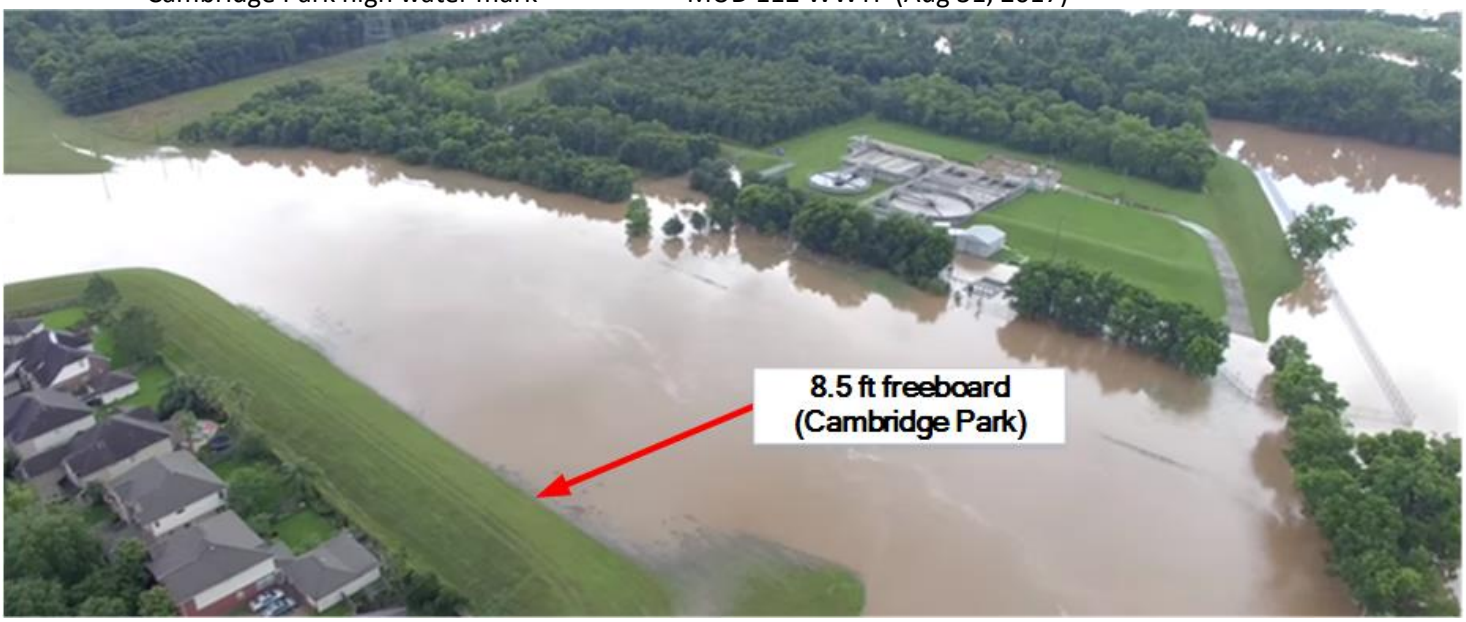
Recommendations

- Assess options for raising barrier at 90A.




Cambridge Park high water mark

MUD 112 WWTP (Aug 31, 2017)




MUD 112 WWTP (Jun 2016 – Memorial Day flood)

# 7 Additional Detention

## 7.1 Convert Baseball Field (w optional new Pump Station)

One option for expanding our detention capacity is to excavate a portion of the Sport Complex as show in the attached diagram. This site has the following advantages:

- Adds capacity of approximately 3 MM cu. ft.
- Close to the Greystone Place, Watermill & Lakewind neighborhoods.
- Adjacent to Ellis Creek.
- Adjacent to the levee.

This project involves temporarily removing the ball fields located on this property, excavating the detention and then rebuilding these fields in the excavated area. This option is preliminary and requires the involvement of both the NTRCA and the WSLLL baseball club.

Beyond detention, this option has several advantages.

