Document No. 01:

<u>Project Report</u>

Foreword

This project was elected, not for the complexity of the sewer line design itself but for the installation of it. The existing geotechnical conditions challenged the constructability of such project located nearby the heart of Fort Worth, Texas.

This area has by far the worst geotechnical ground properties of the whole project. Looking for alternatives solutions to the constructability among different alignments and phasing the works within several traffic control plans provided a stimulating study where many possibilities where studied.

In addition, many of the ideas exposed in this very paper are being considered right now to be implemented on the I-35W development project. My experience in the utility department and for all the reasons state above, I choose this project as my master project.

INDEX - APPENDIX NO. 11: LIFT STATION FLOW CALCULATION

INDEX - FIGURE AND TABLE

0. Project Correspondence

This project, although being presented in Spain, has been developed in the United States of America under their law and rules. Such documentation can be easily found on the Technical specification documentation provided in Document No.3 of this paper.

The **U.S. unit system** has been adopted because such regulations are presented in this unit system. All the designing manuals are in this unit system as well.

On the other hand, the number of **documents** and the structure of this paper is the same asked in Spanish territory. The structure is as follows:

- Document No.1: Project Report and Appendices
    - From the Appendices: Safety and Health Document
        - Safety and Health Report
        - Safety and Health Drawings
        - Safety and Health Regulations
        - Safety and Health Budget
- Document No. 2: Drawings
- Document No.3: Technical Specifications
- Document No.4: Budget

The **Alternative analysis** can be confusing on a first sight. The thought process behind it is to first determine from 5 feasible solutions the best 2. From there, a geotechnical, hydrological and structural exhaustive analysis from the remaining options will lead to a final alternative analysis.

Please note that this paper aimed to provide the most accurate solution to a real problem that could be implement after the approval of it.

1. Project Introduction

This project goal is to find an engineering solution to the sewer utility conflicts born due to the future development at Greenway/Pharr area (Fort Worth, TX) of Interstate I-35W that goes from Texas up to Minnesota through Oklahoma, Kansas, Missouri and Iowa with a total length is 1,694.67 miles (2,727.31km).

To develop such project, real data will be taken as topography, geology, hydrology, population, social and administrative factors, existing and future infrastructures as well any other data needed from the city of Fort Worth, Texas.

The main goal of this very project is to demonstrate the student ability and skill to group and connect the different knowledge acquired during his studies to end up with an engineering solution to a real problem.

1.1. Project Location

The location of I-35W development project which is at the Dallas-Fort Worth Metroplex (Conurbation area) belongs to a greater project called North Tarrant Express. This project aims the renewal and betterment of existing highways at the Tarrant County.

This highway serves as a major connector from North Mid-West United States and South United States. Also connects the local industry, outlying suburbs and the DFW international Airport. The figures on the following page, 1 and 2, show the project location. Figure 3 shows an aerial picture of the area considered to provide the reader a better understanding. At appendix 0 there is a more detail consecution of maps to better understand the surroundings and location of the project.

Greenway neighbor is located northwest of Fort Worth Downtown south of Trinity River. Due to the improvement of I-35W, the sewer system in the area must be relocated to avoid conflicts with the proposed highway design.

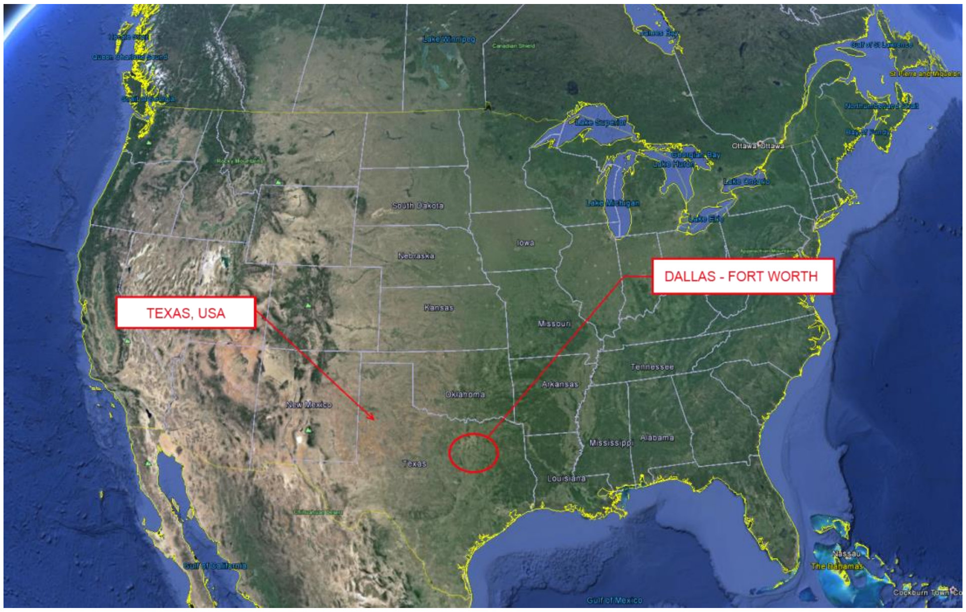


Figure 1. United States of America Aerial Picture.

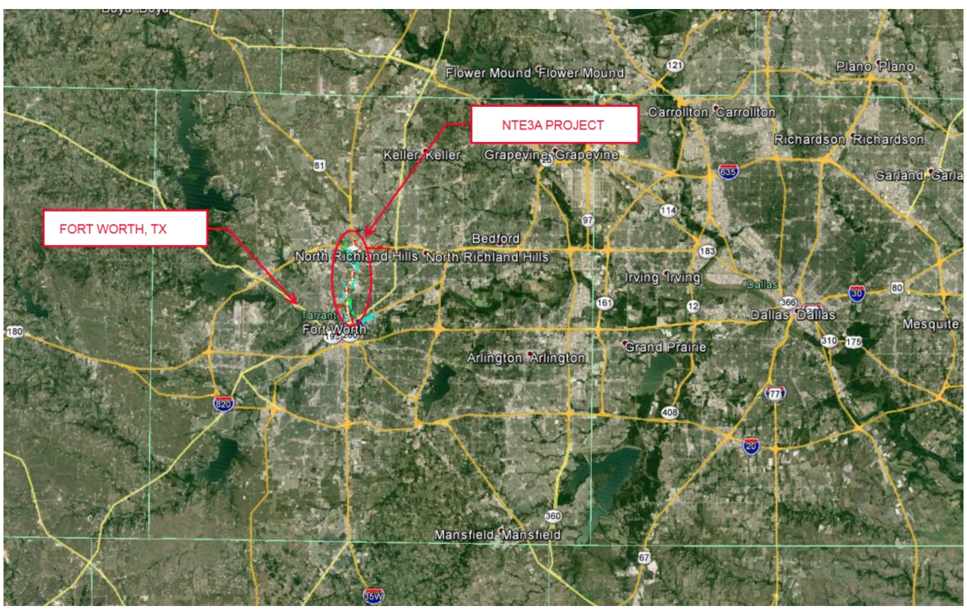


Figure 2. Dallas - Fort Worth (Metroplex) Aerial Picture.

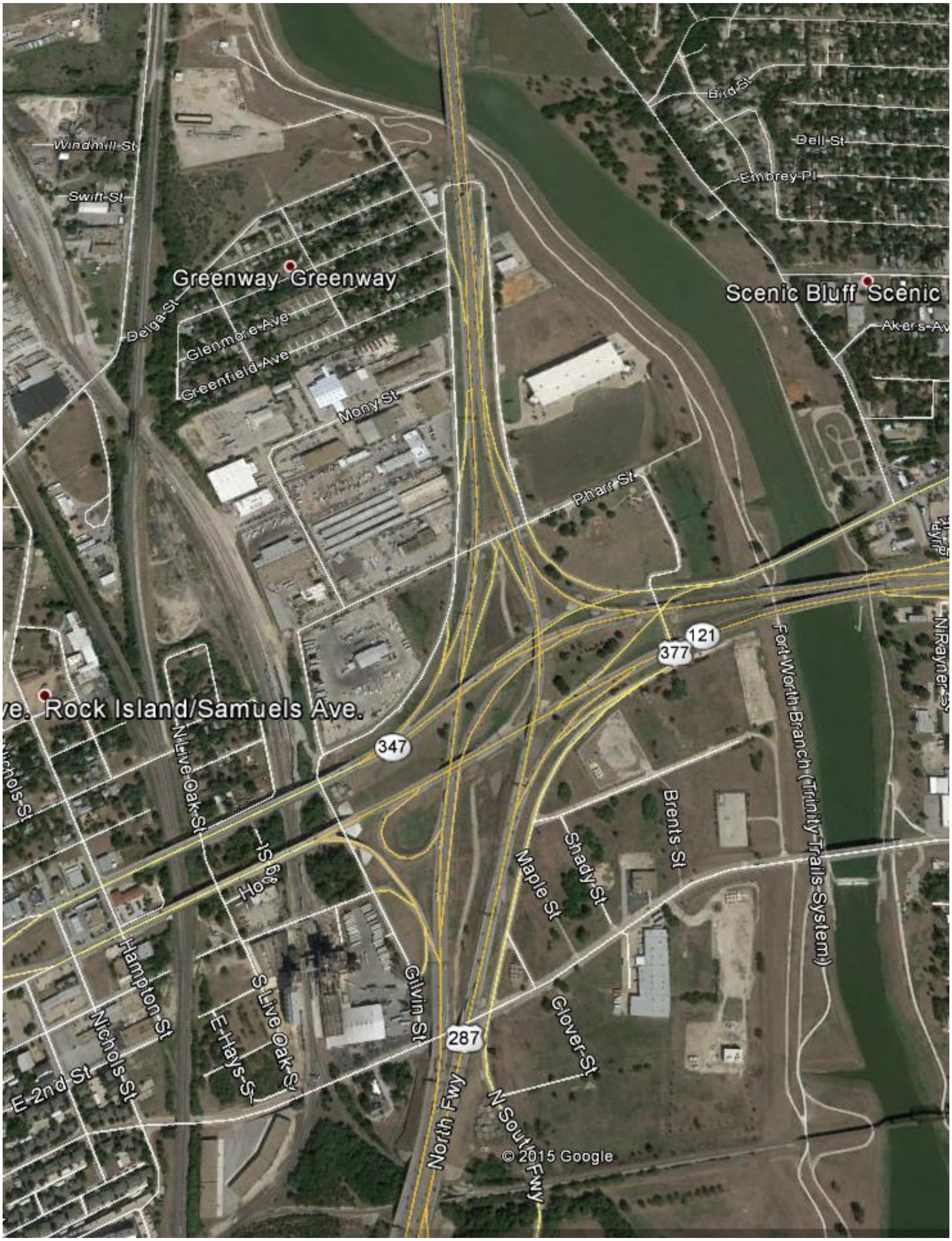


Figure 3. Greenway/Pharr Area (Fort Worth, TX) Overview.

1.1. Actual Sewer System

Our system is composed by two crossings under the actual I-35W and a lift station south of the river. All of them work together in order to evacuate successfully the black waters of residential and industrial properties of the area west of I-35W.

Both crossings are fully operational even though, the southernmost one, a 42" concrete sewer serves a small neighborhood located northwest of it. This line before extensively used, has today a mediocre flow. The properties it served before have been diverged to newly installed services leaving this one oversized. The city of Fort Worth itself is the first interested in relocate or abandon such pipe due to its increased maintenance costs.

Every main a sewer system will be localized and commented in appendix 4 "Conflict Analysis" and the Lift Station within the potential flows will be also analyzed in appendix 11 "Lift Station".

An extensive explanation of each sewer system can be found at appendix 1 "Actual state".

2. Cartography

2.1. Sources of Cartography and Topography

The United States Geological Survey (USGS, formerly simply Geological Survey) is a scientific agency of the United States government. The scientists of the USGS study the landscape of the United States, its natural resources, and the natural hazards that threaten it. The organization has four major science disciplines, concerning biology, geography, geology, and hydrology. The USGS is a fact-finding research organization with no regulatory responsibility.

The USGS produces several national series of topographic maps which vary in scale and extent, with some wide gaps in coverage, notably the complete absence of 1:50,000 scale topographic maps or their equivalent. The largest (both in terms of scale and quantity) and best-known topographic series is the 7.5-minute, 1:24,000 scale, quadrangle, a non-metric scale virtually unique to the United States. Each of these maps covers an area bounded by two lines of latitude and two lines of longitude spaced 7.5 minutes apart.

2.2. Construction Survey

City of Fort Worth requires that all survey staking must be done by the contractor in coordination with city's Project Representative to coordinate sequencing of Construction Staking. Therefore, an independent survey firm or the in site contractor's survey department will do all the staking and will maintain them throughout the project duration.

A more detailed explanation of City's regulations and plans can be found at appendix 2 "Cartography".

3. Geology

3.1. Geological Sources

Geological data from the USGS National Geologic Map have been used to perform the geological analysis of the area encompassing the project.

In addition Bore logs were performed in the area according with TxDOT procedures are used in order to identify the geological characteristics. They were performed by independent consultants specifically for this project.

The appendix presents a geological map besides an exhibit showing the boring locations at the Greenway area and Pharr area as well as plans and geological profiles that apply to the project area only.

3.2. Geological Stratus

The main challenge to beat in order to install the proposed sewer line is the cohesionless silty sand that can be found in between the top clay layer and the lower shale strata considered as rock material. All this information can be easily seen and understand on the appendix 3 “Geology” annex 3.3. – bore log profile.

In order to be able to install the sewer line different actions must be taken to achieve it. This paper goes through several studies of different options to finally choose the most suitable one from a technical and economical point of view. Such options were de-watering, sheet pilling and manhole foundations.

4. Conflict Analysis

There are 4 main conflicts that lead the existing sewer line to be relocated. Such conflicts are extensively explained at Appendix 4. Please see them listed below:

a) Conflict No.1 – Sewer Crossing I-35W by Greenfield Ave.
b) Conflict No.2 – Sewer Along I-35W South Bound Service Road.
c) Conflict No.3 – Sewer at Greenfield Ave. and Glenmore Ave.
d) Conflict No.4 – Sewer at crossing I-35W and Texas 121 by Pharr Street and Maple Street.

The aim of this paper is to found the most suitable solution to put an end to such conflicts in a timely fashion manner. The following points represent the many options considered and the studies behind them to finally choose the best option.

To find most of these conflicts, this paper relied on the information provided from test holes done prior to the commencement of the highway development. Also, such test hole information brought to light, in confluence with the final highway design the conflicts stated above. Without this test holes done with Hydrovac technology and the current design of the highway, no study could be made.

Although test holes were very useful, reader will appreciate that the vast information from record drawings were the ones that finally caught all the conflicts involved in the development of this paper. Such record drawings may be hard to read but they are well extensively commented on the Appendix previously stated.

5. Design Alternatives

As commented at the beginning of the report. The design of alternatives will lead to a preliminary alternative analysis from which 2 options will be thoroughly studied.

5.1. Alternative 1: Follow existing alignment

This option will aim to follow and maintain existing flows and alignments as they are at the present time. The appendix 5 attributes values to the different criteria used to do the preliminary alternative analysis. Every criteria has its own parameters as well.

5.1.1. North crossing relocation

Figure 4. Alternative 1 - North Crossing Relocation.

5.1.2. South crossing relocation

This alignment will relocate the sewer line that runs southeast under the interstate I-35 interchange with Texas 121. and the crossing itself within the same alignment.

Figure 5. Alternative 1 - South Crossing Relocation.

5.2. Alternative 2: Delete S. Crossing and Follow existing north alignment

This option looks to eliminate the south bore which has a great cost to the sewer relocation. Although keeps in place the north crossing as it is right now (extended up to the new Right Of Way).

Figure 6. North Crossing relocation deleting the southern crossing.

5.3. Alternative 3: New Alignment through Mony Street

The third alternative and the following ones have its fundamentals by deleting both existing crossings so no bores needs to be done. As we will see right away, these alternatives will redirect the existing flow of Pharr street and Mony street area towards Greenway Neighborhood Lift Station. The capacity of such lift station will be studied at appendix 11.

This alternative looks as follows:

Figure 7. New Alignment through Mony Street.

5.4. Alternative 4: New Alignment through Greenfield Ave

This alignment has no lateral and looks forward to leave in place the existing Mony Street sewer as it is right now so no extra works in there and its consequential street repair needs to be done.

The only two laterals for this conflict will be Pharr Street (Non-restrictive) and Mony Street. Please find below the alignment of the considered alternative:

Figure 8. New Alignment through Greenfield Ave.

5.5. Alternative 5: New Alignment through Greenfield Ave and Pharr Street

This last, but not least, alternative aims to avoid the connection from Pharr Street up to Greenfield Avenue leading a new whole sewer line though Pharr Street and then Mony Street.

Figure 9. New Alignment through Greenfield Ave and Pharr Street.

6. Preliminary Study of Alternatives

As commented at the beginning of the report. The design of alternatives will lead to a preliminary alternative analysis from which 2 options will be thoroughly studied.

6.1. ELECTRE I Method Description

Electre I method is a tool for alternatives selection. It is based in an analysis multi-criteria method to select the most optimum option. This tool is helpful to consider simultaneously different quantitative targets, both economical and non-economical, and also qualitative targets, which can be quantified in economic terms or non-economical but numerical.

An easy explanation of the method could well be that this method chooses the best option among many but if a good option with average punctuation has a parameter that can't be met, this option will be rejected as well.

6.2. Criteria Values and Definition

We've determined what criteria are going to be evaluated in regards of its relevance on the election of one or another alternative. The criteria selected and its parameters are defined at table 35.

Criteria	Parameters
Execution	Execution Term Earth Hauled off-site
Functionality	Population adjustment Maintenance Cost
Environmental Impact	Length Easements Social Impact
Economical cost	Initial Investment

Table 1. Criteria and Parameters for the Multi-criteria election.

For every criterion, we assign a value to the costs of every alternative, all of them are at the same scale from 1 to 10. Value 1 will be the best option and 10 the worst.

6.2.1. EXECUTION

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Execution Term (days)	93.22	10	54.56	3.88	40.75	1.70	36.34	1	52.24	3.52
Earth removal (CY)	954.59	1	1,303.78	8.27	1,386.91	10	1,236.40	6.87	1,355.30	9.34
Total Cost	11.00		12.15		11.70		7.87		12.86	

Table 2. Execution parameter values.

6.2.2. FUNCTIONALITY

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Population adjustment	High	1	High	1	High	1	High	1	High-Mod	3
Maintenance Cost ($)	67,125.59	10	50,875.59	5.25	49,103.00	4.74	44,030.23	3.26	36,308.06	1
Total Cost	11.00		6.25		5.74		4.26		4.00	

Table 3. Functionality parameter values.

6.2.3. ENVIRONMENTAL IMPACT

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Length (LF)	1,717.55	1	2,713.25	5.07	3,056.86	6.48	2,725.13	5.12	3,917.81	10
Easements (EA)	1.00	1	2.00	10	1.00	1	1.00	1	2.00	10
Social Impact (LF)	-	1	30.00	2.55	1,053.00	5.96	511.78	3.41	1,912.22	10
Total Cost	3.00		17.63		13.43		9.53		30.00	

Table 4. Environmental impact parameter values.

6.2.4. ECONOMICAL COST

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Initial Investment ($)	1,611.210	10	885,309.58	3.82	621,466.77	1.57	554,567	1	759,591.68	2.75
Total Cost	10.00		3.82		1.57		1.00		2.75	

Table 5. Economical cost parameter values.

6.3. 1st approach - Classification of the alternatives

For every criterion, we assign a value to the costs of every alternative, all of them are at the same scale from 1 to 10. Value 1 will be the best option and 10 the worst.

The classification of our 5 different alignments is shown in the table below.

Alternative	Final Order
New Alignment through Greenfield Ave (A_4)	1st
Delete S. Crossing and Follow existing north alignment (A_2)	2nd
New Alignment through Mony Street (A_3)	2nd
New Alignment through Greenfield Ave and Pharr Street (A_5)	2nd
Follow existing alignment (A_1)	5th

Table 6. 1st Approach - Classification of the Alternatives.

It is important to note that we've chosen the ELECTRE I METHOD because it is an adequate multi-criteria analysis based on weighted punctuation.

The strength of this method relies on preventing that alternatives with good average values but unacceptable under any criteria gets chosen.

At this moment we have a clear first option but the unknowns regarding the geotechnical quality of the soil in the whole area asks for a second option to study. In this regards we must run ELECTRE I again without the 5th option so it doesn't hide the ranking among the 2nd best option.

6.4. 2nd approach – FINAL Classification of the alternatives

The classification of our 5 different alignments is shown in the table below.

Alternative	Final Order
New Alignment through Greenfield Ave (A_4)	1st
Alignment through Mony Street (A_3)	2nd
New Alignment through Greenfield Ave and Pharr Street New (A_5)	3rd
Delete S. Crossing and Follow existing north alignment (A_2)	4th

Table 7. Final Classification of the Alternatives.

On this second approach to the ELECTRE I Multi-criteria Method we've discerned between alternatives two through five. As show on table 53, alternative 4 stills in first position but among the other, alternative 3 is over the rest.

For the record, I want to repeat once more that this is the initial approach and extra cost may arise due to the future geotechnical provisions and actions and other expenses as safety or traffic control.

The following pages will explain the thought process and studies to obtain the final alignment and its design.

From now onwards, the only two options being considered will be named as follows:

- Alternative 3: Mony Alignment
- Alternative 4: Greenfield Alignment

7. Geotechnical Study

As commented at the beginning of the report. The design of alternatives will lead to a preliminary alternative analysis from which 2 options will be thoroughly studied.

7.1. Sheet Pilling – Retaining wall

This study is meant to design the possibility of installing a system of sheet piles along the sewer alignment to create a dry environment once the trench is dig. This method would grant the constructability for itself.

The design of sheet pile retaining walls requires several successive operations: (a) evaluation of the forces and lateral pressures that act on the wall, (b) determination of the required depth of piling penetration, (c) computation of the maximum bending moments in the piling, (d) computation of the stresses in the wall and selection of the appropriate piling section and (e) the design of the waling and anchorage system if necessary.

There are two basic types of steel sheet pile walls: cantilevered walls and anchored walls. Due to the length of our trench and the little use that will have (To maintain stable the trench) we will only consider the cantilever walls.

At appendix 7, an extensive explanation of the theories behind the design and the design itself can be found.

After the thorough study the following two tables summarizes the total length pipe to be installed along the trench walls prior to the excavation and its cost for both alternatives:

7.1.1. Greenfield Avenue Alternative Anchorage Profile and Cost

Greenfield Ave - SHEET PILING (PZ-22)							
Station		**Sheet pile LENGTH**	**Application Distance**	**TOTAL ft^2 (Double side)**	**$/SF**		**TOTAL Price**
00+00.00	01+00.00	12.16	100	2432	$	25.22	$ 61,335.04
01+00.00	02+00.00	12.53	100	2506	$	25.22	$ 63,201.32
02+00.00	03+00.00	13.15	100	2630	$	25.22	$ 66,328.60
03+00.00	04+00.00	13.77	100	2754	$	25.22	$ 69,455.88
04+00.00	05+00.00	14.38	100	2876	$	25.22	$ 72,532.72
05+00.00	06+00.00	17.92	100	3584	$	25.22	$ 90,388.48
06+00.00	07+00.00	15.2	100	3040	$	25.22	$ 76,668.80
07+00.00	08+00.00	11.49	100	2298	$	25.22	$ 57,955.56
08+00.00	09+00.00	11.79	100	2358	$	25.22	$ 59,468.76
09+00.00	10+00.00	13.91	100	2782	$	25.22	$ 70,162.04
10+00.00	11+00.00	15.82	100	3164	$	25.22	$ 79,796.08
11+00.00	12+00.00	17.4	100	3480	$	25.22	$ 87,765.60
12+00.00	13+00.00	19.96	100	3992	$	25.22	$ 100,678.24
13+00.00	14+00.00	22.18	100	4436	$	25.22	$ 111,875.92
14+00.00	15+00.00	21.02	100	4204	$	25.22	$ 106,024.88
15+00.00	16+00.00	19.31	100	3862	$	25.22	$ 97,399.64
16+00.00	17+00.00	17.3	100	3460	$	25.22	$ 87,261.20
17+00.00	18+00.00	17.01	100	3402	$	25.22	$ 85,798.44
18+00.00	19+00.00	16.72	100	3344	$	25.22	$ 84,335.68
19+00.00	20+00.00	16.64	100	3328	$	25.22	$ 83,932.16
20+00.00	21+00.00	17.34	100	3468	$	25.22	$ 87,462.96
21+00.00	22+00.00	18.11	100	3622	$	25.22	$ 91,346.84
22+00.00	23+00.00	18.87	100	3774	$	25.22	$ 95,180.28
23+00.00	24+00.00	20.4	100	4080	$	25.22	$ 102,897.60
24+00.00	25+00.00	23.53	100	4706	$	25.22	$ 118,685.32
25+00.00	26+00.00	25.08	100	5016	$	25.22	$ 126,503.52
26+00.00	27+00.00	22.71	100	4542	$	25.22	$ 114,549.24
27+00.00	27+25.13	20.89	25.13	1049.9	$	25.22	$ 26,479.27
			Total square feet	94189.9	TOTAL $ =		$ 2,375,470.07

Table 8. Greenfield Avenue Alternative Cost (Sheet Pile PZ-22).

7.1.2. Mony Street Alternative Anchorage Profile and Cost

Mony Street - SHEET PILING (PZ-22)						
Station		**Sheet pile LENGTH**	**Application Distance**	**TOTAL ft^2 (Double side)**	**$/SF**	**TOTAL Price**
00+00.00	01+00.00	12.21	100	2442	$ 25.22	$ 61,587.24
01+00.00	02+00.00	12.62	100	2524	$ 26.22	$ 66,179.28
02+00.00	03+00.00	13.24	100	2648	$ 27.22	$ 72,078.56
03+00.00	04+00.00	13.86	100	2772	$ 25.22	$ 69,909.84
04+00.00	05+00.00	14.49	100	2898	$ 26.22	$ 75,985.56
05+00.00	06+00.00	18.07	100	3614	$ 27.22	$ 98,373.08
06+00.00	07+00.00	15.33	100	3066	$ 28.22	$ 86,522.52
07+00.00	08+00.00	11.61	100	2322	$ 29.22	$ 67,848.84
08+00.00	09+00.00	11.9	100	2380	$ 30.22	$ 71,923.60
09+00.00	10+00.00	14.08	100	2816	$ 31.22	$ 87,915.52
10+00.00	11+00.00	15.98	100	3196	$ 32.22	$ 102,975.12
11+00.00	12+00.00	17.56	100	3512	$ 33.22	$ 116,668.64
12+00.00	13+00.00	20.15	100	4030	$ 34.22	$ 137,906.60
13+00.00	14+00.00	22.34	100	4468	$ 35.22	$ 157,362.96
14+00.00	15+00.00	21.16	100	4232	$ 36.22	$ 153,283.04
15+00.00	16+00.00	19.53	100	3906	$ 37.22	$ 145,381.32
16+00.00	17+00.00	17.42	100	3484	$ 38.22	$ 133,158.48
17+00.00	18+00.00	17.13	100	3426	$ 39.22	$ 134,367.72
18+00.00	19+00.00	15.97	100	3194	$ 40.22	$ 128,462.68
19+00.00	20+00.00	16.48	100	3296	$ 41.22	$ 135,861.12
20+00.00	21+00.00	15.76	100	3152	$ 42.22	$ 133,077.44
21+00.00	22+00.00	15.03	100	3006	$ 43.22	$ 129,919.32
22+00.00	23+00.00	14.29	100	2858	$ 44.22	$ 126,380.76
23+00.00	24+00.00	13.47	100	2694	$ 45.22	$ 121,822.68
24+00.00	25+00.00	12.54	100	2508	$ 46.22	$ 115,919.76
25+00.00	26+00.00	11.61	100	2322	$ 47.22	$ 109,644.84
26+00.00	26+18.97	7.48	18.97	283.7912	$ 48.22	$ 13,684.41
LATERAL						
00+00.00	01+00.00	12	100	2400	$ 50.22	$ 120,528.00
01+00.00	02+00.00	15.97	100	3194	$ 51.22	$ 163,596.68
02+00.00	03+00.00	16	100	3200	$ 52.22	$ 167,104.00
03+00.00	04+00.00	16.03	100	3206	$ 53.22	$ 170,623.32
04+00.00	04+37.86	15.97	37.86	1209.248	$ 54.22	$ 65,565.45
			Total square feet	94259.04	TOTAL $ =	$ 3,541,618.38

Table 9. Mony Street Alternative Cost (Sheet Pile PZ-22)

7.2. Trench Shoring

Whereas the sheet pilling isn't needed, a shoring must be implemented. Such shoring is included in the Trench Safety Report that every contractor must do before excavating a trench if such trench is deeper than 20ft or if the soil is instable.

In our case is due to this second cause.

7.2.1. Trench Shield

The Contractor will use a Trench Shield if no sheet pile is used or where sheet pile doesn't need to be installed. Requirements set forth in this Option shall include curricular trench shield(s) and or manhole boxes. All slopes above trench shield(s) shall conform to guidelines set forth in Option I. Trench shield(s) used on this project will be required to carry a minimum "PSF" as specified. Certification of trench shield(s) or manufacture's "tabulated data" shall be available for verification during construction at all times.

7.2.2. Plywood Shoring

The contractor can use Plywood as Trench Shores. Shores are to be installed as shown with horizontal spacing determined by the depth of cut and soil type but shall not exceed 6 feet.

8. Hydrology

The Hydrology study seeks the feasibility and cost of implementing a leap frogging de-watering system to build the sewer line in a dry environment. At appendix 8 readers can find the theory and the calculations behind this construction method. The following lines explain the conclusions of such study and the cost of implementing the de-watering dwells.

8.1. De-watering Comparative Greenfield – Mony\

	Distance Wellpoint - Trench (LF)	Wellpoint Separation (LF)	Wellpoint Depth (LF)	Application Length (LF)	Recharge Length (LF)	Wellpoints / 1000LF
Greenfield Ave Alternative	2.50	4.00	26.7	2275.13	575.00	250
Mony Street Alternative	2.50	5.00	27.3	2606.86	1069.00	200

Table 10. De-watering System comparative.

If we apply this data to the case where all the de-watering system is installed at the same time, a percentage different can be obtained between both alternatives.

Greenfield alternative would have installed 569 wellpoints plus 144 due to the recharge at Pharr and Greenfield Ave. In total there will be 713 wellpoints shafted and installed.

Mony alternative would set to work 442 wellpoints with the addition of 214 more due to the recharging operations. This will sum up to 656 wellpoints installed.

With this information, **Mony street alternative** should be almost up to **10% cheaper** (92% of Greenfield's cost) de-watering

8.2. De-watering Cost

Local Construction Company specialized in de-watering offered the following prices with conditions stated on appendix 8. This price doesn't have into account the number of dwells performed but the time used. This means that the last statement on the page above is false. Greenfield will be then less expensive than Mony option.

TRENCH DEWATERING COST SUMMARY

Item	Quantity	UM	Unit	Amount
1 - Sided (First 2000')		LF	$ 68.00	
1 - Sided (After 2000')		LF	$ 58.00	
Equipment Rental (First 6 weeks)		Month	$ -	
Equipment Rental (After 6 weeks)		Month	$ 33,750.00	
Equipment Rental (After 6 weeks)		Day	$ 1,125.00	
Stand by Crew		Day	$ 5,800.00	
Stand by Crew		HR	$ 725.00	

Table 11. Trench dewatering cost summary

8.3. De-watering Comparative

A table as the previous one will be used to finally compare in a quantitative manner the difference between implementing this de-watering system in both alternatives. Due to the failed study of pilling sheets along the trench, de-watering will be a must, even though, the bottom of the trench must be ensured and filled with 3 by 5 inch rock or concrete grout. Either way the initial assumption that the trench would go at a pace of 75 LF per day is too aggressive. In order to find a more conservative solution and probably more accurate to the reality of the area, the new construction pace will be diminished up to 50LF of trench per day. This means more time with the de-watering subcontractor on-site. (Consider 5 working days per week as well)

8.3.1. Greenfield Avenue De-watering Cost

Greenfield Avenue Alternative						
Item	Quantity	UM		Unit		Amount
1 - Sided (First 2000')	2000	LF	$	68.00	$	136,000.00
1 - Sided (After 2000')	275.13	LF	$	58.00	$	15,957.54
Recharge 1 - sided	575	LF	$	58.00	$	33,350.00
Equipment Rental (First 6 weeks)	1	Month	$	-	$	-
Equipment Rental (After 6 weeks)	56.25	Day	$	1,125.00	$	63,274.91
Stand by Crew	9.1	Day	$	5,800.00	$	52,783.02
Stand by Crew	0	Hr	$	725.00	$	-
				TOTAL	$	301,365.47

Table 12. Greenfield Avenue De-watering Cost

To compute this alternative, a 7 days prior dewatering to the start of works was used and also a 20% of the time will be set as downtime due to unpredictable and unknown factors as weather or machinery breakdown. The same preferences have been used for the Mony alternative.

8.3.2. Mony Street De-watering Cost

Mony Avenue Alternative						
Item	Quantity	UM	Unit		Amount	
1 - Sided (First 2000')	2000	LF	$	68.00	$	136,000.00
1 - Sided (After 2000')	206.83	LF	$	58.00	$	11,996.14
Recharge 1 - sided	1069	LF	$	58.00	$	62,002.00
Equipment Rental (First 6 weeks)	1	Month	$	-	$	-
Equipment Rental (After 6 weeks)	67.39	Day	$	1,125.00	$	75,814.31
Stand by Crew	10.43	Day	$	5,800.00	$	60,479.15
Stand by Crew	0	Hr	$	725.00	$	-
				TOTAL	$	369,493.34

Table 13. Mony Street De-watering Cost

9. Structural Analysis

Usually, a sewer line installation has no need of any structural component to be installed. In our case instead, due to the loose silty sands in the area, the possibility of the proposed manholes to sink is high. Therefore this paper proposes to install a drill shaft foundation beneath every manhole that must be set in the sand strata. Such foundation will set as a support and won't be connected to the manholes in order to comply with city specifications, otherwise the city may not agree on such design. To avoid a possible displacement laterally, a concrete pad with curb will be constructed on top of the foundation once the manhole is installed.

The design of it is extensively studied on appendix 9.

9.1. Drill Shafts Comparative

After a long study, the following table will show the different prices and number of drill shafts that needs to be installed in order to build this sewer line within a guarantee of 2 years after finalization.

GREENFIELD AVENUE ALTERNATIVE								
D.S. LENGTH (FT)	MH LENGTH (FT)	Price DS 24"	Price DS 36"	Price DS – no Concrete	Cost A	Mob	Cost B	Total
24.18	9.2	$161.62	$167.73	($85.00)	$5,394.88	$4,500.00	($782.00)	$9,112.88
24.11	9.4	$161.62	$167.73	($85.00)	$5,415.89	$4,500.00	($799.00)	$9,116.89
22.55	9.7	$161.62	$167.73	($85.00)	$5,212.25	$4,500.00	($824.50)	$8,887.75
15.4	5.8	$161.62	$167.73	($85.00)	$3,555.88	$4,500.00	($493.00)	$7,562.88
18.85	8.7	$161.62	$167.73	($85.00)	$4,620.96	$4,500.00	($739.50)	$8,381.46
18.11	11.6	$161.62	$167.73	($85.00)	$4,983.26	$4,500.00	($986.00)	$8,497.26
19.25	11	$161.62	$167.73	($85.00)	$5,073.83	$4,500.00	($935.00)	$8,638.83
15.22	12.3	$161.62	$167.73	($85.00)	$4,615.93	$4,500.00	($1,045.50)	$8,070.43
9.24	13.7	$161.62	$167.73	($85.00)	$3,847.73	$4,500.00	($1,164.50)	$7,183.23
9.17	12.9	$161.62	$167.73	($85.00)	$3,701.80	$4,500.00	($1,096.50)	$7,105.30
					TOTAL Greenfield Alt.			$82,556.89

Table 14. Greenfield Avenue Alternative D.S. Cost.

MONY STREET ALTERNATIVE								
D.S. LENGTH	MH LENGTH	Price DS	Price DS	Price DS – no	Cost A	Mob	Cost B	Total

(FT)	(FT)	24"	36"	Concrete				
24.17	9.2	$161.62	$167.73	($85.00)	$5,393.26	$4,500.00	($782.00)	$9,111.26
24.1	9.5	$161.62	$167.73	($85.00)	$5,430.43	$4,500.00	($807.50)	$9,122.93
22.53	9.7	$161.62	$167.73	($85.00)	$5,209.01	$4,500.00	($824.50)	$8,884.51
16.38	5.8	$161.62	$167.73	($85.00)	$3,584.73	$4,500.00	($493.00)	$7,591.73
20.82	8.8	$161.62	$167.73	($85.00)	$4,968.16	$4,500.00	($748.00)	$8,720.16
17.06	11.6	$161.62	$167.73	($85.00)	$4,807.14	$4,500.00	($986.00)	$8,321.14
19.69	11	$161.62	$167.73	($85.00)	$5,147.63	$4,500.00	($935.00)	$8,712.63
19.05	10.5	$161.62	$167.73	($85.00)	$4,956.42	$4,500.00	($892.50)	$8,563.92
18.77	9.2	$161.62	$167.73	($85.00)	$4,691.41	$4,500.00	($782.00)	$8,409.41
18.06	8.2	$161.62	$167.73	($85.00)	$4,404.59	$4,500.00	($697.00)	$8,207.59
17.17	10.6	$161.62	$167.73	($85.00)	$4,657.86	$4,500.00	($901.00)	$8,256.86
					TOTAL Mony Alt.			$93,902.16

Table 15. Mony Street Alternative D.S. Cost.

Concrete prices in Texas as back charge to drilling companies average low bid of $85 per linear feet.

As we can appreciate on the tables above, Greenfield alternative is $11,345.26 cheaper than Mony alternative. Also, this last one has less drill shafts to be performed on the street than the first one.

10. Final Study of Alternatives

To dot his last study of alternatives we will apply as before the ELECTRE I method. Therefore the criteria and their parameters will stay as they were but updated with all the outcomes of the previous studies.

As Sheet pilling was outrageous expensive in comparison to de-watering, this last option is the one applied to build the sewer line. The manhole foundations would have been done as well in either case so they need to be considered as well in the final pricing.

The study process is at appendix 10.

10.1. Criteria Values

Please find below the parameter values for each criterion.

10.1.1. EXECUTION

	Alt. 1		Alt. 2	
	Value	Cost	Value	Cost
Execution Term	**105**	**1**	**117**	**10**
Earth removal	**1236.4**	1	1,473.22	10
Total Cost	2		20	

Table 16. Execution parameter values.

10.1.2. FUNCTIONALITY

	Alt. 1		Alt. 2	
	Value	Cost	Value	Cost
Population adjustment	**High**	**1**	**High**	**1**
Maintenance Cost	**44,030.23**	1	49,103.00	10
Total Cost	2		11	

Table 17. Functionality parameter values.

10.1.3. ENVIRONMENTAL IMPACT

	Alt. 1	Alt. 2

	Value	Cost	Value	Cost
Length (LF)	**2725.13**	**1**	**3056.86**	**10**
Easements (EA)	**1**	**1**	**1**	**1**
Social Impact (LF)	**511.78**	1	1,053.00	10
Total Cost	3		21	

Table 18. Environmental Impact parameter values.

10.1.4. ECONOMICAL COST

	Alt. 1		**Alt. 2**	
	Value	**Cost**	**Value**	**Cost**
Initial Investment ($)	**755,628.83**	1.00	816,825.23	10.00
Total Cost	**1**		10	

Table 19. Economical cost parameter values.

10.2. Alternative Analysis Conclusion

At this point, it is not even worthy to go through all the Matrix I to Matrix III process because Greenfield alternative outnumber or even Mony alternative in all criteria parameters. This makes an easy final decision.

The Alignment to be designed will be the **GREENFIELD AVENUE ALTERNATIVE.**

11. Lift Station Flow Calculation

Once the decision of what alignment needs to be design, a flow analysis is a must to determine the diameter of the pipe but even more to determine if the lift station where all this sewer flow is being diverged from its natural path can hold the new flow and the future one as well.

11.1. Potential Flow

In order to determine the potential flow that would be conveyed into the existing Greenway Place Lift Station, a sewer basin analysis was performed (see Annex 11.1). According to the 2012 Wastewater Master Plan Hydraulic Model, peak flow values were taken at four locations. The first location modeled the wastewater flow just upstream of the existing Greenway Place Lift Station. The second location modeled the wastewater flow going through the existing 24" sewer main (M-267, X-18382) just before entering into the existing 68" sewer main (M-245-B, X-14471). Third and fourth location modeled the flow that would flow through existing 42" sewer main (M-1-I-1, X-13685) through 6" sewer lateral (L-3484, X-3484) and 10" sewer main (M-2332, X-2332).

Existing Peak Flow into Greenway Place Lift Station		**Peak Flow through 24" Sewer Main (M-267, X-18382)**		**Peak Flow through 6" Sewer Lateral (L-3484, X-3484)**	
Planning Period	Flow	Planning Period	Flow	Planning Period	Flow
Existing	0.53 MGD	Existing	0.145 MGD	Existing	0.045 MGD
2030	1.22 MGD	2030	0.173 MGD	2030	0.054 MGD

Table 20. 2012 Wastewater Master Hydraulic Model Peak Wet Weather Flow (Part 1).

Peak Flow through 10" Sewer Main (M-2332, X-2332)		**Combined Peak Flow into Greenway Place Lift Station**	
Planning Period	Flow	Planning Period	Flow
Existing	0.034 MGD	Existing	0.754 MGD
2030	0.041 MGD	2030	1.488 MGD

Table 21. 2012 Wastewater Master Hydraulic Model Peak Wet Weather Flow (Part 2).

Based on the hydraulic model, the design peak wet-weather flow with the additional M-267 and upper M-1-I-1 drainage area is 1.488 million gallons a day (MGD).

11.2. Flow Analysis Conclusion

After looking at the pump and wet well capacity calculation done at appendix 11, the Greenway Place Lift Station has the capacity to handle the additional wastewater flow from the proposed wastewater system changes.

12. Quality Plan

Quality control plan describes the construction items that will be tested under the quality control during their execution.

Quality Assessment personnel from the general contractor will be in a first instance undertaking the supervision regarding the quality procedures to follow.

In a last instance, a city of Fort Worth inspector will do the final inspection of the bridge once finished before submitting the official end of works.

Appendix 12 defines extensively the items that will be taken into consideration in the quality control plan as well defined by the city specifications.

13. Environmental Plan

The awarded contractor in charge to build the new sewer line has to be committed to the health and safety personnel and the environment. Also has to strive to prevent any accident, spill, or hazard that could potentially harm the environment or employee.

Contractor will comply with any and all state and federal laws pertaining to environmental regulations and will implement and practice procedures to ensure compliance is upheld and maintained.

These practices will assist in minimizing the risk and help to protect their employees and the environment in which the work is done. Contractor will strive to prevent any leak, spill, or other release to the atmosphere, land, or water. Contractor will ensure that all waste is disposed of in a safe, proper manner, in accordance with the appropriate waste management procedure.

Though environmental harm is never planned, Contractor will address procedures in the event that a hazard is created. Contractor will conduct daily verbal and written meetings discussing Job Hazard assessments (JHA's), inspections of machinery and equipment, daily excavation, and general housekeeping to ensure that trash/debris is picked up and placed in the proper trash receptacle.

The necessary permits and Safety Data Sheets will be updated when needed, and kept on file for reference.

All Contractor employees that will be involved in working with the general contractor, will attend General's contractor safety and environmental orientation. Contractor employees will follow all site-specific environmental regulations at worksite.

Contractor will take the necessary steps and precautions to minimize any environmental risk associated with this jobsite. Environmental protection is no small task, but, with proper adherence to federal, state, and local regulatory requirements, it can be achieved.

The identified parts of a work plan can be briefly found at appendix 13.

14. Traffic Control

To build the proposed 18" and 8" wastewater pipe, traffic control must be set in order to cross or go along existing streets. Therefore, traffic control plans must be designed and implemented in a timely fashion so the contractor does not suffer delay while constructing such sewer system.

The proposed traffic control plans can be found at the drawing set and it involves specific street closures that cannot be closed for more than 9 days in a row. There are also specific low profile barrier settings that must meet the engineer expectations once implemented. This traffic control doesn't have a limit of time but can be subject to re-opening if the city of Fort Worth asks for.

If a street must be completely closed for more than 9 days, city council has to approve it. That means a process of 45 days must be done to be able to obtain such closures and there is no approval guarantee from the city council. That's why all work plan must be try to be set in order to avoid such processes.

Finally, there will be sporadically lane closures along the project with flaggers in case the street is two-way condition. This traffic control will be used to unload or load heavy machinery as well as materials. This resources can only be set from 9am to 3pm as per TxDOT requirements unless the city differs and grants a longer period of time. Nightly closure can as well be implemented from 9pm to 5am with the same provisions as the daily ones.

If nigh closures are done, proper illumination must be acquire to provide enough safety to the operation being held. Field engineer, TxDOT inspector or City inspector has the power to stop works as soon as they consider, under reasonable reasons, that the work being done is unsafe, traffic control devices are not well place/in good conditions or such traffic control is not necessary to perform the work.

As well as prior point, an extensive explanation of the traffic control adopter can be found at appendix 14 and the drawings.

15. Right Of Way Acquisition

This chapter is intended to present the information on the process of acquisition of Right of Way required to build the sewer line.

15.1. Acquisition Process

Acquisitions of Right of Way need to be realized according with State and Federal Laws. The following manuals contain procedures, guidelines and methods for the acquisition of Right of Way:

- TxDOT Right of Way Manual Collection
- TxDOT Access Management Manual
- TxDOT Survey Manual
- TxDOT Appraisal and Review Manual

A quick summary of the key guidelines to follow are presented in Appendix 9.

15.2. ROW to be acquired

To build the proposed 18” and 8” sewer lines a determined ROW must be purchased:

15.2.1. Greenway Area ROW

The Greenway neighborhood compressed from Pharr up to the north on the west side of I-35W will be reduced due to the acquisition of ROW necessary to develop I-35W.

An Exhibit of the area to be acquired can be found at annex 15.1.

15.2.2. 1st Street Area ROW

Although being a short run of sewer pipe to be installed (Little more than 600 feet), a large amount of ROW needs to be purchased due to the street configuration. The ROW expansion will be up to 2.72 acres.

16. Maintenance

The newly installed sewer line will be maintenance in a properly manner by the City of Fort Worth but if there is any breakdown or defect on the sewer itself, contractors warranty will be set active and will be entitle to restore the quality of the sewer line.

At appendix 16 there is a wide variety of cleaning and maintaining methods to keep the sewer line in perfect conditions through the contractor's warranty life and afterwards for the city itself.

Contractor has to agree on the lines in order to be awarded to build such sewer system.

16.1. Contractor's Warranty

City of Fort Worth claims to all his utility contractors a 2 year warranty in which contractor agrees to remedy in the time and manner provided herein and without cost to the city, any Defective Work of which it receives Notice within 24 months after the final acceptance of Contractor's Work. Defective Work does not include breakdown or damage arising from I-35W developer willful misconduct, or an alteration or modification without contractor's consent.

As commented before, appendix 16 has as well all the information related to contractor's warranty.

17. Work Plan

A simplified schedule for the work to do in this project is attached in Appendix 17.

The total expected time for the completion of the project is 155 working days.

The need of de-watering and the construction of the manholes foundation will delay the work.

The program used for the virtual Schedule is Microsoft Project.

In this same appendix there is a brief description of the construction process of the line and more thoroughly commented the foundation construction with the phasing of the drill shaft construction and the following support slab for the manhole.

18. Texas Normalized Bid Unit Price

This chapter justifies the bid unit prices used when calculating the Budget of the Project.

TXDOT publishes past bid unit prices both statewide and per counties. For this project, 3- month average bid prices for Dallas County have been used.

Bid item unit prices are found in Appendix 18.

19. Budget Summary

The construction cost of the project is **$ 1,509,336.01.**

Sections taken into account in the construction cost are:

- Prep ROW – Mobilization
- Pavement Repair
- Major Traffic Control
- Structures
- Excavation
- De-watering
- Sewer installation
- Safety & Health

TxDOT Project Manual requires the adding of the following allowances:

- Engineering Consultants
- Quality Assessment
- Contingency
- Sales Tax

After including the allowances in the construction cost the final cost is:

$ 1,987,603.29

The budget document contains more detailed information regarding the budget of the project.

20. Documents of the Project

The project is comprised by the following documents:

Document 1

- Project Report

Appendixes of the Project Report

0. Project Allocation
1. Actual State
2. Cartography
3. Geology
4. Conflict Analysis
5. Design Alternatives
6. Preliminary Study of Alternatives
7. Geotechnical Study
8. Hydrology
9. Structural Analysis
10. Final Study of Alternatives
11. Lift Station Flow Calculation
12. Quality Plan
13. Environmental Plan
14. Traffic Control
15. Right of Way Acquisition
16. Maintenance
17. Work Plan
18. Texas Normalized Bid Unit Price

Other Appendixes

A1-01. Safety Management – Report

A1-02. Safety Management – Drawings

A1-03. Safety Management – Safety Regulations (OSHA)

A1-04. Safety Management - Budget

Document 2

- City of Fort Worth Wastewater Utility Relocation - Drawings

Document 3

- Technical Specifications

Document 4

- Project Budget

The project is completely defined by the documents above and these allow the execution of the City of Fort Worth Wastewater Utility Relocation at the Greenway/Pharr Area due to I-35W Development Project (NTE3A).

Barcelona, January 2016

PABLO CASALS VILAR

CIVIL ENGINEER

Appendix No. 0:

<u>Project Allocation</u>

INDEX - APPENDIX NO. 0: PROJECT ALLOCATION

INDEX - FIGURE AND TABLE

0. Project Allocation

0.1. Allocation of the greenfield/Pharr Area (Fort Worth, TX)

The following pictures have the purpose to allocate with any kind of doubt the location of the project studied. The location determines the character of the project itself, characteristics as the legislation, specifications or even the units.

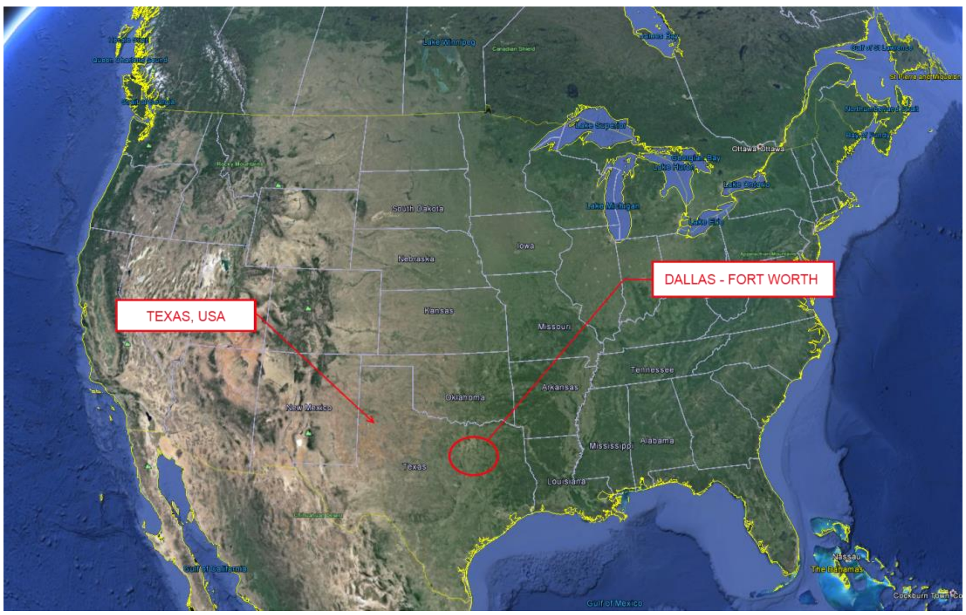


Figure 1. United States Of America Aerial Picture

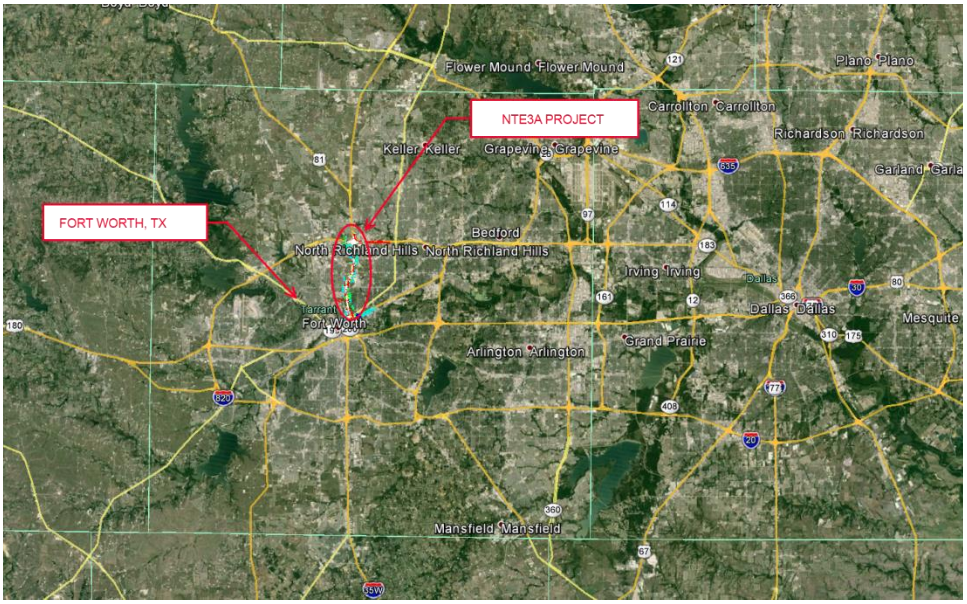


Figure 2. Dallas - Fort Worth (Metroplex) Aerial Picture

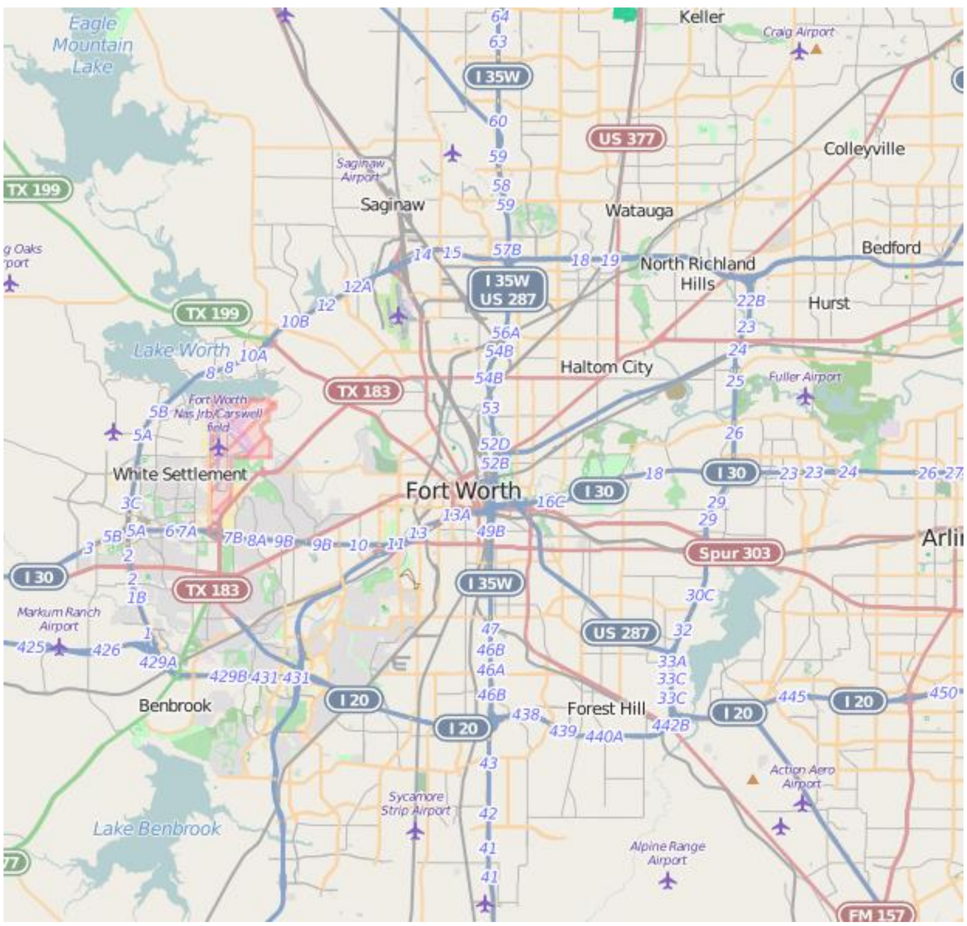


Figure 3. Fort Worth Highway System

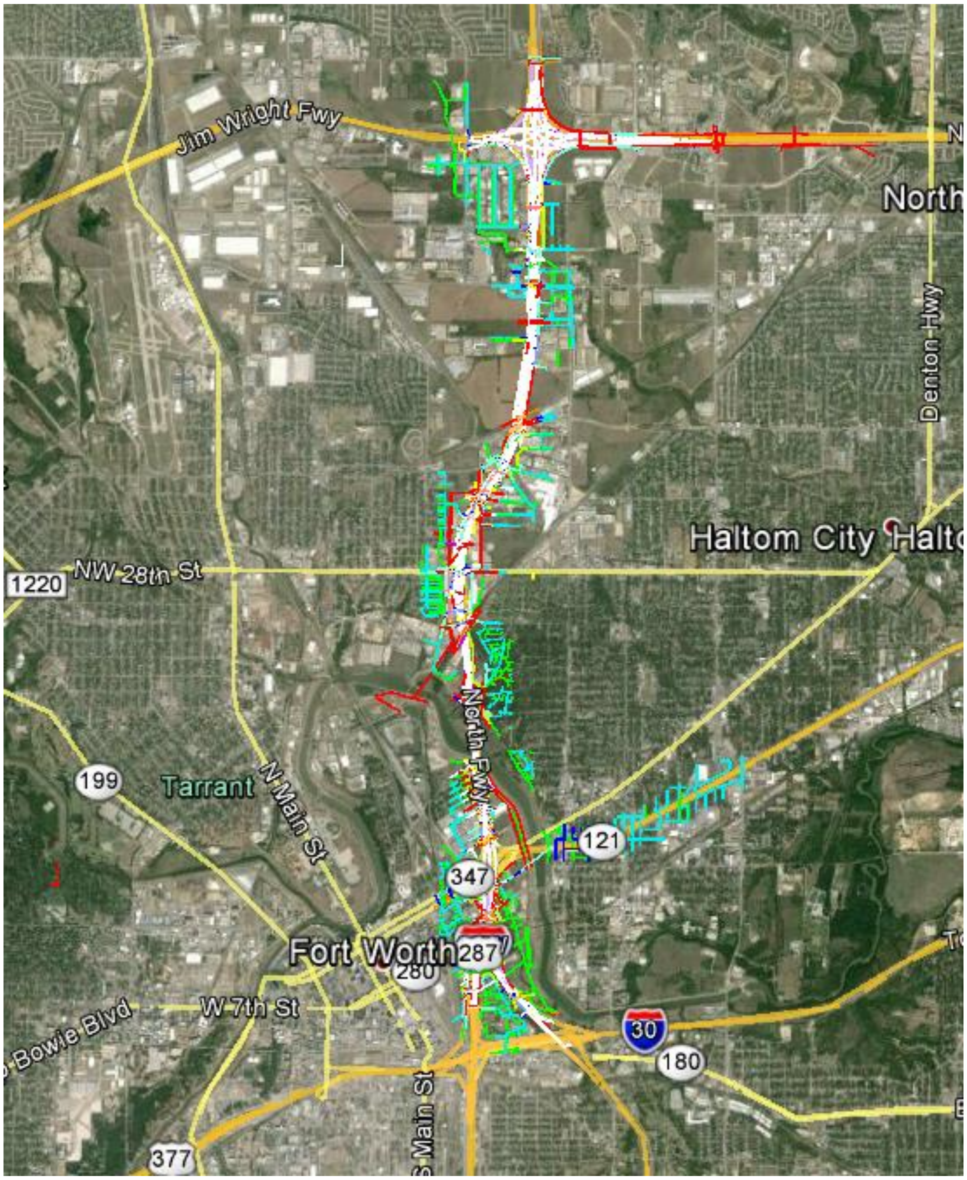


Figure 4. NTE3A Project Overview (Proposed Final Highway in white)

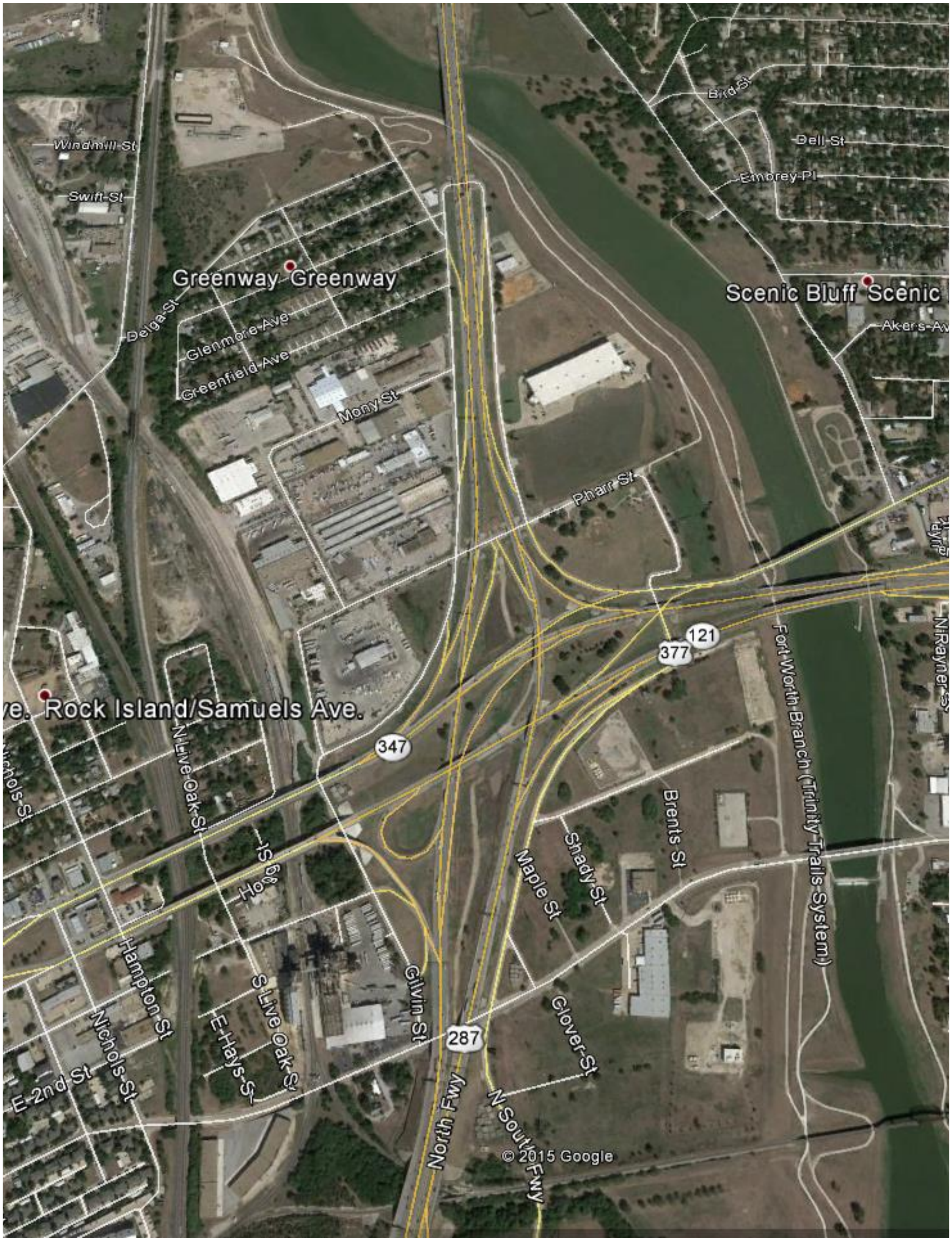


Figure 5. Greenway/Pharr Area (Fort Worth, TX) Overview.

