Memorial Drive Reconstruction and Access Management

From Beltway 8 northbound frontage road to Tallowood Road

Harris County, Texas

CSJ: 0912-72-391

Drainage Impact Analysis

Prepared on Behalf of:

Texas Department of Transportation

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October 2020

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10/22/2020

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1.0 Executive Summary

TxDOT is proposing a mobility project for approximately 5,000 linear feet of Memorial Drive, extending from Beltway 8 northbound frontage road to Tallowood Road. The limits of this project are contained within the City of Houston Right-of-Way under Memorial City Tax Increment Reinvestment Zone (TIRZ 17). The project is partially federally funded; thus, TxDOT is managing the design and construction phases for this project.

LAN was contracted by TIRZ 17 to perform a drainage impact study for the comprehensive Preliminary Engineering Report (PER) and design along the above-mentioned project limits. This drainage study presents the hydrologic and hydraulic analyses to demonstrate no adverse impact to the Memorial Drive corridor and the surrounding drainage systems.

This study analyzed existing and proposed condition peak flow rates and hydrographs for two storm drainage systems with outfalls located at 1) Station 2+20 (System A Outfall) and 2) Station 43+40 (System B Outfall). System A outfalls into a 78" reinforced concrete pipe (RCP) storm sewer at the intersection of Memorial Drive and Beltway 8 northbound frontage road, which further conveys flow southward through the existing storm sewer. System B outfalls into a 9'x9' reinforced concrete box (RCB) that conveys W153-00-00 through its intersection with Memorial Drive. Under the proposed conditions, all newly-constructed storm sewers in System B will outfall into the existing 9'x9' conveyance culvert for W153-00-00. After leaving the project limits through System A and System B outfalls, the respective outfall systems will eventually drain to Buffalo Bayou (W100-00-00).

A drainage analysis was performed to verify that the proposed storm sewer systems have adequate capacity to accommodate the runoff from the project ROW and contributing drainage areas without resulting in adverse impacts to the receiving outfalls. The existing and proposed storm sewer systems were analyzed for 2-year, 10-year and 100-year storm events. The proposed condition flows were compared against the existing conditions flows to demonstrate no increase in peak flows. Peak existing storage volumes are 1.4, 1.9, and 3.3 acre-feet for the 2-, 10-, and 100-year storms, respectively. Peak proposed storage volumes are 4.7, 9.9, and 16.9 acre-feet for the 2-, 10-, and 100-year storms, respectively.

Memorial Drive is topographically high compared to areas around it and therefore has minor ponding for all evaluated events except for the area just south of W153-00-00 which experiences 100-year overtopping into the roadway. Ponding is present along and outside the right-of-way and relies on storm sewers to drain to the current outfalls at Beltway 8 and W153-00-00. Upstream flow from W153-00-00 overtops Memorial Drive for the 100-year, 24-hour storm event and overland storm water runoff continues south on Somerset Place and Legend Lane to W153-00-00 and ultimately to Buffalo Bayou. Mitigation measures shall consist of in-line detention for System B in the form of dual 10'x5' and dual 10'x10' reinforced concrete box (RCB) culverts with inline restrictors that will connect to the existing 9'x9' RCB. Based on the hydrologic and hydraulic analyses and the proposed storm sewer improvements, the proposed project does not cause adverse impacts for the 2-year, 10-year and 100-year storm events.

2.0 Introduction

2.1 Project Description

The Memorial Drive project limits are classified as an urban local road within the City of Houston limits. The existing roadway consists of 40-foot wide undivided pavement with either a curb and gutter or roadside ditch drainage system along with 4-foot sidewalks on each side. Runoff from the project drains to the existing storm sewer system through a combination of roadside ditches and storm sewer. The roadway within the project limits has a prevailing Right-of-Way (ROW) of 100 feet. The existing and proposed roadway cross sections are presented in **Exhibit 1**.

The proposed roadway improvements include four 11-foot travel lanes with a 6- to 20-foot raised median, left turn lanes at all proposed median openings, and upgrade of existing traffic signals at Beltway 8 and West Bough Ln. Proposed drainage improvements include the installation of curb and grate inlets and oversized reinforced concrete boxes to provide in-line detention along the project limits for the purposes of mitigating drainage impacts. Other project amenities include the installation of an 8-foot wide pedestrian pathway along both sides of Memorial Drive, driveway replacements, the upgrade and/or replacement of existing public utilities as required, improved roadway and pedestrian lighting, as well as additional softscaping and landscaping amenities to promote a pedestrian friendly environment along the project corridor.

Referencing existing conditions, the proposed roadway profile includes lowering in some areas to allow positive drainage to and within the roadway, except at the W153-00-00 crossing area where it is important to maintain the current road profile. Ensuring the revised road profile does not adversely impact the rate of overland sheet flow across Memorial Drive during extreme rainfall events to properties on either side of Memorial Drive is a high priority.

The project currently drains to W153-00-00 and the storm sewer network at Beltway 8 and, due to limited ROW in this area, there are no feasible locations for off-site detention. Therefore, the following improvements are proposed to provide inline detention. The following improvements and the associated project stations can be found in the Memorial Drive construction plan and profile sheets: 1) Ranging from 3’x3’ RCB to 4’x4’ RCB from West Bough Lane to an existing 42” RCP at Beltway 8, 2) dual 10’x5’ RCBs from the intersection of Memorial Drive and West Bough Lane to Sta 30+10, 3) dual 10’x10’ RCBs from Sta 30+10.00 to the proposed 42” RCP restrictor at the existing 9’x9’ box culvert between Sta 43+00 and 44+00, and 4) dual 10’x10’ RCBs from the intersection of Memorial Drive and Tallowood Road to the proposed 24” RCP restrictor at the existing 9’x9’ RCB between Sta 43+00 and 44+00. The dual trunklines serve the purpose of providing additional storage for runoff along Memorial. The restrictors at the junction of Memorial Drive and the W153-00-00 conveyance assist in maintaining flows in reference to existing conditions. These improvements are not to divert water from any other watersheds in the area to W153-00-00. No watershed drainage boundary modifications are proposed as part of this project.

Lowering of the road allows stormwater to collect in low regions and provides additional storage on the roadway surface during extreme events. This is a net benefit for minimizing downstream runoff; however, additional water on the roadway during extreme events may impact mobility.

During less extreme events, overland flows move to the low regions of Memorial Drive. Here, inlets capture and convey storm water to HCFCD Channel Unit No. W153-00-00 via the existing 9'x9' RCB. All connections to this existing box culvert will be restricted to a smaller pipe size (a 42" RCP restrictor from the west and a 24" RCP restrictor from the east) to mitigate impacts to W153-00-00 and mimic existing conditions.

2.2 Purpose of Study

The purpose of this study is to present the hydrologic and hydraulic analysis, impacts and corresponding mitigation measures for the proposed reconstruction and access management of Memorial Drive.

The hydrologic analysis shall consist of examining the runoff impacts associated with the proposed roadway improvements and drainage collection system modifications. Mitigation measures shall consist of providing in-line detention within the project ROW. The hydraulic analysis shall consist of examining the design capacity of each affected drainage structure to determine hydraulic adequacy and propose any structure replacement as well as determine any upstream and downstream hydraulic impacts. The drainage study provides detailed analyses for all conventional storm drainage structures.

2.3 Design Criteria and References

The hydrologic and hydraulic analyses were performed in accordance with the methodology and procedures established in the following documents:

- *Infrastructure Design Manual*, City of Houston: Houston Public Works; September 2018.
- *Flood Insurance Study for Harris County, Unincorporated Area (FIS-4802287L)*; Federal Emergency Management Agency; dated June 18, 2007
- *Field Survey topographic data*, by Baseline Corporation dated 2007

2.4 Flood Hazard Area

The proposed project resides in the City of Houston and is shown on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) Panel No. 48201C0645L, data revised February 12, 2016. The effective FIRM panel indicates that the project crosses Harris County Flood Control District (HCFCD) Channel Unit No. W153-00-00 (Tributary to Buffalo Bayou). The effective FIRM panel indicates that the proposed project is located inside of the FEMA 500-YR (Zone X) floodplain. No base flood elevations have been established for Memorial Drive within the project limits. No fill is anticipated to be placed in the 100-year FEMA floodplain for this project. The limits of the project are shown on the FEMA FIRM in **Exhibit 2**.

2.5 Project Datum

The project datum for the proposed roadway improvements is referenced North American Vertical Datum of 1988 with 2001 adjustment. No vertical adjustments to the datums are necessary for this study.

2.6 Analysis Methodology

The existing and proposed peak runoff flows for each drainage area were calculated for the 2-year, 10-year and 100-year storm events. Since this study has been ongoing for several years, all rainfall rates utilized in the modelling were agreed upon prior to the Atlas 14 updates made to the TxDOT Hydraulic Design Manual in September of 2019. The drainage analysis for Memorial Drive is being performed using InfoWorks ICM, a two-dimensional (2D) dynamic model, developed as part of the TIRZ 17 Regional Drainage Study (RDS). The model was calibrated and validated at previous significant rainfall events and concur with observed conditions for the TIRZ 17 region. The storm sewer systems were evaluated with InfoWorks ICM using the City of Houston Infrastructure Design Manual (September 2018). The 100-yr HGL was evaluated per the design criteria, as summarized below:

1) Maximum ponding depth at low points in the street shall not be 18 inches above the top of curb elevation;
2) Maximum ponding depth at high points in the street shall not be 6 inches above the top of curb elevation;
3) The maximum ponding elevation (MPE) at any point along the street shall not be higher than the natural ground elevation at the right-of-way;
4) Maximum ponding depth shall not exceed 12 inches below the finished slab elevations along the project;
5) Ponding of surface runoff is not allowed in the highest travel lane in each direction.

An existing model of the project area was revised to provide a greater level of detail along Memorial Drive. The existing and proposed drainage systems were analyzed based upon:

- Collecting data for the existing drainage facilities from field investigations, as-built plans, the COH Geographic Information Management System (GIMS), and topographic survey.
- Developing project drainage area maps utilizing LiDAR topography, COH GIMS data, existing storm sewer infrastructure, prior studies and field investigations.
- Identifying drainage system outfalls for the project.
- Determining land use for c values in each drainage area and land use patterns within each drainage area.
- Analyze existing and proposed drainage systems in InfoWorks ICM v8.0 and Winstorm v3.05.

3.0 1-D Analysis

A hydrologic analysis was performed to determine the on-site and off-site peak discharges along the project alignment. The flow rates for the 2-year, 10-year and 100-year design frequencies were computed for each of the contributing drainage areas. This section presents the methodologies, watershed parameters and description of drainage areas associated with the runoff calculations for subarea within the project limits.

3.1 Drainage Areas

The drainage areas for each existing and proposed structure were delineated using a combination of LiDAR data and overland flow patterns from GIMS and survey. The overland flow patterns and ponded depths were determined from GIMS. As-built plans for the roadway were also referenced in determining drainage boundaries and storm sewer tie-in locations for off-site drainage areas. A field visit was conducted to verify the drainage area boundaries and drainage patterns. The overall watershed areas within the project limits are broken into two drainage systems designated as Outfall A towards Beltway 8 and Outfall B to channel W153-00-00. The boundaries of these drainage systems primarily follow subdivisions' divides and HCFCD channel. The prominent direction of flow within the project area is from west to east. The overall drainage area map and internal drainage area map can be seen in **Exhibit 3**.

Table 1. Drainage Areas and "C-Values" for Existing and Proposed Conditions

Drainage Area ID	Existing C Value	Proposed C Value	Drainage Area ID	Existing C Value	Proposed C Value	Drainage Area ID	Existing C Value	Proposed C Value	Drainage Area ID	Existing C Value	Proposed C Value
A-01	0.80	0.80	B-44	0.80	0.80	B-102	0.69	0.71	B-116B	0.67	0.81
A-02	0.80	0.80	B-50	0.80	0.80	B-103	0.65	0.84	B-117	0.59	0.64
A-03	0.80	0.80	B-52	0.80	0.80	B-104	0.68	0.75	B-118	0.82	0.82
A-04	0.80	0.80	B-55	0.80	0.80	B-105	0.65	0.77	B-119	0.63	0.64
A-05	0.80	0.80	B-56	0.80	0.80	B-106	0.77	0.82	B-120	0.83	0.81
A-07	0.80	0.80	B-58	0.80	0.80	B-107	0.74	0.82	B-121	0.60	0.83
A-08	0.80	0.80	B-61	0.80	0.80	B-108	0.74	0.81	B-122	0.61	0.64
A-123A	0.71	0.82	B-63	0.54	0.54	B-109	0.80	0.81	B-124	0.66	0.67
A-123B	0.80	0.84	B-64	0.54	0.54	B-110	0.65	0.80	B-125	0.64	0.82
A-127	0.71	0.84	B-69	0.63	0.64	B-111	0.59	0.62	B-126	0.59	0.63
A-130	0.72	0.82	B-70	0.54	0.54	B-112	0.65	0.83	B-131	0.60	0.63
A-132	0.87	0.86	B-70-2	0.72	0.72	B-113	0.59	0.63	B-133	0.71	0.80
B-14	0.80	0.80	B-71	0.54	0.54	B-114A	0.67	0.83	B-134	0.78	0.80
B-15	0.80	0.80	B-73	0.54	0.54	B-115A	0.59	0.64	B-136	0.61	0.64
B-32	0.80	0.80	B-76	0.80	0.80	B-115B	0.59	0.64	B-139	0.59	0.63
B-41	0.80	0.80	B-101	0.73	0.87	B-116A	0.83	0.84	W-153	0.52	0.52

3.2 Land Use

The predominant land use for the project's contributing drainage areas is categorized as urban and fully developed. The majority of the contributing drainage areas are multi-family residential and commercial areas. The existing topography in the proposed project area slopes largely from the relatively high elevations at Beltway 8 to the lower lying region near channel W153-00-00 along Memorial Drive. The land uses for the offsite areas were evaluated using aerial photographs and project topographic files. Along the project corridor, the majority of the offsite contributing drainage area are located north of Memorial Drive within the W153-00-00 watershed. The existing and proposed land use maps can be seen in **Exhibit 4**.

3.3 1-D Hydrologic Methodology

The hydrologic analysis for the proposed project utilized the Rational Method to compute the runoff peak discharges for the contributing drainage areas.

3.4 Rational Method

The Rational Method parameters include the drainage area, the runoff coefficient, time of concentration, and rainfall intensity. The Rational Method equation is provided as Equation 1.

$$Q = CIA \qquad \textit{Equation 1}$$

In which: Q (cfs) is the computed peak runoff discharge,

C is the runoff coefficient,

I (in/hr) is the rainfall intensity,

A (ac) is the drainage area.

Runoff coefficients (C-value) for the roadway and contributing drainage areas are based on land use. Within the project ROW, the impervious cover was measured from a detailed survey and "as-built" construction plans. The impervious areas within the ROW considered pavement, driveways, and intersecting paved roadways. The offsite contributing drainage area impervious covers were determined by using aerial photography and the project topographic files. The C-values selected for the offsite contributing areas included 0.80 for multi-family/business areas and 0.54 for residential/family unit areas. For the large W153 watershed area a composite C was evaluated, and TC was adjusted to match peak flows determined in the 2D analysis for a 10yr event. A summary of the runoff coefficients is provided in **Table 2**. The runoff coefficients were taken from Chapter 9 of the City of Houston Infrastructure Design Manual.

Table 2. Summary of Rational Method Runoff Coefficients "C-Values"

Land Use Description	C-Value
Pavement	0.90
Multi-family/Business areas	0.80
Residential	0.54
Grass	0.35

Time of Concentration was determined by utilizing the time of concentration equation from the City of Houston IDM, Chapter 9.

$$TC = 10A^{0.1761} + 15 \qquad \textit{Equation 2}$$

In which: TC (minutes) is the computed time of concentration,

A (ac) is the drainage area

Rainfall Intensity calculations using the Rational Method is dependent on the time of concentration and the intensity coefficients (e, b, and d), which are storm frequency- and location-specific. The entire project resides within City of Houston, the e, b and d factors were taken from the TxDOT values provided in the TxDOT GeoPAK Drainage library updated in 2016. The equation for computing the rainfall intensity is provided in Equation 3. The multiple frequency intensity coefficient values for Harris County are provided in **Table 3**.

$$I = \frac{b}{(d+Tc)^e} \qquad \textit{Equation 3}$$

In which: T_C (min) is the time of concentration,

I (in/hr) is the rainfall intensity

Table 3. Rational Method e, b, d Coefficients – TxDOT (July 14, 2016)

Coefficient	2-year	10-year	100-year
e	0.7939	0.7829	0.7720
b (in.)	57.73	86.47	136.33
d (min.)	9.48	11.27	14.08

3.5 Peak Discharge Rates

A summary of existing and proposed peak discharge rates is presented in **Exhibit 5**. The peak flow of each drainage area was calculated using the Rational Method. The proposed storm sewers were evaluated for the 2, 10 and 100-year storm events, and designed for the 2-year storm event. The 10-yr and 100-yr hydraulic analysis was performed using a 2D approach to better analyze hydraulic behavior when the storm sewer system is surcharged.

3.6 2-yr Hydraulic Grade Line Determination

The proposed storm sewer was modeled using Microstation GeoPAK application and was used to develop a 2-yr hydraulic grade line for both systems. The 2-yr results can be found in Appendix 2 and Appendix 3.

4.0 2-D Analysis

4.1 Existing Drainage Conditions

The Memorial Drive project is located within the Buffalo Bayou watershed. The existing roadway within the project limits is served by two primary storm sewer systems (A and B). System A collects runoff from the areas north of Memorial from Beltway 8 to West Bough Lane. System B drains from just east of Beltway 8 to the east and then extending south to W153-00-00 and from Memorial Drive east of Paul Revere Drive to W153-00-00.

There are two primary outfall locations for this project:

- System A Outfall – Outfall A receives flow from the alignment following the northern and eastern extents of the ROW and conveys flow from the drainage area to the outfall at the intersection of Beltway 8 and Memorial Drive. It is composed of 24" RCP from West Bough Lane to the confluence at Sta 10+00. From Sta 10+00 to the confluence at Sta 7+00 the storm sewer is composed of 30" RCP and then continues as 42" RCP until terminating into Outfall A at the intersection of Beltway 8 and Memorial Drive.
- System B Outfall –Outfall B receives flow from the alignment following the northern and eastern extents of the ROW conveys flow from the drainage area to the outfall at W153-00-00. It is composed of dual 24" RCP from West Bough Lane to the confluence of the two pipes into a single 24" RCP at Sta 16+60. A single 24" RCP continues from this point until just south of the intersection of Memorial Drive and Old Oaks Drive. A grass-lined ditch then extends from Old Oaks Drive to just south of the intersection of Memorial Drive and Huntingwick Drive. Beyond Huntingwick Drive, dual 24" RCP's continue up to the intersection of Memorial Drive and Memorial Bend. From this intersection to Outfall B, the drainage system is primarily grass-lined ditch. To the east of W153-00-00 along the northern portion of the ROW, a 36" RCP conveys water from the intersection of Memorial Drive and Tallowood Road to Outfall B. The System B alignment following the southern and western extents of the ROW conveys flow from the drainage area to the outfall at W153-00-00. It is composed of grass-lined ditch from the intersection of Memorial Drive and West Bough Lane to Boheme Drive. From Boheme Drive to Sta 30+40, the storm sewer is 24" RCP and to 38+20 is 36" RCP. Sta 38+20 to Sta 39+00 is composed of 42" RCP until the storm sewer expands to 48" RCP at Sta 39+00. The size of the storm sewer remains the same from Sta 39+00 until Outfall B. The portion of the System B alignment west of West Bough Lane following the southern and western extents of the ROW conveys flow from the drainage area to its termination at the intersection of Memorial Drive and West Bough Lane. The system is composed of 18" RCP throughout this alignment.

Memorial Drive is topographically high compared to areas around it and therefore has minor ponding for all evaluated events except for the area just south of W153-00-00 which experiences 100-year overtopping into the roadway. Ponding is present along the right-of-way and relies on storm sewer to drain to the current outfalls at Beltway 8 and W153-00-00. Upstream flow from W153-00-00 overtops Memorial Drive for the 100-year, 24-hour storm event and overland storm

water runoff continues south on Somerset Place and Legend Lane to W153-00-00 and Buffalo Bayou.

4.2 Proposed Drainage Conditions

Compared with existing conditions, the proposed curb and gutter roadway profile will be lowered in certain areas to allow positive drainage from the ROW to roadway, except in the W153-00-00 crossing area where it is important to maintain the current road profile. It was a high priority to ensure the revised road profile did not adversely impact the rate of overland sheet flow across Memorial Drive during extreme rainfall events to properties on either side of Memorial Drive, which was validated from the 2D analysis. LAN iterated proposed roadway and drainage improvement options along Memorial Drive and determined a proposed design that has no adverse drainage impacts to areas along and upstream/downstream of the project.

Most of the project currently drains to Outfall B (W153-00-00), which matches existing drainage conditions. Due to limited ROW in this area there are no feasible locations for off-site detention for this project. Therefore, oversized storm sewer improvements of large reinforced concrete box culverts are proposed to provide inline detention. The larger underground storm sewer culverts are needed to store and hold runoff along Memorial and then restrict flows to W153-00-00 to maintain or reduce flows in comparison to existing conditions. These improvements are not to divert water from any other watersheds in the area to W153-00-00. No watershed drainage boundary modifications are proposed as part of this project.

Reducing the elevation of the road allows stormwater to collect in low regions, which provides additional storage on the roadway surface during extreme events. However, ponding on the roadway during extreme events can impact mobility. During less extreme events, water overland flows to the low regions of Memorial Drive where inlets capture and conveys it to HCFCD Unit W153-00-00 that crosses Memorial Drive as a 9'x9' box culvert. All connections to this existing box culvert will be restricted with a smaller pipe (currently a 42" RCP restrictor on the west, and 24" RCP restrictor on the east) to mitigate impacts to W153-00-00 and match existing conditions. Proposed box sizes along Memorial Drive include dual 10'x5' RCBs from West Bough Lane to Boheme Drive, and dual 10'x10' RCB's from Boheme Drive to W153-00-00. All existing drainage watersheds will match existing conditions. Ponding extents are reduced from existing to proposed conditions outside of the Memorial Drive ROW as seen in **Exhibits 6-11**.

Detention requirements were determined based on the difference between the total proposed impervious area of 255.80 acres and total existing impervious area of 253.99 acres. The required detention was determined to be 0.92 ac-ft. The proposed condition provides adequate storage volume to meet detention requirements.

The differences in the peak volume of stormwater stored in subsurface storm sewer and surface roadway or ditch detention within the Memorial Drive R.O.W. can be seen in Table 4 on the following page.

Table 4. Peak Storage Volumes within Memorial Drive R.O.W.

		Storm Sewer Volume (ac-ft)	Surface Volume (ac-ft)	Total Volume (ac-ft)
2-YR Event	Existing	0.8	0.6	1.4
	Proposed	4.7	0.0	4.7
	Delta	3.9	-0.6	3.3
10-YR Event	Existing	0.9	1.0	1.9
	Proposed	9.2	0.7	9.9
	Delta	8.3	-0.3	8.0
100-YR Event	Existing	1.1	2.1	3.3
	Proposed	13.4	3.5	16.9
	Delta	12.3	1.4	13.7

4.2.1 Hydraulic Grade Lines Along the Project Roadway

Water surface elevations were generated for 10-year and 100-year events for both existing and proposed drainage systems along the profile grade line. Due to the proposed surface adjustments which creates low points within the ROW to store runoff, locations were chosen along the roadway centerline for analyzing any impacts on water surface elevations caused by the proposed improvements. The analysis shows that the proposed drainage system does not meet the City of Houston criteria for the 100-year storm event. Maximum 100-yr ponding depths at high points exceed 6” above curb. Additionally, ponding occurs in all travel lanes for the 100-yr event. In lowering the roadway profile of Memorial Drive, overall flooding depths will be increased within the ROW in order to lessen the impacts to areas outside of the roadway.

Tables 5 and 6 show comparisons between the existing and proposed hydraulic grade lines at specific project roadway stations for the 10-year and 100-year 24-hour storm events, respectively. Roadway centerline stations that experience no ponding (due to the ground elevation exceeding the hydraulic grade line elevation) are assigned that location’s ground elevation.

Table 5. 10-yr Hydraulic Grade Line Comparison

Station	Plan Node ID	ICM Node ID	Existing HGL (ft)	Proposed HGL (ft)	Δ HGL (ft)
4+69.95	#B131	mem59	72.9	72.9	0.00
6+25.36	#B129	mem62	72.9	72.9	0.00
9+73.26	#B150	mem67	72.8	72.8	0.00
12+80.62	#B123	5117	71.7	71.7	0.00
16+44.98	#B120	Memorial_R_01	70.7	70.7	0.00
18+20.17	#B118	Memorial_R_03	69.3	69.3	0.00
21+53.79	#B116	Memorial_R_05	68.2	68.2	0.00
23+00.71	#B138	mem50	68.7	68.7	0.00
24+16.00	#B114	mem54	68.6	68.6	0.00
26+18.05	#B112	Memorial_R_07	68.4	68.4	0.00
27+31.01	#B111	mem48	69	69.0	0.00
29+00.00		BOHEME	68.6	68.6	0.00
30+10.02	#B125	Memorial_R_09	68.4	68.4	0.00
32+16.00	#BXX	mem41	67.9	67.9	0.00
34+37.99	#B106	mem37	67.2	67.2	0.00
36+00.00		36+00.00	67.7	67.7	0.00
38+25.01	#B105	mem26	67.4	67.4	0.00
40+42.98	#B104	mem18	67.9	67.9	0.00
43+18.00	#B102	mem18!	67.1	67.1	0.00
47+49.99	#B133	mem5	67.7	67.7	0.00

Table 6. 100-yr Hydraulic Grade Line Comparison

Station	Plan Node ID	ICM Node ID	Existing HGL (ft)	Proposed HGL (ft)	Δ HGL (ft)
4+69.95	#B131	mem59	72.9	72.9	0.00
6+25.36	#B129	mem62	72.9	72.9	0.00
9+73.26	#B150	mem67	72.8	72.8	0.00
12+80.62	#B123	5117	71.9	71.9	0.00
16+44.98	#B120	Memorial_R_01	70.8	70.8	0.00
18+20.17	#B118	Memorial_R_03	69.4	69.4	0.00
21+53.79	#B116	Memorial_R_05	68.3	68.3	0.00
23+00.71	#B138	mem50	68.7	68.7	0.00
24+16.00	#B114	mem54	68.6	68.6	0.00
26+18.05	#B112	Memorial_R_07	68.4	68.4	0.00
27+31.01	#B111	mem48	69.0	69.0	0.00
29+00.00		BOHEME	68.6	68.6	0.00
30+10.02	#B125	Memorial_R_09	68.4	68.4	0.00
32+16.00	#BXX	mem41	68.1	68.1	0.00
34+37.99	#B106	mem37	68.1	68.1	0.00
36+00.00		36+00.00	68.1	68.1	0.00
38+25.01	#B105	mem26	68.1	68.1	-0.01
40+42.98	#B104	mem18	68.1	68.1	-0.01
43+18.00	#B102	mem18!	68.3	68.3	0.00
47+49.99	#B133	mem5	68.3	68.3	-0.02

4.3 Summary of Roadway Drainage Analysis

As noted previously, the overall goal is to prevent or mitigate adverse hydraulic impacts to areas upstream and downstream of Memorial Drive. Additionally, Memorial Drive project roadway

alignment centerline was evaluated to ensure that the water surface elevation is maintained or lower than existing conditions despite the increased ponding depth generated from a lower roadway profile. As shown in Tables 5 and 6, the water surface elevations are reduced or maintained for the three analyzed storm events at the key alignment stations listed. The following impact analysis demonstrates that there are no impacts at critical locations, in terms of flow and water surface elevation, that would cause impacts to surrounding systems. These locations include system outfalls into both the Beltway 8 storm sewer and the downstream portion of channel W153-00-00. The upstream end of channel W153-00-00 to the north of Memorial Drive was evaluated to determine any potential impacts to the flow entering the Memorial Drive storm sewer and any rises in water surface elevations.

5.0 Impact Analysis

A runoff impact analysis was performed to determine the potential runoff impacts resulting from the proposed roadway improvements. The existing storm sewer is deficient and doesn't meet the 100-year criteria. The intention is to reduce the impacts of areas outside of the Memorial Drive ROW without impacting downstream systems. The roadway ponding criteria is not met for the maximum depth at high points, nor is it met for the removal of ponding from the highest travel lane in each direction. This section contains results from the impact analysis performed in ICM which analyzes the effect of the proposed storm sewer on the hydraulic grade lines and flow rates to upstream and downstream systems. Potential runoff impacts associated with the proposed roadway improvements are presented to quantify the influences to these surrounding systems.

5.1 Runoff and Outflow Impacts

The runoff impact analysis determined the increase in relative peak runoff at each outfall resulting from roadway improvements within the project ROW. No changes to the existing drainage patterns are proposed. Drainage areas are limited to those within project ROW. These areas represent the Memorial Drive ROW runoffs contributing to their respective outfalls.

The existing 10-year and 100-year analyses indicated that the existing storm sewer is severely inadequate and will require major storm sewer upgrades. Solely upsizing the storm sewer can significantly increase the flows at storm sewer outfalls. A hydraulic routing analysis was developed within the project limits to determine the existing flow rates and proposed flow rates. A mitigation analysis was conducted at Outfall B to determine the oversized storm trunk line sizes and the restrictor sizes needed to mitigate increases in peak flows. Runoff hydrographs were developed for both existing and proposed conditions.

The proposed storm sewer improvements include oversized storm sewer boxes and restricted storm sewer outfalls. This was done to increase the capture of overland flows prior to leaving the project ROW while eliminating adverse impacts to the HCFCD channel at the outfall. The hydraulic analysis demonstrated that the proposed drainage improvements will flatten the hydraulic grade line (HGL) slopes within the proposed system trunk line. The increased capacity of the proposed system helps to maintain the water surface elevation in the ROW relative to the tailwater conditions at W153-00-00 at the downstream end of System B.

The proposed Memorial Drive drainage improvements include:

- Replacements of the existing 42" RCP storm sewer along the northern and eastern extents of the Memorial Drive ROW from Beltway 8 to West Bough Lane with 4'x4' and 3'x3' RCB sections, which will connect to Outfall A (West Sam Houston Roll Road SBFR) through a 24" RCP restrictor.
- Replacement of the existing 18" RCP storm sewer along the southern and western extents of the Memorial Drive ROW from Beltway 8 to West Bough Lane with 48" RCP from Sta 4+60 to West Bough Lane.

- Replacement of the existing drainage system along both extents of the Memorial Drive ROW with dual 10'x5' RCBs from West Bough Lane to Sta 30+00.
- Replacement of the existing drainage system along both extents of the Memorial Drive ROW with dual 10'x10' RCBs from Sta 30+00 to Outfall B. At the outfall, 42" RCP restrictor is proposed to reduce outflow from the proposed storm sewer into the existing 9'x9' box culvert at W153-00-00.
- Replacement of the existing 36" RCP storm sewer traversing the northern edge of the Memorial Drive – Tallowood Road intersection with 48" RCP.
- Replacement of the existing 36" RCP storm sewer from Tallowood Road to the outfall at W153-00-00 with dual 10'x10' RCBs. At the outfall, 24" RCP restrictor is proposed to reduce outflow from the proposed storm sewer into the existing 9'x9' box culvert at W153-00-00.
- Installation of a 36" RCP to connect the proposed 36" RCP traversing the southern edge of the Memorial Drive – Tallowood Road intersection with the proposed dual 10'x10' RCBs at Sta 48+00.

The InfoWorks ICM analyses indicate that the proposed improvements will create no increase in 10-year, 100-year and 500-year storm sewer and overland peak flows towards the receiving outfall channel. Flow and water surface elevation were evaluated at four locations to determine no adverse impact to surrounding areas and downstream channels or systems. **Exhibits 6-11** depict locations where overland flow and water surface elevations were evaluated. As seen in these exhibits and the attached hydrographs for each location, there are no increases in peak flows at W153-00-00 south of Memorial Drive for the 10-year, 100-year and 500-year storm events.

5.1.1 Location 1 – Memorial Drive Overflow

As seen on **Exhibits 6-11**, Location 1 is located on the southern border of Memorial Drive near the existing 9'x9' RCB conveying channel W153-00-00, parallel to the road. This analysis line was selected to ensure no additional flow was leaving the Memorial Drive right-of-way. As seen in Table 7, Location 1 displays no adverse impact for both flow and water surface elevation for the 10-year, 100-year and 500-year storm events.

Table 7. Location 1 Impact Evaluation

	10-YR Event	100-YR Event	500-YR Event
Existing Max Flow Q (cfs)	0.00	420.33	1068.84
Proposed Max Flow Q (cfs)	0.00	403.22	976.09
Delta Flow Q (cfs)	0.00	-17.12	-92.75
Existing Max HGL (ft)	66.80	68.29	69.27
Proposed Max HGL (ft)	66.80	68.22	69.26
Delta HGL (ft)	0.00	-0.07	-0.01

5.1.2 Location 2 – W153-00-00 Downstream of Memorial

As seen on **Exhibits 6-11**, Location 2 is located downstream of Memorial Drive along W153-00-00. Location 2 discharges from System Outfall B. This analysis line was selected to ensure no additional flow enters W153-00-00 as a result of the Memorial Drive proposed improvements. This location includes the combined flow generated from both the existing storm sewer outfall and the overland sheet flow into channel W153-00-00. As seen in Table 8, Location 2 details no adverse impact for water surface elevations or streamflow for the 10-year, 100-year and 500-year storm events.

Table 8. Location 2 Impact Evaluation

	10-YR Event	100-YR Event	500-YR Event
Existing Max Flow Q (cfs)	667.18	794.45	906.29
Proposed Max Flow Q (cfs)	647.41	769.15	872.40
Delta Flow Q (cfs)	-19.77	-25.30	-33.89
Existing Max HGL (ft)	58.44	65.29	69.25
Proposed Max HGL (ft)	58.44	65.29	69.25
Delta HGL (ft)	0.00	0.00	0.00

5.1.3 Location 3 – Memorial Drive Outfall to Beltway 8 System

As seen on **Exhibits 6-11**, Location 3 is located at the intersection of Memorial Drive and Beltway 8. Location 3 discharges to System Outfall A. This analysis line was selected to ensure no additional flow enters the Beltway 8 drainage system as a result of the Memorial Drive proposed improvements. As seen in Table 9, Location 3 details no adverse impact for the water surface elevation or flow discharges for the 10-year, 100-year and 500-year storm events.

Table 9. Location 3 Impact Evaluation

	10-YR Event	100-YR Event	500-YR Event
Existing Max Flow Q (cfs)	608.86	766.60	708.26
Proposed Max Flow Q (cfs)	603.96	757.16	704.36
Delta Flow Q (cfs)	-4.90	-9.44	-3.90
Existing Max HGL (ft)	58.59	65.47	69.45
Proposed Max HGL (ft)	58.59	65.47	69.45
Delta HGL (ft)	0.00	0.00	0.00

5.2 Computational Nuances

A proposed terrain was developed within the project ROW to represent post-project conditions for the proposed design of the Memorial Drive roadway. This means that two different terrains were used between existing (LiDAR based) and proposed conditions (LiDAR based supplemented with proposed Memorial Drive roadway). The terrains were used to create the 2D mesh (or ground surface) within the model to simulate overland flow and ponding elevations. Since there are two different terrains, there was also the need to generate separate meshes for existing and proposed conditions. Due to the differences in the terrain within the Memorial Drive project ROW, small differences in the mesh elevations propagate across the full extents of the model. These minor elevation differences result in extremely minor mesh differences even away from the project limits. After evaluating the causes of the mesh differences, it has been determined that these locations are not representative of an increase in flood risk.

These locations do not represent an increase in flood risk because the minimal difference in ground elevation at a particular mesh element can produce a localized artificial impact. In all instances, the artificial impacts are fully surrounded by areas experiencing reductions or no changes to water surface elevation. To minimize these differences and artificial impacts, adjustments were made such as increasing the 2D mesh resolution throughout the entire model and other, more targeted, surface data adjustments such as mesh zones, break lines, and terrain-sensitive meshing.

5.3 Summary of Impact Analysis

As noted previously, the overall goal is to eliminate or mitigate adverse hydraulic impacts to areas upstream and downstream of Memorial Drive. This impact analysis demonstrates that there are no impacts at the critical flow and ponding locations noted above. These locations include system outfalls into both the Beltway 8 storm sewer and the downstream portion of channel W153-00-00. Additionally, the Memorial Drive project roadway alignment was evaluated to ensure that the overall water surface elevation is maintained or lower than existing conditions despite the

increased ponding depth generated from a lower roadway profile. A graphical representation of Tables 7-9 and the source model elements for the comparisons can be found in Appendix 4.

6.0 Conclusion

The purpose of this study is to present a hydrologic and hydraulic analysis for the Memorial Drive Reconstruction and Access Management project. The study shall determine the existing drainage needs of the project area, needs associated with the reconstruction of the new road and required mitigation for the system to avoid increase outflow for the systems.

For the proposed project, it was recommended that all storm sewer conduits within the project ROW be replaced. The coupled 1D/2D InfoWorks ICM analysis indicated that most trunk lines must be upsized to lower the 100-year water surface elevation below critical water surface elevation. This increase in conduit sizes would typically lead to increased outflow. To prevent increased outflow into W153-00-00, pipelines will be restricted to 42" RCP on the west and 24" RCP on the east of the improvements tying into the existing Outfall B. The peak outflows from the project area to downstream systems are decreased for the 10-year, 100-year and 500-year storm event due to proposed improvements. The hydraulic grade line for all the systems are generally lowered with localized areas experiencing marginal increases within the Memorial Drive ROW. However, the proposed improvements do not provide the ponding depth and water surface elevation reductions required to meet the 100-year criteria set by the City of Houston IDM. The recommended mitigation measures will provide additional roadway and underground storage and include a minor reduction in overall ponding extents outside of the Memorial Drive ROW without impacting areas downstream of Outfall A and Outfall B to prevent adverse impacts to the downstream HCFCD channels.

The differences in the peak volume of stormwater stored in subsurface storm sewer and surface roadway or ditch detention can be seen in Table 10 below.

Table 10. Peak Storage Volumes within Memorial Drive R.O.W.

		Storm Sewer Volume (ac-ft)	Surface Volume (ac-ft)	Total Volume (ac-ft)
2-YR Event	Existing	0.8	0.6	1.4
	Proposed	4.7	0.0	4.7
	Delta	3.9	-0.6	3.3
10-YR Event	Existing	0.9	1.0	1.9
	Proposed	9.2	0.7	9.9
	Delta	8.3	-0.3	8.0
100-YR Event	Existing	1.1	2.1	3.3
	Proposed	13.4	3.5	16.9
	Delta	12.3	1.4	13.7

EXHIBITS

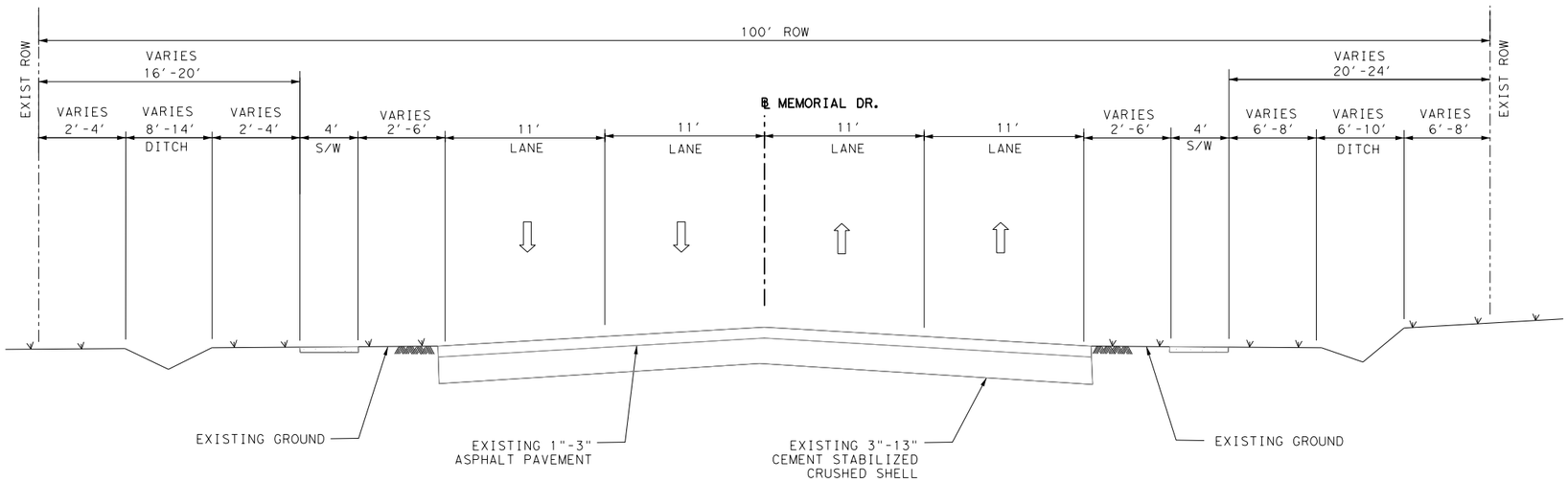
EXHIBIT 1

EXISTING & PROPOSED ROADWAY TYPICAL SECTIONS

LEGEND

⇨ EXISTING TRAFFIC DIRECTION

S/W SIDEWALK



EXIST TYPICAL SECTION

N.T.S.