1. Excavated material can be used as fill for the Brazos river erosion project.
2. Use this material for the Commercial tract & 99/90 berms.
3. Provides a location for an additional pump station.

# 8 Pump Station Capacity, Detention & Rainfall

## 8.1 Detention & Portable Pump Impact on Ellis Creek

**Volume of top Inch in Ellis Creek (at max capacity)**

| | |
|---|---|
| 3.5 | Ellis Creek & Ditch O length (mi) |
| 5,280 | ft / mi |
| 18,480 | length (ft) |
| 120 | Ellis Creek average width (ft) |
| 2,217,600 | Surface area (sq ft) |
| 0.083 | one inch (ft) |
| 184,800 | volume for top 1 inch (cu ft) |
| 7.5 | Gal / cu ft |
| 1,386,000 | Gallons in top 1 inch of water in Ellis Creek at max capacity |

**New Detention**

| | |
|---|---|
| 3,500,000 | New detention capacity (cu ft) |
| 7.5 | Gal / cu ft |
| 26,250,000 | New detention capacity (gal) |
| 1,386,000 | Gallons in top 1 inch of water in Ellis Creek at max capacity |
| 19 | Inch drop due to new detention |

**Portable Pumps**

| | |
|---|---|
| 4,000 | Portable pump capacity (gpm) |
| 6 | Portable pump count |
| 24,000 | gpm |
| 1,386,000 | Gallons in top 1 inch of water in Ellis Creek at max capacity |
| **57.75** | **Minutes pumps need to run to lower Ellis Creek by 1 inch.** |

**Existing pump station (88,000 gpm)**

| | |
|---|---|
| 88,000 | Pump capacity (gpm) |
| 4 | Pump count |
| 88,000 | gpm |
| 1,386,000 | Gallons in top 1 inch of water in Ellis Creek at max capacity |
| **15.75** | **Minutes to lower Ellis Creek by 1 inch** |

**New pump station (300,000 gpm)**

| | |
|---|---|
| 75,000 | Pump capacity (gpm) |
| 4 | Pump count |
| 300,000 | gpm |
| 1,386,000 | Gallons in top 1 inch of water in Ellis Creek at max capacity |
| **4.62** | **Minutes to lower Ellis Creek by 1 inch** |

## 8.2 Pump Station Capacity & Rainfall

**LID 7 drainage area**

| | |
|---|---|
| 2,064 | acres (NT & External tract) |
| 43,564 | sq ft / acre |
| 89,916,231 | sq ft |
| (3,613,864) | - 10% High Meadows exclusion |
| 86,302,367 | NT sq ft |
| | |
| 1 | 12 in rain |
| 86,302,367 | cu ft rain |
| | |
| 7.5 | gal / cu ft |
| 647,267,753 | gal (12 in rain) |
| 53,938,979 | gal (1 in rain) |

**Existing Pump Station Capacity**

| | |
|---|---|
| **88,000** | **max pump capacity (gpm)** |
| 7,355 | minutes to pump 12 in rain |
| 122.59 | hours to pump 12 in rain |
| 5.11 | days to pump 12 in rain |
| | |
| 612.94 | minutes to pump 1 in rain |
| 10.22 | hours to pump 1 in rain |
| 0.43 | days to pump 1 in rain |
| | |
| 2.35 | Pump capacity (in rain/day) |

**Proposed Pump Station Capacity**

| | |
|---|---|
| **300,000** | **max pump capacity (gpm)** |
| 2,158 | minutes to pump 12 in rain |
| 35.96 | hours to pump 12 in rain |
| 1.50 | days to pump 12 in rain |
| | |
| 179.80 | minutes to pump 1 in rain |
| 3.00 | hours to pump 1 in rain |
| 0.12 | days to pump 1 in rain |
| | |
| 8.01 | Pump capacity (in rain/day) |