Appendix No. 1:

Actual State

INDEX - APPENDIX NO. 1: ACTUAL STATE

INDEX - FIGURE AND TABLE

NO TABLE OF FIGURES ENTRIES FOUND.

1. Actual State

1.1. Actual Sewer System and Flow

The city of Fort Worth has an extensive record library summarized in the Annex 1.1 of this appendix. In it we will be able to recognize the name of main sewer lines, collectors and even the lift stations.

Our system is composed by two crossings under the actual I-35W and a lift station south of the river. All of them work together in order to evacuate successfully the black waters of residential and industrial properties of the area west of I-35W.

Both crossings are fully operational even though, the southernmost one, a 42" concrete sewer serves a small neighborhood located northwest of it. This line before extensively used, has today a mediocre flow. The properties it served before have been diverged to newly installed services leaving this one oversized. The city of Fort Worth itself is the first interested in relocate or abandon such pipe due to its increased maintenance costs.

Every main a sewer system will be localized and commented in appendix 4 "Conflict Analysis" and the Lift Station will be also analyzed in appendix 7 "Lift Station".

Note that the sewer lines shown on the annex are the purple ones. Water system is represented in blue.

1.2. Different systems to consider

As can be observed at Annex 1.1, two bubbled areas have been marked in yellow. The northern one (Greenway area, 2 systems) and the southern one (Which its highest point is at Pharr, 1 system). At appendix 5 "Study Of Alternatives", the existence of 3 differentiated system will bring many different options, from relocating them independently to unify them to achieve a higher efficiency.

1.2.1. Greenway Area Systems

1.2.1.1. Greenway Neighborhood

This system collects all the sewer water produced by the residential area known as Greenway. All its water flows down to the north to be lifted at the Lift Station to join M-245-B.

This Lift Station not only lift the sewerage of Greenway but also a greater area west of Greenway.

1.2.1.2. Mony Street sewerage

This second system of the greenway area collects all the industrial sewerage coming from the southbound frontage road and Mony Street. This laterals flow to M-267 to finally join, once again, M-245-B.

1.2.2. Pharr Street Area System

This system collects the black waters of the little neighborhood west of Pharr Street with Mony Street. After that it flows south to the crossing. After the crossing several minor laterals join the flow. This very sewer is already a collector named M-1-I-1. This collector keeps going down to SPUR US 287 to finally join M-245-B as well.

2. ANNEX 1.1 – ACTUAL SEWER SYSTEM OVERVIEW

SHEET 1	DATE:	MAR 2012
	DESIGN:	RDO
	DRAWN:	CPI
	CHECKED:	CTD
	KHA NO.:	061018090

OVERALL PROJECT LOCATION MAP EXISTING SEWER

CITY OF FORT WORTH

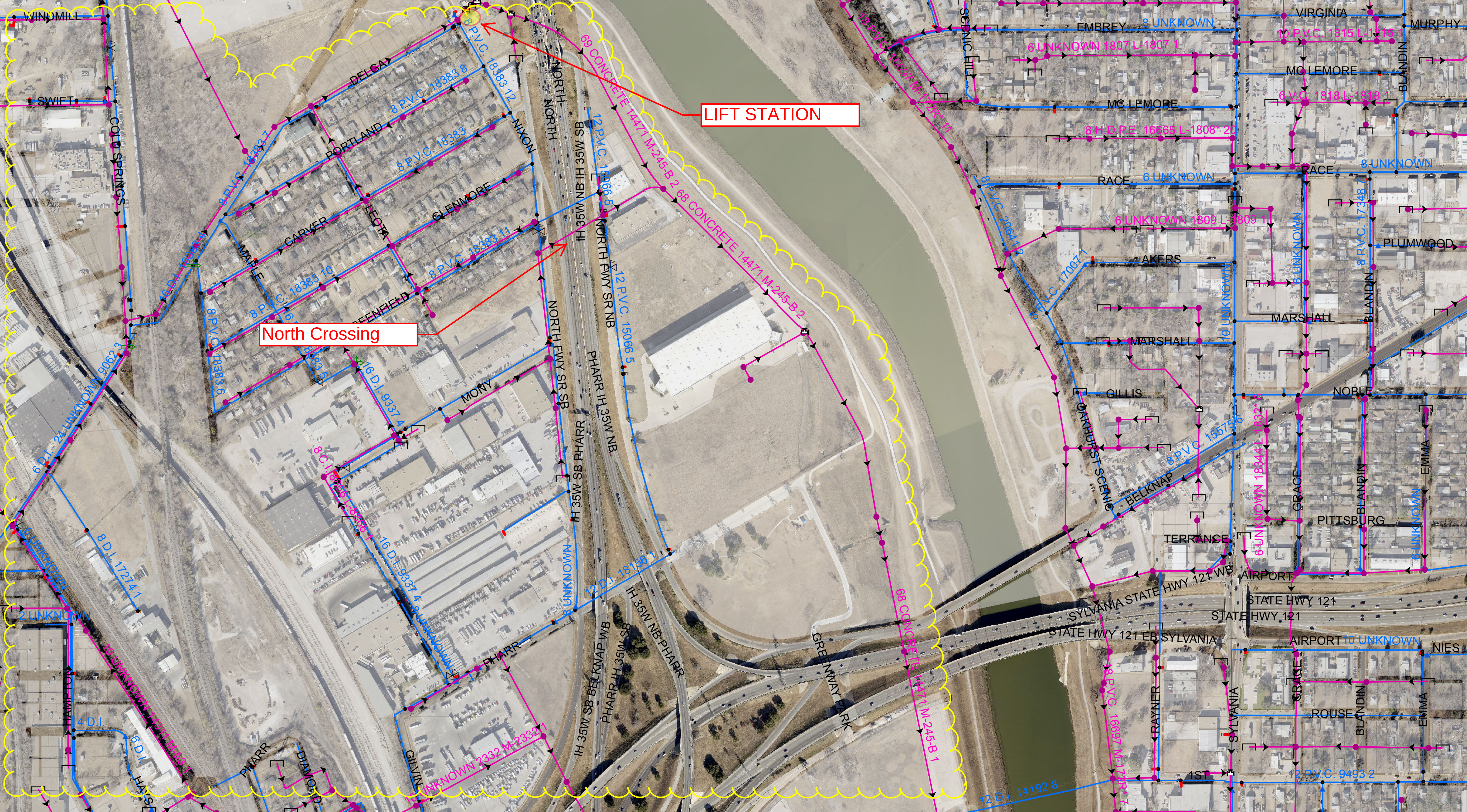
NORTH TARRANT EXPRESS SEGMENT 3A WATER AND SANITARY SEWER CONFLICT ANALYSIS

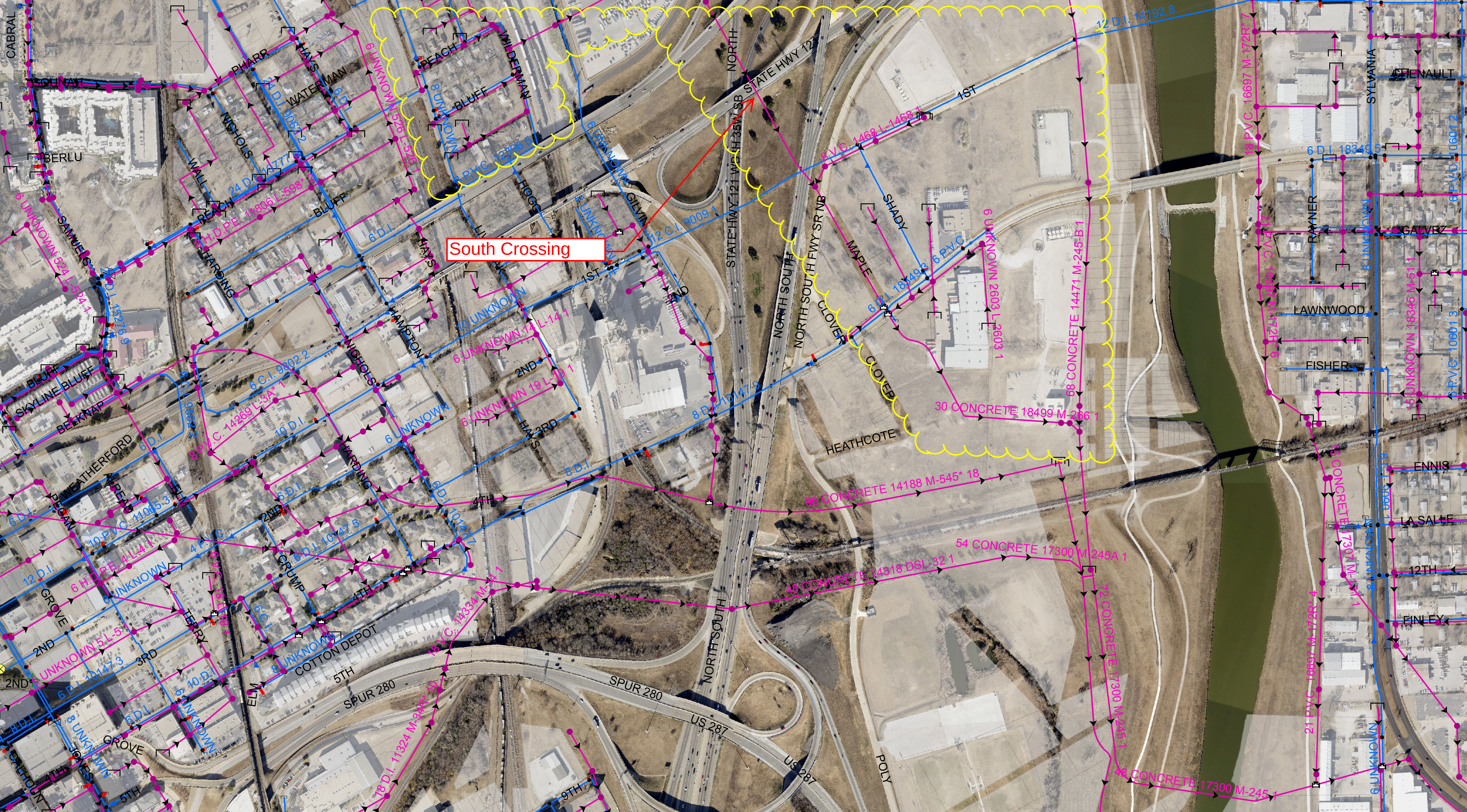
THIS DOCUMENT IS INCOMPLETE AND RELEASED TEMPORARILY FOR INTERM REVIEW ONLY. IT IS NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES
RYAN D. OWEN P.E.
SERIAL NO. 109586
DATE: MARCH 2012

Kimley-Horn and Associates, Inc.

No.	Revision	By	Date

K:\FTW_Utilities\061018090\GIS\MAPS\SEG_3A\FW-Water-Sewer-SEG3A-COVER.mxd


LIFT STATION
North Crossing
WINDMILL
SWIFT
COLD SPRINGS
DELGA
PORTLAND
CARVER
GLENMORE
GREENFIELD
MAPLE
NIXON
MONY
NORTH
EMBREY
8 UNKNOWN
VIRGINIA
MURPHY
10 P.V.C. 1815 L-1815 1
6 UNKNOWN 1807 L-1807 1
MC LEMORE
6 V.C. 1818 L-1818 1
8 H.D.P.E. 16666 L-1808* 20
RACE
6 UNKNOWN
6 UNKNOWN 1809 L-1809 1
PLUMWOOD
AKERS
MARSHALL
GILLIS
NOBLE
BELKNAP
TERRANCE
PITTSBURG
AIRPORT
SYLVANIA STATE HWY 121 WB
STATE HWY 121
STATE HWY 121 EB SYLVANIA
AIRPORT 10 UNKNOWN
NIES
ROUSE
1ST
12 P.V.C. 9493 2
12 D.I. 14192 8
69 CONCRETE 14471 M-245-B 2
68 CONCRETE 14471 M-245-B 2
68 CONCRETE 14471 M-245-B 1
12 P.V.C. 15066 5
12 D.I. 18136 1
IH 35W NB IH 35W SB
NORTH FWY SR NB
NORTH FWY SR SB
PHARR IH 35W NB
IH 35W SB PHARR
IH 35W SB BELKNAP WB
GREENWAY PARK
PHARR
HAMPTON
DIAMOND
GILVIN
8 D.I. 17274 1
8 P.V.C. 18383 8
8 P.V.C. 18383 10
8 P.V.C. 18383 11
16 D.I. 9337 4
6 D.I.
4 D.I.
2 UNKNOWN
BLANDIN
GRACE
EMMA
SCENIC
OAKHURST SCENIC
SYLVANIA
RAYNER
8 P.V.C. 15575 6
18 P.V.C. 16697 M-17-R 7



South Crossing
STATE HWY 121
NORTH
NORTH SOUTH
NORTH SOUTH FWY SR NB
1ST
2ND
3RD
4TH
5TH
SPUR 280
US 287
CABRAL
PHARR
HAYS
WATERMAN
NICHOLS
BLUFF
BEACH
WILDERMAN
SAMUELS
HARDING
HAMPTON
CRUMP
COTTON DEPOT
ELM
GROVE
WEATHERFORD
PECAN
BELKNAP
SKYLINE
BERLU
SHADY
MAPLE
CLOVER
HEATHCOTE
POLY
RAYNER
SYLVANIA
CHENAULT
GALVEZ
LAWNWOOD
FISHER
ENNIS
LA SALLE
12TH
FINLEY
9TH
12 D.I. 14182 8
6 D.I. 18349 5
8 P.V.C. 1468 L-1468 1
6 UNKNOWN 2603 L-2603 1
6 D.I. 18349 3
6 P.V.C.
68 CONCRETE 14471 M-245-B 1
30 CONCRETE 18499 M-266 1
96 CONCRETE 14188 M-545* 18
54 CONCRETE 17300 M-245A 1
45 CONCRETE 14318 DSL-32 1
72 CONCRETE 17300 M-245 1
48 CONCRETE 17300 M-245 1
8 D.I. 11147 9
12 C.I. 8009 1
6 C.I. 9802 2
6 UNKNOWN 19 L-19 1
6 UNKNOWN 14 L-14 1
16 P.V.C. 16697 M-172R* 7
21 P.V.C. 16697 M-172R* 4
18 D.I. 11324 M-3
6 UNKNOWN
8 D.I.
10 D.I.
6 D.I.
12 D.I.

Appendix No. 2:

<u>Cartography</u>

INDEX - APPENDIX NO. 2: CARTOGRAPHY

INDEX - FIGURE AND TABLE

1. Cartography

1.1. United States Geological Survey

The United States Geological Survey (USGS, formerly simply Geological Survey) is a scientific agency of the United States government. The scientists of the USGS study the landscape of the United States, its natural resources, and the natural hazards that threaten it. The organization has four major science disciplines, concerning biology, geography, geology, and hydrology. The USGS is a fact-finding research organization with no regulatory responsibility.

The USGS produces several national series of topographic maps which vary in scale and extent, with some wide gaps in coverage, notably the complete absence of 1:50,000 scale topographic maps or their equivalent. The largest (both in terms of scale and quantity) and best-known topographic series is the 7.5-minute, 1:24,000 scale, quadrangle, a non-metric scale virtually unique to the United States. Each of these maps covers an area bounded by two lines of latitude and two lines of longitude spaced 7.5 minutes apart.

This source provides an excellent topographic information of the U.S. territory. At the annex of this appendix, the reader will find the 7.5-minute, 1:24,000 scale topographic plan of the Haltom City Quadrangle where this project is allocated.

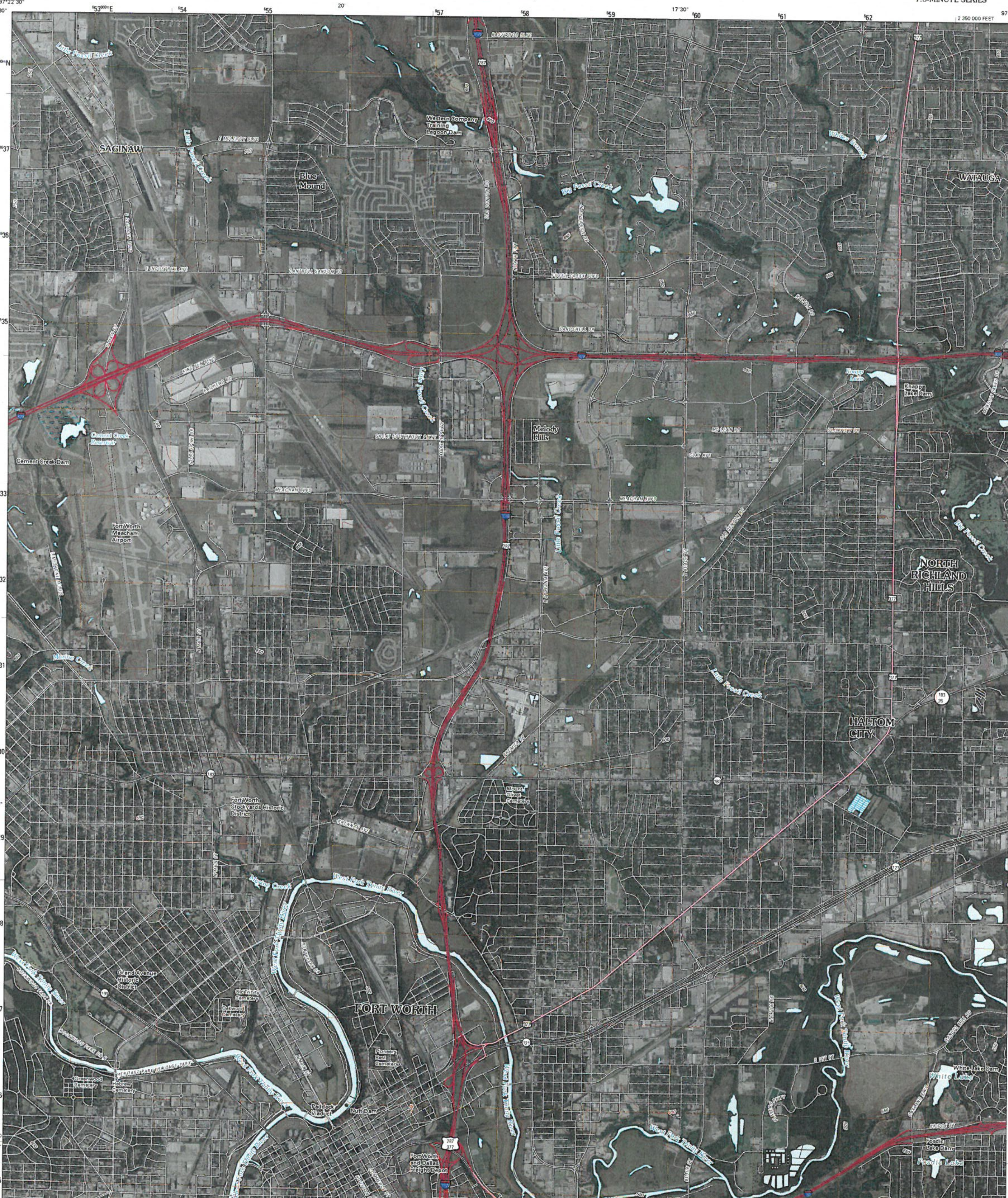
Figure 1. Seal of the United States Geological Survey

2. ANNEX 2.1 – USGS Haltom City Quadrangle Topographical Plan

U.S. DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

The National Map
US Topo

HALTOM CITY QUADRANGLE
TEXAS
7.5-MINUTE SERIES



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and 1 000-meter grid: Universal Transverse Mercator, Zone 14S
10 000-foot ticks: Texas Coordinate System of 1983 (north central zone)

Imagery........NAIP, July 2008
Roads........US Census Bureau TIGER data with limited USGS updates, 2004
Names........GNIS, 2008
Hydrography........National Hydrography Dataset, 1995
Contours........National Elevation Dataset, 2003

UTM GRID AND 2010 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID: PB
Grid Zone Designation: 14S

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with version 0.5.10 of the draft USGS Standards for 7.5-Minute Quadrangle Maps.
A metadata file associated with this product is also draft version 0.5.10

QUADRANGLE LOCATION

Avondale	Keller	Colleyville
Lake Worth	Haltom City	Hurst
Benbrook	Fort Worth	Kennedale

ADJOINING 7.5' QUADRANGLES
TX 3297-431

ROAD CLASSIFICATION
Interstate Route — State Route
US Route — Local Road
Ramp — 4WD
Interstate Route — US Route — State Route

HALTOM CITY, TX
2010

Appendix No. 3:

Geology

INDEX - APPENDIX NO. 3: GEOLOGY

INDEX - FIGURE AND TABLE

3. Geology

3.1. Local Geology of Tarrant County

Our very project is located at the heart of the Tarrant County south of the trinity river. The map below shows the different soil that can be found in this area:

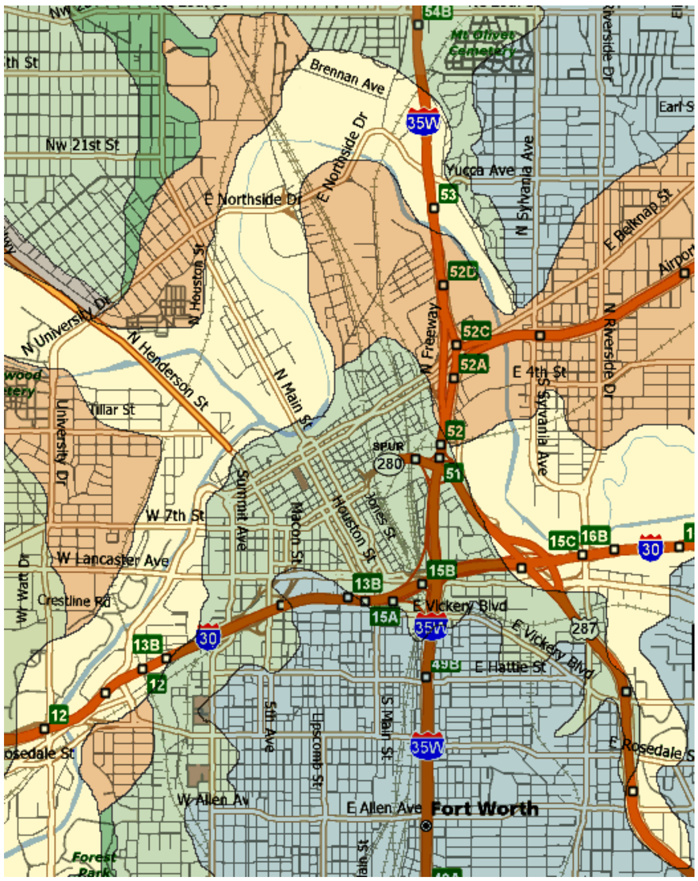


Figure 1. Detail of the Tarrant Geological map at our project location.

The following table will be the legend of such map. We can determine at first sight that the area will have plenty of sedimentary sands due to the river location.

Holocene Period:	**Qal** - Quaternary alluvium	
Pleistocene Period:	**Qt** - Quaternary terrace	
Cretaceous Period:	**Kef** - Eagle Ford	
	Kwb - Woodbine	
	Kgm - Mainstreet & Grayson	
	Kpd - Denton, Weno, Pawpaw (undivided on map)	**Kwl** - Weno
	Kfd - Fort Worth & Duck Creek (undivided on map)	**Kdc** - Duck Creek
	Kki - Kiamichi	
	Kgl - Goodland	
	Kwa - Walnut	
	Kpa - Paluxy sand	

Table 1. Geological map – Legend

Our project location will have several kind of geology. Quaternary alluvium, Quaternary terrace and Kiamichi. Such soils are explained below.

3.1.1. Quaternary alluvium (Holocene):

Alluvium and low terrace deposits along streams are composed of sand, silt, clay, and gravel. Its thickness is variable. The unit appears on Geologic Map of Texas on the lagoon side of barrier islands where they represent lagoon and wind-tidal-flat sand and clay. These deposits of clay and silty, clayey fine to v. fine quartz sand and shell sand accumulate on alternately dry and flooded barren flats 0.3 m below to 1 m above mean sea level.

Its major lithological constituents are Unconsolidated > Coarse-detrital and Unconsolidated > Fined-detrital.

This kind of unconsolidated material will be further studied due to its importance while constructing any underground structure.

3.1.2. Quaternary terrace (Pleistocene):

Sand, silt, clay, and gravel in various proportions, with gravel more predominant in older, higher terrace deposits. Locally indurated with calcium carbonate (caliche) in terraces along streams. Along Colorado River clasts mostly limest., chert, quartz, and various igneous and metamorphic rocks from Llano region and Edwards Plateau. Locally, calcium carbonate-cemented quartz sand, silt, clay, and gravel intermixed and interbedded. Low terraces of major rivers are capped by 2-4 m of clayey sand and silt. Sandy gravel on higher terraces varies somewhat in composition from river to river. Gravel commonly is rounded to angular limestone and chert pebbles and cobbles, some boulders, sparse igneous pebbles along Brazos river in places.

This zone also has unconsolidated material and will need further analysis as well.

3.1.3. Fort Worth & Duck Creek (Cretaceous):

Fort Worth Limestone, limestone and clay. Ls aphanitic to biosparite, burrowed; marine megafossils are Pecten, oysters, echinoids, and ammonites. Clay, calcareous, in units 0.1-5 ft thick, forms low rolling hills. Thickness 25-35 ft. Duck Creek Ls., limestone and marl. ls med. bedded, nodular to wavy bedded; thickness 25-30 ft.

3.2. Detailed Geology

To execute and install the new sewer line with this kind of soil several geotechnical studies must be assessed to determine the best way to do it. The information needed to do such study are the bore logs taken specially for this case and area.

Borings used for the geological analysis are from B01 to B22.

In our main case study area (Greenway and Pharr), bores from B05 to B07 has from 5ft deep onwards a mix of clays and sand very hard to firm. These loose soils are highly unconsolidated and any underground excavation will cave in. As expressed before, a geotechnical study will look to solve the structural problems that this clays and sands will challenge.

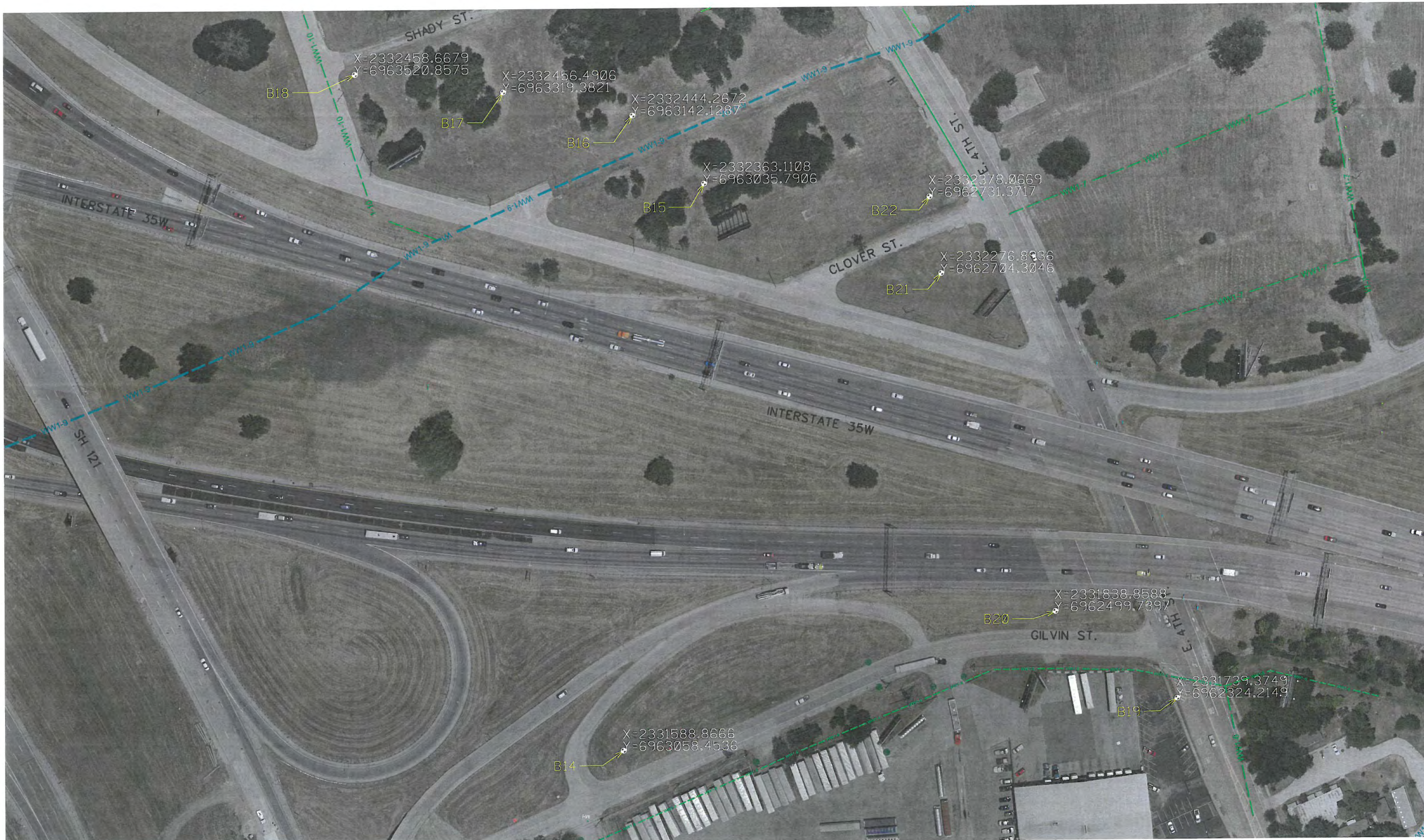
Bore logs B05 to B07 may be the most challenging but the rest from B01 to B11 will need also a thorough study behind.

Bore log locations and the information itself can be found at the annex of this appendix. A profile plan with proposed solutions to our sewer system relocation can also be found at the drawings appendix.

ANNEX 3.1 – Bore Log Locations


INTERSTATE 35W
NIXON ST.
CARVER AVE.
GLENMORE AVE.
GREENFIELD AVE.
MONY ST.
WW1-11
BØ1
X=2331355.5667
Y=6967540.5491
BØ2
X=2331429.4124
Y=6967286.4563
BØ3
X=2331467.1980
Y=6967008.0082
BØ4
X=2331511.7154
Y=6966752.0898
BØ5
X=2331536.9120
Y=6966564.9046


INTERSTATE 35W
INTERSTATE 35W
SH 121
SHARR ST.
B06
X=2331631.0609
Y=6965890.6315
B07
X=2331658.3204
Y=6965600.0935
B08
X=2331663.6601
Y=6965274.9166
B09
X=2331684.0817
Y=6965029.0891
B10
X=2331513.3795
Y=6964933.8723
B11
X=2331449.9791
Y=6964822.9763
B12
X=2331556.2520
Y=6964620.2717
B13
X=2331608.6720
Y=6964482.6480



SHADY ST.
X=2332458.6679
Y=6963520.8575
B18
X=2332456.4906
Y=6963319.3821
B17
X=2332444.2672
Y=6963142.1287
B16
X=2332363.1108
Y=6963035.7906
B15
X=2332378.0669
Y=6962731.3717
B22
E. 4TH ST.
CLOVER ST.
X=2332276.8936
Y=6962704.3046
B21
INTERSTATE 35W
INTERSTATE 35W
SH 121
X=2331838.8588
Y=6962499.7397
B20
GILVIN ST.
E. 4TH ST.
X=2331739.3749
Y=6962324.2149
B19
X=2331588.8666
Y=6963058.4536
B14

ANNEX 3.2 – Bore Log Data

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-01	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-29-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
				CLAY, lean, sandy, very hard, dark brown, with calcareous nodules and sand seams (CL)			12				PP=4.5+ tsf
							13	45	29		PP=4.5+ tsf, -#200=72%
95.	5			CLAY, lean, sandy, very hard, light brown (CL)			11				PP=4.5+ tsf
92.							12				PP=4.0 tsf
	10			SAND, clayey, dense to slightly compact, light brown (SC)			14	24	9		PP=2.0 tsf, -#200=33%
88.				SAND, dense to slightly compact, light brown, with gravel (SP)							
	15						12				SPT=9-16-16
80.	20						9				SPT=6-5-9, -#200=5%
	25										
	30										

Remarks: Groundwater was encountered at about 12 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT | Logger: LEE | Organization: Rone

\\ronedc\Geotech\Projects\2012 Projects\17300\17307\Wincore\Utility Borings - 2015\12-17307Utility Borings 1.CLG

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-02	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-29-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, fat, very hard, dark brown, with sand seams (CH)			17	58	38		PP=4.5+ tsf, -#200=90%
						15				PP=4.5+ tsf
						13				PP=4.5+ tsf
95.	5		SAND, clayey, dense to slightly compact, light brown (SC)			12				PP=4.5+ tsf
						10	26	13		PP=3.75 tsf, -#200=38%
	10					13				PP=2.0 tsf
88.			SAND, slightly compact to loose, light brown, with gravel (SP)							
	15					12				SPT=2-3-6
80.	20					3				
	25									
	30									

Remarks: Groundwater was encountered at about 12 feet during drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT　　Logger: LEE　　Organization: Rone

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-03	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-29-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth (ft)	Texas Cone Penetrometer	Strata Description
94.	0–6		CLAY, lean, very hard, dark brown to brown (CL)
87.	6–13		SAND, clayey, dense to slightly compact, brown (SC)
71.	13–29		SAND, gravelly, compact, brown, with silt (SP-SM)
70.	29–30		SHALE, soft, gray

Depth (approx., ft)	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
2			18				PP=4.5+ tsf
4			16	48	31		PP=4.5+ tsf, -#200=92%
6			15				PP=4.5+ tsf
8	0	46.1	11			137	PP=4.0 tsf
10			11				PP=3.75 tsf
15			11				-#200=12%
20			11				SPT=5-10-13

Remarks: Groundwater was encountered at about 15 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT | Logger: LEE | Organization: Rone

\\ronedc\Geotech\Projects\2012 Projects\17300\17307\Wincore\Utility Borings - 2015\12-17307Utility Borings 1.CLG

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-04	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-29-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
			CLAY, fat, very hard, dark brown to brown (CH)							
						21				PP=4.5+ tsf
						19	57	37		PP=4.5+ tsf, -#200=95%
5										
						15				PP=4.5+ tsf
93.			SAND, clayey, dense to compact, brown (SC)							
						12				PP=4.5+ tsf
10						14	26	13		PP=2.75 tsf, -#200=42%
87.			SAND, gravelly, dense to slightly compact, brown and light brown (SP)							
15						9				SPT=6-20-22
80. 20						9				SPT=3-5-6, -#200=4%
25										
30										

Remarks: Groundwater was encountered at about 10 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT   Logger: LEE   Organization: Rone

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-05	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-29-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
	0			CLAY, lean, sandy, very hard, dark brown and brown, with calcareous clay seams to 2 feet (CL)			10	35	21		PP=4.5+ tsf, -#200=54%
							18				PP=4.5 tsf
94.	6						15	40	26		PP=3.75 tsf, -#200=79%
				CLAY, lean, sandy, very hard to firm, brown (CL)			18				PP=3.0 tsf
							22				PP=1.5 tsf
87.	13			SAND, clayey, loose, brown to gray (SC)			19				SPT=3-3-4
							23				SPT=2-2-3
76.	24			SHALE, soft, gray							
75.	25										

Remarks: Groundwater was encountered at about 12 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT　　Logger: LEE　　Organization: Rone

DRILLING LOG

WinCore
Version 3.1

County Tarrant
Highway Interstate 35W
CSJ

Hole B-06
Structure
Station
Offset

District Ft. Worth
Date 7-30-2015
Grnd. Elev. 100.00 ft
GW Elev. N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, lean, sandy, very hard, brown to gray (CL)			14				
						17	36	22		PP=3.5 tsf, -#200=74%
5				0	57.2	15			136	PP=4.0 tsf
92.						17				PP=3.0 tsf
10			CLAY, lean, sandy, very hard to firm, brown and dark brown (CL)			24	43	28		PP=1.25 tsf, -#200=73%
87.			SAND, clayey, very loose, brown (SC)							
15						23				SPT=0-0-0, -#200=27%
20						19				SPT=0-0-0
25										
71.			SHALE, soft, gray							
70. 30										
35										
40										

Remarks: Groundwater was encountered at about 12 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT Logger: LEE Organization: Rone

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-07	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-30-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
				CLAY, lean, very hard, dark brown and brown (CL)			16	48	31		PP=4.5 tsf, -#200=85%
							17				PP=4.5 tsf
95.	5			SAND, clayey, dense to compact, brown (SC)			18				PP=4.0 tsf
							20				PP=2.0 tsf
90.	10						23				PP=1.75 tsf
				SAND, clayey, loose to very loose, gray (SC)							
	15						15	27	14		SPT=1-1-1, -#200=26%
80.	20						25				SPT=1-1-1
	25										
	30										

Remarks: Groundwater was encountered at about 12 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT

Logger: LEE

Organization: Rone

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-08	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/17/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
			CLAY, sandy, lean, brown (CL)							
98.						19				PP=2.0 tsf
			CLAY, fat, hard, dark brown (CH)			23	68	45		PP=3.5 tsf, -#200=98%
5 / 94.						26				PP=3.0 tsf
			SAND, clayey, slightly compact to loose, brown and light brown (SC)			13				PP=3.75 tsf
10						25				PP=2.75 tsf
15						19	27	14		SPT=2-1-1, -#200=32%
20						23				SPT=4-3-4
25										
30										
66.			SHALE, soft, gray							
65. / 35										
40										

Remarks: Groundwater was encountered at about 10 feet during drilling and remeasured at a depth of about 11.5 feet upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: Logger: Organization:

\\ronedc\Geotech\Projects\2012 Projects\17300\17307\Wincore\Utility Borings - 2015\12-17307Utility Borings 1.CLG

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-09	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-30-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth (ft)	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, fat, very hard, dark brown, with calcareous nodules (CH)			25				PP=4.0 tsf
96.						18				PP=4.0 tsf
	5		CLAY, lean, sandy, hard, brown and light brown (CL)							
94.						13				PP=4.0 tsf
			SAND, silty, dense to loose, brown and light brown (SM)			16	17	2		PP=1.0 tsf, -#200=24%
	10					16				PP=1.0 tsf
87.			SAND, silty, loose to compact, brown, with gravel below 18 feet (SM)							
	15					19				SPT=2-3-6
80.	20					13				SPT=2-11-14, -#200=13%
	25									
	30									

Remarks: Groundwater was encountered at about 11.5 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT | Logger: LEE | Organization: Rone

\\ronedc\Geotech\Projects\2012 Projects\17300\17307\Wincore\Utility Borings - 2015\12-17307Utility Borings 1.CLG

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-10	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	7-30-2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
				CLAY, fat, very hard, dark brown (CH)			27				PP=3.75 tsf
							23	61	40		PP=3.75 tsf, -#200=88%
94.	5				0	34.2	18			132	PP=3.25 tsf
				SAND, clayey, compact, brown and light brown (SC)			16				PP=2.0 tsf
90.	10						15	28	14		PP=3.25 tsf, -#200=41%
	15			SAND, slightly compact to compact, brown, with gravel (SP)			11				SPT=6-8-7
80.	20						10				SPT=6-17-12
	25										
	30										

Remarks: Groundwater was encountered at about 13 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: CT   Logger: LEE   Organization: Rone

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-11	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/18/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
	0			CLAY, fat, very hard to hard, dark brown (CL)			16				PP=4.5+ tsf
							24				PP=4.5+ tsf
	5						21	62	40		PP=4.0 tsf, -#200=92%
							22				PP=3.0 tsf
90.	10						22				PP=3.25 tsf
				SAND, clayey, slightly compact, light brown to brown (SC)							
	15						17				SPT=8-7-6
	20						15	21	6		SPT=7-6-6, -#200=32%
76.5				SAND, gravelly, slightly compact to compact, light brown (SG)							
	25						9				SPT=4-5-9
71.				SHALE, soft, gray							
70.	30						23				SPT=27-32-50/5"
	35										
	40										

Remarks: Groundwater was encountered at about 10 feet during drilling

The ground water elevation was not determined during the course of this boring.

Driler: Logger: Organization:

\\ronedc\Geotech\Projects\2012 Projects\17300\17307\Wincore\Utility Borings - 2015\12-17307Utility Borings 1.CLG

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-14	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/17/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, sandy, lean, hard, light brown (CL)							
98.						6				PP=2.25 tsf
			CLAY, fat, hard to very hard, dark brown (CH)			21				PP=4.5+ tsf
5						24	68	45		PP=2.75 tsf, -#200=88%
92.						22				PP=4.5 tsf
			CLAY, sandy, lean, hard to soft, light brown (CL)							
10						16				PP=2.5 tsf
15						25	37	23		PP=0.25 tsf, -#200=52%
80. 20						22				
25										
30										
35										
40										

Remarks: Groundwater was encountered at about 11 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: Logger: Organization:

\\ronedc\Geotech\Projects\2012 Projects\17300\17307\Wincore\Utility Borings - 2015\12-17307Utility Borings 1.CLG

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-15	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/17/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
				CLAY, fat, hard, dark brown, with limestone fragments and light brown clay seams at 4'to 6' (CH)			22	59	38		PP=4.0 tsf, -#200=74%
							25				PP=3.5 tsf
	5						22				PP=3.0 tsf
92.				CLAY, sandy, lean, hard, light brown (CH)			27				PP=3.0 tsf
	10						21				PP=2.25 tsf
87.				SAND, clayey, compact, light brown (SC)							
	15						18	30	16		PP=3.5 tsf, -#200=43%
82.				CLAY, sandy, lean, hard, dark brown (CL)							
80.	20						27				PP=2.5 tsf
	25										
	30										
	35										
	40										

Remarks: Groundwater was not encountered during drilling

The ground water elevation was not determined during the course of this boring.

Driller: Logger: Organization:

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-16
Highway	Interstate 35W	Structure	
CSJ		Station	
		Offset	

District	Ft. Worth
Date	8/18/2015
Grnd. Elev.	100.00 ft
GW Elev.	N/A

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
			CLAY, sandy, calcareous, hard, light brown (CL)			14	58	38		SPT=5-6-8, -#200=84%
						12				SPT=8-10-17
96.			CLAY, fat, hard, dark brown (CH)			21				SPT=7-10-5
						23	66	44		SPT=8-8-9, -#200=98%
						22				PP=2.5 tsf
92.			CLAY, sandy, fat, hard to firm, brown to light brown, with calcareous nodules (CH)			22				PP=2.75 tsf
						18	50	33		PP=1.5 tsf, -#200=74%
82.			SAND, clayey, slightly compact to compact, light brown (SC)			14				
77.			SAND, gravelly, very dense to dense, light brown to gray (SG)			11				SPT=15-30-34, -#200=9%
						16				SPT=10-13-18
66.5			SHALE, soft, gray			19				SPT=28-50/5"
65.										

Depth scale (ft): 5, 10, 15, 20, 25, 30, 35, 40

Remarks: Groundwater was encountered at about 18 feet during and upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: Logger: Organization:

\\onedc\Geotech\Projects\2012 Projects\17300\17307\Wincore\Utility Borings - 2015\12-17307Utility Borings 1.CLG

DRILLING LOG

WinCore Version 3.1	County: Tarrant	Hole: B-17		District: Ft. Worth	
	Highway: Interstate 35W	Structure:		Date: 8/18/2015	
	CSJ:	Station:		Grnd. Elev.: 100.00 ft	
		Offset:		GW Elev.: N/A	

Elev. (ft)	Depth	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
				SAND, silty, slightly compact, light brown, with gravel			5				SPT=11-8-10
96.							3				-#200=21%
	5			CLAY, fat, very hard, dark brown, with calcareous nodules (CL)			20				PP=4.5+ tsf
94.				CLAY, sandy, lean, hard, brown, with calcareous nodules (CL)			20				PP=3.25 tsf
	10						21	63	42		PP=2.5 tsf, -#200=91%
87.				SAND, clayey, loose to slightly compact, light brown (SC)							
	15						20				PP=0.25 tsf
	20						14				SPT=4-6-6
	25						18	20	6		SPT=5-8-10, -#200=32%
71.5				SANDSTONE, brown							
	30						33				SPT=50/1"
	35						32				SPT=50/1"
62.				SHALE, hard, gray							
	40						27				SPT=50/1"

Remarks: Groundwater was not encountered during drilling

The ground water elevation was not determined during the course of this boring.

Driller:

Logger:

Organization:

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-18	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/17/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
	0			CLAY, fat, firm to hard, dark brown, with limestone fragments (CH)							
							25				PP=2.0 tsf
							22				PP=2.5 tsf
	5										
							20	61	40		PP=3.0 tsf, -#200=80%
							24				PP=2.25 tsf
90.	10						24				PP=2.0 tsf
				CLAY, sandy, lean, firm to hard, light brown (CL)							
85.	15						14				PP=2.0 tsf
				SAND, clayey, loose to very dense, light brown (SC)							
	20						18				SPT=2-1-3, -#200=19%
	25						9				SPT=18-27-32
71.				SHALE, soft, gray							
70.	30						18				SPT=11-18-50/5"
	35										
	40										

Remarks: Groundwater was encountered at about 13 feet during drilling and remeasured at a depth of about 9 feet upon completion of drilling

The ground water elevation was not determined during the course of this boring.

Driller: Logger: Organization:

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-20	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/19/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, fat, hard, light brown, with calcareous nodules (CH)							
98.						18				PP=4.5 tsf
			CLAY, fat, hard, dark brown, with limestone fragments (CH)			15	53	35		PP=4.5 tsf, -#200=78%
	5					18				PP=4.5 tsf
92.						20				PP=3.0 tsf
			CLAY, fat, hard to firm, brown and light brown (CH)							
	10									SPT=50/1"
	15					24	60	39		SPT=8-7-9, -#200=87%
82.			SAND, clayey, compact to dense, brown and light brown (SC)							
	20					24				SPT=9-8-12
75.	25									SPT=50/1"
			SHALE, hard, gray							
70.	30					16				SPT=50/1"
	35									
	40									

Remarks: Groundwater was not encountered during drilling

The ground water elevation was not determined during the course of this boring.

Driler: Logger: Organization:

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-21	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/19/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

Elev. (ft)	Depth	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
				SAND, clayey, brown (SC)			8				
98.				CLAY, fat, hard, dark brown (CH)			24				PP=3.0 tsf
	5						25	75	50		PP=3.5 tsf, -#200=98%
							26				PP=2.5 tsf
	10						26				PP=3.0 tsf
87.				CLAY, fat, hard, brown (CH)							
	15						22	54	34		PP=3.0 tsf, -#200=89%
80.	20						19				PP=2.75 tsf
				CLAY, lean, hard, light brown (CL)							
	25						20	46	29		PP=3.0 tsf, -#200=87%
72.				SAND, clayey, dense, light brown (SC)							
	30						21				SPT=20-19-25
69.5				SHALE, soft to hard, gray							
	35						14				SPT=50/1"
60.	40						18				SPT=50/1"

Remarks: Groundwater was encountered at about 23 feet during drilling

The ground water elevation was not determined during the course of this boring.

Driller: Logger: Organization:

DRILLING LOG

WinCore
Version 3.1

County	Tarrant	Hole	B-22	District	Ft. Worth
Highway	Interstate 35W	Structure		Date	8/18/2015
CSJ		Station		Grnd. Elev.	100.00 ft
		Offset		GW Elev.	N/A

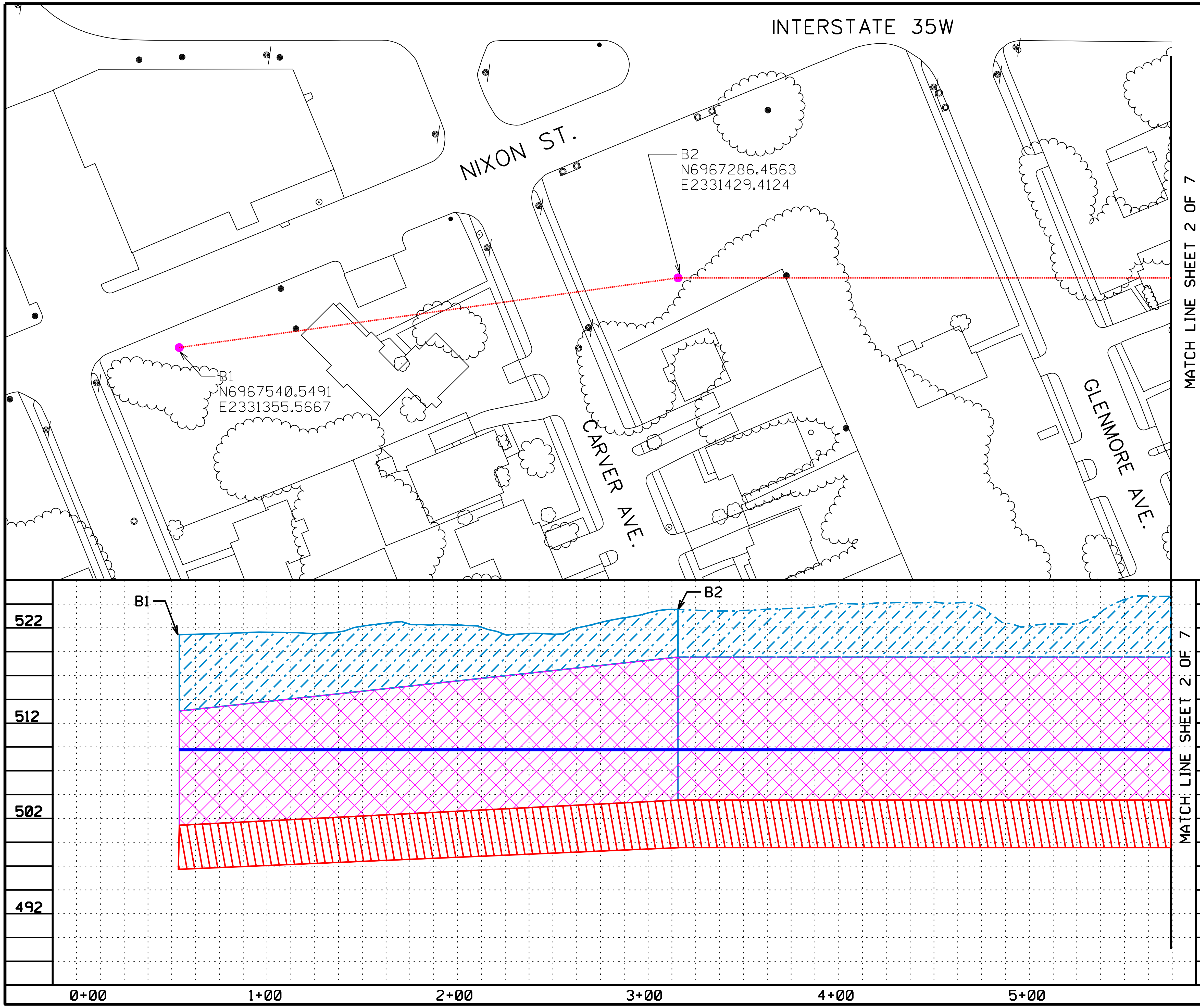
Elev. (ft)	Depth	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	MC	LL	PI	Wet Den. (pcf)	Additional Remarks
			CLAY, fat, hard, dark brown, with limestone fragments to 2' (CH)			16				SPT=8-10-22
						26	76	50		PP=3.5 tsf, -#200=98%
	5					27				PP=2.5 tsf
						26				PP=2.5 tsf
90.	10					26				PP=2.5 tsf
			SAND, clayey, slightly compact, light brown (SC)							
	15					19	19	5		-#200=49.5%
82.			SAND, clayey, compact to dense, light brown							
	20					19				SPT=9-10-11
	25									SPT=11-10-12
	30					19	21	7		SPT=11-22-15, -#200=42%
69.			SHALE, soft to hard, gray							
65.	35					23				SPT=50/1"
	40									

Remarks: Groundwater was encountered at about 15 feet during drilling

The ground water elevation was not determined during the course of this boring.

Driller: Logger: Organization:

ANNEX 3.3 – Bore Log Profile



0 25 50 100

CLAY

SAND

SHALE

GROUND WATER TABLE

FORT WORTH

Texas Department of Transportation

POLYTECHNIC UNIVERSITY OF CATALONIA

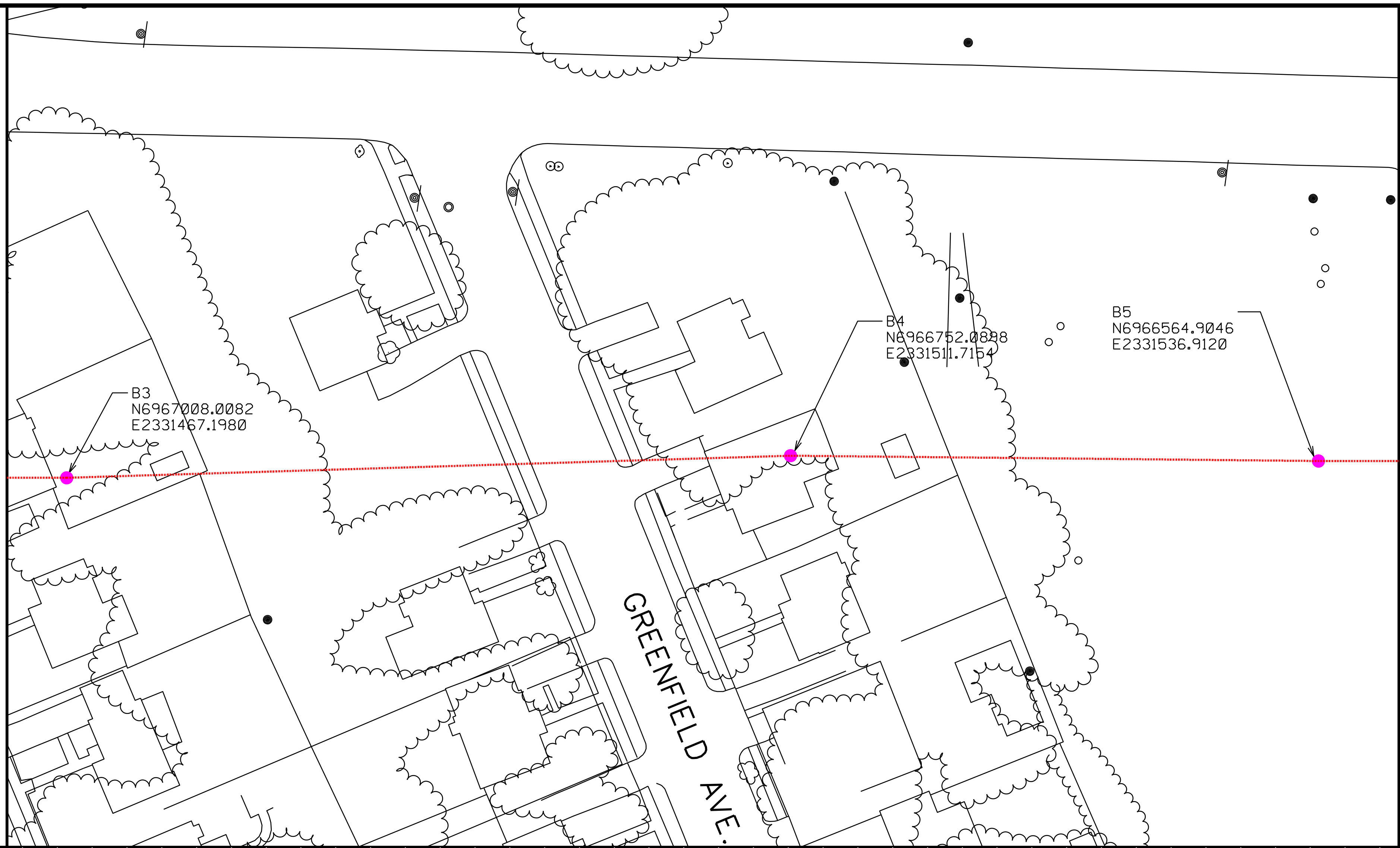
Greenway/Pharr Area (Fort Worth, TX)
Sewer Utility System Relocation

GEOTECHNICAL INVESTIGATION

HORZ.: 1" = 50'
VERT.: 1" = 10'

SHEET 01 OF 07

STATE	DISTRICT	COUNTY

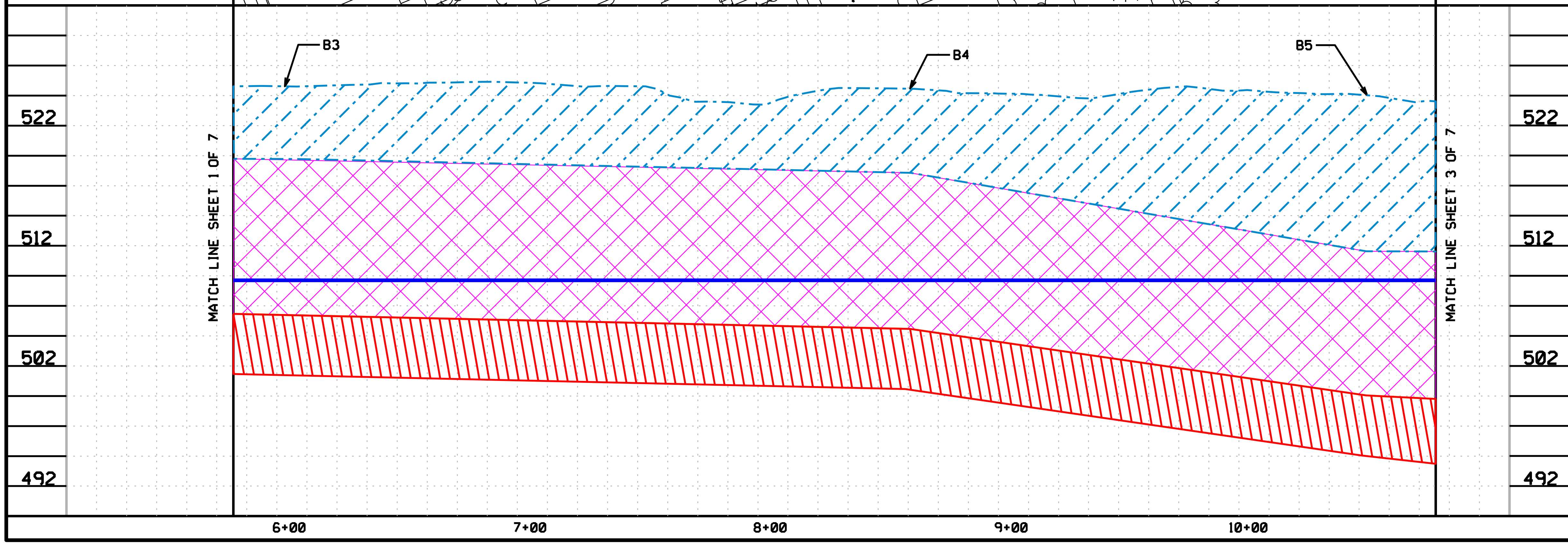


CLAY

SAND

SHALE

GROUND WATER TABLE



FORT WORTH

Texas Department of Transportation

POLYTECHNIC UNIVERSITY OF CATALONIA

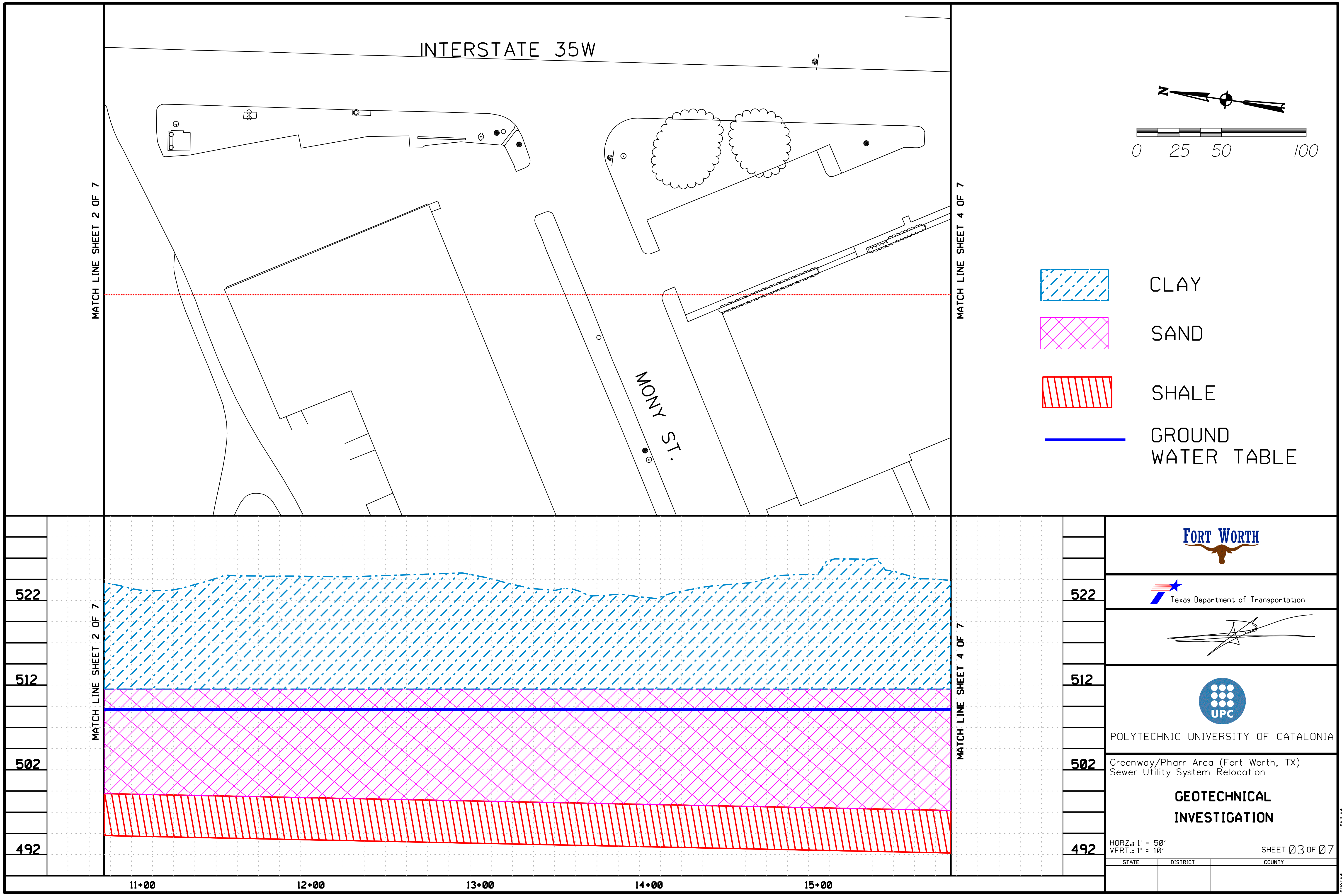
Greenway/Pharr Area (Fort Worth, TX)
Sewer Utility System Relocation