POSTED SPEED 35 MPH

REV. NO.	DATE	DESCRIPTION	BY

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EXIST TYPICAL SECTION

EXHIBIT 1 SHEET 1 OF 1

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	6

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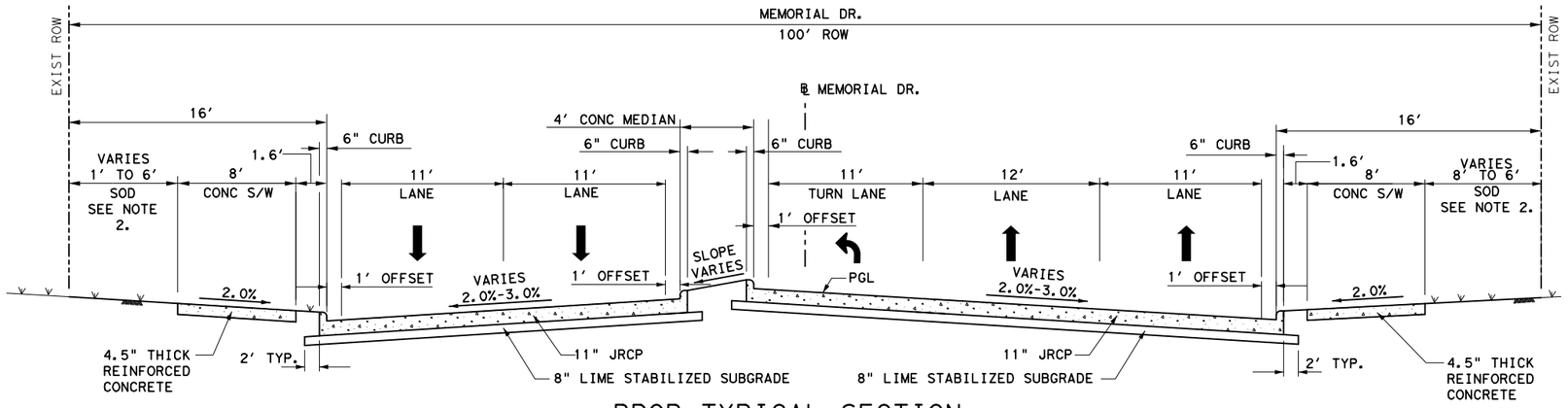
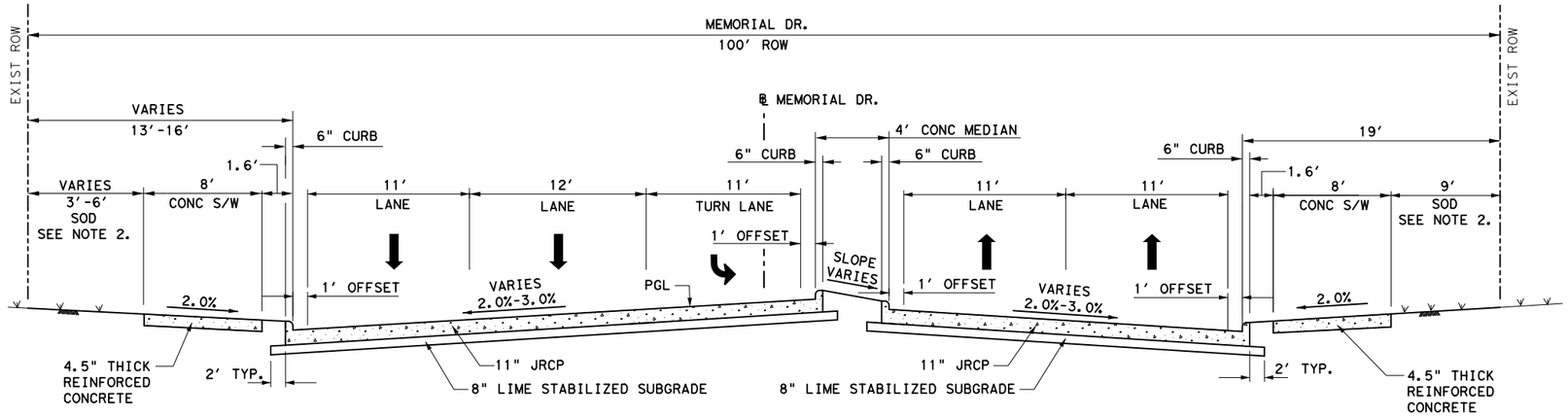


PROP TYPICAL SECTION

STA 4+45 TO STA 10+33
STA 11+98 TO STA 15+20
STA 16+55 TO STA 18+88
STA 20+60 TO STA 22+34
STA 23+50 TO STA 25+98
STA 31+65 TO STA 33+52
STA 34+55 TO STA 36+70
STA 39+40 TO STA 42+50
STA 46+77 TO END PROJECT



PROP TYPICAL SECTION

BEGIN TO STA 4+45
STA 15+20 TO STA 16+55
STA 29+32 TO STA 31+65
STA 38+20 TO STA 39+40
STA 42+50 TO STA 43+11
STA 45+69 TO STA 46+77

POSTED SPEED 35 MPH

LEGEND

➡	DIRECTION OF TRAVEL
▱	PROP CONC PAVEMENT
S/W	SIDEWALK
JRCP	JOINT REINFORCED CONCRETE PAVEMENT
PGL	PROFILE GRADE LINE

NOTES:

1. REFER TO DETAILS UNDER ROADWAY STANDARDS FOR PERTINENT INFORMATION.
2. PLACE ONE SOD STRIP ADJACENT TO BACKS OF CURB AND BETWEEN SIDEWALK AND ROW WHEN 12 INCHES APART OR LESS.
3. EXTEND CROSS SLOPES TO MEET IF NO MEDIAN IS PROPOSED.

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PROPOSED TYPICAL SECTION

EXHIBIT 1 SHEET 1 OF 3

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DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	7

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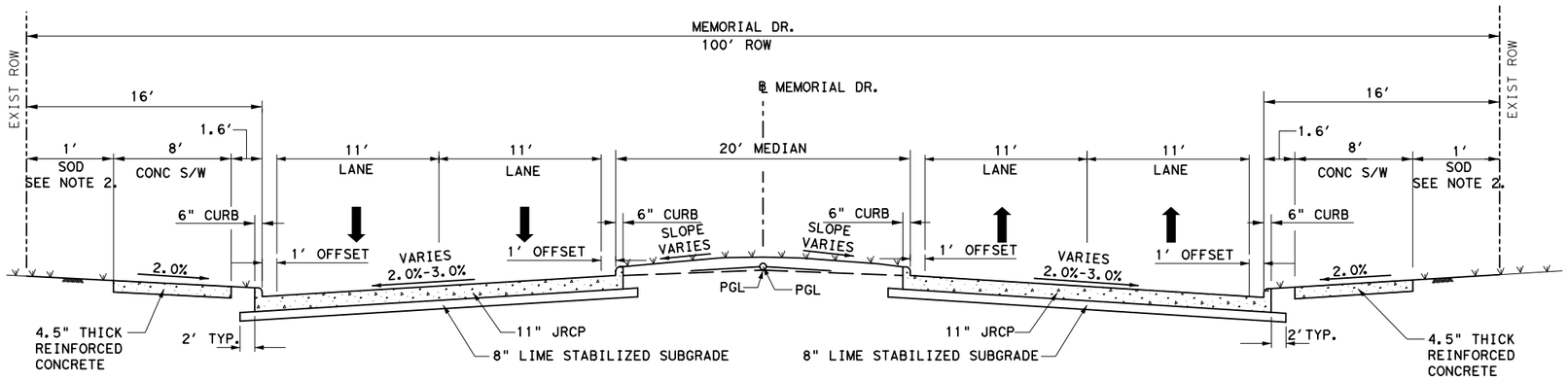
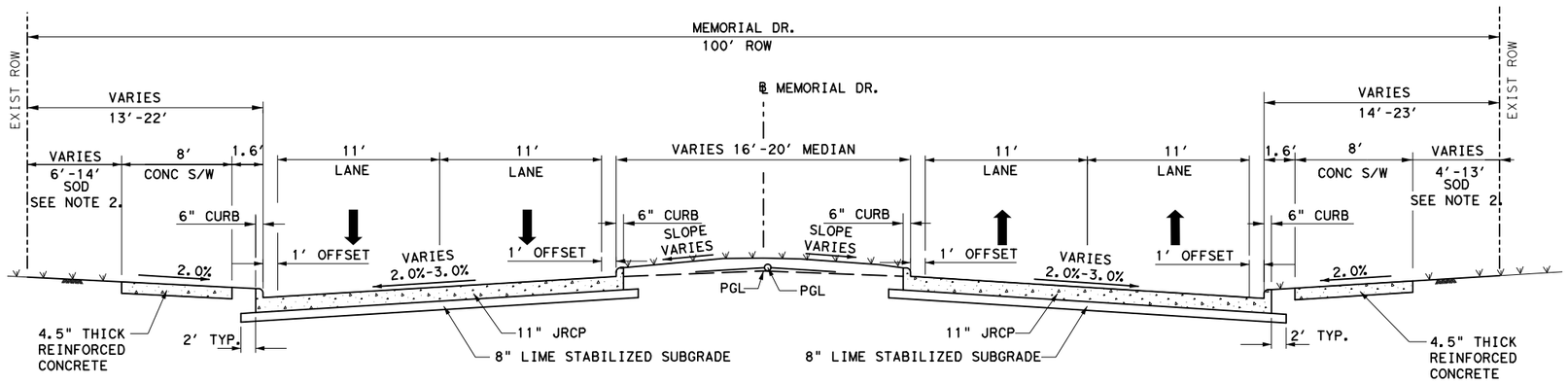


PROP TYPICAL SECTION

STA 10+33 TO STA 11+98
STA 18+88 TO STA 20+60
STA 22+34 TO STA 23+50



PROP TYPICAL SECTION

STA 25+98 TO STA 29+32
STA 43+11 TO STA 45+69

POSTED SPEED 35 MPH

LEGEND

➡	DIRECTION OF TRAVEL
▱	PROP CONC PAVEMENT
S/W	SIDEWALK
JRCP	JOINTED REINFORCED CONCRETE PAVEMENT
PGL	PROFILE GRADE LINE

NOTES:

1. REFER TO DETAILS UNDER ROADWAY STANDARDS FOR PERTINENT INFORMATION.
2. PLACE ONE SOD STRIP ADJACENT TO BACKS OF CURB AND BETWEEN SIDEWALK AND ROW WHEN 12 INCHES APART OR LESS.
3. EXTEND CROSS SLOPES TO MEET IF NO MEDIAN IS PROPOSED.

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PROPOSED TYPICAL SECTION

EXHIBIT 1 SHEET 2 OF 3

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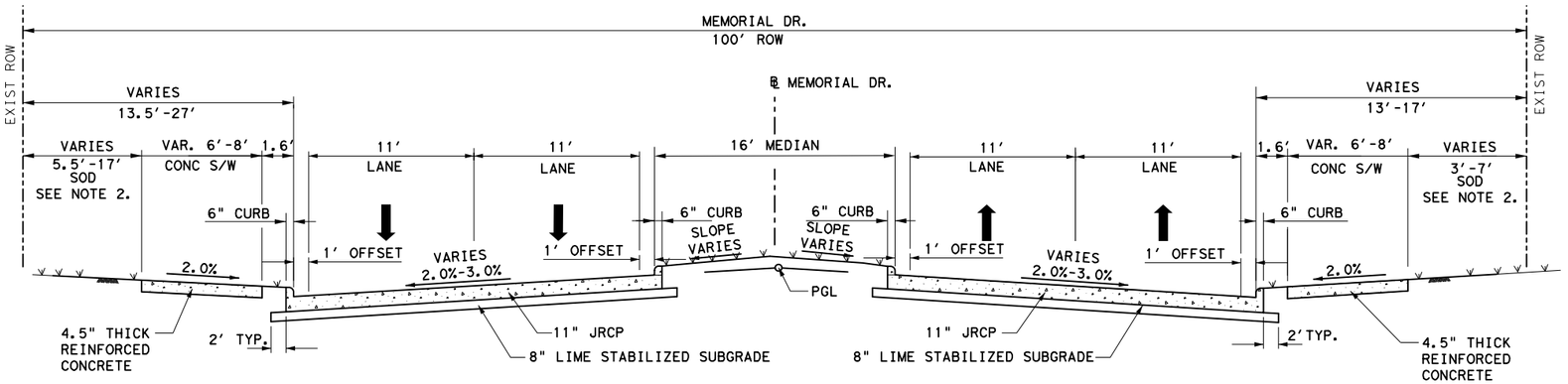


PROP TYPICAL SECTION

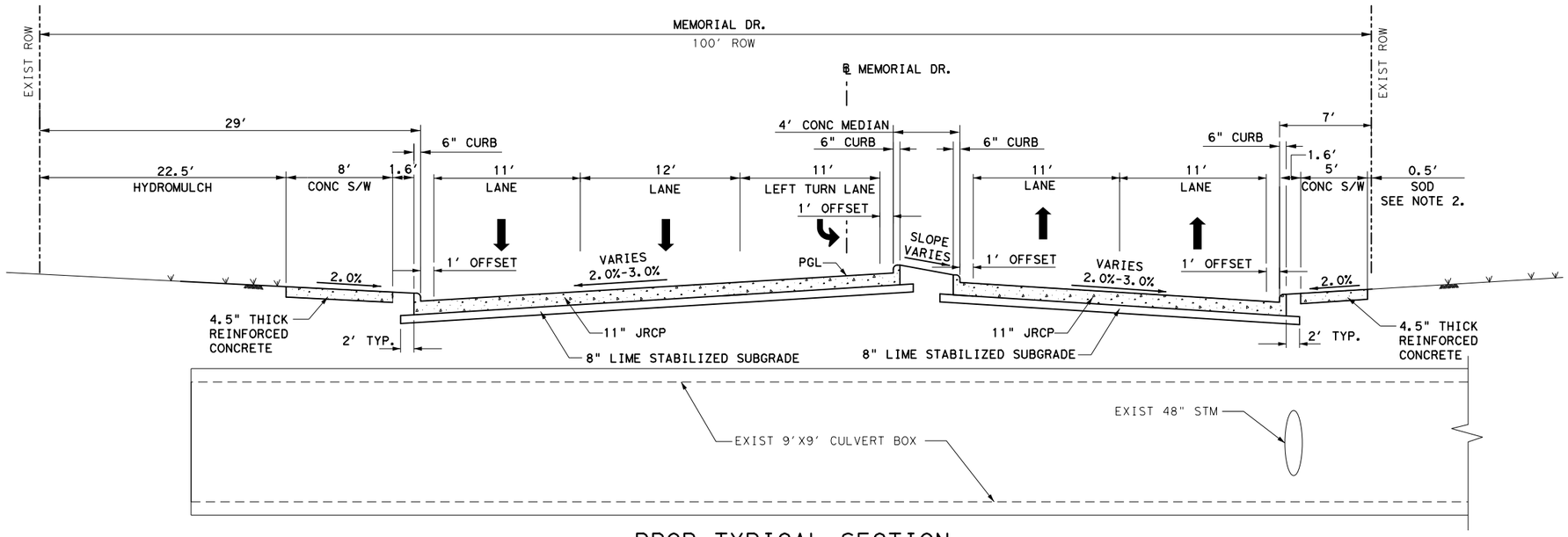
STA 26+92 TO STA 28+80
STA 33+52 TO STA 34+55
STA 44+76 TO STA 45+16
STA 36+70 TO STA 38+20

LEGEND

➡	DIRECTION OF TRAVEL
▱	PROP CONC PAVEMENT
S/W	SIDEWALK
JRCP	JOINTED REINFORCED CONCRETE PAVEMENT
PGL	PROFILE GRADE LINE

NOTES:

1. REFER TO DETAILS UNDER ROADWAY STANDARDS FOR PERTINENT INFORMATION.
2. PLACE ONE SOD STRIP ADJACENT TO BACKS OF CURB AND BETWEEN SIDEWALK AND ROW WHEN 12 INCHES APART OR LESS.
3. EXTEND CROSS SLOPES TO MEET IF NO MEDIAN IS PROPOSED.



PROP TYPICAL SECTION

STA 43+50.00

POSTED SPEED 35 MPH

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PROPOSED TYPICAL SECTION

EXHIBIT 1 SHEET 3 OF 3

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	9

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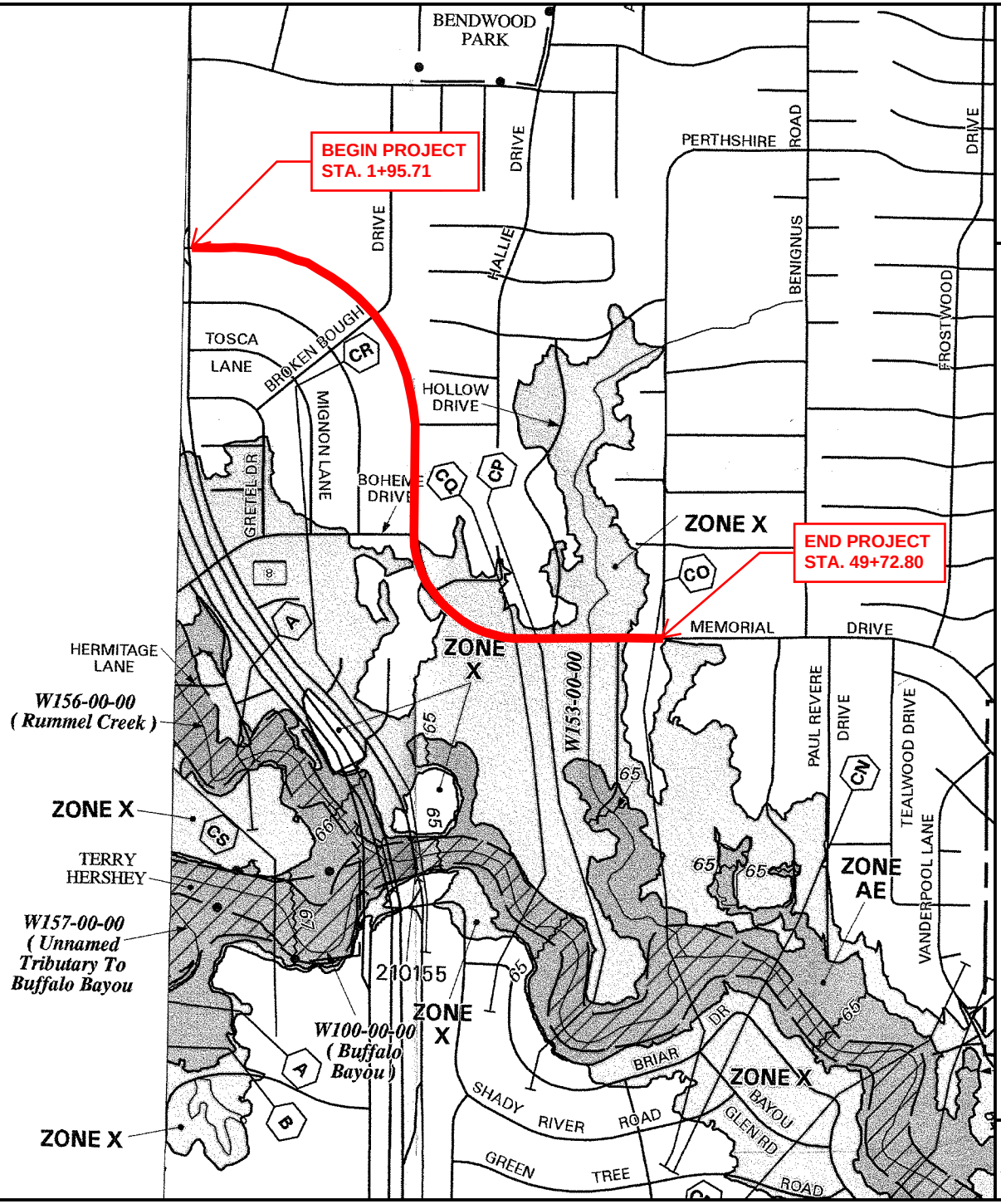
EXHIBIT 2

FEMA FIRM PANEL



MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0645L

FIRM

FLOOD INSURANCE RATE MAP

HARRIS COUNTY, TEXAS AND INCORPORATED AREAS

PANEL 645 OF 1150

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
HOUSTON, CITY OF	480296	0645	L
SPRING VALLEY, CITY OF	480313	0645	L
HEDWIG VILLAGE, CITY OF	480294	0645	L

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

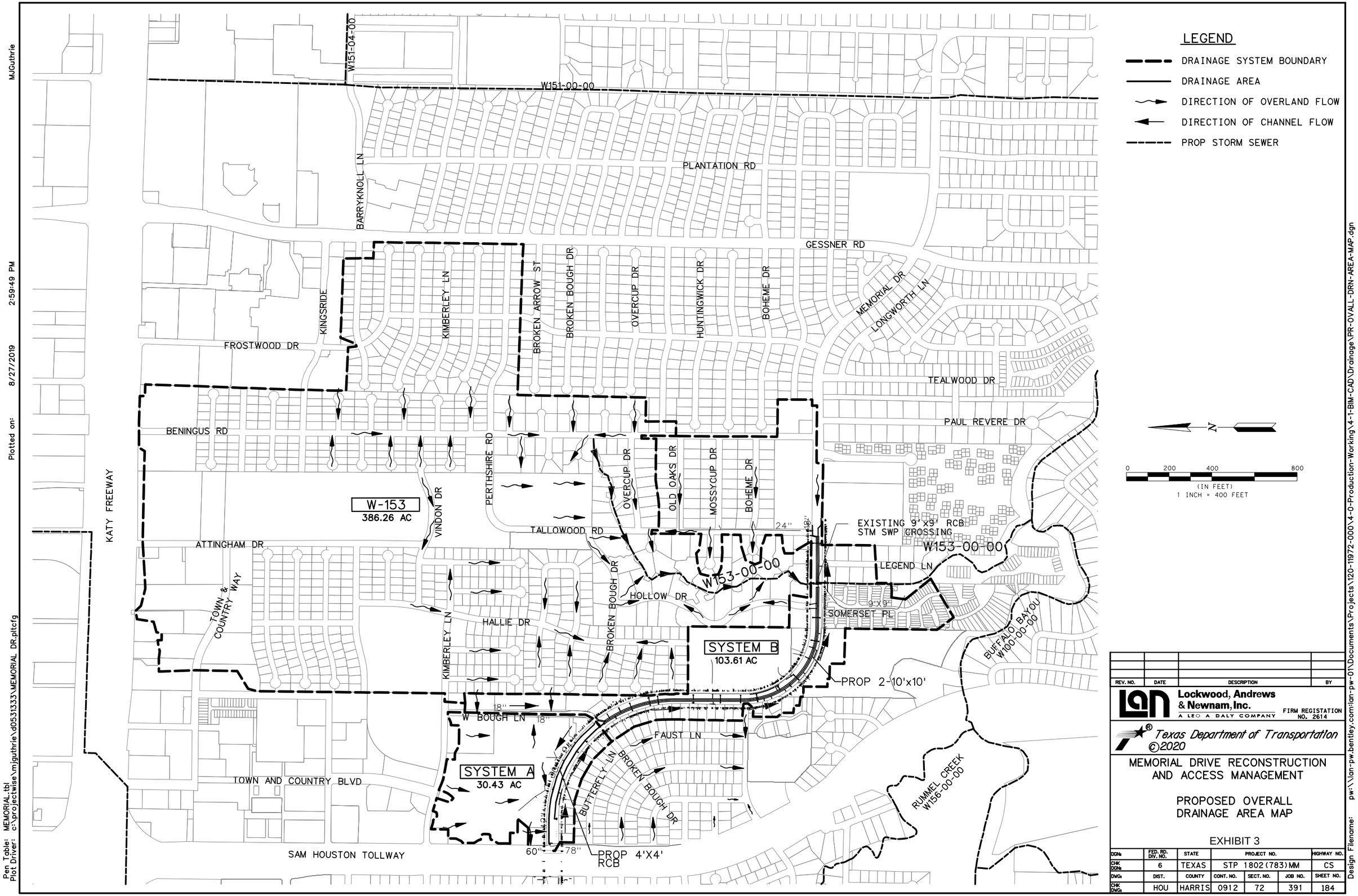
MAP NUMBER 48201C0645L

MAP REVISED: JUNE 18, 2007

Federal Emergency Management Agency

EXHIBIT 3

DRAINAGE AREA MAPS



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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED OVERALL DRAINAGE AREA MAP

EXHIBIT 3

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	184

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SAM HOUSTON TOLLWAY

MEMORIAL DRIVE

EXIST 60" RCP

EXIST 78" RCP

EXIST 42" RCP

EXIST 30" RCP

MATCHLINE SEE STA 11+00

5+00

10+00

A-01

A-02

A-03

A-04

A-123

A-126

A-126A

A-127

A-130

A-131

A-132

B-126

B-129

B-131

B-139

MA-01
30.66
73.65

MH-A03
28.43
69.33

MH-A04
15.18
37.87

A-OUT
30.68
73.47

MH-A-3
30.31
72.65

MH-22
1.81
3.85

MH-21
1.81
3.85

MH-19
3.16
6.31

MH-58
3.16
6.31

LEGEND

MH•
AREA
FLOW — MANHOLE NUMBER; TOTAL CUMULATIVE AREA (AC); 2-YR Q (CFS)

B-- — DRAINAGE AREA

B-- — INLET ID

EXISTING STORM SEWER

2 YR FLOW DIRECTION

SYSTEM DRAINAGE BOUNDARY

DRAINAGE AREA

NOTE:

1. REFER TO THE DRAINAGE IMPACT ANALYSIS REPORT AUGUST 2019 PREPARED BY LOCKWOOD, ANDREWS & NEWMAN, INC. FOR ADDITIONAL HYDROLOGIC AND HYDRAULIC INFORMATION.

0 80 160
(IN FEET)
SCALE: PLAN 1": 80'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED DRAINAGE AREA MAP

EXHIBIT 3

SHEET 1 OF 5

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
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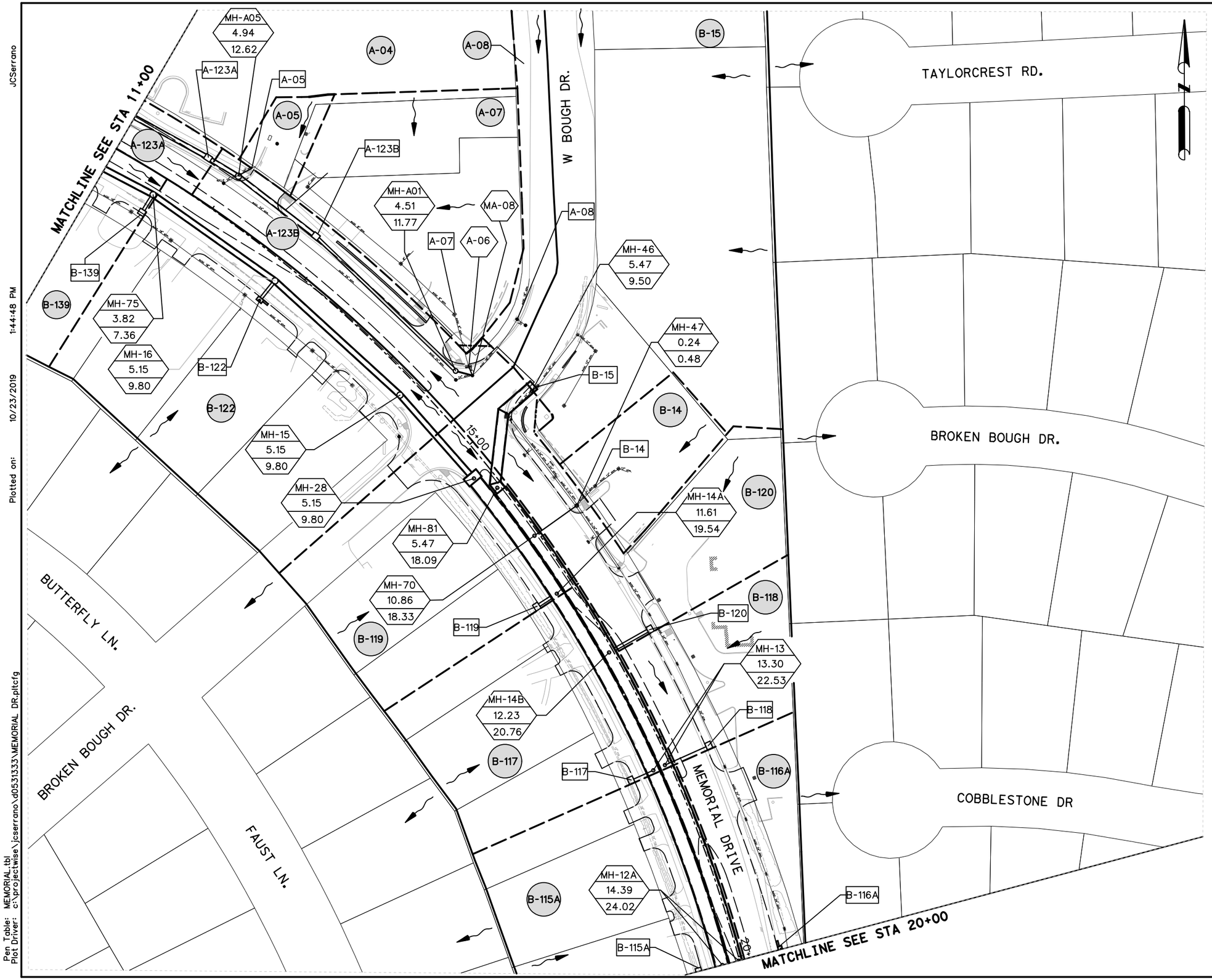

LEGEND

- MH• / AREA / FLOW — MANHOLE NUMBER; TOTAL CUMULATIVE AREA (AC); 2-YR Q (CFS)
- B-- — DRAINAGE AREA
- B-- — INLET ID
- EXISTING STORM SEWER
- 2 YR FLOW DIRECTION
- SYSTEM DRAINAGE BOUNDARY
- DRAINAGE AREA

NOTE:

1. REFER TO THE DRAINAGE IMPACT ANALYSIS REPORT AUGUST 2019 PREPARED BY LOCKWOOD, ANDREWS & NEWMAN, INC. FOR ADDITIONAL HYDROLOGIC AND HYDRAULIC INFORMATION.

0 80 160

(IN FEET)

SCALE: PLAN 1" = 80'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc. — A LEO A DALY COMPANY — FIRM REGISTATION NO. 2614

Texas Department of Transportation ©2020

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED DRAINAGE AREA MAP

EXHIBIT 3

SHEET 2 OF 5

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	186

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LEGEND

MH# / AREA / FLOW	MANHOLE NUMBER TOTAL CUMULATIVE AREA (AC) 2-YR Q (CFS)
B-- (circle)	DRAINAGE AREA
B-- (box)	INLET ID
X	WINSTORM RUN NO.
	EXISTING STORM SEWER
	2 YR FLOW DIRECTION
	SYSTEM DRAINAGE BOUNDARY
	DRAINAGE AREA

NOTE:

1. REFER TO THE DRAINAGE IMPACT ANALYSIS REPORT AUGUST 2019 PREPARED BY LOCKWOOD, ANDREWS & NEWMAN, INC. FOR ADDITIONAL HYDROLOGIC AND HYDRAULIC INFORMATION.

N

0 80 160

(IN FEET)

SCALE: PLAN 1":80'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED DRAINAGE AREA MAP

EXHIBIT 3

SHEET 3 OF 5

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	187

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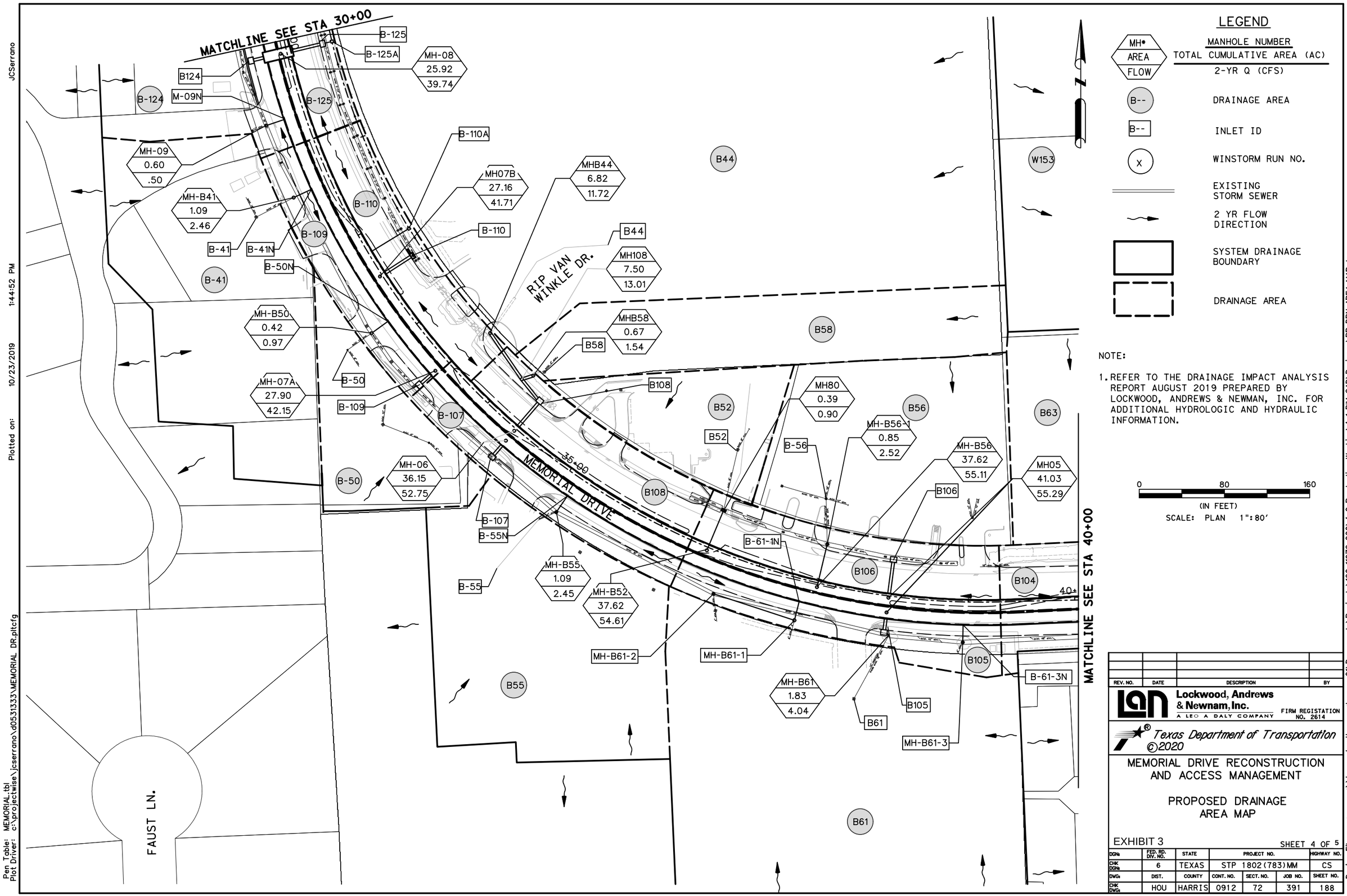

LEGEND

- MH• / AREA / FLOW — MANHOLE NUMBER; TOTAL CUMULATIVE AREA (AC); 2-YR Q (CFS)
- B-- — DRAINAGE AREA
- B-- — INLET ID
- X — WINSTORM RUN NO.
- EXISTING STORM SEWER
- 2 YR FLOW DIRECTION
- SYSTEM DRAINAGE BOUNDARY
- DRAINAGE AREA

NOTE:

1. REFER TO THE DRAINAGE IMPACT ANALYSIS REPORT AUGUST 2019 PREPARED BY LOCKWOOD, ANDREWS & NEWMAN, INC. FOR ADDITIONAL HYDROLOGIC AND HYDRAULIC INFORMATION.

0 80 160
(IN FEET)
SCALE: PLAN 1": 80'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED DRAINAGE AREA MAP

EXHIBIT 3

SHEET 4 OF 5

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	188

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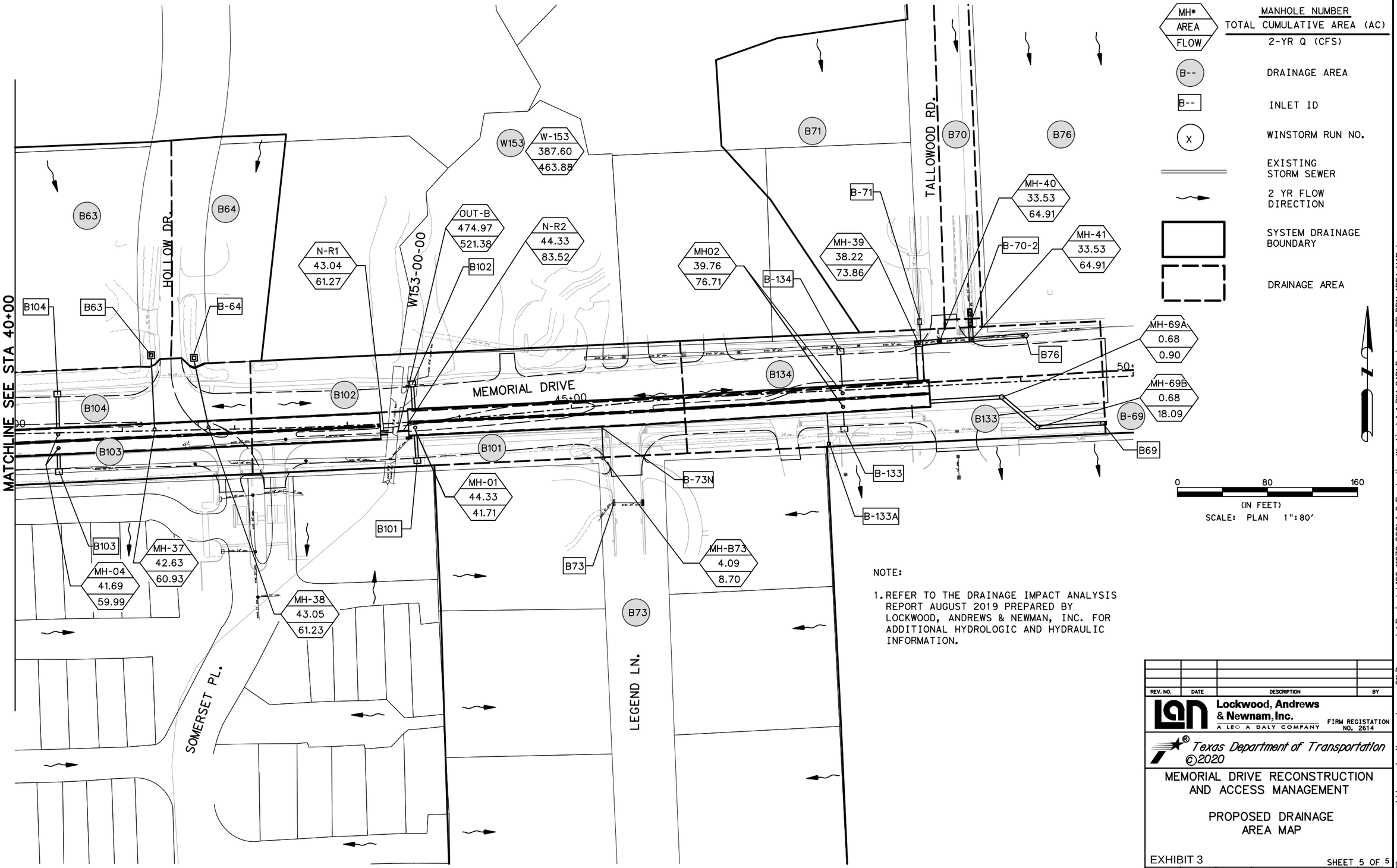

LEGEND

- MH# / AREA / FLOW — MANHOLE NUMBER; TOTAL CUMULATIVE AREA (AC); 2-YR Q (CFS)
- B-- — DRAINAGE AREA
- B-- — INLET ID
- X — WINSTORM RUN NO.
- EXISTING STORM SEWER
- 2 YR FLOW DIRECTION
- SYSTEM DRAINAGE BOUNDARY
- DRAINAGE AREA

NOTE:

1. REFER TO THE DRAINAGE IMPACT ANALYSIS REPORT AUGUST 2019 PREPARED BY LOCKWOOD, ANDREWS & NEWMAN, INC. FOR ADDITIONAL HYDROLOGIC AND HYDRAULIC INFORMATION.