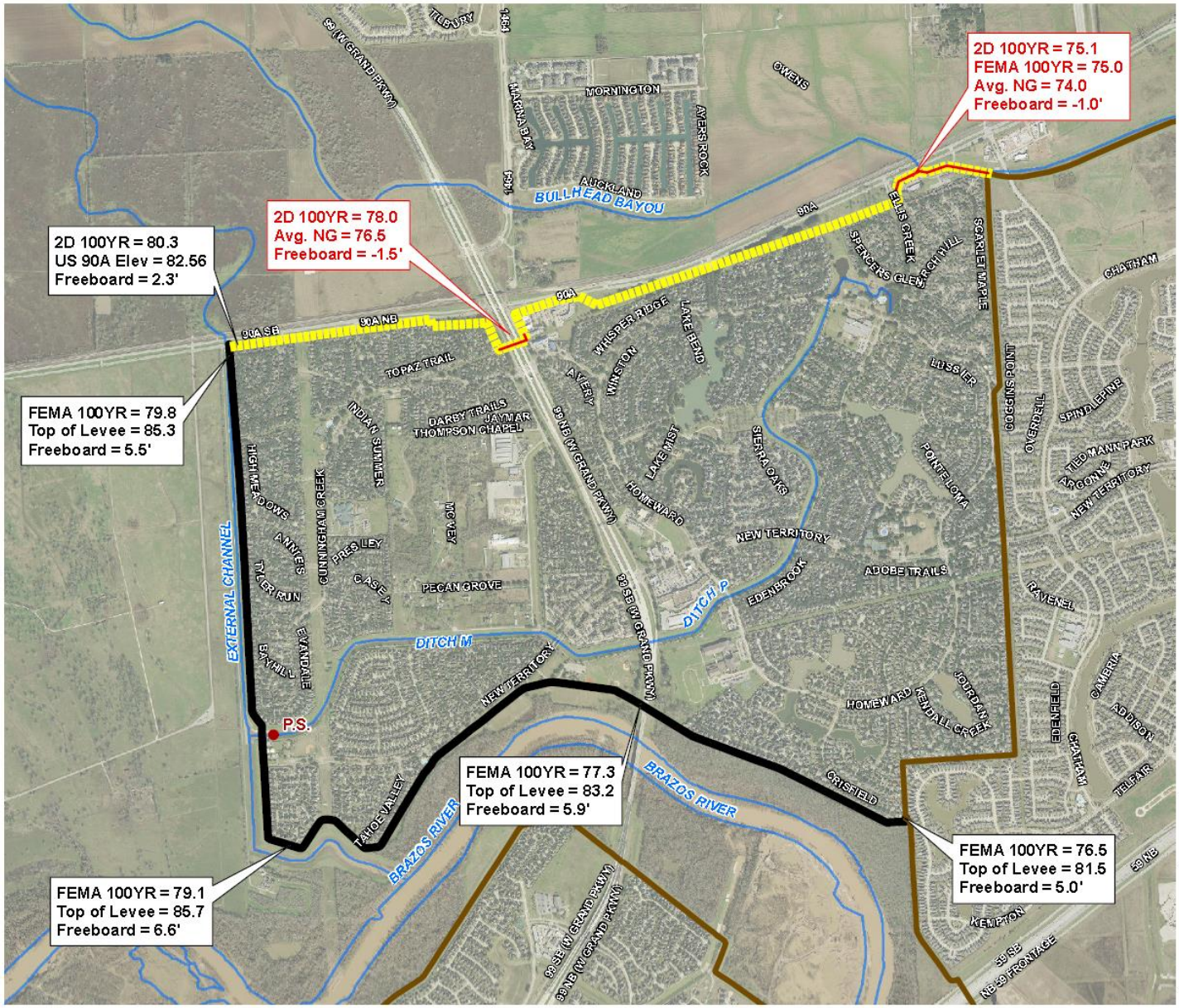
* High Meadows drains directly to external channel. Rainfall from this area does not enter Ellis Creek.

# 9 Stavinoha Bridge

River bank erosion at Stavinoha bridge is out of scope for this assessment. Photos are included for reference (Aug 30).