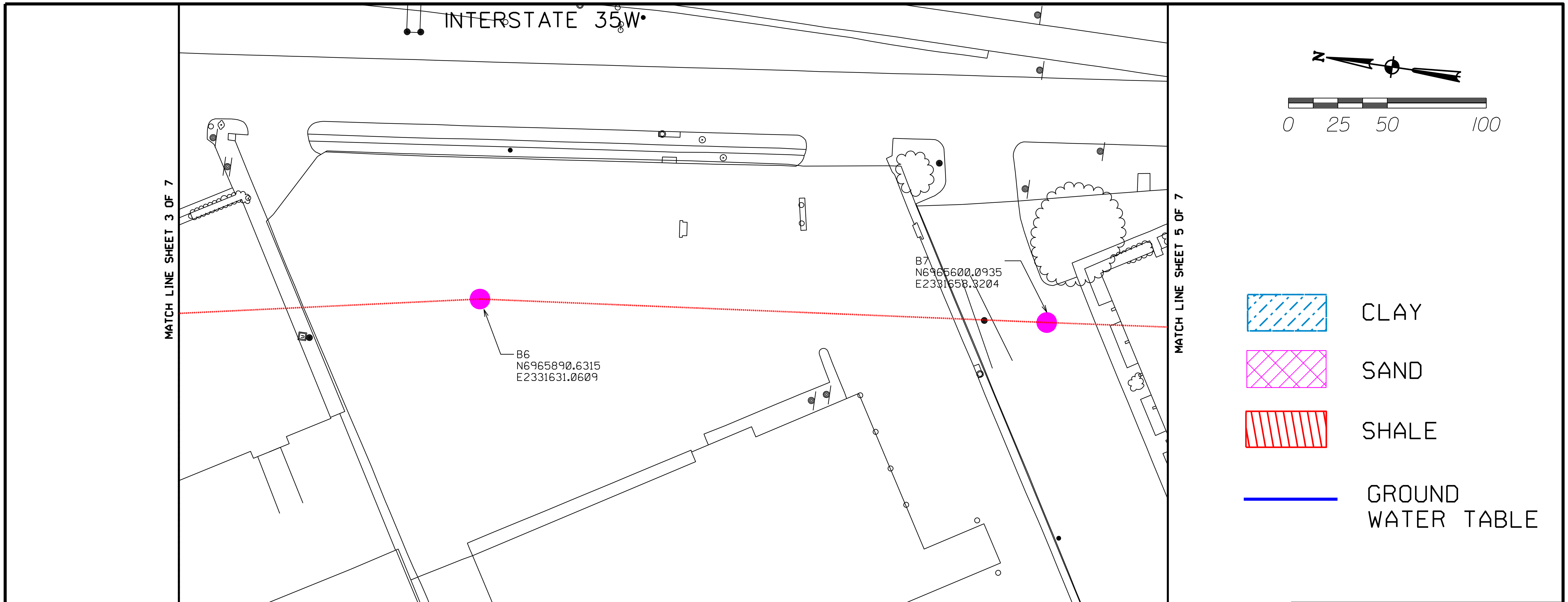
GEOTECHNICAL INVESTIGATION

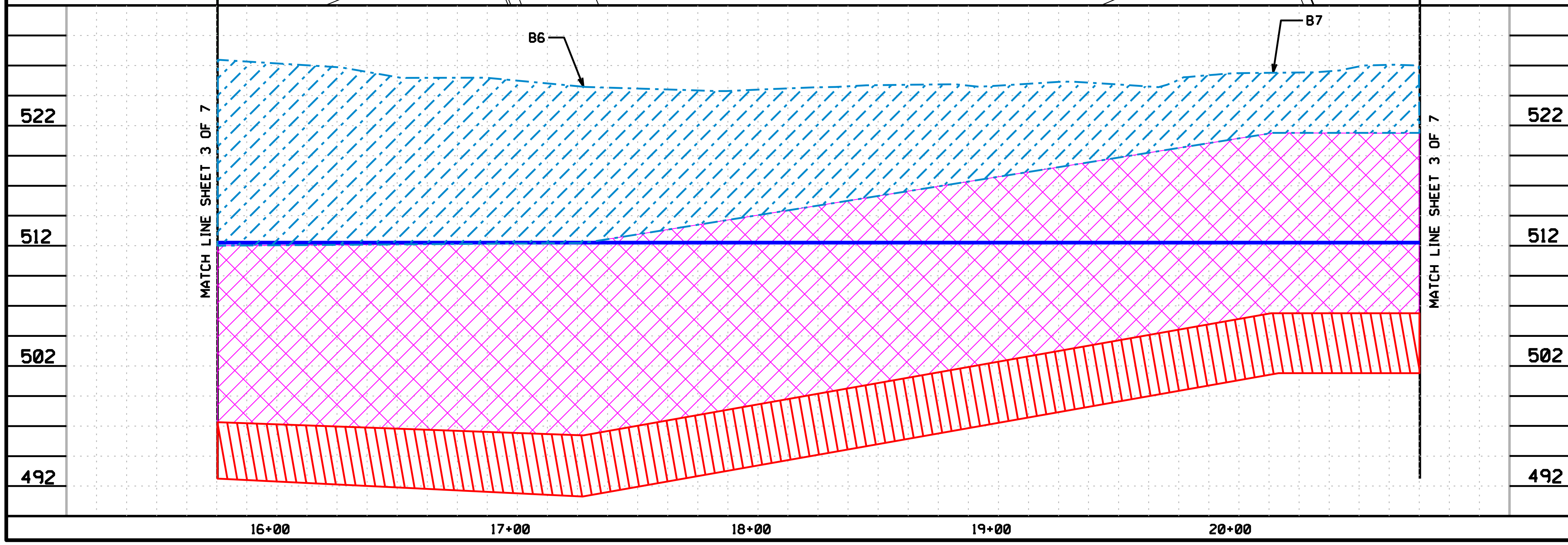
HORZ.: 1" = 50'
VERT.: 1" = 10'

SHEET 02 OF 07

STATE	DISTRICT	COUNTY


INTERSTATE 35W
MONY ST.
MATCH LINE SHEET 2 OF 7
MATCH LINE SHEET 4 OF 7
N
0
25
50
100
CLAY
SAND
SHALE
GROUND WATER TABLE
522
512
502
492
MATCH LINE SHEET 2 OF 7
MATCH LINE SHEET 4 OF 7
522
512
502
492
11+00
12+00
13+00
14+00
15+00
FORT WORTH
Texas Department of Transportation
UPC
POLYTECHNIC UNIVERSITY OF CATALONIA
Greenway/Pharr Area (Fort Worth, TX)
Sewer Utility System Relocation
GEOTECHNICAL INVESTIGATION
HORZ.: 1" = 50'
VERT.: 1" = 10'
SHEET 03 OF 07
STATE
DISTRICT
COUNTY





FORT WORTH

Texas Department of Transportation

POLYTECHNIC UNIVERSITY OF CATALONIA

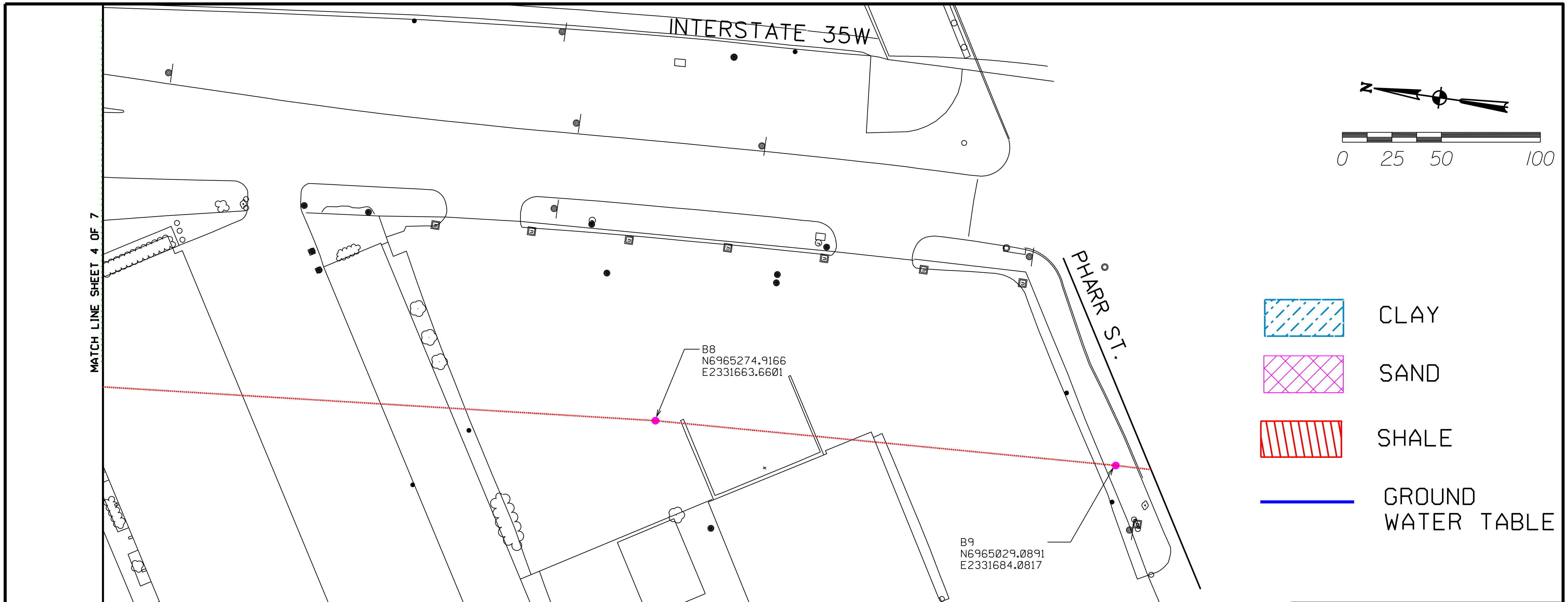
Greenway/Pharr Area (Fort Worth, TX)
Sewer Utility System Relocation

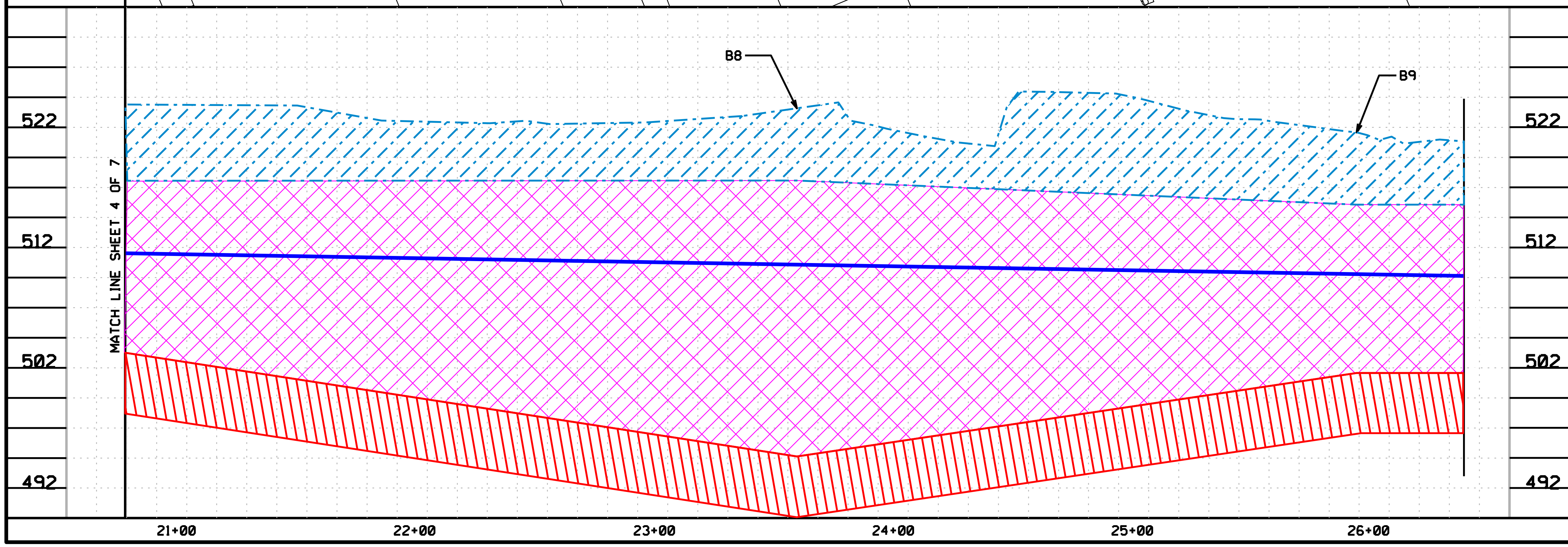
GEOTECHNICAL INVESTIGATION

HORZ.: 1" = 50'
VERT.: 1" = 10'

SHEET 04 OF 07

STATE	DISTRICT	COUNTY





FORT WORTH

Texas Department of Transportation

POLYTECHNIC UNIVERSITY OF CATALONIA

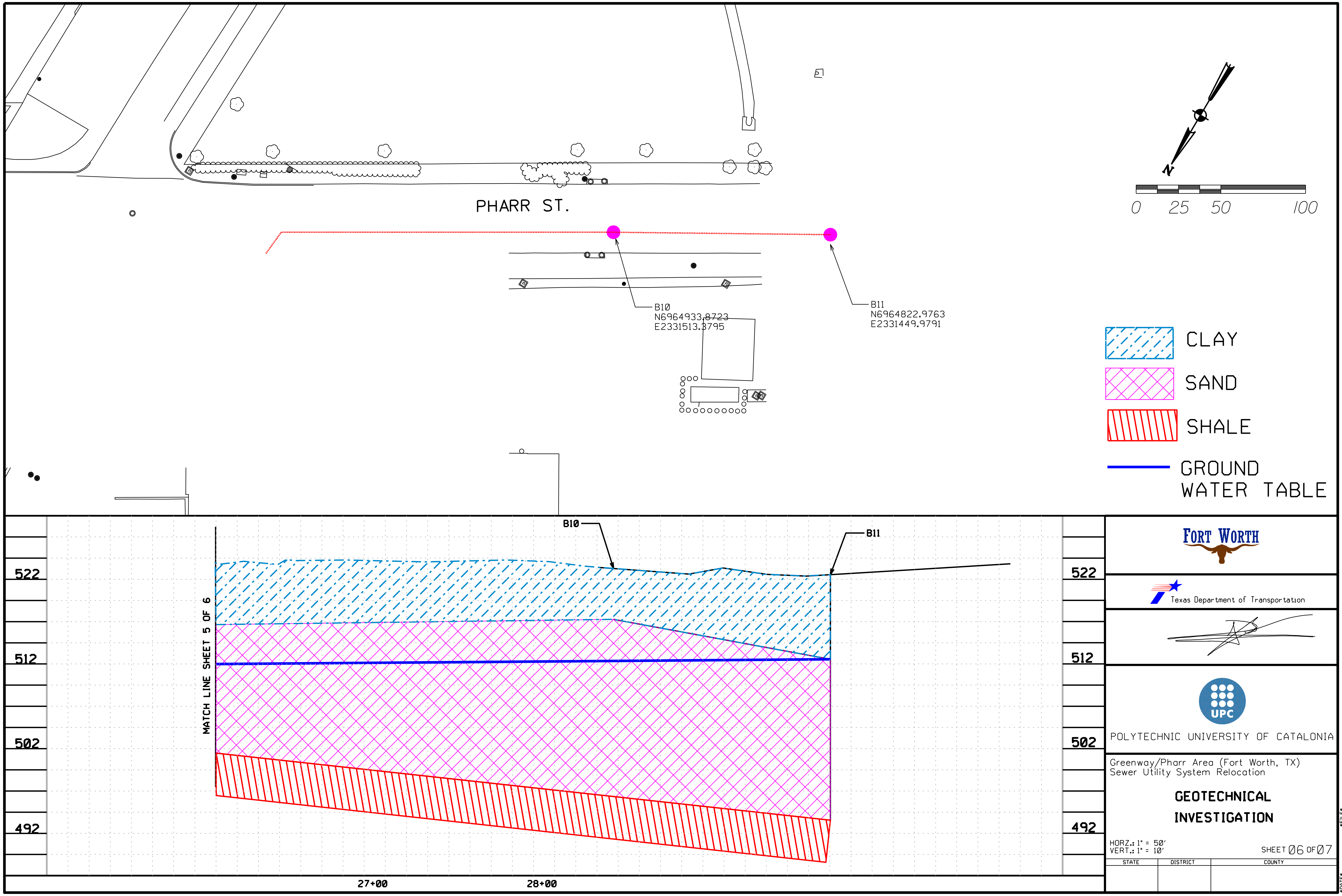
Greenway/Pharr Area (Fort Worth, TX)
Sewer Utility System Relocation

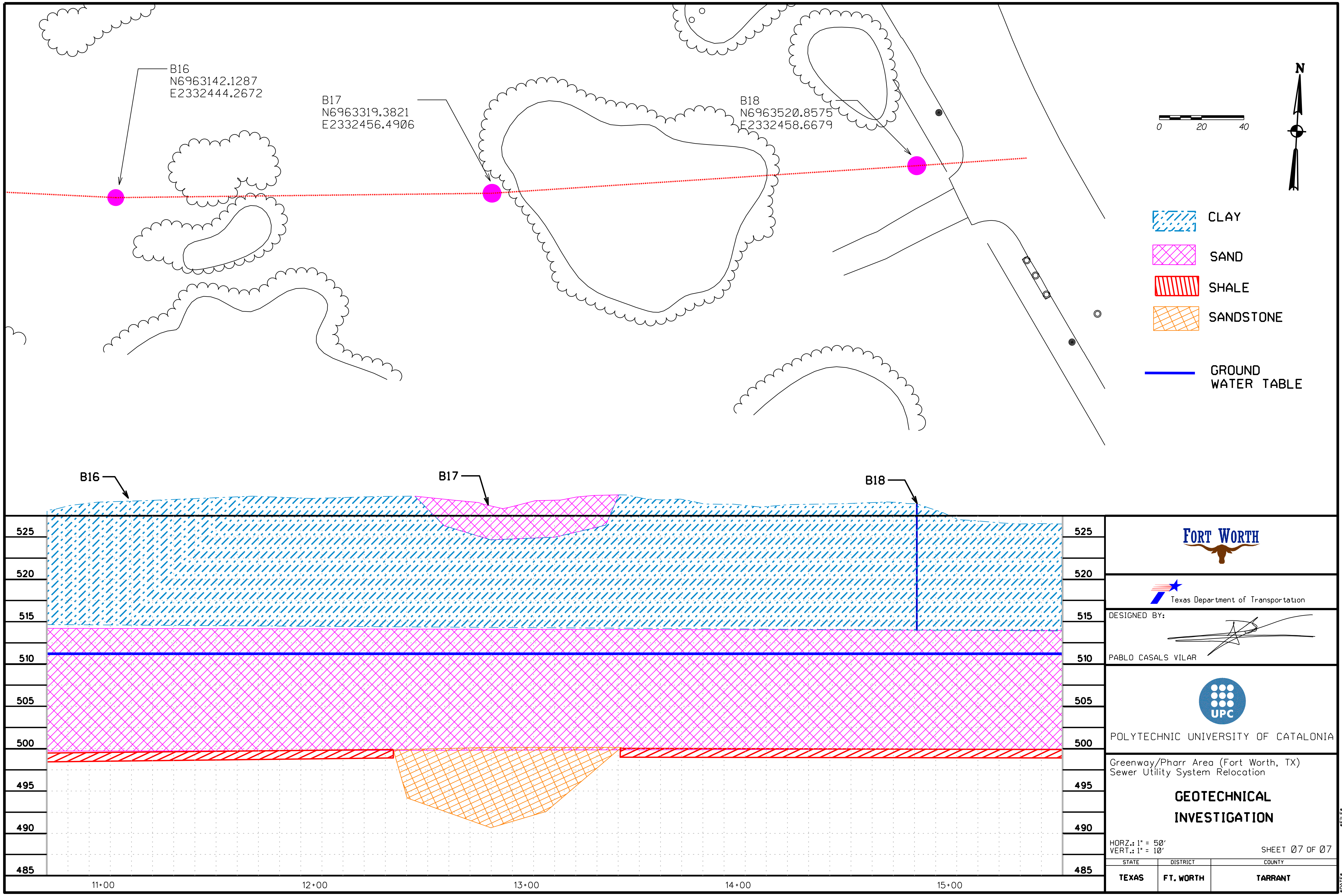
GEOTECHNICAL INVESTIGATION

HORZ.: 1" = 50'
VERT.: 1" = 10'

SHEET 05 OF 07

STATE	DISTRICT	COUNTY


PHARR ST.
N
0
25
50
100
B10
N6964933.8723
E2331513.3795
B11
N6964822.9763
E2331449.9791
CLAY
SAND
SHALE
GROUND WATER TABLE
522
512
502
492
MATCH LINE SHEET 5 OF 6
27+00
28+00
FORT WORTH
Texas Department of Transportation
UPC
POLYTECHNIC UNIVERSITY OF CATALONIA
Greenway/Pharr Area (Fort Worth, TX)
Sewer Utility System Relocation
GEOTECHNICAL INVESTIGATION
HORZ.: 1" = 50'
VERT.: 1" = 10'
SHEET 06 OF 07
STATE
DISTRICT
COUNTY


B16
N6963142.1287
E2332444.2672
B17
N6963319.3821
E2332456.4906
B18
N6963520.8575
E2332458.6679
0
20
40
N
CLAY
SAND
SHALE
SANDSTONE
GROUND
WATER TABLE
B16
B17
B18
525
520
515
510
505
500
495
490
485
11+00
12+00
13+00
14+00
15+00
FORT WORTH
Texas Department of Transportation
DESIGNED BY:
PABLO CASALS VILAR
UPC
POLYTECHNIC UNIVERSITY OF CATALONIA
Greenway/Pharr Area (Fort Worth, TX)
Sewer Utility System Relocation
GEOTECHNICAL
INVESTIGATION
HORZ.: 1" = 50'
VERT.: 1" = 10'
SHEET 07 OF 07
STATE
DISTRICT
COUNTY
TEXAS
FT. WORTH
TARRANT

Appendix No. 4:

Conflict Analysis

INDEX - APPENDIX NO. 4: CONFLICT ANALYSIS

INDEX - FIGURE AND TABLE

4. Conflict Identification

4.1. Conflict No.1 – Sewer Crossing I-35W by Greenfield Ave.

The pictures below shows the record drawing of the existing sewer line (M-267) that crosses the actual I-35W from southwest to northeast (358 LF) and an aerial picture of the same one. This is a 24" vitrified clay pipe (VCP) installed during the 60's decade. A VCP pipe is made from a blend of clay and shale that has been subjected to high temperature to achieve vitrification, a process which results in a hard, inert ceramic. Introduced in the 50's as environmentally friendly VCP is commonly used in gravity sewer collection mains because of its long life and resistance to almost all domestic and industrial sewage. Nowadays Cast Iron and PVC pipes are more common than VCP, this last one becomes fragile and can be broken due to little utility strikes or high vibration/loads on top of it. (North is on the top on both pictures):

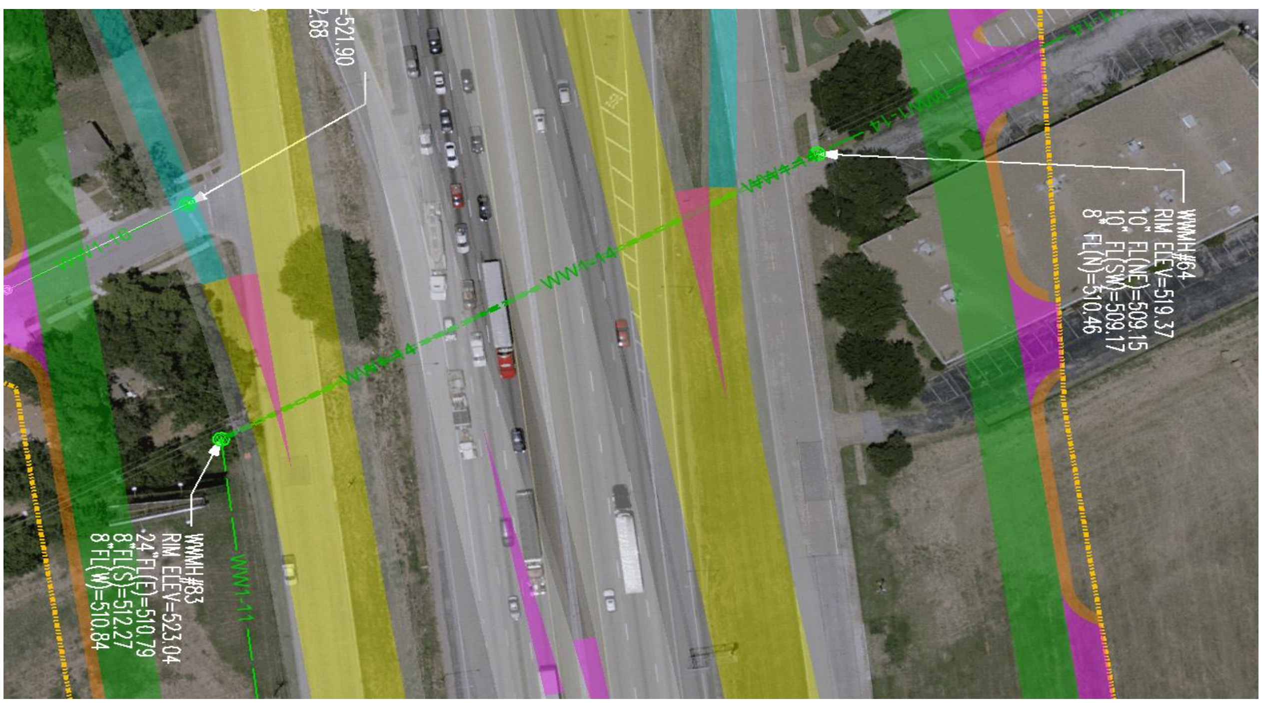


Figure 1. Aerial picture with M-267 and in shade the proposed Highway. Doted orange lines shows the new ROW.

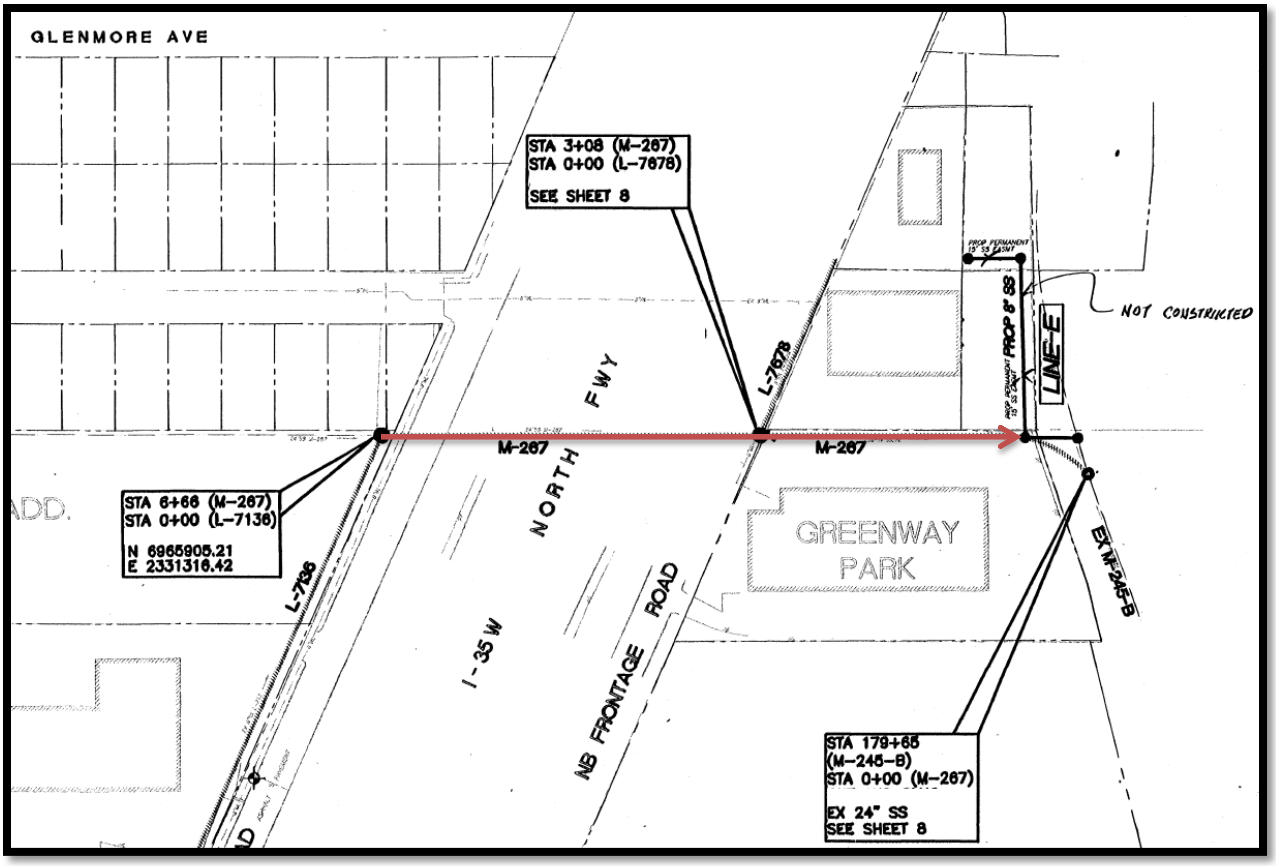


Figure 2. Record Drawing from the City of Fort Worth records of M-267.

There can be 3 main conflicts that needs to be analyzed: alignment, manhole location and/or depth.

4.1.1. *Alignment Conflict Analysis*

The alignment will be in conflict in case we need to do any kind of works on this sewer line. As per the CDA agreement, any utility that crosses the new proposed I-35W needs to be installed at a 90 degrees from the highway alignment. In our case, if we need to do minor works, as a manhole relocation or a sewer extension, the whole sewer line would be affected and TxDOT would enforce the developer to comply and relocate completely the crossing according to specs. Any work related to any lateral that may come feed this main utility sewer line will make this crossing to be relocated as well. As we will see on our second conflict, the lateral sewer X-7136 line that feeds M-267 on the west side will be relocated farther west to be in compliance, once again, with the CDA. This relocation will modify the crossing and consequently it's need to be relocated, which will be affirmative.

4.1.2. Manhole Location Conflict Analysis

Due to the increase of TxDOT's right of way both manholes shown at Sta. 6+66 and 3+08 of the record drawing shown at the exhibit "Conflict 1, Record Drawing" at end of this appendix must be replaced and situated at 4 feet from the ROW as per the CDA agreement even though the existing manholes aren't in conflict with the future highway section shown as well at the end of this appendix as "Conflict 1, Typical proposed section".

4.1.3. Depth Conflict Analysis

The proposed typical cross shows that there is no conflict depth wise. Usually sewer lines goes deeper than any other utility, so the most common conflicts are regarding the alignment of those. Although, as the sewer lines needs to meet TCEQ regulations, the future location of the water line can be a conflict itself but we won't take this into account because the water lines doesn't have the gradient restriction design, so sewer line location is pretty much fixed and any other utility must comply with the Texas Commission of Environmental Quality regulations taking in account it's final proposed design.

In conclusion, we are going to relocate or abandon such utility basically to meet the CDA agreement regarding the location of the sewer lines due to the new ROW and the laterals that feeds it.

4.2. Conflict No.2 – Sewer Along I-35W South Bound Service Road.

As done on the prior conflict analysis, please find below a record drawing of the existing sewer line (X-07136) that goes along the South Bound Service Road (or South Bound Frontage Road, SBFR) of the actual I-35W from south to north (1,055.6 LF) and an aerial picture of the same one. There are 3 manholes at stations 0+00, 5+00 and 7+30. It is an 8" VCP constructed on 1969.

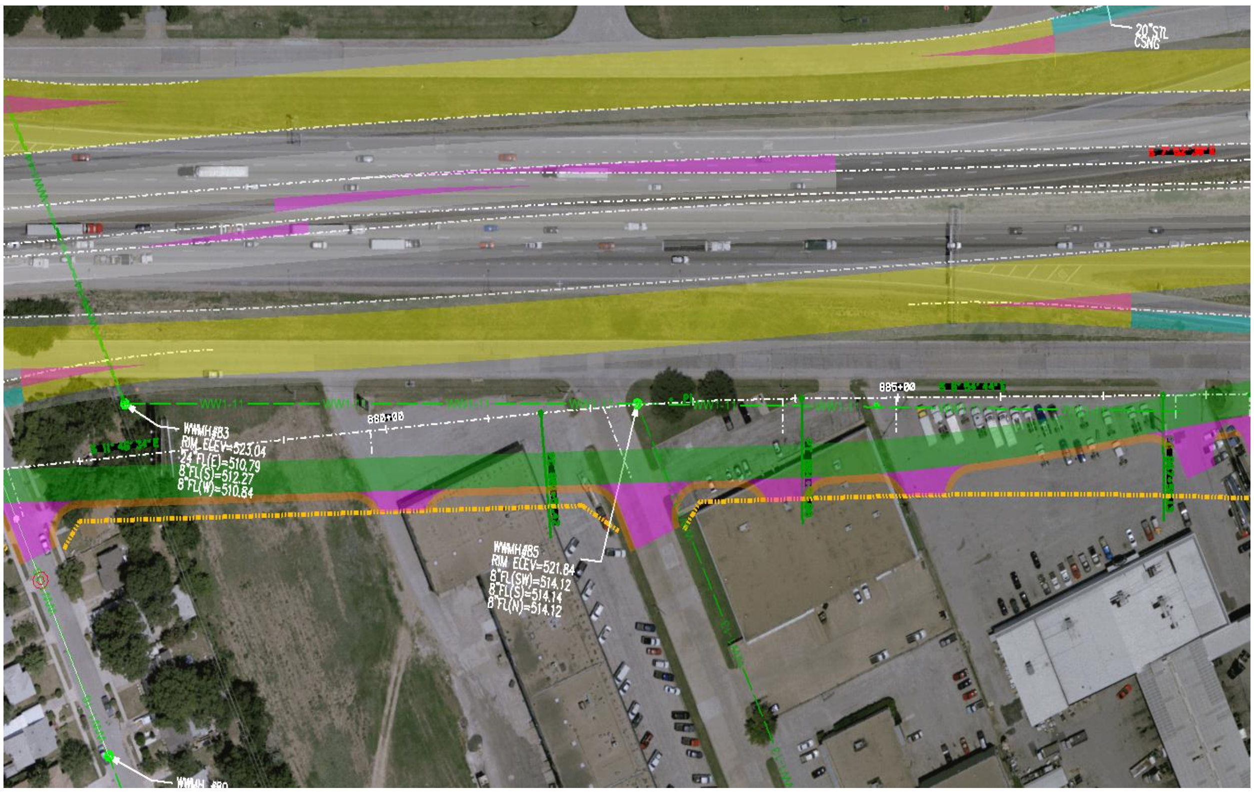


Figure 3. Aerial picture with L-7136 and in shade the proposed Highway. Doted orange lines shows the new ROW.

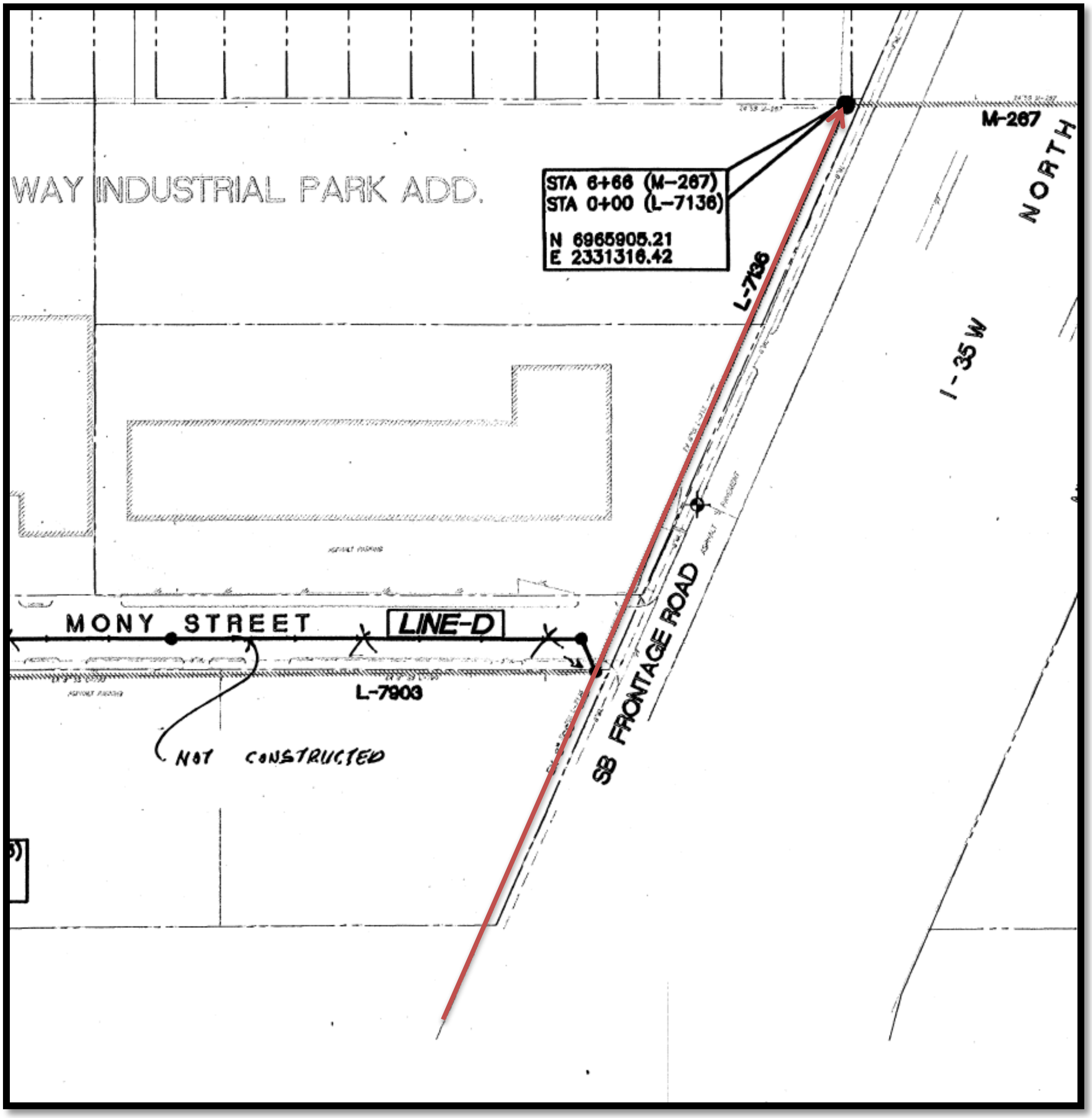


Figure 4. Record Drawing from the City of Fort Worth records of L-7136.

4.2.1. *Alignment Conflict Analysis*

The alignment in this case is all completely in conflict. All this sewer line should run 4 feet away from the new acquire right of way line inside TxDOT's property. This means that at least 1,055 feet must be relocated. On the north end, X-7136 and M-267 must be tied again so an extra 98 feet to the east must be installed so the systems can run again (In case we want to relocate the crossing instead of re-routing the whole sewer system of the area). As commented before, this extra 98 feet to tie-in into the existing crossing will modify M-267 manhole and therefore, M-267 would be relocated or abandoned as well.

4.2.2. Manhole Location Conflict Analysis

No Manholes are in conflict with the future alignment of the south bound service road of I-35W, but at this point, known the need to abandon or relocation this will make no difference.

4.2.3. Depth Conflict Analysis

The proposed final grade on the south bound service road alignment shown on the final alignment profile provided by the developer shows that there is no conflict with the depth of the sewer line. This plan can be found on the exhibit “Conflict 2, SBFR Alignment profile” at the end of this appendix.

In conclusion, we are going to relocate or abandon such utility basically to meet the CDA agreement regarding the location of the sewer lines due to the new ROW and road alignment.

4.3. Conflict No.3 – Sewer at Greenfield Ave. and Glenmore Ave.

This conflict involves two different sewer lines. The first one called L-3355 runs along Greenfield Ave. from I-35W south bound Service Road down to Leota Street (633 LF). It is the most southern street of the neighborhood called as Greenway developed in the 70's decade. The second one called L-3356 runs along Glenmore Ave. also from I-35W south bound Service Road down to the same street, Leota St, with a total length of 683 LF. It runs parallel and north of Greenfield Avenue. Both of them are PVC pipes.

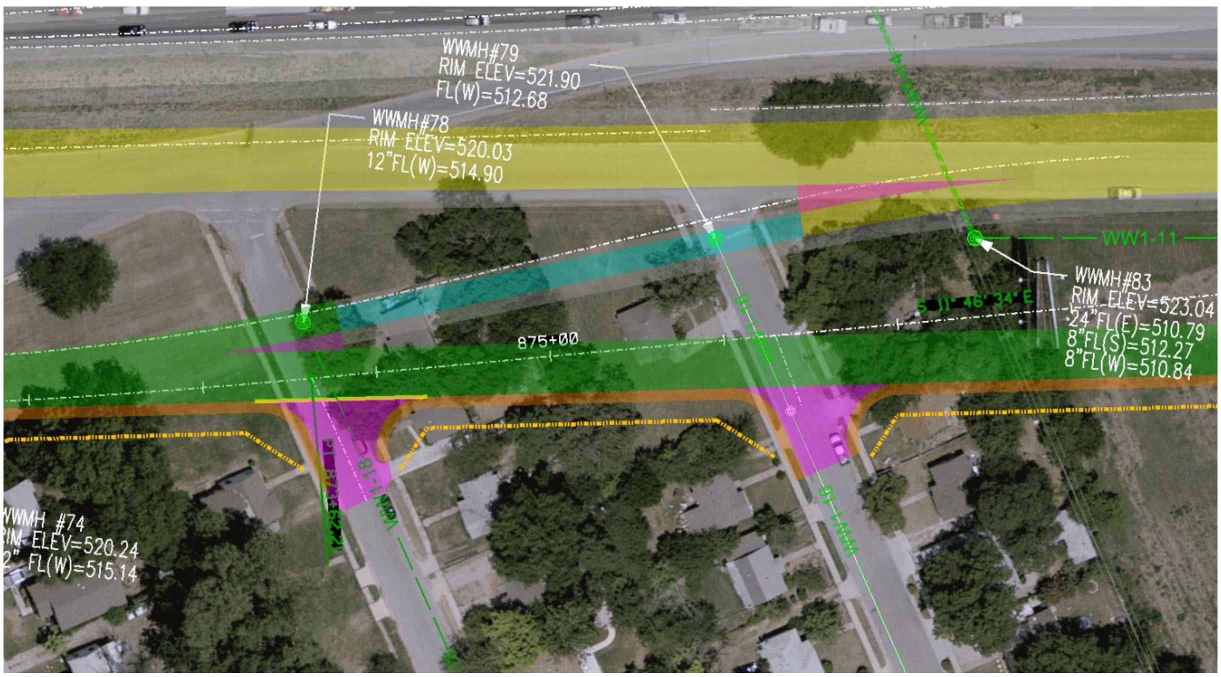


Figure 5. Aerial picture with L-3355 (Greenfield Ave.) and L-3356 (Glenmore Ave.). In shade the proposed Highway. Doted orange lines shows the new ROW.

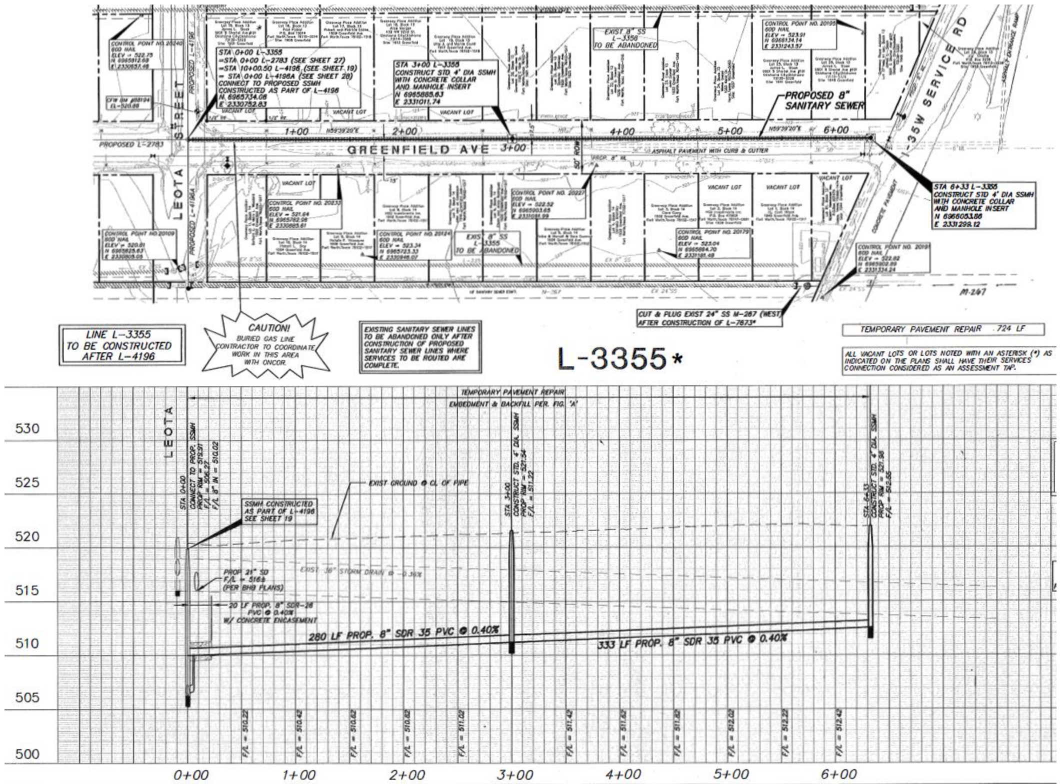


Figure 6. Record Drawing from the City of Fort Worth records of L-3355.

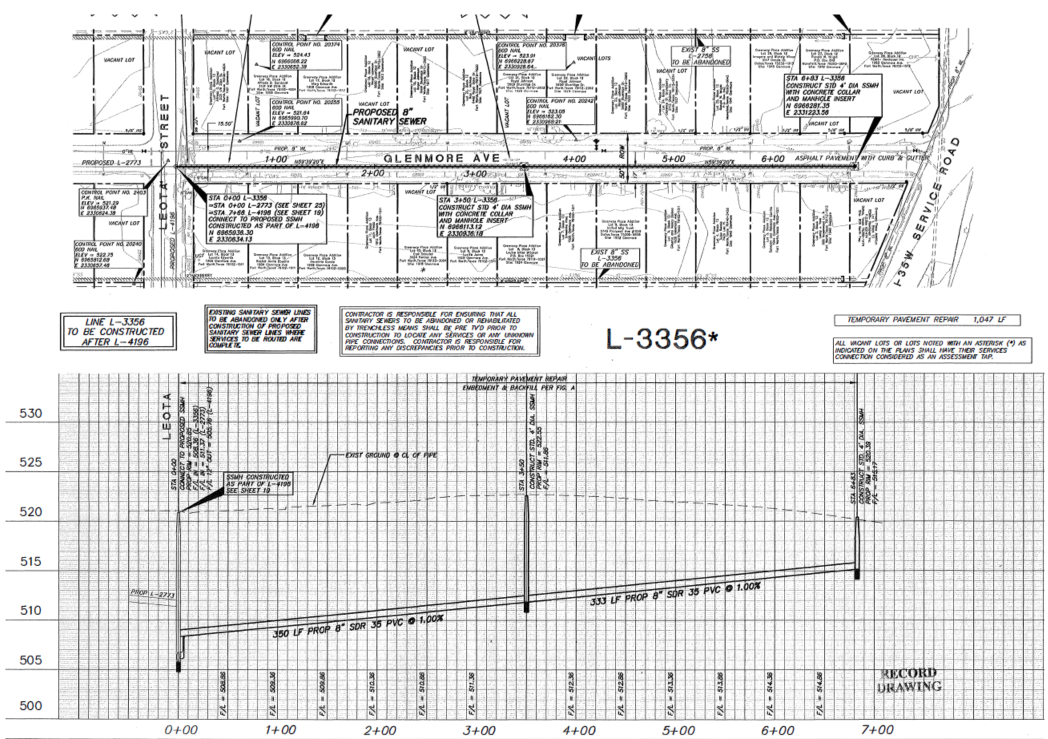


Figure 7. Record Drawing from the City of Fort Worth records of L-3356.

4.3.1. Alignment Conflict Analysis

The alignment, as can be observed on **figure 5**, it is in conflict with the proposed I-35W South Bound Service Road and the South Bound On-Ramp to I-35W from Nixon Ave.

4.3.2. Manhole Location Conflict Analysis

Manholes are in conflict as-well. Both of them are in conflict with the On-Ramp said on the prior paragraph.

4.3.3. Depth Conflict Analysis

The following **Figure 8** shows the SBFR alignment profile (Final pavement elevation) and it is pretty clear where Greenfield Ave. and Glenmore Ave are located. To analyze the depth conflict we will consider the worst case scenario that would be the elevation of the pipe (Take at the its top) on the eastern end of the sewer line. This depths are shown below:

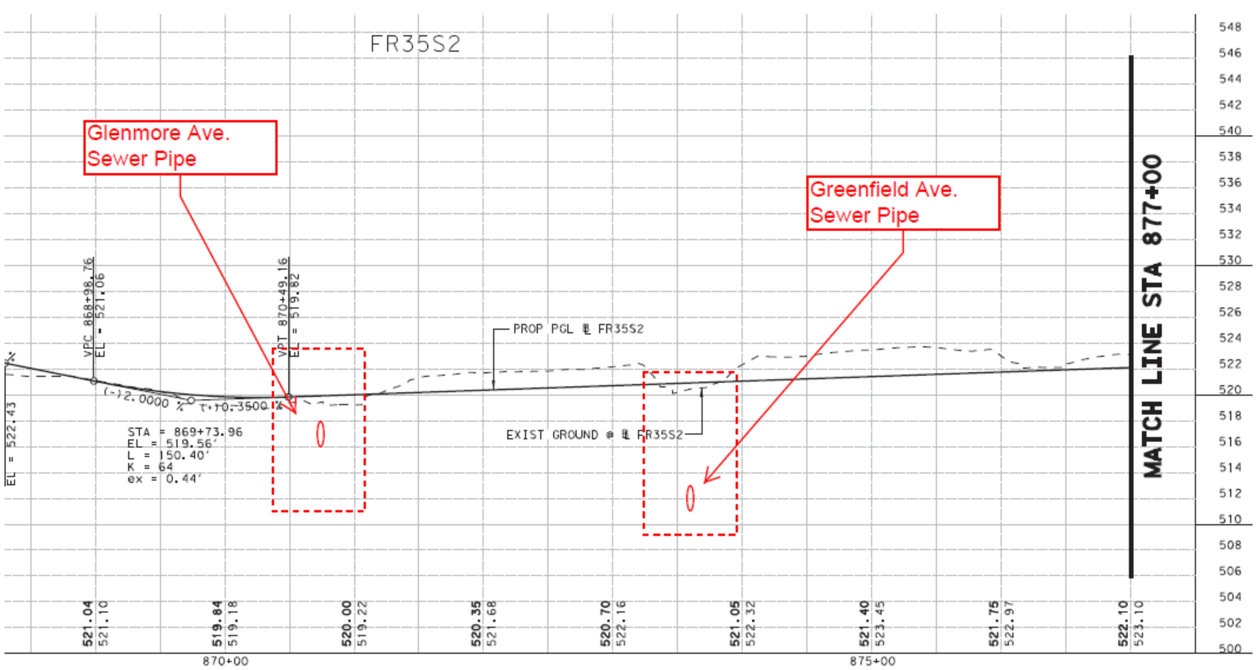


Figure 8. SBFR Profile alignment with L-3355 and L-3356 eastern end elevations at the Top Of Pipe (TOP).

Glenmore Ave. pipe is the shallowest and considering that the package of pavement has usually up to 3 feet (on Frontage Roads only) it is in conflict. This fact must be considered while designing the possible relocations/ Abandonments.

This two sewer lines must be relocated to be able to build correctly the SBFR and the On-Ramp from Nixon Ave to the South Bound General Purpose Lanes of I-35W.

4.4. Conflict No.4 – Sewer at crossing I-35W and Texas 121 by Pharr Street and Maple Street.

This conflict involves a sewer collector at its highest point (Pharr Street). This line feeders are L-2332 and L-1468. As per city of Fort Worth, there are no reliable data regarding the collector we need to analyze. Therefore, to find out the conflicts with the new I-35W Highway we will relay on field Data as Manhole depths and existing test holes provided by NTI's utilities department. The picture below shows the Test Holes and manhole information on a detailed plan view basis. The extended Test Hole information and the overall sewer plan view can be found as-well at the end of this appendix.

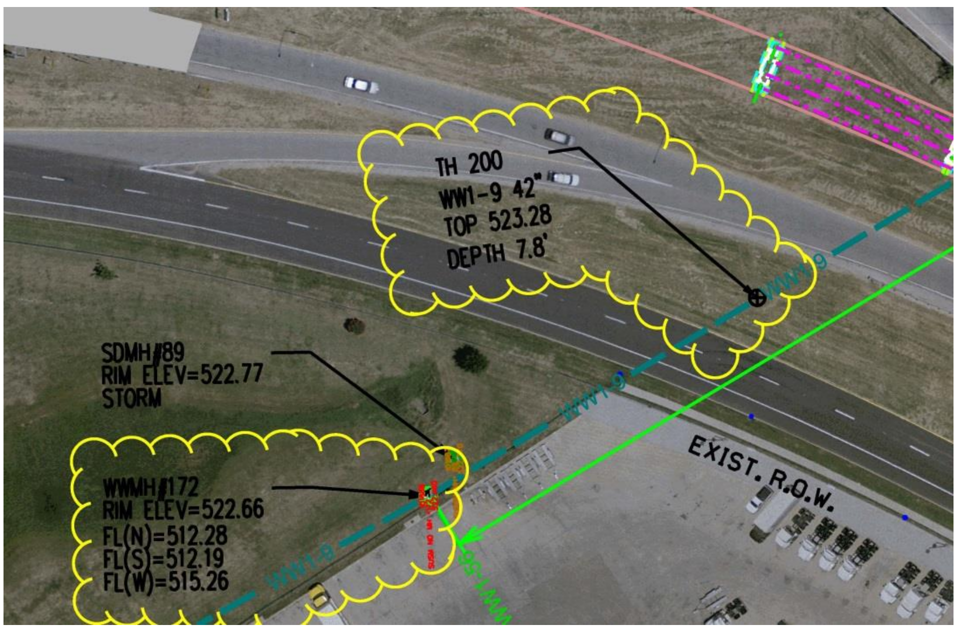


Figure 9. North Manhole and Test Hole (#200) of sewer under analysis.

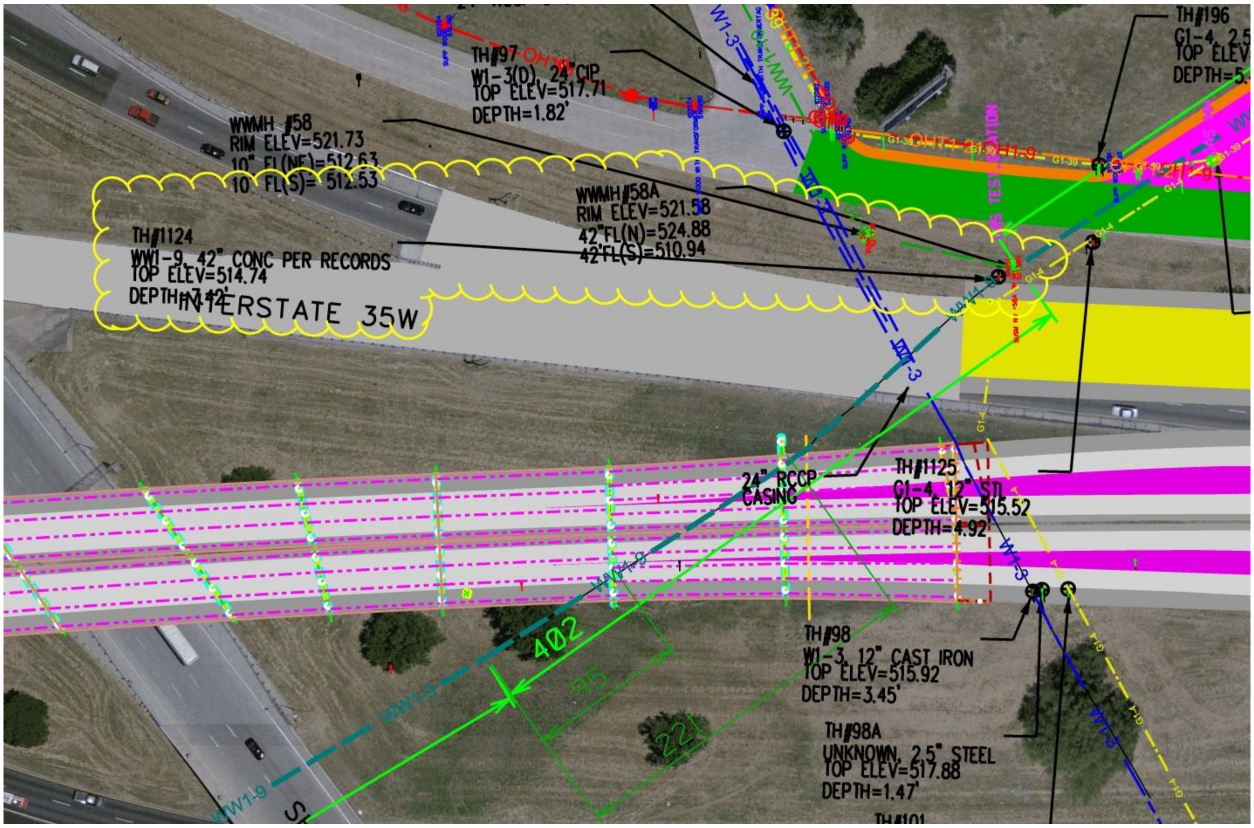
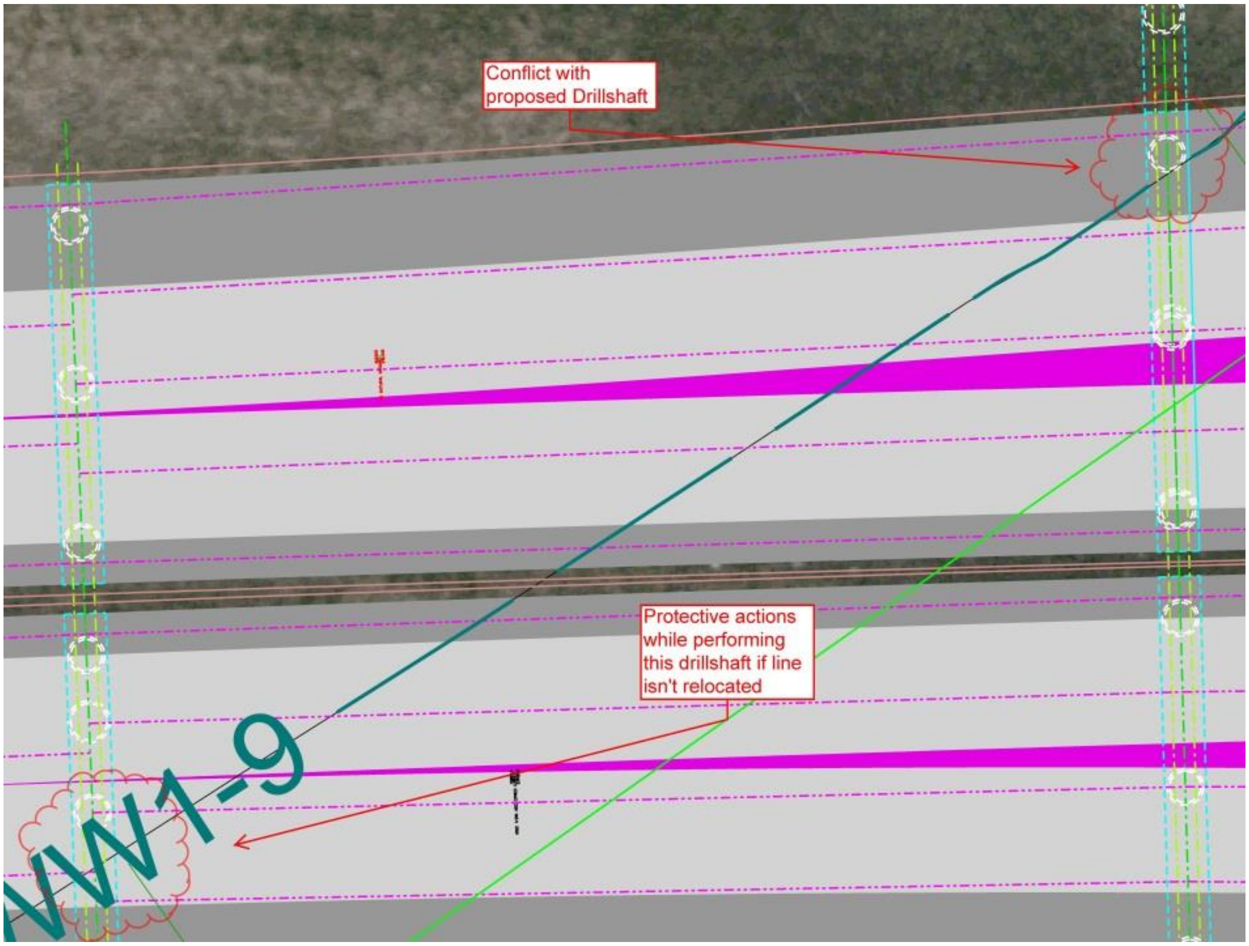


Figure 10. South Manhole and Test Hole (#1124) of sewer under analysis.

This conflict Using the information of the two pictures above we can discern if the sewer line will be in conflict with the two southernmost bents of the proposed bridges. The detail of such conflict as alignment wise can be found on the next page.

If we use the manhole information on both ends to project the elevation of the 42” sewer line at the location of the drill shaft in conflict.

The distance between the Manholes is 1273LF and the distance between the southern manhole and the proposed drill shaft is 185 LF. Comparing both 42” FL(S) values (0.098% grade), the elevation of the waste water collector by the drill shaft is 511.12’.