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc. — A LEO A DALY COMPANY — FIRM REGISTATION NO. 2614

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED DRAINAGE AREA MAP

EXHIBIT 3

SHEET 5 OF 5

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	189

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EXHIBIT 4

EXISTING & PROPOSED LAND USE MAPS

LEGEND:

- DRAINAGE SYSTEM BOUNDARY
- INTERNAL DRAINAGE BOUNDARY
- PAVEMENT
- MULTI-FAMILY/BUSINESS AREAS
- RESIDENTIAL
- GRASS

0 200 400
(IN FEET)
SCALE: PLAN 1":200'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

EXISTING LAND USE MAP

EXHIBIT 4

SHEET 1 OF 2

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	$EDA1$

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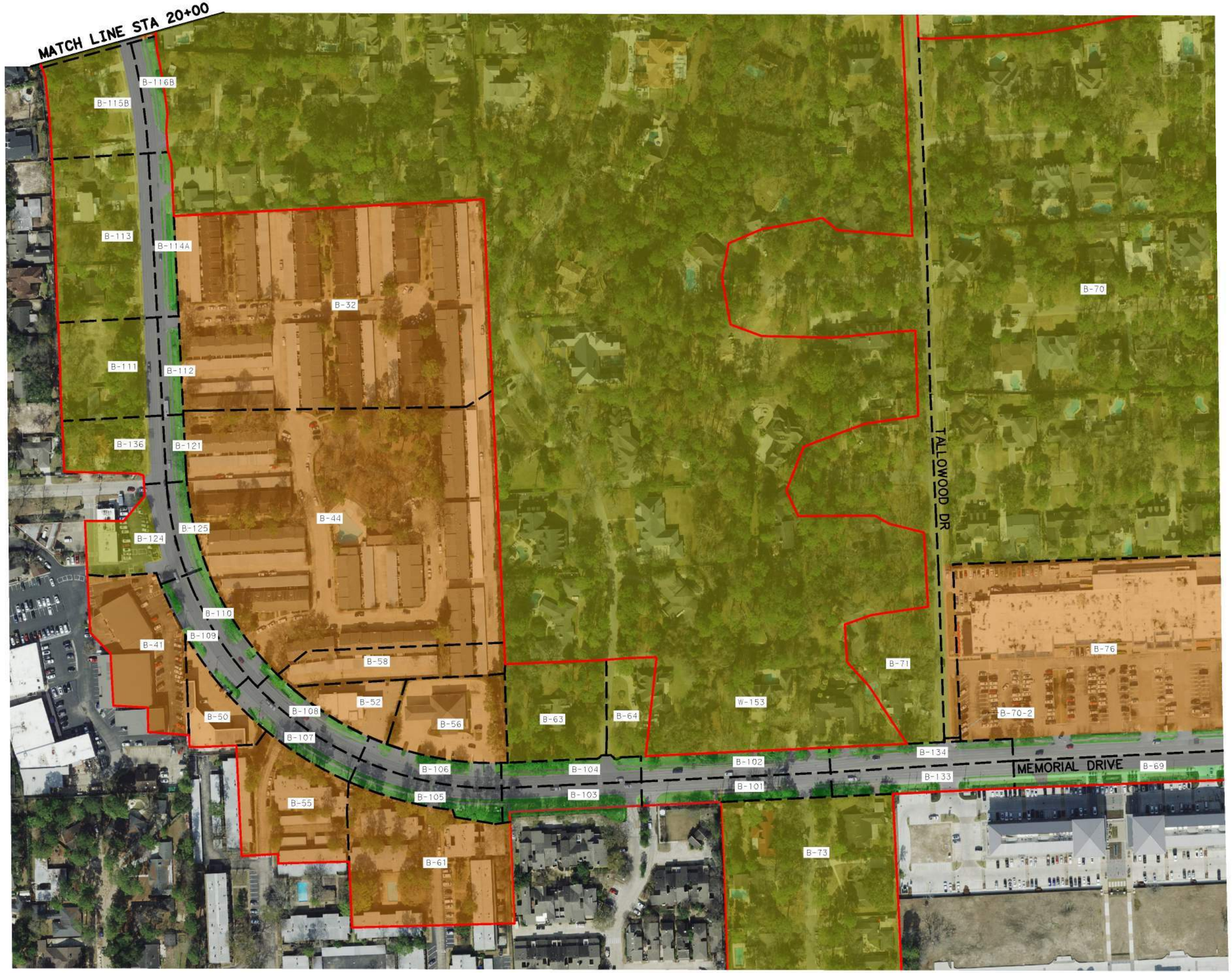

N

LEGEND:

- DRAINAGE SYSTEM BOUNDARY
- INTERNAL DRAINAGE BOUNDARY
- PAVEMENT
- MULTI-FAMILY/BUSINESS AREAS
- RESIDENTIAL
- GRASS

0 200 400

(IN FEET)

SCALE: PLAN 1" = 200'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc. A LEO A DALY COMPANY FIRM REGISTATION NO. 2614

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

EXISTING LAND USE MAP

EXHIBIT 4

SHEET 2 OF 2

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	#EDA2#

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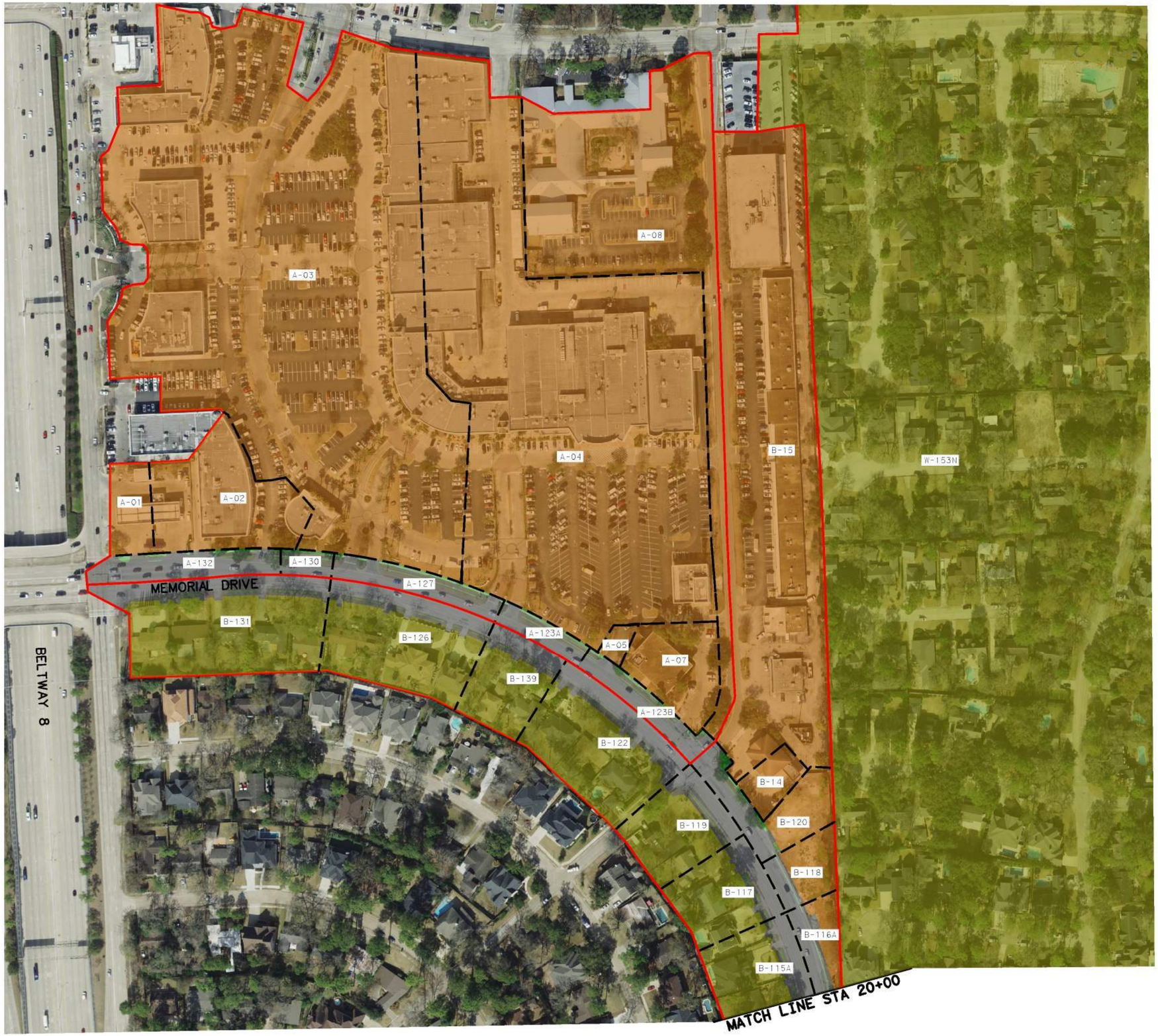

LEGEND:

- DRAINAGE SYSTEM BOUNDARY
- INTERNAL DRAINAGE BOUNDARY
- PAVEMENT
- MULTI-FAMILY/BUSINESS AREAS
- RESIDENTIAL
- GRASS

0 200 400

(IN FEET)

SCALE: PLAN 1 " = 200'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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FIRM REGISTATION NO. 2614

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED LAND USE MAP

EXHIBIT 4

SHEET 1 OF 2

DGN:	DIST. CONT. NO. DIV. NO.	STATE:	PROJECT NO.			FEDERAL NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	SPDA01(

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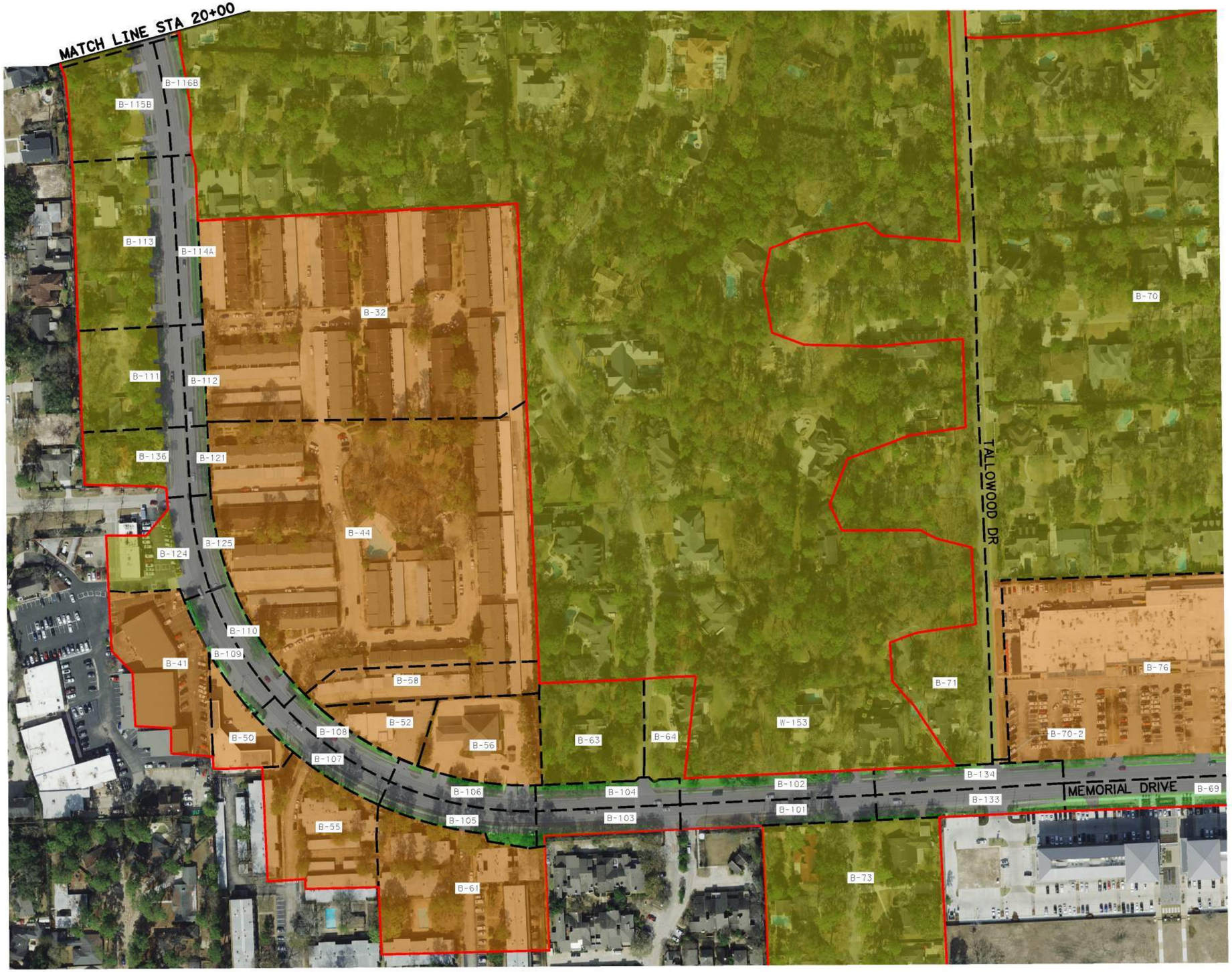

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LEGEND:

- DRAINAGE SYSTEM BOUNDARY
- INTERNAL DRAINAGE BOUNDARY
- PAVEMENT
- MULTI-FAMILY/BUSINESS AREAS
- RESIDENTIAL
- GRASS

0 200 400

(IN FEET)

SCALE: PLAN 1" = 200'

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc. A LEO A DALY COMPANY FIRM REGISTATION NO. 2614

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

PROPOSED LAND USE MAP

EXHIBIT 4

SHEET 2 OF 2

DSN:	SCD. NO. DIV NO.	STATE	PROJECT NO.			FEDERAL NO.
CHK DSN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	PDA024

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EXHIBIT 5

EXISTING & PROPOSED RUNOFF COMPUTATIONS

EXHIBIT 5

EXISTING CONDITIONS RUNOFF COMPUTATION										
Drainage Area ID	Drainage Area (AC)	Runoff Coefficient Weighted C Value	Percent Impervious (%)	Time of Concentration (MIN)	2-Year Intensity (IN/HR)	10-Year Intensity (IN/HR)	100-Year Intensity (IN/HR)	2-Year Peak Discharge (CFS)	10-Year Peak Discharge (CFS)	100-Year Peak Discharge (CFS)
A-01	0.35	0.80	85%	23.30	3.62	5.40	8.33	1.00	1.50	2.31
A-02	1.29	0.80	85%	25.46	3.44	5.15	7.98	3.55	5.31	8.23
A-03	12.86	0.80	85%	30.68	3.08	4.64	7.25	31.66	47.73	74.54
A-04	10.03	0.80	85%	30.01	3.12	4.70	7.33	25.02	37.69	58.81
A-05	0.09	0.80	85%	21.51	3.78	5.63	8.65	0.26	0.39	0.60
A-07	0.70	0.80	85%	24.40	3.52	5.27	8.14	1.98	2.96	4.57
A-08	3.81	0.80	85%	27.66	3.28	4.92	7.65	9.98	14.99	23.30
A-123A	0.21	0.71	66%	22.61	3.68	5.48	8.45	0.55	0.83	1.27
A-123B	0.34	0.80	82%	23.28	3.62	5.40	8.33	0.99	1.48	2.28
A-127	0.40	0.71	65%	23.50	3.60	5.37	8.29	1.01	1.51	2.33
A-130	0.12	0.72	67%	21.92	3.74	5.57	8.57	0.33	0.49	0.76
A-132	0.47	0.87	94%	23.76	3.58	5.34	8.25	1.47	2.19	3.38
B-14	0.24	0.80	85%	22.80	3.66	5.46	8.42	0.71	1.06	1.64
B-15	5.47	0.80	85%	28.49	3.22	4.84	7.53	14.08	21.17	32.97
B-32	5.93	0.80	85%	28.68	3.21	4.82	7.51	15.20	22.85	35.59
B-41	1.09	0.80	85%	25.16	3.46	5.18	8.02	3.02	4.53	7.01
B-44	6.82	0.80	85%	29.03	3.18	4.79	7.46	17.37	26.14	40.72
B-50	0.42	0.80	85%	23.57	3.59	5.37	8.28	1.19	1.78	2.75
B-52	0.39	0.80	85%	23.46	3.60	5.38	8.30	1.11	1.66	2.56
B-55	1.09	0.80	85%	25.15	3.46	5.18	8.02	3.01	4.51	6.98
B-56	0.85	0.80	85%	24.72	3.50	5.23	8.09	2.37	3.55	5.49
B-58	0.67	0.80	85%	24.33	3.53	5.28	8.16	1.90	2.84	4.39
B-61	1.83	0.80	85%	26.13	3.39	5.08	7.87	4.97	7.45	11.55
B-63	0.94	0.54	38%	24.89	3.48	5.21	8.06	1.76	2.64	4.09
B-64	0.42	0.54	38%	23.57	3.59	5.37	8.28	0.81	1.21	1.86
B-69	0.68	0.63	52%	24.36	3.53	5.27	8.15	1.52	2.27	3.51
B-70	22.76	0.54	38%	32.34	2.98	4.50	7.05	36.62	55.32	86.59
B-70-2	0.01	0.72	69%	19.07	4.04	5.98	9.14	0.02	0.03	0.04
B-71	4.69	0.54	38%	28.13	3.24	4.87	7.58	8.21	12.34	19.20
B-73	4.09	0.54	38%	27.82	3.26	4.90	7.63	7.21	10.84	16.85
B-76	10.77	0.80	85%	30.20	3.11	4.68	7.31	26.77	40.34	62.96
B-101	0.44	0.73	68%	23.65	3.59	5.36	8.27	1.14	1.71	2.64
B-102	0.45	0.69	62%	23.68	3.58	5.35	8.26	1.10	1.65	2.54
B-103	0.33	0.65	55%	23.23	3.62	5.41	8.34	0.78	1.16	1.78
B-104	0.34	0.68	59%	23.26	3.62	5.40	8.34	0.83	1.24	1.91
B-105	0.40	0.65	55%	23.50	3.60	5.37	8.29	0.93	1.38	2.13
B-106	0.33	0.77	76%	23.23	3.62	5.41	8.34	0.92	1.37	2.11
B-107	0.35	0.74	70%	23.32	3.61	5.40	8.33	0.94	1.40	2.16
B-108	0.40	0.74	71%	23.51	3.60	5.37	8.29	1.06	1.58	2.44
B-109	0.33	0.80	81%	23.21	3.62	5.41	8.34	0.94	1.41	2.17
B-110	0.15	0.65	54%	22.14	3.72	5.54	8.53	0.36	0.53	0.82
B-111	0.94	0.59	47%	24.89	3.48	5.21	8.06	1.92	2.88	4.45
B-112	0.20	0.65	54%	22.50	3.69	5.50	8.47	0.47	0.70	1.07
B-113	1.53	0.59	46%	25.78	3.41	5.11	7.93	3.08	4.61	7.15
B-114A	0.34	0.67	58%	23.28	3.62	5.40	8.33	0.83	1.24	1.91
B-115A	0.74	0.59	47%	24.49	3.52	5.26	8.13	1.53	2.29	3.55
B-115B	0.91	0.59	47%	24.85	3.49	5.22	8.07	1.88	2.81	4.35
B-116A	0.34	0.83	90%	23.29	3.62	5.40	8.33	1.03	1.54	2.38
B-116B	0.24	0.67	59%	22.79	3.66	5.46	8.42	0.59	0.89	1.37
B-117	0.71	0.59	47%	24.42	3.52	5.27	8.14	1.47	2.20	3.40
B-118	0.37	0.82	88%	23.39	3.61	5.39	8.31	1.09	1.62	2.50
B-119	0.75	0.63	53%	24.50	3.51	5.26	8.13	1.65	2.47	3.83
B-120	0.62	0.83	89%	24.19	3.54	5.29	8.18	1.82	2.72	4.20

EXHIBIT 5

EXISTING CONDITIONS RUNOFF COMPUTATION										
Drainage Area ID	**Drainage Area (AC)**	**Runoff Coefficient Weighted C Value**	**Percent Impervious (%)**	**Time of Concentration (MIN)**	**2-Year Intensity (IN/HR)**	**10-Year Intensity (IN/HR)**	**100-Year Intensity (IN/HR)**	**2-Year Peak Discharge (CFS)**	**10-Year Peak Discharge (CFS)**	**100-Year Peak Discharge (CFS)**
B-121	0.13	0.60	46%	21.99	3.74	5.56	8.56	0.29	0.43	0.67
B-122	1.33	0.61	49%	25.52	3.43	5.14	7.97	2.78	4.16	6.45
B-124	0.60	0.66	59%	24.14	3.54	5.30	8.19	1.40	2.09	3.23
B-125	0.18	0.64	52%	22.40	3.70	5.51	8.49	0.43	0.64	0.98
B-126	1.35	0.59	47%	25.55	3.43	5.14	7.96	2.74	4.10	6.35
B-131	1.81	0.60	48%	26.10	3.39	5.08	7.88	3.67	5.50	8.53
B-133	0.45	0.71	66%	23.69	3.58	5.35	8.26	1.14	1.70	2.63
B-134	0.41	0.78	78%	23.54	3.60	5.37	8.29	1.15	1.71	2.64
B-136	0.55	0.61	50%	24.00	3.56	5.31	8.21	1.19	1.77	2.74
B-139	0.67	0.59	47%	24.31	3.53	5.28	8.16	1.39	2.07	3.20
W-153	387.60	0.52	45%	70.00	1.79	2.77	4.45	360.78	557.29	897.70

EXHIBIT 5

PROPOSED CONDITIONS RUNOFF COMPUTATIONS										
Drainage Area ID	Drainage Area (AC)	Runoff Coefficient Weighted C Value	Percent Impervious (%)	Time of Concentration (MIN)	2-Year Intensity (IN/HR)	10-Year Intensity (IN/HR)	100-Year Intensity (IN/HR)	2-Year Peak Discharge (CFS)	10-Year Peak Discharge (CFS)	100-Year Peak Discharge (CFS)
A-01	0.35	0.80	85%	23.30	3.62	5.40	8.33	1.00	1.50	2.31
A-02	1.29	0.80	85%	25.46	3.44	5.15	7.98	3.55	5.31	8.23
A-03	12.86	0.80	85%	30.68	3.08	4.64	7.25	31.66	47.73	74.54
A-04	10.03	0.80	85%	30.01	3.12	4.70	7.33	25.02	37.69	58.81
A-05	0.09	0.80	85%	21.51	3.78	5.63	8.65	0.26	0.39	0.60
A-07	0.70	0.80	85%	24.40	3.52	5.27	8.14	1.98	2.96	4.57
A-08	3.81	0.80	85%	27.66	3.28	4.92	7.65	9.98	14.99	23.30
A-123A	0.21	0.82	86%	22.61	3.68	5.48	8.45	0.64	0.95	1.47
A-123B	0.34	0.84	89%	23.28	3.62	5.40	8.33	1.04	1.55	2.39
A-127	0.40	0.84	88%	23.50	3.60	5.37	8.29	1.20	1.78	2.75
A-130	0.12	0.82	85%	21.92	3.74	5.57	8.57	0.38	0.56	0.87
A-132	0.47	0.86	93%	23.76	3.58	5.34	8.25	1.45	2.17	3.34
B-14	0.24	0.80	85%	22.80	3.66	5.46	8.42	0.71	1.06	1.64
B-15	5.47	0.80	85%	28.49	3.22	4.84	7.53	14.08	21.17	32.97
B-32	5.93	0.80	85%	28.68	3.21	4.82	7.51	15.20	22.85	35.59
B-41	1.09	0.80	85%	25.16	3.46	5.18	8.02	3.02	4.53	7.01
B-44	6.82	0.80	85%	29.03	3.18	4.79	7.46	17.37	26.14	40.72
B-50	0.42	0.80	85%	23.57	3.59	5.37	8.28	1.19	1.78	2.75
B-52	0.39	0.80	85%	23.46	3.60	5.38	8.30	1.11	1.66	2.56
B-55	1.09	0.80	85%	25.15	3.46	5.18	8.02	3.01	4.51	6.98
B-56	0.85	0.80	85%	24.72	3.50	5.23	8.09	2.37	3.55	5.49
B-58	0.67	0.80	85%	24.33	3.53	5.28	8.16	1.90	2.84	4.39
B-61	1.83	0.80	85%	26.13	3.39	5.08	7.87	4.97	7.45	11.55
B-63	0.94	0.54	38%	24.89	3.48	5.21	8.06	1.76	2.64	4.09
B-64	0.42	0.54	38%	23.57	3.59	5.37	8.28	0.81	1.21	1.86
B-69	0.68	0.64	52%	24.36	3.53	5.27	8.15	1.54	2.31	3.57
B-70	22.76	0.54	38%	32.34	2.98	4.50	7.05	36.62	55.32	86.59
B-70-2	0.01	0.72	69%	19.07	4.04	5.98	9.14	0.02	0.03	0.04
B-71	4.69	0.54	38%	28.13	3.24	4.87	7.58	8.21	12.34	19.20
B-73	4.09	0.54	38%	27.82	3.26	4.90	7.63	7.21	10.84	16.85
B-76	10.77	0.80	85%	30.20	3.11	4.68	7.31	26.77	40.34	62.96
B-101	0.44	0.87	95%	23.65	3.59	5.36	8.27	1.36	2.04	3.14
B-102	0.45	0.71	65%	23.68	3.58	5.35	8.26	1.14	1.70	2.62
B-103	0.33	0.84	88%	23.23	3.62	5.41	8.34	1.00	1.50	2.31
B-104	0.34	0.75	72%	23.26	3.62	5.40	8.34	0.91	1.36	2.10
B-105	0.40	0.77	77%	23.50	3.60	5.37	8.29	1.10	1.64	2.52
B-106	0.33	0.82	86%	23.23	3.62	5.41	8.34	0.98	1.46	2.25
B-107	0.35	0.82	85%	23.32	3.61	5.40	8.33	1.04	1.55	2.40
B-108	0.40	0.81	83%	23.51	3.60	5.37	8.29	1.16	1.73	2.67
B-109	0.33	0.81	83%	23.21	3.62	5.41	8.34	0.96	1.42	2.20
B-110	0.15	0.80	82%	22.14	3.72	5.54	8.53	0.44	0.65	1.00
B-111	0.94	0.62	52%	24.89	3.48	5.21	8.06	2.02	3.02	4.68
B-112	0.20	0.83	88%	22.50	3.69	5.50	8.47	0.60	0.89	1.37
B-113	1.53	0.63	53%	25.78	3.41	5.11	7.93	3.29	4.93	7.63
B-114A	0.34	0.83	87%	23.28	3.62	5.40	8.33	1.03	1.53	2.37
B-115A	0.74	0.64	54%	24.49	3.52	5.26	8.13	1.66	2.49	3.85
B-115B	0.91	0.64	55%	24.85	3.49	5.22	8.07	2.04	3.05	4.72
B-116A	0.34	0.84	91%	23.29	3.62	5.40	8.33	1.05	1.56	2.41
B-116B	0.24	0.81	84%	22.79	3.66	5.46	8.42	0.72	1.07	1.65
B-117	0.71	0.64	55%	24.42	3.52	5.27	8.14	1.60	2.39	3.69
B-118	0.37	0.82	88%	23.39	3.61	5.39	8.31	1.09	1.62	2.50
B-119	0.75	0.64	54%	24.50	3.51	5.26	8.13	1.68	2.51	3.89
B-120	0.62	0.81	85%	24.19	3.54	5.29	8.18	1.77	2.65	4.09

EXHIBIT 5

PROPOSED CONDITIONS RUNOFF COMPUTATIONS										
Drainage Area ID	**Drainage Area (AC)**	**Runoff Coefficient Weighted C Value**	**Percent Impervious (%)**	**Time of Concentration (MIN)**	**2-Year Intensity (IN/HR)**	**10-Year Intensity (IN/HR)**	**100-Year Intensity (IN/HR)**	**2-Year Peak Discharge (CFS)**	**10-Year Peak Discharge (CFS)**	**100-Year Peak Discharge (CFS)**
B-121	0.13	0.83	86%	21.99	3.74	5.56	8.56	0.40	0.60	0.92
B-122	1.33	0.64	54%	25.52	3.43	5.14	7.97	2.92	4.37	6.77
B-124	0.60	0.67	60%	24.14	3.54	5.30	8.19	1.42	2.12	3.28
B-125	0.18	0.82	86%	22.40	3.70	5.51	8.49	0.55	0.81	1.25
B-126	1.35	0.63	53%	25.55	3.43	5.14	7.96	2.92	4.38	6.78
B-131	1.81	0.63	53%	26.10	3.39	5.08	7.88	3.85	5.78	8.96
B-133	0.45	0.80	81%	23.69	3.58	5.35	8.26	1.28	1.92	2.96
B-134	0.41	0.80	82%	23.54	3.60	5.37	8.29	1.17	1.75	2.71
B-136	0.55	0.64	55%	24.00	3.56	5.31	8.21	1.25	1.86	2.88
B-139	0.67	0.63	54%	24.31	3.53	5.28	8.16	1.48	2.21	3.42
W-153	387.60	0.52	45%	70.00	1.79	2.77	4.45	360.78	557.29	897.70

EXHIBIT 6

EXISTING 10-YEAR EVENT PONDING

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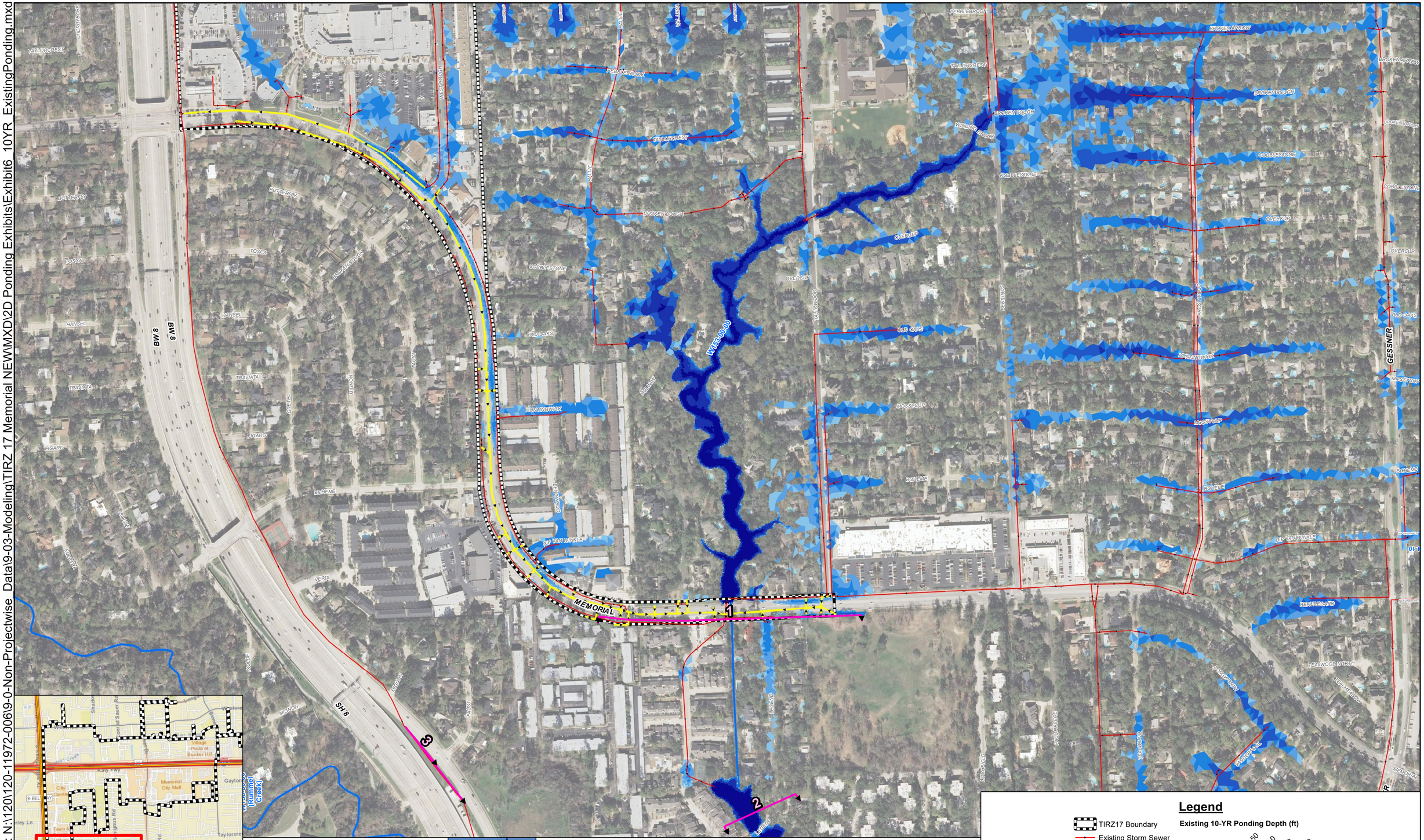

LOCATION MAP

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

EXISTING 10-YEAR EVENT PONDING
EXHIBIT 6

Legend

- TIRZ17 Boundary
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

Existing 10-YR Ponding Depth (ft)

< 0.25 | 0.25 - 0.50 | 0.50 - 1.0 | 1.0 - 2.0 | 2.0 - 5.0 | > 5.0

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 7

PROPOSED 10-YEAR EVENT PONDING

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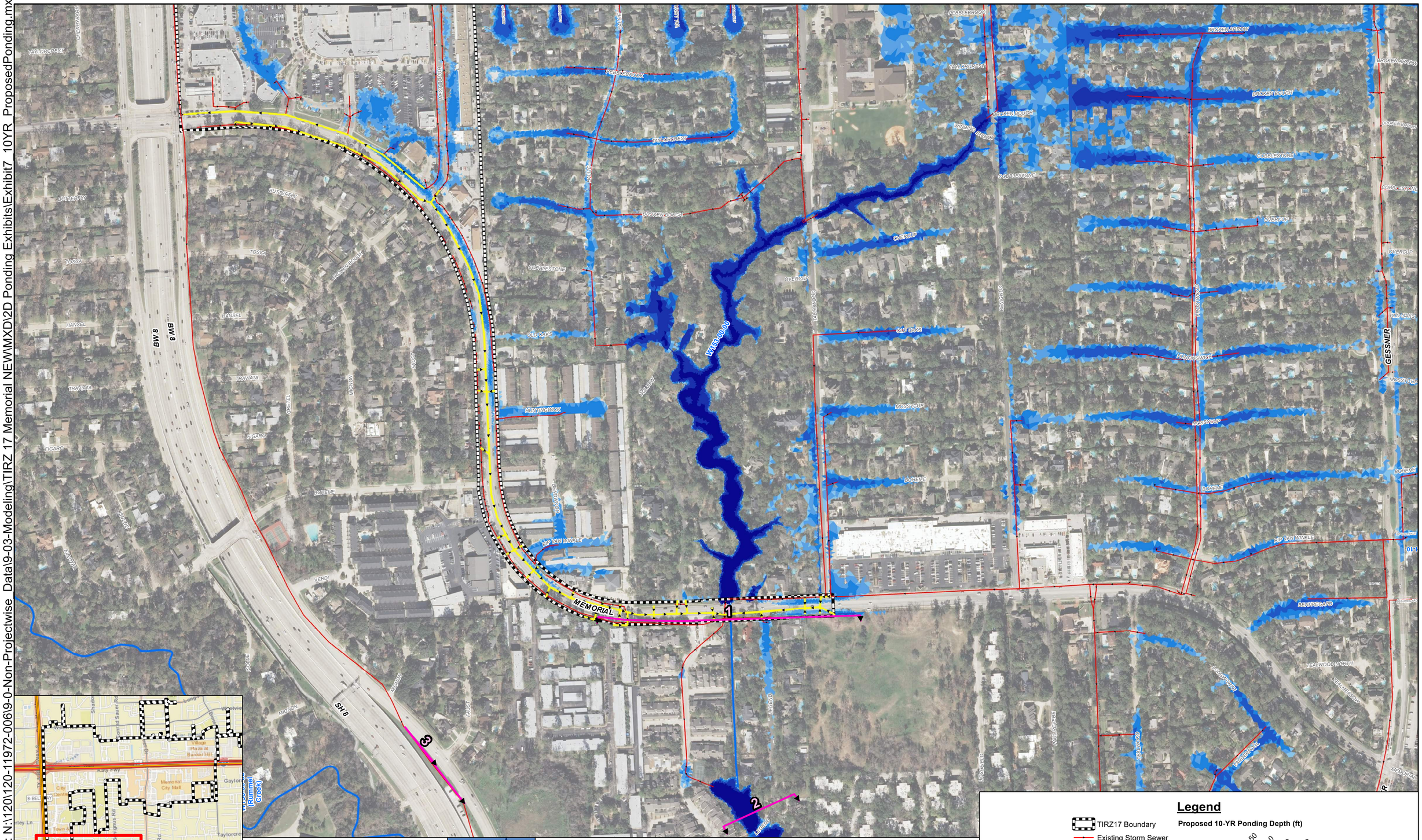

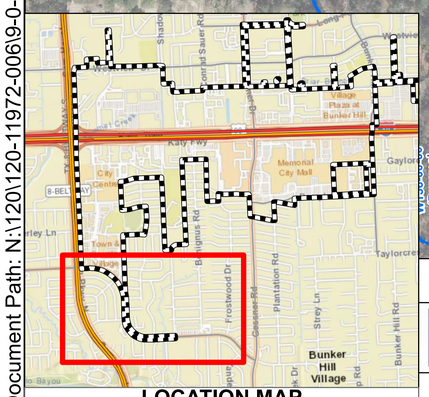

LOCATION MAP

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

PROPOSED 10-YEAR EVENT PONDING
EXHIBIT 7

Legend

- TIRZ17 Boundary
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

Proposed 10-YR Ponding Depth (ft)

< 0.25 | 0.25 - 0.50 | 0.50 - 1.0 | 1.0 - 2.0 | 2.0 - 5.0 | > 5.0

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 8

PROPOSED VS. EXISTING
10-YEAR EVENT PONDING

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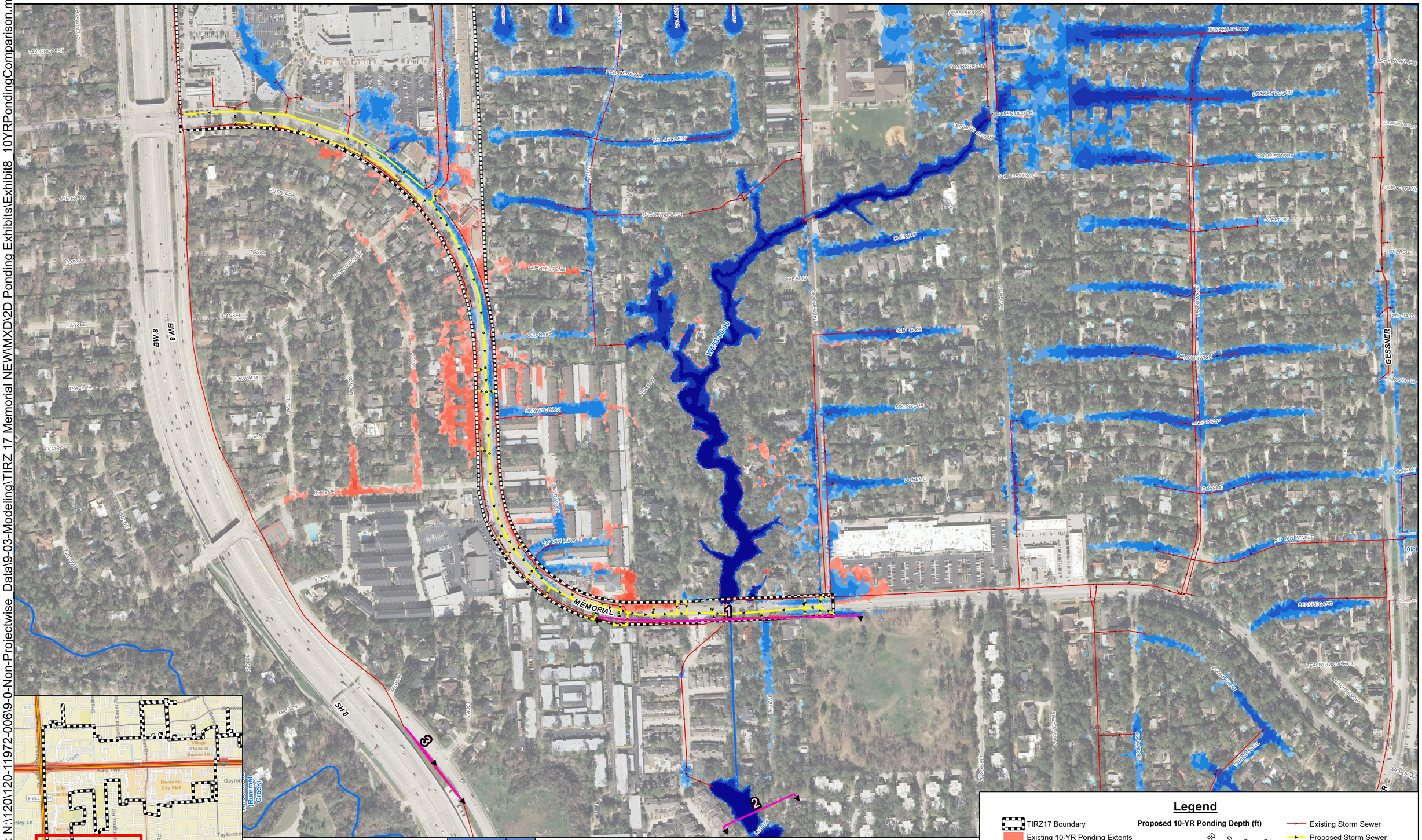