# 10 LID 7 Maps

## 10.1 Levees (Actual & Proposed)




Costello

Costello, Inc.
Engineering and Surveying
TBPE Firm Registration No. 280

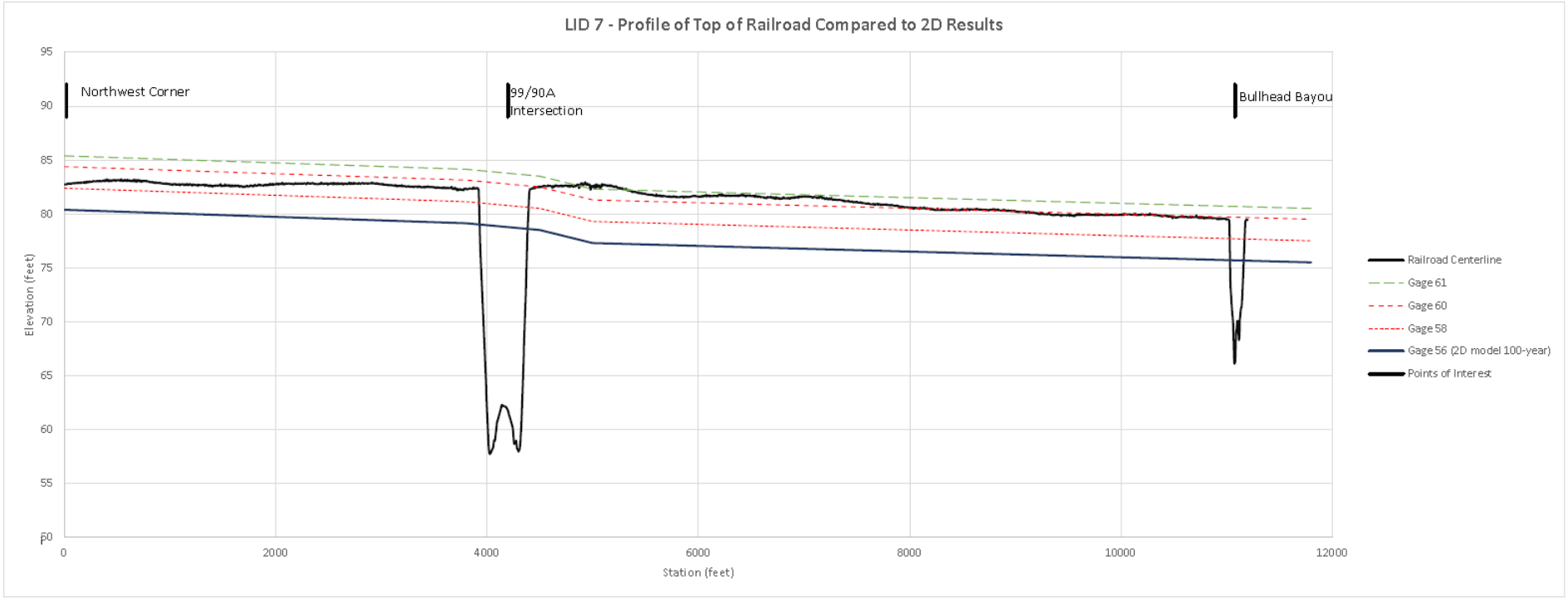
**FBC LID NO. 7**
**NORTH LEVEE CLOSURE**