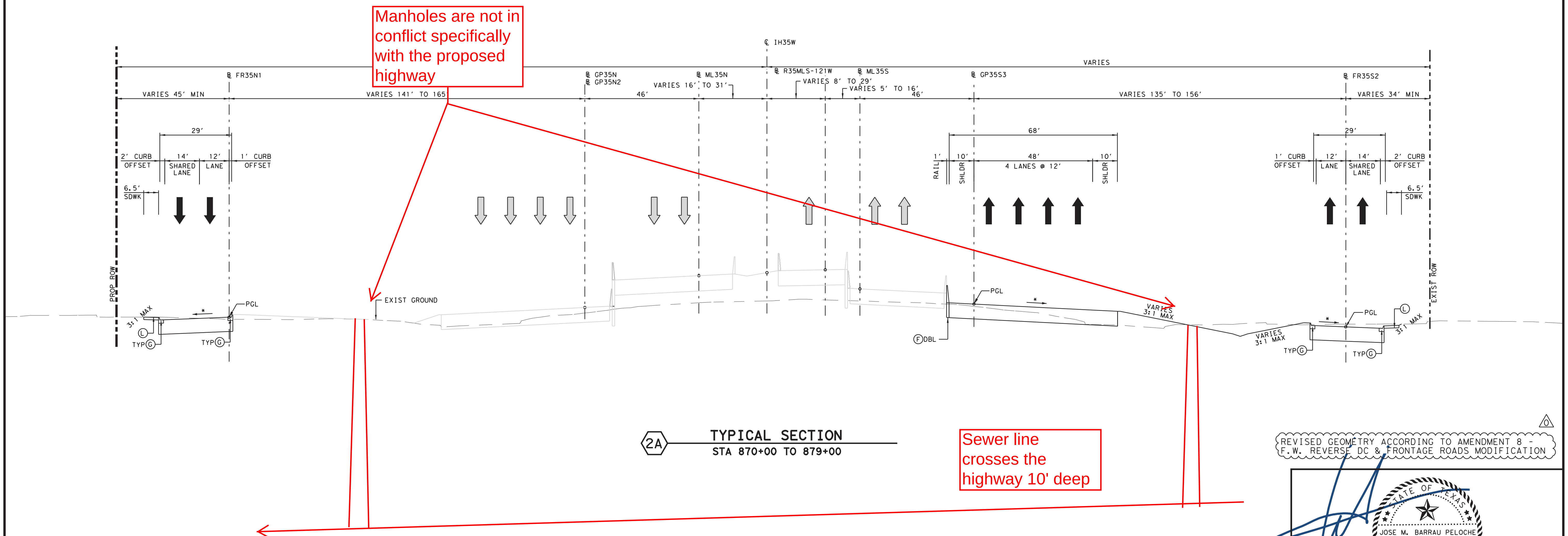


1

The drill shaft in conflict name is : Bridge 242.1-Drillshaft 2 of Bent 20. The specifications of such bent is shown on the annex at the end of this appendix. The elevation of the deepest part of the drill shaft will be 472. This means that this Sewer line is in conflict with the drill shaft itself and, in consequence, the relocation of the line must be done.

ANNEX 4.1 – CONFLICT 1

IFC	REV	DATE	BY	DESCRIPTION
18	0	04/29/2015	JBP	IFC NDC S-040



REVISED GEOMETRY ACCORDING TO AMENDMENT 8 - F.W. REVERSE DC & FRONTAGE ROADS MODIFICATION

ROADWAY LEGEND

(A) MBGF	(L) SIDEWALK (4") (CONC)
(B) RIPRAP (4")	(M) RET WALL
(C) RIPRAP (5")	(N) LANDSCAPE
(D) CABLE BARRIER	(O) PAVERS
(E) TRF RL-SSCB (42")	(Q) DRILL SEED
(F) TRF RL-SSTR (36")	(R) PED RAMP
(G) CURB & GUTTER	(S) DRIVEWAY
(H) TRF RL FDN-(RW-BTR)	(T) PEDESTRIAN RAIL PR1
(I) TRF RL FDN-(TRF)	(X) TYP SECT
(J) TRF RL-C411	➡ TRAF FLOW
(K) NOISE BARRIER	⇨ TRAF FLOW OTHER PACKAGE

NOTE 1. REFER TO PROPOSED PAVEMENT STRUCTURE FOR ADDITIONAL INFORMATION

* SEE HORIZONTAL ALIGNMENT, SUPERELEVATION AND CROSS SLOPE LAYOUT

STATE OF TEXAS
JOSE M. BARRAU PELOCHE
112681
LICENSED PROFESSIONAL ENGINEER
04/29/2015

Texas Department of Transportation

north tarrant express | segments 3

north tarrant infrastructure, llc

OTHON CONSULTING ENGINEERS
F-1471 HOUSTON · AUSTIN · DALLAS

Louis Berger DCE
F-12788

NORTH TARRANT EXPRESS - SEGMENT 3AS
Advanced Package 02

PROPOSED TYPICAL SECTIONS

NTS

SHEET 3 OF 16

FED. RD. DIV. NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6	IM 0355(152)		RDW-13A
STATE	DISTRICT	COUNTY	
TEXAS	FT. WORTH	TARRANT	
CONT	SECT	JOB	HIGHWAY NO
0014	16	179	IH35W

c:\pw_temp\dms09329\NTE3AS_AP02_RDWY_TYP0024.dgn
10/04/2015 9:30:16

X-18382

PLAN & PROFILE
SANITARY SEWER MAIN

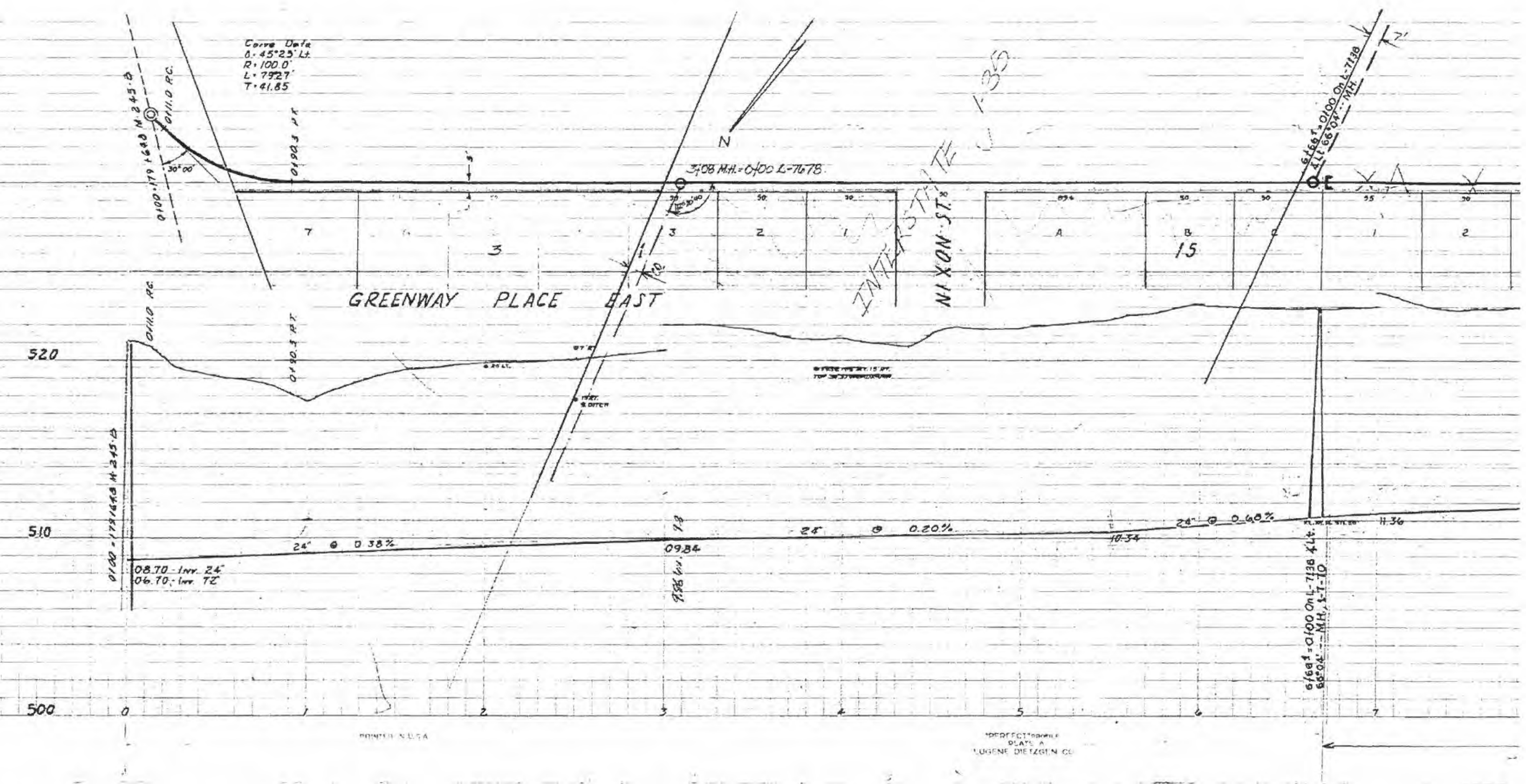
C.M. THELIN — PUBLIC WORKS DIRECTOR
W. S. VAN NATTA — SANITARY SEWER SUPT.

NOTES TAKEN 8-59 ANDRESS
NOTES PLATTED 6-61 JONES

MAIN 267

2054-400

Reference
X-12383
X-18381



X-7678

(G) (S)

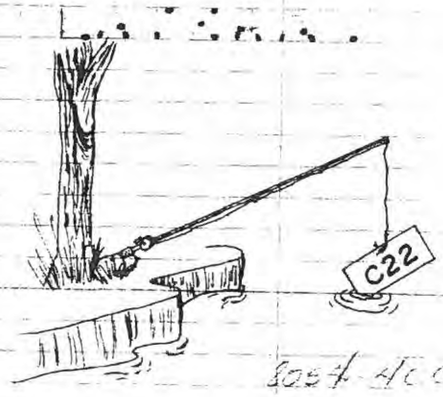
PLAN and PROFILE

Sanitary Sewer

J.L. Robinson — Water Department Director

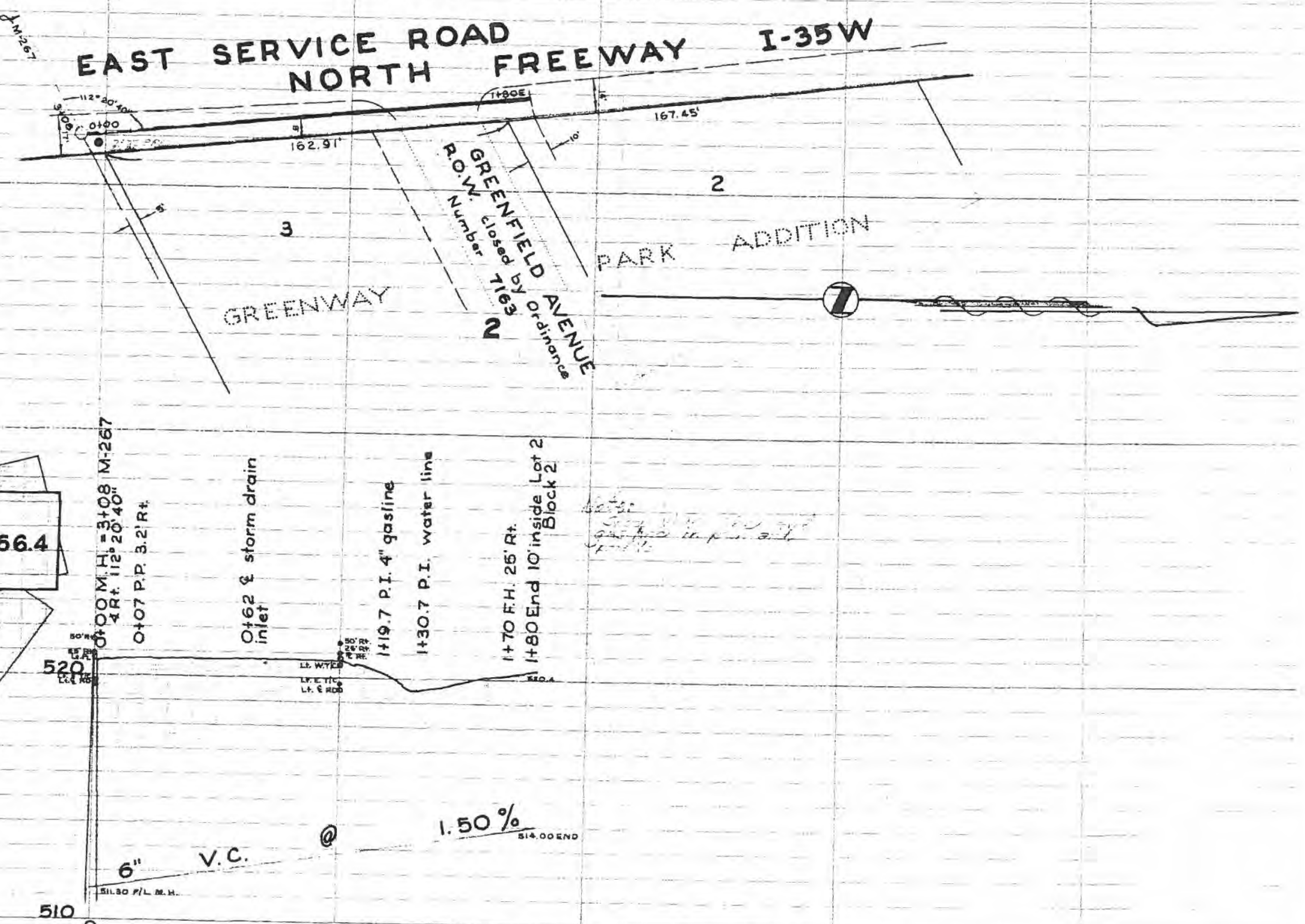
Notes Taken	July 1975	Clark
Notes Platted	December 1975	S.J.

Sta. 0+00 to Sta. 1+80
Force Account S-7506-I → X-7678



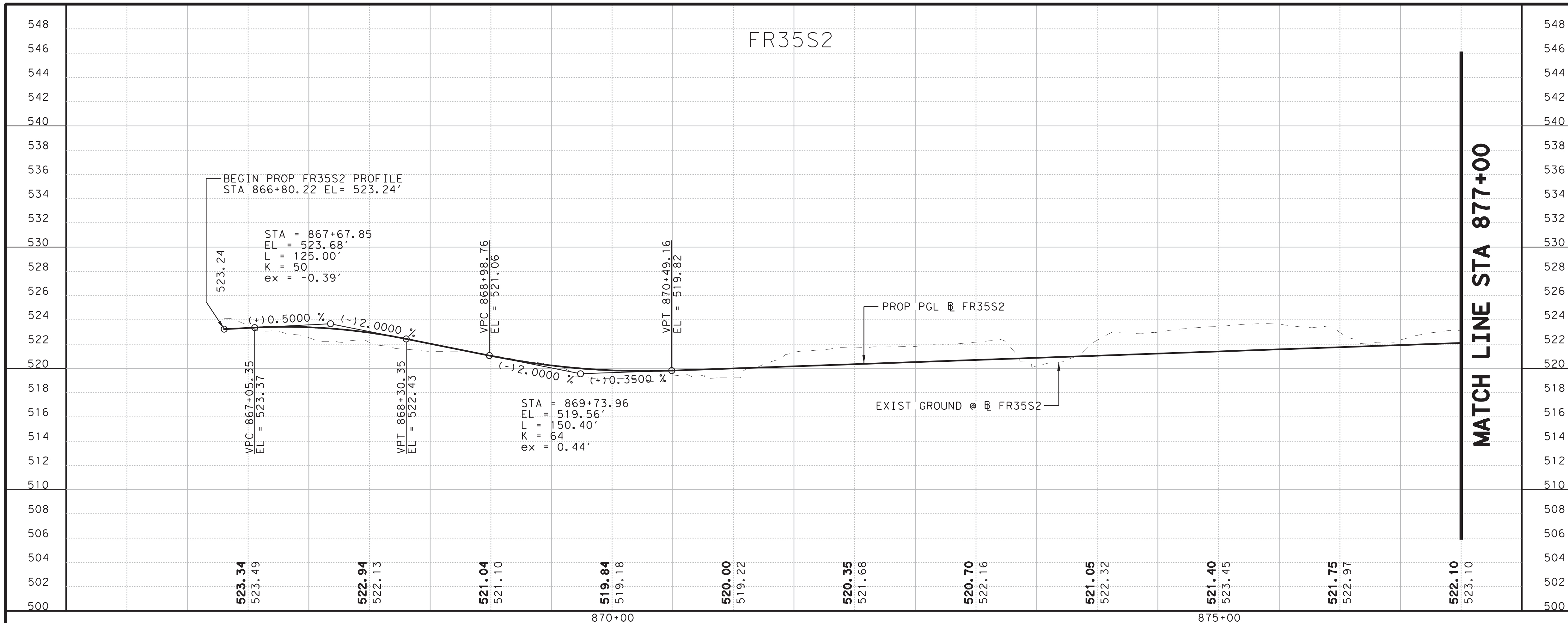
B.M. 511.20
flowline of M.H. Sta. 6+66.4 on M-267.

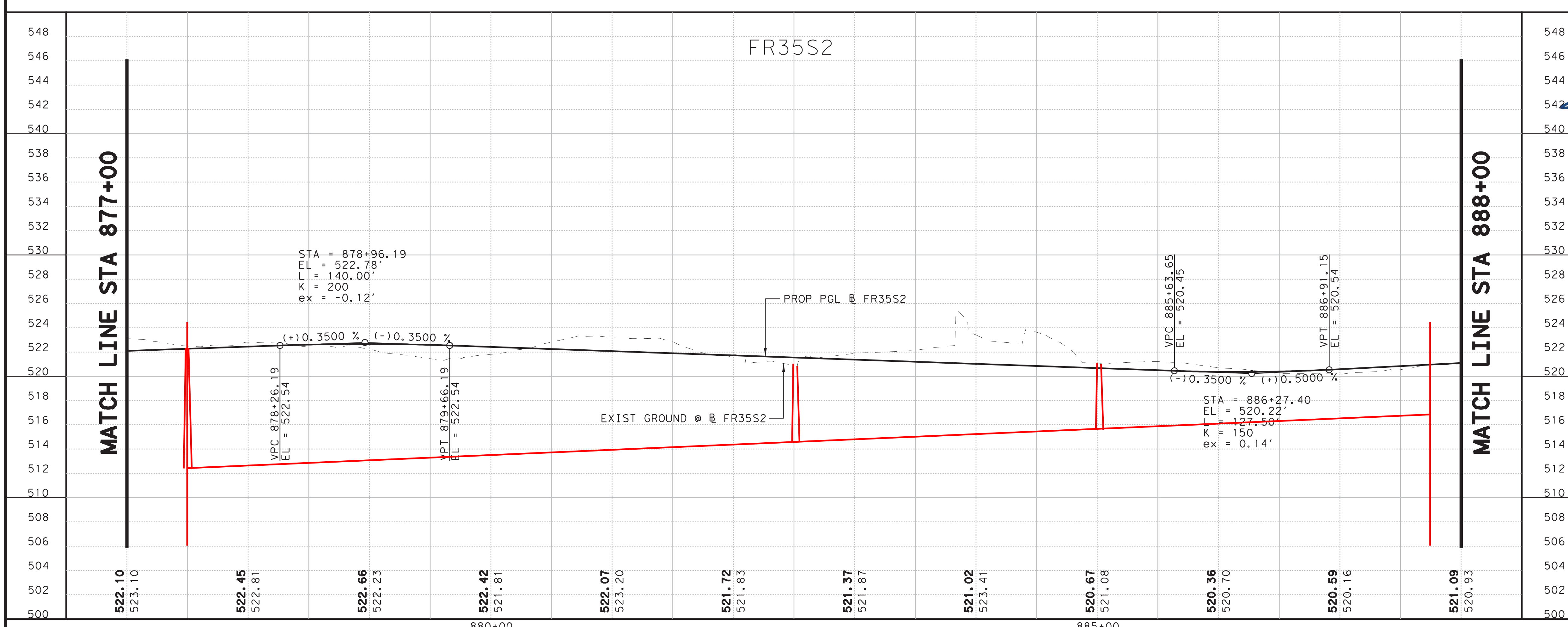
NOTE:
FRONT FOOT CHARGES ARE DUE ON THIS LINE FROM STA. 0+00 TO STA. 1+80 UNDER PROJECT # S 7506-I



PROFILE PLATE A

ANNEX 4.2 – CONFLICT 2





IFC	REV	DATE	BY	DESCRIPTION
0	0	03/04/2014	JBP	AP02-S IFC
18	1	04/29/2015	JBP	IFC NDC S-040

REVISED GEOMETRY ACCORDING TO AMENDMENT 8 - F.W. REVERSE DC & FRONTAGE ROADS MODIFICATION

NOTE:

VERTICAL CLEARANCES AS SHOWN ARE MINIMUM CLEARANCES TO CRITICAL POINTS AT THE BRIDGE. THEY DO NOT REFLECT ACTUAL CLEARANCE AT THE PGL LABELED. REFER TO BRIDGE LAYOUT FOR LOCATION OF MINIMUM CLEARANCE

STATE OF TEXAS
JOSE M. BARRAU PELOCHE
112681
LICENSED PROFESSIONAL ENGINEER
04/29/2015

 Texas Department of Transportation

north tarrant express | segments 3

north tarrant infrastructure, llc

OTHON CONSULTING ENGINEERS
F-1471 HOUSTON · AUSTIN · DALLAS

Louis Berger DCE
F-12788

NORTH TARRANT EXPRESS - SEGMENT 3AS
Advanced Package 02

ROADWAY PROFILES
SOUTHBOUND FRONTAGE ROAD

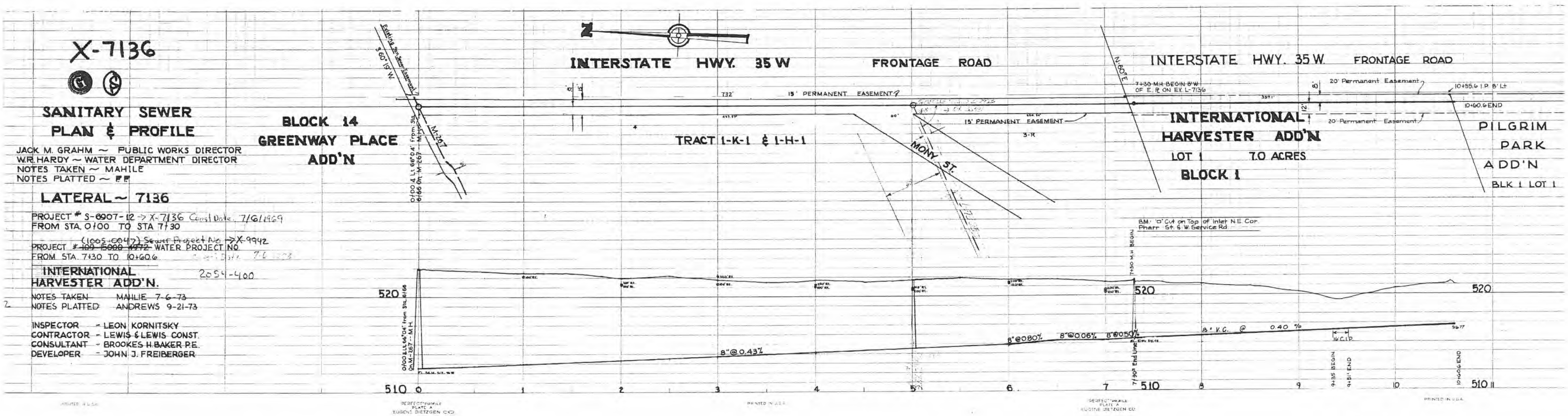
BEGIN TO STA 888+00

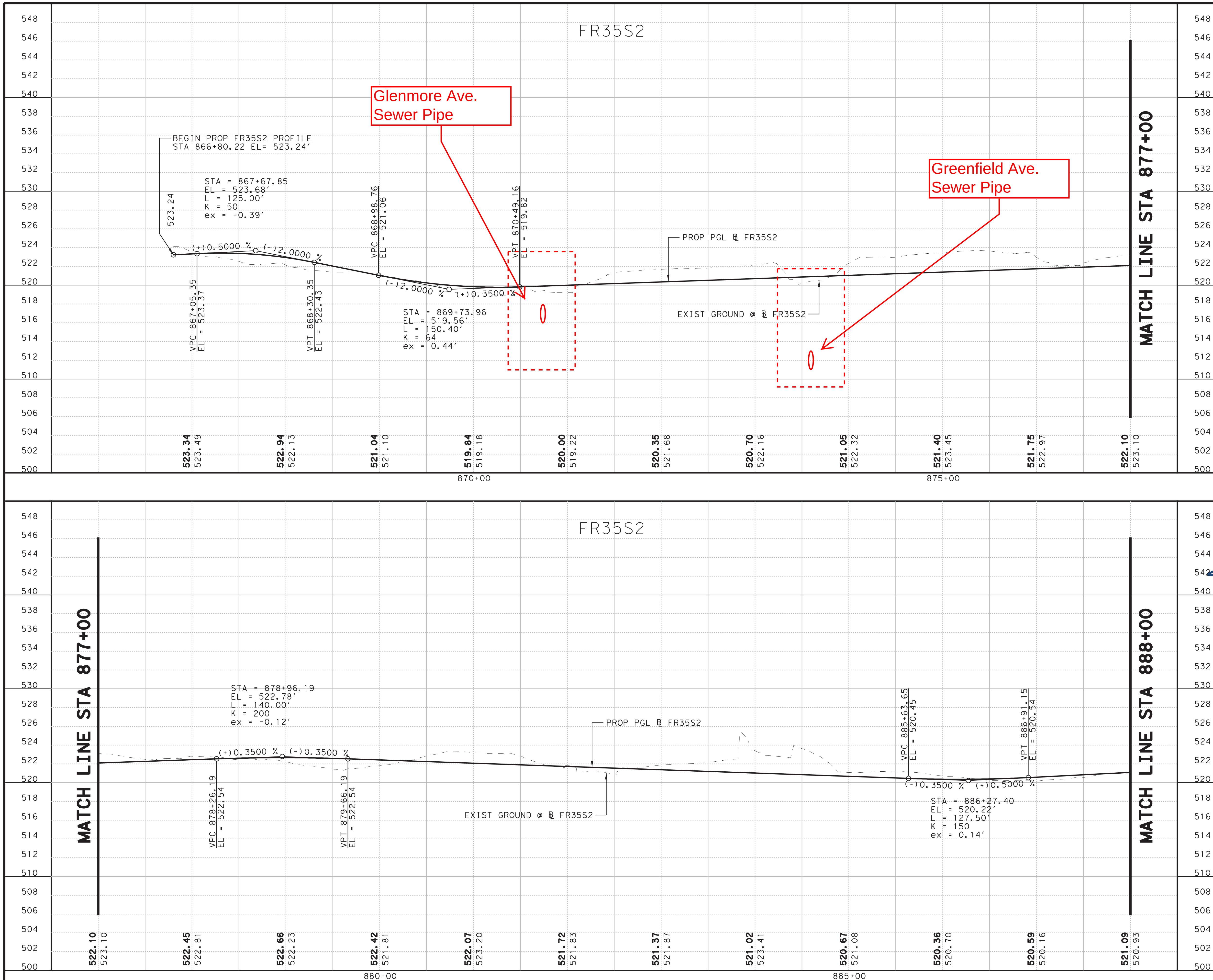
HORZ.: 1" = 100'
VERT.: 1" = 10'

SHEET 1 OF 2

FED. RD. DIV. NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6	IM 0355(152)		RDW-102
STATE	DISTRICT	COUNTY	
TEXAS	FT. WORTH	TARRANT	
CONT	SECT	JOB	HIGHWAY NO
0014	16	179	IH35W

c:\pw_temp\ams09402\NTE3AS_AP02_RDWY_PRFR004.dgn
30/04/2015 9:34:25


X-7136
SANITARY SEWER
PLAN & PROFILE
JACK M. GRAHM ~ PUBLIC WORKS DIRECTOR
W.R. HARDY ~ WATER DEPARTMENT DIRECTOR
NOTES TAKEN ~ MAHILE
NOTES PLATTED ~ FF
LATERAL ~ 7136
PROJECT # S-6907-12 -> X-7136 Const Date 7/6/1969
FROM STA. 0+00 TO STA 7+30
(1005-0047) Sewer Project No -> X-9942
PROJECT # 109-15000 4972 WATER PROJECT NO.
FROM STA. 7+30 TO 10+60.6
INTERNATIONAL HARVESTER ADD'N.
2054-400
NOTES TAKEN MAHLIE 7-6-73
NOTES PLATTED ANDREWS 9-21-73
INSPECTOR - LEON KORNITSKY
CONTRACTOR - LEWIS & LEWIS CONST.
CONSULTANT - BROOKES H. BAKER P.E.
DEVELOPER - JOHN J. FREIBERGER
BLOCK 14
GREENWAY PLACE
ADD'N
INTERSTATE HWY. 35 W
FRONTAGE ROAD
15' PERMANENT EASEMENT
TRACT 1-K-1 & 1-H-1
MONY ST.
15' PERMANENT EASEMENT
3-R
INTERSTATE HWY. 35 W.
FRONTAGE ROAD
7+30 MH BEGIN 8"W OF E. R. ON EX. L-7136
20' Permanent Easement
10+55.6 I.P. 8' Lt
10+60.6 END
INTERNATIONAL HARVESTER ADD'N
LOT 1 7.0 ACRES
BLOCK 1
20' Permanent Easement
PILGRIM PARK ADD'N
BLK 1 LOT 1
BM: "o" Cut on Top of Inlet N.E. Cor. Pharr St. & W. Service Rd.
520
8"@ 0.43%
8"@0.80%
8"@0.06%
8"@0.50%
8" V.C. @ 0.40 %
C.I.P.
510
0 1 2 3 4 5 6 7 8 9 10 11



IFC	REV	DATE	BY	DESCRIPTION
0	0	03/04/2014	JBP	AP02-S IFC
18	1	04/29/2015	JBP	IFC NDC S-040

REVISED GEOMETRY ACCORDING TO AMENDMENT 8 - F.W. REVERSE DC & FRONTAGE ROADS MODIFICATION

NOTE:

VERTICAL CLEARANCES AS SHOWN ARE MINIMUM CLEARANCES TO CRITICAL POINTS AT THE BRIDGE. THEY DO NOT REFLECT ACTUAL CLEARANCE AT THE PGL LABELED. REFER TO BRIDGE LAYOUT FOR LOCATION OF MINIMUM CLEARANCE

STATE OF TEXAS
JOSE M. BARRAU PELOCHE
112681
LICENSED PROFESSIONAL ENGINEER
04/29/2015

Texas Department of Transportation

north tarrant express | segments 3

north tarrant infrastructure, llc

OTHON CONSULTING ENGINEERS
F-1471 HOUSTON · AUSTIN · DALLAS

Louis Berger DCE
F-12788

NORTH TARRANT EXPRESS - SEGMENT 3AS
Advanced Package 02

ROADWAY PROFILES
SOUTHBOUND FRONTAGE ROAD
BEGIN TO STA 888+00

HORZ.: 1" = 100'
VERT.: 1" = 10'

SHEET 1 OF 2

FED. RD. DIV. NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6	IM 0355(152)		RDW-102
STATE	DISTRICT	COUNTY	
TEXAS	FT. WORTH	TARRANT	
CONT	SECT	JOB	HIGHWAY NO
0014	16	179	IH35W

c:\pw_temp\dms09402\NTE3AS_AP02_RDWY_PRFR004.dgn
30/04/2015 9:34:25

ANNEX 4.3 – CONFLICT 3

(6)

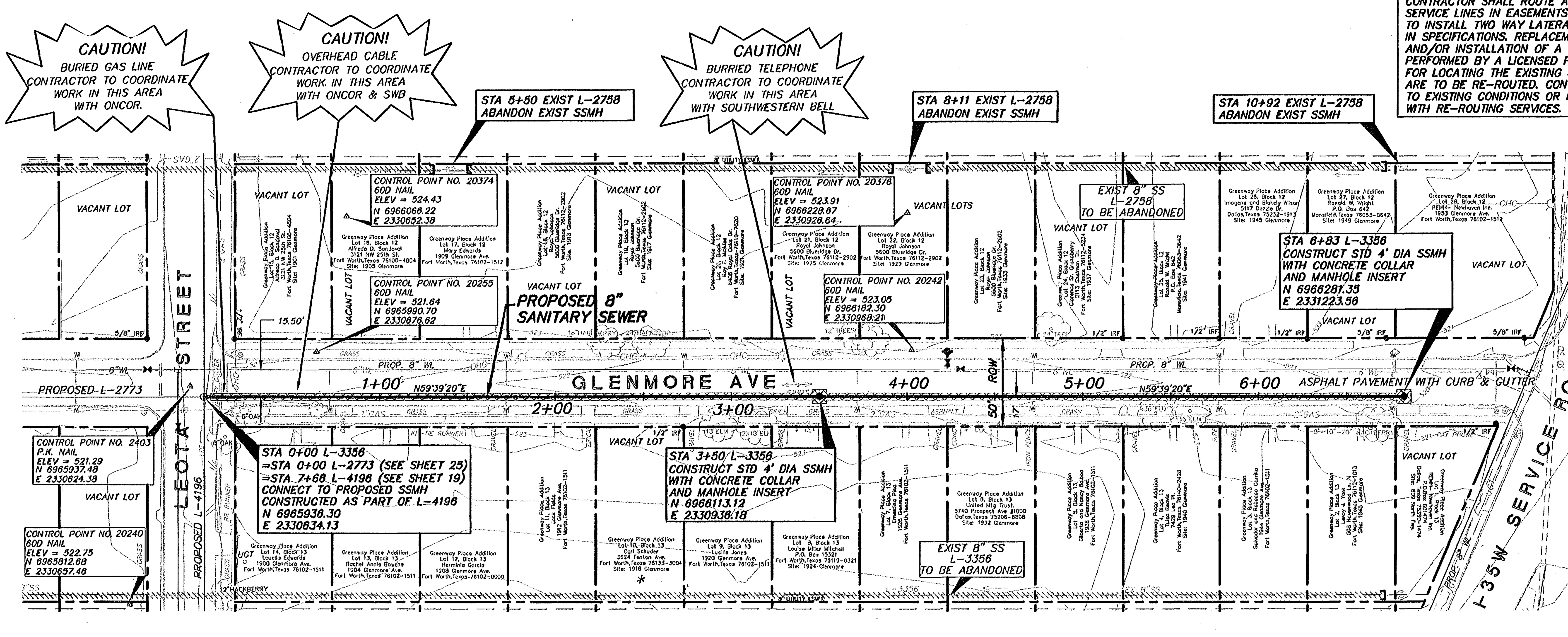
NOTE:
CONTRACTOR SHALL ROUTE ACTIVE SEWER SERVICE FROM ABANDONED SEWER SERVICE LINES IN EASEMENTS TO PROPOSED SEWER LINES IN STREET. CONTRACTOR TO INSTALL TWO WAY LATERAL CLEANOUT AT PROPERTY LINE PER DETAIL IN SPECIFICATIONS. REPLACEMENT OF SANITARY SEWER SERVICES FROM AND/OR INSTALLATION OF A CLEAN OUT AT THE BUILDING, SHALL BE PERFORMED BY A LICENSED PLUMBER. CONTRACTOR IS RESPONSIBLE FOR LOCATING THE EXISTING SERVICES ON BUILDINGS WHERE SERVICES ARE TO BE RE-ROUTED. CONTRACTOR SHALL RETURN ALL PROPERTY TO EXISTING CONDITIONS OR BETTER AFTER PERFORMING WORK ASSOCIATED WITH RE-ROUTING SERVICES.

GRAPHIC SCALE
SCALE : 1" = 40'

COORDINATES ON THIS SHEET ARE SPECIFIC TO THIS PROJECT AND DO NOT CORRESPOND WITH OTHER CITY COORDINATES.

WARNING TO CONTRACTOR:

CALL 1-800-344-8377 (DIG-TESS) OR OTHER UTILITY LOCATING SERVICES 48 HOURS PRIOR TO CONSTRUCTION ACTIVITY. DUNAWAY ASSOCIATES INC IS NOT RESPONSIBLE FOR KNOWING ALL EXISTING UTILITIES OR DEPICTING EXACT LOCATIONS OF UTILITIES ON DRAWINGS.



BENCHMARKS

1. CITY MONUMENT # 87264:
   ON THE S.W. CORNER OF NIXON ST AND CARVER AVE ON THE WEST CURB OF NIXON ST. 21.6' FT SOUTH OF THE SOUTH CURB OF CARVER AVE. SET IN THE CENTER OF A 10' FT INLET.
   ELEV = 519.68

2. CITY MONUMENT # 88194:
   ON THE N.E. CORNER OF LEOTA ST. AND GREENFIELD AVE. ON THE EAST CURB OF LEOTA ST. 21' FT NORTH OF THE NORTH CURB OF GREENFIELD AVE. IN THE CENTER OF A 10' FT INLET 1' FT OFF THE FACE OF THE CURB SET IN THE TOP OF THE CURB.
   ELEV = 520.80

GENERAL UTILITY NOTE

All existing utility data is provided for information only. Although this data is shown as accurately as possible, the contractor is cautioned that the owner and the engineer neither assumes nor implies any responsibility for the accuracy of this data. It shall be the contractor's responsibility to contact the utility affected and verify these locations and elevations prior to construction.

Fort Worth Water Dept.	(817) 871-8296
Fort Worth TPW	(817) 871-8100
Charter Communications (TV Cable)	(817) 246-5538
MCI (Owner of Western Union Lines)	(800) 624-9675
Southwestern Bell Telephone Co.	(800) 395-0440
Texas One Call (locating service)	(800) 245-4545
ONCOR	(800) 242-9113
Verizon	(800) 483-1000

LINE L-3356 TO BE CONSTRUCTED AFTER L-4196

EXISTING SANITARY SEWER LINES TO BE ABANDONED ONLY AFTER CONSTRUCTION OF PROPOSED SANITARY SEWER LINES WHERE SERVICES TO BE ROUTED ARE COMPLETE.

CONTRACTOR IS RESPONSIBLE FOR ENSURING THAT ALL SANITARY SEWERS TO BE ABANDONED OR REHABILITATED BY TRENCHLESS MEANS SHALL BE PRE TV'D PRIOR TO CONSTRUCTION TO LOCATE ANY SERVICES OR ANY UNKNOWN PIPE CONNECTIONS. CONTRACTOR IS RESPONSIBLE FOR REPORTING ANY DISCREPANCIES PRIOR TO CONSTRUCTION.

L-3356*

TEMPORARY PAVEMENT REPAIR 1,047 LF

ALL VACANT LOTS OR LOTS NOTED WITH AN ASTERISK (*) AS INDICATED ON THE PLANS SHALL HAVE THEIR SERVICES CONNECTION CONSIDERED AS AN ASSESSMENT TAP.

SEWER MAP NO
2054-400

SEE SHEETS 4 TO 12 FOR PROPOSED WATERLINES

THERE ARE APPROXIMATELY **28** SERVICES ON THIS SHEET TO BE REINSTATED AND THERE ARE APPROXIMATELY **700** LF OF **4"** SANITARY SEWER SERVICES TO BE CONSTRUCTED WITHIN PUBLIC ROW NUMBER OF SERVICES ARE ESTIMATED ON BEST AVAILABLE INFORMATION. CONTRACTOR TO FIELD VERIFY THE ACTUAL LOCATIONS AND NUMBER OF SERVICES.

NO	REVISION	BY	DATE

IPV DESIGNED · IPV / JPS DRAWN · BSD CHECKED

FORT WORTH WATER

Scale	Date
HORIZ 1" = 40' VERT 1" = 4'	2003
Project Number	DOE No
PS58-070580175450	3089

Dunaway Associates, Inc. | Engineers Planners Surveyors Landscape Architects

1601 Merrimac Circle, Ste. 100 Fort Worth, TX 76107 Ph: 817.335.1121 Metro: 817.429.2135 Fax: 817.335.7437

STATE OF TEXAS · BRIAN S. DARBY · 82623 · REGISTERED PROFESSIONAL ENGINEER

PROJECT ENGINEER
DATE 9/3/3

CITY OF FORT WORTH, TEXAS
WATER AND SANITARY SEWER IMPROVEMENTS
GREENWAY PLACE ADDITION
L-3356 - GLENMORE AVEUE
STA 0+00 TO STA 6+83

DAI PROJECT 2001089

SHEET 24 OF 31

(24)

NOTE:
CONTRACTOR SHALL ROUTE ACTIVE SEWER SERVICE FROM ABANDONED L-3356 IN EASEMENTS TO PROPOSED L-3355 SEWER IN STREET. CONTRACTOR TO INSTALL TWO WAY LATERAL CLEANOUT AT PROPERTY LINE PER DETAIL IN SPECIFICATIONS. REPLACEMENT OF SANITARY SEWER SERVICES FROM AND/OR INSTALLATION OF A CLEAN OUT AT THE BUILDING, SHALL BE PERFORMED BY A LICENSED PLUMBER. CONTRACTOR IS RESPONSIBLE FOR LOCATING THE EXISTING SERVICES ON BUILDINGS WHERE SERVICES ARE TO BE RE-ROUTED. CONTRACTOR SHALL RETURN ALL PROPERTY TO EXISTING CONDITIONS OR BETTER AFTER PERFORMING WORK ASSOCIATED WITH RE-ROUTING SERVICES.

CONTRACTOR IS RESPONSIBLE FOR ENSURING THAT ALL SANITARY SEWERS TO BE ABANDONED OR REHABILITATED BY TRENCHLESS MEANS SHALL BE PRE TV'D PRIOR TO CONSTRUCTION TO LOCATE ANY SERVICES OR ANY UNKNOWN PIPE CONNECTIONS. CONTRACTOR IS RESPONSIBLE FOR REPORTING ANY DISCREPANCIES PRIOR TO CONSTRUCTION.

GRAPHIC SCALE

SCALE : 1" = 40'

(G)

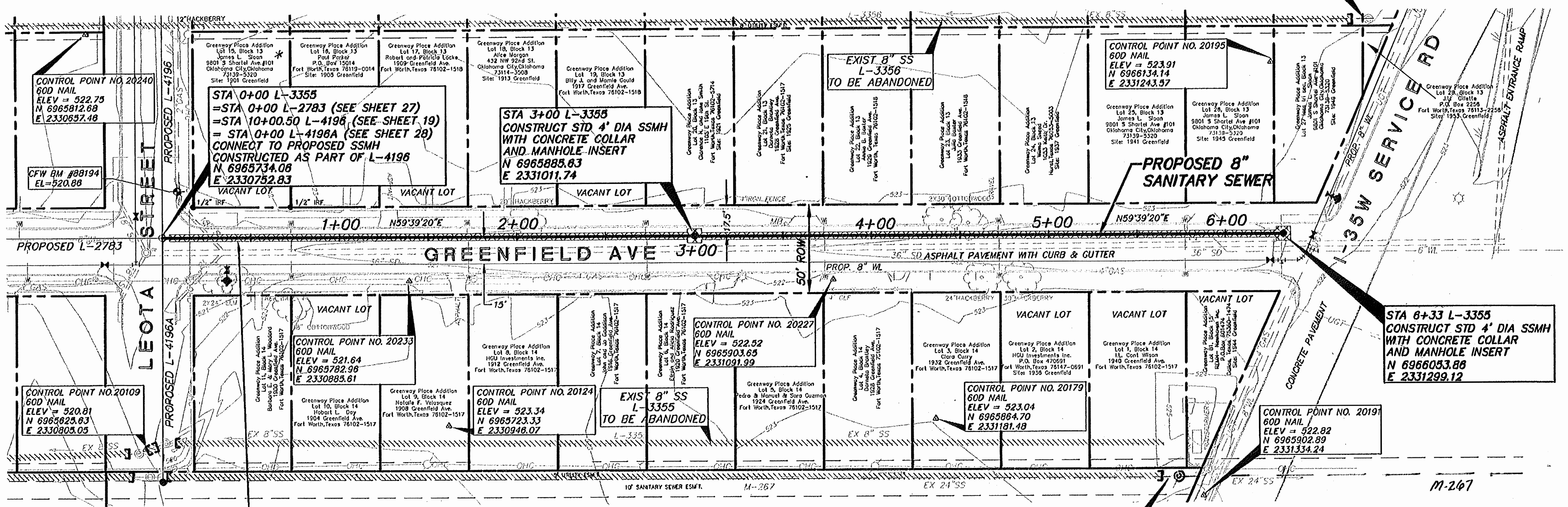
COORDINATES ON THIS SHEET ARE SPECIFIC TO THIS PROJECT AND DO NOT CORRESPOND WITH OTHER CITY COORDINATES.

WARNING TO CONTRACTOR:
CALL 1-800-344-8377 (DIG-TESS) OR OTHER UTILITY LOCATING SERVICES 48 HOURS PRIOR TO CONSTRUCTION ACTIVITY. DUNAWAY ASSOCIATES INC IS NOT RESPONSIBLE FOR KNOWING ALL EXISTING UTILITIES OR DEPICTING EXACT LOCATIONS OF UTILITIES ON DRAWINGS.

BENCHMARKS
1. CITY MONUMENT # 87264: ON THE S.W. CORNER OF NIXON ST AND CARVER AVE ON THE WEST CURB OF NIXON ST. 21.6' FT SOUTH OF THE SOUTH CURB OF CARVER AVE. SET IN THE CENTER OF A 10' FT INLET. ELEV = 519.68
2. CITY MONUMENT # 88194: ON THE N.E. CORNER OF LEOTA ST. AND GREENFIELD AVE. ON THE EAST CURB OF LEOTA ST. 21' FT NORTH OF THE NORTH CURB OF GREENFIELD AVE. IN THE CENTER OF A 10' FT INLET 1' FT OFF THE FACE OF THE CURB SET IN THE TOP OF THE CURB. ELEV = 520.80

GENERAL UTILITY NOTE
All existing utility data is provided for information only. Although this data is shown as accurately as possible, the contractor is cautioned that the owner and the engineer neither assumes nor implies any responsibility for the accuracy of this data. It shall be the contractor's responsibility to contact the utility affected and verify these locations and elevations prior to construction.

Fort Worth Water Dept.	(817) 871-8296
Fort Worth TPW	(817) 871-8100
Charter Communications (TV Cable)	(817) 246-5538
MCI (Owner of Western Union Lines)	(800) 624-9675
Southwestern Bell Telephone Co.	(800) 395-0440
Texas One Call (locating service)	(800) 245-4545
ONCOR	(800) 242-9113
Verizon	(800) 483-1000



CUT & PLUG EXIST 24" SS M-267 (WEST) AFTER CONSTRUCTION OF L-7673*

CONTRACTOR SHALL NOT DISTURB 36" STORM DRAIN. CONTRACTOR WILL BE RESPONSIBLE FOR REPAIR OR REPLACEMENT IN THE EVENT OF DAMAGE.

SEWER MAP NO 2054-400

SEE SHEETS 4 TO 12 FOR PROPOSED WATERLINES

THERE ARE APPROXIMATELY 25 SERVICES ON THIS SHEET TO BE REINSTATED AND THERE ARE APPROXIMATELY 630 LF OF 4" SANITARY SEWER SERVICES TO BE CONSTRUCTED WITHIN PUBLIC ROW NUMBER OF SERVICES ARE ESTIMATED ON BEST AVAILABLE INFORMATION. CONTRACTOR TO FIELD VERIFY THE ACTUAL LOCATIONS AND NUMBER OF SERVICES.

LINE L-3355 TO BE CONSTRUCTED AFTER L-4196

CAUTION! BURIED GAS LINE CONTRACTOR TO COORDINATE WORK IN THIS AREA WITH ONCOR.

EXISTING SANITARY SEWER LINES TO BE ABANDONED ONLY AFTER CONSTRUCTION OF PROPOSED SANITARY SEWER LINES WHERE SERVICES TO BE ROUTED ARE COMPLETE.

L-3355*

TEMPORARY PAVEMENT REPAIR 724 LF

ALL VACANT LOTS OR LOTS NOTED WITH AN ASTERISK (*) AS INDICATED ON THE PLANS SHALL HAVE THEIR SERVICES CONNECTION CONSIDERED AS AN ASSESSMENT TAP.

NO	REVISION	BY	DATE		
				IPV DESIGNED	
				IPV / JPS DRAWN	
				BSD CHECKED	

FORT WORTH WATER

Scale	Date
HORIZ 1" = 40' VERT 1" = 4'	2003
Project Number	DOE No
PS58-070580175450	3089

Dunaway Associates, Inc. Engineers Planners Surveyors Landscape Architects

1501 Merrimac Circle, Ste. 100 Fort Worth, TX 76107 Ph: 817.335.1121 Metro: 817.429.2135 Fax: 817.335.7437

STATE OF TEXAS BRIAN S. DARBY 82623 REGISTERED PROFESSIONAL ENGINEER

PROJECT ENGINEER 9/3/3 DATE

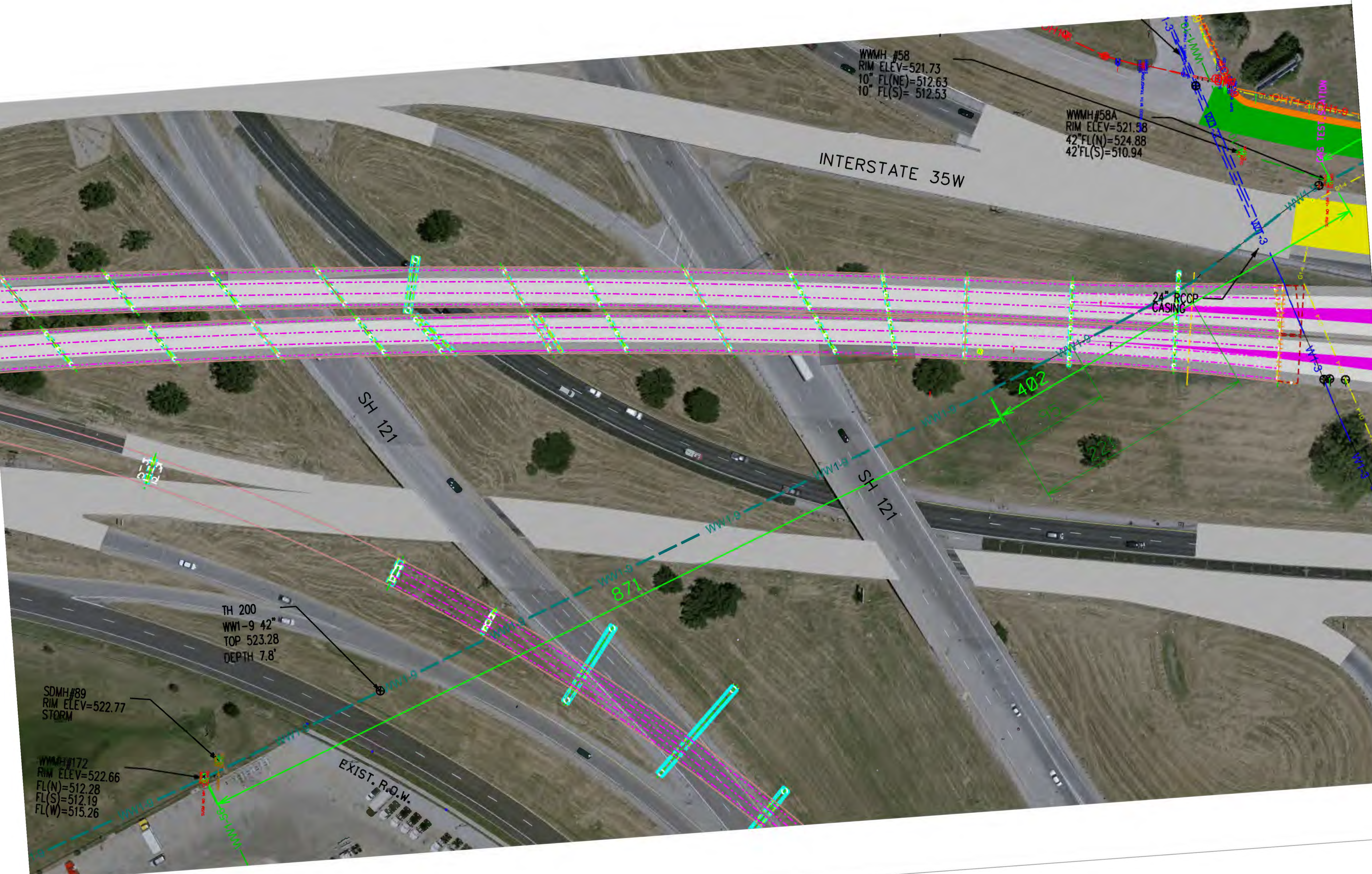
CITY OF FORT WORTH, TEXAS
WATER AND SANITRY SEWER IMPROVEMENTS GREENWAY PLACE ADDITION
L-3355 - GREENFIELD AVENUE STA 0+00 TO STA 6+33

DAI PROJECT 2001089

SHEET 26 OF 31

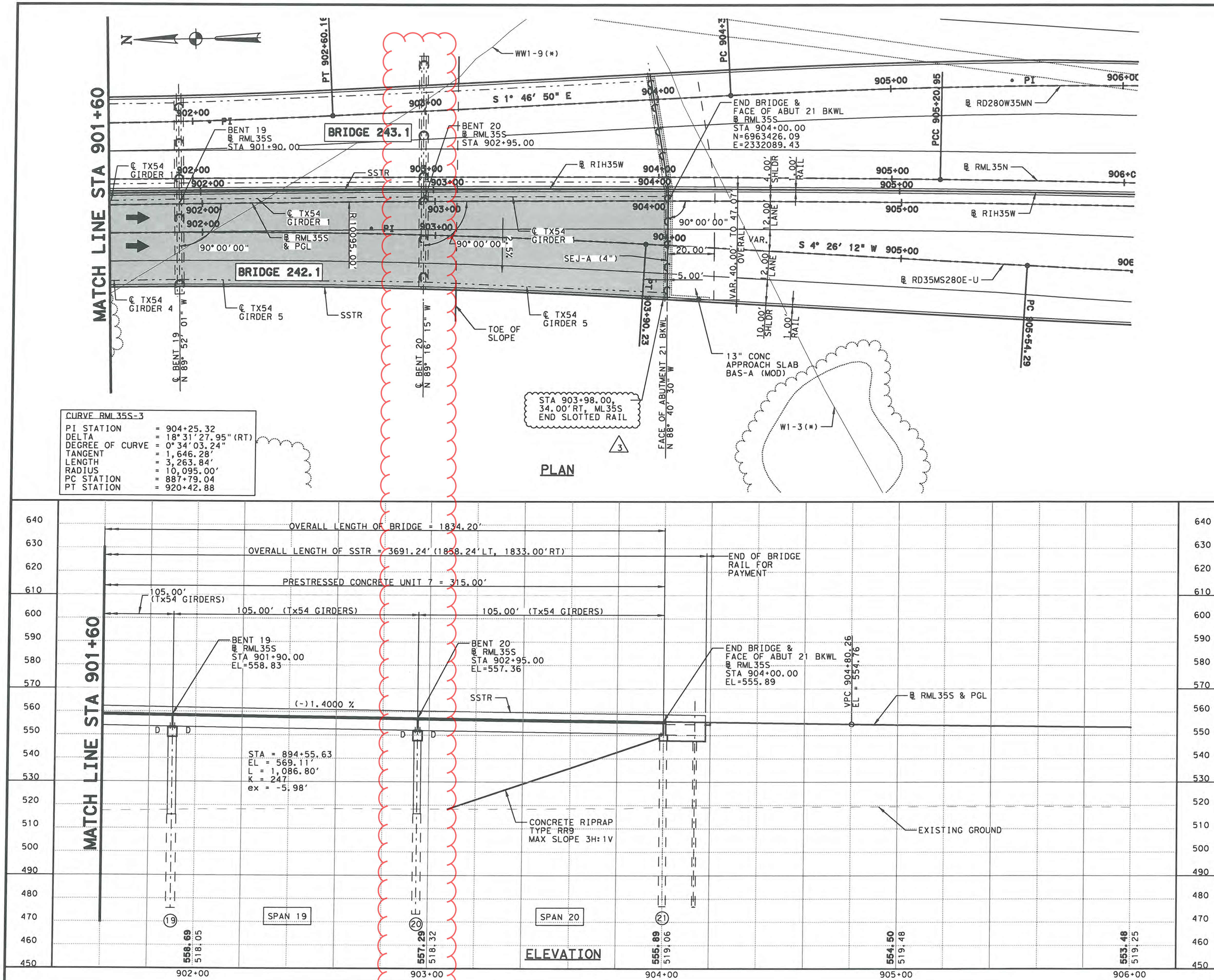
(26)

ANNEX 4.4 – CONFLICT 4



WWMH #58
RIM ELEV=521.73
10" FL(NE)=512.63
10" FL(S)= 512.53
WWMH #58A
RIM ELEV=521.58
42"FL(N)=524.88
42"FL(S)=510.94
INTERSTATE 35W
24" RCCP
CASING
402
SH 121
SH 121
871
TH 200
WW1-9 42"
TOP 523.28
DEPTH 7.8'
SDMH #89
RIM ELEV=522.77
STORM
WWMH #172
RIM ELEV=522.66
FL(N)=512.28
FL(S)=512.19
FL(W)=515.26
EXIST. R.O.W.

IFC	REV	DATE	BY	DESCRIPTION
0	0	03/04/2014	MC	AP02-S IFC
2	1	05/15/2014	MC	NDC S-004
8	2	09/15/2014	MC	NDC S-011
15	3	03/23/2015	MC	NDC S-029



CURVE RML35S-3	
PI STATION	= 904+25.32
DELTA	= 18°31'27.95" (RT)
DEGREE OF CURVE	= 0°34'03.24"
TANGENT	= 1,646.28'
LENGTH	= 3,263.84'
RADIUS	= 10,095.00'
PC STATION	= 887+79.04
PT STATION	= 920+42.88

NOTES:

1. DESIGNED IN ACCORDANCE WITH THE FA, TXDOT 2011 BRIDGE DESIGN MANUAL AND AASHTO LRFD BRIDGE SPECIFICATIONS, 5TH EDITION WITH ALL INTERIM SPECIFICATIONS FOR AN HL93 LOADING.
2. ALL CONSTRUCTION SHALL BE GOVERNED BY THE 2004 TXDOT STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MAINTENANCE OF HIGHWAYS, STREETS, AND BRIDGES.
3. CONTRACTOR SHALL LOCATE ALL UTILITIES PRIOR TO CONSTRUCTION AND INFORM ENGINEER OF ANY CONFLICTS.
4. CONTACT BILLY MANNING AT 817-370-6500, PRIOR TO TRENCHING OR DRILLING FOR EXISTENCE OF FIBER OPTICS.
5. ANY ULTIMATE ROADWAY CONDITIONS SHOWN ARE NOT PART OF THIS PROJECT. THEY ARE SHOWN FOR INFORMATION ONLY.
6. SEE DRAINAGE PLANS FOR BRIDGE DECK DRAIN LOCATIONS.
7. SEE TRAFFIC CONTROL PLANS FOR CONSTRUCTION SEQUENCING.
8. EXISTING UTILITY INFORMATION SHOWN IS BASED ON SUBSURFACE UTILITY ENGINEERING DATA, DATED NOV 07, 2013 AND SIGNED ON NOV 08, 2013 AND IS SUBJECT TO CHANGE. FINAL RELOCATED UTILITY LOCATIONS WILL BE SHOWN IN THE PROPOSED UTILITY LAYOUTS.
9. DESIGN INCLUDES ALLOWANCE FOR FUTURE UTILITIES LOAD OF 125 LBS/LF/12' LANE (125 LBS/LF/STRUCTURE ON DIRECT CONNECTORS).
10. REFER TO COLUMN DETAILS AND BENT DETAILS SHEETS FOR COLUMN HEIGHTS.

(*) INFORMATION AND LOCATION OF 48" WASTE WATER LINE WW1-9 AND 12" WATER LINE W1-3 WAS PROVIDED BY CONTRACTOR ON AUGUST 28, 2014 VIA EMAIL.

HL93 LOADING

STATE OF TEXAS
MANUEL A. CORREIA SANTOS
112763
LICENSED PROFESSIONAL ENGINEER
03/23/2015

©2015 ® Texas Department of Transportation

north tarrant express | segments 3

north tarrant infrastructure, llc

OTHON CONSULTING ENGINEERS
F-1471 HOUSTON · AUSTIN · DALLAS

Louis Berger DCE
F-12788

NORTH TARRANT EXPRESS - SEGMENT 3AS
Advanced Package 02

BRIDGE LAYOUT

BRIDGE 242.1

HORZ.: 1" = 40'
VERT.: 1" = 40'

SHEET 5 OF 5

FED. RD. DIV. NO.	FEDERAL AID PROJECT NO.		SHEET NO.
6	IM 0355(152)		BRG-104
STATE	DISTRICT	COUNTY	
TEXAS	FT. WORTH	TARRANT	
CONT	SECT	JOB	HIGHWAY NO
0014	16	179	IH35W

c:\pw_temp\dmsl2883\NTE3AS_BRDG_242_1_BL005.dgn
3/24/2015

RKI TEST HOLE NUMBER
LEVEL A INFORMATION

FINAL
1124

RABA KISTNER INFRASTRUCTURE

TEST HOLE DATA SHEET

Texas Department of Transportation

CSJ# 0014-16-266

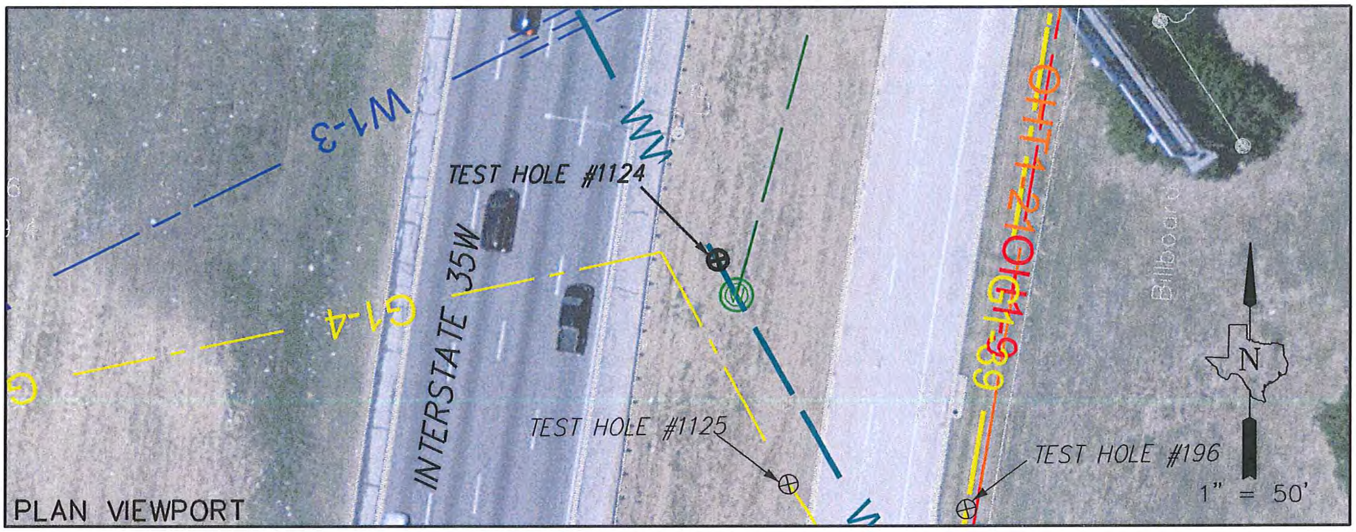
COUNTY TARRANT

LOCATION/ STATION I35W

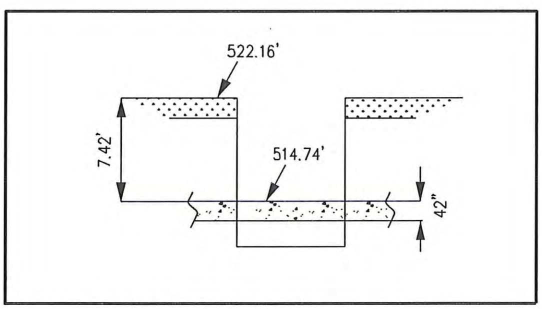
DATE OF FIELD WORK 10/03/13

UTILITY OWNER CITY OF FT. WORTH

DESCRIPTION OF TYPE WASTEWATER

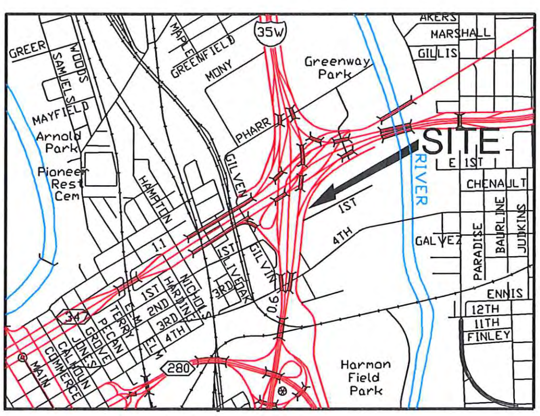


NORTHING	6963393.90	TEST HOLE DEPTH (FT)	7.42
EASTING	2332244.05	SOIL CLASSIFICATION	B
UTILITY WIDTH (FT) OR (IN)	42" PER RECORDS	PAVEMENT THICKNESS/TYPE	NA
UTILITY TOP ELEVATION	514.74	BASE THICKNESS/TYPE	NA
UTILITY BOTTOM ELEVATION	511.24	UTILITY MATERIAL	CONCRETE



PROFILE VIEWPORT

CONTROL POINT ID	2200117	ELEVATION	520.93
DESCRIPTION	PK NAIL SET		
NORTHING	6965357.29		
EASTING	2332274.43		
CONTROL POINT ID	2200118	ELEVATION	522.19
DESCRIPTION	MONUMENT SET		
NORTHING	6965002.86		
EASTING	2332901.51		



VICINITY MAP

Utilities in the drawings not performed by vacuum excavation are based on the mapping information compiled as of 10-28-13 and are depicted and defined per ASCE 38-02 as a SUE Quality Level B, C or D activity or combination thereof.