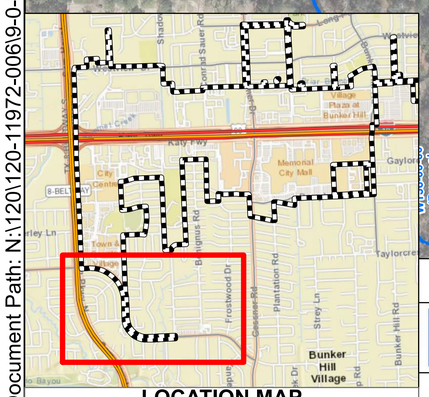

LOCATION MAP

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

PROPOSED VS. EXISTING 10-YEAR EVENT PONDING
EXHIBIT 8

Legend

- TIRZ17 Boundary
- Existing 10-YR Ponding Extents
- **Proposed 10-YR Ponding Depth (ft)**
  - < 0.25
  - 0.25 - 0.50
  - 0.50 - 1.0
  - 1.0 - 2.0
  - 2.0 - 5.0
  - > 5.0
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 9

EXISTING 100-YEAR EVENT PONDING

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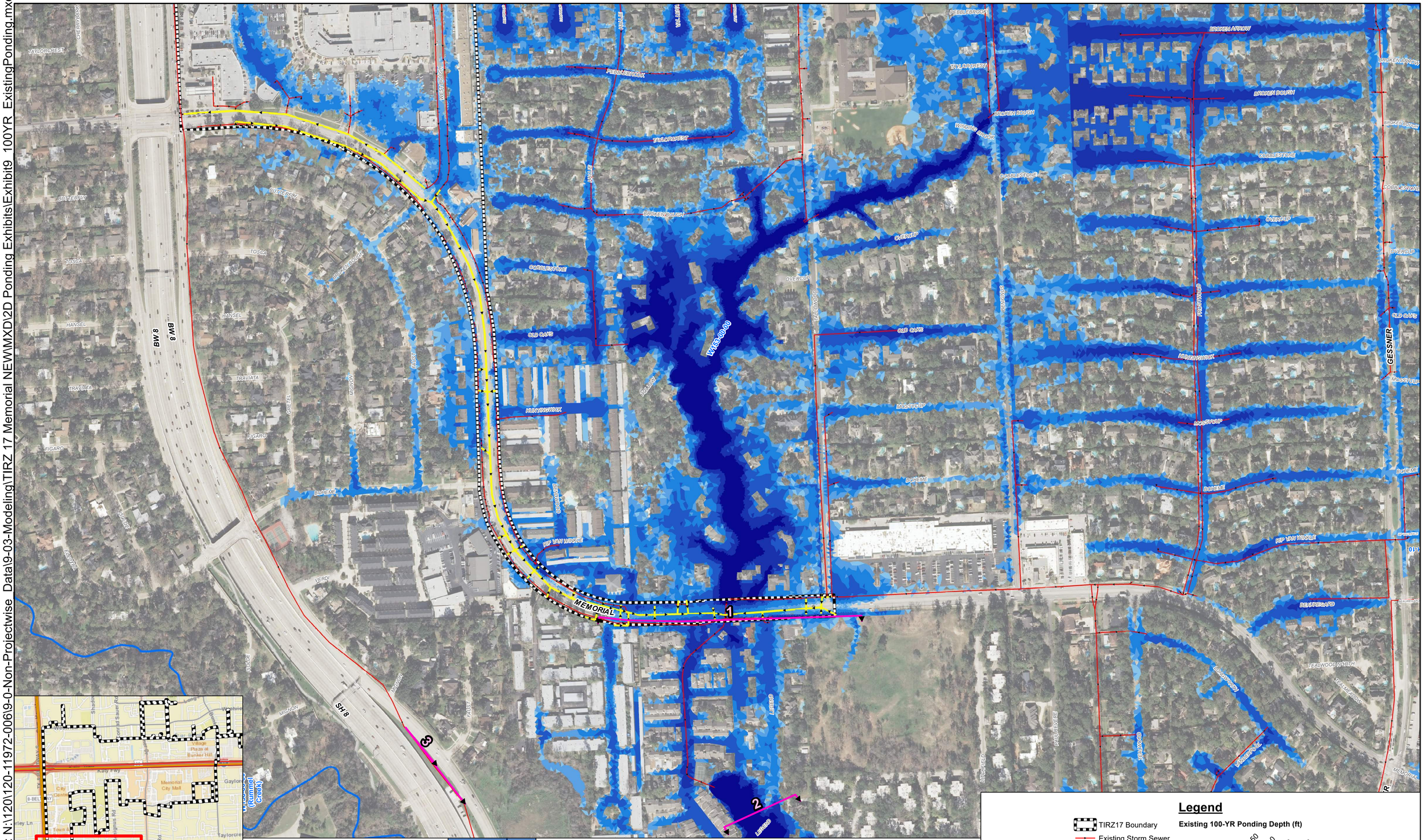

LOCATION MAP

Legend

- TIRZ17 Boundary
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

Existing 100-YR Ponding Depth (ft)

< 0.25 | 0.25 - 0.50 | 0.50 - 1.0 | 1.0 - 2.0 | 2.0 - 5.0 | > 5.0

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

EXISTING 100-YEAR EVENT PONDING
EXHIBIT 9

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 10

PROPOSED 100-YEAR EVENT PONDING

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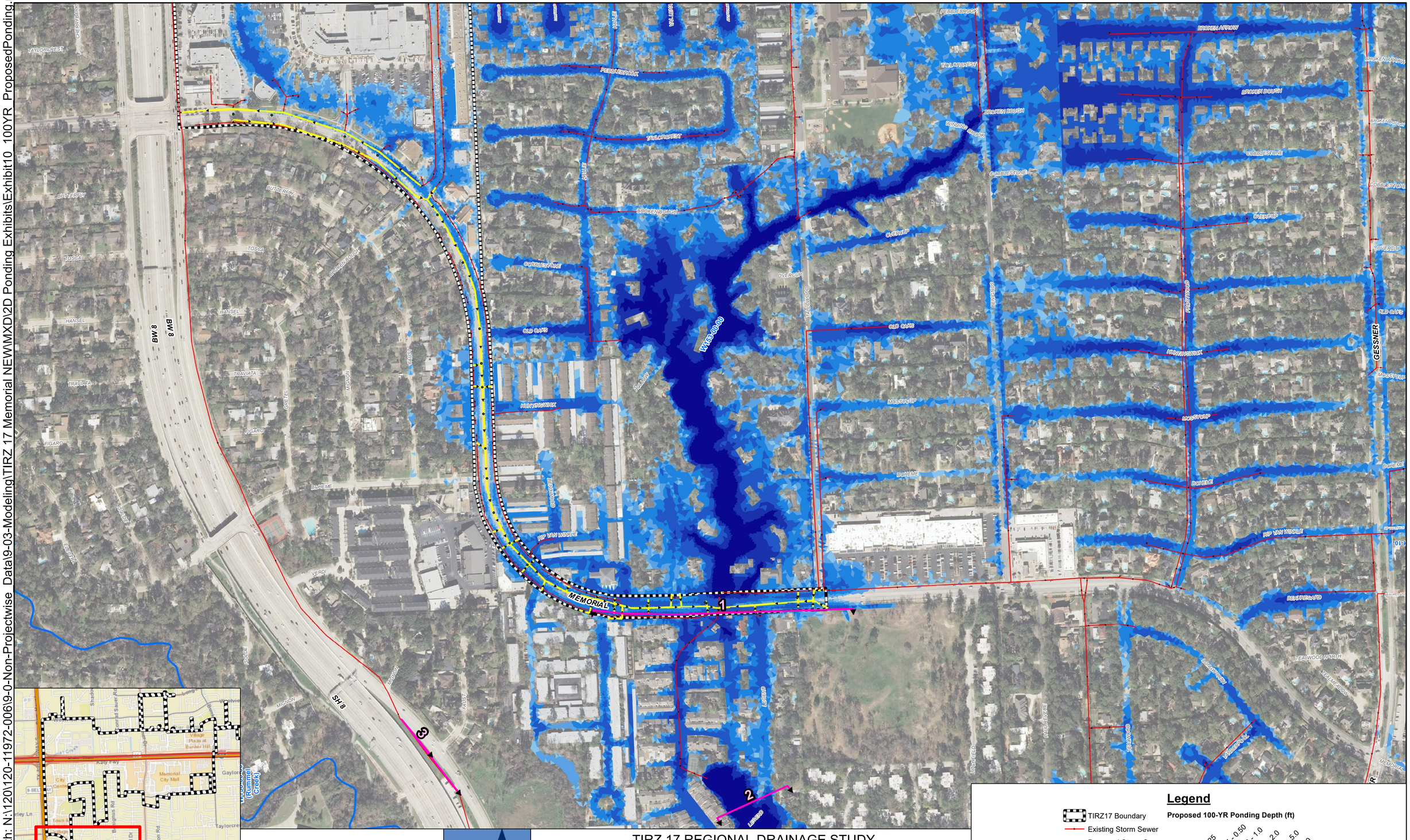

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

PROPOSED 100-YEAR EVENT PONDING
EXHIBIT 10

Legend

- TIRZ17 Boundary
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

Proposed 100-YR Ponding Depth (ft)

< 0.25 | 0.25 - 0.50 | 0.50 - 1.0 | 1.0 - 2.0 | 2.0 - 5.0 | > 5.0

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 11

PROPOSED VS. EXISTING 100-YEAR EVENT PONDING

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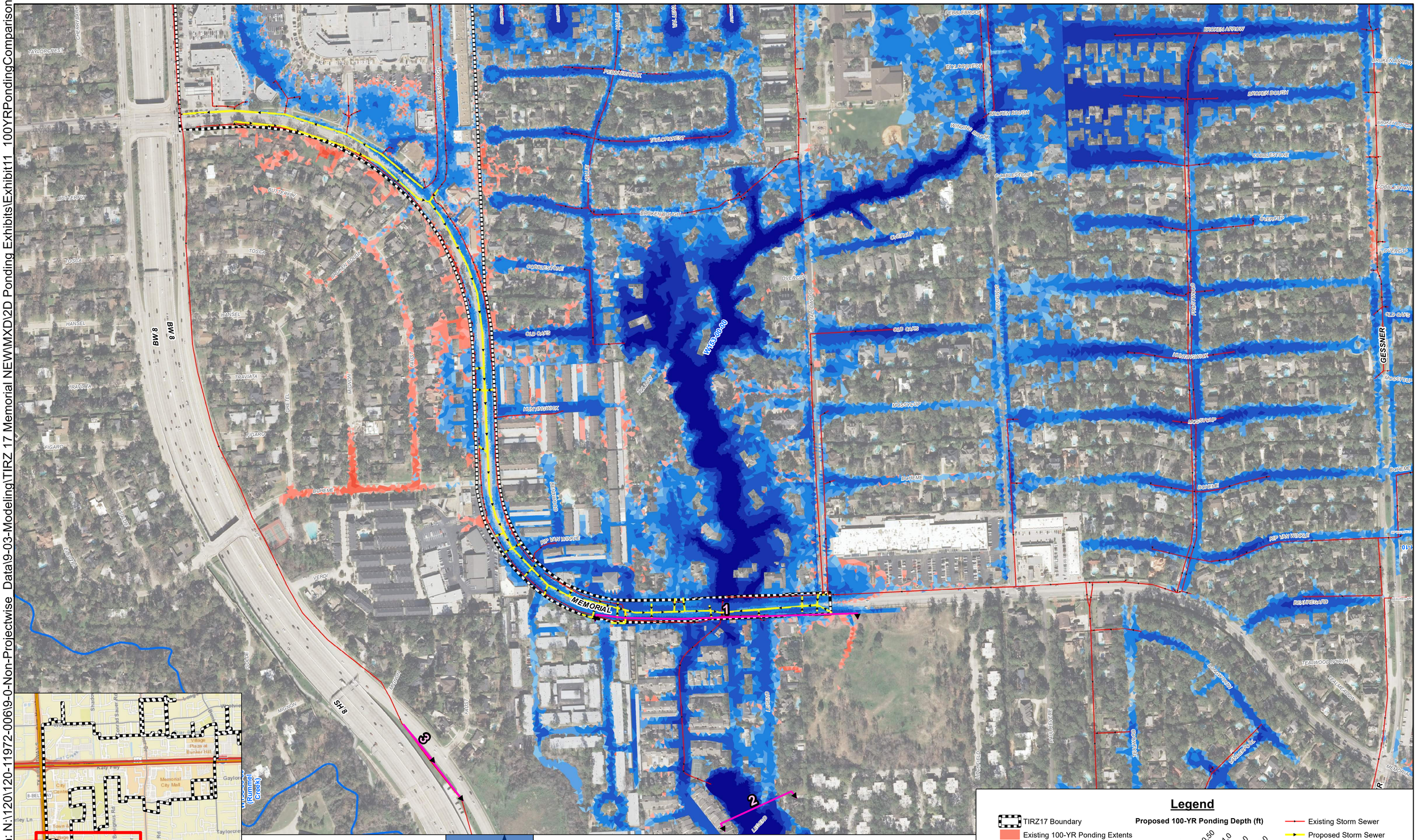

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

PROPOSED VS. EXISTING 100-YEAR EVENT PONDING
EXHIBIT 11

Legend

- TIRZ17 Boundary
- Existing 100-YR Ponding Extents

Proposed 100-YR Ponding Depth (ft)

< 0.25 | 0.25 - 0.50 | 0.50 - 1.0 | 1.0 - 2.0 | 2.0 - 5.0 | > 5.0

- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 12

EXISTING 500-YR PONDING

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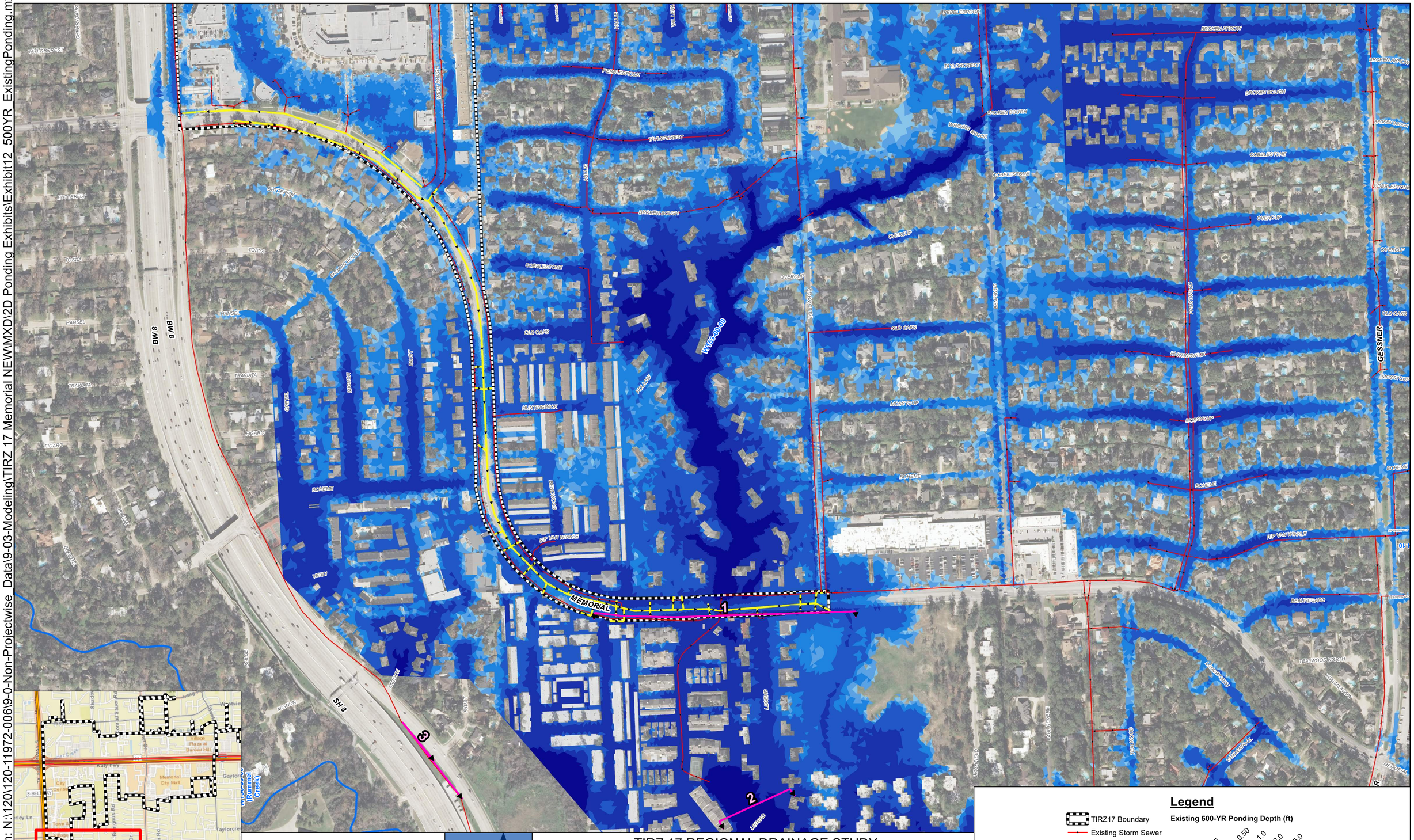

LOCATION MAP

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

EXISTING 500-YEAR EVENT PONDING
EXHIBIT 12

Legend

- TIRZ17 Boundary
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

Existing 500-YR Ponding Depth (ft)

< 0.25 | 0.25 - 0.50 | 0.50 - 1.0 | 1.0 - 2.0 | 2.0 - 5.0 | > 5.0

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 13

PROPOSED 500-YR PONDING

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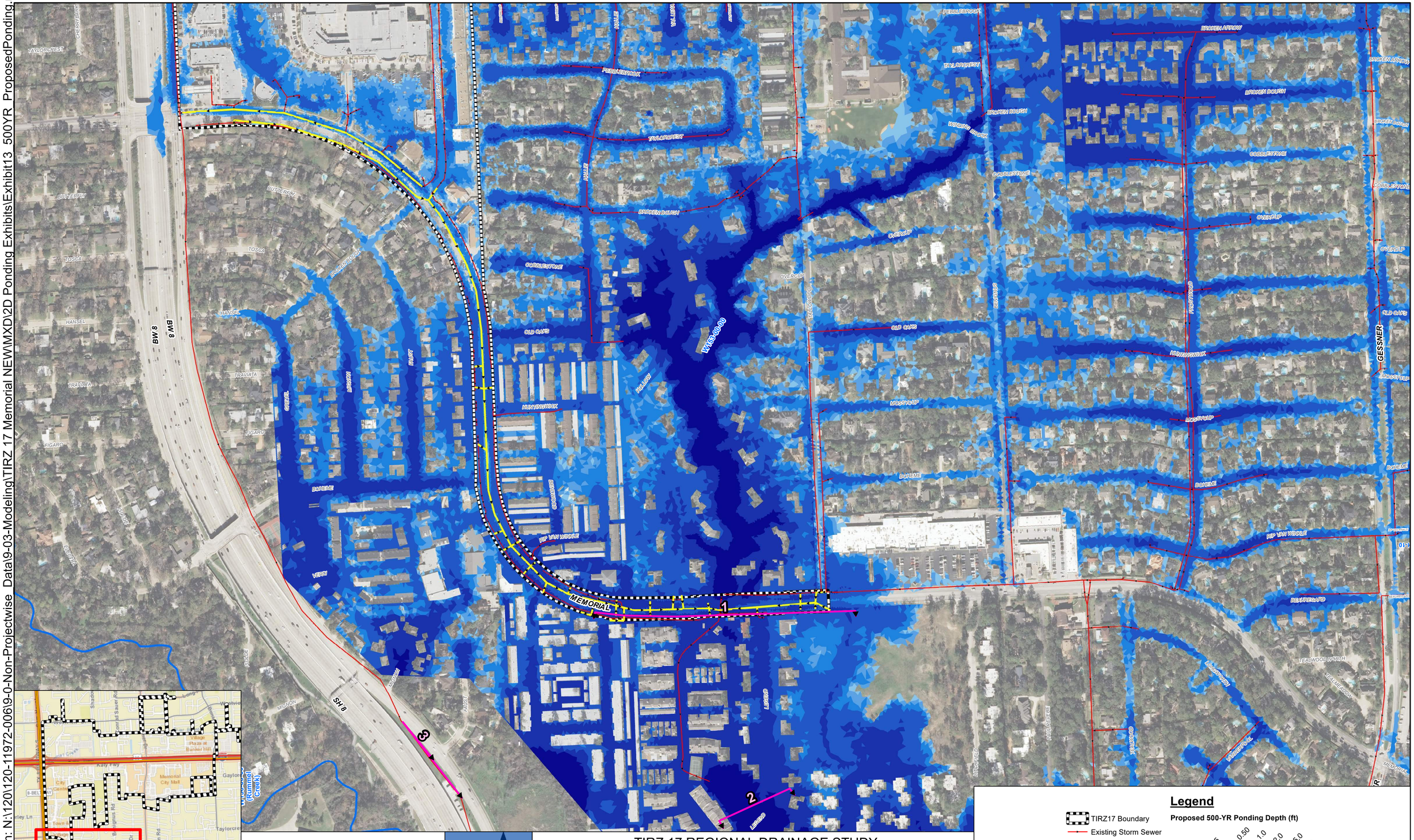


Legend

- TIRZ17 Boundary
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

Proposed 500-YR Ponding Depth (ft)

< 0.25 | 0.25 - 0.50 | 0.50 - 1.0 | 1.0 - 2.0 | 2.0 - 5.0 | > 5.0

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

PROPOSED 500-YEAR EVENT PONDING
EXHIBIT 13

SCALE: AS NOTED
DATE: OCT 2020

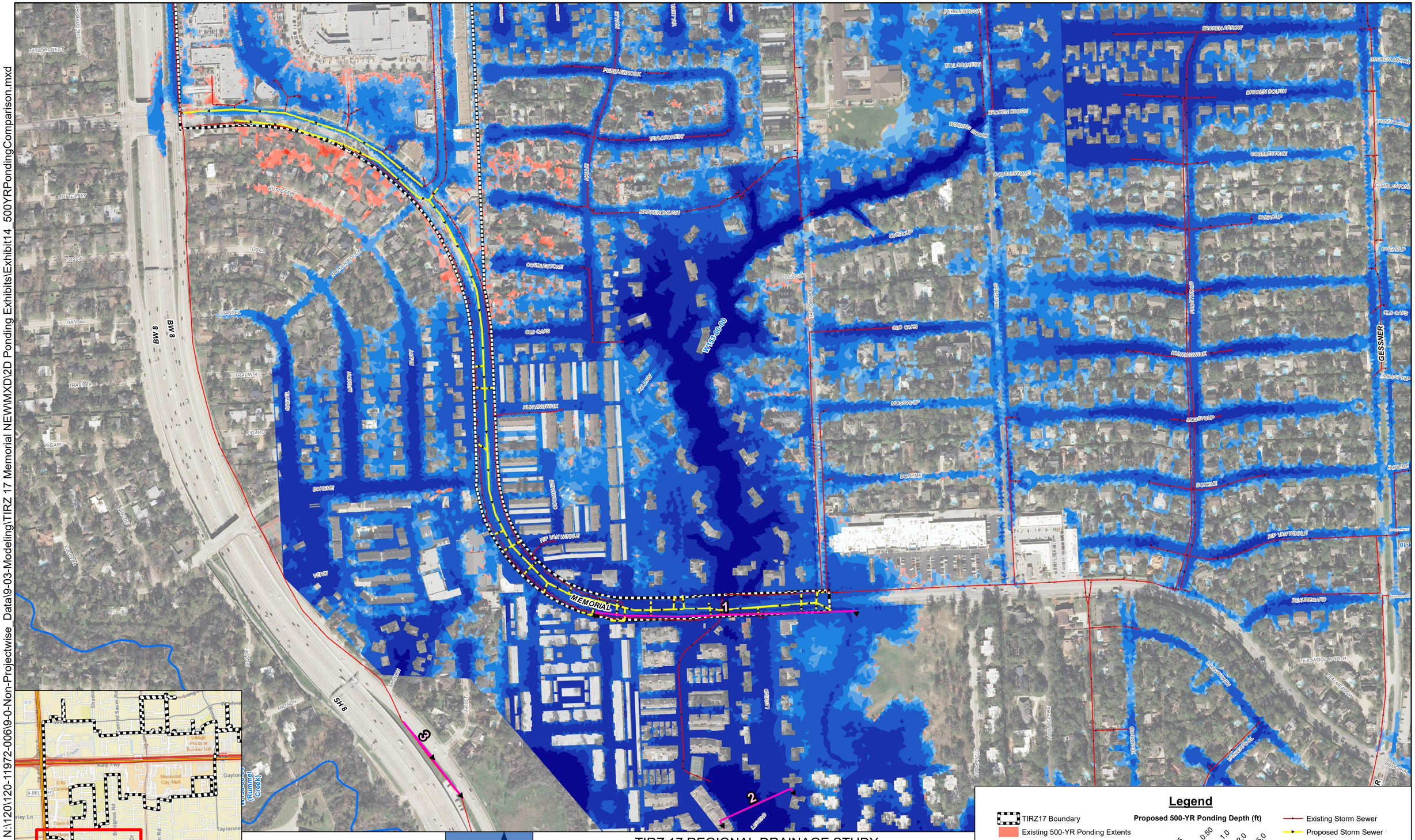
0 120 240 480 Feet

N

EXHIBIT 14

PROPOSED VS. EXISTING 500-YEAR EVENT PONDING

Document Path: N:\120\120-11972-006\9-0-Non-Projectwise_Data\9-03-Modeling\TIRZ 17 Memorial NEW\MXD\2D Ponding Exhibits\Exhibit14_500YRPondingComparison.mxd



LOCATION MAP

Legend

- TIRZ17 Boundary
- Existing 500-YR Ponding Extents
- **Proposed 500-YR Ponding Depth (ft)**: < 0.25; 0.25 - 0.50; 0.50 - 1.0; 1.0 - 2.0; 2.0 - 5.0; > 5.0
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- Evaluation Locations

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

PROPOSED VS. EXISTING 500-YEAR EVENT PONDING
EXHIBIT 14

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 15

10-YEAR MAXIMUM WATER SURFACE ELEVATION COMPARISON

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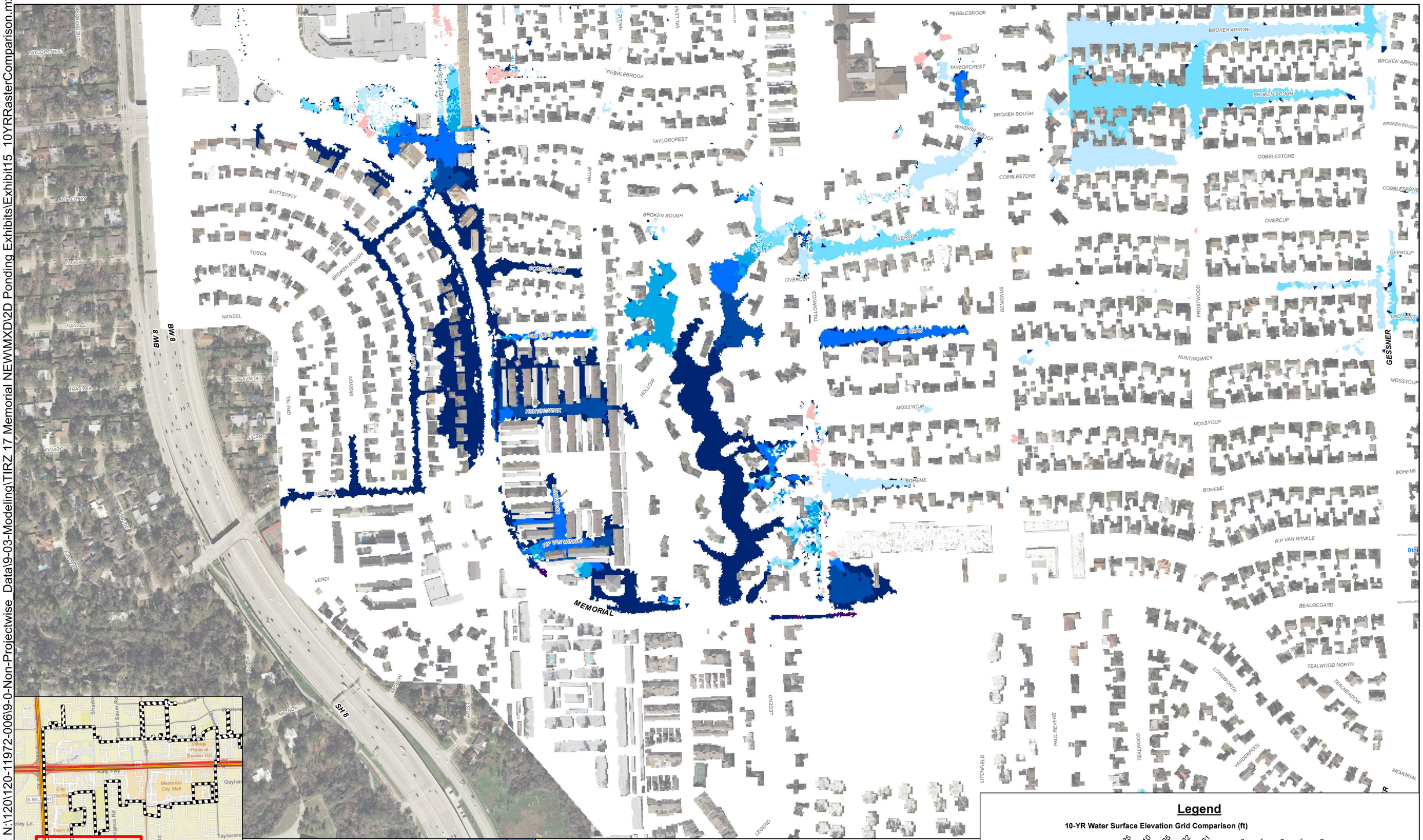
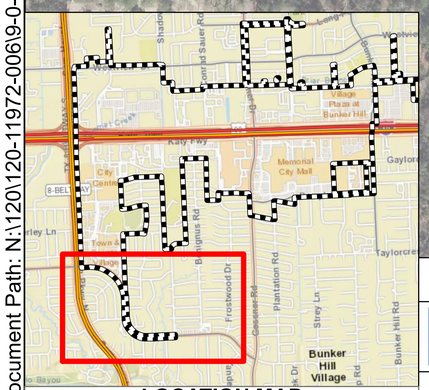




LOCATION MAP

Legend

10-YR Water Surface Elevation Grid Comparison (ft)

< -0.50 | -0.50 to -0.25 | -0.25 to -0.10 | -0.10 to -0.05 | -0.05 to -0.02 | -0.02 to -0.01 | 0 | 0.01 to 0.02 | 0.02 to 0.05 | 0.05 to 0.10 | 0.10 to 0.25 | 0.25 to 0.50 | > 0.50

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

MAX WATER SURFACE ELEVATION COMPARISON 10-YR
EXHIBIT 15

SCALE: AS NOTED
DATE: OCT 2020

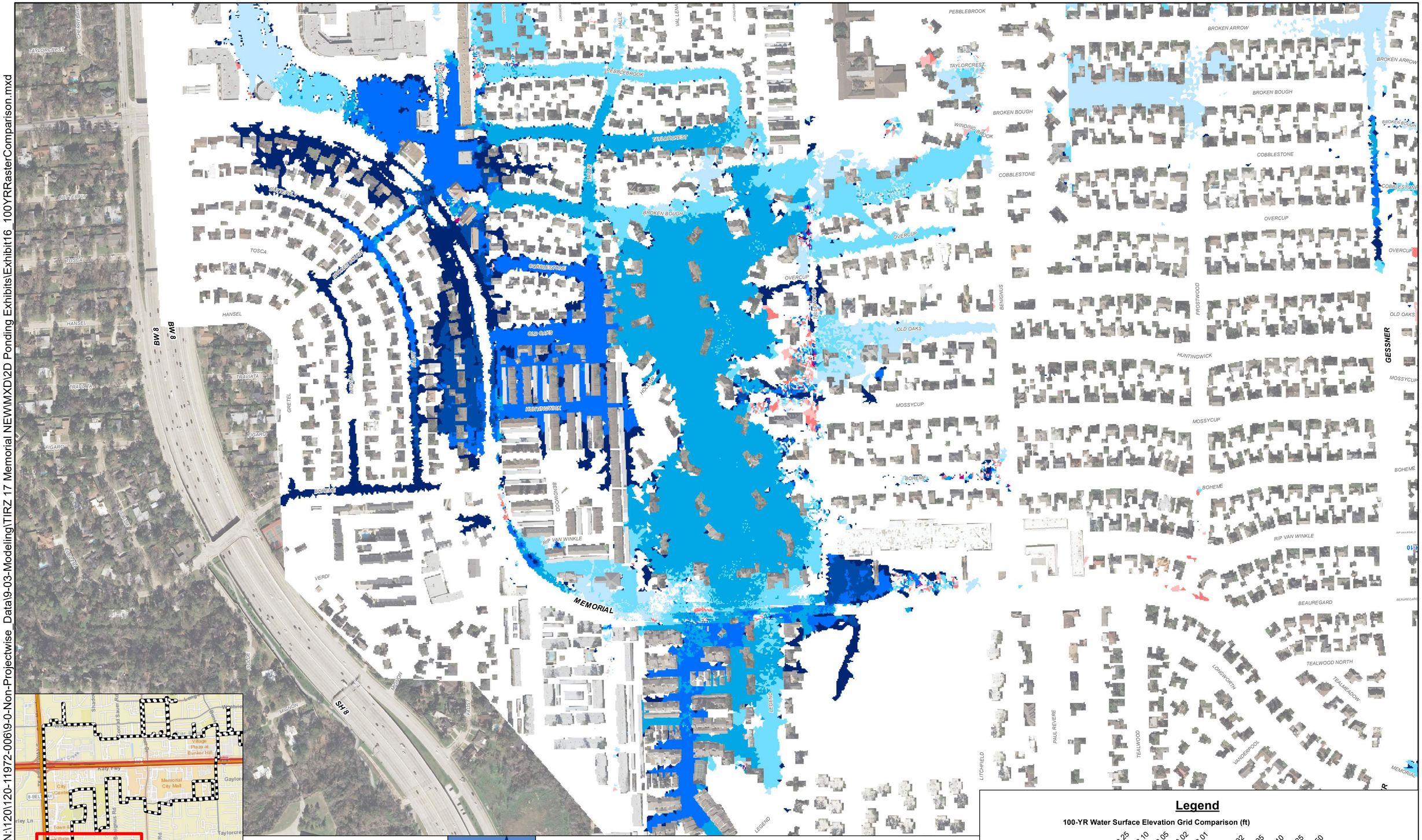
0 120 240 480 Feet

N

EXHIBIT 16

100-YEAR MAXIMUM WATER SURFACE ELEVATION COMPARISON

Document Path: N:\120\120-11972-006\9-0-Non-Projectwise_Data\9-03-Modeling\TIRZ 17 Memorial NEW\MXD\2D Ponding Exhibits\Exhibit16_100YRRasterComparison.mxd



LOCATION MAP

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

MAX WATER SURFACE ELEVATION COMPARISON 100-YR
EXHIBIT 16

Legend

100-YR Water Surface Elevation Grid Comparison (ft)

< -0.50 | -0.50 to -0.25 | -0.25 to -0.10 | -0.10 to -0.05 | -0.05 to -0.02 | -0.02 to -0.01 | 0 | 0.01 to 0.02 | 0.02 to 0.05 | 0.05 to 0.10 | 0.10 to 0.25 | 0.25 to 0.50 | > 0.50

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 17

500-YEAR MAXIMUM WATER SURFACE ELEVATION COMPARISON

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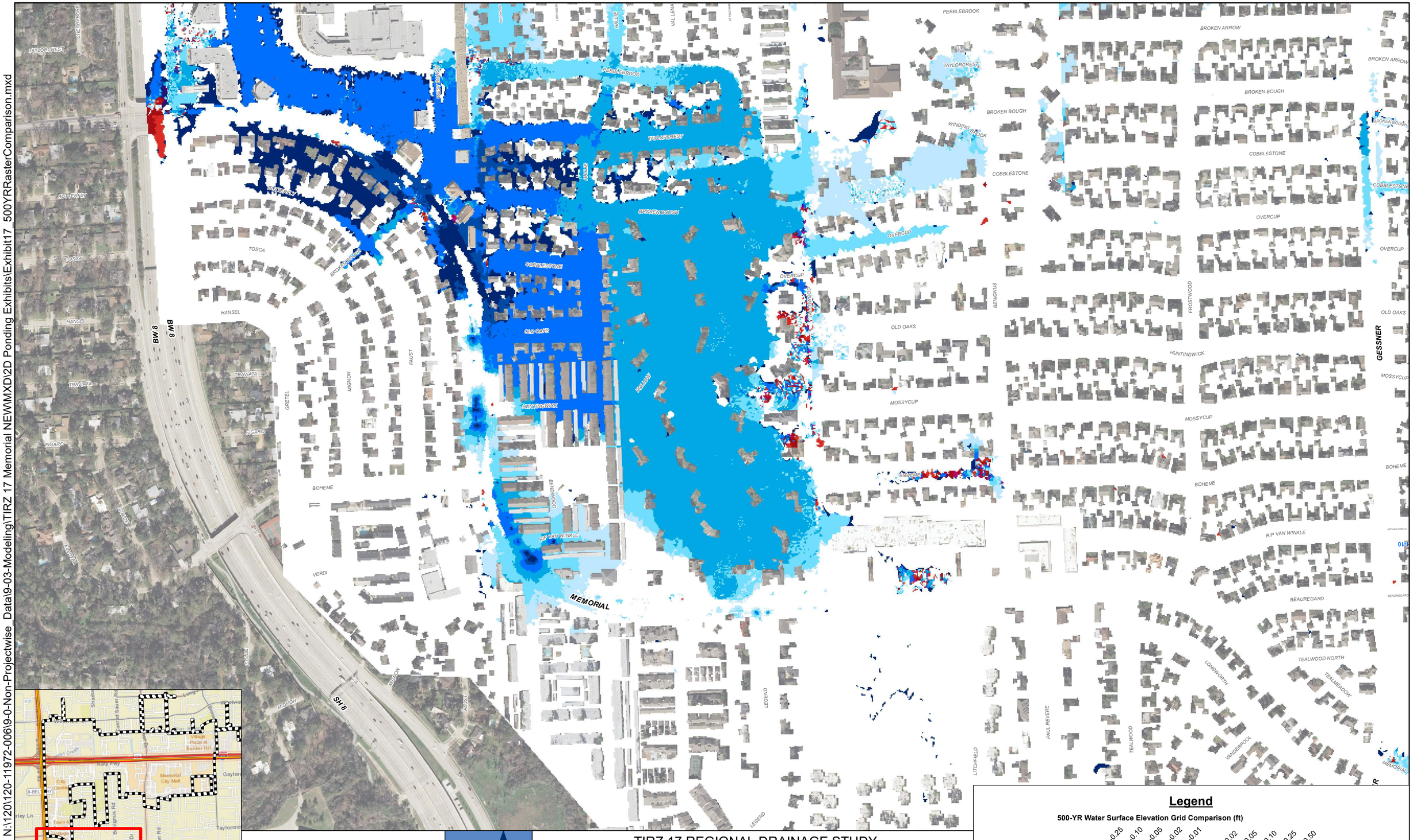

LOCATION MAP

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

MAX WATER SURFACE ELEVATION COMPARISON 500-YR
EXHIBIT 17

Legend

500-YR Water Surface Elevation Grid Comparison (ft)

< -0.50 | -0.50 to -0.25 | -0.25 to -0.10 | -0.10 to -0.05 | -0.05 to -0.02 | -0.02 to -0.01 | 0 | 0.01 to 0.02 | 0.02 to 0.05 | 0.05 to 0.10 | 0.10 to 0.25 | 0.25 to 0.50 | > 0.50

SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

EXHIBIT 18

2D DRAINAGE AREA MAP (SUBCATCHMENTS)

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Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

TIRZ 17 REDEVELOPMENT AUTHORITY

TIRZ 17 REGIONAL DRAINAGE STUDY
MEMORIAL WEST IMPROVEMENTS
(W153)

2D DRAINAGE AREAS AND OUTFALLS (PROPOSED SYSTEM A & B)
EXHIBIT 18

Legend

- TIRZ17 Boundary
- Existing Storm Sewer
- Proposed Storm Sewer
- HCFCD Channel
- System A Outfall
- System B Outfall
- System A - Drainage Area
- System B - Drainage Area

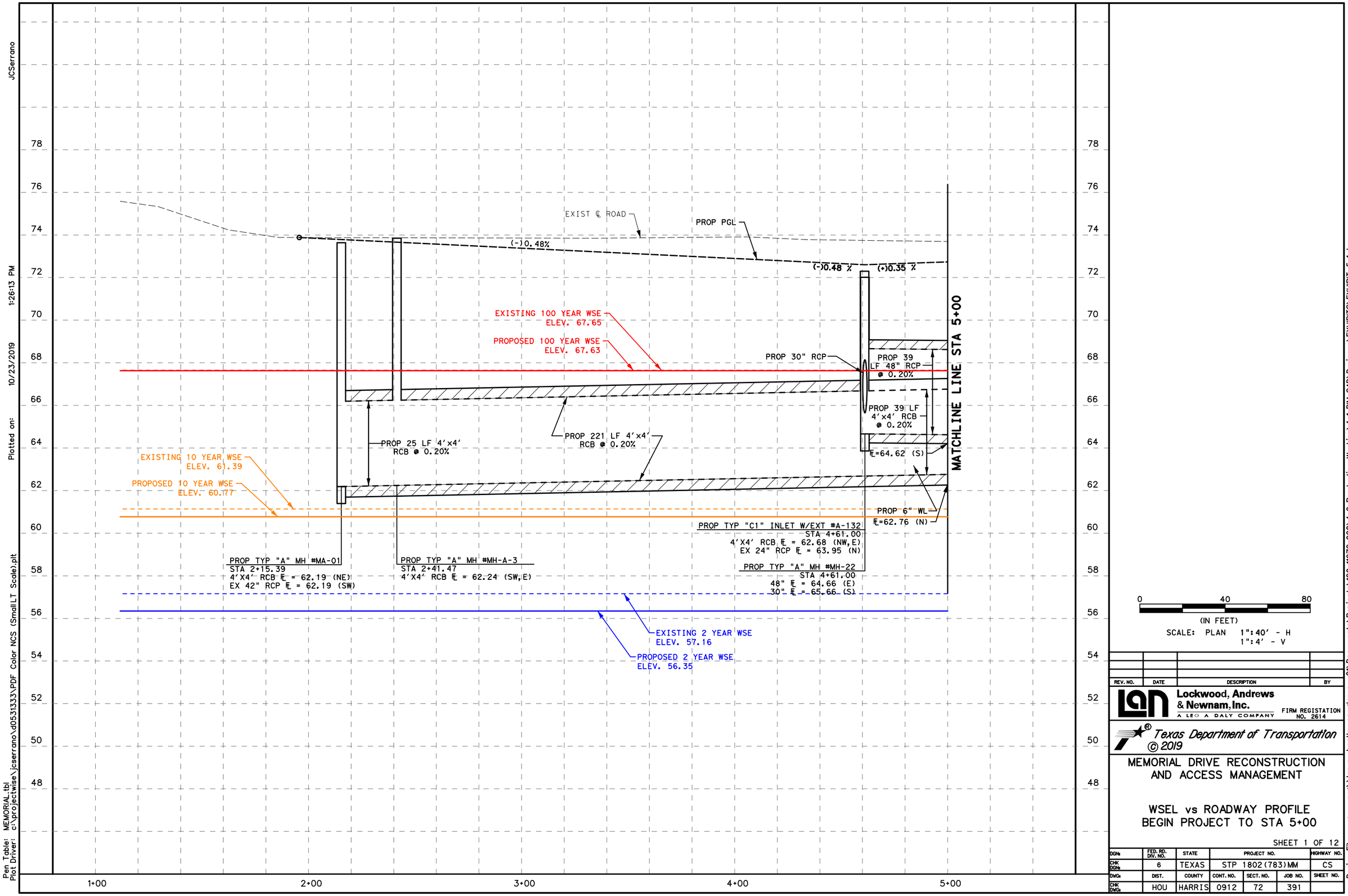
SCALE: AS NOTED
DATE: OCT 2020

0 120 240 480 Feet

N

APPENDIX 1.