**EXISTING FREEBOARD**

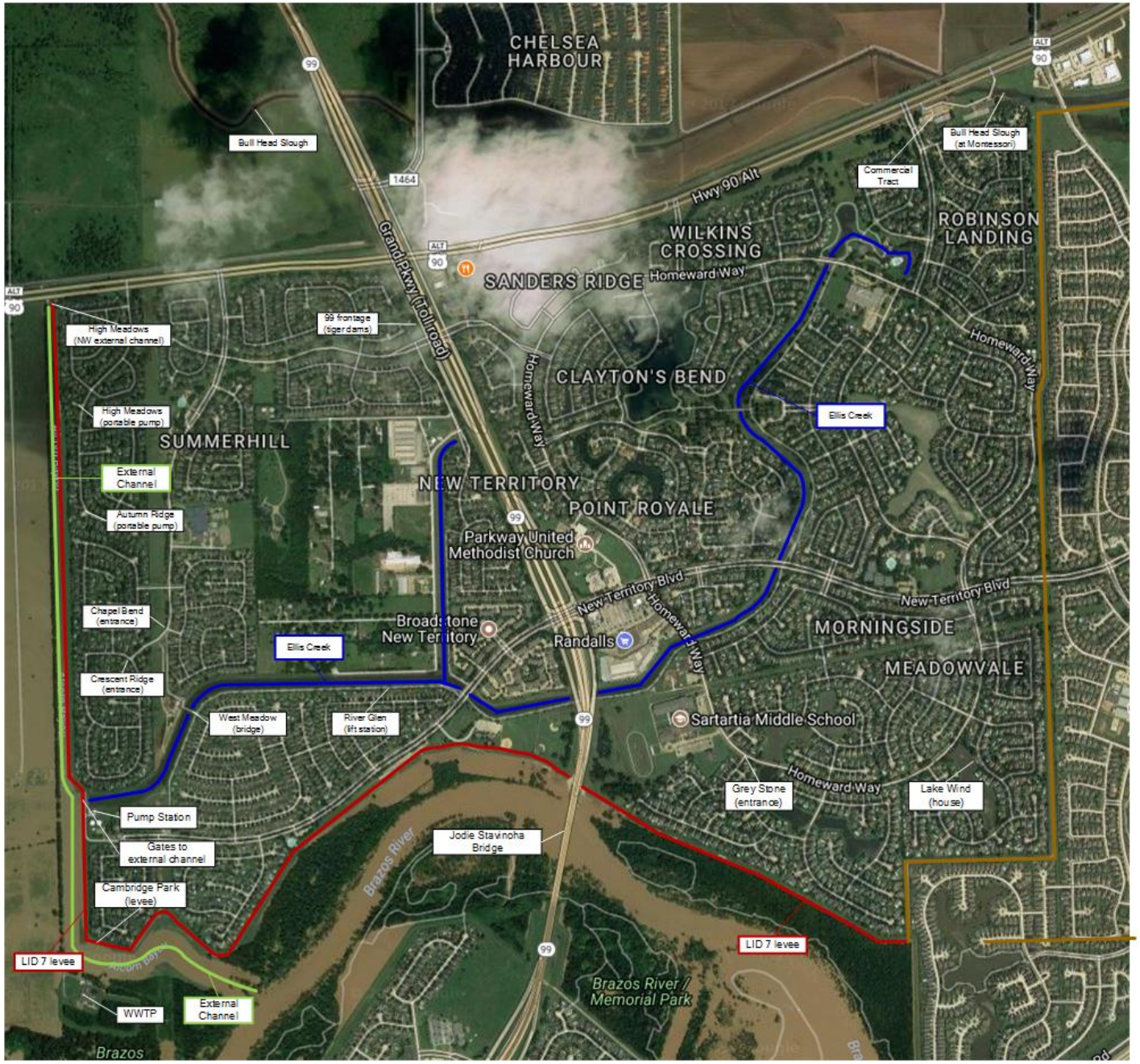
| JOB NO.: 1992020-OPR-15-069 | DATE: NOV 2016 | BY: JG |
|---|---|---|