STATE OF TEXAS
TERRY L. MAY
59666
LICENSED PROFESSIONAL ENGINEER

MAY 07 2014

Appendix No. 5:

Design Alternatives

INDEX - APPENDIX NO. 5: DESIGN ALTERNATIVES

INDEX - FIGURE AND TABLE

5. Alternatives to consider

Due to the extension of the works there are many possibilities to consider. This appendix will review five different options considered feasible and suitable. Later a multi-criteria analysis will be made considering three main factors: Execution, functionality, social impact and economic cost. Note that final design may vary once chosen the appropriately alternative due to a more exhaustive study of the same.

This alternatives will try to find a solution to conflicts explained at appendix 4 “Conflict Analysis”. It is important to clarify that conflict 3 (At Greenway sewer system) has no alternative but to shorten the length of the pipe and install new manholes appropriately. Also the lateral relocation at Maple street, south of the southern crossing will be a constant on every alternative and its design won’t change as well. These designs can be found at the drawings and further explained at appendix 10 “Final Study of Alternatives”.

The geotechnical provisions to apply sheet piling can be found at appendix 7 “Geotechnical Study” which will be considered as well in the future multi-criteria analysis at appendix 10, “Final Study of Alternatives”. Other appendix studies done considered in appendix 10 till be appendix 8, “Hydrology” studying the de-watering option and appendix 9, “Structural analysis” studying the foundations of the manholes.

The designs must comply with TECQ regulations and City of Fort Worth specifications. The main restrictions will come through the grade analysis. All designs must comply with the table below:

Size of Pipe in Inches I.D.	Minimum Slope in percent	Maximum Slope in percent
8	0.4	8.4
10	0.29	6.23
12	0.22	4.88
15	0.16	3.62
18	0.12	2.83
21	0.09	2.3
24	0.08	1.93
27	0.06	1.64
30	0.055	1.43
33	0.05	1.26
36	0.045	1.12
39	0.04	1.01
>39	See Below	See Below

Table 1. Minimum and Maximum Grades for Wastewater Pipe (City Of Fort Worth Design Policies)

For lines larger than 39 inches in diameter (I.D.), the slope may be determined by the Manning's formula to maintain a minimum of 2.0 feet per second when flowing full and a maximum velocity less than ten feet per second when flowing full.

$$V = (\frac{1.49}{n})({R_h}^{0.67})(S^{0.5})$$

Where:

V = velocity (feet/second)

n = Manning's roughness coefficient (n = 0.13)

Rh = hydraulic radius (feet)

S = slope (feet/feet)

At the end of every alternative analysis a summary will be added to have an objective view of it. The criteria to do it so will be explained in every summary but all the grave geotechnical considerations of the area won't be accounted in **execution term** or **initial investment**.

5.1. Alternative 1: Follow existing alignment

This option will aim to follow and maintain existing flows and alignments as they are at the present time. At Annex 1 you can find an aerial picture with a self-explaining exhibit showing the proposed alignment. Variations of the same could be discussed as well as execution methods. The proposed sewer line runs along the existing line so it goes through the same city of Fort Worth 5' utility easement east of I-35W. This option is completely feasible, although costly. A pumping operation onto Greenfield Avenue sewerage must be used in such case and therefore considered afterward on our alternative analysis at appendix 6, "Preliminary Study Of Alternatives".

The picture below extracted from the drawings will help to better explain the analysis of this alternative:

5.1.1. North crossing relocation

Figure 1. North Crossing Relocation.

This alignment will relocate the south bound frontage road sewer line and the crossing itself within the same alignment.

TOTAL LENGTH: 1746.91 LF

Bore Length: 459.5 LF

Trench Length: 1287.41 LF

The bore is meant to go from Sta. 9+98.68 to Sta. 14+58.18 The rest can be done by an open trench. The feasibility of this option is obvious because it follows the existing alignment, but a study of grades and distances must be done on every design alternative.

There must be several restrictive points along the sewer line. Usually the start and the end of the line are restrictive but some connections to lateral sewer lines may act as restriction points as well. The minimum depth of any line is the minimum embedded material which is 12 inches.

The restriction points in this case are the following:

- **Starting point**: It won't be a restrictive point because is where starts a new sewer line and it can't be found under the lime extension package (15' from the back of the curb). Service connection can be done at 2 foot depth from the final alignment. If we check appendix 4, "Conflict Analysis", conflict 2 – Final grade profile we will be able to find what final grade will be on top of our initial point of this sewer line design. As per the picture below, Stationing respect the South Bound Frontage Road is 887+58.13 plus 28.12 LF. The final Station is: 887+86.76.

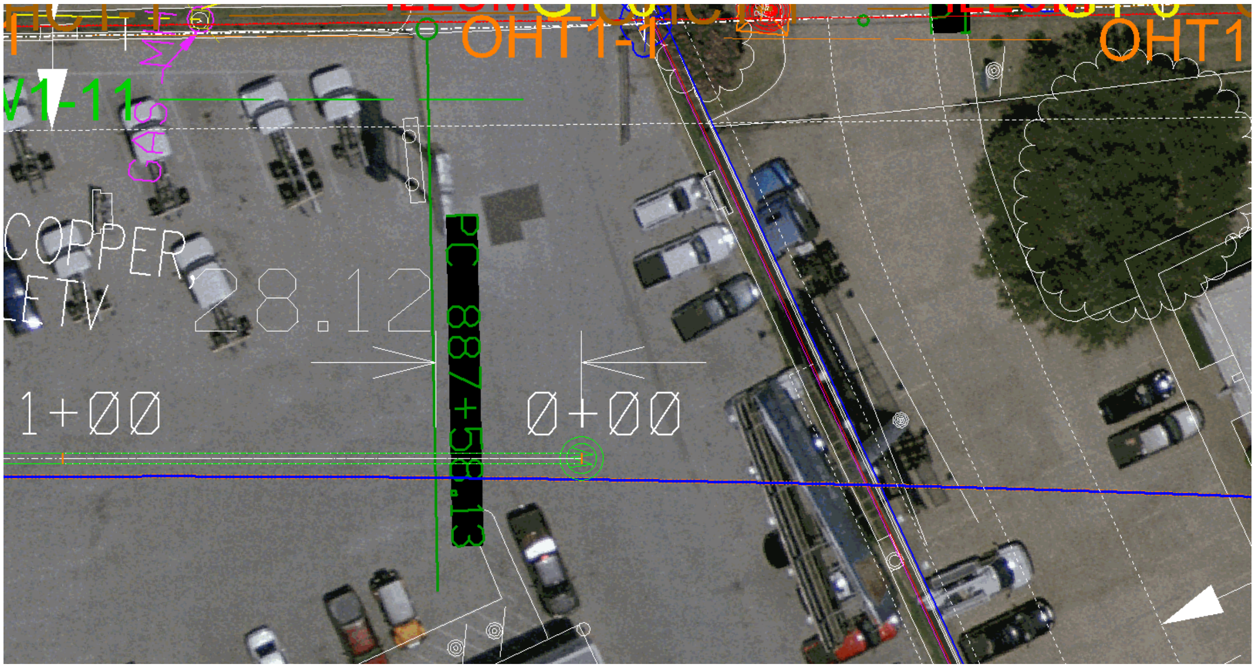


Figure 2. Detail - Initial Stationing respect SBFR Alignment.

The final grade at this very point will be 521'. Ergo, the minimum depth on top of the pipe will be 519'. The diameter of the pipe will be a changing factor, although this parameter will be constant.

- **Intermediate points**: There are two lateral sewer lines connecting to this main line.
    - *Mony Street Lateral Connection*: As per Record Drawing showed at appendix 4, "Conflict analysis", the tie in point can be extrapolated from the actual manhole elevation and the new tie-in point. Such distance (**89.39LF**) can be found in the picture below.

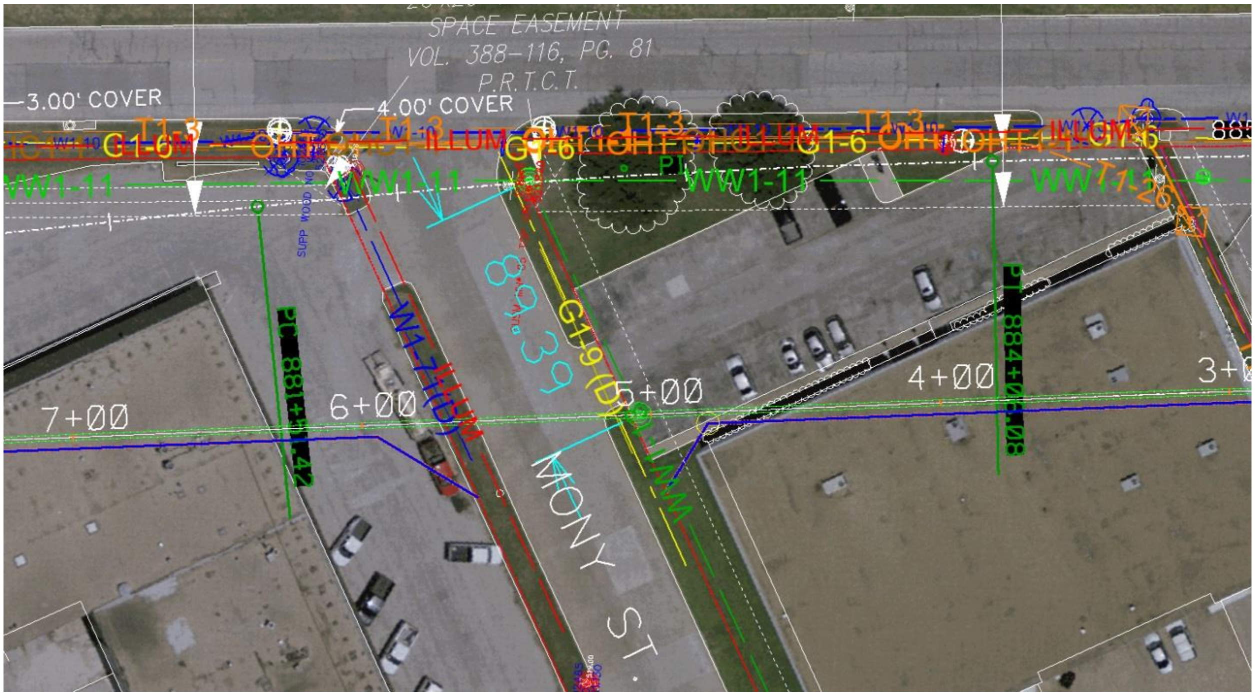


Figure 3. Detail - Distance from the existing Manhole connection at Mony w/ SBFR to proposed manhole.

The grade of Mony Street existing lateral sewer is 0.43% and the initial Flow line elevation at its deepest point is 512.50'. Therefore, the tie-in elevation at Sta. 5+04.4 of the proposed alignment will be 513.94'.

- *NBFR Lateral Connection*: This manhole will be replaced for a new one but the location won't change. The actual depth of this lateral at the connecting point is 511.30'. This manhole is at Station 14+58.4.

- **Final Connection:** The final connection for this proposed sewer line, at station 17+46.91 will be 508.80'.

The following Tables summarizes the prior analysis:

1.1.1. North crossing relocation		
Owner	**Facility Type**	**ID**
City of Fort Worth	Wastewater	1.1.1.1
City of Fort Worth	Wastewater	1.1.1.2
City of Fort Worth	Wastewater	1.1.1.3

Table 2. North Crossing Relocation - Sections ID.

1.1.1. North crossing relocation				
	Station			
Begin Node	**Begin**	**End**	**Distance (LF)**	**Diameter (FT)**
4' DIA WWMH	00+00.00	05+04.40	504.4	1.50
4' DIA WWMH	05+04.40	14+58.40	954.0	1.50
4' DIA WWMH	14+58.40	17+46.91	288.5	1.50

Table 3. North Crossing Relocation – Sections length and pipe diameter.

1.1.1. North crossing relocation				
Design		**Slope**	**Manning**	**Comments**
Out-Flow	**In-Flow**		**Speed**	
518.50	513.94	0.90%	5.67	Starting Point - Mony Lat
513.94	511.3	0.28%	3.14	Mony Lat - NBFR Lat
511.3	508.8	0.87%	5.55	NBFR Lat- End Point

Table 4. North Crossing Relocation - Gradient analysis (First approach)

A second approach must be done to give a more homogenous grading to all the proposed sewer line. As all restrictions are high points but the ending point which is a maximum and a minimum point (Cannot be changed). Due to this premises, our second approach to the sewer grading will be the following:

1.1.1. North crossing relocation				
Design		**Slope**	**Manning**	**Comments**
Out-Flow	**In-Flow**		**Speed**	
515.79	513.77	0.40%	3.77	Starting Point - Mony Lat
513.77	509.954	0.40%	3.77	Mony Lat - NBFR Lat
509.954	508.8	0.40%	3.77	NBFR Lat- End Point

Table 5. North Crossing Relocation - Gradient analysis (Second approach)

This second approach aims to have an average slope of 0.40% in all 3 sections. This will ease construction and the structural design of the proposed sewer line. With this final check, the North Crossing relocation following the original alignment is a feasible alternative to consider.

5.1.2. South crossing relocation

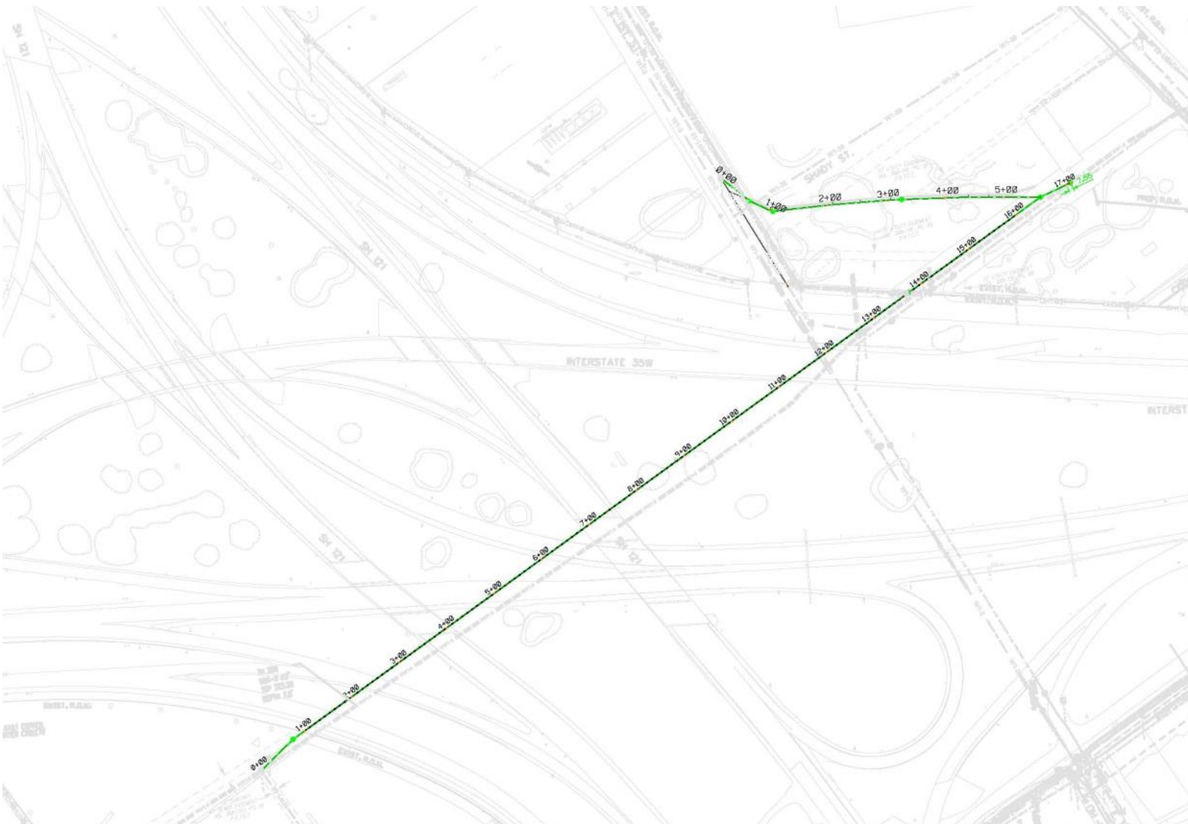


Figure 4. South Crossing Relocation.

This alignment will relocate the sewer line that runs southeast under the interstate I-35 interchange with Texas 121. and the crossing itself within the same alignment.

TOTAL LENGTH: 1707.55 LF

Bore Length: 1298.50 LF

Trench Length: 420.14 LF

The bore is meant to go from Sta. 0+75.64 to Sta. 13+74.14 The rest can be done by an open trench. The feasibility of this option is obvious because it follows the existing alignment as the north crossing did before, although study of grades and distances must be done on every design alternative as well.

In regards of the proposed lateral alignment south of the bore, as said at the beginning of this appendix, this relocation will be a constant on every alternatives so, on this section we will check the feasibility but it should be included (Which it won't be done) in every other alternative.

The restriction points in this case are the following:

- **Starting point**: Tie-in manhole south of Pharr street. There are 2 in-flow connections.
    - *North Connection:* Flow line level is at 512.21' coming from Pharr Street
    - *West Connection:* Flow line level is at 513.73'.

Figure 5. Detail - Initial manhole FL elevations.

- **Intermediate points**: There are no intermediate points in this case.
- **Final Connection:** There are no record drawings for this sewer line but the final tie-in flow line elevation can be found extrapolating the depth due to the grade between know manholes elevations. There are 2 manholes in this collector within 1269.87 LF:
    - *North Manhole elevation: 512.21'*
    - *South Manholes elevation: 511.06'*
    - *Gradient*: *0.09056%*
    - *Extrapolated final connection FL (at 434.66 LF from S. MH): 510.67'.*

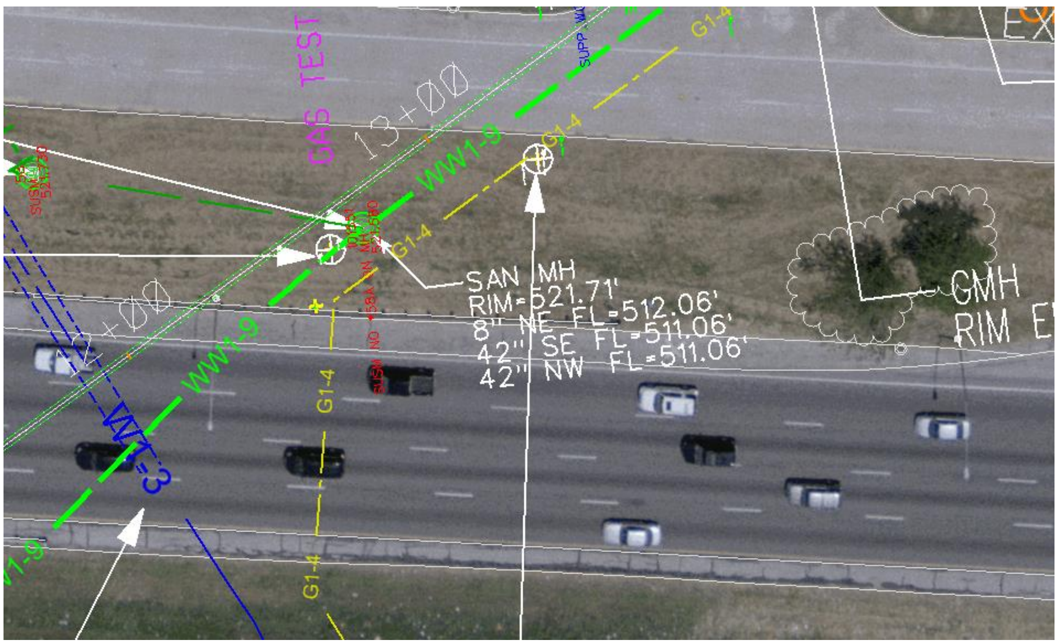


Figure 6. Detail - Intermediate existing Manhole flow lines to extrapolate south tie-in elevation.

The following Tables summarizes the prior analysis:

1.1.2. South crossing relocation		
Owner	**Facility Type**	**ID**
City of Fort Worth	Wastewater	1.1.2.1

Table 6. South Crossing Relocation - Sections ID.

1.1.2. South crossing relocation				
	Station			
Begin Node	Begin	End	Distance (LF)	Diameter (FT)
4' DIA WWMH	00+00.00	17+07.55	1707.6	3.50

Table 7. South Crossing Relocation – Sections length and pipe diameter (First approach).

1.1.2. South crossing relocation				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
512.21	510.67	0.09%	3.15	Starting Point - End Point

Table 8. South Crossing Relocation - Gradient analysis (First approach)

As we can see, on this first approach, we have used the same diameter as the existing pipe (42") giving us an speed 1.15 LF/S over the minimum. In order to reduce installation and material costs, we should reduce the diameter of the same. As specified at appendix 1, "Actual State", this old collector it's has a lower income as it used to have. A great amount of the water that used to go through it now goes to the Lift Station at Greenway Neighborhood. Now the pipe could be up to 12" in diameter. But, as table 1 states, at a 0.09% grade, a minimum 21" pipe must be installed. The analysis will look as it follows:

1.1.2. South crossing relocation				
	Station			
Begin Node	Begin	End	Distance (LF)	Diameter (FT)
4' DIA WWMH	00+00.00	17+07.55	1707.6	1.75

Table 9. South Crossing Relocation – Sections length and pipe diameter (Second approach).

1.1.2. South crossing relocation				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
512.21	510.67	0.09%	1.98	Starting Point - End Point

Table 10. South Crossing Relocation - Gradient analysis (Second approach)

This second approach shows that a 21" diameter pipe at 0.09% has, even though approved by city of Fort Worth, an speed lower than 2 FT/S. As long as the city agrees with it, we can keep on with the design of such alternative but, because it is at the very limit, any error during the construction could make the awarded contractor to re-install a portion or the whole line again. Probably a higher diameter should be used. Also, such small slope and speed leads to a continuous problems on pipe maintenance.

Once designed the alignment, length and grades, the following analysis must be done to set this alternatives comparable with the following ones:

5.1.3. Summary - Alternative 1

Execution:

- Execution Term:

  The execution depends primarily on the alternative length and if it is a done by bore or not. The average pace for a bore, up to my experience on this field is around 25LF/day. The trenching pace will be, on the conservative side, 75 LF/day. This paces will be affected due to the geotechnical provisions taken in account in the final alignment decision.

  Execution of Alternative 1 will last 93.22 working days. This is a total of 4 months and a half.

- Earth Hauled off-site:

  This value will vary depending on if it is a bore or not and obviously the size of the pipe.

  Earth Hauled off-site due to bores: 151.67 CY

  Earth Hauled off-site due to trench embedment: 802.92 CY

  Total Earth Hauled off-site of Alternative 1 is 954.59 CY

Functionality:

- Population Adjustment:

  The area of influence of such sewer system won't be able to grow unless an structural change on the city of Fort Worth happens. Also, to accommodate the grade the pipe size is already oversized so there will be a great population adjustment.

  Population adjustment of Alternative 1: High

- Maintenance Cost:

  On the other hand, the bigger the pipe and an slow flow pace will lead to a higher maintenance cost due to solids accumulation and dam formations. This cost is proportional to the length of the pipe considered. The Hunter Water Corporation "Operating and Maintenance Cost Estimating Guideline" (2013), states that the annual network operation and maintenance cost for a gravity main sewer is calculated as shown below:

$$Cost = \$2872 - 28.702 * DN + 0.0472 * DN^2 * L$$

Where:

- DN – Pipe nominal diameter (inch)
- L – pipeline length (feet)

Maintenance Cost of Alternative 1 = $29,076.5 (North Crossing) + $38,049.09 (South Crossing) = $67,125.59

Environmental Impact:

On the environmental impact we will consider the length and the easements crossed by the pipe. Both of them are related directly to the debris, erosion soil and spoils related to the construction. The longer the construction, the higher the environmental impact. Also, if the construction is done in an easement, it usually is located between businesses or residential areas that will be affected in a greater measure than the normal construction on the street. Only trenching length will be considered in this case.

- <u>Length:</u>

  Total Trench Length of Alternative 1 = 1,717.55 LF

- <u>Easement:</u>

  Easements crossed by Alternative 1 = 1 Parcel

- <u>Social Impact:</u>

  This impact will be considered among the linear footage that the works affects to existing roads and streets. A industrial Street will have a factor of 1 and a residential on a factor of 0.8 on the footage.

  Total LF of Alternative 1 performed in a road = 0.00 LF

Economical Cost:

The Economical cost will be purely due to the length of the pipe installed which price varies depending on the depth and pipe diameter. This is an approximate budget and a more exhaustive one will be done with the final alignment elected. 5' diameter manholes will be set every 300' (at a price of $5,000.00).

Bores with a 24" steel casing prices are around $600.00 plus the carrier pipe which will be $125.00.

18" pipe installation, as per my experience, in an area with loose sands is $185.00. **21" pipe** installation cost $215.00.

Economical Cost of Alternative 1 = $1,611,210.00 (Cost Doesn't include Geotechnical provision and actions)

5.2. Alternative 2: Delete S. Crossing and Follow existing north alignment

This option looks to eliminate the south bore which has a great cost to the sewer relocation. Although keeps in place the north crossing as it is right now (extended up to the new Right Of Way).

Figure 7. North Crossing relocation deleting the southern crossing.

TOTAL LENGTH: 3172.75 LF

Bore Length: 459.5 LF

Trench Length: 2713.25 LF

The bore is meant to go from Sta. 24+06.47 to Sta. 28+65.97. The rest can be done by an open trench. The feasibility of this option depends in great measure of the flow line at the very beginning of the line. Referring to figure 5, we will focus on the western in-flow flow line elevation, it is the determining starting flow line.

The restriction points/elevations in this case can be found below:

- **Starting point**: As said before, Our very initial point will be the first Manhole through its western in-flow elevation checked on the south crossing relocation alternative (Figure 5). At station 0+00, the elevation must be 513.73'.

- **Intermediate points**: There are three lateral sewer lines connecting to this main line.

    - Pharr street: At station 3+78.79, our main line must connect to the prior main collector that we are deleting. The elevation of the same can be found as done before: extrapolating the elevation using 2 know elevations. In this case, both manholes surrounding such tie-in point. This calculus has no purpose itself because we are reverting the flow from the lowest point, so any point located north of it will have a highest point, which in this case is: 514.70'. Clearly less restrictive than the initial point as expected.
      (The grade between manholes is 2.5%)

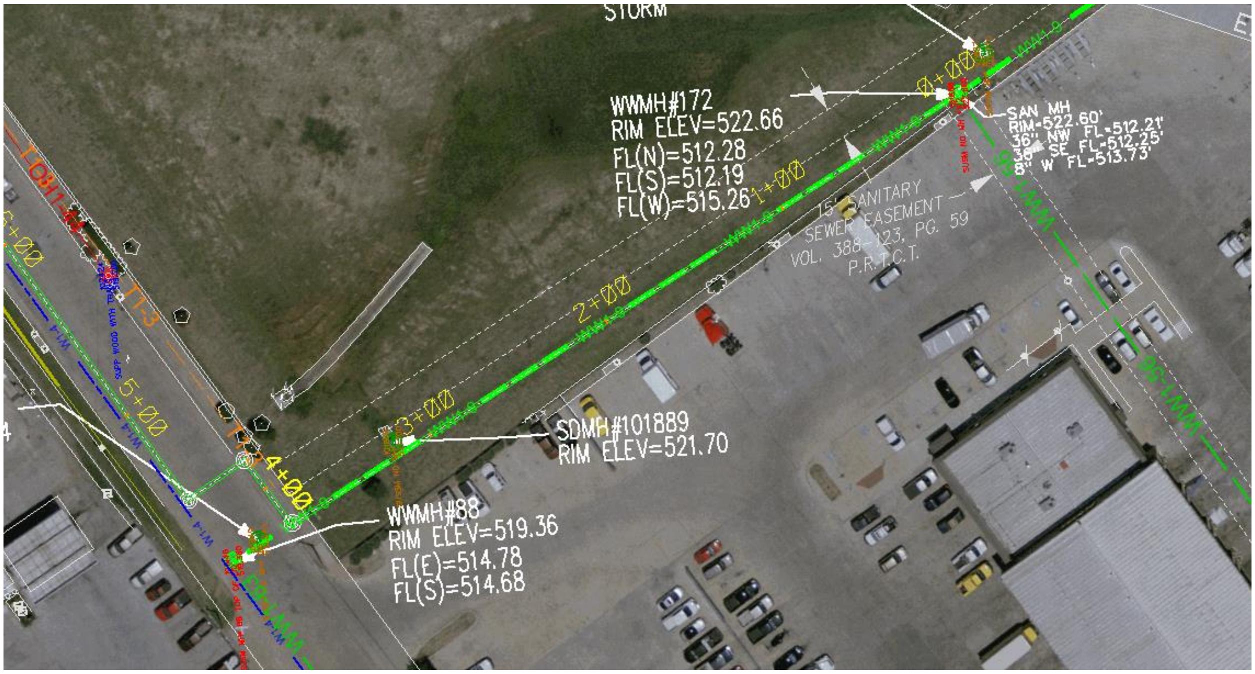


Figure 8. Detail - Lateral connection at Pharr street.

- *Mony Street Lateral Connection*: As explained in the first alternative analysis, the maximum elevation at Mony street can be: 513.94'. the station at this point is: 19+13.83.

- *NBFR Lateral Connection*: Also, as explained before, this manhole will be replaced for a new one but the location won't change. The actual depth of this lateral at the connecting point is 511.30'. This manhole is at Station 28+66.05.

- **Final Connection:** The final connection for this proposed sewer line, at station 31+72.75 will be 508.80'.

The following Tables summarizes the prior analysis, although we won't consider the lateral at Pharr street because it isn't a restrictive point:

1.2. North crossing + Deleting south crossing		
Owner	**Facility Type**	**ID**
City of Fort Worth	Wastewater	1.2.1
City of Fort Worth	Wastewater	1.2.2
City of Fort Worth	Wastewater	1.2.3

Table 11. North crossing + Deleting south crossing Relocation - Sections ID.

1.2. North crossing + Deleting south crossing				
	Station			
Begin Node	**Begin**	**End**	**Distance (LF)**	**Diameter (FT)**
4' DIA WWMH	00+00.00	19+13.83	1913.8	1.00
4' DIA WWMH	19+13.83	28+66.05	952.2	1.00
4' DIA WWMH	28+66.05	31+72.75	306.7	1.00

Table 12. North crossing + Deleting south crossing Relocation – Sections length and pipe diameter. (First approach)

1.2. North crossing + Deleting south crossing				
Design			Manning	
Out-Flow	**In-Flow**	**Slope**	**Speed**	**Comments**
513.73	513.94	0.01%	0.48	Starting Point - Mony lateral
513.94	511.3	0.28%	2.39	Mony Lat - NBFR Lat
511.3	508.8	0.82%	4.11	NBFR Lat- End Point

Table 13. North crossing + Deleting south crossing Relocation - Gradient analysis (First approach)

1.2. North crossing + Deleting south crossing				
	Station			
Begin Node	**Begin**	**End**	**Distance (LF)**	**Diameter (FT)**
4' DIA WWMH	00+00.00	19+13.83	1913.8	1.50
4' DIA WWMH	19+13.83	28+66.05	952.2	1.50
4' DIA WWMH	28+66.05	31+72.75	306.7	1.50

Table 14. North crossing + Deleting south crossing Relocation – Sections length and pipe diameter. (Second approach)

1.2. North crossing + Deleting south crossing				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
513.73	510.5625	0.17%	2.42	Starting Point - Mony lateral
510.5625	509.2294	0.14%	2.23	Mony Lat - NBFR Lat
509.2294	508.8	0.14%	2.23	NBFR Lat- End Point

Table 15. North crossing + Deleting south crossing Relocation - Gradient analysis (Second approach)

As it can be appreciated, on table 14 there is a different diameter chosen to make this alternative feasible. A minimum of 18" diameter is necessary to build this relocation. Although, once chosen such diameter, construction shouldn't have any problem installation wise.

With this we finalize the initial design of alternative 2.

5.2.1. Summary - Alternative 2

Execution:

- Execution Term:

As explained on alternative 1, the execution depends primarily on the alternative length and if it is a done by bore or not. The average pace for a bore, up to my experience on this field is around 25LF/day. The trenching pace will be, on the conservative side, 75 LF/day. This paces will be affected due to the geotechnical provisions taken in account in the final alignment decision.

Execution of Alternative 2 will last 54.56 working days. This is a total of 2 months and 3 weeks.

- Earth Hauled off-site:

This value will vary depending on if it is a bore or not and obviously the size of the pipe.

Earth Hauled off-site due to bores: 72.77 CY

Earth Hauled off-site due to trench embedment: 1231.01 CY

Total Earth Hauled off-site of Alternative 2 is 1303.78 CY

Functionality:

- Population Adjustment:

The area of influence of such sewer system won't be able to grow unless an structural change on the city of Fort Worth happens. Also, to accommodate the grade the pipe size is already oversized so there will be a great population adjustment.

Population adjustment of Alternative 2: High

- Maintenance Cost:

The maintenance cost will be the following:

$$Cost = \$2872 - 28.702 * DN + 0.0472 * DN^2 * L$$

Where:

- DN – Pipe nominal diameter (inch)
- L – pipeline length (feet)

Maintenance Cost of Alternative 2 = $50875.59

Environmental Impact:

Only trenching length will be considered in the environmental impact.

- Length:

Total Trench Length of Alternative 2 = 2713.25 LF

- Easements:

Easements crossed by Alternative 2 = 2 Parcels

- Social Impact:

This impact will be considered among the linear footage that the works affects to existing roads and streets. A industrial Street will have a factor of 1 and a residential on a factor of 0.8 on the footage.

Total LF of Alternative 2 performed in a road = 330.00 LF

Economical Cost:

The Economical cost will be purely due to the length of the pipe installed which price varies depending on the depth and pipe diameter. This is an approximate budget and a more exhaustive one will be done with the final alignment elected. 5' diameter manholes will be set every 300' (at a price of $5,000.00).

Bores with a 24" steel casing prices are around $600.00 plus the carrier pipe which will be $125.00.

18" pipe installation, as per my experience, in an area with loose sands is $185.00.

Economical Cost of Alternative 2 = $885,309.58

(Cost Doesn't include Geotechnical provision and actions)

5.3. Alternative 3: New Alignment through Mony Street

The third alternative and the following ones has its fundamentals by deleting both existing crossings so no bores needs to be done. As we will see right away, these alternatives will redirect the existing flow of Pharr street and Mony street area towards Greenway Neighborhood Lift Station. The capacity of such lift station will be studied at appendix 11.

This alternative looks as follows:

Figure 9. New Alignment through Mony Street.

TOTAL LENGTH: 3056.86 LF

Bore Length: 0 LF

Trench Length: 3056.86 LF

- *Main Distance*: 2618.97 LF

- *Lateral North of Mony Street*: 437.89 LF

Let's consider now all restrictive points in regards of this alternative as done on the previous cases:

- **Starting point**: the beginning point of this alternative will be the first Manhole through its western in-flow elevation. It will be the same as alternative 2. At station 0+00, the elevation must be 513.73' as well.
- **Intermediate points**: There are two lateral sewer lines connecting to this main line.
  - Pharr street: We won't consider this connection point as it isn't restrictive at all. Its stationing is 3+78.79.
  - *North of Mony Street Lateral Connection*: In this alternative, a whole new line is aimed to be built with a reverse flow at Mony street. The lateral tie-in coming from the SBFR north of Mony, as it is a newly constructed sewerage, it will not be a restrictive point.
- **Final Connection:** The final connection for this proposed sewer line, at station 26+18.97 of the main sewer can be two different elevations. On the next page, a detail of the existing sewer that heads north at alternative 3 final tie-in point, shows that the flow going north at the southern manholes is 516.50'. Although 30 LF heading north there is a drop manholes to 508.40'. As we can see at first sight, elevation 516.50 is already too high so the extra 30LF must be considered if this design is the final one.

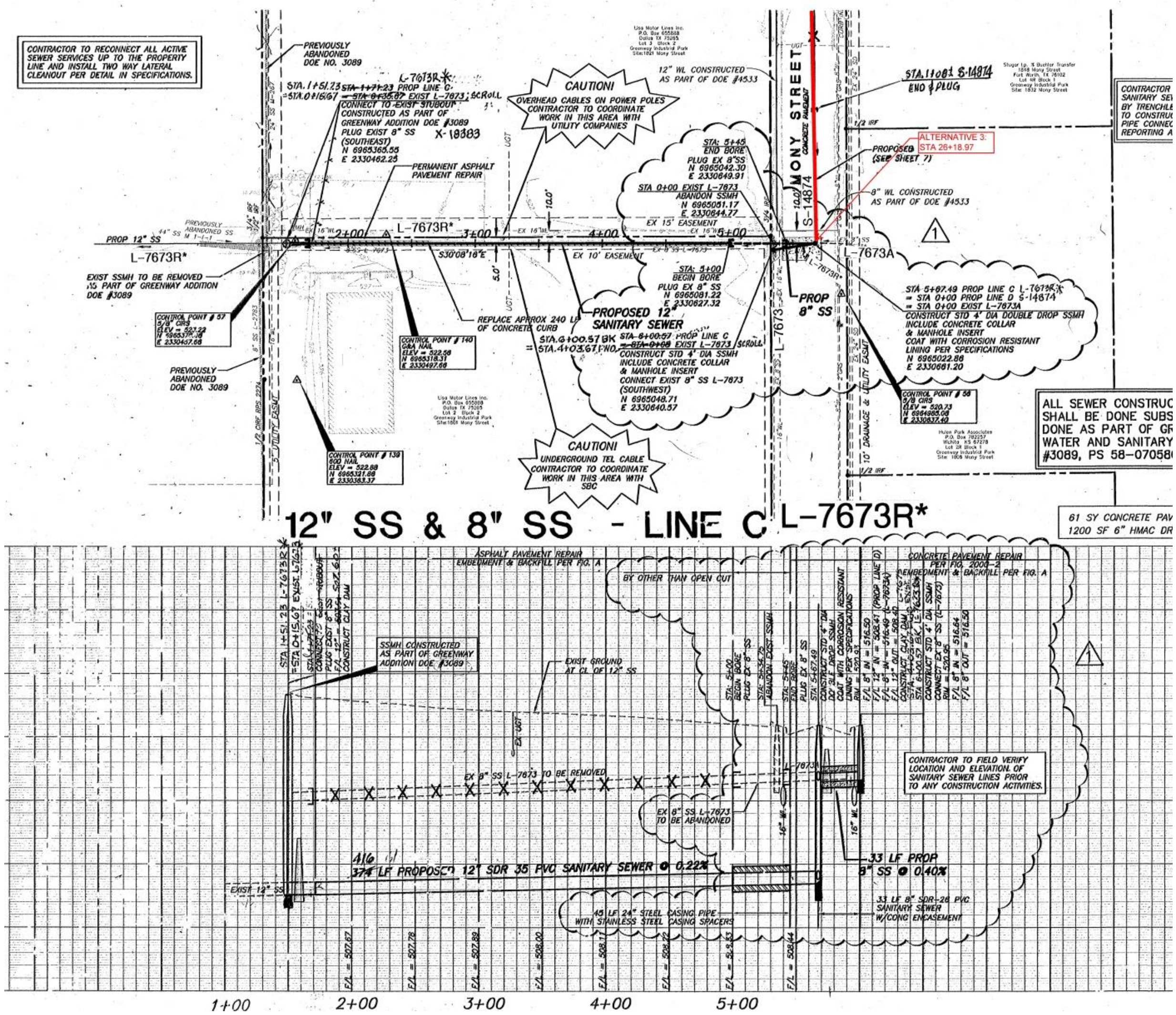


Figure 10. Connection between Pharr/Mony area with Greenway Neighborhood sewer records.

The following Tables summarizes the prior analysis:

1.3. New Alignment through Mony Street		
Owner	**Facility Type**	**ID**
City of Fort Worth	Wastewater	1.3.1

Table 16. New Alignment through Mony Street Relocation - Sections ID.

1.3. New Alignment through Mony Street				
	Station			
Begin Node	Begin	End	Distance (LF)	Diameter (FT)
4' DIA WWMH	00+00.00	26+18.97	2619.0	1.50

Table 17. New Alignment through Mony Street Relocation – Sections length and pipe diameter.

1.3. New Alignment through Mony Street				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
513.73	508.4	0.20%	2.69	Starting Point - End Point

Table 18. New Alignment through Mony Street Relocation - Gradient analysis (First approach)

If we insert directly our boundary conditions, we obtain an slope 8 points higher than what the city of Fort Worth asks for. Therefore, in our second approach, a lower grade up to 0.16% (Even though we can get up to 0.12% as per city of Fort Worth specifications) will be set to obtain a higher tie-in point making easier to build this alternative 3.

1.3. New Alignment through Mony Street				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
513.73	509.5397	0.16%	2.38	Starting Point - End Point

Table 19. New Alignment through Mony Street Relocation - Gradient analysis (Second approach)

As expected, our new In-flow elevation at our final tie-in point will be 1.14' higher than the previous approach. This conservative slope should be consider to avoid the problems commented on alternative 2. The lower the grade is, the harder to build it gets.

5.3.1. Summary - Alternative 3

Execution:

- Execution Term:

The average pace for a bore, up to my experience on this field is around 25LF/day. The trenching pace will be, on the conservative side, 75 LF/day. This paces will be affected due to the geotechnical provisions taken in account in the final alignment decision.

Execution of Alternative 3 will last 40.75 working days. This is a total of 2 months.

- Earth Hauled off-site:

Total Earth Hauled off-site of Alternative 3 is 1386.91 CY

Functionality:

- Population Adjustment:

The area of influence of such sewer system won't be able to grow unless an structural change on the city of Fort Worth happens. Also, to accommodate the grade the pipe size is already oversized so there will be a great population adjustment.

Population adjustment of Alternative 3: High

- Maintenance Cost:

The maintenance cost will be the following:

$$Cost = \$2872 - 28.702 * DN + 0.0472 * DN^2 * L$$

Where:

- DN – Pipe nominal diameter (inch)
- L – pipeline length (feet)

Maintenance Cost of Alternative 3 = $49,103.00

Environmental Impact:

Only trenching length will be considered in the environmental impact.

- Length:

Total Trench Length of Alternative 3 = 3056.86 LF

- Easements:

Easements crossed by Alternative 3 = 1 Parcels

- Social Impact:

This impact will be considered among the linear footage that the works affects to existing roads and streets. A industrial Street will have a factor of 1 and a residential on a factor of 0.8 on the footage.

Total LF of Alternative 3 performed in a road = 1,053.00 LF

Economical Cost:

The Economical cost will be purely due to the length of the pipe installed which price varies depending on the depth and pipe diameter. This is an approximate budget and a more exhaustive one will be done with the final alignment elected. 5' diameter manholes will be set every 300' (at a price of $5,000.00).

18" pipe installation, as per my experience, in an area with loose sands is $185.00.

Economical Cost of Alternative 3 = $621,466.77 (Cost Doesn't include Geotechnical provision and actions)

5.4. Alternative 4: New Alignment through Greenfield Ave

This alignment has no lateral and looks forward to leave in place the existing Mony Street sewer as it is right now so no extra works in there and its consequential street repair needs to be done.

The only two laterals for this conflict will be Pharr street (Non-restrictive) and Mony Street. Please find below the alignment of the considered alternative:

Figure 11. New Alignment through Greenfield Ave.

TOTAL LENGTH: 2725.13 LF

Bore Length: 0 LF

Trench Length: 2725.13 LF

With this disclosure, the boundary conditions will be the following.

- **Starting point**: Again, our very initial point will be the first Manhole through its western in-flow elevation. At station 0+00, the elevation must be 513.73'.

- **Intermediate points**: There are two lateral sewer lines connecting to this main line.

    - Pharr street: At station 3+78.79, with an elevation once again of 514.70', it is not a boundary and won't be take into consideration in this alternative.

    - *Mony Street Lateral Connection*: As explained in the earliest alternatives analysis, the maximum elevation at Mony street can be: 513.94'. the station at this point is: 19+13.83.

- **Final Connection:** The final connection for this proposed sewer line, at Greenfield Avenue (station 27+25.13) will be 510.00'. Please take a look to the detail below for more information.

Figure 12. Detail - End connection at Greenfield Avenue.

All this information is showed analyzed on the following tables:

1.4. New Alignment through Greenfield Avenue		
Owner	**Facility Type**	**ID**
City of Fort Worth	Wastewater	1.4.1
City of Fort Worth	Wastewater	1.4.2

Table 20. New Alignment through Greenfield Avenue Relocation - Sections ID.

1.4. New Alignment through Greenfield Avenue				
	Station			
Begin Node	**Begin**	**End**	**Distance (LF)**	**Diameter (FT)**
4' DIA WWMH	00+00.00	19+13.83	1913.8	1.50
4' DIA WWMH	19+13.83	27+25.13	811.3	1.50

Table 21. New Alignment through Greenfield Avenue Relocation – Sections length and pipe diameter.

1.4. New Alignment through Greenfield Avenue				
Design			**Manning**	
Out-Flow	**In-Flow**	**Slope**	**Speed**	**Comments**
513.73	509.5397	0.22%	2.79	Starting Point - Mony Lat
510.5625	510	0.07%	1.57	Mony Lat - End Point

Table 22. New Alignment through Greenfield Avenue Relocation - Gradient analysis (First approach)

On our second approach we will need to fix the slope between station 19+13.83 and 27+25.13. As per right now, it isn't in compliance with TCEQ regulations nor City of Fort Worth specification. We will have to lower Mony street lateral conection with a drop manhole to make this work. In this alternative, due to its low grading we will have to aim to a grade less conservative than alternative 3 which was 0.16%. In this case it will be 0.14% as it is shown in table below.

1.4. New Alignment through Greenfield Avenue				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
513.73	511.1358	0.14%	2.19	Starting Point - Mony Lat
511.1358	510	0.14%	2.23	Mony Lat - End Point

Table 23. New Alignment through Greenfield Avenue Relocation - Gradient analysis (Second approach)

With an slope of 0.14% we will meet al rules and regulations and we will have an homogeneous grade throughout all the proposed sewer line.

5.4.1. Summary - Alternative 4

Execution:

- Execution Term:

  The average pace for a bore, up to my experience on this field is around 25LF/day. The trenching pace will be, on the conservative side, 75 LF/day. This paces will be affected due to the geotechnical provisions taken in account in the final alignment decision.

  Execution of Alternative 4 will last 36.34 working days. This is a total of 1 month and 3 weeks.

- Earth Hauled off-site:

  Total Earth Hauled off-site of Alternative 4 is 1236.40 CY

Functionality:

- Population Adjustment:

  The area of influence of such sewer system won't be able to grow unless an structural change on the city of Fort Worth happens. Also, to accommodate the grade the pipe size is already oversized so there will be a great population adjustment.

  Population adjustment of Alternative 4: High

- Maintenance Cost:

  The maintenance cost will be the following:

$$Cost = \$2872 - 28.702 * DN + 0.0472 * DN^2 * L$$

  Where:

  - DN – Pipe nominal diameter (inch)
  - L – pipeline length (feet)

Maintenance Cost of Alternative 4 = $44,030.23

Environmental Impact:

Only trenching length will be considered in the environmental impact.

- <u>Length:</u>

  Total Trench Length of Alternative 4 = 2725.13 LF

- <u>Easements:</u>

  Easements crossed by Alternative 4 = 1 Parcels

- <u>Social Impact:</u>

  This impact will be considered among the linear footage that the works affects to existing roads and streets. A industrial Street will have a factor of 1 and a residential on a factor of 0.8 on the footage.

  Total LF of Alternative 3 performed in a road = 511.78 LF

Economical Cost:

The Economical cost will be purely due to the length of the pipe installed which price varies depending on the depth and pipe diameter. This is an approximate budget and a more exhaustive one will be done with the final alignment elected. 5' diameter manholes will be set every 300' (at a price of $5,000.00).

18" pipe installation, as per my experience, in an area with loose sands is $185.00.

Economical Cost of Alternative 4 = $554,567.00 (Cost Doesn't include Geotechnical provision and actions)

5.5. Alternative 5: New Alignment through Greenfield Ave and Pharr Street

This last, but not least, alternative aims to avoid the connection from Pharr street up to Greenfield Avenue leading a new whole sewer line though Pharr street and then Mony street.

Figure 13. New Alignment through Greenfield Ave and Pharr Street.

5.5.1. Greenfield Avenue relocation

TOTAL LENGTH: 1217.81 LF

Bore Length: 0 LF

Trench Length: 1217.81 LF

The restriction points in this case are the following:

- **Starting point**: the beginning point of this alternative will be the first Manhole through its western in-flow elevation. It will be the same as alternative 2. At station 0+00, the elevation must be 513.73'.

- **Intermediate points**: There is only the Mony street lateral sewer line connecting to this main line.

  Mony Street Lateral Connection: As per Record Drawing showed at appendix 4, "Conflict analysis", the tie in point can be extrapolated from the actual manhole elevation and the new tie-in point already done in the analysis of alternative 1. The elevation at Sta. 4+03.63 of the proposed alignment will be 513.94'.

- **Final Connection:** The final connection for this proposed sewer line is located at Greenfield Ave, at station 12+17.81 and the elevation will be 510.00'.

The following Tables summarizes the prior analysis:

1.5.1. New Alignment through Greenfield Ave and Pharr Street		
Owner	**Facility Type**	**ID**
City of Fort Worth	Wastewater	1.5.1.1
City of Fort Worth	Wastewater	1.5.1.2

Table 24. New Alignment through Greenfield Ave and Pharr Street Relocation (1) - Sections ID.

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
	Station			
Begin Node	**Begin**	**End**	**Distance (LF)**	**Diameter (FT)**
4' DIA WWMH	00+00.00	04+03.63	403.6	1.50
4' DIA WWMH	04+03.63	12+17.81	814.2	1.50

Table 25. New Alignment through Greenfield Ave and Pharr Street Relocation (1) – Sections length and pipe diameter. (First approach)

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
518.50	513.94	1.13%	6.34	Starting Point - Mony Lat
513.94	510	0.48%	4.15	Mony Lat - End Point

Table 26. New Alignment through Greenfield Ave and Pharr Street Relocation (1) - Gradient analysis (First approach)

As we can see above, there is a lot of slack while designing this small main sewer line. We can drastically reduce the diameter of the pipe even up to 6” but we will keep it at 10” so it can work accordingly with the volume of service it has to offer.

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
Begin Node	Station		Distance (LF)	Diameter (FT)
	Begin	End		
4' DIA WWMH	00+00.00	04+03.63	403.6	0.83
4' DIA WWMH	04+03.63	12+17.81	814.2	0.83

Table 27. New Alignment through Greenfield Ave and Pharr Street Relocation (1) – Sections length and pipe diameter. (Second approach)

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
Design		Slope	Manning	Comments
Out-Flow	In-Flow		Speed	
514.26	512.8496	0.35%	2.38	Starting Point - Mony Lat
512.8496	510	0.35%	2.38	Mony Lat - End Point

Table 28. New Alignment through Greenfield Ave and Pharr Street Relocation (1) - Gradient analysis (Second approach)

5.5.2. Pharr Street - Mony relocation

TOTAL LENGTH: 2700.00 LF

Bore Length: 0 LF

Trench Length: 2700.00 LF

This length may be excessive. If this line at station 21+33.06 matches as it did alternative 3 at Mony street with the greenfield sewer connection, the new length of this alternative will be 2133.06 LF instead.

Therefore our first approach will be at this shorter distance. In this alternative there are no laterals apart from the Pharr one which we already discarded as boundary one. So we will only check start and end boundaries.

- **Starting point**: the beginning point of this alternative will be the first Manhole through its western in-flow elevation. It will be the same as alternative 2, 3 and 4. At station 0+00, the elevation must be 513.73'.
- **Intermediate points**: There is no restrictive intermediate point.
- **Final Connection:** The final connection for this proposed sewer line, at station 21+33. 06 of the main sewer must be 508.40'.

The following tables will explain summarize all the grade design.

1.5.1. New Alignment through Greenfield Ave and Pharr Street		
Owner	**Facility Type**	**ID**
City of Fort Worth	Wastewater	1.5.2.1

Table 29. New Alignment through Greenfield Ave and Pharr Street Relocation (2) - Sections ID.

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
	Station			
Begin Node	**Begin**	**End**	**Distance (LF)**	**Diameter (FT)**
4' DIA WWMH	00+00.00	21+33.06	2133.1	1.50

Table 30. New Alignment through Greenfield Ave and Pharr Street Relocation (2) – Sections length and pipe diameter. (First approach)

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
Design		**Slope**	**Manning**	**Comments**
Out-Flow	**In-Flow**		**Speed**	
513.73	508.4	0.25%	2.98	Starting Point - End Point

Table 31. New Alignment through Greenfield Ave and Pharr Street Relocation (2) - Gradient analysis (First approach)

There is plenty of grade to play with within this alignment. Therefore we should tight he results and make the pipe smaller down to 12" diameter. This reduction will give us a more economic pipe and an easier construction. Depth boundaries, in this case, will remain as it is right now.

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
	Station			
Begin Node	**Begin**	**End**	**Distance (LF)**	**Diameter (FT)**
4' DIA WWMH	00+00.00	21+33.06	2133.1	1.00

Table 32. New Alignment through Greenfield Ave and Pharr Street Relocation (2) – Sections length and pipe diameter. (Second approach)

1.5.1. New Alignment through Greenfield Ave and Pharr Street				
Design		**Slope**	**Manning**	**Comments**
Out-Flow	**In-Flow**		**Speed**	
513.73	508.4	0.25%	2.27	Starting Point - End Point

Table 33. New Alignment through Greenfield Ave and Pharr Street Relocation (2) - Gradient analysis (Second approach)

Please see that we are 3 points above the minimum grade for a 12" diameter pipe which its minimum grade is 0.22%.

5.5.3. Summary - Alternative 5

Execution:

- Execution Term:

The average pace for a bore, up to my experience on this field is around 25LF/day. The trenching pace will be, on the conservative side, 75 LF/day. This paces will be affected due to the geotechnical provisions taken in account in the final alignment decision.

Execution of Alternative 5 will last 52.24 working days. This is a total of 2 months and 2 weeks.

- Earth Hauled off-site:

Total Earth Hauled off-site of Alternative 5 is 1355.30 CY

Functionality:

- Population Adjustment:

The area of influence of such sewer system won't be able to grow unless an structural change on the city of Fort Worth happens. Although this pipe is smaller than the other alternatives with 2700.00 LF at a 10" diameter.

Population adjustment of Alternative 5: Moderate-High

- Maintenance Cost:

The maintenance cost will be the following:

$$Cost = \$2872 - 28.702 * DN + 0.0472 * DN^2 * L$$

Where:

- DN – Pipe nominal diameter (inch)
- L – pipeline length (feet)

Maintenance Cost of Alternative 5 = $36,308.06

Environmental Impact:

Only trenching length will be considered in the environmental impact.

- Length:

Total Trench Length of Alternative 5 = 3917.81 LF

- Easements:

Easements crossed by Alternative 5 = 2 Parcels

- Social Impact:

This impact will be considered among the linear footage that the works affects to existing roads and streets. A industrial Street will have a factor of 1 and a residential on a factor of 0.8 on the footage.

Total LF of Alternative 5 performed in a road = 1912.22 LF

Economical Cost:

The Economical cost will be purely due to the length of the pipe installed which price varies depending on the depth and pipe diameter. This is an approximate budget and a more exhaustive one will be done with the final alignment elected. 5' diameter manholes will be set every 300' (at a price of $5,000.00).

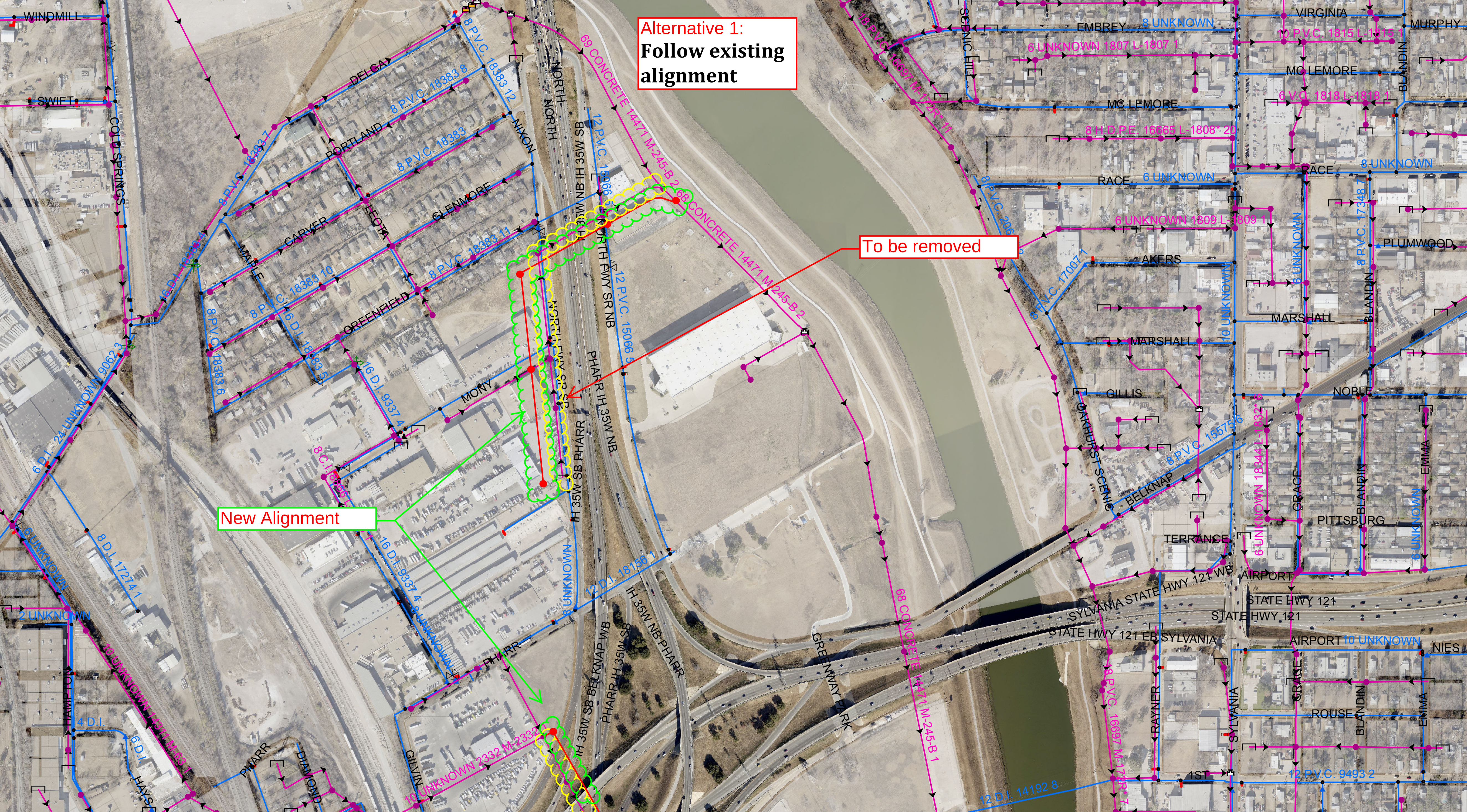
18" pipe installation, as per my experience, in an area with loose sands is $185.00. **10" pipe** installation cost is around $170.00 because it can be mainly found under the street.