ROADWAY PROFILE VS. 2-YR, 10-YR, & 100-YR WSEL OF W153-00-00



0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE BEGIN PROJECT TO STA 5+00

SHEET 1 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	

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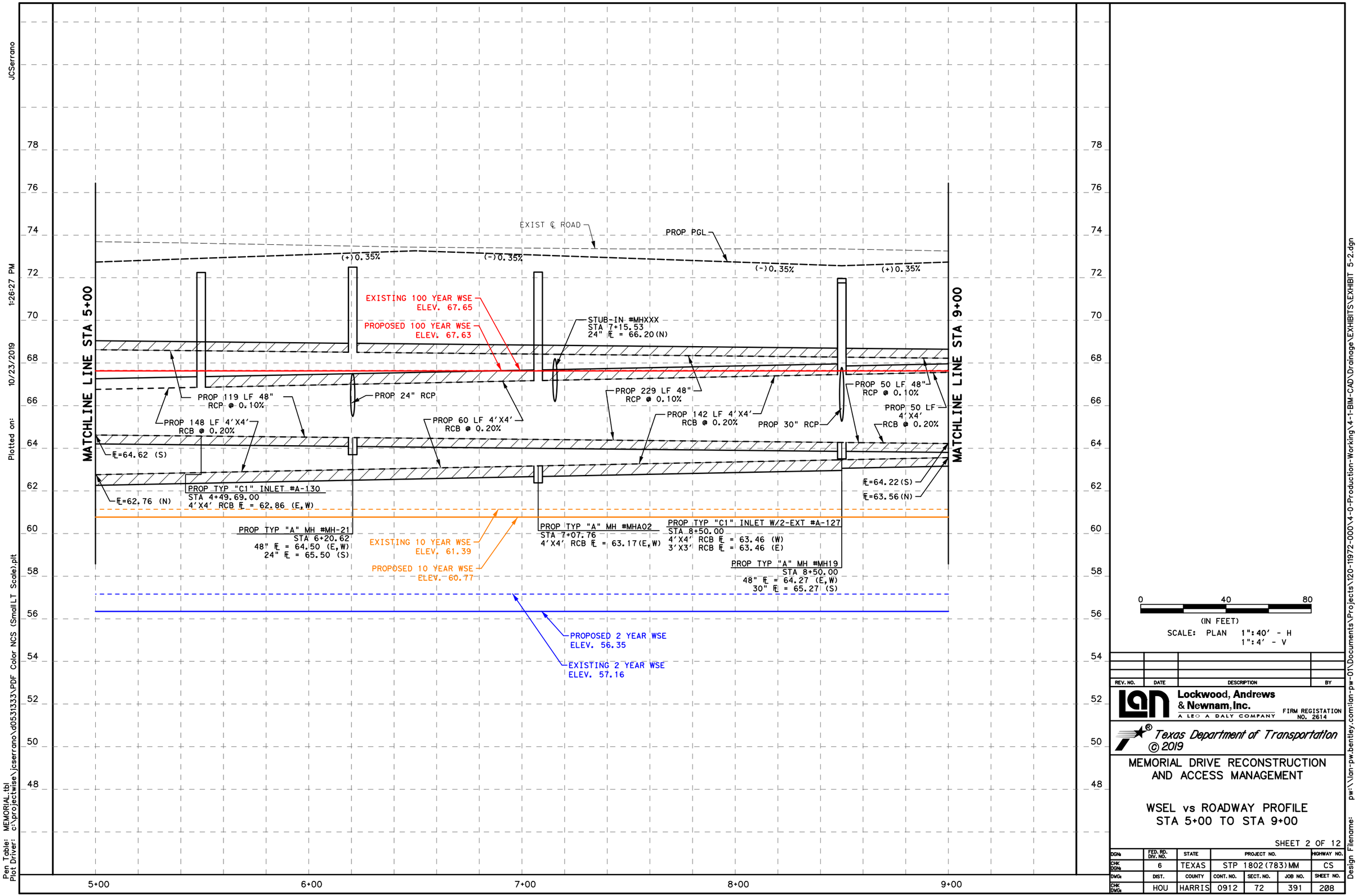

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

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WSEL vs ROADWAY PROFILE STA 5+00 TO STA 9+00

SHEET 2 OF 12

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	208

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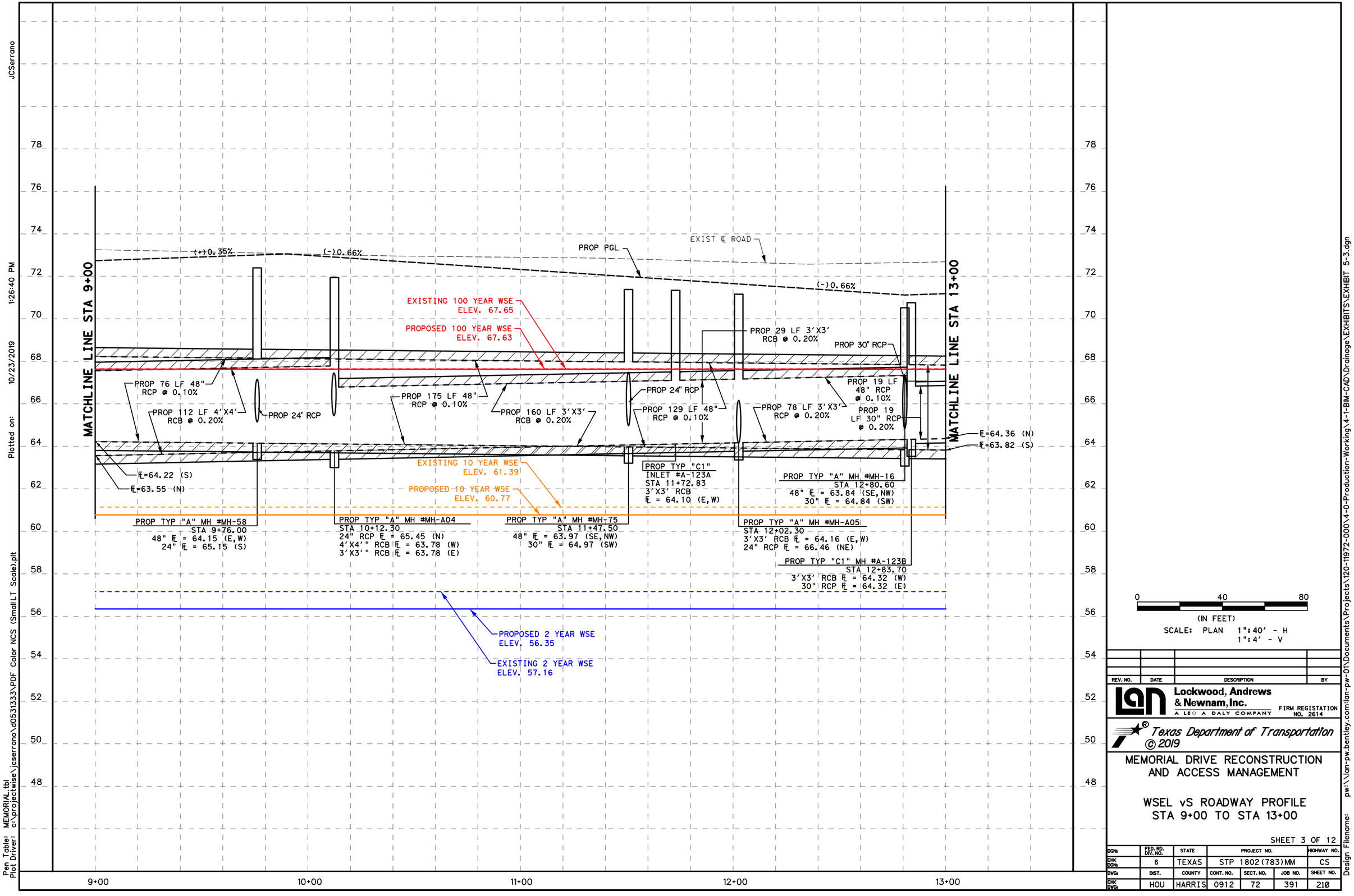

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vS ROADWAY PROFILE STA 9+00 TO STA 13+00

SHEET 3 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	210

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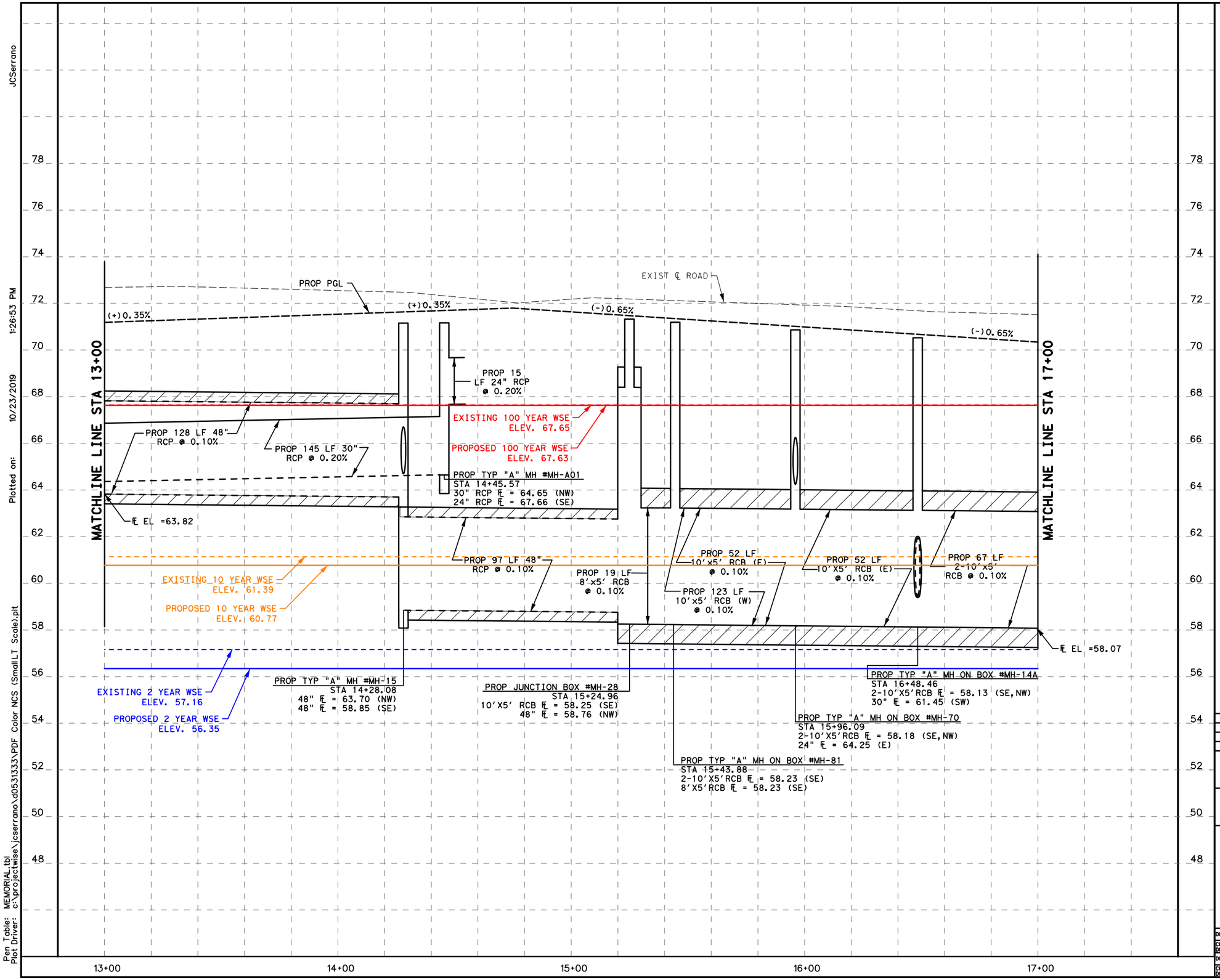

0 40 80
(IN FEET)
SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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WSEL vs ROADWAY PROFILE STA 13+00 TO STA 17+00

SHEET 4 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	212

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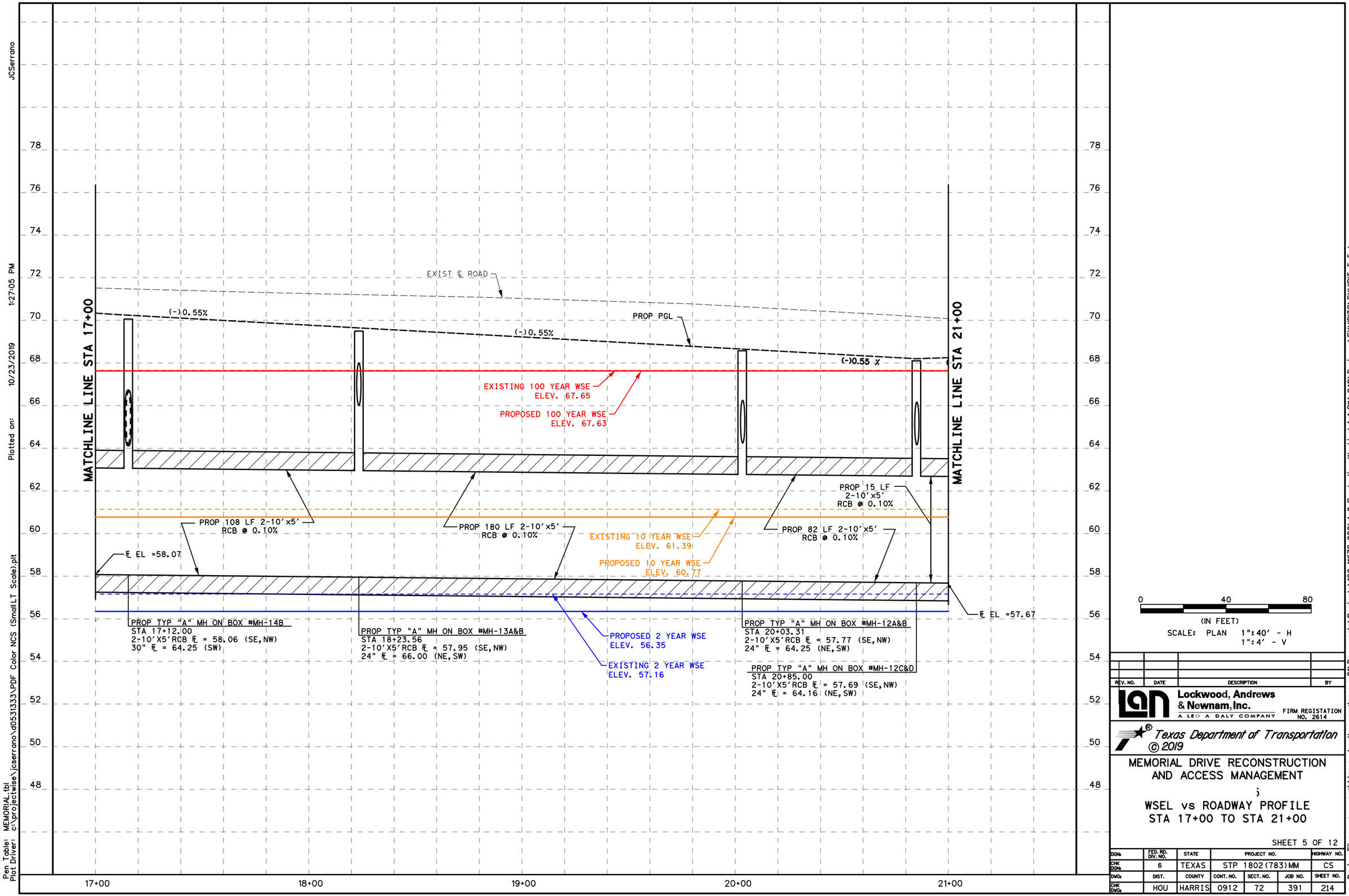

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

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WSEL vs ROADWAY PROFILE
STA 17+00 TO STA 21+00

SHEET 5 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	214

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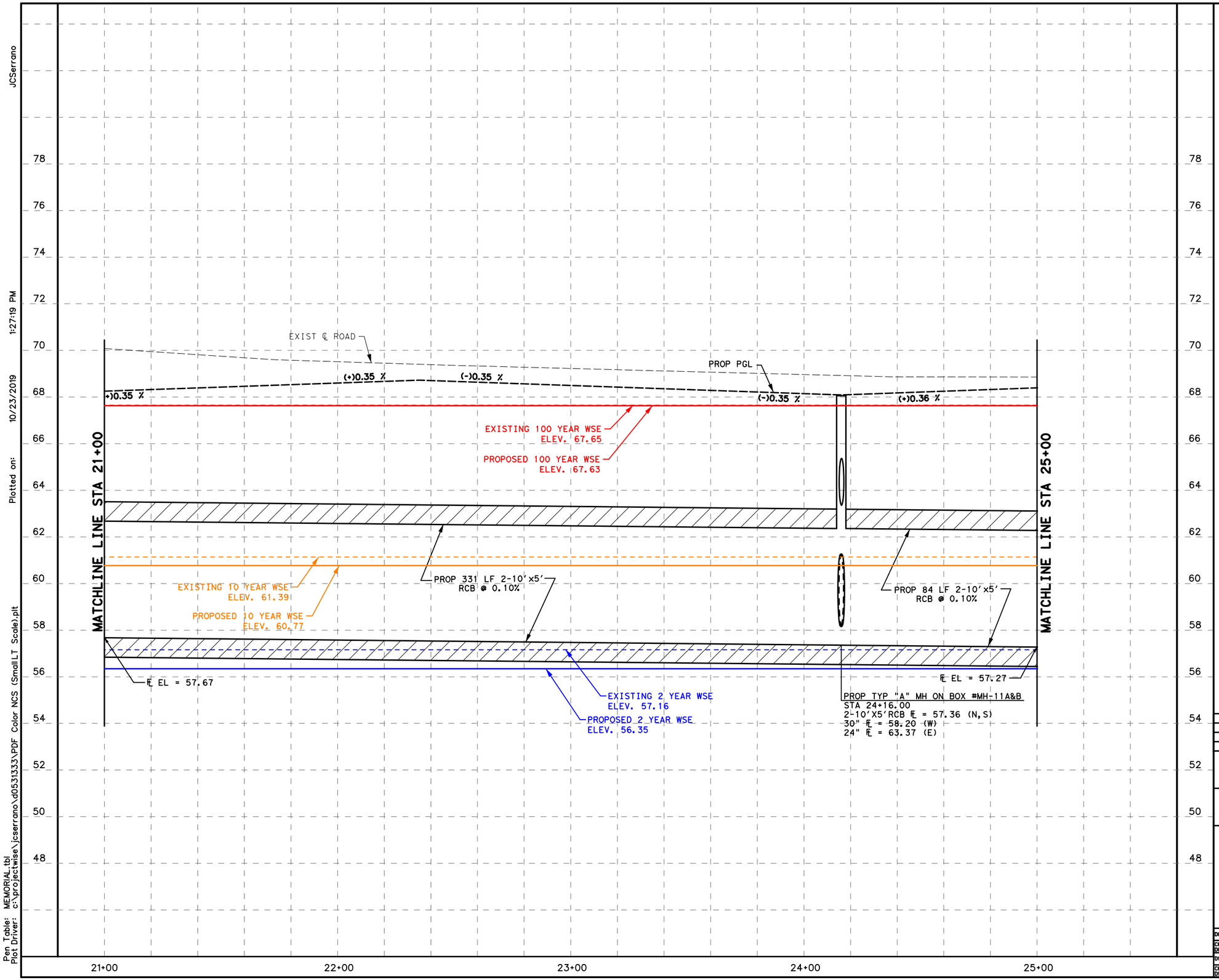

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE STA 21+00 TO STA 25+00

SHEET 6 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	216

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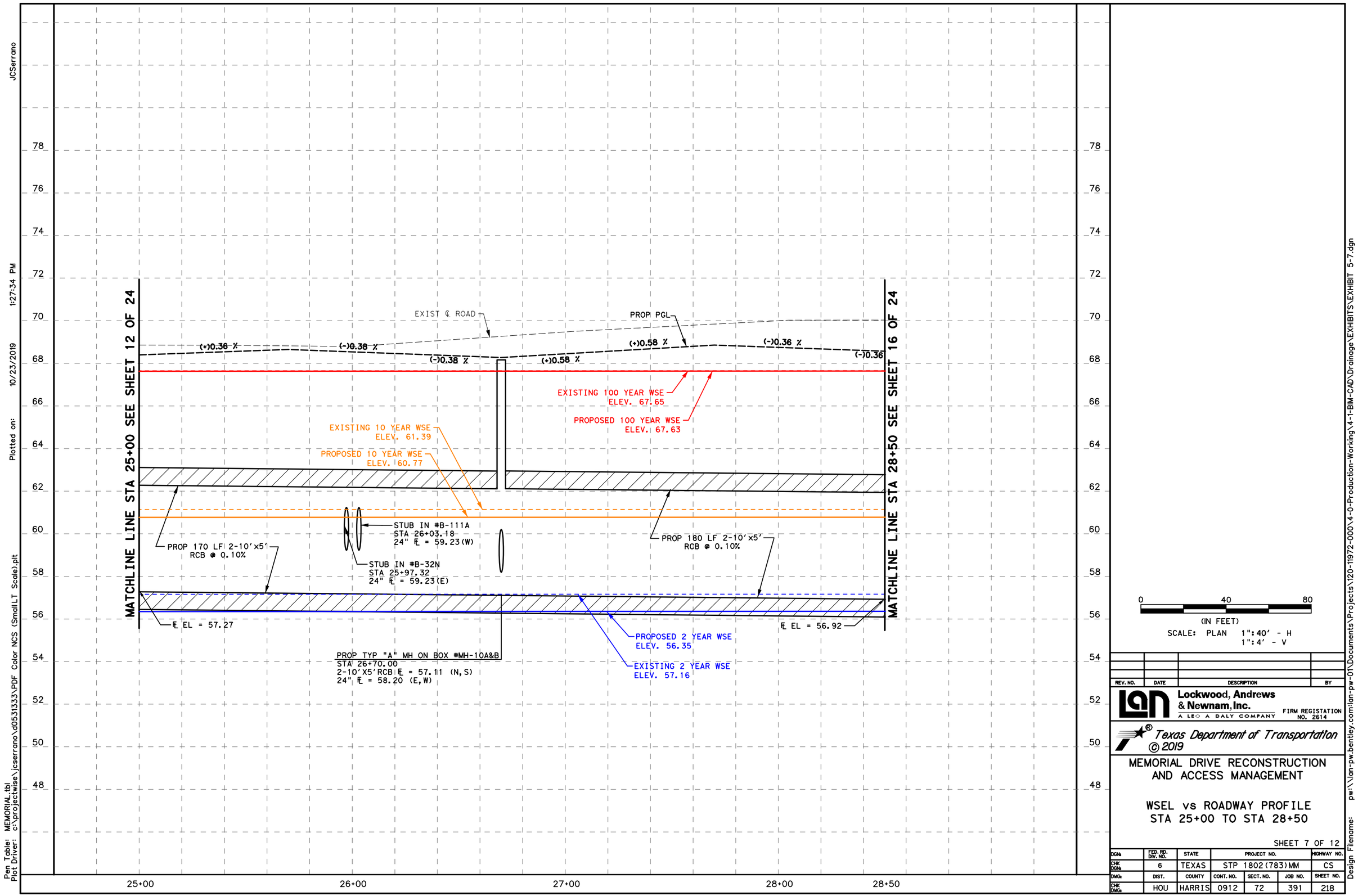

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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FIRM REGISTATION NO. 2614

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE STA 25+00 TO STA 28+50

SHEET 7 OF 12

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
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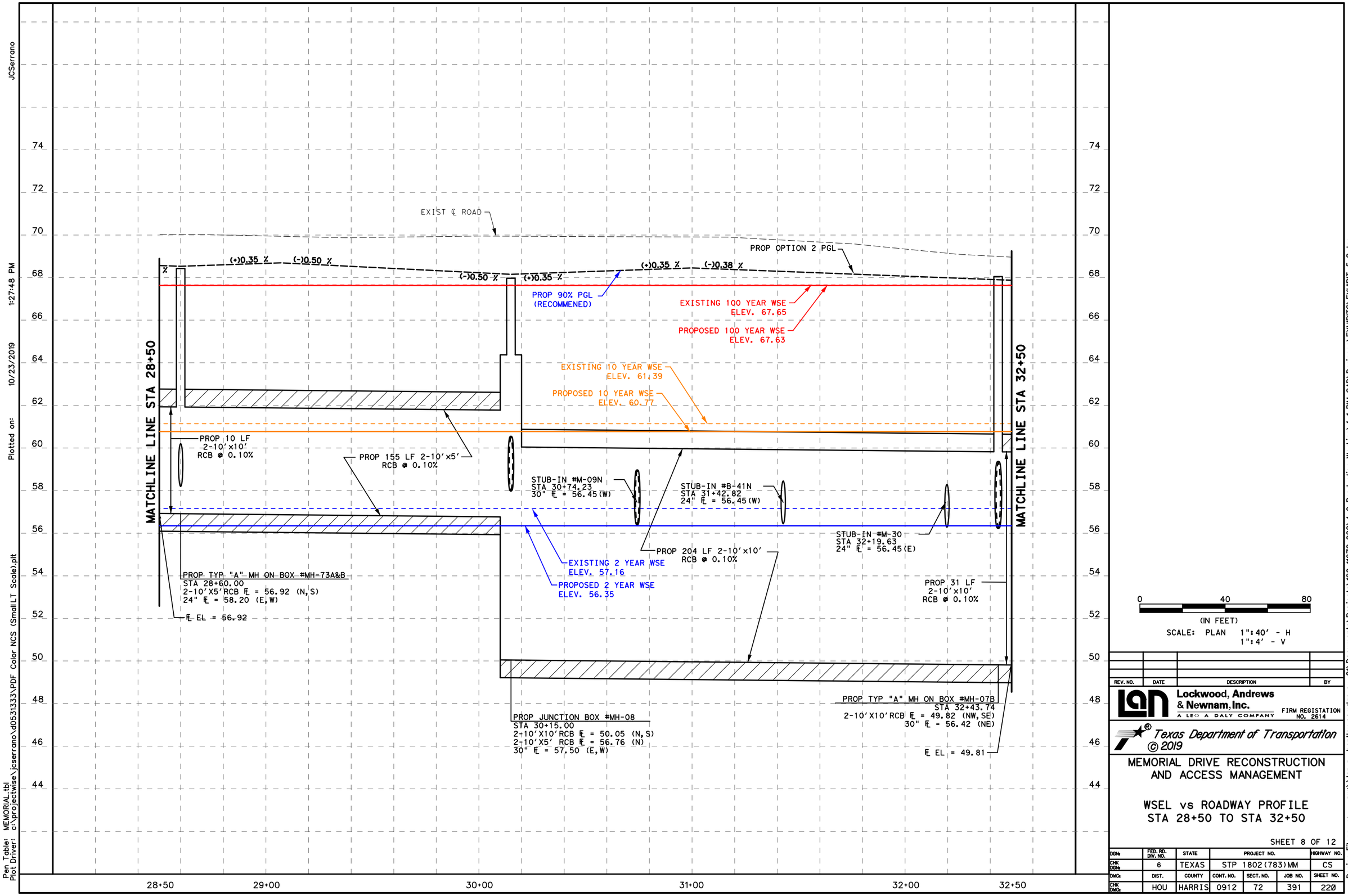

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE
STA 28+50 TO STA 32+50

SHEET 8 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
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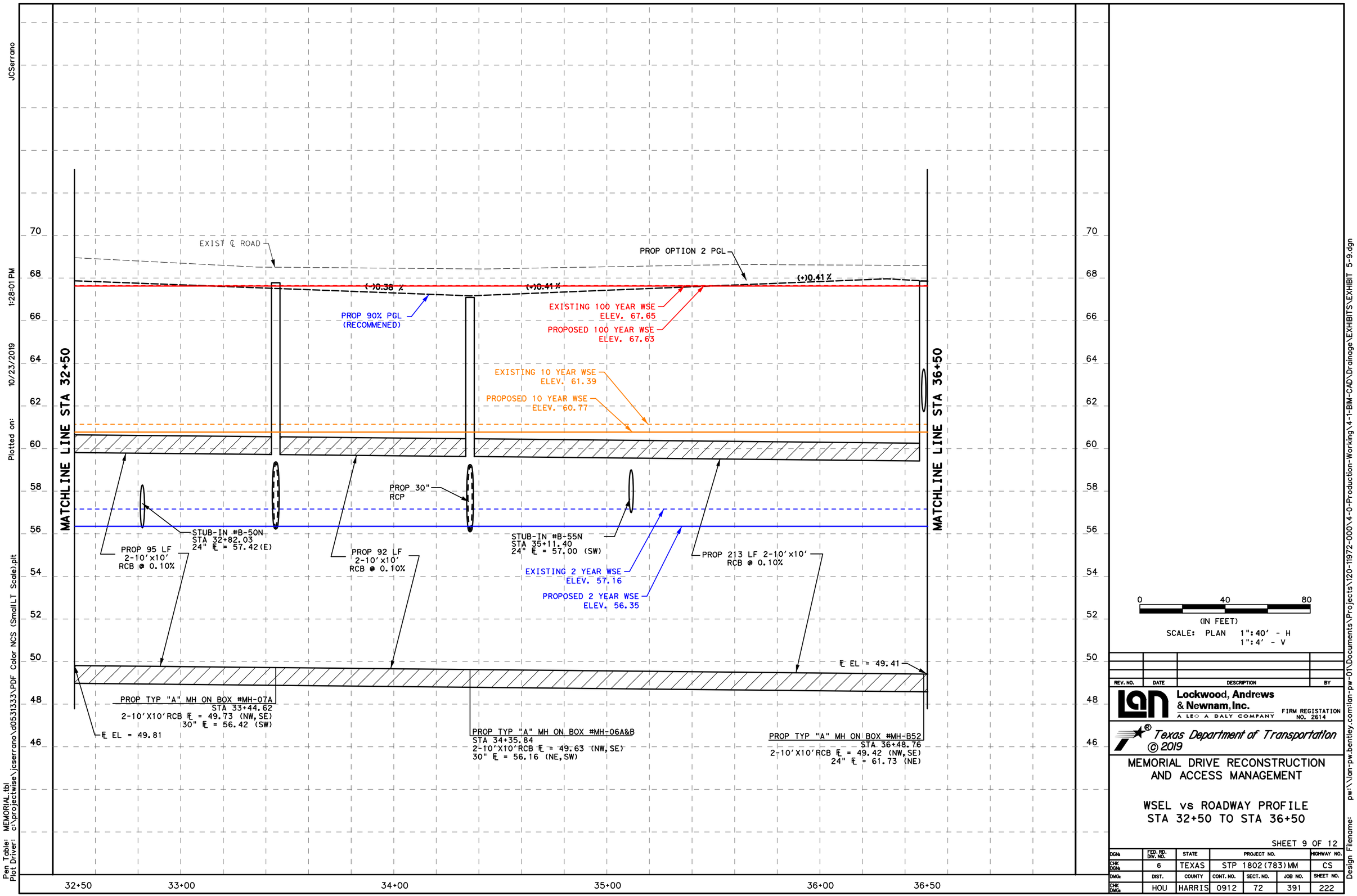

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE
STA 32+50 TO STA 36+50

SHEET 9 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
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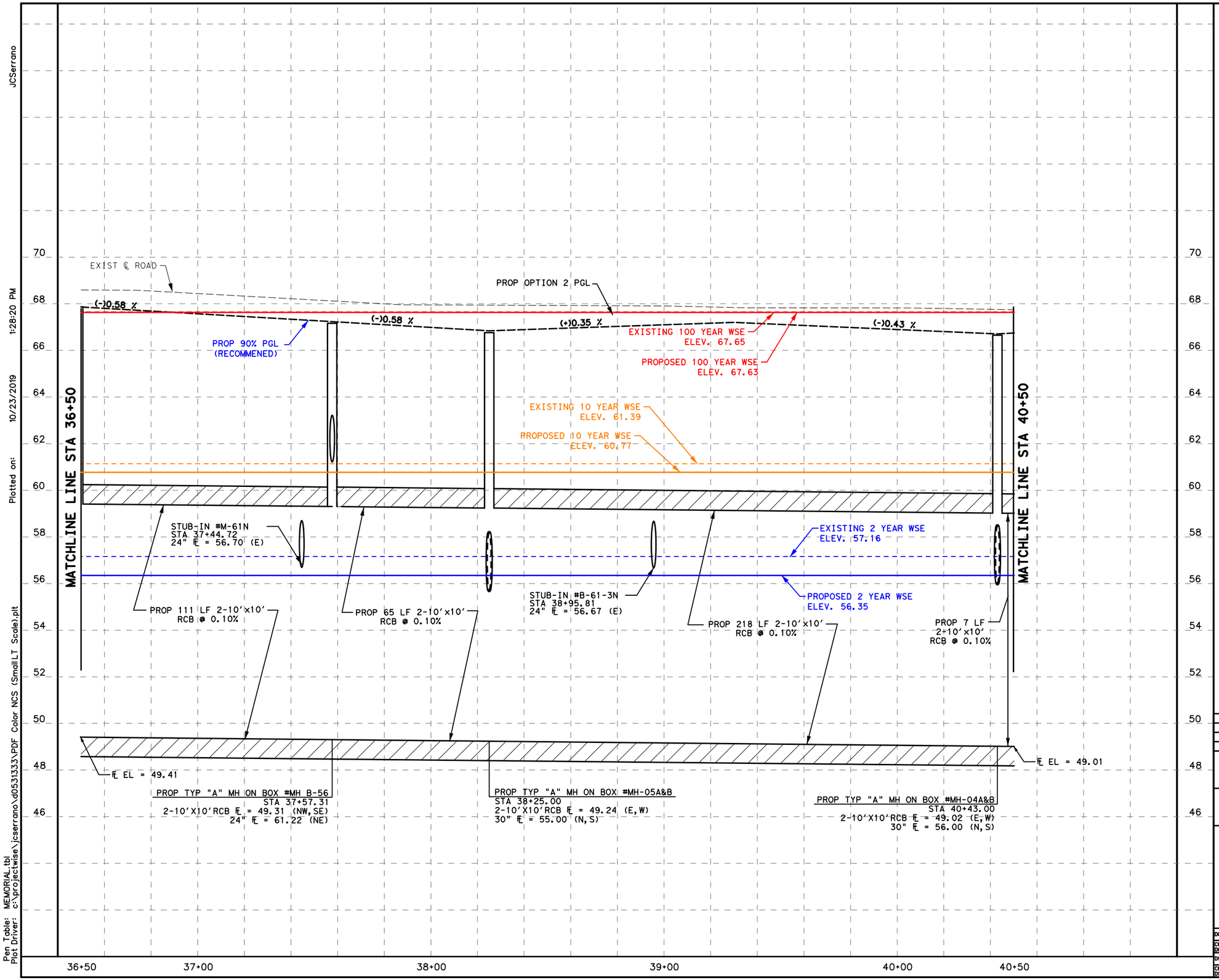

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE STA 36+50 TO STA 40+50

SHEET 10 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
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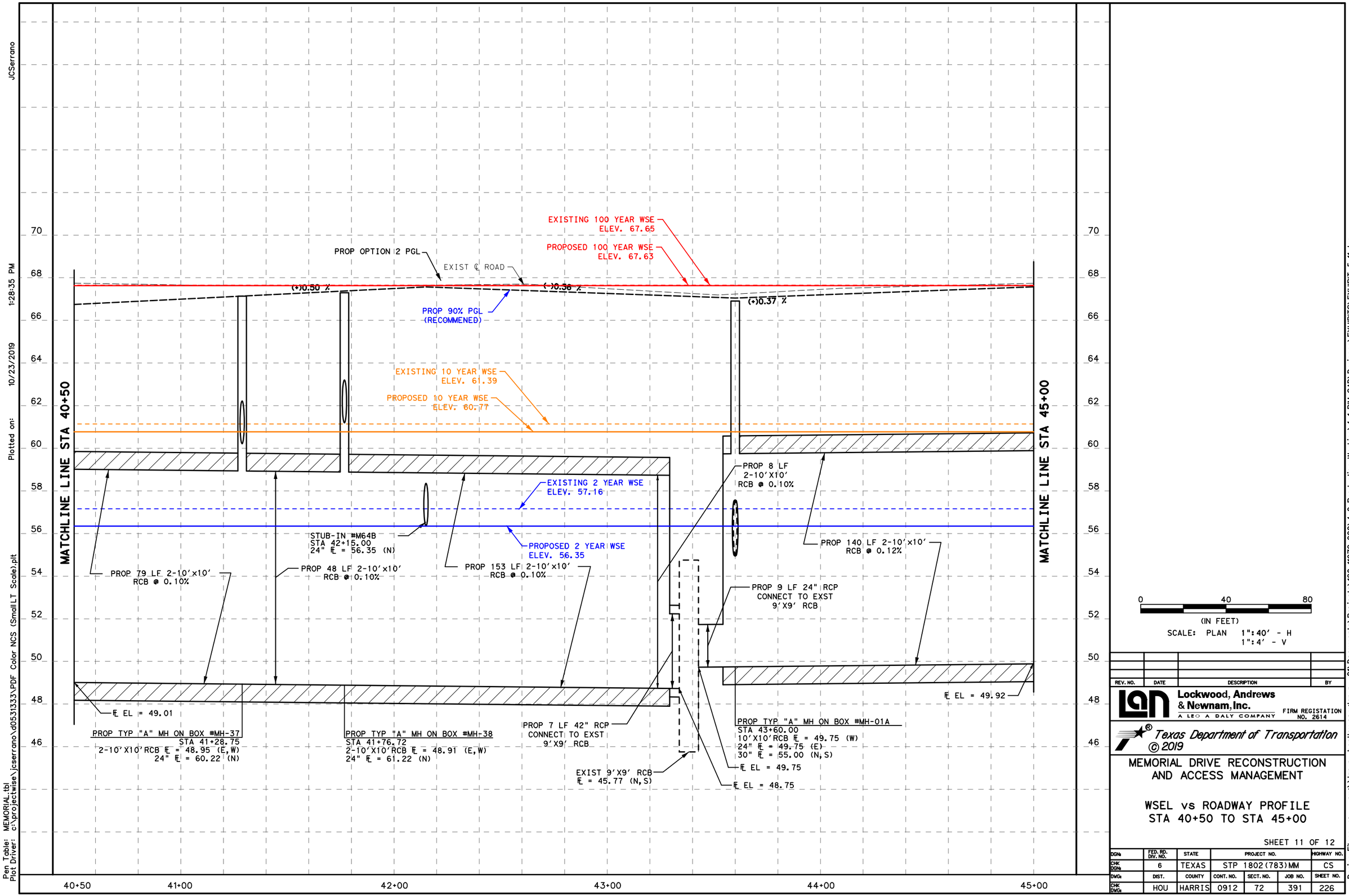

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE STA 40+50 TO STA 45+00

SHEET 11 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
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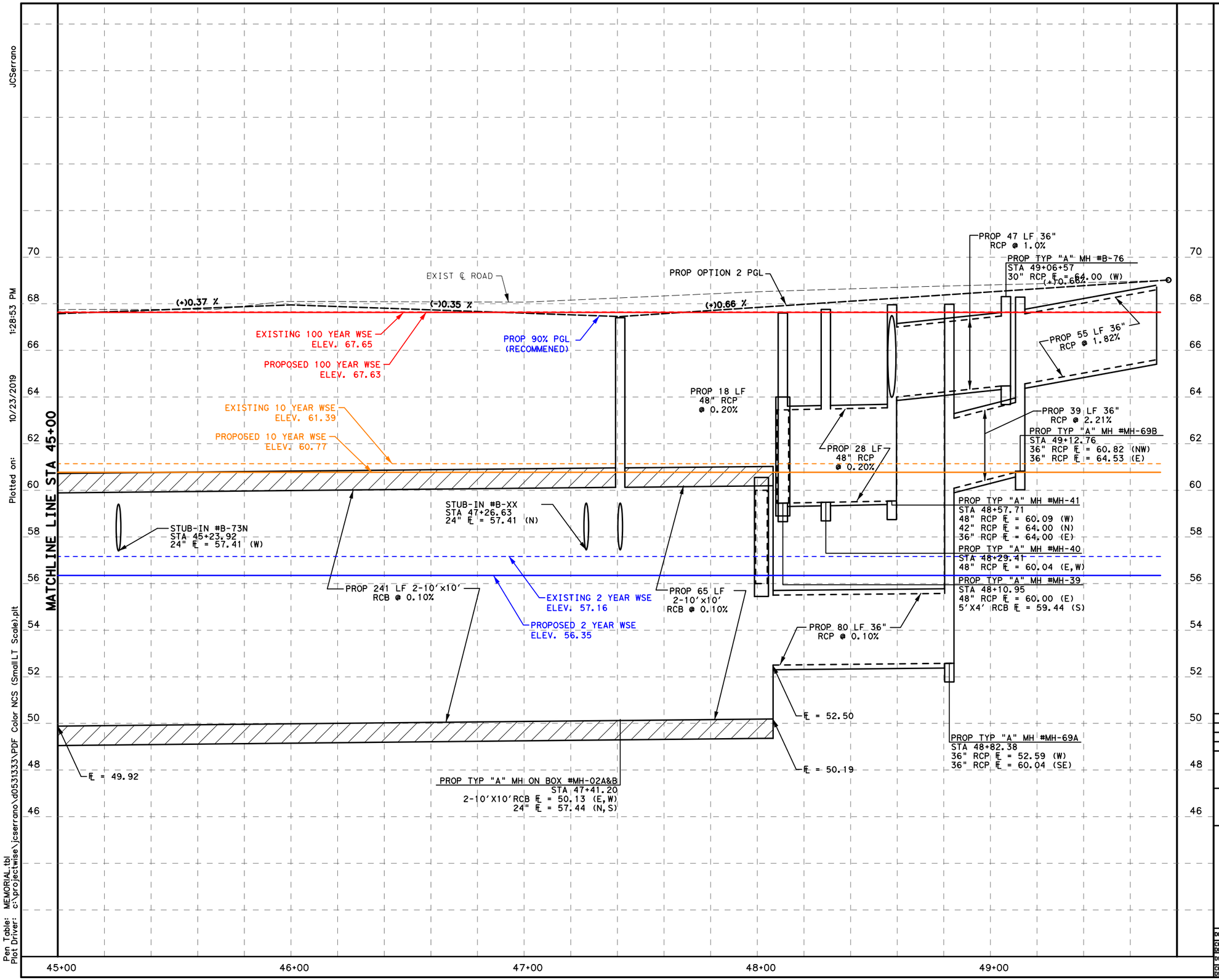

0 40 80

(IN FEET)

SCALE: PLAN 1":40' - H
1":4' - V

REV. NO.	DATE	DESCRIPTION	BY

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

WSEL vs ROADWAY PROFILE STA 40+50 TO END PROJECT

SHEET 12 OF 12

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
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CHK DWG:	HOU	HARRIS	0912	72	391	

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JCSerrano

APPENDIX 2.