**EXHIBIT 1**

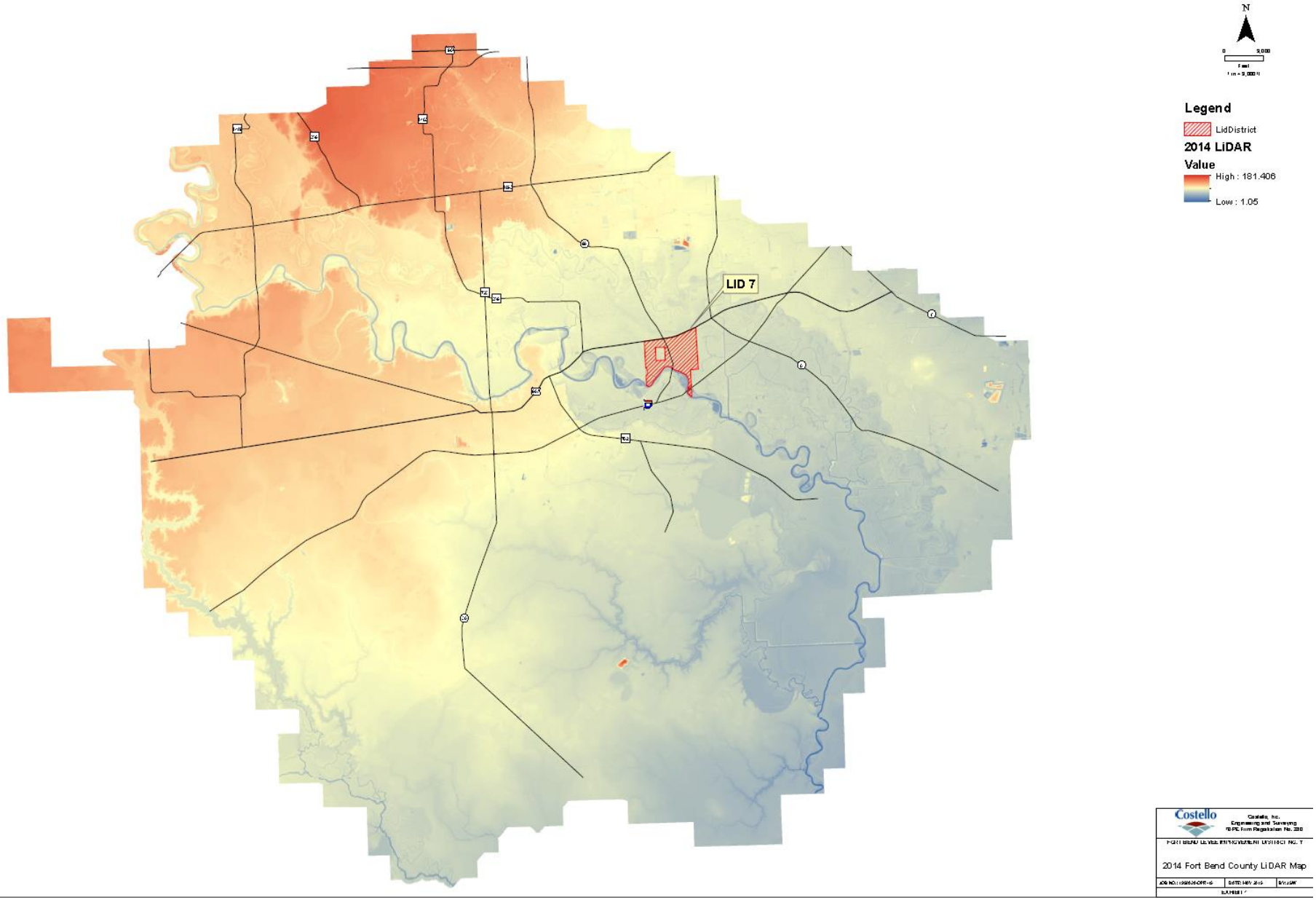
## 10.2 Railroad Track Elevation



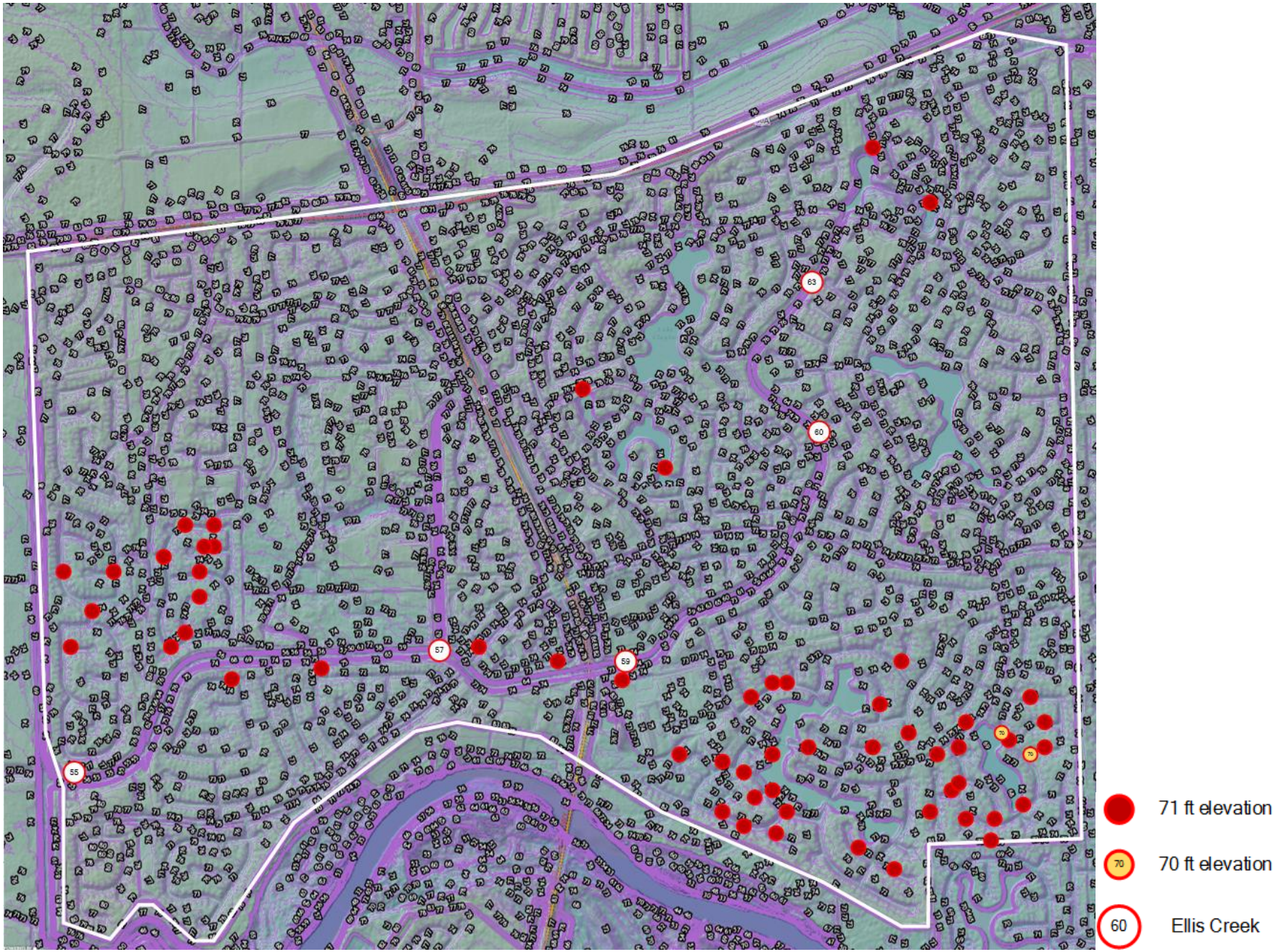
## 10.3 Drainage



## 10.4 LIDAR Full Ft. Bend County



## 10.5 LIDAR LID 7




Lowest elevations within LID 7 are shown as red dots.