Economical Cost of Alternative 5 = $759,591.68 (Cost Doesn't include Geotechnical provision and actions)

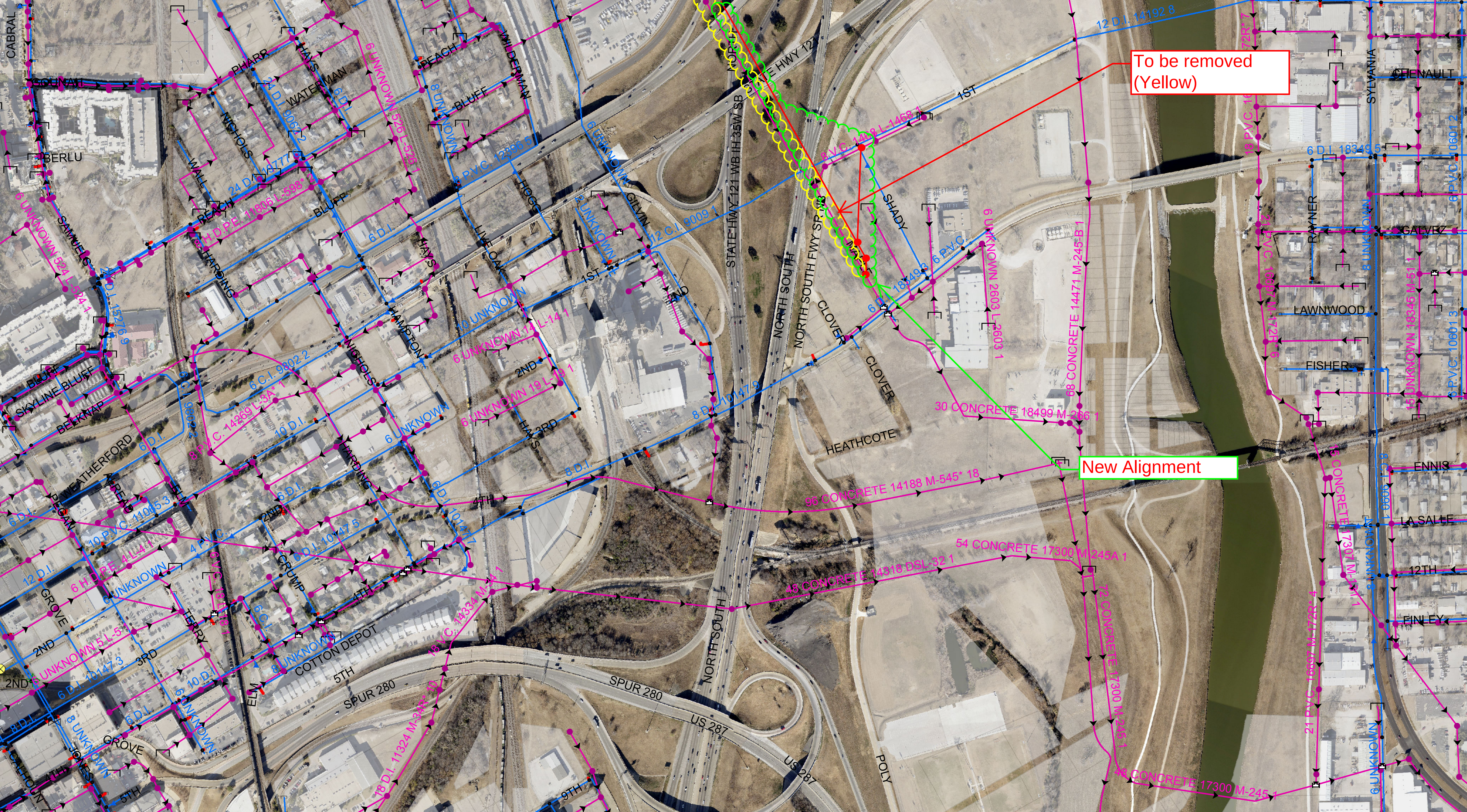
5.6. Alternatives Conclusion

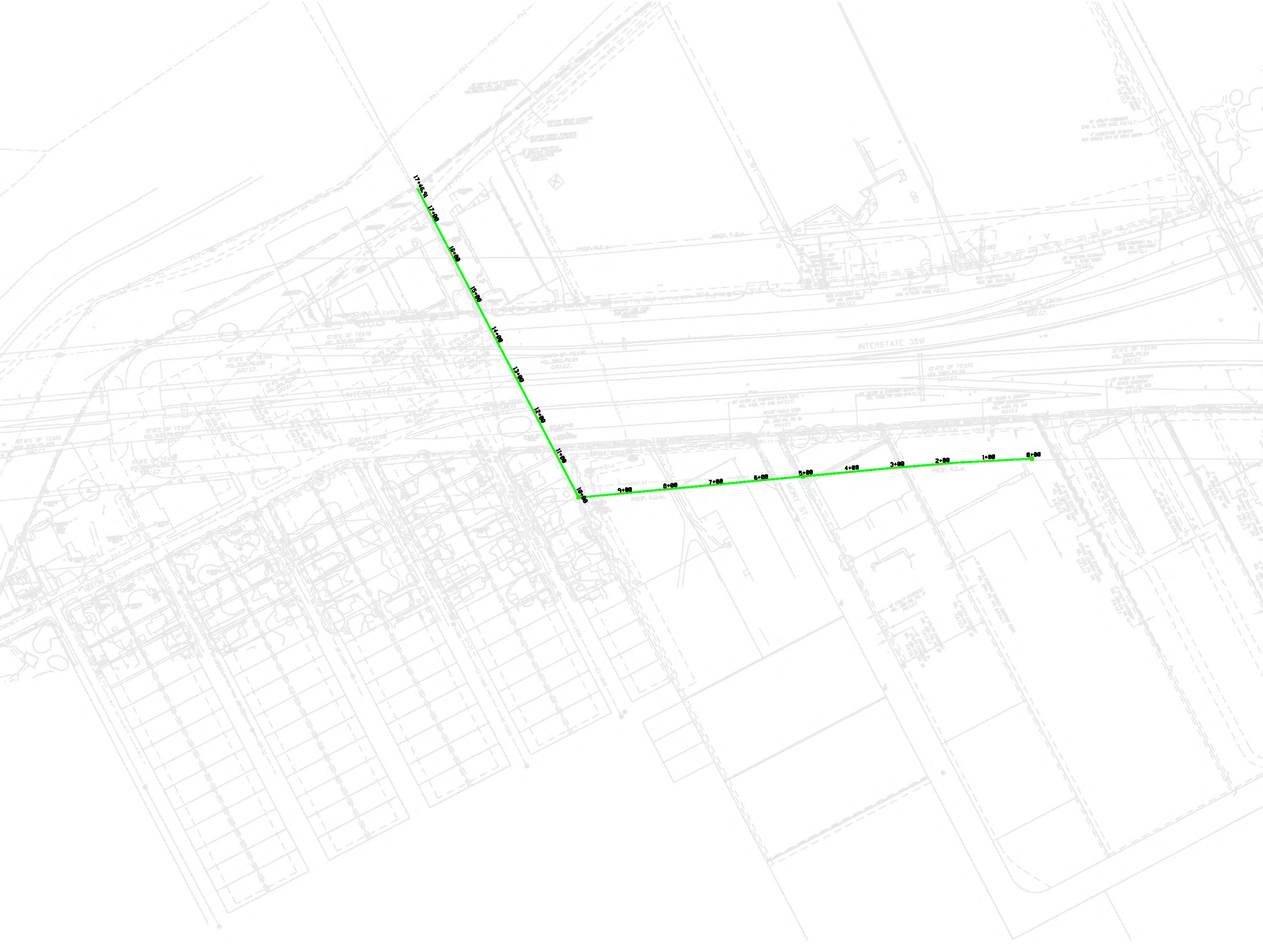
All five alternatives are feasible and should be taken in consideration while we do the multi-criteria analysis at appendix 6. Some of them are longer than the others but they may be shallower than the short ones. All this considerations, applied to the construction method, will bring us a clear detail of how much every alternative will cost. Summed up to the functionality and social/environmental impact, we will be able to choose among one of them with a reasoned basis.

ANNEX 5.1 – ALTERNATIVE 1 EXHIBIT



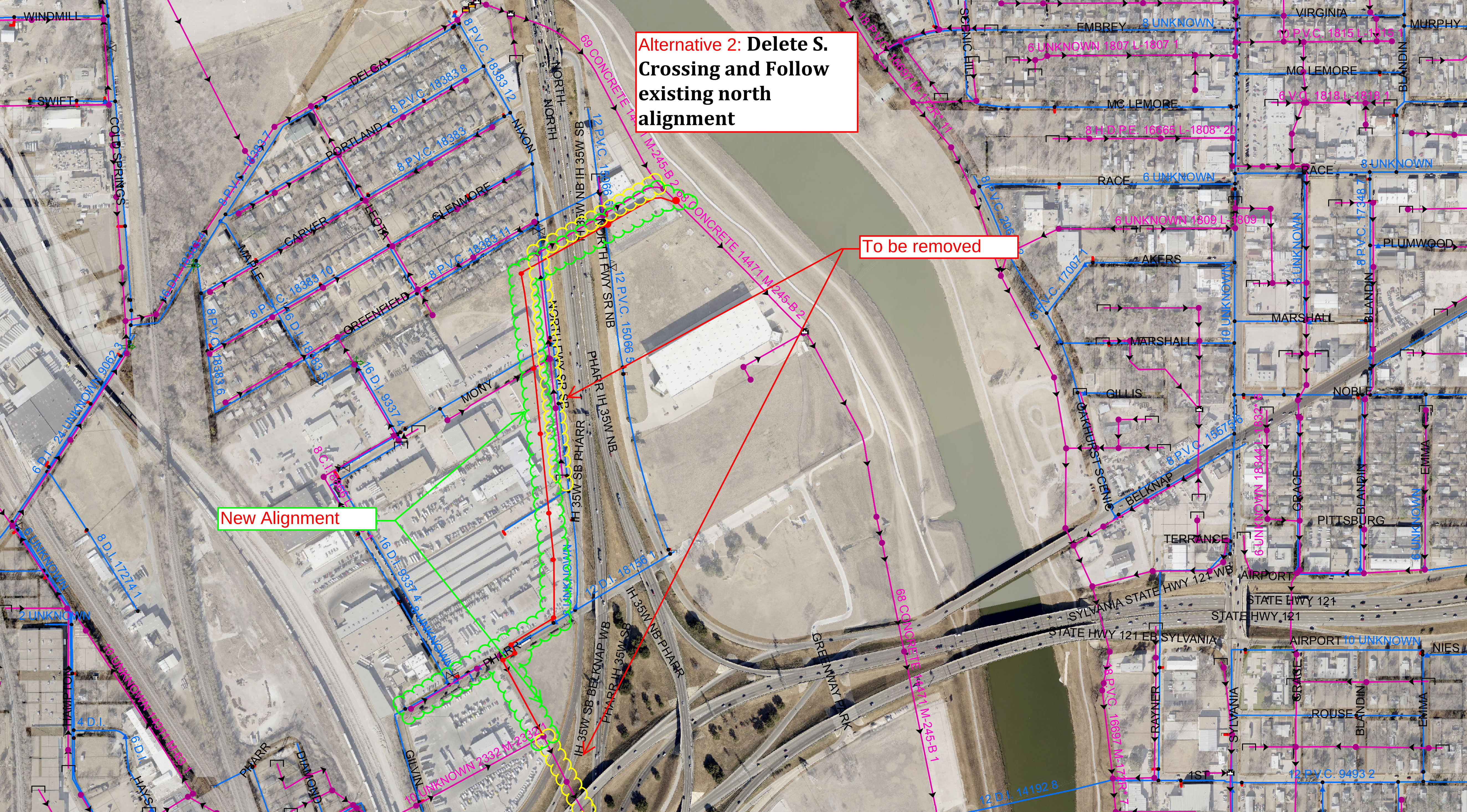
Alternative 1:
Follow existing alignment
To be removed
New Alignment
WINDMILL
SWIFT
COLD SPRINGS
DELGA
PORTLAND
GLENMORE
CARVER
MAPLE
GREENFIELD
MONY
NIXON
NORTH
PHARR
EMBREY
VIRGINIA
MURPHY
MC LEMORE
RACE
PLUMWOOD
AKERS
MARSHALL
GILLIS
NOBLE
BELKNAP
TERRANCE
PITTSBURG
AIRPORT
SYLVANIA STATE HWY 121 WB
STATE HWY 121
STATE HWY 121 EB SYLVANIA
NIES
ROUSE
GREENWAY PARK
RAYNER
SYLVANIA
GRACE
BLANDIN
EMMA
OAKHURST SCENIC
HAMPTON
HAYS
GILVIN
DIAMOND
1ST
69 CONCRETE 14471 M-245-B 2
68 CONCRETE 14471 M-245-B 2
68 CONCRETE 14471 M-245-B 1
10 UNKNOWN 2332 M-2332
12 P.V.C. 15066 5
12 D.I. 18156 1
12 P.V.C. 9493 2
12 D.I. 14192 8

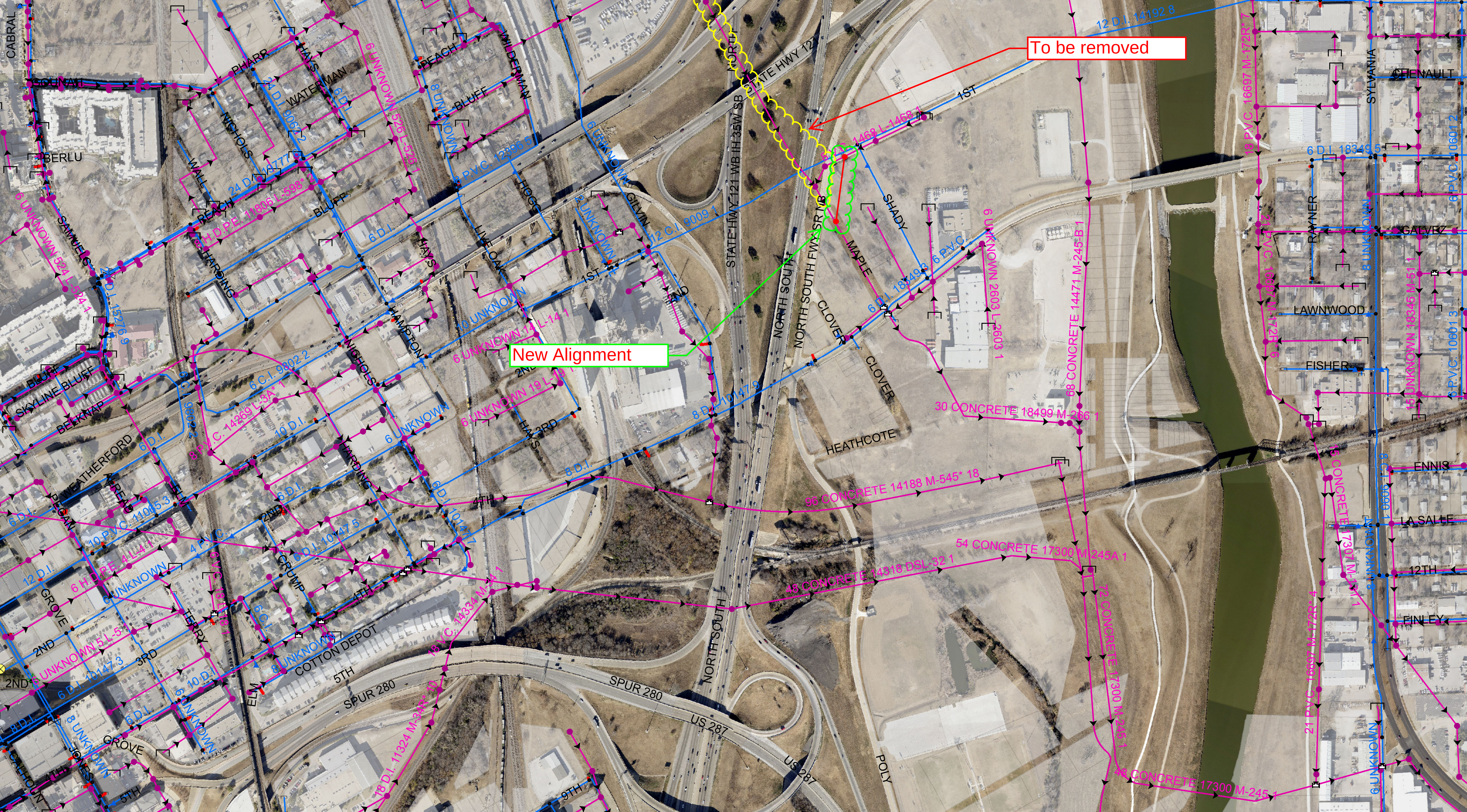

To be removed
(Yellow)
New Alignment
12 D.I. 14292 8
1ST
SHADY
CLOVER
HEATHCOTE
30 CONCRETE 18499 M-266 1
66 CONCRETE 14188 M-545* 18
54 CONCRETE 17300 M-245A 1
48 CONCRETE 24318 DSL-32 1
68 CONCRETE 14471 M-245-B 1
72 CONCRETE 17300 M-245 1
48 CONCRETE 17300 M-245 1
NORTH SOUTH
NORTH SOUTH FWY SB
STATE HWY 121 WB IH 35W SB
SPUR 280
US 287
POLY
COTTON DEPOT
5TH
4TH
3RD
2ND
GROVE
ELM
BELKNAP
WEATHERFORD
SKYLINE
BLUFF
BERLU
CABRAL
SAMUELS
HARDING
NICHOLS
WATERMAN
PHARR
PEACH
HAYS
LIVE OAK
JONES
CRUMP
HAMPTON
WALL
GALVEZ
LAWNWOOD
FISHER
ENNIS
LA SALLE
12TH
FINLEY
RAYNER
SYLVANIA
CHENAULT
9TH


17+46.91
17+00
16+00
15+00
14+00
13+00
12+00
11+00
10+00
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
INTERSTATE 35W
INTERSTATE 35W
PROP. R.O.W.

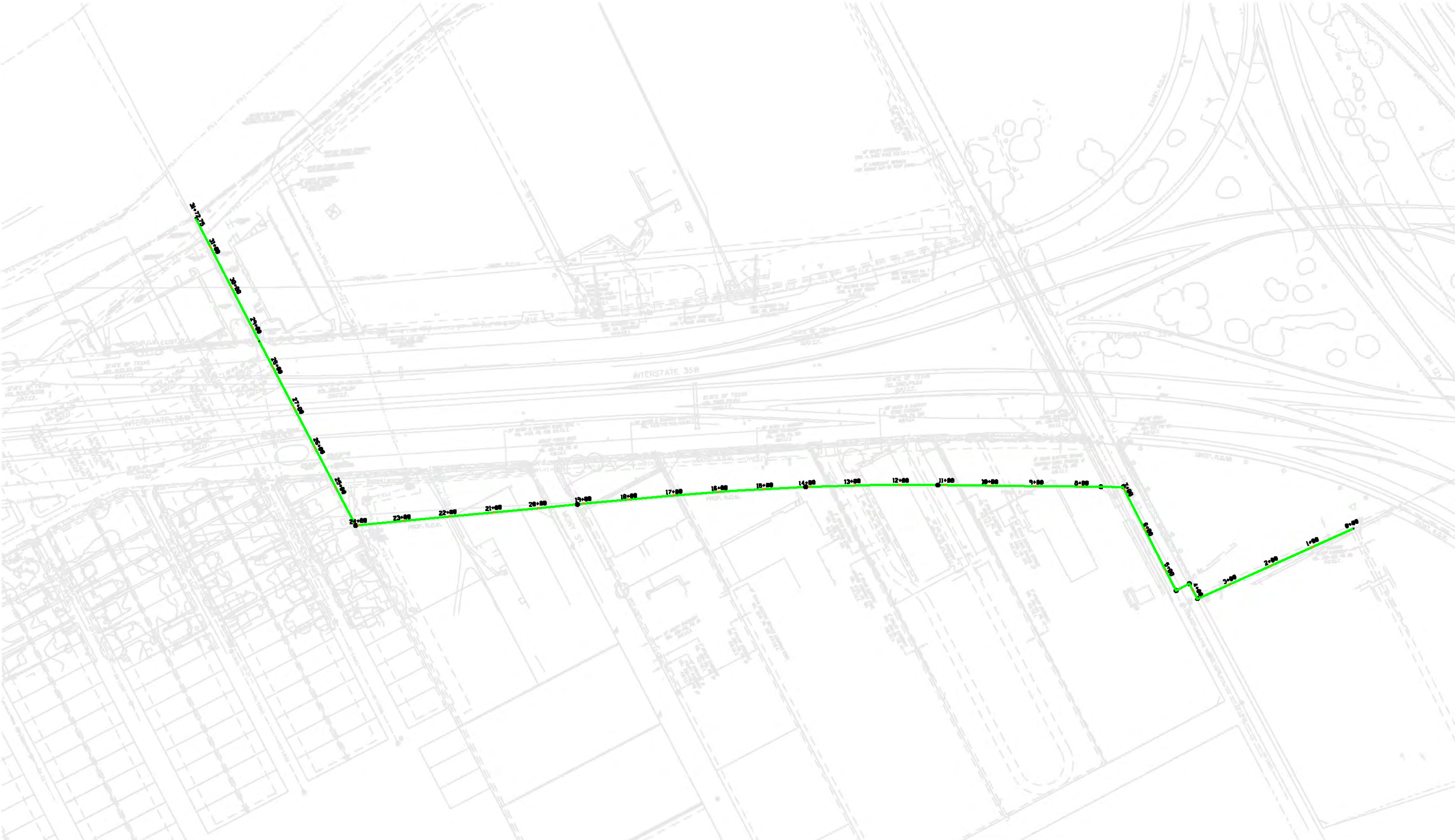
SH 121
INTERSTATE 35W
INTERSTATE 35W
INTERSTATE 35W
SHADY ST.
EXIST. R.O.W.
0+00
1+00
2+00
3+00
4+00
5+00
17+00
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00

ANNEX 5.2 – ALTERNATIVE 2 EXHIBIT


Alternative 2: Delete S. Crossing and Follow existing north alignment
To be removed
New Alignment
WINDMILL
SWIFT
COLD SPRINGS
DELGA
PORTLAND
CARVER
MAPLE
LEOTA
GLENMORE
GREENFIELD
MONY
NIXON
NORTH
PHARR
GILVIN
DIAMOND
HAYS
HAMPTON
PHARR IH 35W NB
IH 35W SB PHARR
IH 35W SB BELKNAP WB
GREENWAY PARK
EMBREY
VIRGINIA
MURPHY
MC LEMORE
RACE
AKERS
MARSHALL
PLUMWOOD
GILLIS
NOBLE
BELKNAP
OAKHURST SCENIC
TERRANCE
PITTSBURG
AIRPORT
STATE HWY 121
SYLVANIA STATE HWY 121 WB
STATE HWY 121 EB SYLVANIA
NIES
ROUSE
GRACE
BLANDIN
EMMA
SYLVANIA
RAYNER
1ST
69 CONCRETE
68 CONCRETE 14471 M-245-B 1
12 P.V.C. 15066 5
12 D.I. 18136 1
12 P.V.C. 9493 2
12 D.I. 14182 8
10 UNKNOWN 2332 M-232-1

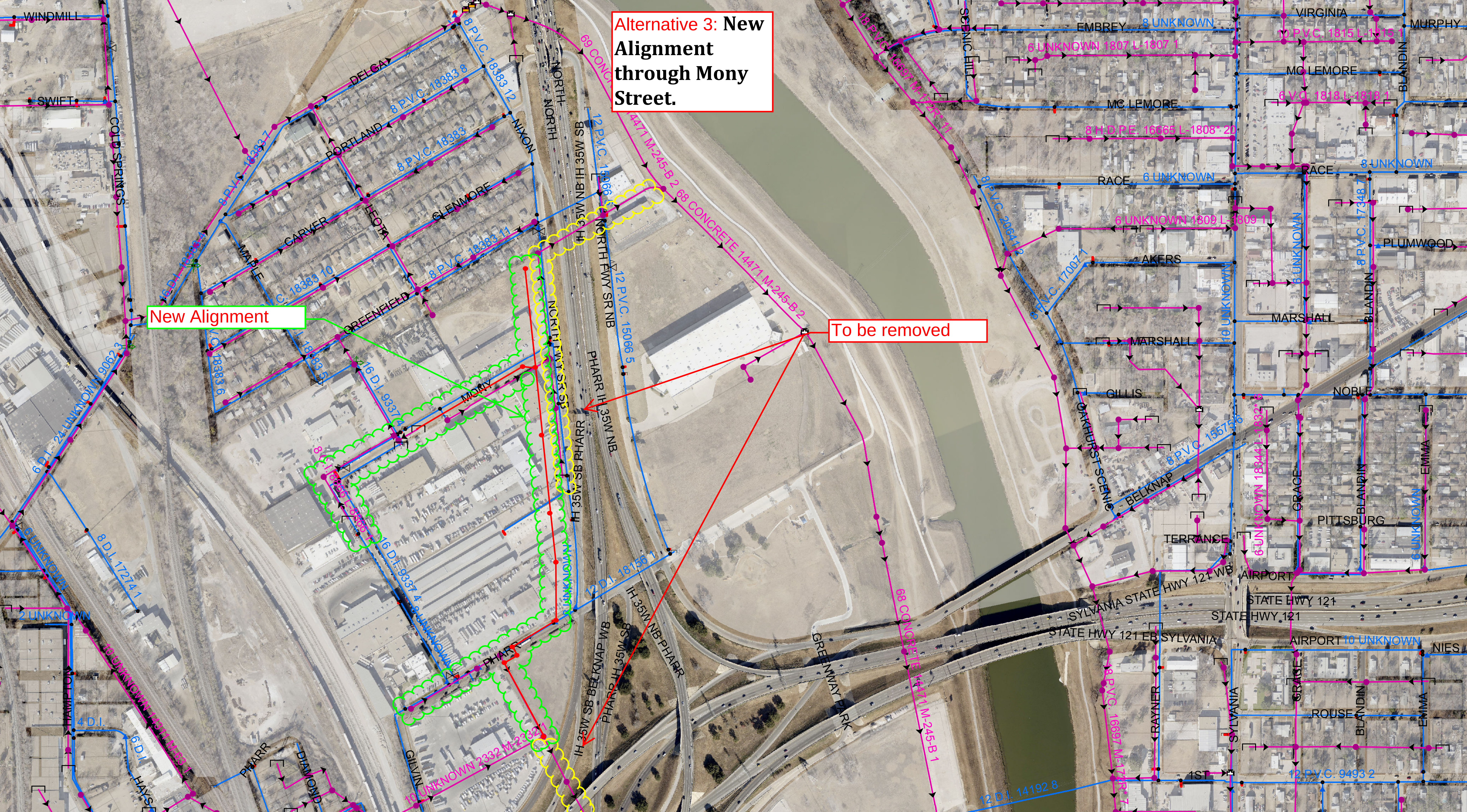


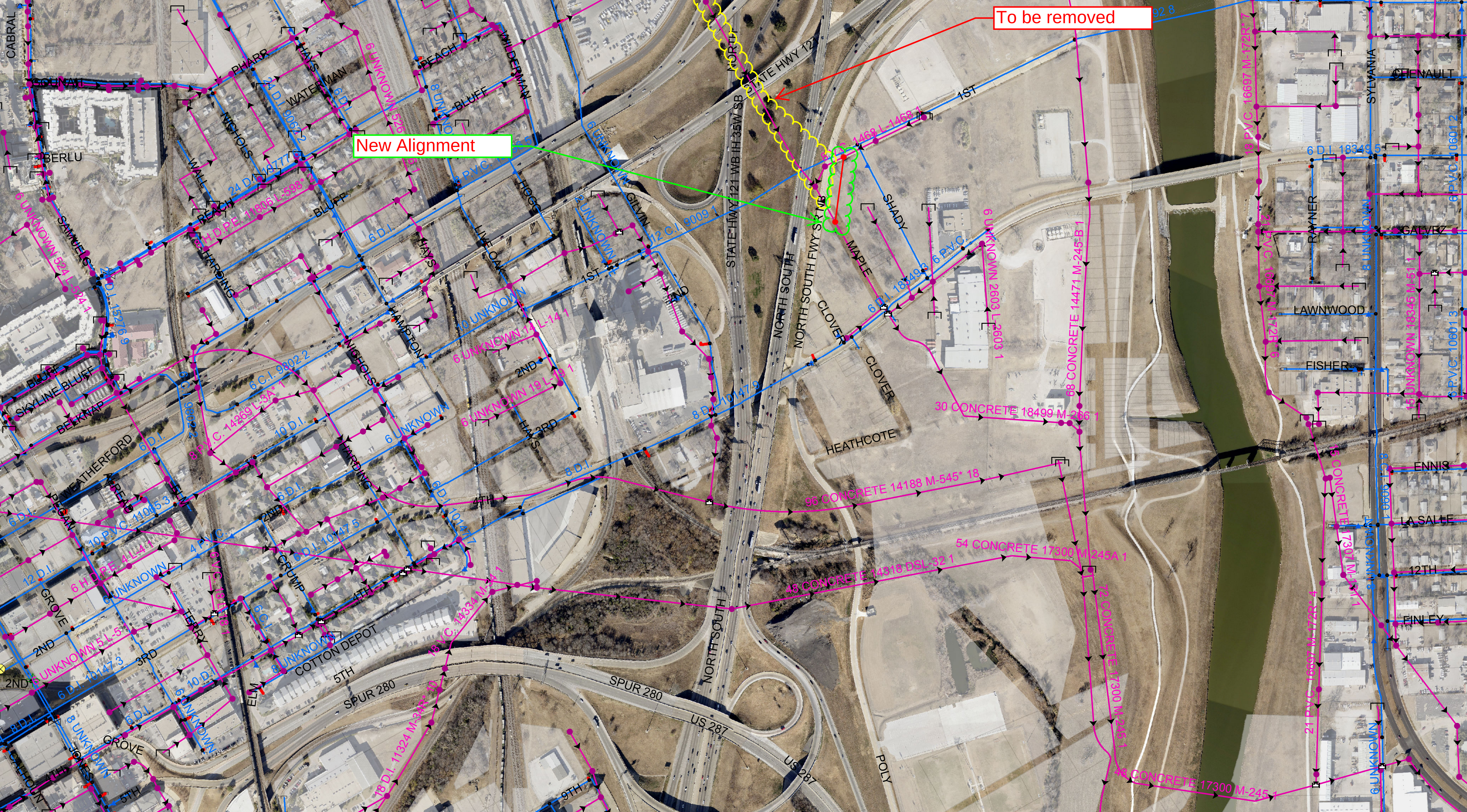
To be removed
New Alignment
12 D.I. 14092 8
1ST
STATE HWY 121
STATE HWY 121 WB IH 35W SB
NORTH SOUTH FWY SR NB
NORTH SOUTH
SHADY
MAPLE
CLOVER
HEATHCOTE
POLY
SPUR 280
US 287
COTTON DEPOT
30 CONCRETE 18499 M-266 1
68 CONCRETE 14471 M-245-B 1
96 CONCRETE 14188 M-545* 18
54 CONCRETE 17300 M-245A 1
48 CONCRETE 17300 M-245 1
72 CONCRETE 17300 M-245 1
6 D.I. 18348 5
12 C.I. 9009 1
SYLVANIA
CHENAULT
RAYNER
GALVEZ
LAWNWOOD
FISHER
ENNIS
LA SALLE
12TH
FINLEY
BERLU
PHARR
WATERMAN
BLUFF
NICHOLS
HARDING
SAMUELS
WEATHERFORD
BELKNAP
HAMPTON
LIVE OAK
WILDERMAN
ELM
GROVE
2ND
3RD
4TH
5TH
9TH



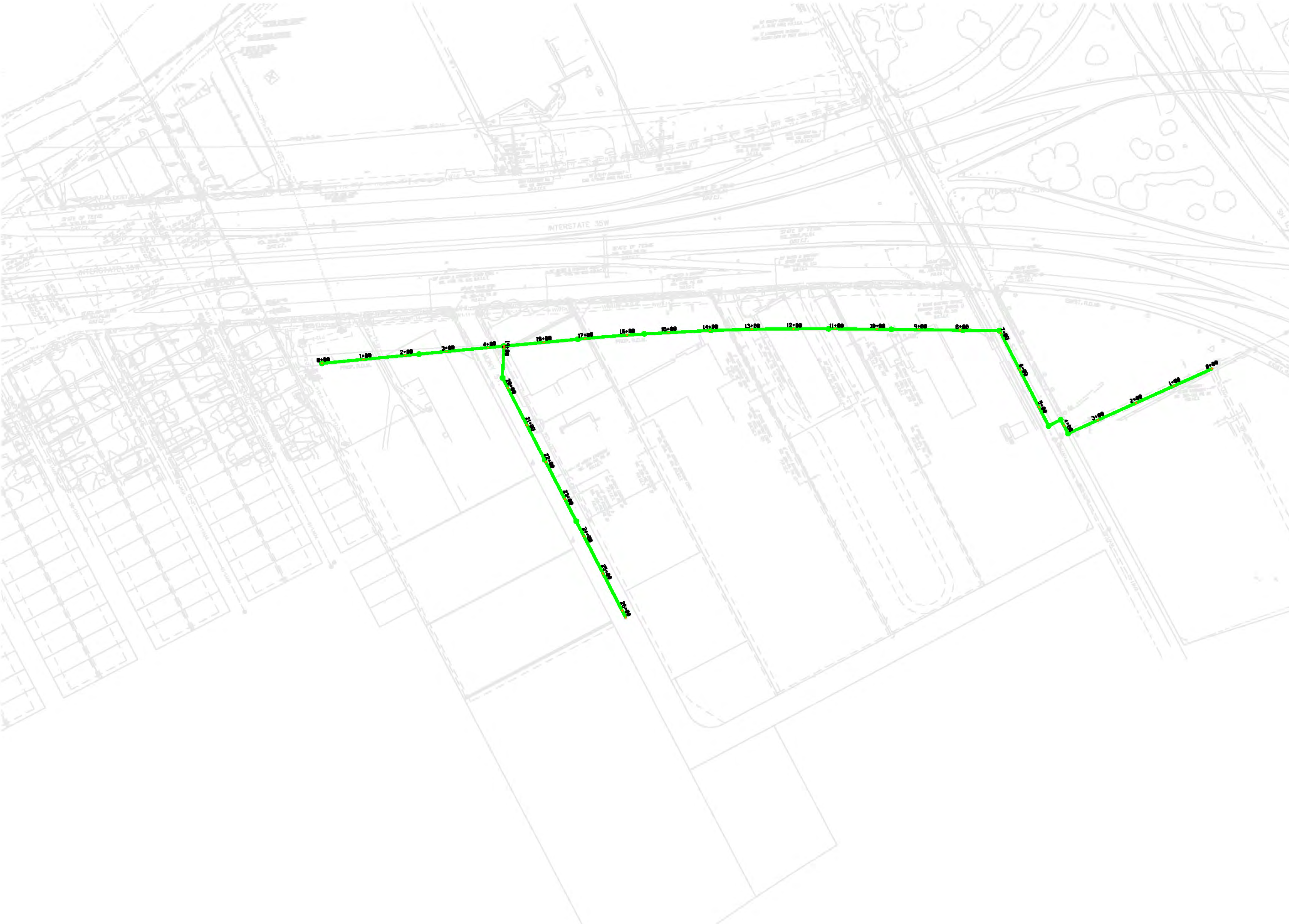
31+72.75
31+00
30+00
29+00
28+00
27+00
26+00
25+00
24+00
23+00
22+00
21+00
20+00
19+00
18+00
17+00
16+00
15+00
14+00
13+00
12+00
11+00
10+00
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
INTERSTATE 35W

ANNEX 5.3 – ALTERNATIVE 3 EXHIBIT

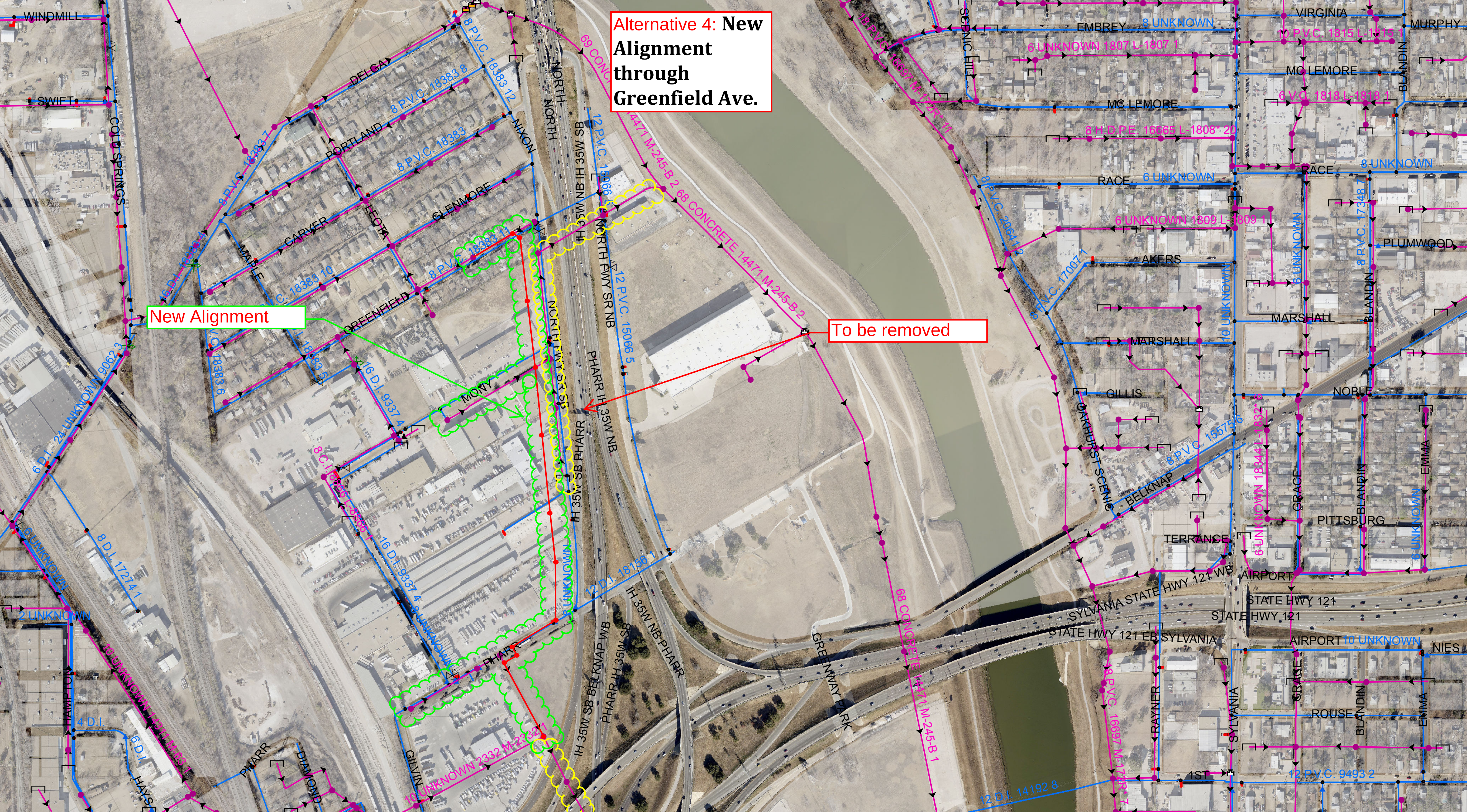

Alternative 3: New Alignment through Mony Street.
New Alignment
To be removed

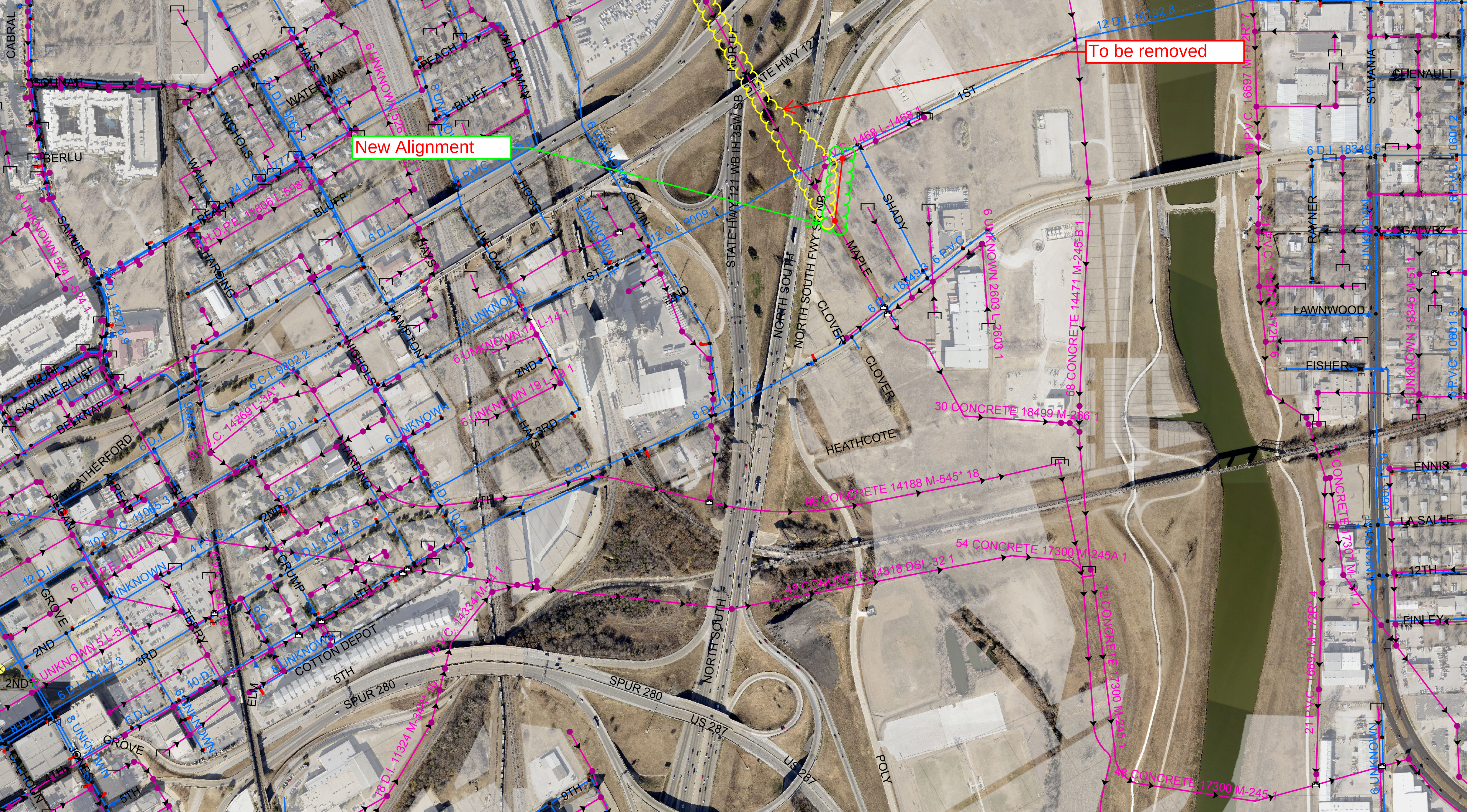


To be removed
New Alignment
STATE HWY 12
1ST
SHADY
MAPLE
CLOVER
HEATHCOTE
POLY
NORTH SOUTH FWY
STATE HWY 121 WB IH 35W SB
NORTH SOUTH
SPUR 280
US 287
COTTON DEPOT
5TH
4TH
3RD
2ND
GROVE
BELKNAP
WEATHERFORD
BLUFF
SKYLINE
PHARR
WATERMAN
NICHOLS
SAMUELS
HARDING
HAMPTON
LIVE OAK
ELM
SYLVANIA
CHENAULT
GALVEZ
LAWNWOOD
FISHER
ENNIS
LA SALLE
12TH
FINLEY
RAYNER
30 CONCRETE 18499 M-266 1
36 CONCRETE 14188 M-545* 18
54 CONCRETE 17300 M-245A 1
48 CONCRETE 14318 DSL-32 1
68 CONCRETE 14471 M-245-B 1
72 CONCRETE 17300 M-245 1
48 CONCRETE 17300 M-245 1

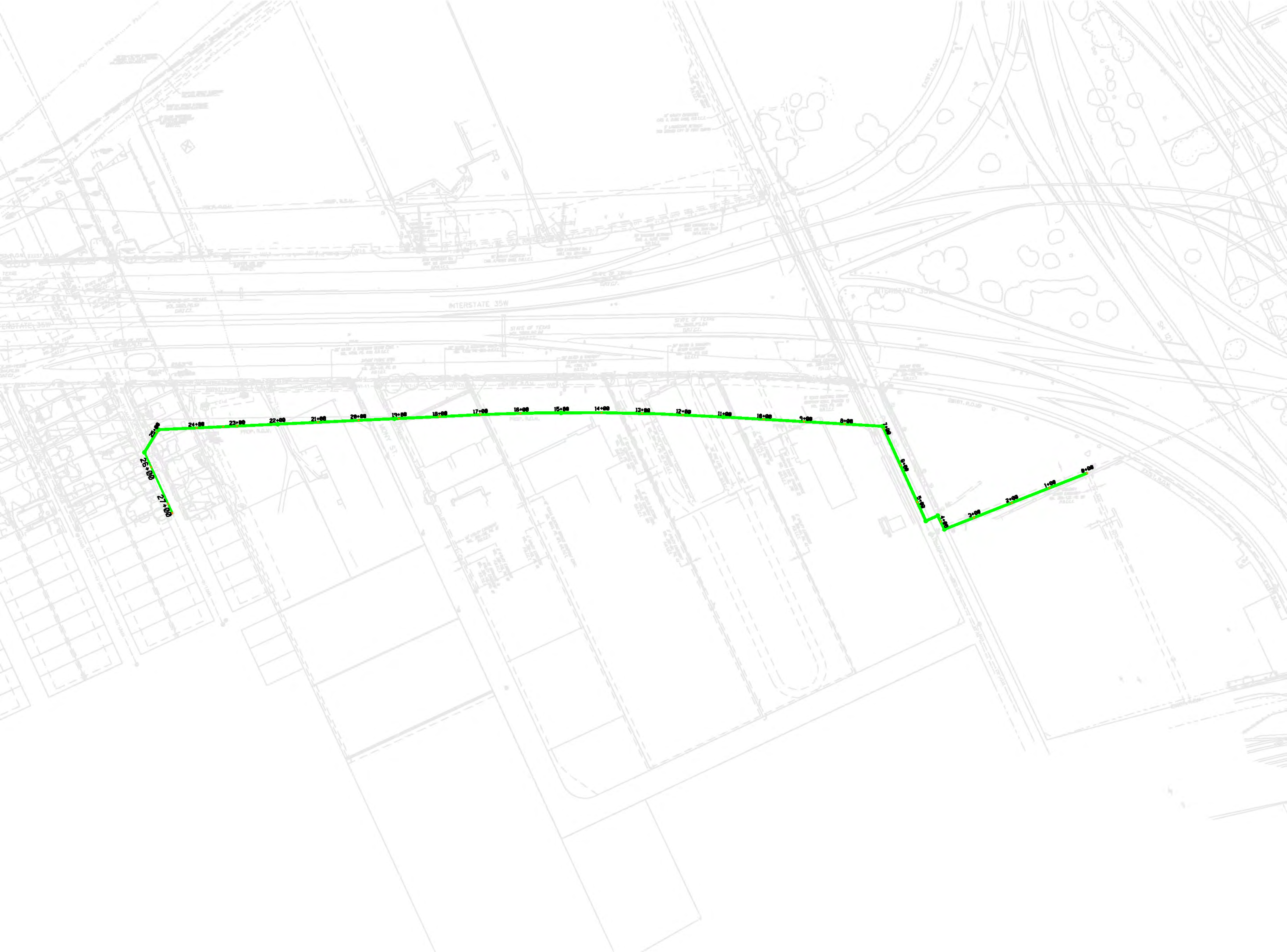

INTERSTATE 35W
0+00
1+00
2+00
3+00
4+00
18+00
17+00
16+00
15+00
14+00
13+00
12+00
11+00
10+00
9+00
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0+00
21+00
22+00
23+00
24+00
25+00

ANNEX 5.4 – ALTERNATIVE 4 EXHIBIT

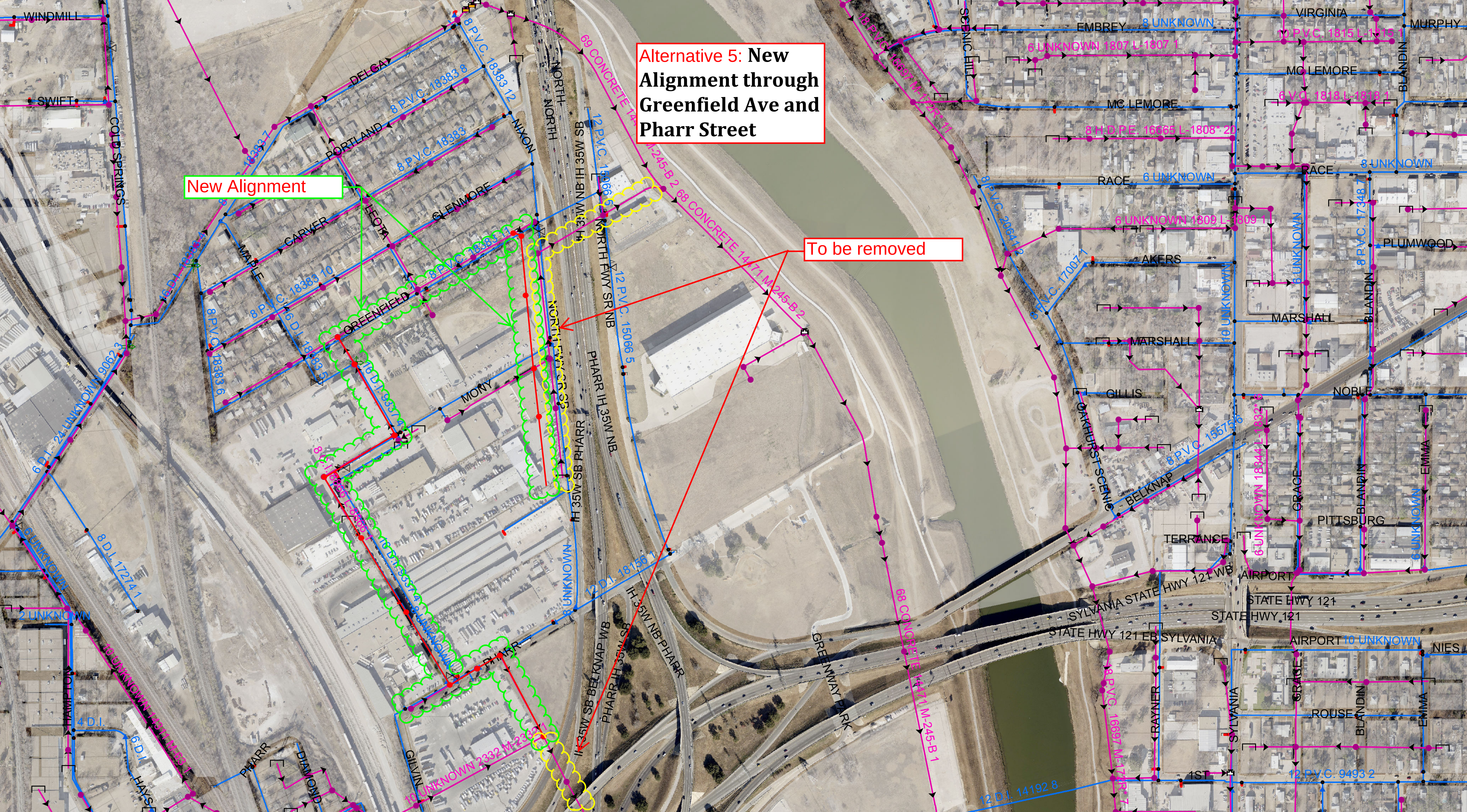

Alternative 4: New Alignment through Greenfield Ave.
New Alignment
To be removed

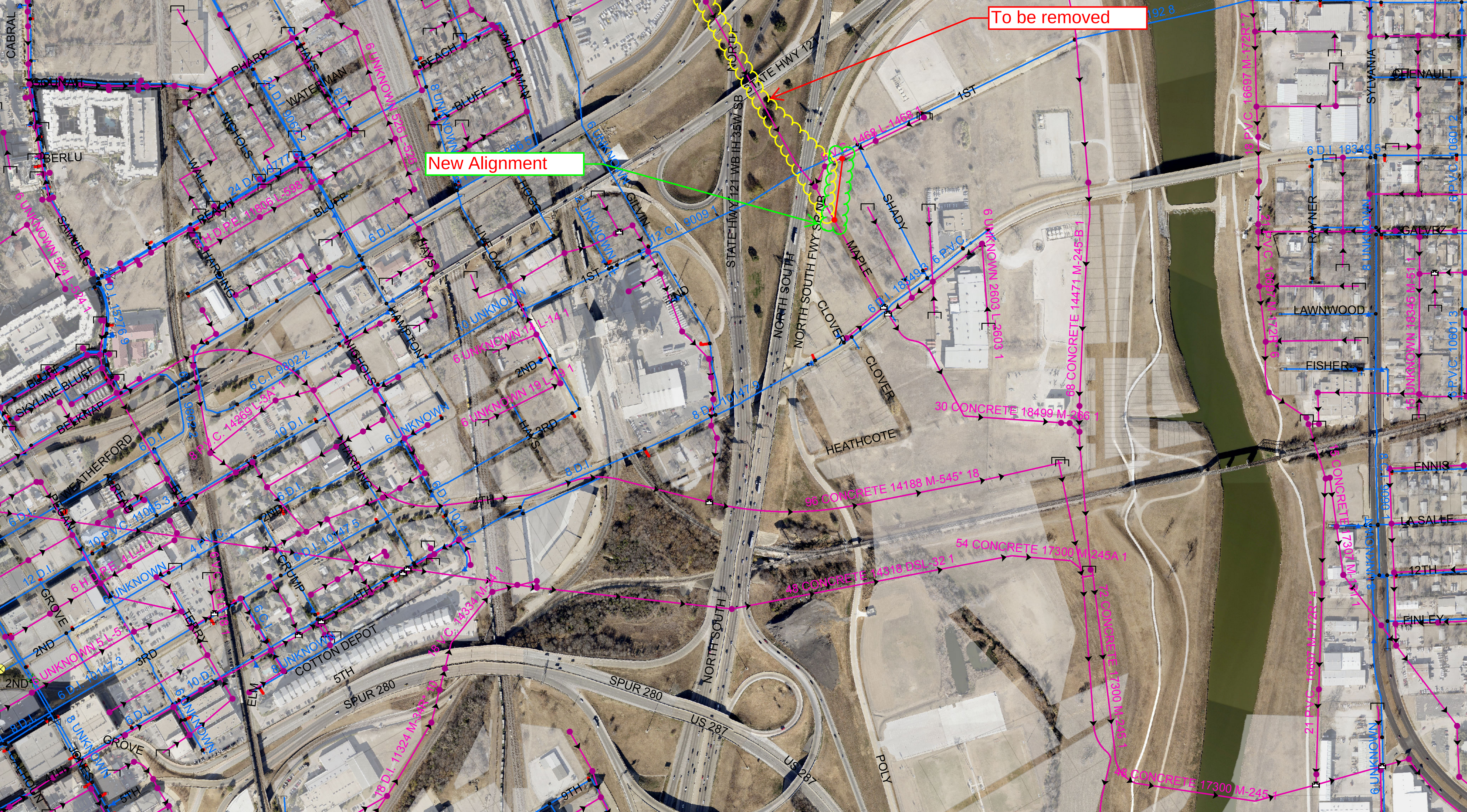


To be removed
New Alignment
STATE HWY 121 WB IH 35W SB
NORTH SOUTH FWY SB
NORTH SOUTH
1ST
SHADY
MAPLE
CLOVER
HEATHCOTE
30 CONCRETE 18499 M-266 1
68 CONCRETE 14471 M-245-B 1
96 CONCRETE 14188 M-545* 18
54 CONCRETE 17300 M-245A 1
48 CONCRETE 14318 DSL-32 1
72 CONCRETE 17300 M-245 1
48 CONCRETE 17300 M-245 1
SPUR 280
US 287
COTTON DEPOT
SYLVANIA
RAYNER
LAWNWOOD
FISHER
ENNIS
LA SALLE
12TH
FINLEY
GALVEZ
CHENAULT
BLUFF
BELKNAP
WEATHERFORD
SAMUELS
NICHOLS
HAMPTON
GROVE
CRUMP
POLY

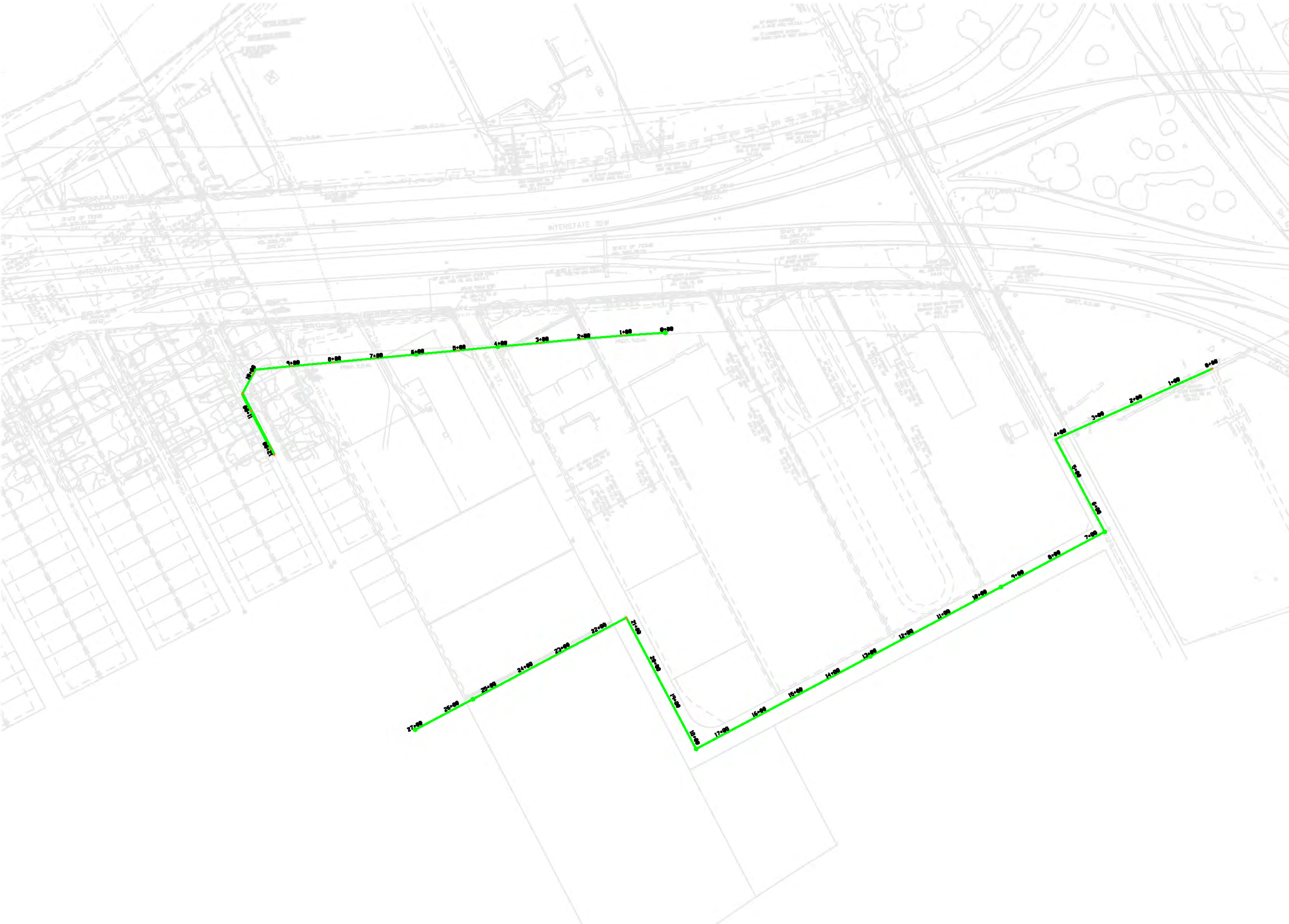

INTERSTATE 35W
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00
23+00
24+00
25+00
26+00
27+00

ANNEX 5.5 – ALTERNATIVE 5 EXHIBIT


Alternative 5: New Alignment through Greenfield Ave and Pharr Street
New Alignment
To be removed
WINDMILL
SWIFT
COLD SPRINGS
DELGA
PORTLAND
NIXON
NORTH
GLENMORE
LEOTA
CARVER
MAPLE
GREENFIELD
MONY
PHARR
GILVIN
HAMPTON
HAYS
DIAMOND
NORTH FWY SR SB
PHARR IH 35W SB
PHARR IH 35W NB
IH 35W SB BELKNAP WB
GREENWAY PARK
EMBREY
VIRGINIA
MURPHY
MC LEMORE
RACE
PLUMWOOD
AKERS
MARSHALL
GILLIS
NOBLE
BELKNAP
PITTSBURG
TERRANCE
AIRPORT
SYLVANIA STATE HWY 121 WB
STATE HWY 121
STATE HWY 121 EB SYLVANIA
NIES
ROUSE
RAYNER
SYLVANIA
GRACE
BLANDIN
EMMA
1ST
OAKHURST SCENIC
SCENIC HILL



To be removed
New Alignment
STATE HWY 12
STATE HWY 121 WB IH 35W SB
NORTH SOUTH FWY SB
NORTH SOUTH
1ST
2ND
3RD
4TH
5TH
SHADY
MAPLE
CLOVER
HEATHCOTE
POLY
SPUR 280
US 287
COTTON DEPOT
ELM
GROVE
CRUMP
HARDING
HAMPTON
NICHOLS
WATERMAN
BLUFF
PHARR
HAYS
LIVE OAK
WEATHERFORD
BELKNAP
SKYLINE BLUFF
BERLU
CABRAL
SAMUELS
PECAN
SYLVANIA
SHENAULT
RAYNER
GALVEZ
LAWNWOOD
FISHER
ENNIS
LA SALLE
12TH
FINLEY
30 CONCRETE 18499 M-266 1
36 CONCRETE 14188 M-545* 18
54 CONCRETE 17300 M-245A 1
48 CONCRETE 14318 DSL-32 1
68 CONCRETE 14471 M-245-B 1
72 CONCRETE 17300 M-245 1
48 CONCRETE 17300 M-245 1
18 P.V.C. 16697 M-172R 7
21 P.V.C. 16697 M-172R 4
18 D.I. 11324 M-394 29
6 D.I. 18349 5
6 UNKNOWN 2603 L-2603 1
8 D.I. 11147 9
12 C.I. 9009 1
6 C.I. 9802 2
6 P.V.C.
6 UNKNOWN 19 L-19 1
6 UNKNOWN 14 L-14 1


INTERSTATE 35W

Appendix No. 6:

Preliminary Study of Alternatives

INDEX - APPENDIX NO. 6: PRELIMINARY STUDY OF ALTERNATIVES

INDEX - FIGURE AND TABLE

6. Preliminary Study of Alternatives

Previously we have considered up to 5 different alternatives so we could find the best suitable one to be constructed. The aim of this project is to do an intensive study using different construction means and methods but within 5 different alternatives, analysis can get confusing and hinder the final purpose of this paper. Therefore, in this second point of appendix 5 we will look forward to eliminate 3 out of this 5 options with the multi-criteria method ELECTRE I.

6.1. ELECTRE I Method Description

Electre I method is a tool for alternatives selection. It is based in an analysis multi-criteria method to select the most optimum option. This tool is helpful to consider simultaneously different quantitative targets, either economical and non-economical, and also qualitative targets, which can be quantified in economic terms or non-economical but numerical. In general, a problem of multi-criteria decision, it is said that the alternative “a” can overcome the alternative “b” if, given the level of knowledge and the preferences of the decision maker and the quality of information on all relevant criteria available to evaluate each alternative, is sufficient for considering that the alternative “a” is at least as good as alternative “b” arguments, and there are no solid arguments to the contrary.

How it Works?

- Based in the comparison of a pair of variables
- Matrix Data
- All criteria/variables must be adjusted to the same scale. Previous homogenization.

Final Target

- Establish and ordinal ranking of the considered alternatives

Process. Phasing.

- Study of alternatives and criteria
- Assign weight to every criteria (Determine the relevance of each criteria)
- Data normalization (Normalized Matrix)
- Normalized and weighted Matrix
- Concordance Matrix
- Credibility Matrix
- Dominative aggregate Matrix (Concordant-Discordant)
- Electre Graph

6.2. Alternatives to consider

Alternatives	Alignment
Alternative 1	Follow existing alignment
Alternative 2	Delete S. Crossing and Follow existing north alignment
Alternative 3	New Alignment through Mony Street
Alternative 4	New Alignment through Greenfield Ave
Alternative 5	New Alignment through Greenfield Ave and Pharr Street

Table 1. Considered Alternatives.

6.3. Criteria Definition

We've determined what criteria is going to be evaluated in regards of its relevance on the election of one or another alternative. The criteria selected and its parameters are defined at table 35.