2-YR HYDRAULIC GRADE LINE (HGL) SUMMARY TABLE

SYSTEM A - PROPOSED 2-YR LINK & HGL SUMMARY

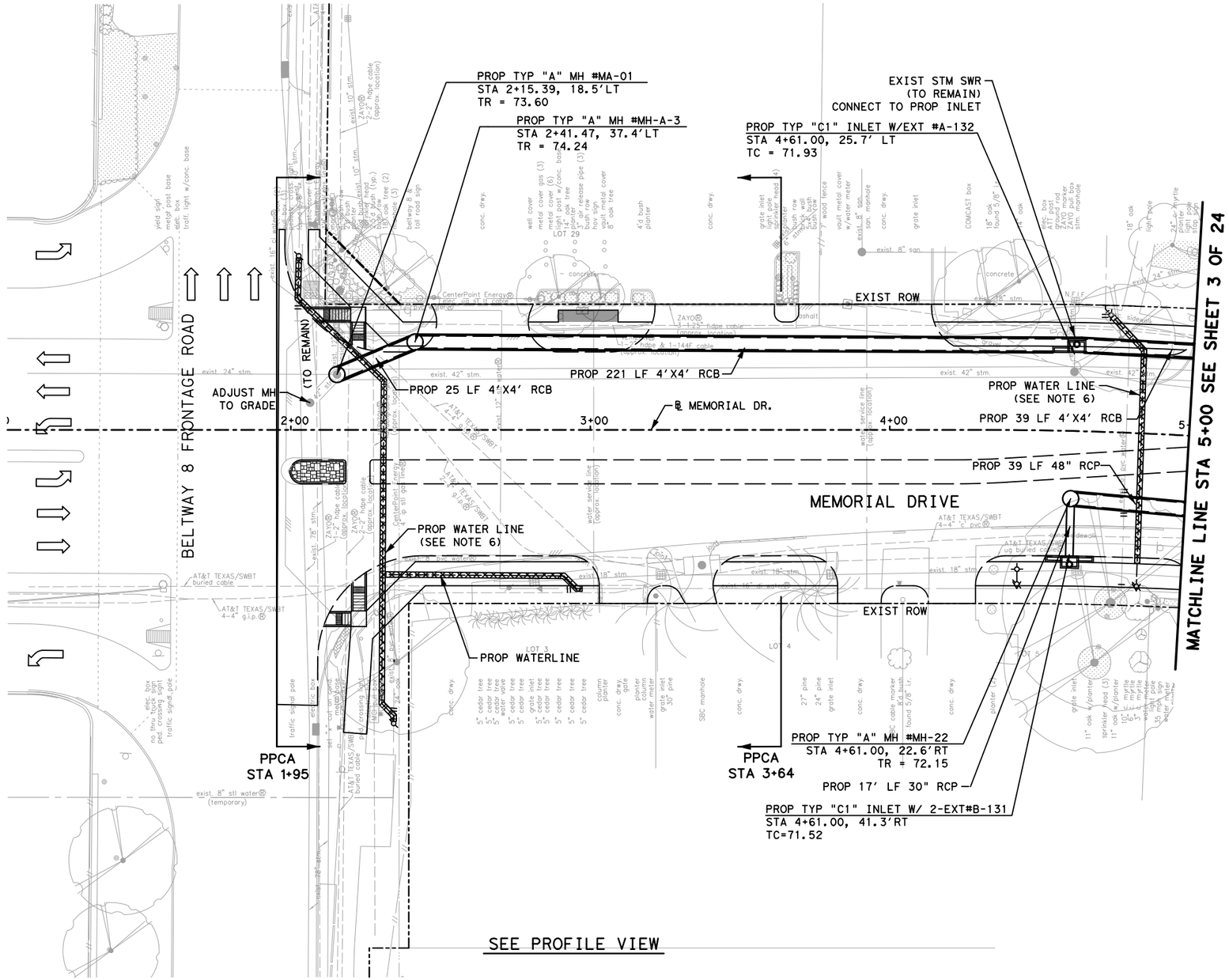
LINK ID	US NODE	DS NODE	HGL	
			US (ft)	DS (ft)
MA-01	MA-01	A-OUT	65.61	63.40
A-01	A-01	MA-01	69.32	66.76
MH-A-3	MH-A-3	MA-01	65.73	65.61
A-132	A-132	MH-A-3	66.24	65.73
A-02	A-02	A-132	66.27	66.24
A-130	A-130	A-132	66.43	66.24
MH-A03	MH-A03	A-130	67.05	66.43
A-03	A-03	MH-A03	67.47	67.05
A-127	A-127	MH-A03	67.11	67.05
MH-A04	MH-A04	A-127	67.44	67.11
A-04	A-04	MH-A04	69.29	67.44
A-123A	A-123A	MH-A04	67.50	67.44
MH-A05	MH-A05	A-123A	67.51	67.50
A-05	A-05	MH-A05	67.51	67.51
A-123B	A-123B	MH-A05	67.54	67.51
MH-A01	MH-A01	A-123B	67.70	67.54
MH-A07	MH-A08	MH-A01	67.71	67.70
A-07	A-07	MH-A08	68.89	68.63
A-08	A-08	MH-A08	71.64	70.37

SYSTEM B - PROPOSED 2-YR LINK & HGL SUMMARY

LINK ID	US NODE	DS NODE	HGL		LINK ID	US NODE	DS NODE	HGL		LINK ID	US NODE	DS NODE	HGL	
			US (ft)	DS (ft)				US (ft)	DS (ft)				US (ft)	DS (ft)
W-153	W-153	OUT-B	57.29	56.35	B-56	B-56	MH-B56-1	63.39	62.21	B-32N	B-32N	MH-10	58.28	58.02
N-R1	N-R1	W-153	57.66	57.29	B-76	B-76	MH-41	64.83	63.24	MH-11	MH-11	B-32N	58.34	58.28
N-R2	N-R2	W-153	62.56	57.29	B-70-2	B-70-2	MH-41	63.76	63.73	MH-B32	MH-B32	B-32N	61.05	60.60
MH-38	MH-38	N-R1	57.66	57.66	B-55N	B-55N	MH-B52	57.67	57.67	B-113	B-113	MH-11	59.07	58.79
MH-01	MH-01	N-R2	62.56	62.56	MH-80	MH-80	MH-B52	62.30	62.10	B-114A	B-114A	MH-11	58.35	58.34
B-64	B-64	MH-38	61.78	61.53	MH-B61-2	MH-B61-2	MH-B61-1	57.68	57.67	MH-12C	MH-12C	MH-11	58.49	58.34
MH-37	MH-37	MH-38	57.66	57.66	B-70	B-70	B-70-2	64.00	63.76	B-32	B-32	MH-B32	65.91	65.01
B-101	B-101	MH-01	62.56	62.56	MH-06	MH-06	B-55N	57.73	57.67	B-115B	B-115B	MH-12C	58.94	58.70
B-102	B-102	MH-01	62.56	62.56	MH-B55	MH-B55	B-55N	57.68	57.67	B-116B	B-116B	MH-12C	58.68	58.50
B-73N	B-73N	MH-01	62.57	62.56	B-52	B-52	MH-80	64.75	62.76	MH-12A	MH-12A	MH-12C	58.54	58.49
B-63	B-63	MH-37	61.00	60.68	B-107	B-107	MH-06	57.73	57.73	MH-13	MH-13	MH-12A	58.66	58.54
MH-04	MH-04	MH-37	57.66	57.66	B-108	B-108	MH-06	58.54	57.73	B-115A	B-115A	MH-12A	64.91	64.70
MH-02	MH-02	B-73N	62.57	62.57	MH-07A	MH-07A	MH-06	57.73	57.73	B-116A	B-116A	MH-12A	64.82	64.60
MH-B73	MH-B73	B-73N	62.61	62.57	B-55	B-55	MH-B55	65.12	64.73	B-117	B-117	MH-13	64.90	64.69
B-103	B-103	MH-04	57.67	57.66	MH-108	MH-108	B-108	58.99	58.64	B-118	B-118	MH-13	64.84	64.61
B-104	B-104	MH-04	57.67	57.66	B-109	B-109	MH-07A	57.73	57.73	MH-14B	MH-14B	MH-13	58.74	58.66
B-61-3N	B-61-3N	MH-04	57.67	57.66	B-50N	B-50N	MH-07A	57.73	57.73	B-120	B-120	MH-14B	64.93	64.68
B-133	B-133	MH-02	62.57	62.57	MH-B44	MH-B44	MH-108	59.44	58.99	MH-14A	MH-14A	MH-14B	58.79	58.74
B-134	B-134	MH-02	62.57	62.57	MH-B58	MH-B58	MH-108	59.00	58.99	B-119	B-119	MH-14A	60.08	59.87
MH-03	MH-03	MH-02	62.57	62.57	MH-07B	MH-07B	B-50N	57.73	57.73	MH-70	MH-70	MH-14A	58.83	58.79
B-73	B-73	MH-B73	64.96	63.67	MH-B50	MH-B50	B-50N	57.74	57.73	MH-47	MH-47	MH-70	64.71	64.54
MH-05	MH-05	B-61-3N	57.67	57.67	B-44	B-44	MH-B44	65.86	64.52	MH-81	MH-81	MH-70	58.85	58.83
MH-B61-3	MH-B61-3	B-61-3N	57.67	57.67	B-58	B-58	MH-B58	65.08	64.88	B-14	B-14	MH-47	69.59	69.06
MH-39	MH-39	MH-03	63.32	62.57	B-110	B-110	MH-07B	57.73	57.73	B-15C	B-15C	MH-81	58.89	58.85
MH-69A	MH-69A	MH-03	62.57	62.57	B-41N	B-41N	MH-07B	57.73	57.73	MH-28	MH-28	MH-81	58.92	58.85
B-105	B-105	MH-05	58.93	56.13	B-50	B-50	MH-B50	66.08	64.72	B-15B	B-15B	B-15C	59.04	58.89
B-106	B-106	MH-05	61.74	61.54	M-09N	M-09N	B-41N	57.73	57.73	MH-15	MH-15	MH-28	60.01	59.67
MH-B56	B-56N	MH-05	57.67	57.67	MH-B41	MH-B41	B-41N	57.75	57.73	MH-46	MH-46	B-15B	59.17	59.04
B-71	B-71	MH-39	63.37	63.32	MH-08	MH-08	M-09N	57.73	57.73	MH-16	MH-16	MH-15	65.11	64.61
MH-40	MH-40	MH-39	63.36	63.32	MH-09	MH-09	M-09N	57.73	57.73	B-15	B-15	MH-46	71.32	70.51
MH-69B	MH-69B	MH-69A	62.57	62.57	B-41	B-41	MH-B41	66.14	65.23	B-122	B-122	MH-16	65.65	65.40
MH-B61	MH-B61	B-105	62.47	61.92	B-124	B-124	MH-08	58.58	58.39	MH-75	MH-75	MH-16	65.21	65.11
B-61-1N	MH-B56	B-56N	57.67	57.67	B-125	B-125	MH-08	58.40	58.23	B-139	B-139	MH-75	65.55	65.37
MH-B56-1	MH-B56-1	B-56N	61.99	61.76	MH-73	MH-73	MH-08	57.86	57.73	MH-58	MH-58	MH-75	65.29	65.21
MH-41	MH-41	MH-40	63.73	63.36	B-121	B-121	MH-73	58.57	58.42	MH-19	MH-19	MH-58	65.43	65.29
B-69	B-69	MH-69B	66.12	64.77	B-136	B-136	MH-73	58.78	58.59	B-126	B-126	MH-19	66.09	65.83
B-61	B-61	MH-B61	64.38	63.47	MH-10	MH-10	MH-73	58.02	57.86	MH-21	MH-21	MH-19	65.49	65.43
MH-52	MH-B52	MH-B56	57.67	57.67	B-111	B-111	MH-10	58.89	58.66	MH-22	MH-22	MH-21	65.63	65.49
MH-B61-1	MH-B61-1	MH-B56	57.67	57.67	B-112	B-112	MH-10	58.62	58.45	B-131	B-131	MH-22	66.59	66.30

APPENDIX 3.

PROPOSED STORM SEWER PLAN & PROFILE



LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

1. ALL RCP ARE CLASS III UNLESS OTHERWISE NOTED.
2. CONTRACTOR TO MAINTAIN POSITIVE DRAINAGE DURING CONSTRUCTION AND FIELD VERIFY FLOWLINES OF ALL TO CONNECTIONS TO EXISTING DRAINAGE STRUCTURES TO VERIFY POSITIVE DRAINAGE TO PROPOSED STORM SEWER PRIOR TO CONSTRUCTION.
3. REFER TO TXDOT HOUSTON DISTRICT BRIDGE MISCELLANEOUS SEWER DETAILS (MSD) FOR PIPE COLLAR, PIPE BEND, AND OTHER PIPE AND MANHOLE INLET CAP CONNECTION DETAILS.
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6. REFER TO PAVEMENT IMPROVEMENTS PLAN & PROFILE, WATERLINE & SAN SWR PLAN & PROFILE, SIGNING AND PAVEMENT MARKINGS PLAN SHEETS FOR MORE INFORMATION.
7. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED
PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation
©2020

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN
BEGIN PROJECT TO STA 5+00

SHEET 1 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	187

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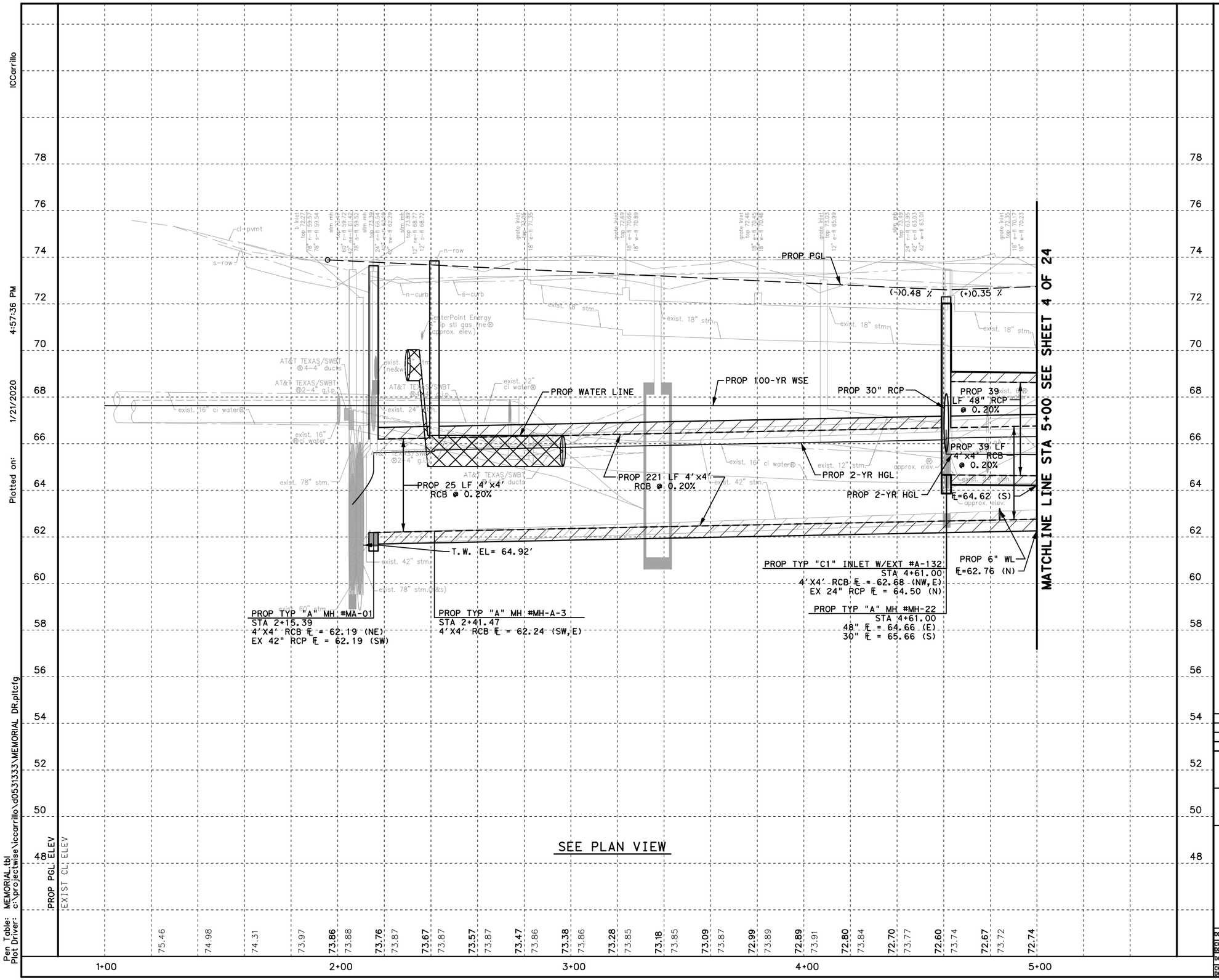

NOTES:

1. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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Texas Department of Transportation
©2020

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE
BEGIN PROJECT TO STA 5+00

SHEET 2 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	188

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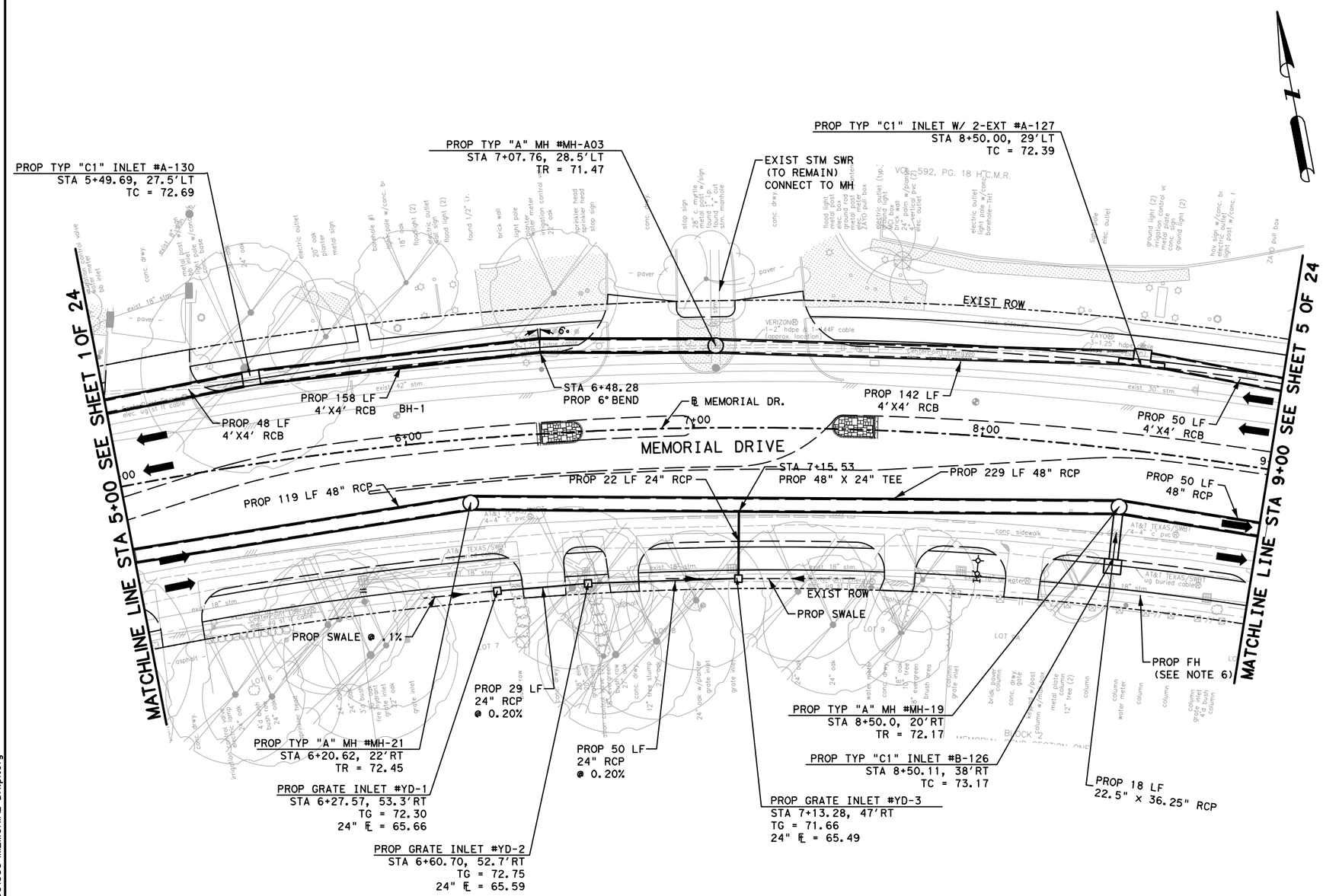

SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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7. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED
PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN
STA 5+00 TO STA 9+00

SHEET 3 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	189

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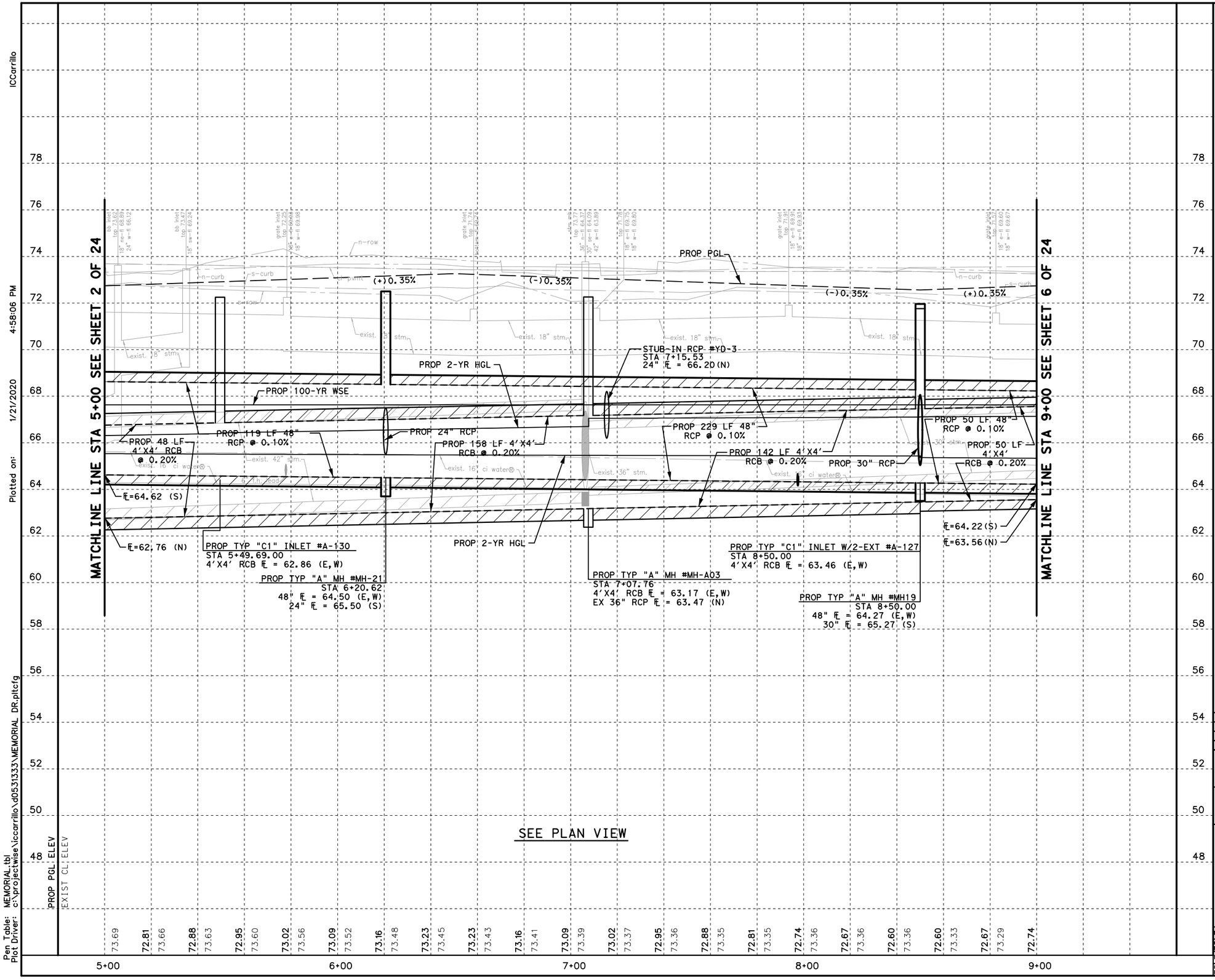
MATCHLINE LINE STA 5+00 SEE SHEET 2 OF 24

MATCHLINE LINE STA 9+00 SEE SHEET 6 OF 24



PROP PGL ELEV	EXIST CL ELEV
73.69	72.81
73.66	72.88
73.63	72.95
73.60	73.02
73.56	73.09
73.52	73.16
73.48	73.23
73.45	73.23
73.43	73.16
73.41	73.09
73.39	73.02
73.37	72.95
73.36	72.88
73.35	72.81
73.35	72.74
73.36	72.67
73.36	72.60
73.36	72.60
73.33	72.67
73.29	72.74

5+00 6+00 7+00 8+00 9+00

78 76 74 72 70 68 66 64 62 60 58 56 54 52 50 48

NOTES:

1. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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FIRM REGISTATION NO. 2614

Texas Department of Transportation
©2020

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE
STA 5+00 TO STA 9+00

SHEET 4 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	190

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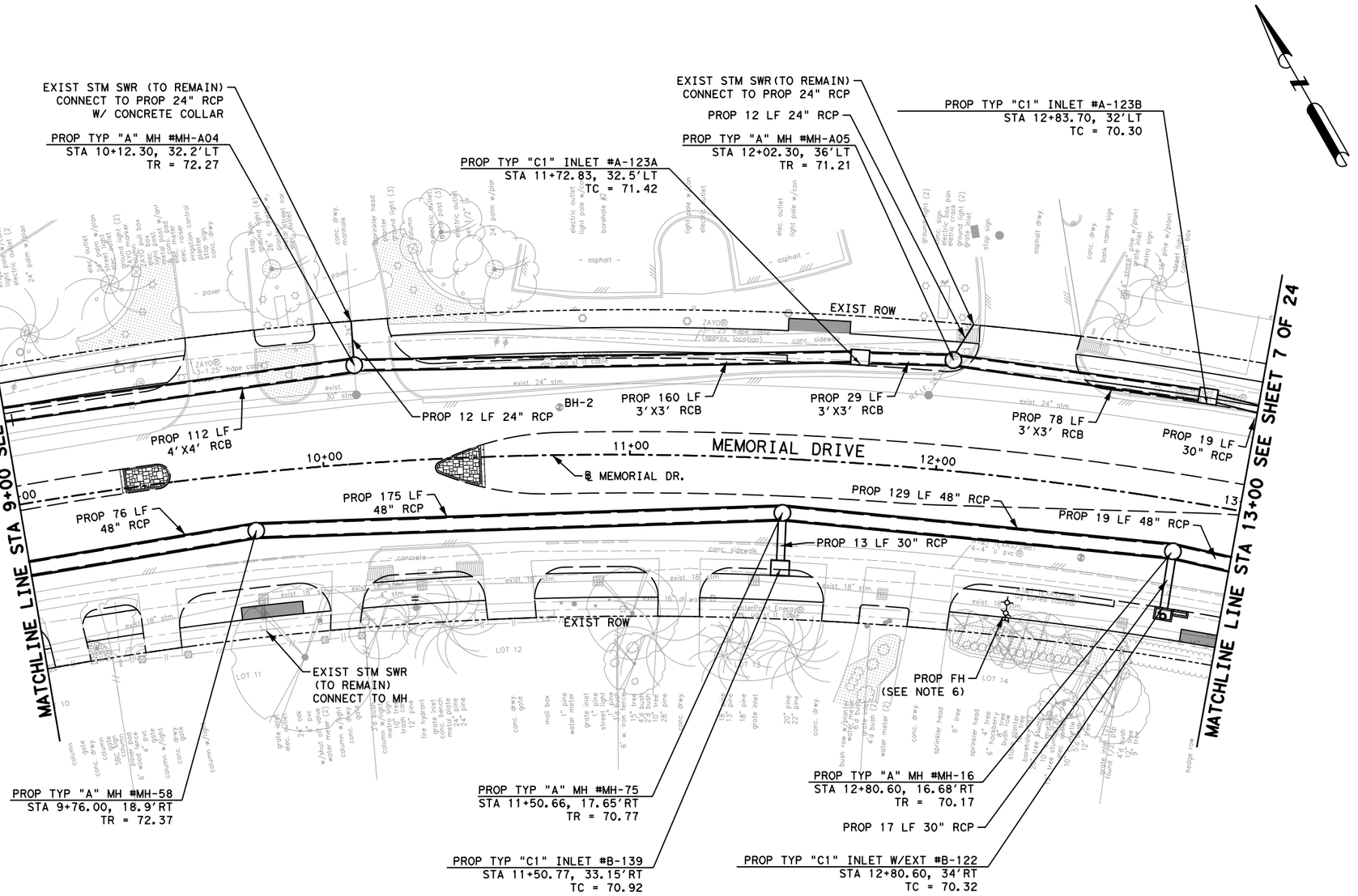

SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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7. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN STA 9+00 TO STA 13+00

SHEET 5 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	191

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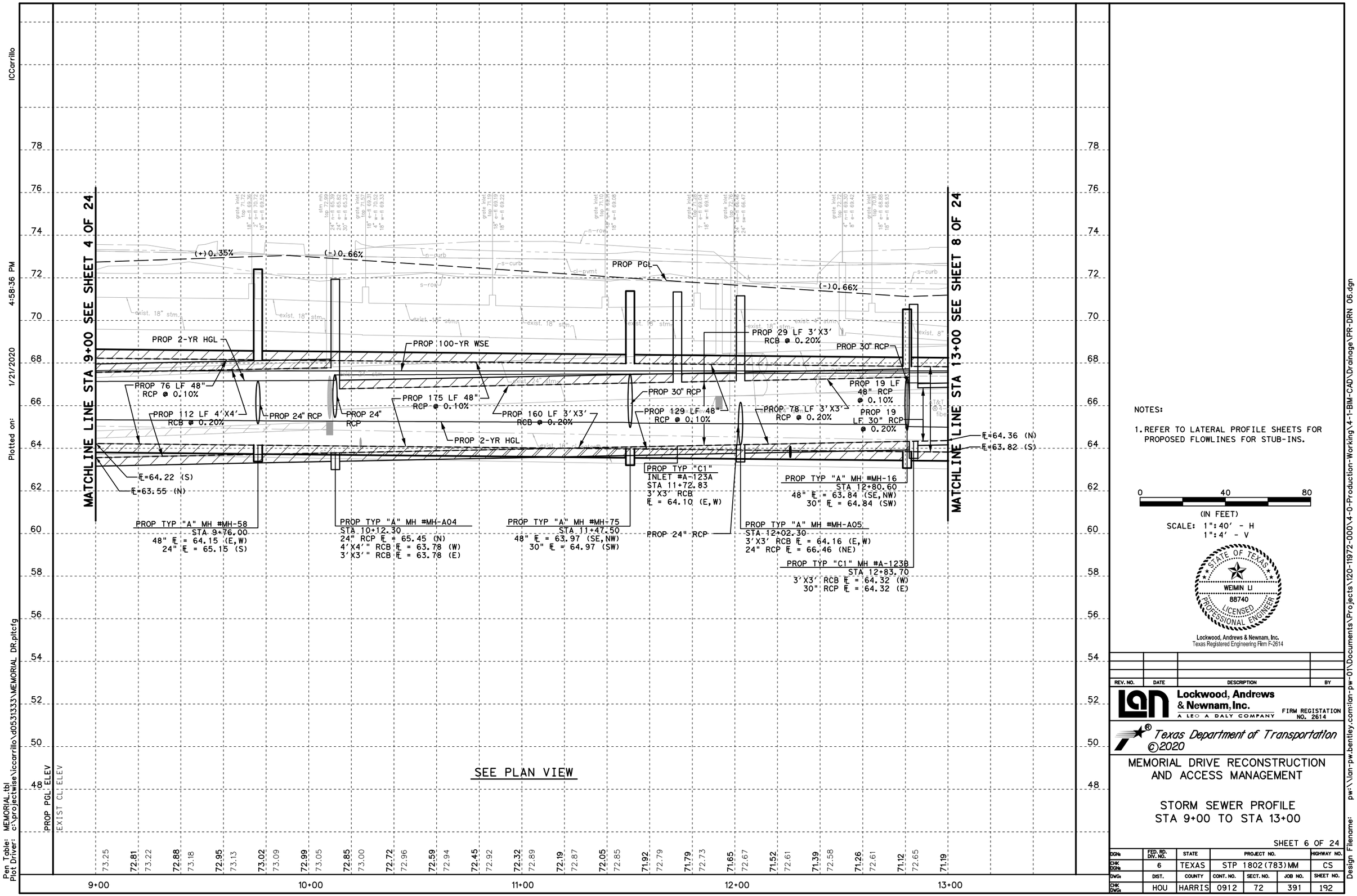

NOTES:

1. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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Texas Department of Transportation
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE
STA 9+00 TO STA 13+00

SHEET 6 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	192

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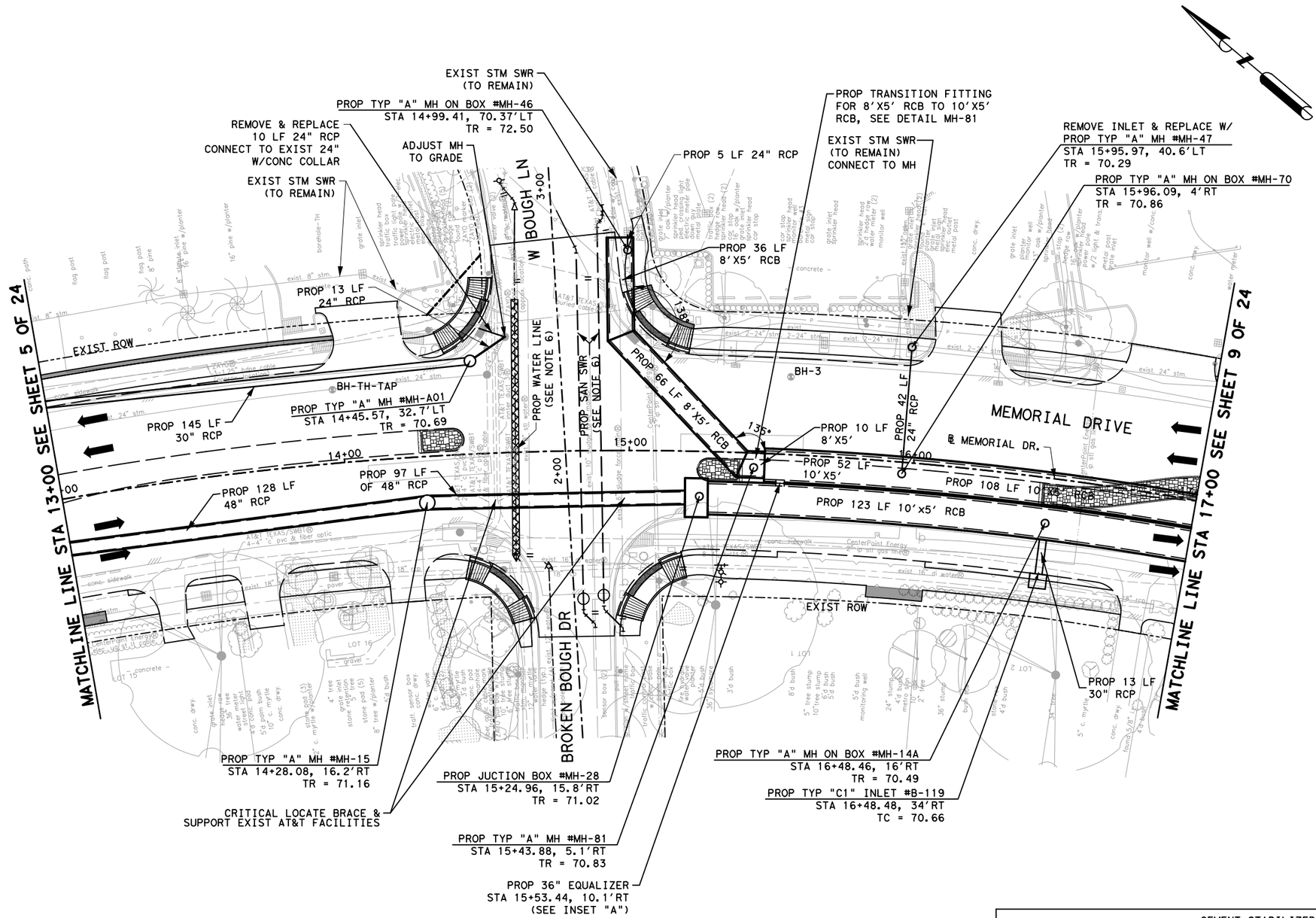
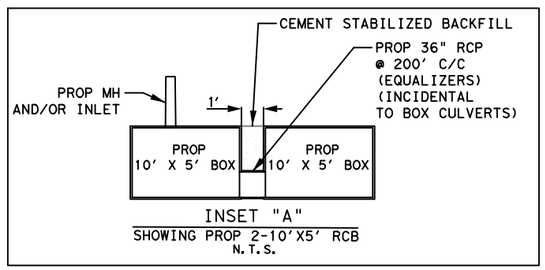


SEE PROP PROFILE VIEW



INSET "A"
SHOWING PROP 2-10'X5' RCB
N.T.S.