## 10.6 New Territory Storm Sewers (East)

## 10.7 New Territory Storm Sewers (West)

# 11 Elevation Cross-Reference

## 11.1 Brazos River

| | Location | RG Elevation | Harvey HWM | Harvey Freeboard | LIDAR Elevation |
|---|---|---|---|---|---|
| A | RR track (90A at Ext channel) | 59.8 | 55.2 | 4.6* | 82.5 |
| A | 90A at Ext channel | 59.3 | 55.2 | 4.1 | 82.0 |
| A | Detention wall (90A at Ext channel) | 61.7 | 55.2 | 6.5* | 83.0 |
| B | Levee (at pump station) | 63.7 | 55.2 | 8.5 | 85.0 |
| C | Levee (SW of Cambridge Park) | 63.7 | 55.2 | 8.5* | 85.0 |
| D | Levee (S of Greystone Place) | 62.2 | 55.2 | 7.0 | 81.0 |
| E | Levee (SE of Lakewind) | | | | 81.0 |
| F | RR track (99 & 90A) | | | | 82.0 |
| F | 99 (frontage NW of Sandhill) | | | | 76.5 |
| F | 99 (frontage NE of Sandhill) | | | | 76.0 |
| G | 90A (commercial NE of school) | 62.2 | 55.2 | 7.0 | 77.5 |
| G | RR track (90A NE corner LID 7) | 63.7 | 55.2 | 8.5* | 79.0 |

## 11.2 Rain Water

| | Location | Rainwater elevation | Theoretical Brazos HWM level | Theoretical Freeboard | Richmond Gauge | Theoretical LID 7 Flood level at RG |
|---|---|---|---|---|---|---|
| F | 99 (frontage NW of Sandhill) | 76.5 | 74.5 | 2.0 | 55.2 | 57.2 |
| G | Commercial tract (NE of school) | 74.0 | | | | |

HWM – High water mark

RG – Richmond Gauge

* Verified by laser level telemetry.

LIDAR (Light Detection and Ranging) – true elevation from LID 7 LIDAR Contour Map (provided by Costello)

All elevations in ft.

# 12 Internal Flood Control

**Overview**

There are only two effective mechanisms to control flooding within the LID 7 levees. These are:

Detention
Pumpage

Detention

New detention is usually an expensive option.

- Land of sufficient acreage must first be available.
- The land must be purchased, which involves either a willing seller or the use of emanant domain.
- The land must be cleared of structures and trees.
- The soil must be removed and the remaining area landscaped to prevent erosion.

Expanded detention is another option available to LID 7. This involves:

- Adding sluice gates to the existing lakes.
- Manually removing the gates to lower lake levels several feet when a Harvey type of event is anticipated.
- This materially increases the detention without the need to acquire new land.

The lake sluice gate option does have a few limitations:

- It is not a passive system. Human action is required to anticipate an event, remove the gates and turn off the lake pumps to prevent them from trying to refill the lakes.
- The action must be timely. Removing the gates after the event has begun, and the pump station external gates have closed, has little benefit.
- There is a small cost to refilling the lakes after the event.
- There may be some aesthetic issues with lowered lake levels.

Pumpage

Two options exist for increasing pumpage:

- Building an entirely new pump station.
- Expanding the existing LID 7 pump station.

Building a new station requires:

- Land with nearby access to both Ellis Creek and the levee.
- Acquiring the land.
- Resolving access issues.
- Building a new pump station.

Expanding capacity at the existing pump station involves either:

- Replacing the existing 22,000 GPM pumps with larger 30,000 GPM pumps.
  - Approximate cost $ 1.0 MM
  - 30% capacity increase
- Adding new pumps in addition to the existing pumps.
  - Approximate cost $ 6.0 MM
  - 120% capacity increase
- Combining both options.

**Recommendations**

- Implement the sluice gate option to increase detention.
  - Lowering lake level has the potential to add 42 MM Gal of additional capacity
  - This compares to 26 MM Gal of capacity added by converting the ball field.
- Expand the existing pump station to increase capacity by 120%.
  - This option requires acquiring a small amount of land from the City of Sugar Land.