Criteria	Parameters
Execution	Execution Term Earth Hauled off-site
Functionality	Population adjustment Maintenance Cost
Environmental Impact	Length Easements Social Impact
Economical cost	Initial Investment

Table 2. Criteria and Parameters for the Multi-criteria election.

Down below, for every criteria, we assign a value to the costs of every alternative, all of them must be at the same scale from 1 to 10. Value 1 will be the best option and 10 the worst. The associated cost depends on the criteria value range.

6.3.1. EXECUTION

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Execution Term (days)	93.22	10	54.56	3.88	40.75	1.70	36.34	1	52.24	3.52
Earth removal (CY)	954.59	1	1,303.78	8.27	1,386.91	10	1,236.40	6.87	1,355.30	9.34
Total Cost	11.00		12.15		11.70		7.87		12.86	

Table 3. Execution parameter values.

Execution Term Range:

- **1 –** 36.34 working days
- **10 –** 93.22 working days

Earth Hauled off-site Range:

- **1 –** 954.59 CY
- **10 –** 1386.91 CY

6.3.2. FUNCTIONALITY

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Poblation adjustment	High	1	High	1	High	1	High	1	High-Mod	3
Maintenance Cost ($)	67,125.59	10	50,875.59	5.25	49,103.00	4.74	44,030.23	3.26	36,308.06	1
Total Cost	11.00		6.25		5.74		4.26		4.00	

Table 4. Functionality parameter values.

Population adjustment Range:

- **1 –** High
- **10 –** Poor

Maintenance Cost Range:

- **1 –** $36,308.06
- **10 –** $67,125.59

Length Range:

- **1 –** 1,717.55 LF
- **10 –** 3917.81 LF

6.3.3. ENVIRONMENTAL IMPACT

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Length (LF)	1,717.55	1	2,713.25	5.07	3,056.86	6.48	2,725.13	5.12	3,917.81	10
Easements (EA)	1.00	1	2.00	10	1.00	1	1.00	1	2.00	10
Social Impact (LF)	-	1	30.00	2.55	1,053.00	5.96	511.78	3.41	1,912.22	10
Total Cost	3.00		17.63		13.43		9.53		30.00	

Table 5. Environmental impact parameter values.

Easements Range:

- **1 –** 1
- **10 –** 2

Social Impact Range:

- **1 –** 0.00 LF
- **10 –** 1912.22 LF

6.3.4. ECONOMICAL COST

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	Value	Cost	Value	Cost	Value	Cost	Value	Cost	Value	Cost
Initial Investment ($)	1,611.210	10	885,309.58	3.82	621,466.77	1.57	554,567	1	759,591.68	2.75
Total Cost	10.00		3.82		1.57		1.00		2.75	

Table 6. Economical cost parameter values.

Initial Investment Range:

- **1 –** $554,567.00
- **10 –** $1,611,210.00

6.4. 1st approach - ELECTRE I Method Application

- INITIAL MATRIX (I)

This Matrix is obtained from the "m" alternatives a_i evaluated within criteria factors c_j. Results are named a_{ij} which appears in the matrix (I) below.

	Execution (c_1)	Functionality (c_2)	Environmental Impact (c_3)	Economical Cost (c_4)
Alt. 1 (a_1)	11	11	3	10
Alt. 2 (a_2)	12.15	6.25	17.63	3.82
Alt. 3 (a_3)	11.7	5.74	13.43	1.57
Alt. 4 (a_4)	7.87	4.26	9.53	1
Alt. 5 (a_5)	12.86	4	30	2.75
Weight (Pj)	**0.2**	**0.2**	**0.2**	**0.4**
Range	4.99	7	27	9

Table 7. Initial Matrix (I)

- NORMALIZED MATRIX (II)

The elements v_{ij} are obtained from dividing every a_{ij} element by the range of every criteria c_j. Such range is the difference between the c_j extreme values.

	Execution (c_1)	Functionality (c_2)	Environmental Impact (c_3)	Economical Cost (c_4)
Alt. 1 (a_1)	2.20	1.57	0.11	1.11
Alt. 2 (a_2)	2.43	0.89	0.65	0.42
Alt. 3 (a_3)	2.34	0.82	0.50	0.17
Alt. 4 (a_4)	1.58	0.61	0.35	0.31
Alt. 5 (a_5)	2.58	0.57	1.11	0.13

Table 8. Normalized Matrix (II)

- NORMALIZED AND WEIGHTED MATRIX (III)

This matrix is obtained by multiplying al vij elements from normalized matrix by its respective weight factor p_j.

	Execution (c_1)	Functionality (c_2)	Environmental Impact (c_3)	Economical Cost (c_4)
Alt. 1 (a_1)	0.44	0.31	0.02	0.44
Alt. 2 (a_2)	0.49	0.18	0.13	0.17
Alt. 3 (a_3)	0.47	0.16	0.10	0.07
Alt. 4 (a_4)	0.32	0.12	0.07	0.04
Alt. 5 (a_5)	0.52	0.11	0.22	0.12
Weight (Pj)	**0.2**	**0.2**	**0.2**	**0.4**

Table 9. Normalized and Weighted Matrix (III)

- CONCORDANCE MATRIX (IV)

The values of this matrix cij are denominated "Concordance rates" resultant from the binary comparison between every a_i and a_j. its value is obtained by summing up every weight coefficient p_{ij} related to the columns where alternative a_i is greater or equal to a_j and then dividing the result by the sum of all weight p_j. If this values are equal in both alternatives, then half of p_j value will be assigned to both of them.

	Alt. 1 (a_1)	Alt. 2 (a_2)	Alt. 3 (a_3)	Alt. 4 (a_4)	Alt. 5 (a_5)
Alt. 1 (a_1)		0.6	0.6	0.8	0.6
Alt. 2 (a_2)	0.4		1	1	0.6
Alt. 3 (a_3)	0.4	0		1	0.2
Alt. 4 (a_4)	0.2	0	0		0.2
Alt. 5 (a_5)	0.4	0.4	0.8	0.8	

Table 10. Concordance Matrix (IV)

- CREDIBILITY MATRIX (V)

The elements of matrix d_{ij} are known as “Discordance rates” are the result of dividing the maximum relative deviation between the criteria where alternative a_i is more unfavorable respect a_j and the maximum relative deviation of the overall criteria, if a_i is more or at least as unfavorable as a_j.

	Alt. 1 (a_1)	Alt. 2 (a_2)	Alt. 3 (a_3)	Alt. 4 (a_4)	Alt. 5 (a_5)
Alt. 1 (a_1)		0.27	0.19	0.12	0.50
Alt. 2 (a_2)	0.69		0.00	0.00	0.23
Alt. 3 (a_3)	0.94	0.25		0.00	0.31
Alt. 4 (a_4)	1.00	1.00	1.00		0.50
Alt. 5 (a_5)	0.81	0.16	0.12	0.02	

Table 11. Credibility Matrix (V)

- DOMINATIVE AGGREGATE MATRIX (CONCORDANT-DISCORDANT) (VI)

Previous to obtain this last matrix we need to determine the threshold values. A minimum to the concordance index (p) and a maximum one for the credibility index (q). From those two values, within the range of 0 to 1, it will be considered that alternative a_i is over a_j if the following equations are simultaneously verified:

$$c_{ij} \leq p$$

$$d_{ij} \geq q$$

In such case, the corresponding element eij matrix homologous to the domain aggregate matrix will be equal to one and zero in the opposite case.

In our specific case, to apply the ELECTE algorithm, we will adopt as threshold values the mean values of both concordance and discordance matrices. This values are: p = 0.50 and q = 0.30.

	Alt. 1 (a_1)	Alt. 2 (a_2)	Alt. 3 (a_3)	Alt. 4 (a_4)	Alt. 5 (a_5)
Alt. 1 (a_1)		0.00	0.00	0.00	0.00
Alt. 2 (a_2)	1.00		0.00	0.00	0.00
Alt. 3 (a_3)	1.00	0.00		0.00	0.00
Alt. 4 (a_4)	1.00	1.00	1.00		1.00
Alt. 5 (a_5)	1.00	0.00	0.00	0.00	

Table 12. Dominative Aggregate Matrix (VI)

From the matrix above, representing all five alternatives in the vertices of a pentagon and tracing an arc from vertex a_i to a_j if the element e_{ij} is equal to 1 we will obtain the following graph:

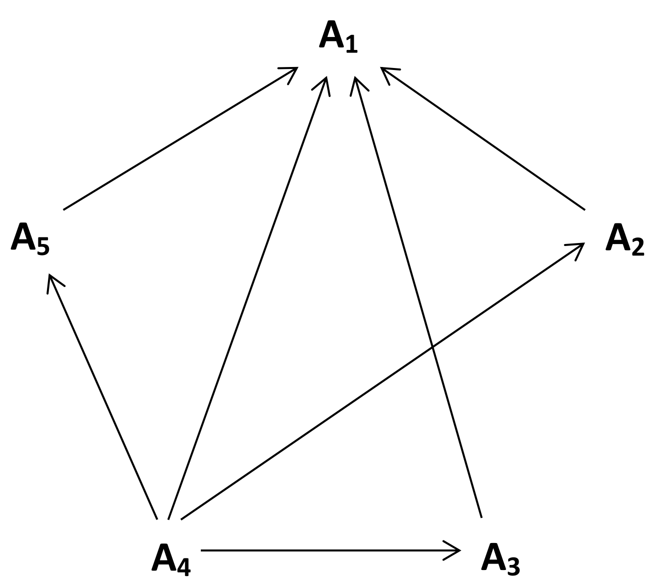


Figure 1. ELECTRE Graph.

6.5. 1st approach - Classification of the alternatives

The classification of our 5 different alignments is shown in the table below.

Alternative	Final Order
New Alignment through Greenfield Ave (A_4)	1st
Delete S. Crossing and Follow existing north alignment (A_2)	2nd
New Alignment through Mony Street (A_3)	2nd
New Alignment through Greenfield Ave and Pharr Street (A_5)	2nd
Follow existing alignment (A_1)	5th

Table 13. 1st Approach - Classification of the Alternatives.

It is important to note that we've chosen the ELECTRE I METHOD because it is an adequate multi-criteria analysis based on weighted punctuation.

The strength of this method relies on preventing that alternatives with good average values but unacceptable under any criteria gets chosen.

At this moment we have a clear first option but the unknowns regarding the geotechnical quality of the soil in the whole area asks for a second option to study. In this regards we must run ELECTRE I again without the 5th option so it doesn't hide the ranking among the 2nd best option.

6.6. 2nd approach - ELECTRE I Method Application

As commented before, in this second approach we will remove the 1st alternative which is "Follow the existing alignment" that had had to be considered as the first and most logical solution.

- INITIAL MATRIX (I)

	Execution (c_1)	Functionality (c_2)	Environmental Impact (c_3)	Economical Cost (c_4)
Alt. 2 (a_2)	12.15	6.25	17.63	3.82
Alt. 3 (a_3)	11.7	5.74	13.43	1.57
Alt. 4 (a_4)	7.87	4.26	9.53	1
Alt. 5 (a_5)	12.86	4	30	2.75
Weight (Pj)	**0.2**	**0.2**	**0.2**	**0.4**
Range	4.99	2.25	20.47	2.82

Table 14. 2nd Approach - Initial Matrix (I)

- NORMALIZED MATRIX (II)

	Execution (c_1)	Functionality (c_2)	Environmental Impact (c_3)	Economical Cost (c_4)
Alt. 2 (a_2)	2.43	2.78	0.86	1.35
Alt. 3 (a_3)	2.34	2.55	0.66	0.56
Alt. 4 (a_4)	1.58	1.89	0.47	0.35
Alt. 5 (a_5)	2.58	1.78	1.47	0.97

Table 15. 2nd Approach - Normalized Matrix (II)

- NORMALIZED AND WEIGHTED MATRIX (III)

	Execution (c_1)	Functionality (c_2)	Environmental Impact (c_3)	Economical Cost (c_4)
Alt. 2 (a_2)	0.49	0.56	0.17	0.54
Alt. 3 (a_3)	0.47	0.51	0.13	0.22
Alt. 4 (a_4)	0.32	0.38	0.09	0.14
Alt. 5 (a_5)	0.52	0.36	0.29	0.39
Weight (Pj)	**0.2**	**0.2**	**0.2**	**0.4**

Table 16. 2nd Approach - Normalized and Weighted Matrix (III)

- CONCORDANCE MATRIX (IV)

	Alt. 2 (a_2)	Alt. 3 (a_3)	Alt. 4 (a_4)	Alt. 5 (a_5)
Alt. 2 (a_2)		1.00	1.00	0.60
Alt. 3 (a_3)	0.00		1.00	0.20
Alt. 4 (a_4)	0.00	0.00		0.20
Alt. 5 (a_5)	0.40	0.80	0.80	

Table 17. 2nd Approach - Concordance Matrix (IV)

- CREDIBILITY MATRIX (V)

The elements of matrix d_{ij} are known as "Discordance rates" are the result of dividing the maximum relative deviation between the criteria where alternative a_i is more unfavorable respect a_j and the maximum relative deviation of the overall criteria, if a_i is more or at least as unfavorable as a_j.

	Alt. 2 (a_2)	Alt. 3 (a_3)	Alt. 4 (a_4)	Alt. 5 (a_5)
Alt. 2 (a_2)		0.00	0.00	0.30
Alt. 3 (a_3)	0.80		0.00	0.42
Alt. 4 (a_4)	1.00	0.38		0.62
Alt. 5 (a_5)	0.50	0.58	0.38	

Table 18. 2nd Approach - Credibility Matrix (V)

- DOMINATIVE AGGREGATE MATRIX (CONCORDANT-DISCORDANT) (VI)

Previous to obtain this last matrix we need to determine the threshold values. A minimum to the concordance index (p) and a maximum one for the credibility index (q). From those two values, within the range of 0 to 1, it will be considered that alternative a_i is over a_j if the following equations are simultaneously verified:

$$c_{ij} \leq p$$

$$d_{ij} \geq q$$

In such case, the corresponding element eij matrix homologous to the domain aggregate matrix will be equal to one and zero in the opposite case.

On this second approach, to apply the ELECTE algorithm, we will adopt as threshold values the mean values of both concordance and discordance matrices. This values are: p = 0.50 and q = 0.42.

	Alt. 2 (a_2)	Alt. 3 (a_3)	Alt. 4 (a_4)	Alt. 5 (a_5)
Alt. 2 (a_2)		0.00	0.00	0.00
Alt. 3 (a_3)	1.00		0.00	1.00
Alt. 4 (a_4)	1.00	0.00		1.00
Alt. 5 (a_5)	1.00	0.00	0.00	

Table 19. 2nd Approach - Dominative Aggregate Matrix (VI)

From the matrix above, representing all four alternatives in the vertices of a square and tracing an arc from vertex a_i to a_j if the element e_{ij} is equal to 1 we will obtain the following graph:

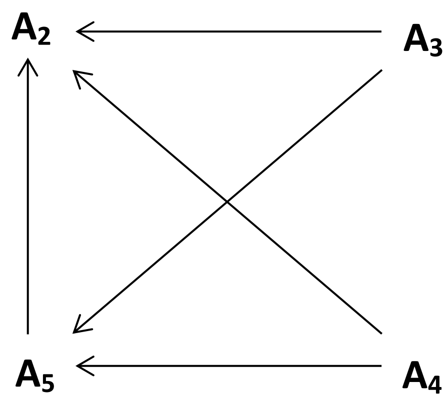


Figure 2. ELECTRE Graph - Second approach.

6.7. 2nd approach – FINAL Classification of the alternatives

The classification of our 5 different alignments is shown in the table below.

Alternative	Final Order
New Alignment through Greenfield Ave (A_4)	1st
Alignment through Mony Street (A_3)	2nd
New Alignment through Greenfield Ave and Pharr Street New (A_5)	3rd
Delete S. Crossing and Follow existing north alignment (A_2)	4th

Table 20. Final Classification of the Alternatives.

On this second approach to the ELCTRE I Multi-criteria Method we've discerned between alternatives two through five. As show on table 53, alternative 4 stills in first position but among the other, alternative 3 is over the rest.

For the record, I want to repeat once more that this is the initial approach and extra cost may arise due to the future geotechnical provisions and actions and other expenses as safety or traffic control.

Appendix No. 7:

Geotechnical Study

INDEX - APPENDIX NO. 7: GEOTECHNICAL STUDY

INDEX - FIGURE AND TABLE

On this appendix Sheet pilling will be consider as a functional solution to our soil problems. There will be an study to where it is worthy to install it and how it can be adapted to work with the de-watering system discussed in appendix 8. Also an engineered trenching will be studied in case of not applying any sheet pilling method at all.

7. Sheet Pilling and Shoring

7.1. Earth Pressure Theories

Earth pressure is the force per unit area exerted by the soil on the sheet pile structure. The magnitude of the earth pressure depends upon the physical properties of the soil, the interaction at the soil-structure interface and the magnitude and character of the deformations in the soil-structure system. Earth pressure is also influenced by the time-dependent nature of soil strength, which varies due to creep effects and chemical changes in the soil.

Earth pressure against a sheet pile structure is not a unique function for each soil, but rather a function of the soil-structure system. Accordingly, movements of the structure are a primary factor in developing earth pressures. The problem, therefore, is highly indeterminate.

Two stages of stress in the soil are of particular interest in the design of sheet pile structures, namely the **active** and **passive** states. When a vertical plane, such as a flexible retaining wall, deflects under the action of lateral earth pressure, each element of soil adjacent to the wall expands laterally, mobilizing shear resistance in the soil and causing a corresponding reduction in the lateral earth pressure. One might say that the soil tends to hold itself up by its boot straps; that is, by its inherent shear strength. The lowest state of lateral stress, which is produced when the full strength of the soil is activated (a state of shear failure exists), is called the active state. The active state accompanies outward movement of the wall. On the other hand, if the vertical plane moves toward the soil, such as the lower embedded portion of a sheet pile wall, lateral pressure will increase as the shearing resistance of the soil is mobilized. When the full strength of the soil is mobilized, the passive state of stress exists. Passive stress tends to resist wall movements and failure.

There are two well-known classical earth pressure theories; the Rankine Theory and the Coulomb Theory. Each furnishes expressions for active and passive pressures for a soil mass at the state of failure.

7.1.1. Rankine Theory

The Rankine Theory is based on the assumption that the wall introduces no changes in the shearing stresses at the surface of contact between the wall and the soil. It is also assumed that the ground surface is a straight line (horizontal or sloping surface) and that a plane failure surface develops.

When the Rankine state of failure has been reached, active and passive failure zones will develop as shown in Figure 1.

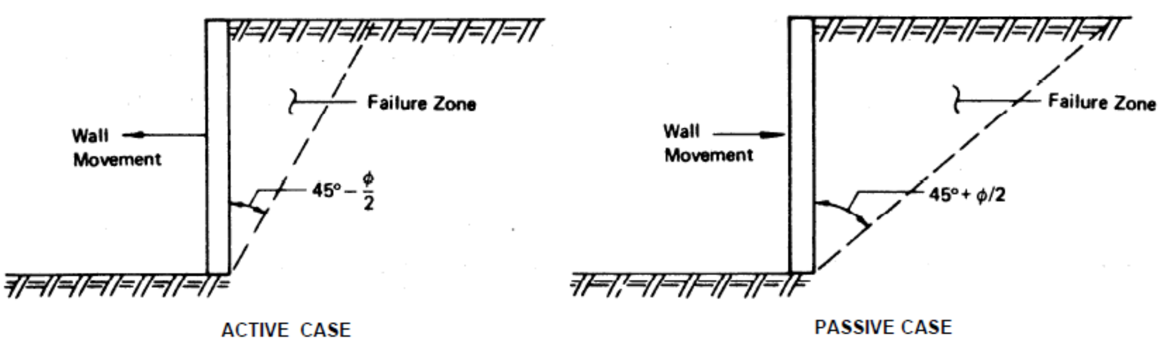


Figure 1. Rankine failure zones (ϕ = angle of internal friction of soil in degrees)

The active and passive earth pressures for these states are expressed by the following equations:

$$p_a = \gamma Z K_a - 2c\sqrt{K_a}$$

$$p_p = \gamma Z K_p + 2c\sqrt{K_p}$$

Where;

P_a and p_p = unit active and passive earth pressure, respectively, at a depth Z below the ground surface.

γZ = vertical pressure at a depth Z due to the weight of soil above, using submerged weight for the soil below ground water level.

C = unit cohesive strength of soil.

K_a and K_p = coefficients of active and passive earth pressures, respectively.

The coefficients K_a and K_p, according to the Rankine Theory, are functions of the ϕ angle of the soil and the slope of the backfill, β (Which in our cases will be zero). For the case of a level backfill, they are given by the expressions:

$$K_a = \frac{1-\sin(\varphi)}{1+\sin(\varphi)} = tan^2(45 - \frac{\varphi}{2})$$

$$K_p = \frac{1+\sin(\varphi)}{1-\sin(\varphi)} = tan^2(45 + \frac{\varphi}{2})$$

7.1.2. *Coulomb Theory*

An inherent assumption of the Rankine Theory is that the presence of the wall does not affect the shearing stresses at the surface of wall contact. However, since the friction between the retaining wall and the soil has a significant effect on the vertical shear stresses in the soil, the lateral stresses on the wall are actually different than those assumed by the Rankine Theory. As the wall yields, the failure wedge tends to move downward for the active case. For the passive case, where the wall is forced against the soil, the wedge slides upward along the failure plane. These differential movements involve vertical displacements between the wall and backfill and create tangential stresses on the back of the wall due to soil friction and adhesion. The resulting force on the wall is, therefore, inclined at an angle to the normal to the wall. This angle is known as the angle of wall friction, δ. For the active case, when the active wedge slides downward relative to the wall, is taken as positive. For the passive case, when the passive wedge slides upward relative to the wall, δ is taken as negative. If the angle of wall friction is known, the following analytical expressions for K_a and K_p in the horizontal direction for a vertical wall are:

$$K_a = \frac{cos^2(\varphi)}{\cos(\delta)\left[1+\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi-\beta)}{\cos(\delta)\cos(\beta)}}\right]^2}$$

$$K_p = \frac{cos^2(\varphi)}{\cos(\delta)\left[1-\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi+\beta)}{\cos(\delta)\cos(\beta)}}\right]^2}$$

In our case, as explained before, β angle will be equal to zero because we will have a leveled backfill at all times.

7.2. Design of Sheet pile retaining walls

The design of sheet pile retaining walls requires several successive operations: (a) evaluation of the forces and lateral pressures that act on the wall, (b) determination of the required depth of piling penetration, (c) computation of the maximum bending moments in the piling, (d) computation of the stresses in the wall and selection of the appropriate piling section and (e) the design of the waling and anchorage system.

There are two basic types of steel sheet pile walls: cantilevered walls and anchored walls. Due to the length of our trench and the little use that will have (To maintain stable the trench) we will only consider the cantilever walls.

7.2.1. Cantilever Walls

In the case of a cantilevered wall, sheet piling is driven to a sufficient depth into the ground to become fixed as a vertical cantilever in resisting the lateral active earth pressure. This type of wall is suitable for moderate height. Walls designed as cantilevers usually undergo large lateral deflections and are readily affected by scour and erosion in front of the wall. Since the lateral support for a cantilevered wall comes from passive pressure exerted on the embedded portion, penetration depths can be quite high, resulting in excessive stresses and severe yield. Therefore, cantilevered walls using steel sheet piling are restricted to a maximum height of approximately 15 feet.

Earth pressure against a cantilevered wall is illustrated in Figure 2. When the lateral active pressure (P) is applied to the top of the wall, the piling rotates about the pivot point, b, mobilizing passive pressure above and below the pivot point. The term (p_p-p_a) is the net passive pressure, p_p, minus the active pressure, p_a. (Since both are exerting pressure upon the wall.)

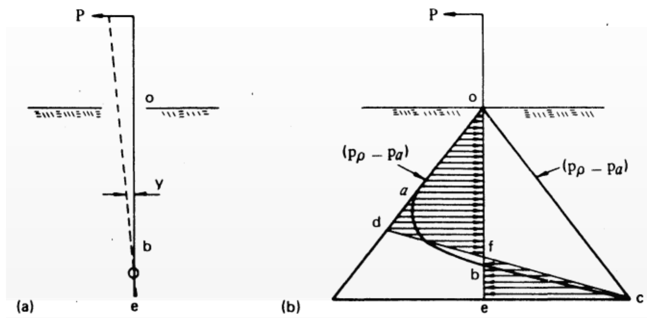


Figure 2. Earth pressure on cantilever sheet piling.

At point b the piling does not move and would be subjected to equal and opposite at-rest earth pressures with a net pressure equal to zero. The resulting earth pressure is represented by the diagram oabc. For the purpose of design, the curve abc is replaced by a straight line dc. The point d is located so as to make the sheet piling in a state of static equilibrium. Although the assumed pressure distribution is in error, it is sufficient for design purposes.

The distribution of earth pressure is different for sheet piling in granular soils and sheet piling in cohesive soils. As long as it will be used to maintain the loose sand, we won't consider the pressure distribution in clays. Also, clays are considered differently because the pressures change over time and our case is, as said before, temporary.

7.2.2. Cantilever Sheet Piling in Granular Soils

A cantilevered sheet pile wall may be designed in accordance with the principles and assumptions just discussed or by an approximate method based on further simplifying assumptions shown in Figure 3.

As we want to design this retaining wall as efficient as possible, the simplified method is excluded and all our calculations will be done with the conventional method.

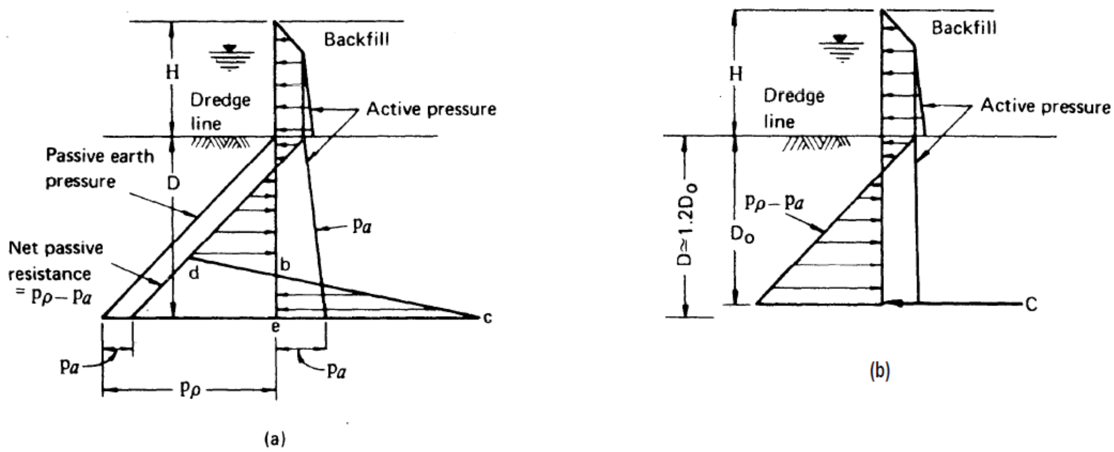


Figure 3. Design of cantilever sheet piling in granular soils: (a) conventional method; (b) simplified method.

The conventional design procedure for granular soils is as follows:

1. Assume a trial depth of penetration, D. This may be estimated from the following approximate correlation.

Standard Penetration Resistance, N Blows/Foot	Relative Density of Soil, D_d	Depth of Penetration*
0-4	Very Loose	2.0 H
5-10	Loose	1.5 H
11-30	Medium dense	1.25 H
31-50	Dense	1.0 H
+50	Very dense	0.75 H

Table 1. Trial depth penetration, D. Table 2 (H* = Height of piling above dredge line)

2. Determine the active and passive lateral pressures using appropriate coefficients of lateral earth pressure. The resulting earth pressure diagram for a homogeneous granular soil is shown in Figure 4 where the active and passive pressures are overlain to pictorially describe the resulting soil reactions.

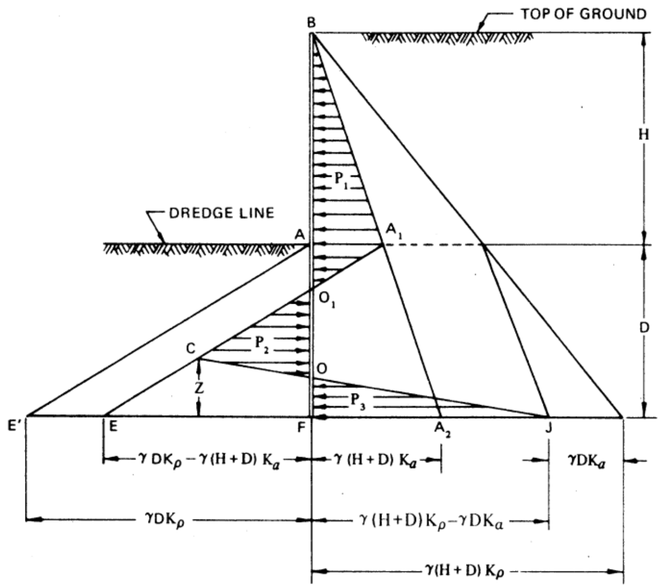


Figure 4. Resultant earth-pressure diagram.

3. Satisfy the requirements of static equilibrium: the sum of the forces in the horizontal direction must be zero and the sum of the moments about any point must be zero. The sum of the horizontal forces may be written in terms of pressure areas:

$$\Delta(\overleftrightarrow{EA1A2}) - \Delta(\overleftarrow{FBA2}) - \Delta(\overleftarrow{ECJ}) = 0$$

Solve the above equation for the distance, Z. For a uniform granular soil,

$$Z = \frac{K_p D^2 - K_a (H + D)^2}{(K_p - K_a)(H + 2D)}$$

Take moments about the point F and check to determine if the sum of the moments is equal to zero, as it must be. Readjust the depth of penetration, D, and repeat until convergence is reached; i.e., the sum of the moments about F is zero.

4. Add 20 to 40 percent to the calculated depth of penetration. This will give a safety factor of approximately 1.5 to 2.0. An alternate and more desirable method is the use of a reduced value of the passive earth pressure coefficient for design. The maximum allowable earth pressure should be limited to 50 to 75 percent to the ultimate passive resistance.

5. Compute the maximum bending moment, which occurs at the point-of zero shear, prior to increasing the depth by 20 to 40 percent.

7.3. Greenfield Avenue Alternative

The design of this alternative will be done exhaustively every 100 feet and at "Annex 1: Greenfield Avenue Alternative Report Compilation" the reader will found each report .

The internal friction (ϕ) and the density of the soil (γ), as well as the strata and trench elevation, will be the main changing factors. The external friction angle (δ) will remain at 20 degrees at all times. It is common to assign such values for steel sheet piles. This value was taken from the naval facilities Engineering Command Geotechnical Manual.

A surcharge action will be added to make sure that the loads do not exceed the allowable loading of the shoring equipment. This loads are usually around 150 to 200 PSF but we will set them at a 300 PSF due to the unknown quantity of machinery and material that will be stored next to the trench.

The final steel pile depth embedded in the ground will be extended up to a 35% as a safety factor. Sheet piles won't usually get until the shale strata and our sand is very instable.

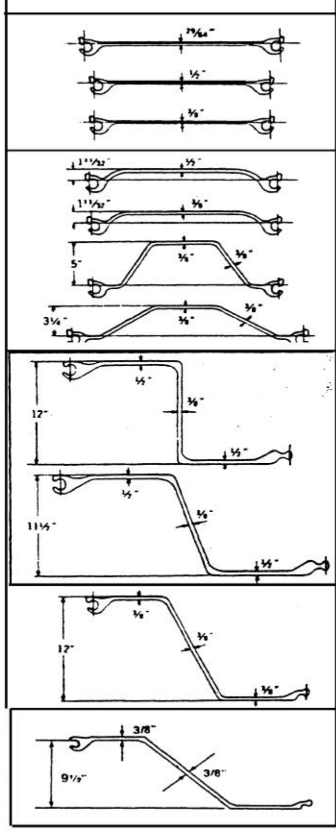
7.3.1. Greenfield Avenue Alternative Anchorage Profile and Cost

As we can see on the reports at the very end of this appendix, there are several sheet piling sections. All of them depends on the steel quality. We will keep the regular carbon grade (ASTM A 328) as it is the most common and our work is for temporary use.

Suggested Allowable Design Stresses-Sheet Piling		
Steel Brand or Grade	Minimum Yield Point, psi	Allowable Design Stress, psi*
USS-EX-TEN 55 (ASTM A572 GR 55)	55,000	35,000
USS EX-TEN 50 (ASTM A572 GR 50)	50,000	32,000
USS MARINER STEEL	50,000	32,000
USS EX-TEN 45 (ASTM A572 GR 45)	45,000	29,000
Regular Carbon Grade (ASTM A 328)	38,500	25,000

Table 3. Allowable Desing Stresses. (*Based on 65% of minimum yield point. Some increase for temporary Overstresses generally permissible)

The following chart (table 4) indicates what kind of anchorage can be used related to the sheet piling sections.



Steel Sheet Piling Sections													
Profile	Section Index		Distri Rolle	Driving Distance per Pile	Weight		Web Thickness	Section Modulus		Area	Moment of Inertia		
					Per Foot	Per Square Foot of Wall		Per Pile	Per Foot of Wall	Per Pile	Per Pile	Per Foot of Wall	
				In.	Lbs.	Lbs.	In.	In.³	In.³	In.²	In.⁴	In.⁴	
	Interlock with Each Other	PSX 32	H.	16½	44.0	32.0	29/64	3.3	2.4	12.94	5.1	3.7	
		PS32*	H.S.	15	40.0	32.0	½	2.4	1.9	11.77	3.6	2.9	
		PS 28	H.S.	15	35.0	28.0	⅜	2.4	1.9	10.30	3.5	2.8	
	Interlock with Each Other	PSA 28*	H.	16	37.3	28.0	½	3.3	2.5	10.98	6.0	4.5	
		PSA 23	H.S.	16	30.7	23.0	⅜	3.2	2.4	8.99	5.5	4.1	
		PDA 27	H.S.	16	36.0	27.0	⅜	14.3	10.7	10.59	53.0	39.8	
		PMA 22	H.S.	19⅝	36.0	22.0	⅜	8.8	5.4	10.59	22.4	13.7	
	Interlock with Each Other and with PSA23 or PSA28	PZ38	H.	18	57.0	38.0	⅜	70.2	46.8	16.77	421.2	280.8	
		PZ32	H.	21	56.0	32.0	⅜	67.0	38.3	16.47	385.7	220.4	
		PZ27	H.	18	40.5	27.0	⅜	45.3	30.2	11.91	276.3	184.2	
		PZ 22	H.	22	0.3	22.0	⅜	34.8	9.0	11.9	167	91.1	

Table 4. Sheet piling sections.

Checking all necessary sections throughout the project, we need a section modulus per foot of wall up to almost 6.0 in^3. Taking into account that the Texas Low bid prices shows price only for the PZ 22, this one is the sheet pilling section that we are going to use. It fits our purposes and it isn't exaggeratedly oversized.

Therefore, the following table 5 shows the final price if the whole project is sheet piled. Price is good if sheet pilling crew installs more than 42,000 ft^2.

Greenfield Ave - SHEET PILING (PZ-22)						
Station		**Sheet pile LENGTH**	**Application Distance**	**TOTAL ft^2 (Double side)**	**$/SF**	**TOTAL Price**
00+00.00	01+00.00	12.16	100	2432	$ 25.22	$ 61,335.04
01+00.00	02+00.00	12.53	100	2506	$ 25.22	$ 63,201.32
02+00.00	03+00.00	13.15	100	2630	$ 25.22	$ 66,328.60
03+00.00	04+00.00	13.77	100	2754	$ 25.22	$ 69,455.88
04+00.00	05+00.00	14.38	100	2876	$ 25.22	$ 72,532.72
05+00.00	06+00.00	17.92	100	3584	$ 25.22	$ 90,388.48
06+00.00	07+00.00	15.2	100	3040	$ 25.22	$ 76,668.80
07+00.00	08+00.00	11.49	100	2298	$ 25.22	$ 57,955.56
08+00.00	09+00.00	11.79	100	2358	$ 25.22	$ 59,468.76
09+00.00	10+00.00	13.91	100	2782	$ 25.22	$ 70,162.04
10+00.00	11+00.00	15.82	100	3164	$ 25.22	$ 79,796.08
11+00.00	12+00.00	17.4	100	3480	$ 25.22	$ 87,765.60
12+00.00	13+00.00	19.96	100	3992	$ 25.22	$ 100,678.24
13+00.00	14+00.00	22.18	100	4436	$ 25.22	$ 111,875.92
14+00.00	15+00.00	21.02	100	4204	$ 25.22	$ 106,024.88
15+00.00	16+00.00	19.31	100	3862	$ 25.22	$ 97,399.64
16+00.00	17+00.00	17.3	100	3460	$ 25.22	$ 87,261.20
17+00.00	18+00.00	17.01	100	3402	$ 25.22	$ 85,798.44
18+00.00	19+00.00	16.72	100	3344	$ 25.22	$ 84,335.68
19+00.00	20+00.00	16.64	100	3328	$ 25.22	$ 83,932.16
20+00.00	21+00.00	17.34	100	3468	$ 25.22	$ 87,462.96
21+00.00	22+00.00	18.11	100	3622	$ 25.22	$ 91,346.84
22+00.00	23+00.00	18.87	100	3774	$ 25.22	$ 95,180.28
23+00.00	24+00.00	20.4	100	4080	$ 25.22	$ 102,897.60
24+00.00	25+00.00	23.53	100	4706	$ 25.22	$ 118,685.32
25+00.00	26+00.00	25.08	100	5016	$ 25.22	$ 126,503.52
26+00.00	27+00.00	22.71	100	4542	$ 25.22	$ 114,549.24
27+00.00	27+25.13	20.89	25.13	1049.9	$ 25.22	$ 26,479.27
			Total square feet	94189.9	TOTAL $ =	$ 2,375,470.07

Table 5. Greenfield Avenue Alternative Cost (Sheet Pile PZ-22).

7.4. Mony Street Alternative

The following table shows the results of the study of the sheet pile length needed at any station as did with the prior alternative. Parameters were maintained.

7.4.1. Mony Street Alternative Anchorage Profile and Cost

Mony Street - SHEET PILING (PZ-22)									
Station		Sheet pile LENGTH	Application Distance	TOTAL ft^2 (Double side)	$/SF		TOTAL Price		
00+00.00	01+00.00	12.21	100	2442	$	25.22	$	61,587.24
01+00.00	02+00.00	12.62	100	2524	$	26.22	$	66,179.28
02+00.00	03+00.00	13.24	100	2648	$	27.22	$	72,078.56
03+00.00	04+00.00	13.86	100	2772	$	25.22	$	69,909.84
04+00.00	05+00.00	14.49	100	2898	$	26.22	$	75,985.56
05+00.00	06+00.00	18.07	100	3614	$	27.22	$	98,373.08
06+00.00	07+00.00	15.33	100	3066	$	28.22	$	86,522.52
07+00.00	08+00.00	11.61	100	2322	$	29.22	$	67,848.84
08+00.00	09+00.00	11.9	100	2380	$	30.22	$	71,923.60
09+00.00	10+00.00	14.08	100	2816	$	31.22	$	87,915.52
10+00.00	11+00.00	15.98	100	3196	$	32.22	$	102,975.12
11+00.00	12+00.00	17.56	100	3512	$	33.22	$	116,668.64
12+00.00	13+00.00	20.15	100	4030	$	34.22	$	137,906.60
13+00.00	14+00.00	22.34	100	4468	$	35.22	$	157,362.96
14+00.00	15+00.00	21.16	100	4232	$	36.22	$	153,283.04
15+00.00	16+00.00	19.53	100	3906	$	37.22	$	145,381.32
16+00.00	17+00.00	17.42	100	3484	$	38.22	$	133,158.48
17+00.00	18+00.00	17.13	100	3426	$	39.22	$	134,367.72
18+00.00	19+00.00	15.97	100	3194	$	40.22	$	128,462.68
19+00.00	20+00.00	16.48	100	3296	$	41.22	$	135,861.12
20+00.00	21+00.00	15.76	100	3152	$	42.22	$	133,077.44
21+00.00	22+00.00	15.03	100	3006	$	43.22	$	129,919.32
22+00.00	23+00.00	14.29	100	2858	$	44.22	$	126,380.76
23+00.00	24+00.00	13.47	100	2694	$	45.22	$	121,822.68
24+00.00	25+00.00	12.54	100	2508	$	46.22	$	115,919.76
25+00.00	26+00.00	11.61	100	2322	$	47.22	$	109,644.84
26+00.00	26+18.97	7.48	18.97	283.7912	$	48.22	$	13,684.41
	LATERAL							
00+00.00	01+00.00	12	100	2400	$	50.22	$	120,528.00

01+00.00	02+00.00	15.97	100	3194	$ 51.22	$ 163,596.68
02+00.00	03+00.00	16	100	3200	$ 52.22	$ 167,104.00
03+00.00	04+00.00	16.03	100	3206	$ 53.22	$ 170,623.32
04+00.00	04+37.86	15.97	37.86	1209.248	$ 54.22	$ 65,565.45
			Total square feet	94259.04	TOTAL $ =	$ 3,541,618.38

Table 6. Mony Street Alternative Cost (Sheet Pile PZ-22)

7.5. Sheet Pilling Conclusion

This option to stabilize and create a stable construction area without predictable settlement and with an extra safety component is a feasible option but, even though the scope of its installation was reduced up to the worst areas, the cost of sheet pilling would still be that high that it makes no sense to use it. Also, a reduced square footage installation could lead to higher prices per square foot.

After all this study we can accept that sheet pilling is not an economically feasible option and that an usual shoring has to be used combining it with the a de-watering proposal explain in the following appendix.

With that said, Sheet pilling isn't anymore an option and will have no further study.

7.6. Trench Shoring

Whereas the sheet pilling isn't needed, a shoring must be implemented. such shoring is included in the Trench Safety Report that every contractor must do before excavating a trench if such trench is deeper than 20ft or if the soil is instable.

In our case is due to this second cause.

Trenches more than five feet deep shall be shored, laid back to a stable slope, or some other equivalent means of protection shall be provided where employees may be exposed to moving ground or cave-ins. Trenches less than five feet in depth shall also be effectively protected when examination of ground indicates hazardous ground movement may be expected. In our area, if sand is hit before such 5 feet, shoring will be implemented without hesitation.

The following calculations will be applied in both alternatives as the area and the depth of the excavations are quite similar.

7.7. Lateral earth Pressure:

We will assume Clay as its effective weight is higher than the sand. All calculations are in reference to OSHA Rules and Regulations-Part 1926 of29 CFR as amended by the Federal Register Volume 54, Number 209, October 31, 1989.

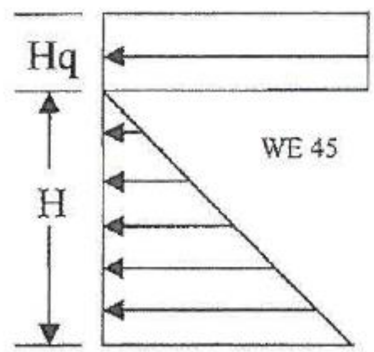


Figure 5. Uniform distributed lateral soil pressure, in lbs/ft^2.

Lateral Earth Pressure: P = We (H+Hq)

P = a uniformly distributed lateral soil pressure, in lbs/ft^2.

We = Effective Soil Weight, (Use We=45) .

H = Depth of excavation from top of supported bank to bottom of excavation in feet.

Hq = Equivalent Height of Surcharge, in feet. (Hq = Surcharge/We)

$$P = 45 \cdot \left(10 + {}^{300}/_{45}\right) = 750\ PSF$$

Maximum anticipated lateral earth pressure for this project is 750 "PSF"

7.8. Trench Safety Specifications

7.8.1. Option 1 – Slope

The Contractor can use Slope as shown in the Option 1 section of the specification. Applicable slopes may be obtained. by either straight cut or benched method. Vertical cuts for the benched method shall not exceed four feet. Easement or Right of Way restrictions may limit the use of this option. See Drawing Option 1.

HIV - REQUIRED SLOPE PER SOIL TYPE

H/V= ¾ to 1	Stiff clays less than 12 ft. in depth
H/V = 1 to 1	Stiff clays greater than 12 feet in depth.
H/V= 1.5 to 1	Loose or saturated soils.

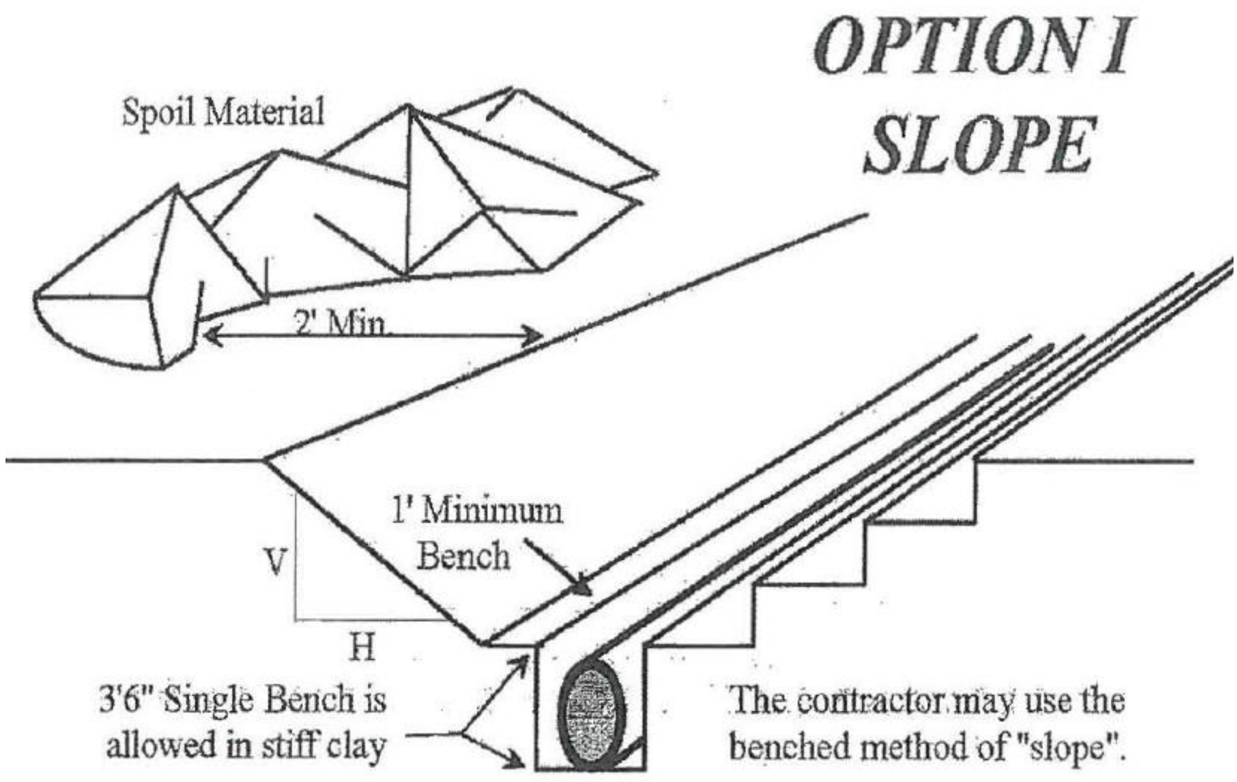


Figure 6. Option 1 - Slope Diagram.

Notes:

- Water shall not be permitted to stand in the bottom of the trench and suction pumps of adequate capacity shall be installed to ensure that such standing water is removed.
- All slopes assume sufficient right-of-way exists.
- All slopes shall be flattened an additional ½ foot if an existing parallel utility line is located within the horizontal distance equal to the depth of the new utility excavation.
- No spoil or equipment shall be permitted nearer than 2 feet from the edge of the excavation.
- Exposed existing utility lines are to be supported.
- 3' - 6" Vertical cut allowed in stiff clay or limestone.

7.8.2. Option 2 – Trench Shield

The Contractor may use a Trench Shield as shown in the Option II section of this specification. Requirements set forth in this Option shall include curricular trench shield(s) and or manhole boxes. All slopes above trench shield(s) shall conform to guidelines set forth in Option I. Trench shield(s) used on this project will be required to carry a minimum "PSF" as specified. Certification of trench shield(s) or manufacture's "tabulated data" shall be available for verification during construction. See Drawing Option II.

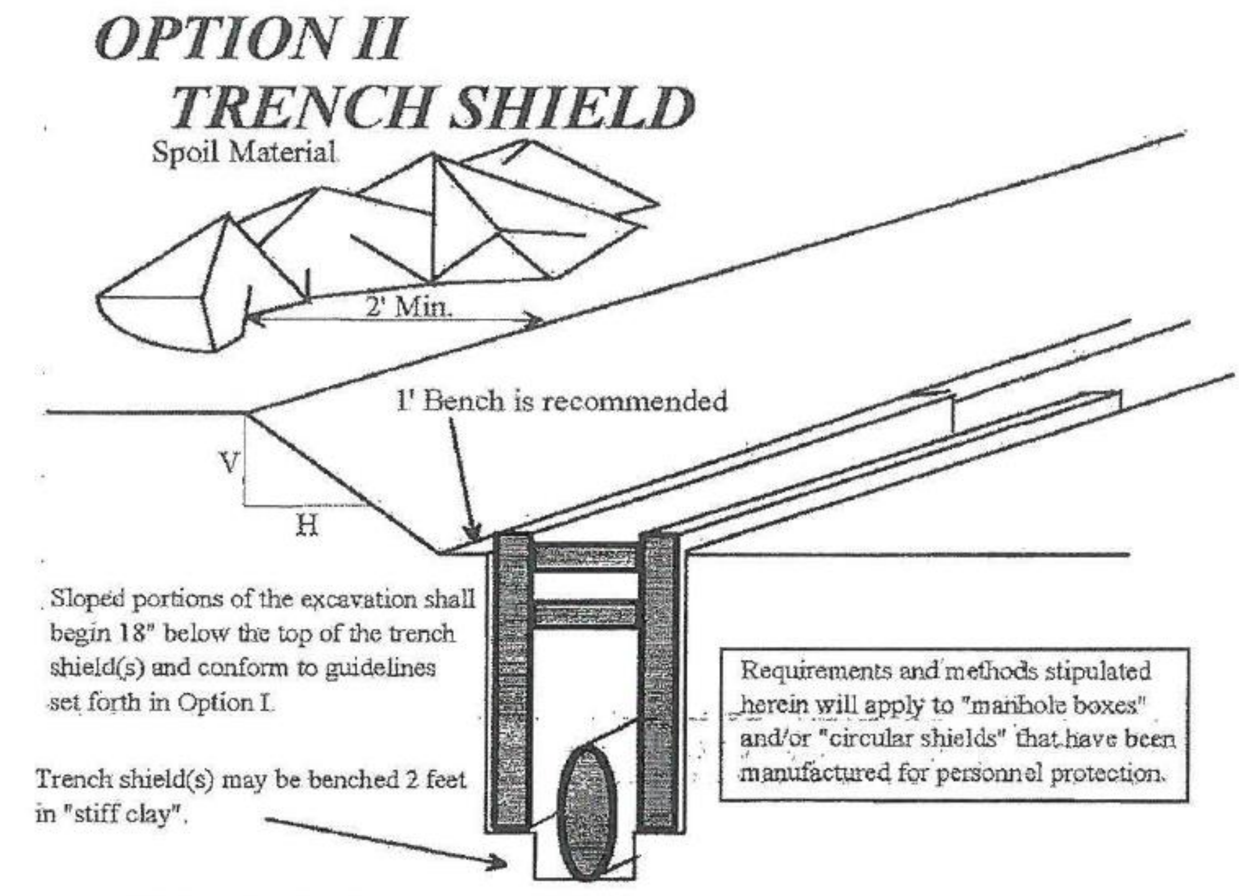


Figure 7. Option 2 - Trench Shield Diagram.

Notes:

- Trench shields shall be inspected and be free of structural defects that may impair their proper function.
- Trench shields shall be used in accordance with the manufacturer's guidelines and recommendations.
- Trench shields shall be installed so as to prevent any lateral or other hazardous movement.
- Personnel shall not be allowed in the trench shield during its installation or removal from the excavation.
- When shield(s) are stacked, the upper shield shall be rated for its physical depth in the trench.
- Manufacture's tabulated data or certification shall be maintained on site.

7.8.3. Option 2 – Plywood Shoring

The contractor can use Trench Shores as shown in the Option III Section of this specification. Shores are to be installed as shown with horizontal spacing determined by the depth of cut and soil type but shall not exceed 6 feet. See Drawing Option ill. If there is raveling of the trench wall, the contractor shall install plywood behind the shores as shown on the Option III figure 8.

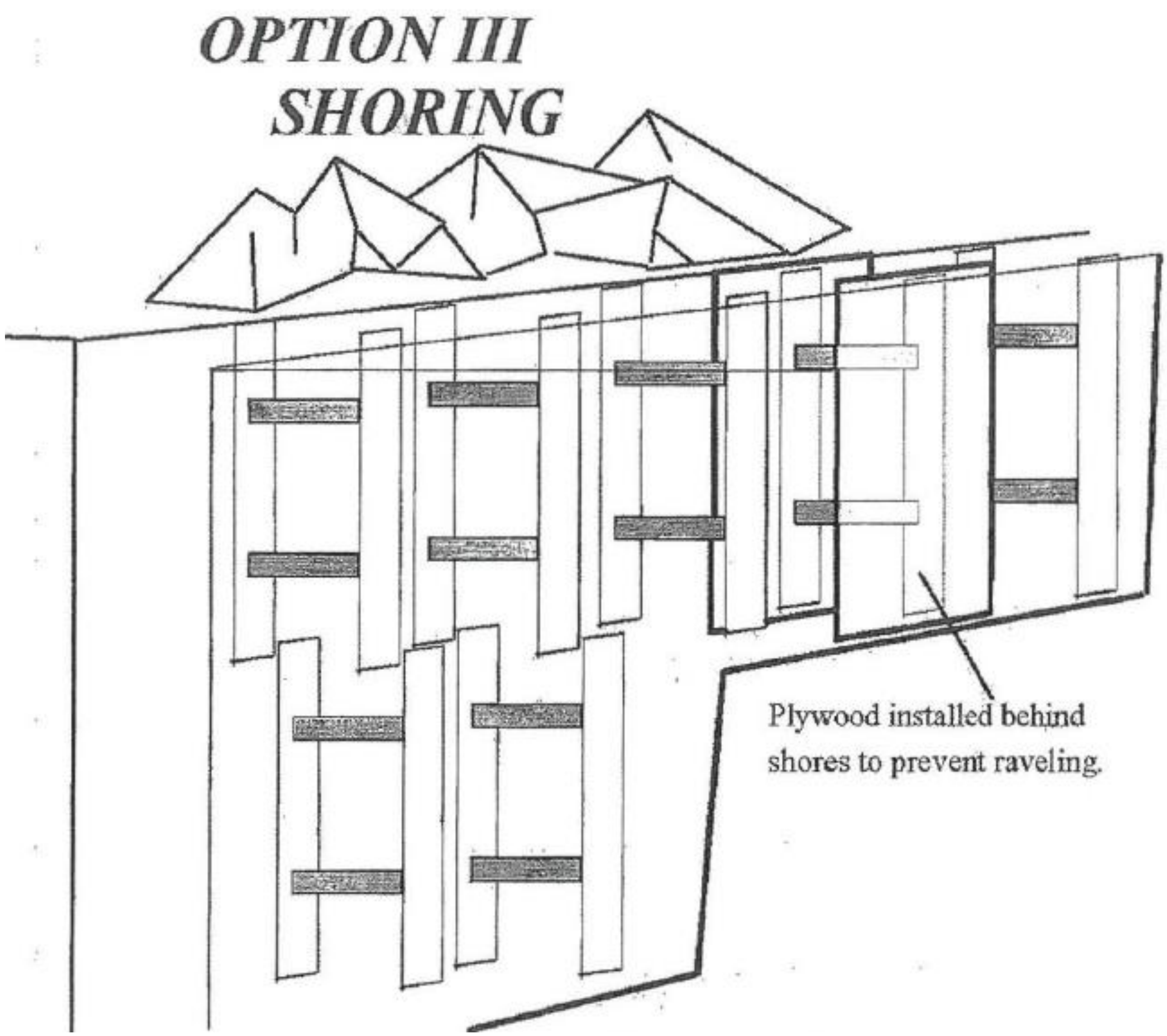


Figure 8. Option 3 – Shoring

Notes:

- Shores shall be double stacked when trench depths exceed nine (9) feet.
- Maximum horizontal spacing for double stacked shores shall be five (5) feet.
- Maximum allowable depth of cut for this Option shall be fourteen (14) feet.
- Aluminum hydraulic shoring may be used in Type "A" or "B" soils only.
- Maximum horizontal spacing of shores in Type "A" soil shall be 6 feet.
- Maximum horizontal spacing of shores in Type "B" soil shall be 5 feet.
- The contractor's competent person shall inspect shores and verify that they are in good working order.
- The hydraulic shores shall have a minimum working pressure of750 psi.
- The contractor shall adhere to the shoring manufacturer's guidelines for use in trench excavations.
- If there is evidence of raveling or caving the contractor is required to install 1’ - 1/8” thick plywood or ¾” thick 14 ply arctic white birch (Finnland form).
- Spoil material will not be allowed nearer than 2' from the edge of the excavation.

7.9. Shoring Cost – Trench Excavation protection

Texas Department of Transportation publishes every 3 months a average low bid unit price statewide at a 3 month moving average time. From this prices we can extract the following ones:

Item Description	Unit of measure	Three month Moving Quantity	Three Month Avg Bid	Usage
TRENCH EXCAVATION PROTECTION	LF	4,641.00	$3.57	2
TRENCH EXCAVATION PROTECTION	LF	85,433.00	$4.04	32

Table 7. Trench Excavation Protection - Item Description.

From the prices stated above we should use the one used for a 4,641 feet trench excavation protection. Although, the last column shows how many times this price it's been used. Therefore it seems more realistic to use the second row item as it is the most common one among Texas contractors. With that said, the trench excavation cost for this work will be:

SHORING COST - COMPARATIVE				
	Unit Cost	Quantity	Unit of Measure	Shoring Cost
Greenfield Ave Alternative	$ 4.04	2725.13	LF	$ 11,009.53
Mony Street Alternative	$ 4.04	3056.86	LF	$ 12,349.71

Table 8. Shoring Cost - Comparative.