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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0 40 80
(IN FEET)
SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN STA 13+00 TO STA 17+00

SHEET 7 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	193

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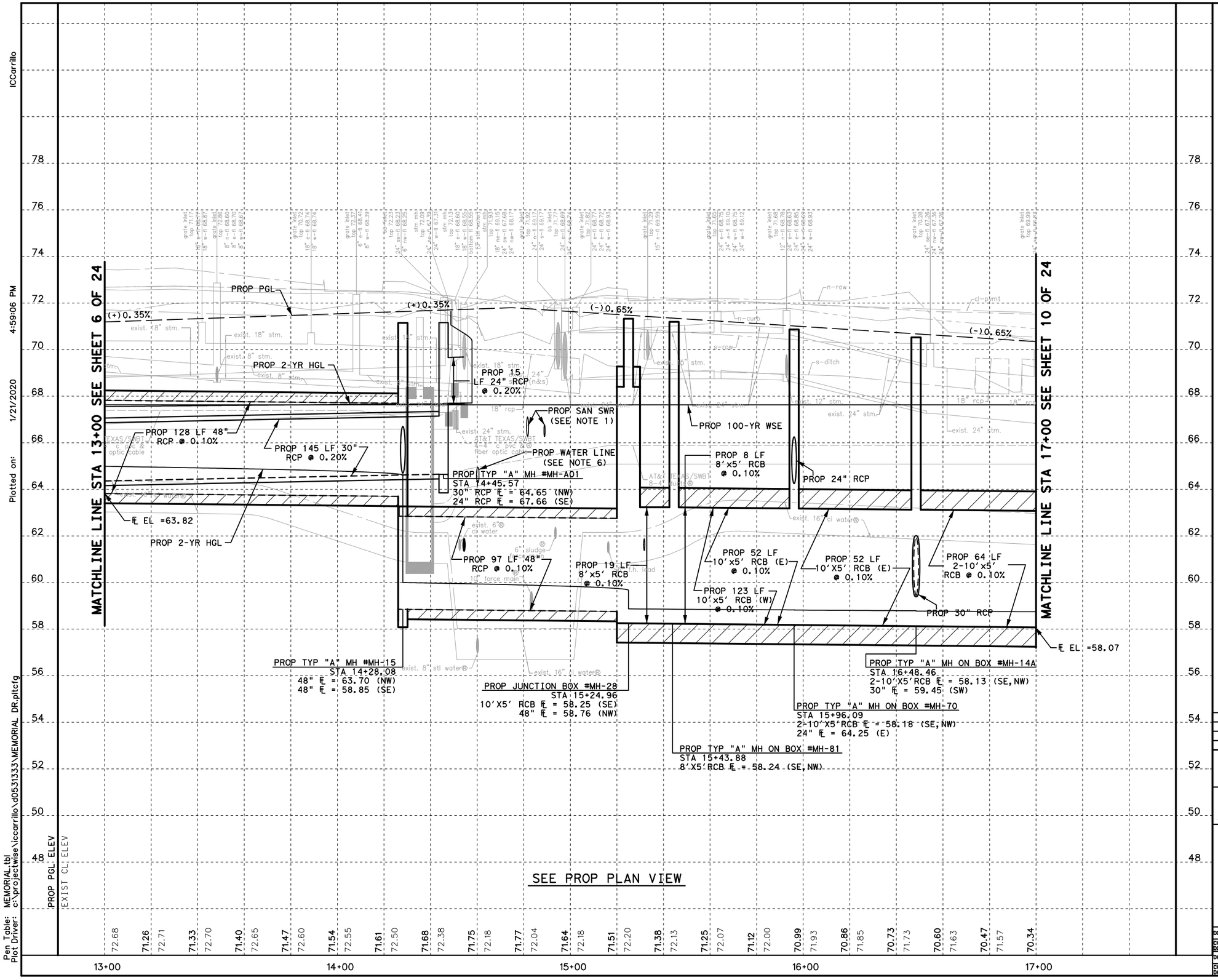

NOTES:

1. REFER TO PAVEMENT IMPROVEMENTS PLAN & PROFILE, WATERLINE & SAN SWR PLAN & PROFILE, SIGNING AND PAVEMENT MARKINGS PLAN SHEETS FOR MORE INFORMATION.
2. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80
(IN FEET)
SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE STA 13+00 TO STA 17+00

SHEET 8 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	194

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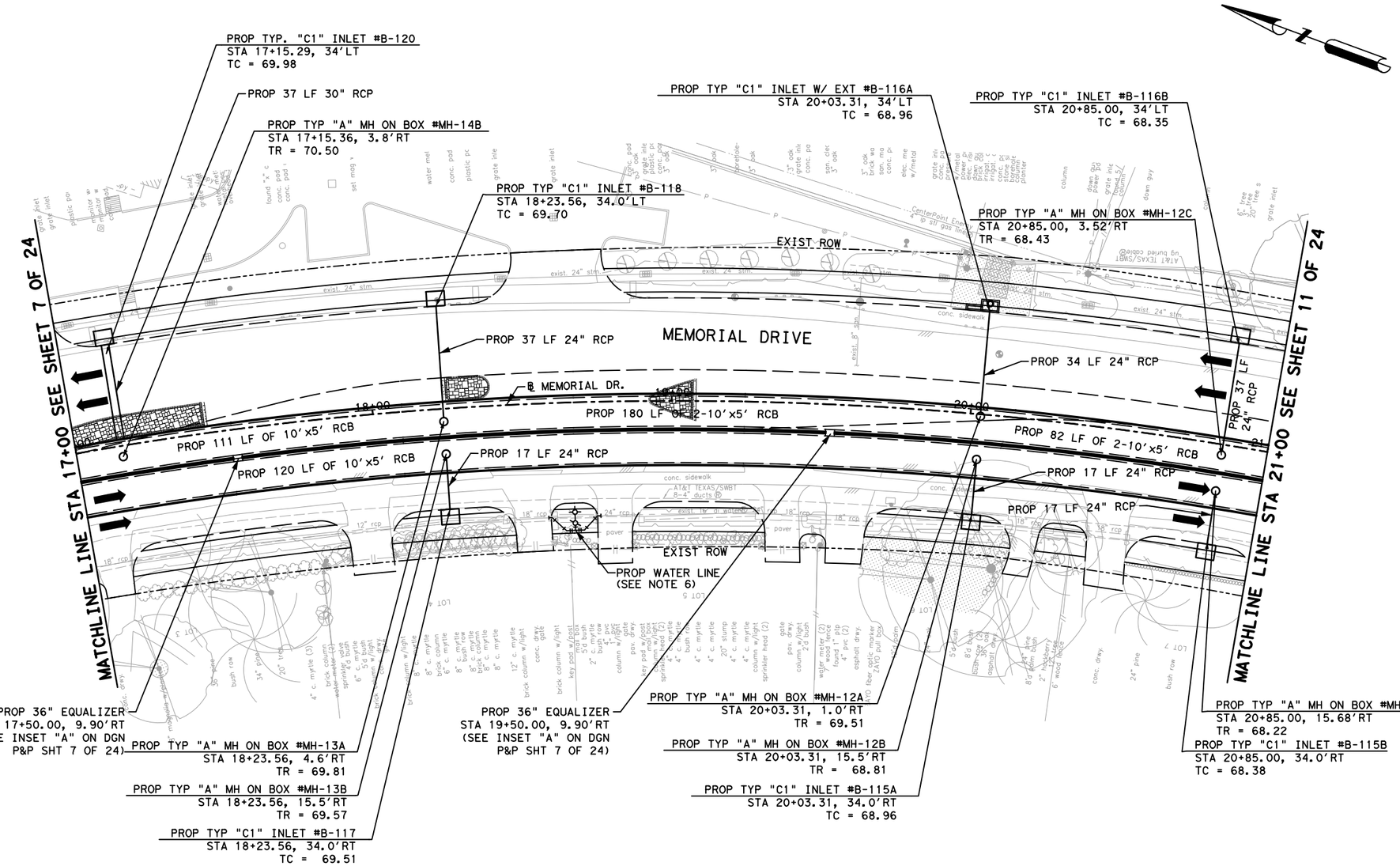

SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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7. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN STA 17+00 TO STA 21+00

SHEET 9 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	195

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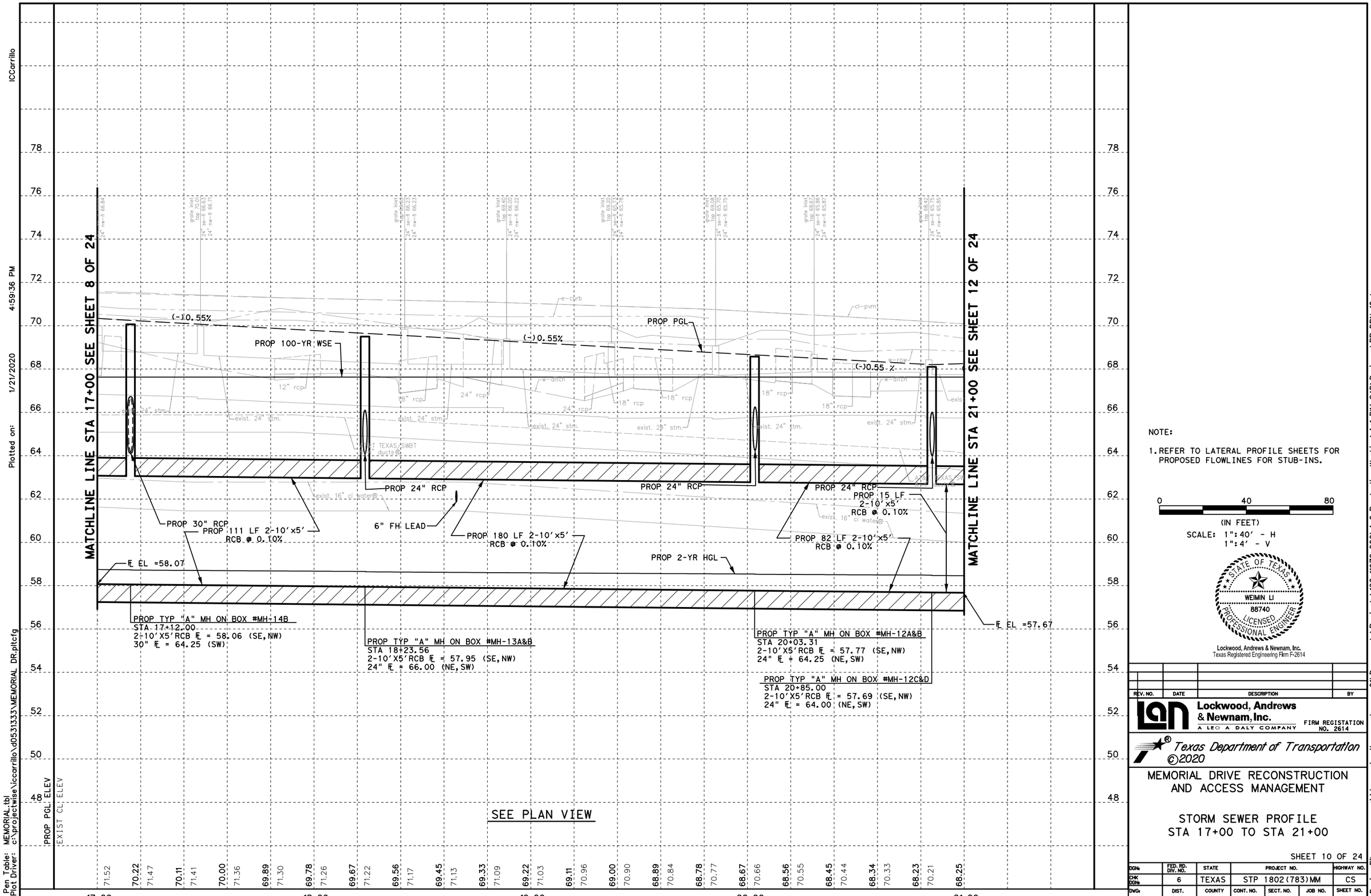


NOTE:

1. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

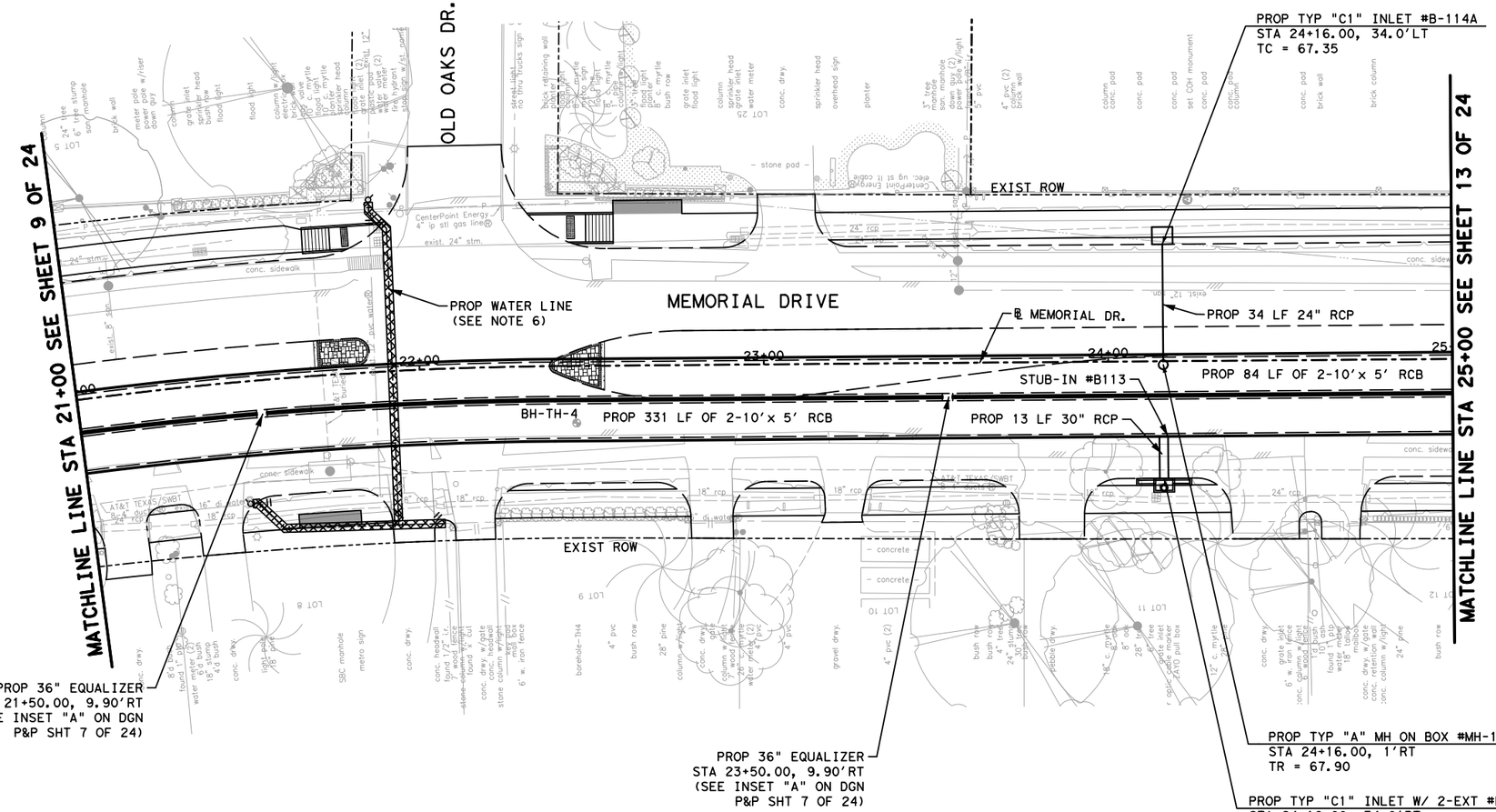
Texas Department of Transportation

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE
STA 17+00 TO STA 21+00

SHEET 10 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	196



SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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7. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED
PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN
STA 21+00 TO STA 25+00

SHEET 11 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	197

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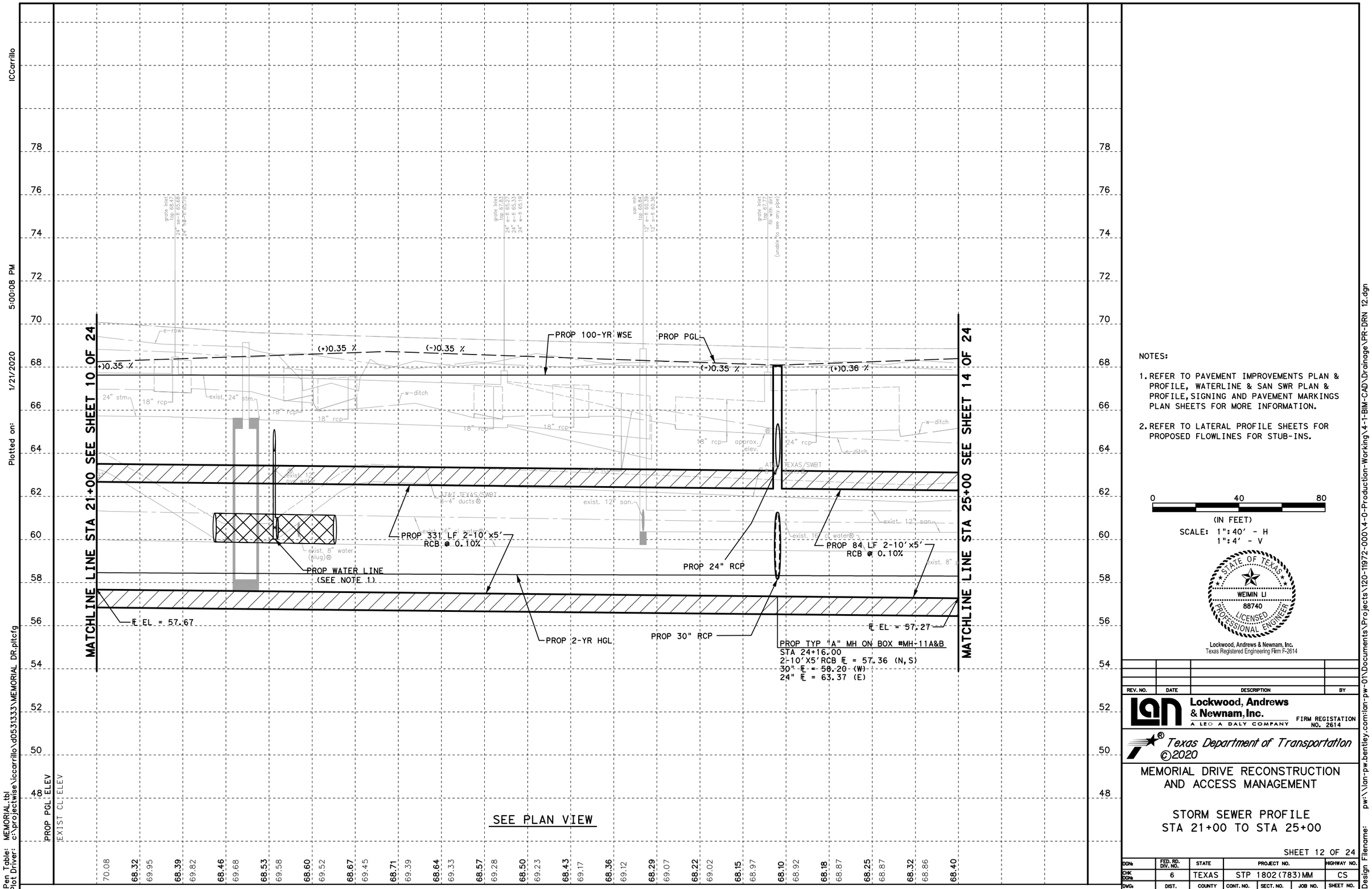

NOTES:

1. REFER TO PAVEMENT IMPROVEMENTS PLAN & PROFILE, WATERLINE & SAN SWR PLAN & PROFILE, SIGNING AND PAVEMENT MARKINGS PLAN SHEETS FOR MORE INFORMATION.
2. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE STA 21+00 TO STA 25+00

SHEET 12 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	198

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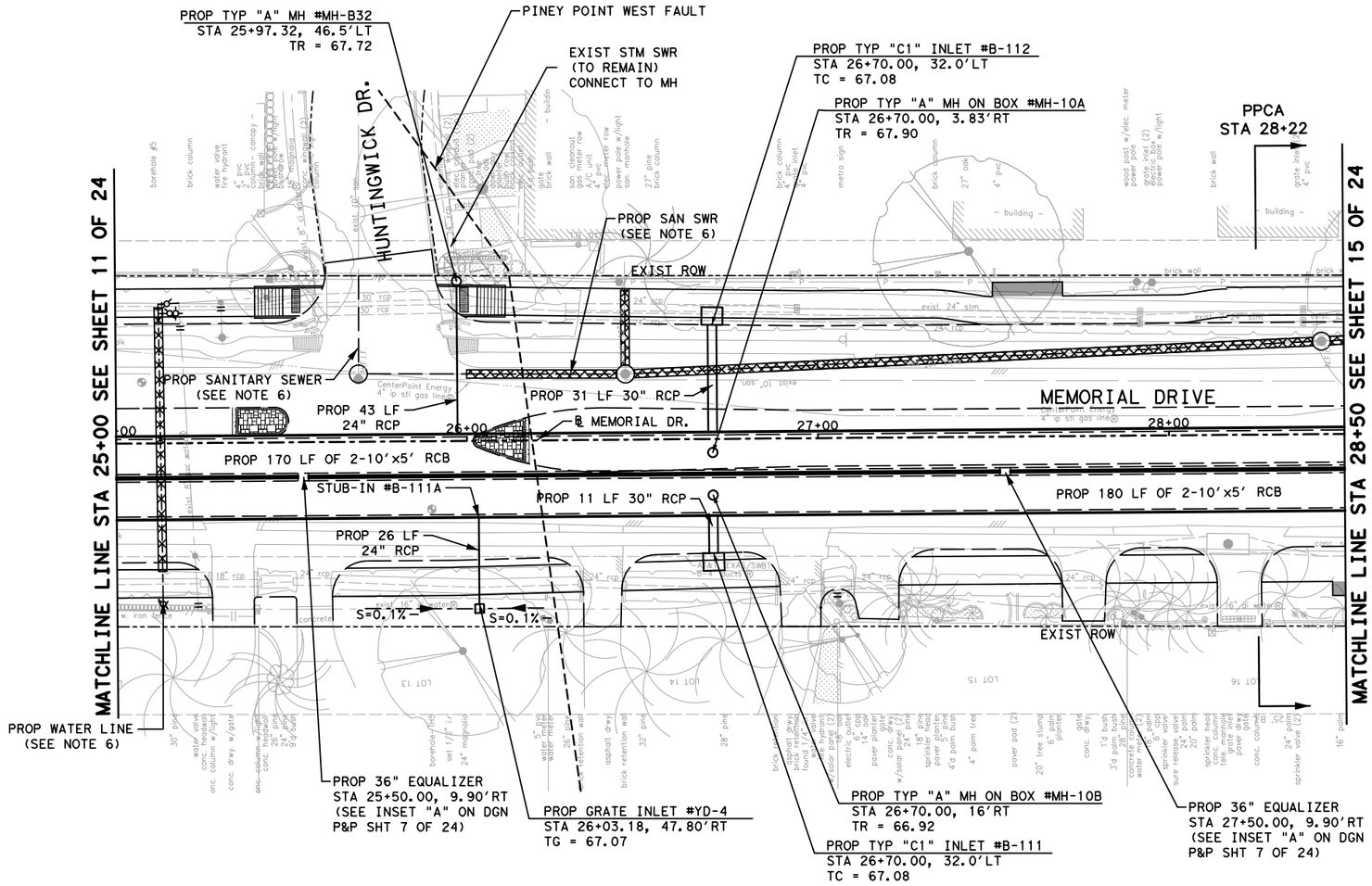

SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

1. ALL RCP ARE CLASS III UNLESS OTHERWISE NOTED.
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7. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED
PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

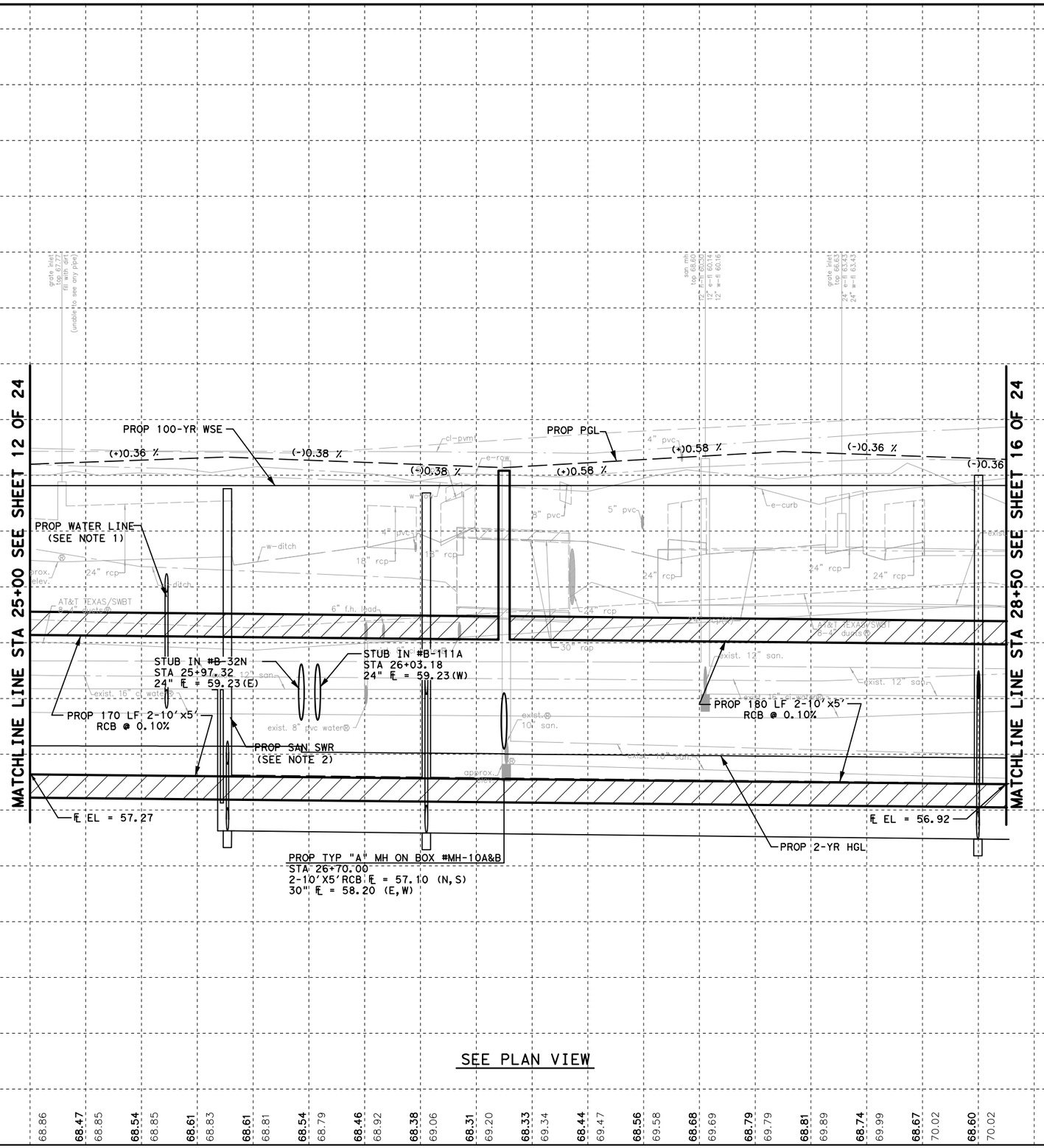
Texas Department of Transportation

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN
STA 25+00 TO STA 28+50

SHEET 13 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	199



NOTES:

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0 40 80
(IN FEET)
SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

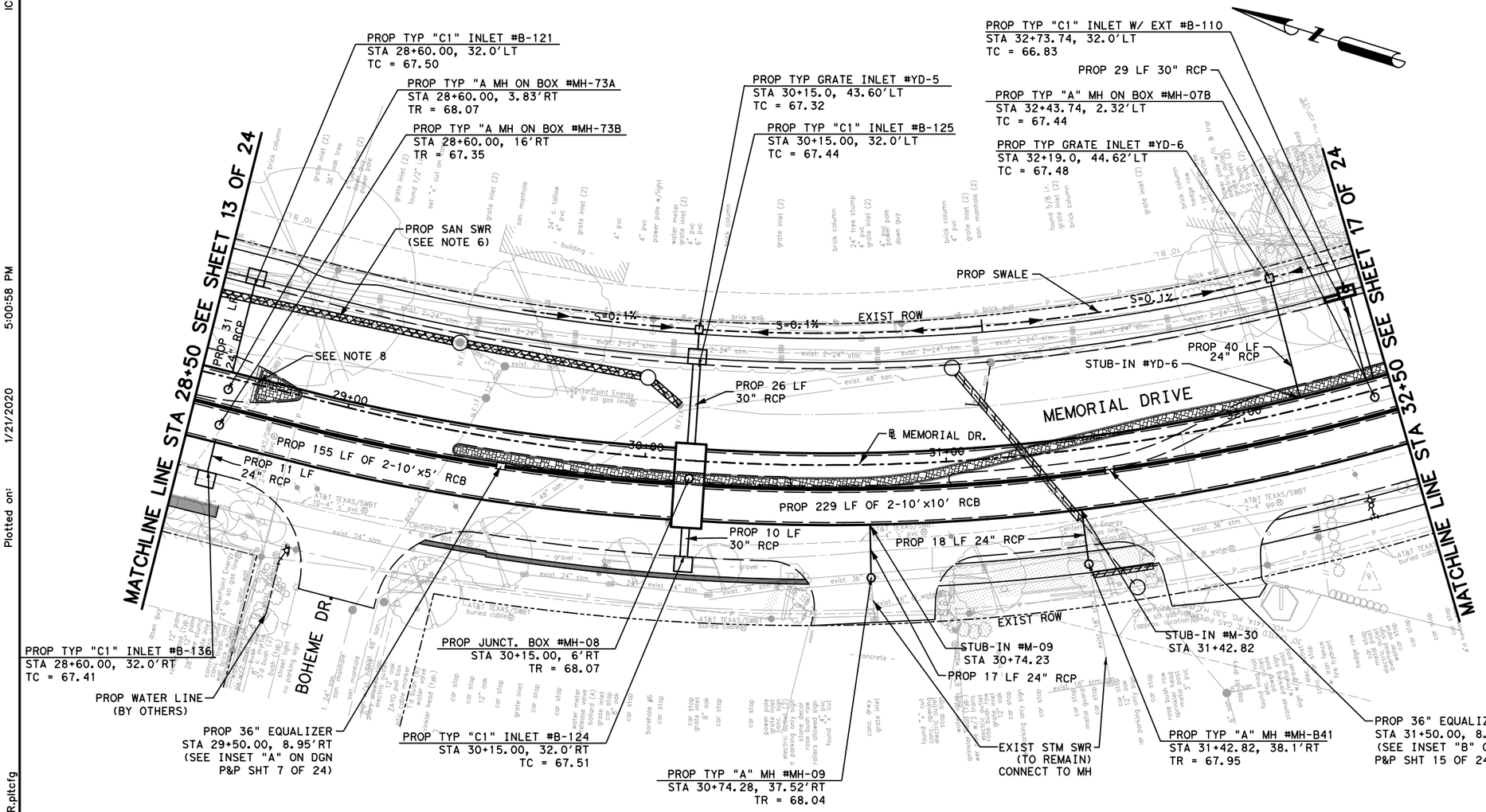
Texas Department of Transportation

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE STA 25+00 TO STA 28+50

SHEET 14 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	200



SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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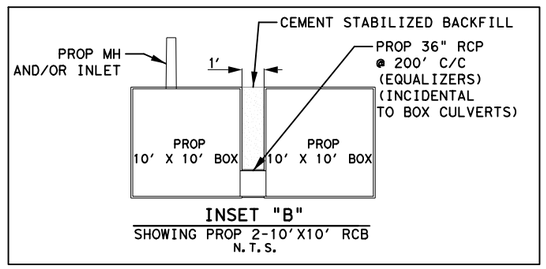
NOTE:

8. AT&T WILL REMOVE CONDUIT, CONTACT AT&T A MINIMUM OF 2 WEEKS PRIOR TO PERFORMING EXCAVATION IN THE VICINITY.



INSET "B"
SHOWING PROP 2-10'X10' RCB
N.T.S.

0 40 80
(IN FEET)
SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED
PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN
STA 28+50 TO STA 32+50

SHEET 15 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	201

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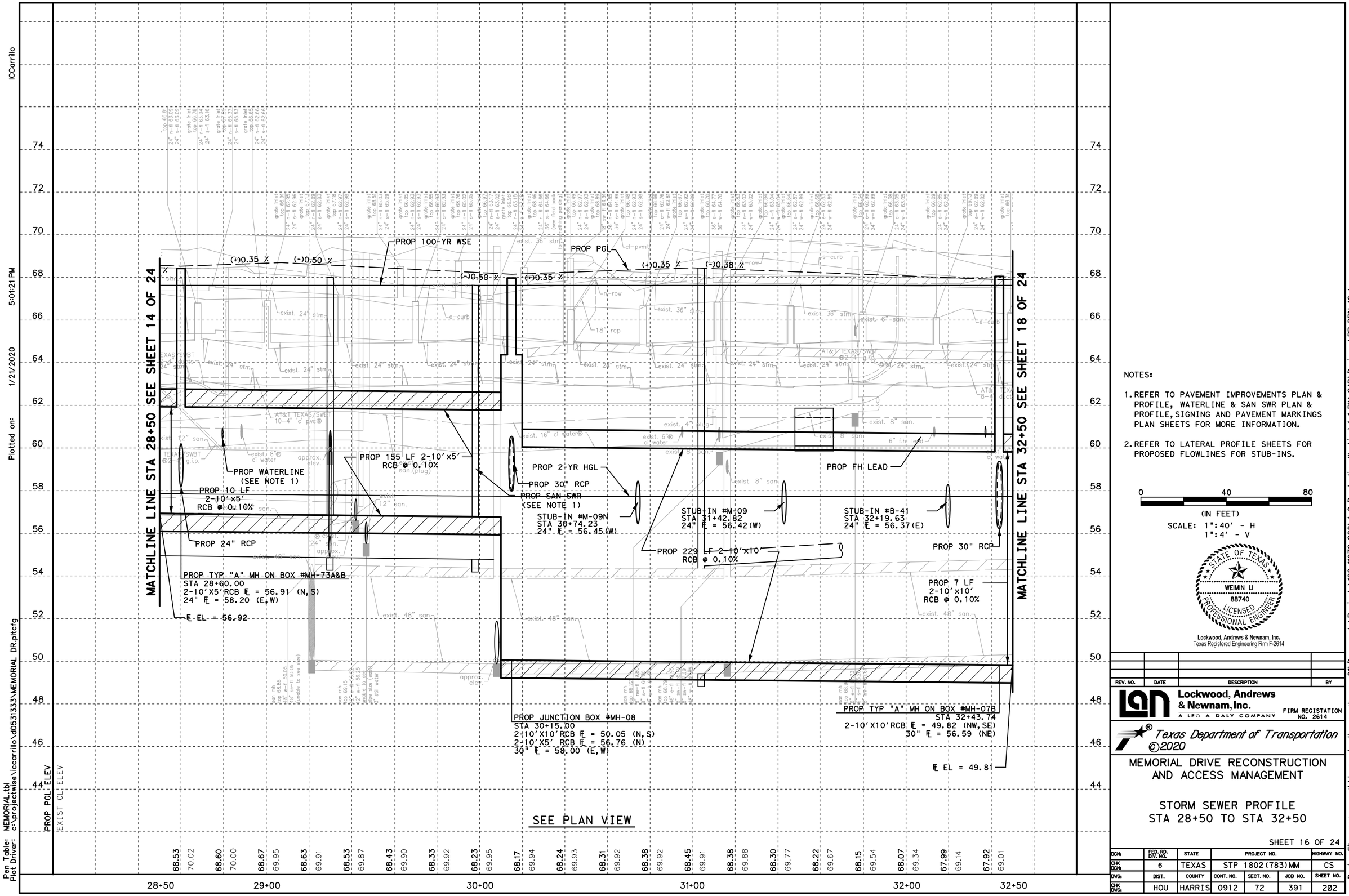

NOTES:

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0 40 80

(IN FEET)

SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation
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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE STA 28+50 TO STA 32+50

SHEET 16 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	202

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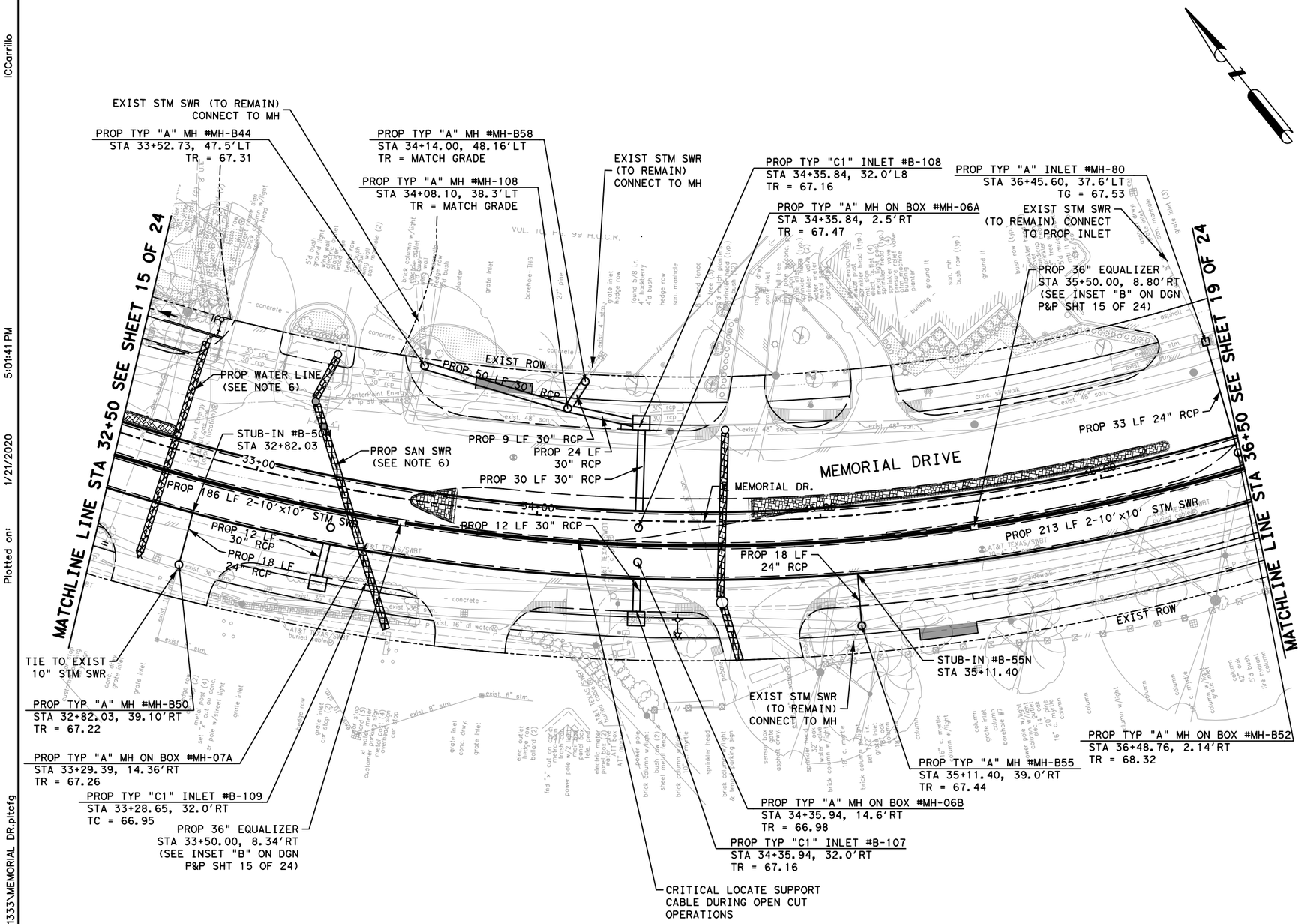

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

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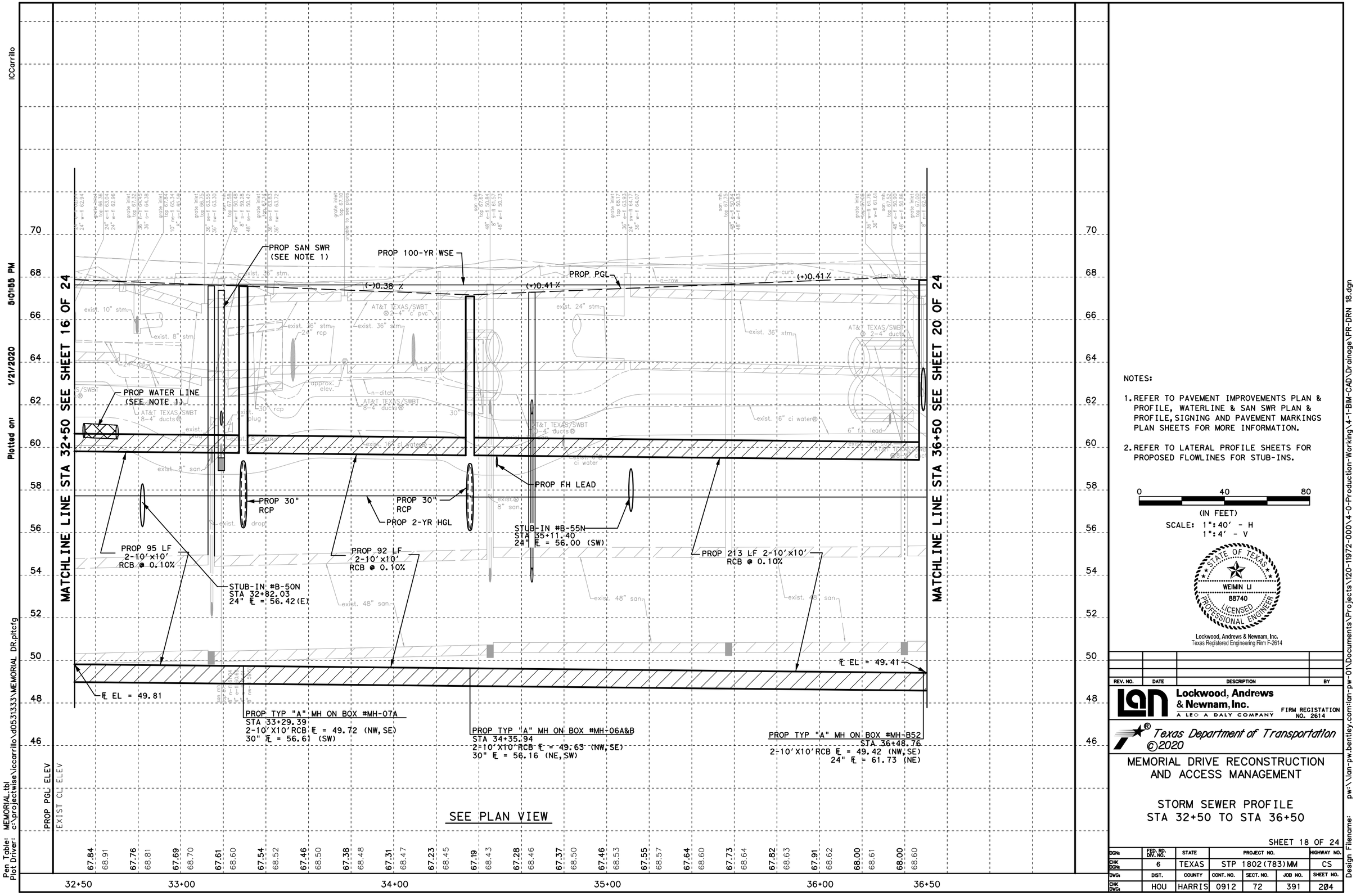
MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN STA 32+50 TO STA 36+50

SHEET 17 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	203



NOTES:

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2. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80
(IN FEET)
SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

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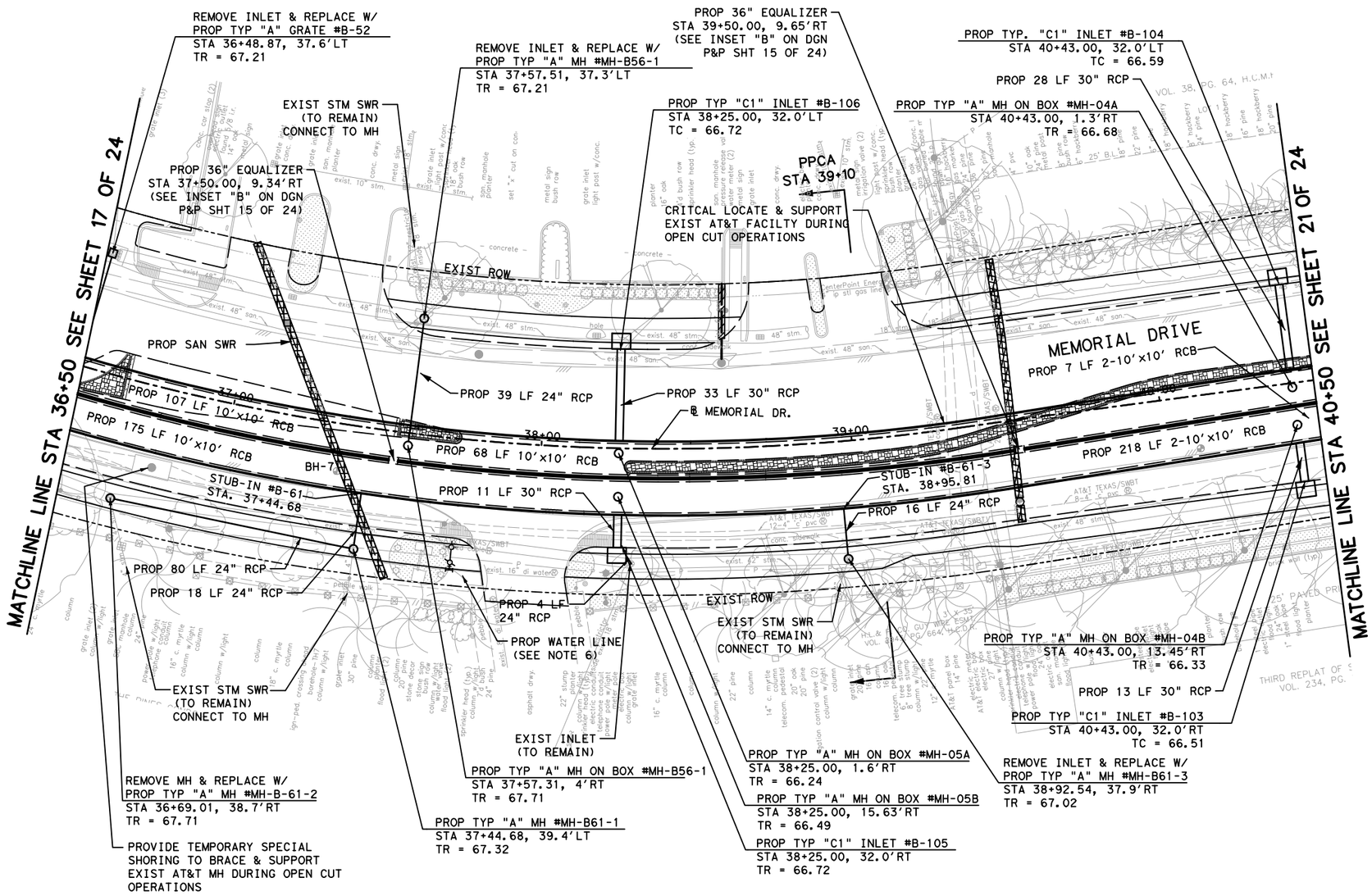
MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE STA 32+50 TO STA 36+50

SHEET 18 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	204



SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN STA 36+50 TO STA 40+50

SHEET 19 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	205

MATCHLINE LINE STA 36+50 SEE SHEET 18 OF 24

MATCHLINE LINE STA 40+50 SEE SHEET 22 OF 24

PROP PGL ELEV

EXIST CL ELEV

(-)0.58 %

(-)0.58 %

(+)0.35 %

(-)0.43 %

PROP PGL

PROP 100-YR WSE

PROP 2-YR HGL

PROP WATER LINE
(SEE NOTE 1)

STUB-IN #M-61N
STA 37+44.72
24" FE = 56.70 (E)

STUB-IN #B-61-3N
STA 38+95.81
24" FE = 56.64 (E)

PROP 109 LF 2-10'x10'
RCB @ 0.10%

PROP 68 LF 2-10'x10'
RCB @ 0.10%

PROP 218 LF 2-10'x10'
RCB @ 0.10%

PROP 7 LF
2-10'x10'
RCB @ 0.10%

PROP STM SWR
(SEE NOTE 1)

FE EL = 49.41

FE EL = 49.01

PROP TYP "A" MH ON BOX #MH B-56-1
STA 37+57.31
2-10'X10'RCB FE = 49.32 (NW,SE)
24" FE = 61.22 (NE)

PROP TYP "A" MH ON BOX #MH-05A&B
STA 38+25.00
2-10'X10'RCB FE = 49.24 (E,W)
30" FE = 55.71 (S)
30" FE = 61.22 (N)

PROP TYP "A" MH ON BOX #MH-04A&B
STA 40+43.00
2-10'X10'RCB FE = 49.03 (E,W)
30" FE = 56.00 (N,S)

SEE PLAN VIEW

PROP PGL ELEV	EXIST CL ELEV
67.87	68.59
67.75	68.55
67.62	68.44
67.49	68.33
67.37	68.22
67.24	68.11
67.12	68.00
66.99	67.95
66.87	67.95
66.89	67.94
66.96	67.93
67.03	67.92
67.10	67.91
67.17	67.86
67.16	67.83
67.07	67.83
66.98	67.82
66.90	67.82
66.81	67.80
66.72	67.76

36+50 37+00 38+00 39+00 40+00 40+50

70 68 66 64 62 60 58 56 54 52 50 48 46

NOTES:

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2. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

0 40 80

(IN FEET)

SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
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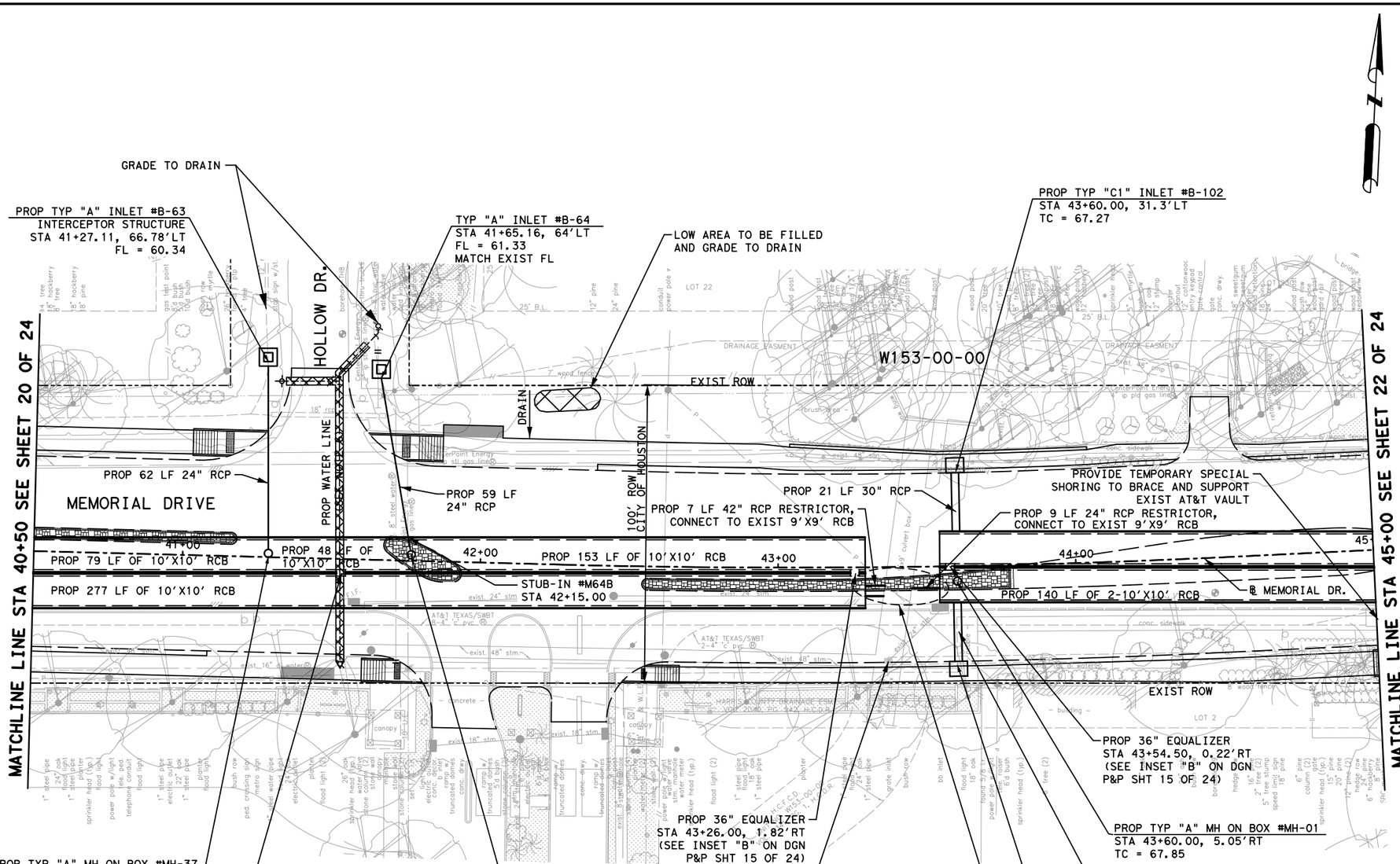
MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE
STA 36+50 TO STA 40+50

SHEET 20 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	206



LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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7. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.

NOTE:

8. PERFORM CRITICAL LOCATE WITHIN 30 DAYS AFTER NTP. NOTIFY PROJECT MANAGER IF PROP CONNECTION FALLS WITHIN A JOINT.

SEE PROFILE VIEW

0 40 80

(IN FEET)

SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED
PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN STA 40+50 TO STA 45+00

SHEET 21 OF 24

DGNs	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGNs	6	TEXAS	STP 1802(783)MM			CS
DWGs	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWGs	HOU	HARRIS	0912	72	391	207

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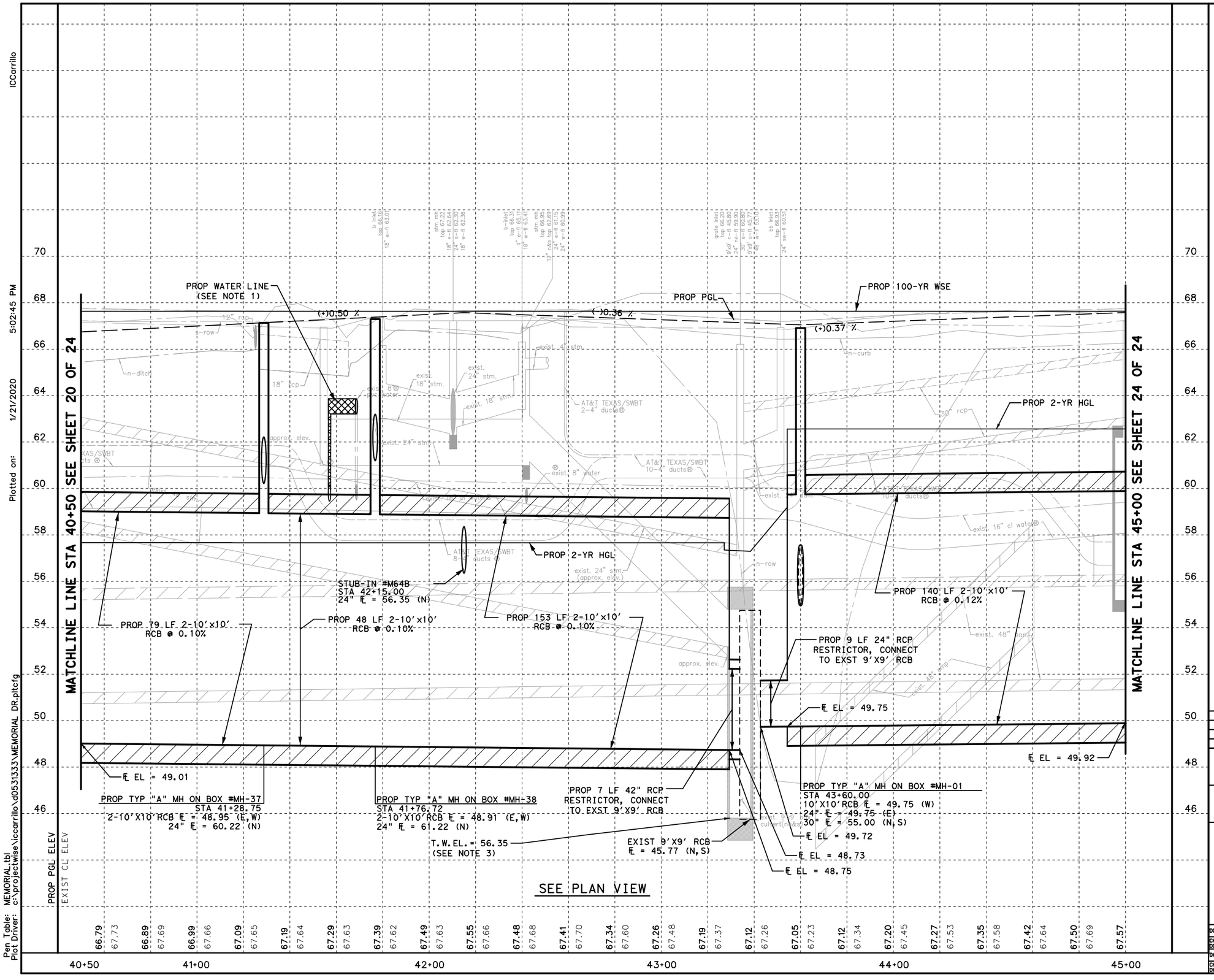

NOTES:

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2. REFER TO LATERAL PROFILE SHEETS FOR PROPOSED FLOWLINES FOR STUB-INS.
3. DRAINAGE AREA RUNOFFS ARE CALCULATED USING RATIONAL METHOD. REFER TO THE FINAL DRAINAGE IMPACT ANALYSIS REPORT AUGUST 2019 PREPARED BY LOCKWOOD, ANDREWS, & NEWNAM, INC.

0 40 80
(IN FEET)
SCALE: 1":40' - H
1":4' - V

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER
Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PROFILE STA 40+50 TO STA 45+00

SHEET 22 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	208

MATCHLINE LINE STA 45+00 SEE SHEET 21 OF 24

MATCHLINE LEGEND LN.

MEMORIAL DRIVE

℄ MEMORIAL DR.

TALLOWOOD RD.

EXIST ROW

EXIST ROW

STUB-IN #B-73M

PROP SANITARY SEWER (SEE NOTE 6)

PROP 36" EQUALIZER STA 45+50.00, 8.26'RT (SEE INSET "B" ON DGN P&P SHT 15 OF 24)

PROP TYP "C1" INLET #B-134 STA 47+41.20, 32' LT TC = 67.44

SAWCUT, INSTALL PAVING HEADER, AND TIE INTO EXIST PAVEMENT (SEE NOTE 5)

EXIST 24" STM SWR (TO REAMIN) CONNECT TO PROP MH

PROP PRECAST SAFETY END TREATMENT

PROP 15 LF 30" RCP

PROP TYP "A" MH #MH-39 STA 48+10.95, 38.3'LT TR = 67.74

PROP TYP "A" MH #MH-40 STA 48+29.41, 39.2'LT TR = 67.85

PROP TYP "AAD" GRATE INLET #B-70 STA 48+57.75, 63.6'LT TR = 67.00

PROP 4 LF 42" RCP

PROP TYP "AAD" GRATE INLET #B-70-2 STA 48+57.75, 54.50'LT TR = 67.00

PROP 11 LF 42" RCP

PROP TYP "A" MH #MH-41 STA 48+57.71, 39.4'LT TR = 67.93

EXIST 18" STM SWR (TO REMAIN) CONNECT TO PROP MH

PROP 47 LF 36" RCP

TIE INTO EXIST SIDEWALK

STUB IN #MH-03 STA 48+11.78

PROP 29 LF 24" RCP

PROP 28 LF 48" RCP

PROP 17 LF 48" RCP

PROP TYP "A" MH #MH-76 STA 49+06.57, 40.61'LT TR = 68.14

PROP 35 LF 48" RCP

100' ROW

PROP 62 LF 36" RCP

PROP 39 LF 36" RCP

PROP 55 LF 36" RCP

PROP 241 LF 2-10'x10' STM SWR

PROP 77 LF 2-10'x10' STM SWR

PROP WATER LINE (SEE NOTE 6)

PROP 27 LF 24" RCP

PROP GRATE INLET #YD-7 STA 47+26.96, 46'RT TG = 67.47

PROP PRECAST SAFETY END TREATMENT

TIE INTO EXIST SIDEWALK

PROPTYP "C1" INLET #B-69 STA 49+69.07

PROP TYP "A" MH #MH-69B STA 49+12.76, 41.38'RT TR = 68.78

PROP TYP "A" MH #MH-69A STA 48+82.38, 13'RT TR = 68.13

SAWCUT, INSTALL PAVING HEADER, AND TIE INTO EXIST PAVEMENT AND CURBS (SEE NOTE 5)

PROP 27 LF 24" RCP

PROP TYP "A" MH #MH-B73 STA 45+23.92, 46.7'RT TR = 67.46

EXIST 24" STM SWR (TO REMAIN) CONNECT TO PROP MH

PROP TYP "A" MH ON BOX #MH-02B STA 47+41.20, 2.6'LT TR = 67.55

PROP TYP "A" MH ON BOX #MH-02A STA 47+41.24, 14.76'RT TR = 67.44

PROP TYP "C1" INLET #B-133 STA 47+41.20, 32.0'RT TC = 67.44

PROP 13 LF 24" RCP

STUB-IN #YD-7

PROP 36" EQUALIZER STA 47+53.00, 7.51'RT (SEE INSET "B" ON DGN P&P SHT 15 OF 24)

SEE PROFILE VIEW

LEGEND:

- PROP STORM SEWER
- EXIST STORM SEWER
- PROP ROADWAY FACE OF CURB
- PROP INLET OR JCT BOX
- PROP MANHOLE
- EXIST INLET OR JUNCTION BOX
- EXIST MANHOLE
- BORE HOLE LOCATION

NOTES:

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0 40 80
(IN FEET)
SCALE: PLAN 1": 40'

STATE OF TEXAS
WEIMIN LI
88740
LICENSED PROFESSIONAL ENGINEER

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

Texas Department of Transportation

MEMORIAL DRIVE RECONSTRUCTION AND ACCESS MANAGEMENT

STORM SEWER PLAN STA 40+50 TO END PROJECT

SHEET 23 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	209

ICCarrillo

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NOTES:

1. REFER TO PAVEMENT IMPROVEMENTS PLAN & PROFILE, WATERLINE & SAN SWR PLAN & PROFILE, SIGNING AND PAVEMENT MARKINGS PLAN SHEETS FOR MORE INFORMATION.
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0 40 80
(IN FEET)
SCALE: 1":40' - H
1":4' - V

WEIMIN LI
88740

Lockwood, Andrews & Newnam, Inc.
Texas Registered Engineering Firm F-2614

REV. NO.	DATE	DESCRIPTION	BY

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A LEO A DALY COMPANY
FIRM REGISTATION NO. 2614

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MEMORIAL DRIVE RECONSTRUCTION
AND ACCESS MANAGEMENT

STORM SEWER PROFILE
STA 40+50 TO END PROJECT

SHEET 24 OF 24

DGN:	FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY NO.
CHK DGN:	6	TEXAS	STP 1802(783)MM			CS
DWG:	DIST.	COUNTY	CONT. NO.	SECT. NO.	JOB NO.	SHEET NO.
CHK DWG:	HOU	HARRIS	0912	72	391	210

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APPENDIX 4.

IMPACT ANALYSIS LOCATIONS & RESULTS

Location 1:

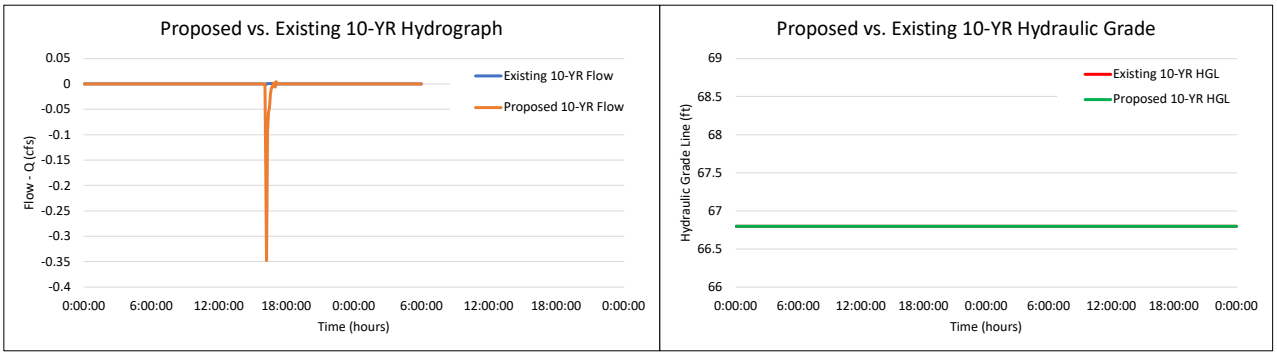
Overland flow leaving the southern right of way of Memorial Drive near channel W153

Location 1 Impacts			
	10-YR Event	100-YR Event	500-YR Event
Existing Max Flow Q (cfs)	0.00	420.33	1068.84
Proposed Max Flow Q (cfs)	0.00	403.22	976.09
Delta Flow Q (cfs)	0.00	-17.12	-92.75
Existing Max HGL (ft)	66.80	68.29	69.27
Proposed Max HGL (ft)	66.80	68.22	69.26
Delta HGL (ft)	0.00	-0.07	-0.01

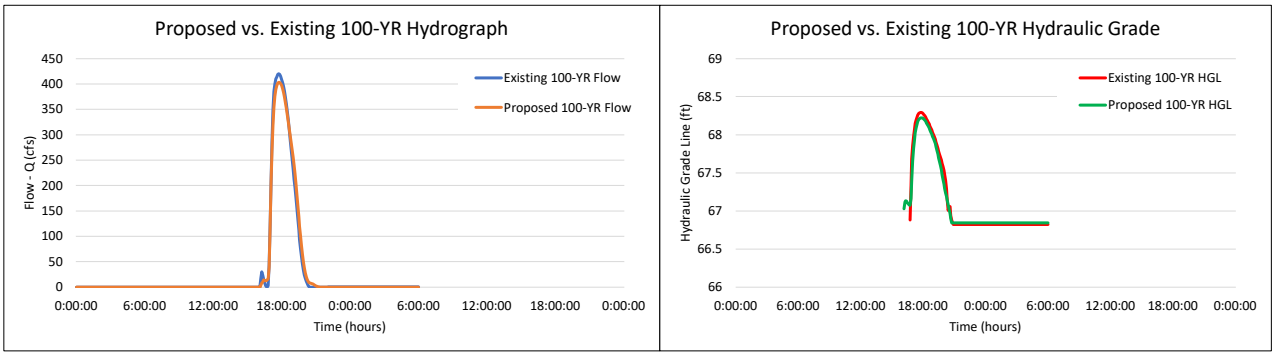
* Flow evaluated with ICM Results Line Object named **'Location 1 - Flow'**

Elevation evaluated with ICM Results Point Object named **'Location 1 - WSEL'

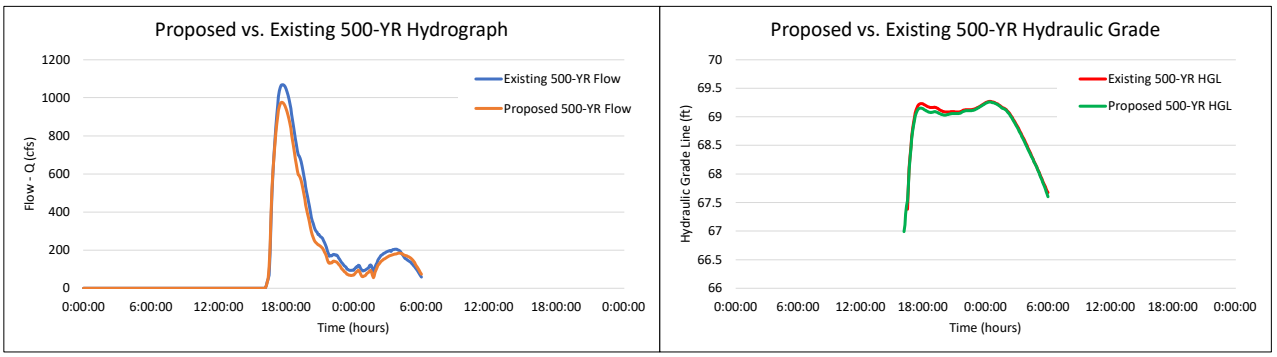
10-YR Flow and Elevation Comparisons



100-YR Flow and Elevation Comparisons



500-YR Flow and Elevation Comparisons



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Location 2:

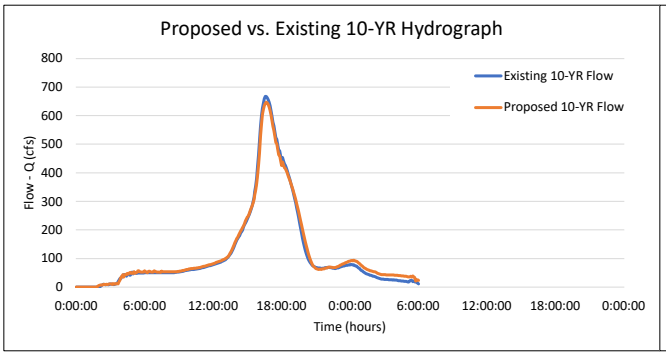
Channel W153 downstream of Memorial Drive improvements

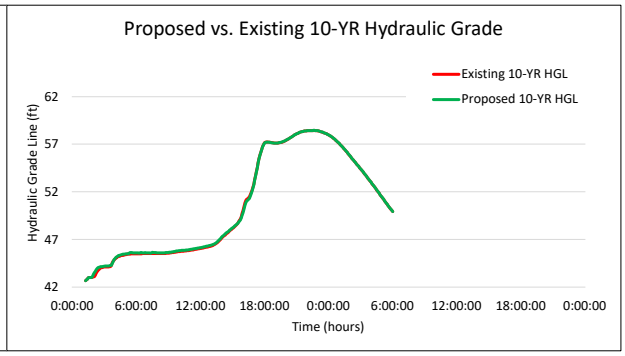
Location 2 Impacts			
	10-YR Event	100-YR Event	500-YR Event
Existing Max Flow Q (cfs)	667.18	794.45	906.29
Proposed Max Flow Q (cfs)	647.41	769.15	872.40
Delta Flow Q (cfs)	-19.77	-25.30	-33.89
Existing Max HGL (ft)	58.44	65.29	69.25
Proposed Max HGL (ft)	58.44	65.29	69.25
Delta HGL (ft)	0.00	0.00	0.00

* Flow evaluated with ICM Results Line Object named **'Location 2 - Flow'**

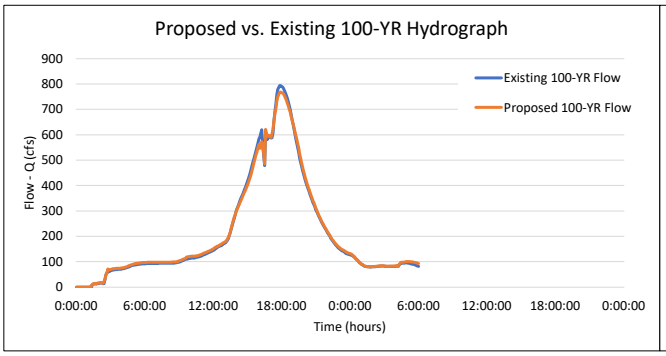
Elevation evaluated with ICM Results Point Object named **'Location 2 - WSEL'

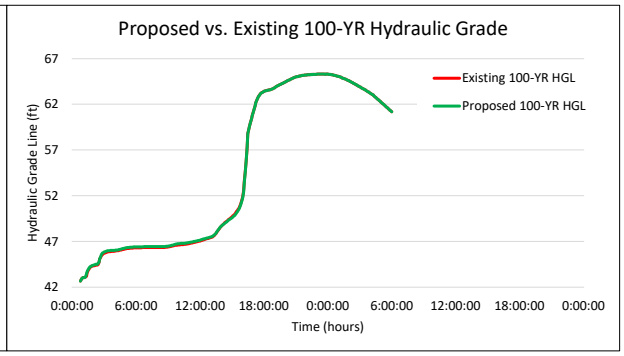
10-YR Flow and Elevation Comparisons



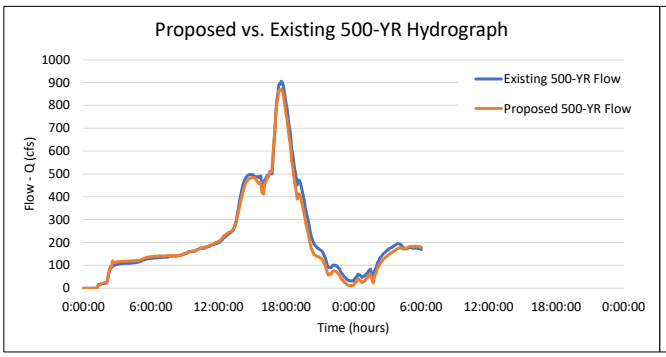


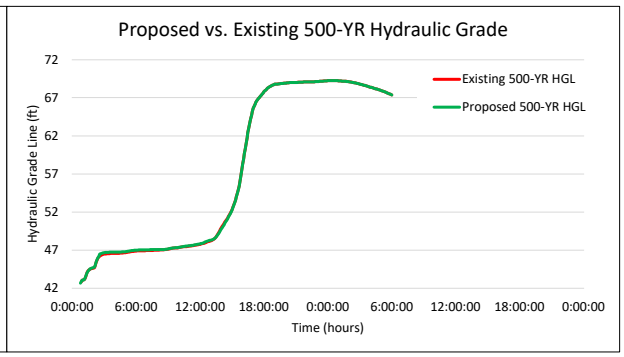
100-YR Flow and Elevation Comparisons





500-YR Flow and Elevation Comparisons





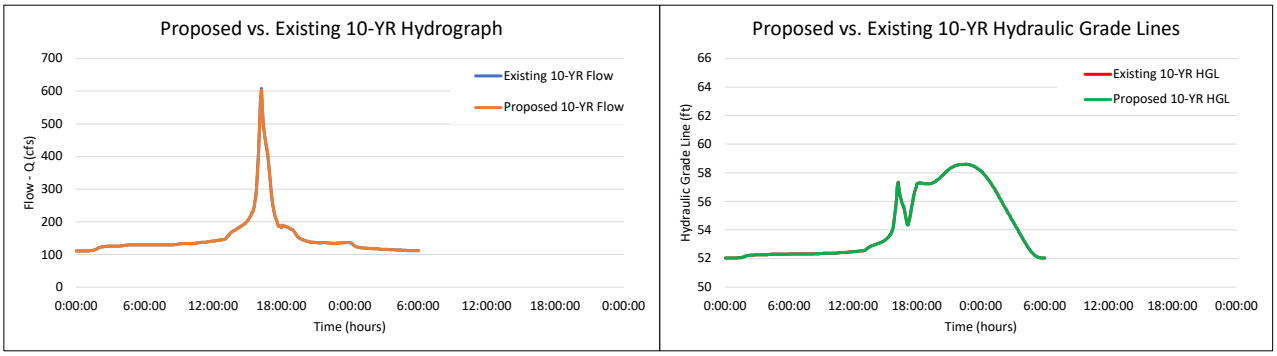
Location 3:

Memorial Drive storm sewer discharging to the west into the Beltway 8 storm sewer system and Buffalo Bayou

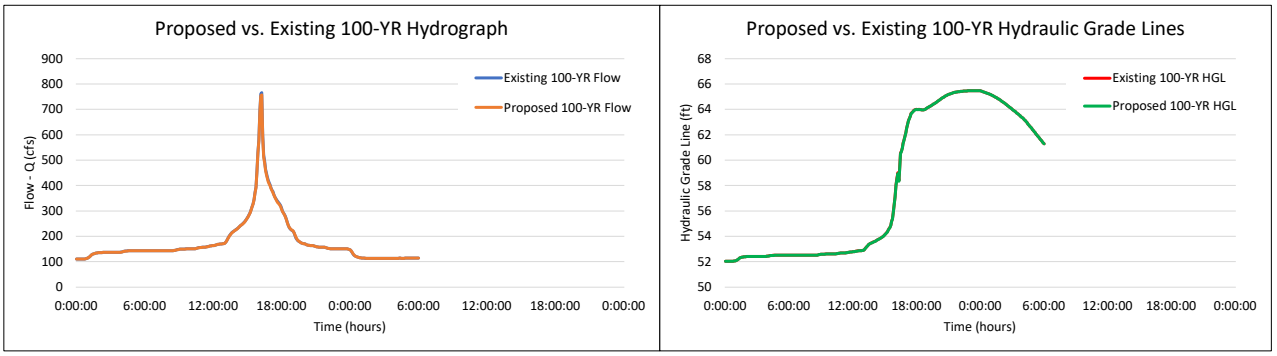
Location 3 Impacts			
	10-YR Event	100-YR Event	500-YR Event
Existing Max Flow Q (cfs)	608.86	766.60	708.26
Proposed Max Flow Q (cfs)	603.96	757.16	704.36
Delta Flow Q (cfs)	-4.90	-9.44	-3.90
Existing Max HGL (ft)	58.59	65.47	69.45
Proposed Max HGL (ft)	58.59	65.47	69.45
Delta HGL (ft)	0.00	0.00	0.00

* Flow evaluated with 'DS Flow' property of ICM Conduit Link named **'3124545.1'**
Elevation evaluated with 'DS Head' property of ICM Conduit Link named **'3124545.1'

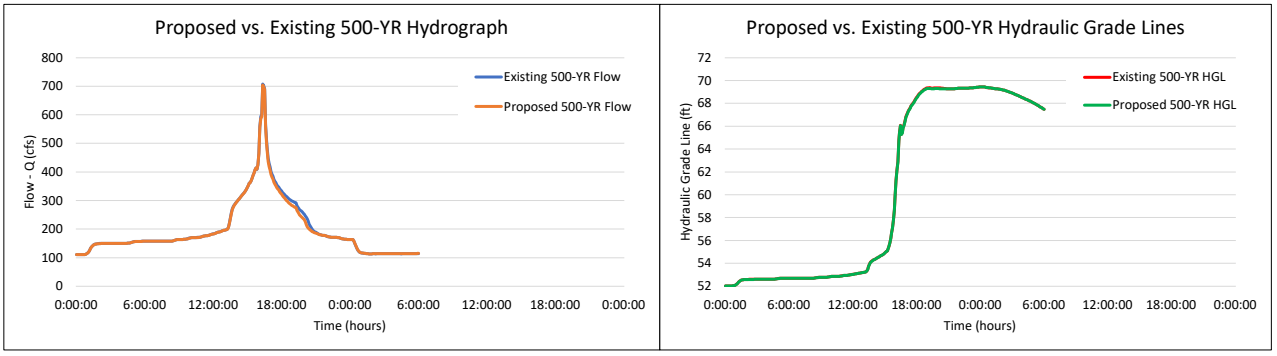
10-YR Flow and Elevation Comparisons



100-YR Flow and Elevation Comparisons



500-YR Flow and Elevation Comparisons



Lockwood, Andrews & Newnam, Inc.
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Texas Department of Transportation