ANNEX 7.1 – Greenfield Avenue Sheet Pilling Report

INITIAL DATA

Initial Sta. =	0+00.00
Final Sta. =	1+00.00
Ground elev. =	522.6
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.6615

FORCES

Pa =	396.023544	psf
Pa2 =	462.978461	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	911.944737	psf
Pj =	1307.96828	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	7.9385	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.1277701 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.72691266 LF

Moment equilibrium

Mo = 9.05421E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

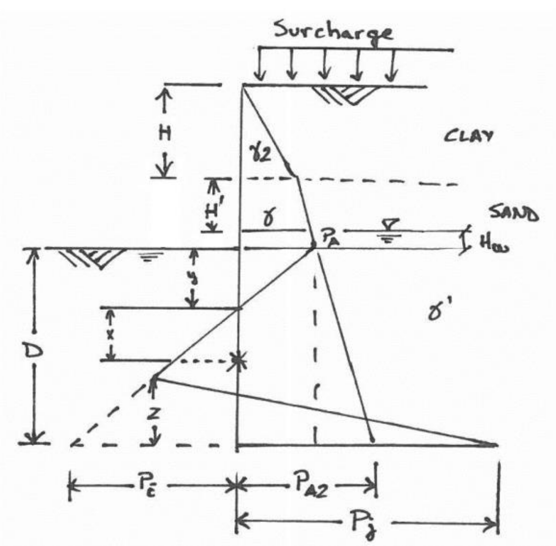
y =	0.94701884	LF
ΣPa at y=	187.520879	Lb
x =	0.94701884	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 236.781073 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.08118208 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.0887929 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.0887929 in^3

USS MARINER STEEL

S4 = 0.09797837 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.11365491 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.22	LF
Total Length =	12.16	LF

INITIAL DATA

Initial Sta. =	1+00.00
Final Sta. =	2+00.00
Ground elev. =	522.725
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.5245

FORCES

Pa =	406.150054	psf
Pa2 =	474.817212	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	935.266954	psf
Pj =	1341.41701	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	8.2005	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	3.2077567	LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z =	0.74550456	LF

Moment equilibrium

Mo =	6.06344E-03	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

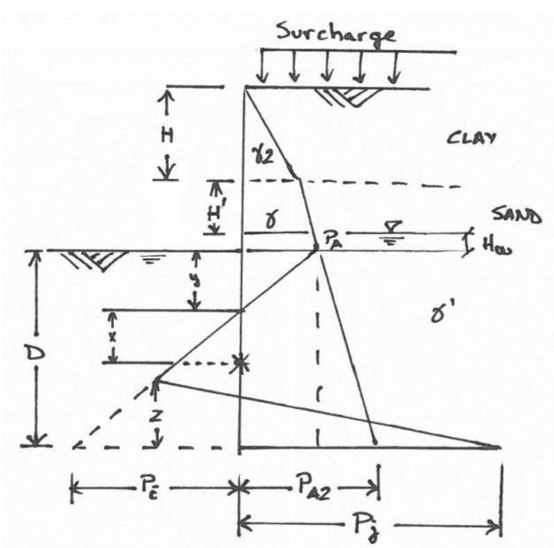
y =	0.97123456	LF
ΣPa at y=	197.233485	Lb
x =	0.97123456	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	255.413302	Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 =	0.08757028	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	0.09577999	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	0.09577999	in^3

USS MARINER STEEL

S4 =	0.10568826	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	0.12259839	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.33	LF
Total Length =	12.53	LF

INITIAL DATA

Initial Sta. =	2+00.00
Final Sta. =	3+00.00
Ground elev. =	523.025
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.3875

FORCES

Pa =	423.040455	psf
Pa2 =	494.563538	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	974.167241	psf
Pj =	1397.2077	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	8.6375	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.3411701 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.77651505 LF

Moment equilibrium

Mo = 1.40177E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

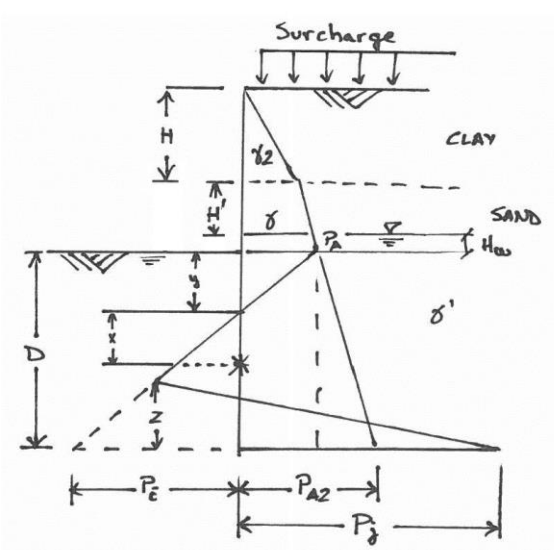
y =	1.0116249	LF
ΣPa at y=	213.97913	Lb
x =	1.0116249	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 288.622155 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.09895617 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.10823331 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.10823331 in^3

USS MARINER STEEL

S4 = 0.11942986 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.13853863 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.51	LF
Total Length =	13.15	LF

INITIAL DATA

Initial Sta. =	3+00.00
Final Sta. =	4+00.00
Ground elev. =	523.325
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.2505

FORCES

Pa =	439.930855	psf
Pa2 =	514.309584	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1013.06204	psf
Pj =	1452.9929	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	9.0745	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.4745703 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.80751835 LF

Moment equilibrium

Mo = 1.38937E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

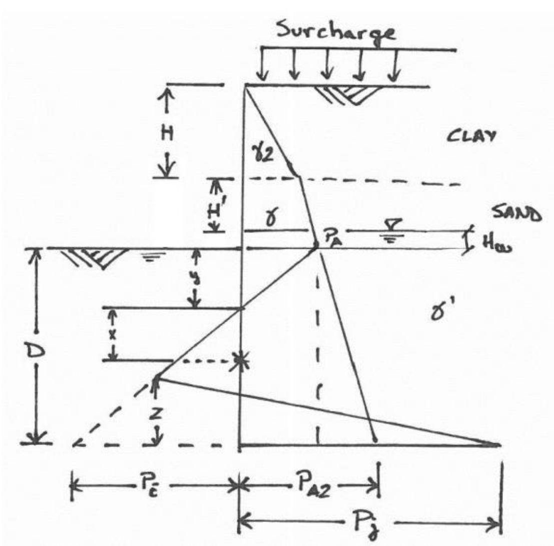
y =	1.05201525	LF
ΣPa at y=	231.406984	Lb
x =	1.05201525	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 324.591567 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.11128854 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.12172184 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.12172184 in^3

USS MARINER STEEL

S4 = 0.13431375 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.15580395 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.69	LF
Total Length =	13.77	LF

INITIAL DATA

Initial Sta. =	4+00.00
Final Sta. =	5+00.00
Ground elev. =	523.625
Sand Strata elev. =	513.25
Shale Strata elev. =	493.75
Water elevation =	512.375
Bottom trench =	514.1135

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

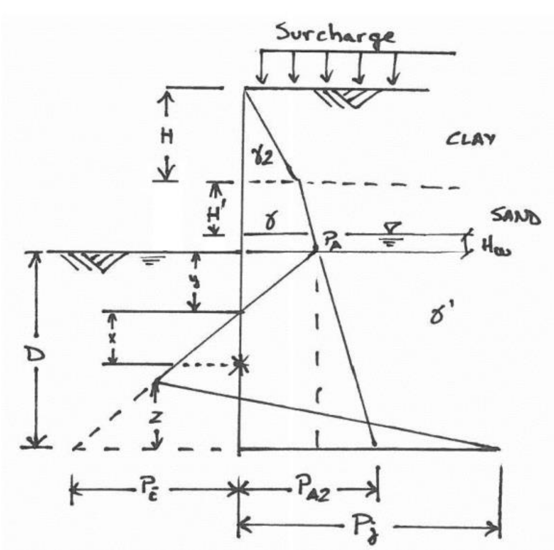
H =	9.5115	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.6079706 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	456.821255	psf
Pa2 =	534.055629	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1051.95685	psf
Pj =	1508.7781	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.83852165 LF

Moment equilibrium

Mo = 1.33630E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.09240559	LF
ΣPa at y=	249.517047	Lb

x = 1.09240559 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 363.431756 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.12460517 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.13628691 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.13628691 in^3

USS MARINER STEEL

S4 = 0.15038555 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.17444724 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.87	LF
Total Length =	14.38	LF

INITIAL DATA

Initial Sta. =	5+00.00
Final Sta. =	6+00.00
Ground elev. =	524.025
Sand Strata elev. =	516.75
Shale Strata elev. =	497.25
Water elevation =	512
Bottom trench =	513.9765

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

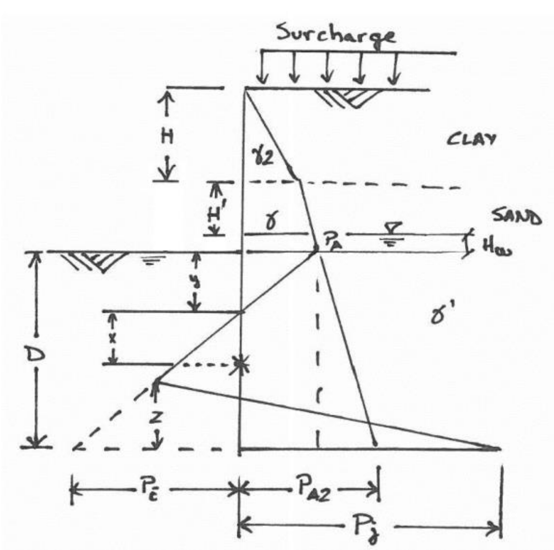
H =	7.275	LF
H' =	2.7735	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	5.827495	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	469.330736	psf
Pa2 =	594.077577	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1967.60624	psf
Pj =	4468.92215	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	1.15427195	LF

Moment equilibrium

Mo =	5.94341E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.12231976	LF
ΣPa at y=	914.213976	Lb
x =	2.09101781	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	2803.6429	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.96124899 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 1.05136609 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 1.05136609 in^3

USS MARINER STEEL

S4 = 1.1601281 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 1.34574859 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.87	LF
Total Length =	17.92	LF

INITIAL DATA

Initial Sta. =	6+00.00
Final Sta. =	7+00.00
Ground elev. =	521.845
Sand Strata elev. =	517
Shale Strata elev. =	501.25
Water elevation =	512
Bottom trench =	513.8395

FORCES

Pa =	389.216544	psf
Pa2 =	503.360735	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1840.59704	psf
Pj =	4545.33157	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	4.845	LF
H' =	3.1605	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	5.3321968	LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z =	1.01926093	LF

Moment equilibrium

Mo =	9.97208E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

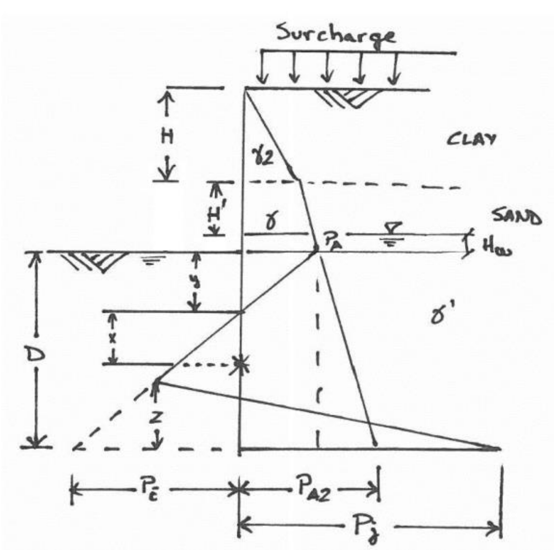
y =	0.93074112	LF
ΣPa at y=	796.189365	Lb
x =	1.95138063	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	2368.59529	Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 =	0.81208981	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	0.88822323	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	0.88822323	in^3

USS MARINER STEEL

S4 =	0.9801084	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	1.13692574	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.20	LF
Total Length =	15.20	LF

INITIAL DATA

Initial Sta. =	7+00.00
Final Sta. =	8+00.00
Ground elev. =	519.4
Sand Strata elev. =	516.45
Shale Strata elev. =	500.95
Water elevation =	512
Bottom trench =	513.7025

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

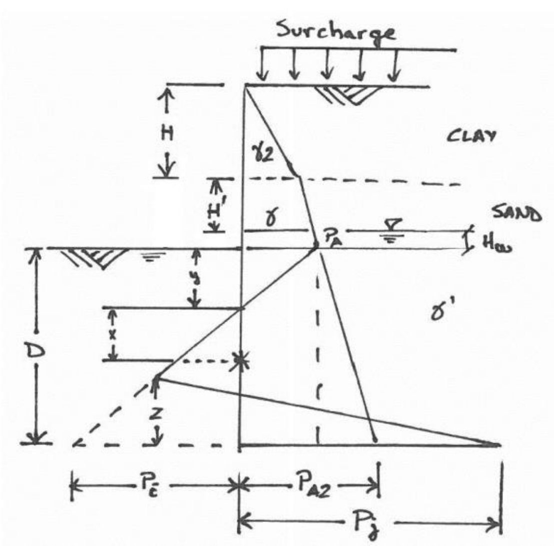
H =	2.95	LF
H' =	2.7475	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	4.2904718	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	301.2384	psf
Pa2 =	393.082804	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1492.9475	psf
Pj =	3807.12236	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	0.8085444	LF

Moment equilibrium

Mo =	1.13004E-03	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.72035727	LF
ΣPa at y=	522.325888	Lb
x =	1.58053668	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	1279.57444	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.43871124 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.47984042 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.47984042 in^3

USS MARINER STEEL

S4 = 0.52947908 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.61419573 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.79	LF
Total Length =	11.49	LF

INITIAL DATA

Initial Sta. =	8+00.00
Final Sta. =	9+00.00
Ground elev. =	519.515
Sand Strata elev. =	516.2
Shale Strata elev. =	499.4
Water elevation =	512
Bottom trench =	513.5655

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

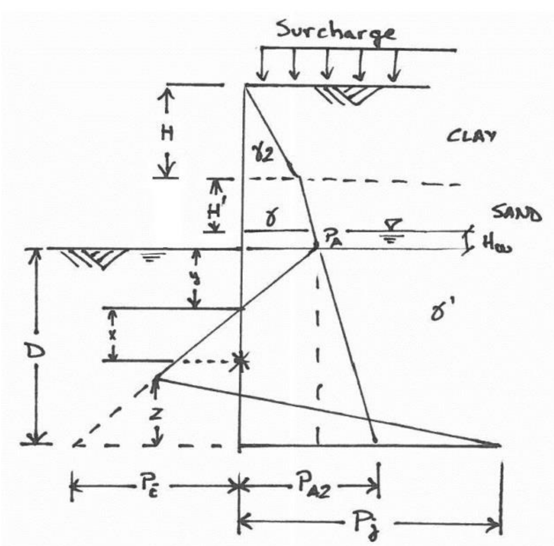
H =	3.315	LF
H' =	2.6345	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.3235164 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	311.314367	psf
Pa2 =	403.866142	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1496.69009	psf
Pj =	3738.15226	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.82234256 LF

Moment equilibrium

Mo = 6.86939E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.74445213	LF
ΣPa at y=	525.958171	Lb

x = 1.58602273 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 1279.0338 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.43852587 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.47963767 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.47963767 in^3

USS MARINER STEEL

S4 = 0.52925536 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.61393622 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.84	LF
Total Length =	11.79	LF

INITIAL DATA

Initial Sta. =	9+00.00
Final Sta. =	10+00.00
Ground elev. =	520.375
Sand Strata elev. =	517
Shale Strata elev. =	496.525
Water elevation =	512
Bottom trench =	513.4285

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

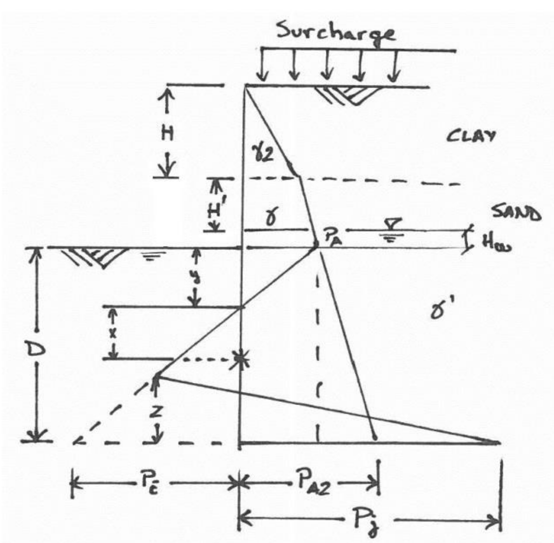
H =	3.375	LF
H' =	3.5715	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	5.1550311	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	347.063385	psf
Pa2 =	457.415062	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1808.6632	psf
Pj =	4772.36082	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	0.95654652	LF

Moment equilibrium

Mo =	-5.74599E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.82993945	LF
ΣPa at y=	763.789238	Lb
x =	1.91126352	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	2305.09197	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.79031725 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.86440949 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.86440949 in^3

USS MARINER STEEL

S4 = 0.95383116 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 1.10644415 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	6.96	LF
Total Length =	13.91	LF

INITIAL DATA

Initial Sta. =	10+00.00
Final Sta. =	11+00.00
Ground elev. =	521.235
Sand Strata elev. =	517.5
Shale Strata elev. =	495.15
Water elevation =	512
Bottom trench =	513.2915

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

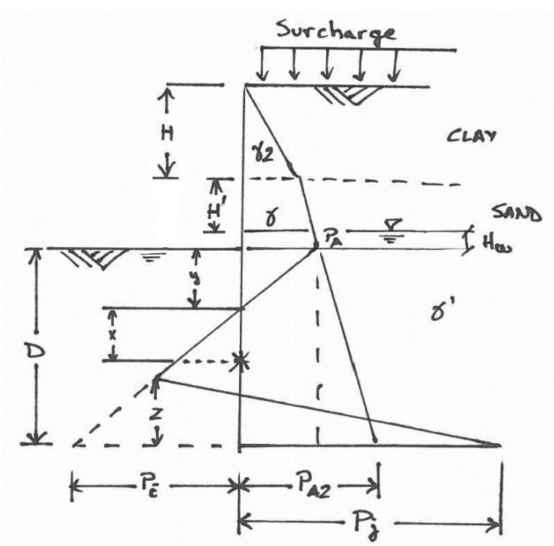
H =	3.735	LF
H' =	4.2085	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	5.8308042	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	383.704345	psf
Pa2 =	508.522025	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2054.61649	psf
Pj =	5521.64861	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	1.07281646	LF

Moment equilibrium

Mo =	5.42728E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.9175597	LF
ΣPa at y=	983.445688	Lb
x =	2.16874751	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	3403.0874	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 =	1.16677282	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	1.27615778	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	1.27615778	in^3

USS MARINER STEEL

S4 =	1.4081741	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	1.63348195	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.87	LF
Total Length =	15.82	LF

INITIAL DATA

Initial Sta. =	11+00.00
Final Sta. =	12+00.00
Ground elev. =	522.095
Sand Strata elev. =	517.5
Shale Strata elev. =	498.05
Water elevation =	512
Bottom trench =	513.1545

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

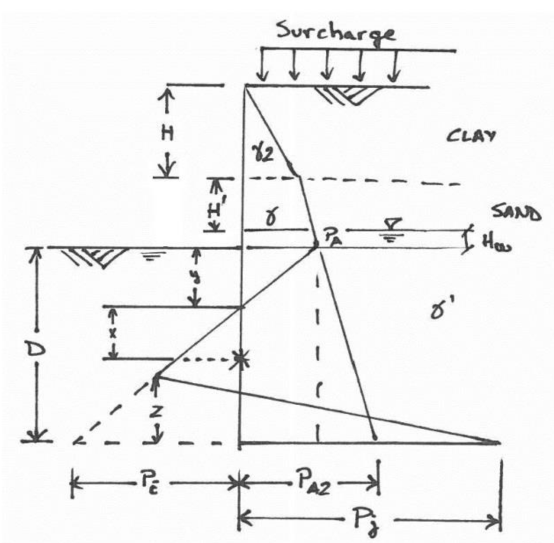
H =	4.595	LF
H' =	4.3455	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 6.2679338 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	421.831874	psf
Pa2 =	556.007012	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2199.28744	psf
Pj =	5804.81918	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.16289099 LF

Moment equilibrium

Mo = -6.37724E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.0087348	LF
ΣPa at y=	1129.29345	Lb

x = 2.3240058 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 4144.87632 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 1.42110045 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 1.55432862 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 1.55432862 in^3

USS MARINER STEEL

S4 = 1.71512123 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 1.98954063 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	8.46	LF
Total Length =	17.40	LF

INITIAL DATA

Initial Sta. =	12+00.00
Final Sta. =	13+00.00
Ground elev. =	523.28
Sand Strata elev. =	518.25
Shale Strata elev. =	501.5
Water elevation =	512
Bottom trench =	513.0175

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

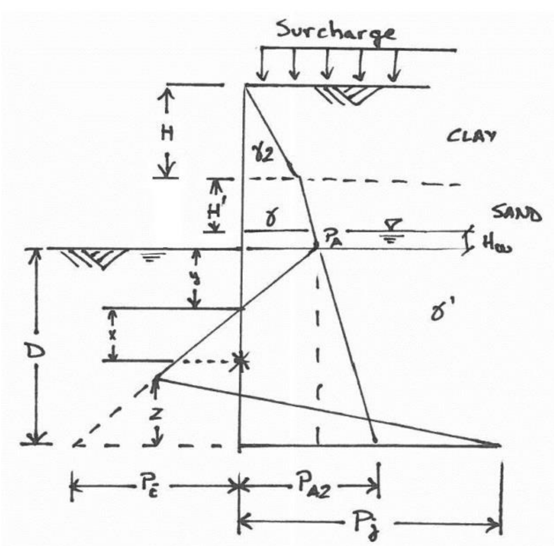
H =	5.03	LF
H' =	5.2325	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 7.1836935 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	470.291059	psf
Pa2 =	624.069496	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2533.77986	psf
Pj =	6837.62507	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.31919101 LF

Moment equilibrium

Mo = 2.93159E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.1246162	LF
ΣPa at y=	1494.84746	Lb
x =	2.67382046	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 6392.65202 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 2.19176641 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 2.39724451 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 2.39724451 in^3

USS MARINER STEEL

S4 = 2.64523532 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 3.06847297 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	9.70	LF
Total Length =	19.96	LF

INITIAL DATA

Initial Sta. =	13+00.00
Final Sta. =	14+00.00
Ground elev. =	523.6
Sand Strata elev. =	520.7
Shale Strata elev. =	505.25
Water elevation =	512
Bottom trench =	512.8805

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

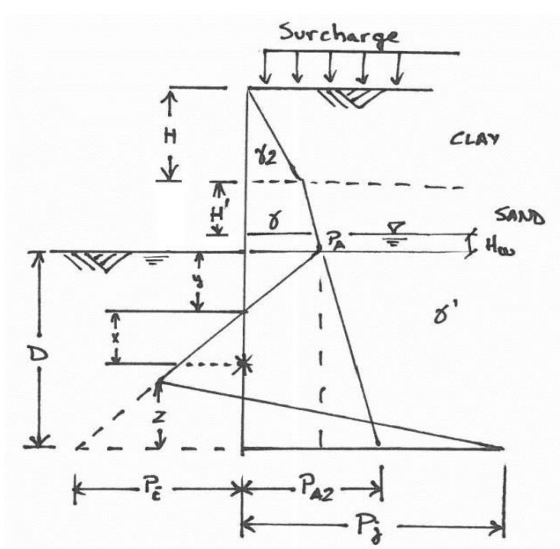
H =	2.9	LF
H' =	7.8195	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 8.4867798 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	480.262966	psf
Pa2 =	661.936048	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	3068.73151	psf
Pj =	9277.89589	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.47508674 LF

Moment equilibrium

Mo = 3.98633E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.14846221	LF
ΣPa at y=	2153.49007	Lb

x = 3.20926249 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 11869.2831 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 4.06946849 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 4.45098116 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 4.45098116 in^3

USS MARINER STEEL

S4 = 4.91142749 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 5.69725589 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	11.46	LF
Total Length =	22.18	LF

INITIAL DATA

Initial Sta. =	14+00.00
Final Sta. =	15+00.00
Ground elev. =	523.92
Sand Strata elev. =	517.5
Shale Strata elev. =	502.25
Water elevation =	512
Bottom trench =	512.7435

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

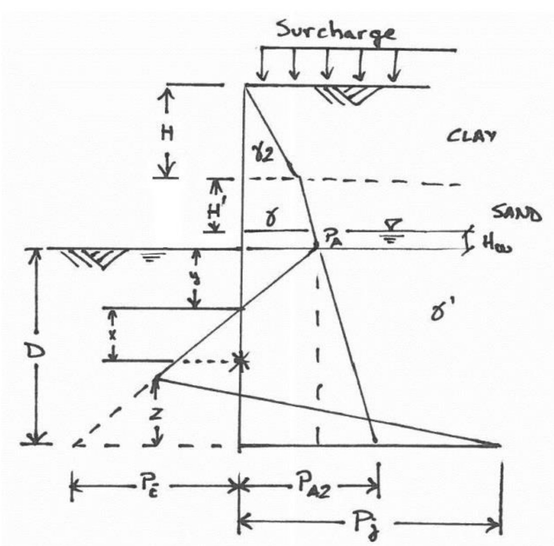
H =	6.42	LF
H' =	4.7565	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 7.2915406 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	507.033106	psf
Pa2 =	663.120181	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2542.13721	psf
Pj =	6533.98643	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.36923445 LF

Moment equilibrium

Mo = 2.44976E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.21247817	LF
ΣPa at y=	1513.23477	Lb

x = 2.69021481 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 6336.36088 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 2.17246659 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 2.37613533 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 2.37613533 in^3

USS MARINER STEEL

S4 = 2.62194243 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 3.04145322 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	9.84	LF
Total Length =	21.02	LF

INITIAL DATA

Initial Sta. =	15+00.00
Final Sta. =	16+00.00
Ground elev. =	524.23
Sand Strata elev. =	514.35
Shale Strata elev. =	499.25
Water elevation =	512
Bottom trench =	512.6065

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

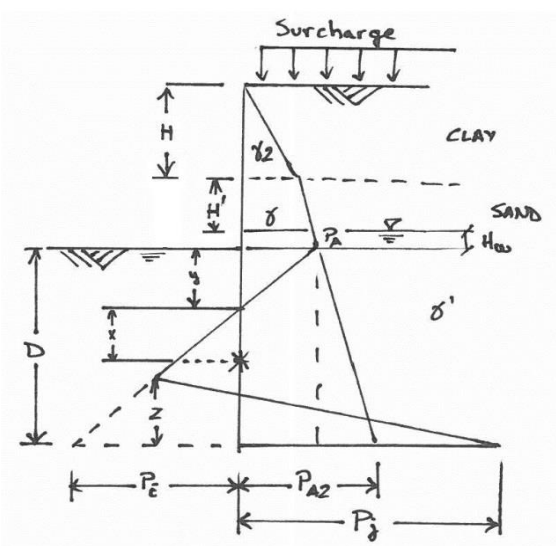
Ka =	0.2973139	
Kp =	6.1053578	
kp-ka =	5.8080439	
H =	9.88	LF
H' =	1.7435	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	5.6920272	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	533.268081	psf
Pa2 =	655.115018	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1847.0191	psf
Pj =	3657.65013	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	1.18956351	LF

Moment equilibrium

Mo =	4.77849E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.27521438	LF
ΣPa at y=	804.892011	Lb
x =	1.96201631	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	2204.85715	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 =	0.75595102	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	0.82682143	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	0.82682143	in^3

USS MARINER STEEL

S4 =	0.91235468	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	1.05833143	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.68	LF
Total Length =	19.31	LF

INITIAL DATA

Initial Sta. =	16+00.00
Final Sta. =	17+00.00
Ground elev. =	524.045
Sand Strata elev. =	512
Shale Strata elev. =	497
Water elevation =	512
Bottom trench =	512.4695

FORCES

Pa =	536.596509	psf
Pa2 =	627.318405	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1235.66112	psf
Pj =	1772.25763	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	11.5755	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	4.2380343	LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z =	0.9849534	LF

Moment equilibrium

Mo =	4.72563E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

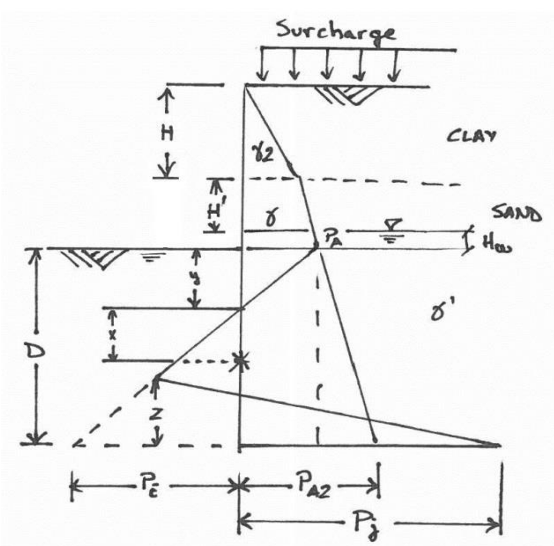
y =	1.28317372	LF
ΣPa at y=	344.273268	Lb
x =	1.28317372	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	589.016545	Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 =	0.20194853	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	0.2208812	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	0.2208812	in^3

USS MARINER STEEL

S4 =	0.24373098	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	0.28272794	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.72	LF
Total Length =	17.30	LF

INITIAL DATA

Initial Sta. =	17+00.00
Final Sta. =	18+00.00
Ground elev. =	523.705
Sand Strata elev. =	512
Shale Strata elev. =	497
Water elevation =	512
Bottom trench =	512.3325

FORCES

Pa =	528.750397	psf
Pa2 =	618.145768	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1217.59352	psf
Pj =	1746.34392	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	11.3725	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.1760663 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.97055172 LF

Moment equilibrium

Mo = 1.92833E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

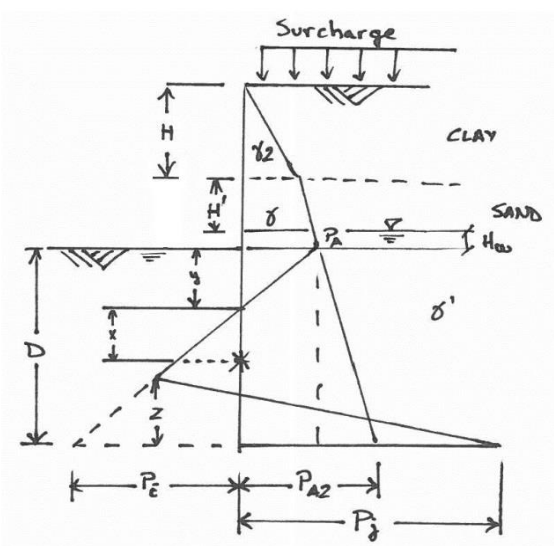
y =	1.26441115	LF
ΣPa at y=	334.278949	Lb
x =	1.26441115	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 563.554709 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.19321876 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.21133302 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.21133302 in^3

USS MARINER STEEL

S4 = 0.23319505 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.27050626 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.64	LF
Total Length =	17.01	LF

INITIAL DATA

Initial Sta. =	18+00.00
Final Sta. =	19+00.00
Ground elev. =	523.365
Sand Strata elev. =	512
Shale Strata elev. =	497.405
Water elevation =	511.73
Bottom trench =	512.1955

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

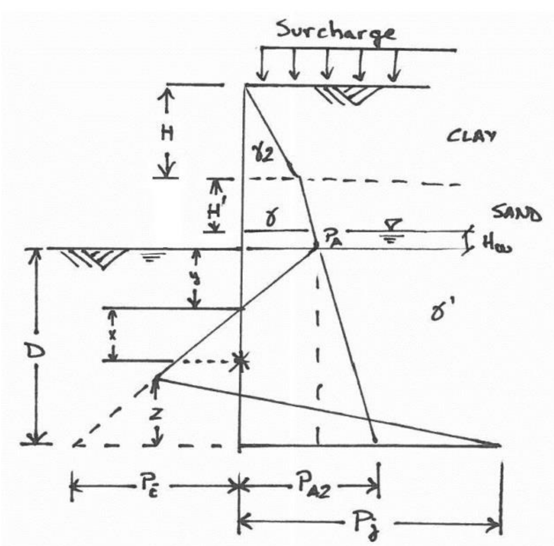
H =	11.1695	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.1140978 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	520.904284	psf
Pa2 =	608.97312	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1199.52568	psf
Pj =	1720.42997	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.95614973 LF

Moment equilibrium

Mo = 1.96890E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.24564859	LF
ΣPa at y=	324.431844	Lb

x = 1.24564859 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 538.837425 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.18474426 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.20206403 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.20206403 in^3

USS MARINER STEEL

S4 = 0.22296721 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.25864196 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.55	LF
Total Length =	16.72	LF

INITIAL DATA

Initial Sta. =	19+00.00
Final Sta. =	20+00.00
Ground elev. =	523.17
Sand Strata elev. =	512
Shale Strata elev. =	497.945
Water elevation =	511.37
Bottom trench =	512.0585

FORCES

Pa =	518.662537	psf
Pa2 =	606.352364	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1194.36345	psf
Pj =	1713.02599	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	11.1115	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.0963925 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.95203489 LF

Moment equilibrium

Mo = 3.82506E-06 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

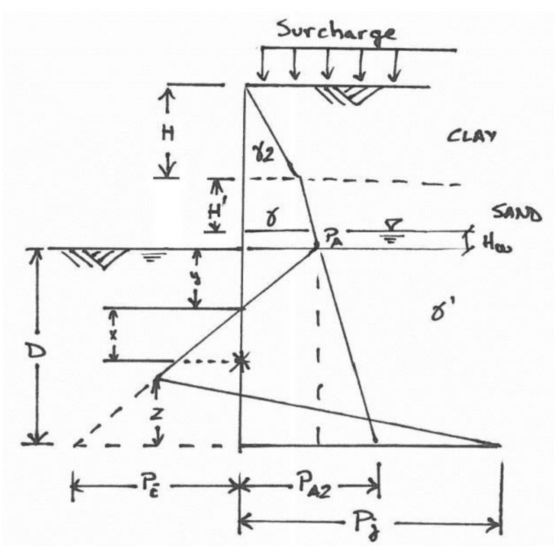
y =	1.24028786	LF
ΣPa at y=	321.645424	Lb
x =	1.24028786	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 531.910552 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.18236933 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.19946646 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.19946646 in^3

USS MARINER STEEL

S4 = 0.22010092 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.25531707 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.53	LF
Total Length =	16.64	LF

INITIAL DATA

Initial Sta. =	20+00.00
Final Sta. =	21+00.00
Ground elev. =	523.45
Sand Strata elev. =	512
Shale Strata elev. =	498.485
Water elevation =	511.01
Bottom trench =	511.9215

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

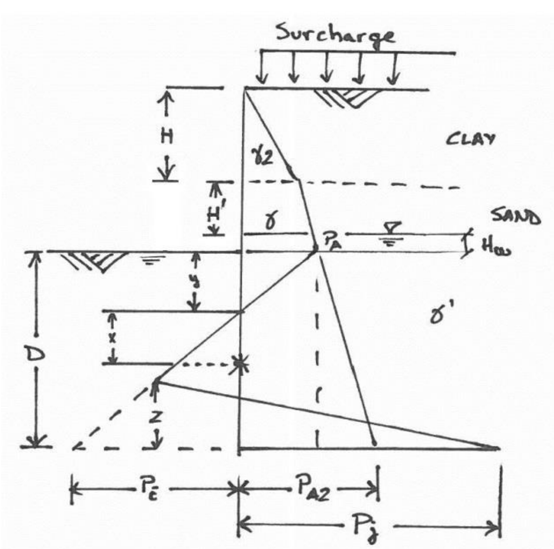
H =	11.45	LF
H' =	0.0785	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.3029011 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	534.54653	psf
Pa2 =	626.657002	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1264.83703	psf
Pj =	1856.89603	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.99316815 LF

Moment equilibrium

Mo = 1.43699E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.27827156	LF
ΣPa at y=	362.628765	Lb

x = 1.31693679 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 636.886918 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.21836123 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.23883259 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.23883259 in^3

USS MARINER STEEL

S4 = 0.26353941 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.30570572 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.81	LF
Total Length =	17.34	LF

INITIAL DATA

Initial Sta. =	21+00.00
Final Sta. =	22+00.00
Ground elev. =	523.73
Sand Strata elev. =	512
Shale Strata elev. =	499.025
Water elevation =	510.65
Bottom trench =	511.7845

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

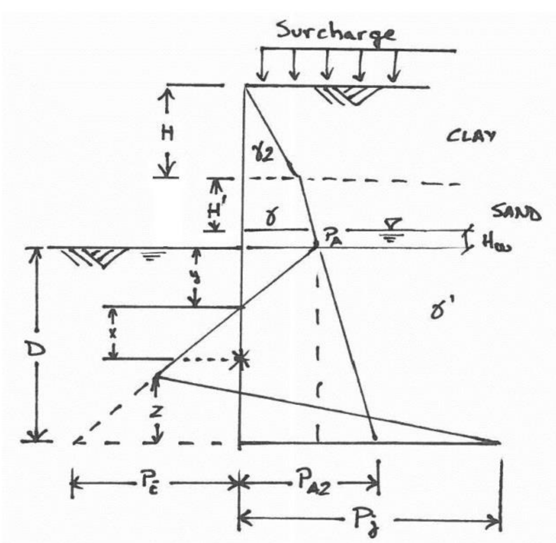
H =	11.73	LF
H' =	0.2155	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.5638767 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	550.256594	psf
Pa2 =	647.953666	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1358.26152	psf
Pj =	2066.40267	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.04216189 LF

Moment equilibrium

Mo = 1.98995E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.31583934	LF
ΣPa at y=	421.314786	Lb

x = 1.41950574 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 798.558667 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.27379154 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.2994595 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.2994595 in^3

USS MARINER STEEL

S4 = 0.33043807 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.38330816 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	6.16	LF
Total Length =	18.11	LF

INITIAL DATA

Initial Sta. =	22+00.00
Final Sta. =	23+00.00
Ground elev. =	524.01
Sand Strata elev. =	512
Shale Strata elev. =	499.565
Water elevation =	510.29
Bottom trench =	511.6475

FORCES

Pa =	565.966659	psf
Pa2 =	669.147309	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1449.6735	psf
Pj =	2273.89679	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	12.01	LF
H' =	0.3525	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	4.8200397	LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z =	1.09035106	LF

Moment equilibrium

Mo =	1.67467E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

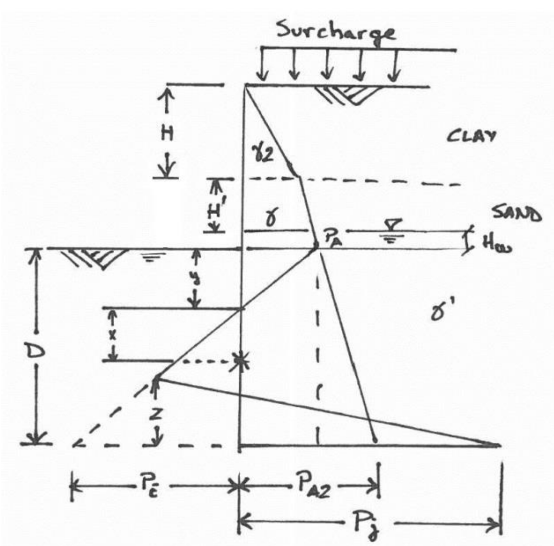
y =	1.35340713	LF
ΣPa at y=	482.743279	Lb
x =	1.51946927	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	981.29685	Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 =	0.33644463	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	0.36798632	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	0.36798632	in^3

USS MARINER STEEL

S4 =	0.40605387	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	0.47102249	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	6.51	LF
Total Length =	18.87	LF

INITIAL DATA

Initial Sta. =	23+00.00
Final Sta. =	24+00.00
Ground elev. =	524.29
Sand Strata elev. =	512.69
Shale Strata elev. =	500.625
Water elevation =	510
Bottom trench =	511.5105

FORCES

Pa =	579.625257	psf
Pa2 =	700.466403	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1781.01373	psf
Pj =	3224.79133	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	11.6	LF
H' =	1.1795	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	5.6450421	LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z =	1.21822974	LF

Moment equilibrium

Mo =	9.71663E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

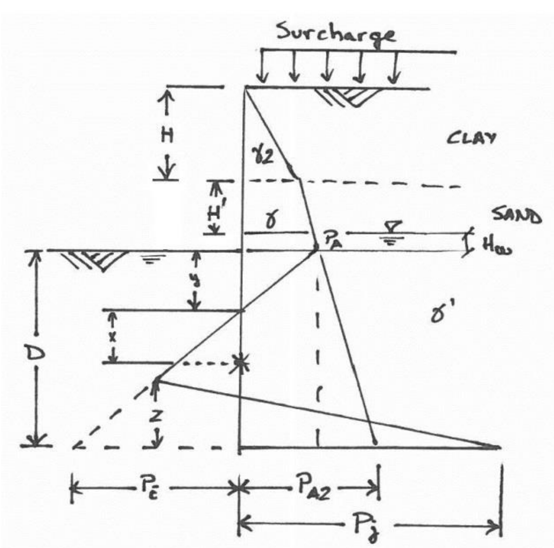
y =	1.3860692	LF
ΣPa at y=	743.534354	Lb
x =	1.8857509	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	1914.14002	Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 =	0.65627658	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	0.71780251	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	0.71780251	in^3

USS MARINER STEEL

S4 =	0.79205794	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	0.91878721	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.62	LF
Total Length =	20.40	LF

INITIAL DATA

Initial Sta. =	24+00.00
Final Sta. =	25+00.00
Ground elev. =	524.57
Sand Strata elev. =	515.45
Shale Strata elev. =	503.125
Water elevation =	510
Bottom trench =	511.3735

FORCES

Pa =	587.129459	psf
Pa2 =	750.927527	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2612.67556	psf
Pj =	6186.42394	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	9.12	LF
H' =	4.0765	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 7.6517563 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 1.48941967 LF

Moment equilibrium

Mo = 1.10959E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

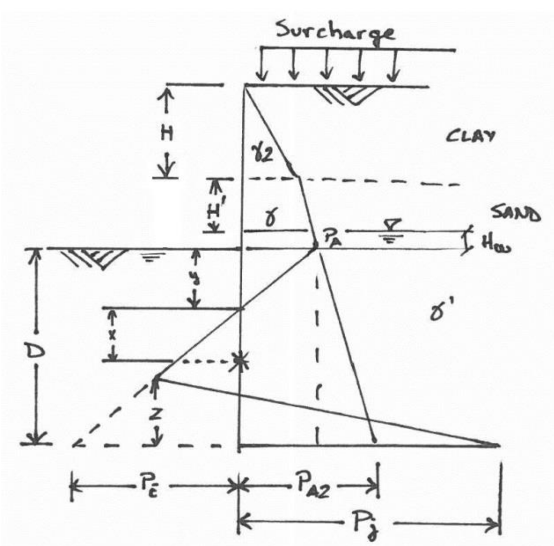
y =	1.40401415	LF
ΣPa at y=	1608.88565	Lb
x =	2.77393572	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 6667.43652 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 2.28597824 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 2.5002887 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 2.5002887 in^3

USS MARINER STEEL

S4 = 2.75893925 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 3.20036953 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	10.33	LF
Total Length =	23.53	LF

INITIAL DATA

Initial Sta. = 25+00.00
Final Sta. = 26+00.00
Ground elev. = 524.46
Sand Strata elev. = 517.5
Shale Strata elev. = 505
Water elevation = 510
Bottom trench = 511.2365

FORCES

Pa = 581.670777 psf
Pa2 = 769.63587 psf
Note: Active forces / Added 300 PSF Surcharge

Pe = 3090.23852 psf
Pj = 8260.81831 psf
Note: Pasive forces

PARAMETERS

γ = 120 PCF
γ2 = 130 PCF
γ' = 72 PCF
Note: All soil is considered saturated
ϕ = 30 º
δ = 20 º
β = 0 º

Ka = 0.2973139
Kp = 6.1053578
kp-ka = 5.8080439

H = 6.96 LF
H' = 6.2635 LF
Hw = 0 LF
Note: if Hw>0, Siphon study needed
D = 8.7807084 LF
Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium
Z = 1.61955907 LF

Moment equilibrium
Mo = 5.31359E-03 Ft-Lb
Note: Correct if equal to 0

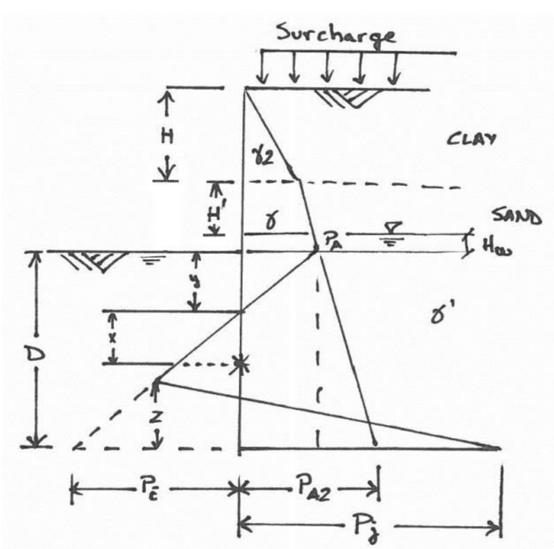
MAXIMUM MOMENT

y = 1.39096069 LF
ΣPa at y= 2226.18805 Lb

x = 3.26298237 LF
Note: where ΣPa = ΣPp
Note2: Plane of zero shear

Mx = 11554.9446 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 3.96169528 in^3
USS-EX-TEN 55 (ASTM A572 GR 55)
S2 = 4.33310421 in^3
USS EX-TEN 50 (ASTM A572 GR 50)
S3 = 4.33310421 in^3
USS MARINER STEEL
S4 = 4.78135637 in^3
USS EX-TEN 45 (ASTM A572 GR 45)
S5 = 5.54637339 in^3
Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D = 11.85 LF
Total Length = 25.08 LF

INITIAL DATA

Initial Sta. =	26+00.00
Final Sta. =	27+00.00
Ground elev. =	522.7
Sand Strata elev. =	517.5
Shale Strata elev. =	505
Water elevation =	510
Bottom trench =	511.0995

FORCES

Pa =	518.533206	psf
Pa2 =	694.697774	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2922.85214	psf
Pj =	8130.66644	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	5.2	LF
H' =	6.4005	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 8.229452 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 1.48978403 LF

Moment equilibrium

Mo = 5.64683E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

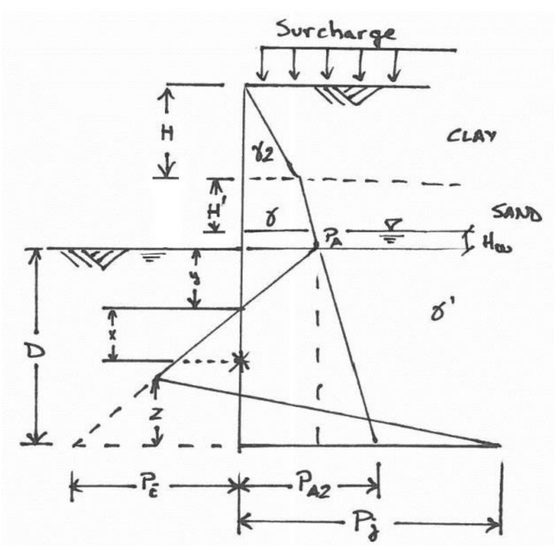
y =	1.23997859	LF
ΣPa at y=	1980.92093	Lb
x =	3.0779912	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 9928.66594 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 3.40411404 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 3.72324973 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 3.72324973 in^3

USS MARINER STEEL

S4 = 4.10841349 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 4.76575965 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	11.11	LF
Total Length =	22.71	LF

INITIAL DATA

Initial Sta. =	27+00.00
Final Sta. =	27+25.13
Ground elev. =	521.36
Sand Strata elev. =	517.5
Shale Strata elev. =	505
Water elevation =	510
Bottom trench =	510.99657

FORCES

Pa =	470.413366	psf
Pa2 =	637.259578	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2788.93733	psf
Pj =	8024.04133	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	3.86	LF
H' =	6.5034281	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 7.794149 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 1.38829662 LF

Moment equilibrium

Mo = 3.79796E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

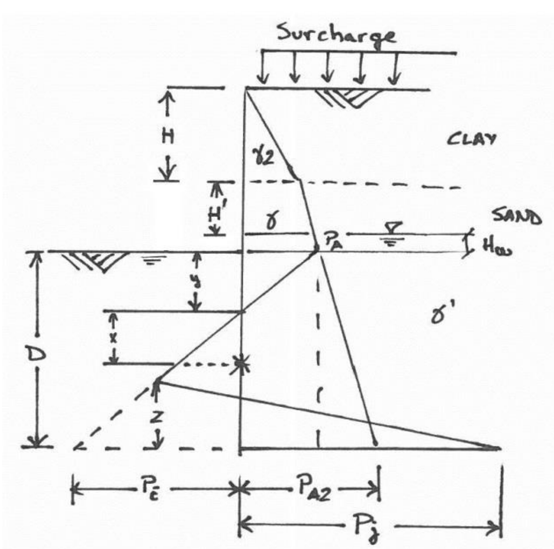
y =	1.12490867	LF
ΣPa at y=	1794.23579	Lb
x =	2.92936549	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 8739.11035 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 2.99626641 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 3.27716638 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 3.27716638 in^3

USS MARINER STEEL

S4 = 3.61618359 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 4.19477297 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	10.52	LF
Total Length =	20.89	LF

ANNEX 7.2 – Mony Street Sheet Pilling Report

INITIAL DATA

Initial Sta. =	0+00.00
Final Sta. =	1+00.00
Ground elev. =	522.6
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.625

FORCES

Pa =	397.434299	psf
Pa2 =	464.628157	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	915.201731	psf
Pj =	1312.63603	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	7.975	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.1389322 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.72951311 LF

Moment equilibrium

Mo = 3.06022E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.9503924	LF
ΣPa at y=	188.859269	Lb

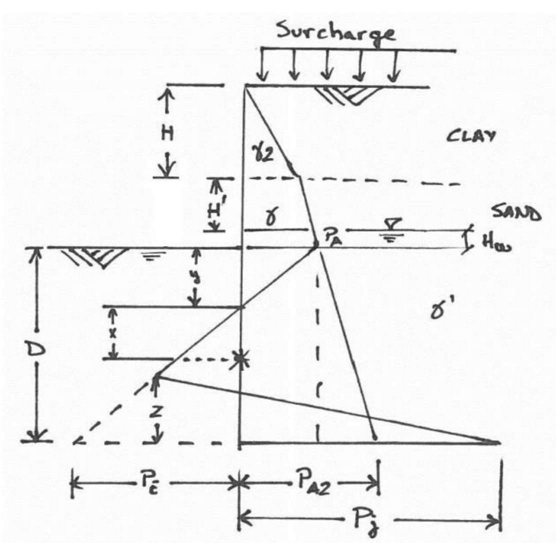
x = 0.9503924 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 239.320553 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.08205276 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.08974521 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.08974521 in^3

USS MARINER STEEL

S4 = 0.09902919 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.11487387 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D = 4.24 LF

Total Length = 12.21 LF

INITIAL DATA

Initial Sta. =	1+00.00
Final Sta. =	2+00.00
Ground elev. =	522.75
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.485

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

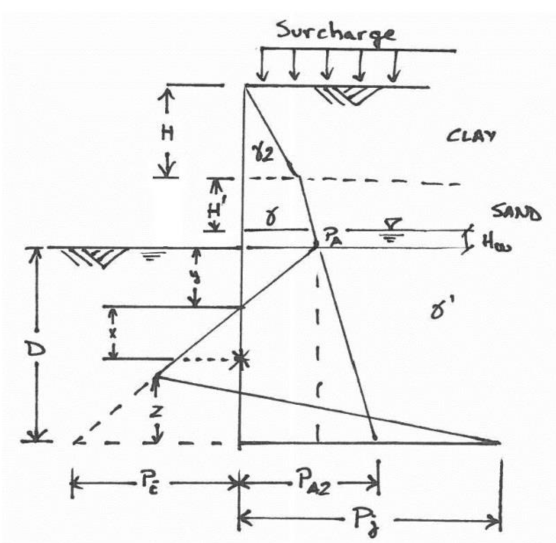
H =	8.265	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.2274594 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	408.643031	psf
Pa2 =	477.731956	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	941.013232	psf
Pj =	1349.65626	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.75008778 LF

Moment equilibrium

Mo = -1.76553E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.97719606	LF
ΣPa at y=	199.662181	Lb

x = 0.97719606 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 260.145463 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.08919273 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.09755455 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.09755455 in^3

USS MARINER STEEL

S4 = 0.1076464 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.12486982 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.36	LF
Total Length =	12.62	LF

INITIAL DATA

Initial Sta. =	2+00.00
Final Sta. =	3+00.00
Ground elev. =	523.05
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.345

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

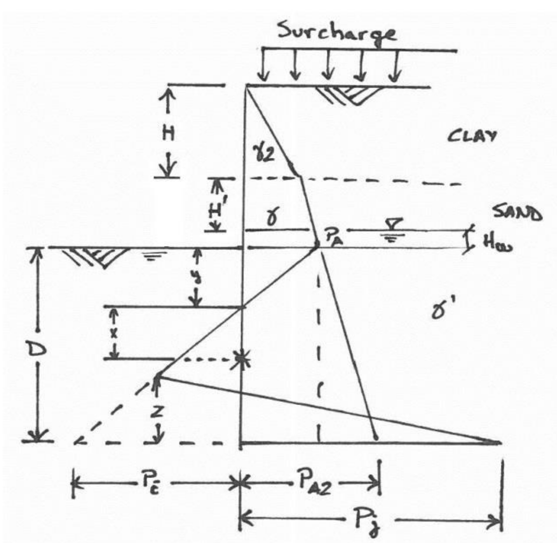
H =	8.705	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.3617754 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	425.649384	psf
Pa2 =	497.613557	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	980.175031	psf
Pj =	1405.82441	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.7813039 LF

Moment equilibrium

Mo = 4.09273E-12 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.01786369	LF
ΣPa at y=	216.626526	Lb

x = 1.01786369 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 293.995032 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.1007983 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.11024814 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.11024814 in^3

USS MARINER STEEL

S4 = 0.12165312 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.14111762 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.54	LF
Total Length =	13.24	LF

INITIAL DATA

Initial Sta. =	3+00.00
Final Sta. =	4+00.00
Ground elev. =	523.35
Sand Strata elev. =	512.5
Shale Strata elev. =	493
Water elevation =	512.5
Bottom trench =	514.205

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

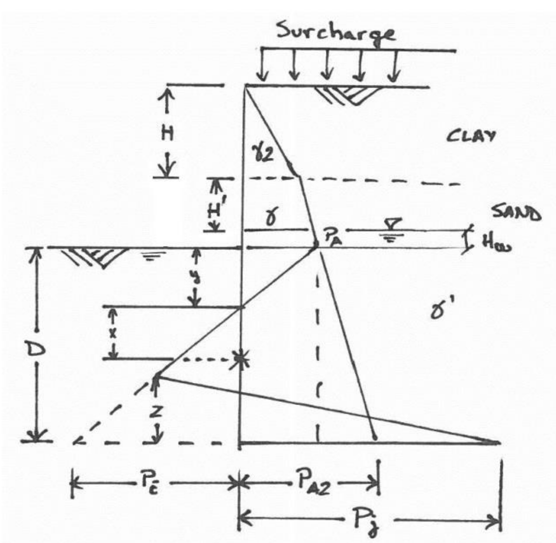
H =	9.145	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.4960914 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	442.655736	psf
Pa2 =	517.495158	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1019.33683	psf
Pj =	1461.99257	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.81252002 LF

Moment equilibrium

Mo = 1.41883E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.05853131	LF
ΣPa at y=	234.282478	Lb

x = 1.05853131 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 330.660452 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.1133693 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.12399767 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.12399767 in^3

USS MARINER STEEL

S4 = 0.13682501 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.15871702 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.72	LF
Total Length =	13.86	LF

INITIAL DATA

Initial Sta. =	4+00.00
Final Sta. =	5+00.00
Ground elev. =	523.65
Sand Strata elev. =	513.25
Shale Strata elev. =	493.75
Water elevation =	512.375
Bottom trench =	514.065

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

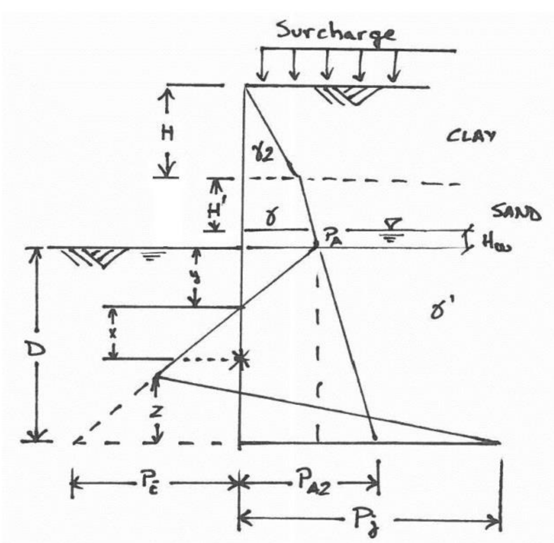
H =	9.585	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.6304074 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	459.662089	psf
Pa2 =	537.37676	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1058.49865	psf
Pj =	1518.16074	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.84373616 LF

Moment equilibrium

Mo = 1.36519E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.09919893	LF
ΣPa at y=	252.630039	Lb

x = 1.09919893 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 370.254226 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.12694431 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.13884533 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.13884533 in^3

USS MARINER STEEL

S4 = 0.15320865 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.17772203 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.90	LF
Total Length =	14.49	LF

INITIAL DATA

Initial Sta. =	5+00.00
Final Sta. =	6+00.00
Ground elev. =	524.05
Sand Strata elev. =	516.75
Shale Strata elev. =	497.25
Water elevation =	512
Bottom trench =	513.925

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

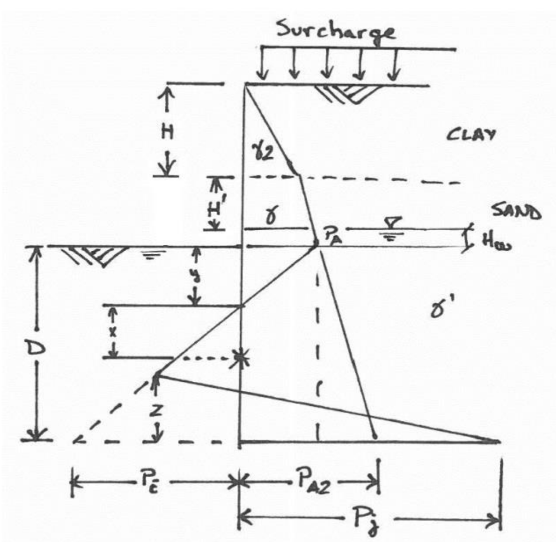
H =	7.3	LF
H' =	2.825	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 5.883611 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	472.134405	psf
Pa2 =	598.082498	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1988.2691	psf
Pj =	4530.11979	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.16387149 LF

Moment equilibrium

Mo = 1.44797E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.12902423	LF
ΣPa at y=	933.415438	Lb

x = 2.11286279 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 2896.3178 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.99302324 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 1.08611917 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 1.08611917 in^3

USS MARINER STEEL

S4 = 1.19847633 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 1.39023254 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.94	LF
Total Length =	18.07	LF

INITIAL DATA

Initial Sta. =	6+00.00
Final Sta. =	7+00.00
Ground elev. =	521.85
Sand Strata elev. =	517
Shale Strata elev. =	501.25
Water elevation =	512
Bottom trench =	513.785

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

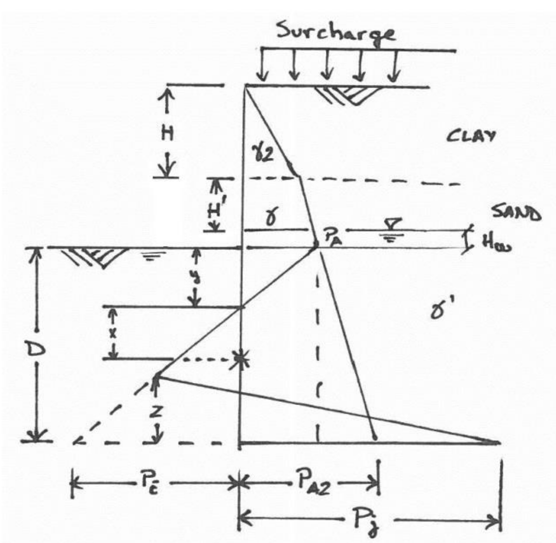
H =	4.85	LF
H' =	3.215	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 5.3819915 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	391.35423	psf
Pa2 =	506.564357	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1859.28246	psf
Pj =	4606.08372	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.02734683 LF

Moment equilibrium

Mo = 1.02855E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.93585302	LF
ΣPa at y=	812.226944	Lb

x = 1.9709359 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 2444.41806 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.83808619 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.91665677 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.91665677 in^3

USS MARINER STEEL

S4 = 1.01148333 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 1.17332067 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.27	LF
Total Length =	15.33	LF

INITIAL DATA

Initial Sta. =	7+00.00
Final Sta. =	8+00.00
Ground elev. =	519.4
Sand Strata elev. =	516.45
Shale Strata elev. =	500.95
Water elevation =	512
Bottom trench =	513.645

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

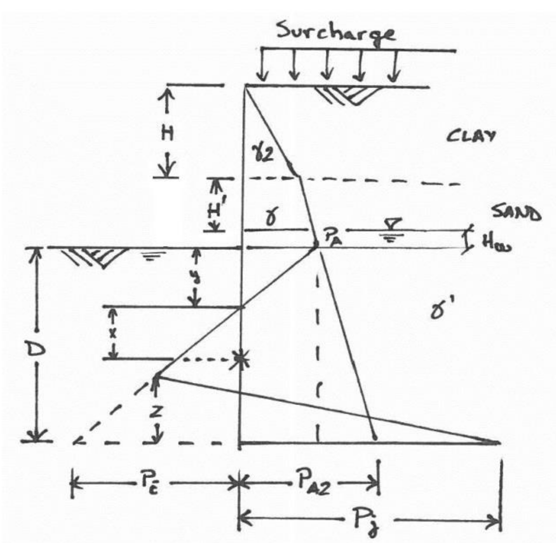
H =	2.95	LF
H' =	2.805	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	4.3403015	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	303.289866	psf
Pa2 =	396.200955	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1511.73379	psf
Pj =	3870.08709	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	0.81650487	LF

Moment equilibrium

Mo =	9.58031E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.72526298	LF
ΣPa at y=	535.346493	Lb
x =	1.60011533	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	1330.47105	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.4561615 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.49892664 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.49892664 in^3

USS MARINER STEEL

S4 = 0.55053975 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.6386261 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.86	LF
Total Length =	11.61	LF

INITIAL DATA

Initial Sta. =	8+00.00
Final Sta. =	9+00.00
Ground elev. =	519.5
Sand Strata elev. =	516.2
Shale Strata elev. =	499.4
Water elevation =	512
Bottom trench =	513.505

FORCES

Pa =	312.893103	psf
Pa2 =	406.463458	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1515.00935	psf
Pj =	3802.37516	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	3.3	LF
H' =	2.695	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	4.3710989	LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z =	0.82960373	LF

Moment equilibrium

Mo =	-2.06280E-05	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

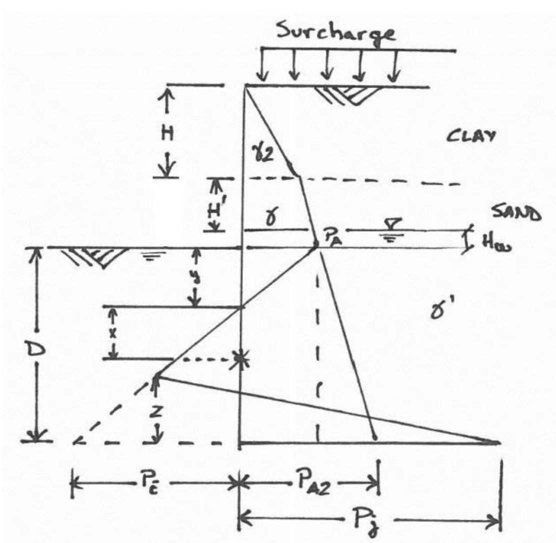
y =	0.74822739	LF
ΣPa at y=	538.681052	Lb
x =	1.60509098	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	1329.04049	Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.45567102 in^3
USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.49839018 in^3
USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.49839018 in^3
USS MARINER STEEL

S4 = 0.54994779 in^3
USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.63793943 in^3
Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.90	LF
Total Length =	11.90	LF

INITIAL DATA

Initial Sta. =	9+00.00
Final Sta. =	10+00.00
Ground elev. =	520.4
Sand Strata elev. =	517
Shale Strata elev. =	496.525
Water elevation =	512
Bottom trench =	513.365

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

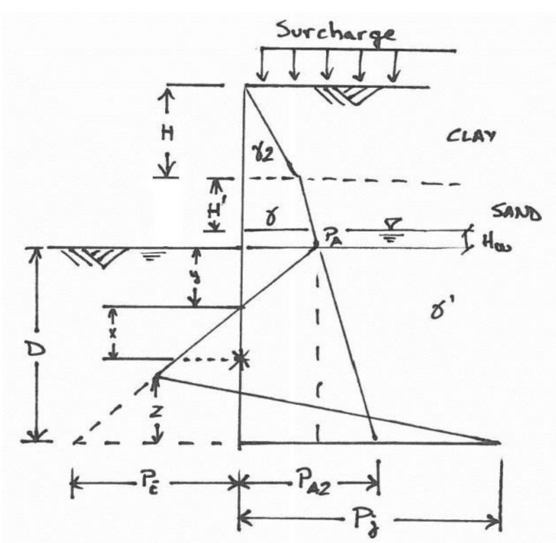
H =	3.4	LF
H' =	3.635	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 5.2184829 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	350.295187	psf
Pa2 =	462.005151	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1831.96562	psf
Pj =	4845.41787	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.96725744 LF

Moment equilibrium

Mo = -6.42084E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.83766772	LF
ΣPa at y=	783.376987	Lb

x = 1.93561602 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 2397.54289 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.82201471 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.89907859 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.89907859 in^3

USS MARINER STEEL

S4 = 0.99208671 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 1.15082059 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.04	LF
Total Length =	14.08	LF

INITIAL DATA

Initial Sta. =	10+00.00
Final Sta. =	11+00.00
Ground elev. =	521.25
Sand Strata elev. =	517.5
Shale Strata elev. =	495.15
Water elevation =	512
Bottom trench =	513.225

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

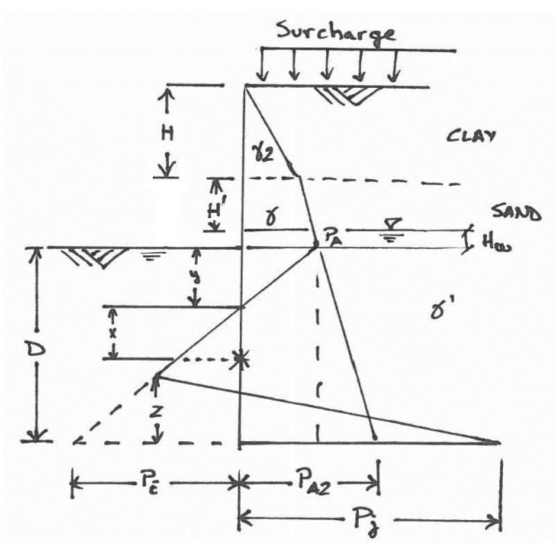
Ka =	0.2973139	
Kp =	6.1053578	
kp-ka =	5.8080439	
H =	3.75	LF
H' =	4.275	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 5.8927253 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	386.656671	psf
Pa2 =	512.799872	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2077.55827	psf
Pj =	5596.26348	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.08304072 LF

Moment equilibrium

Mo = 4.36666E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.92461965	LF
ΣPa at y=	1005.23381	Lb
x =	2.19264008	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 3521.50811 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 1.20737421 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 1.32056554 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 1.32056554 in^3

USS MARINER STEEL

S4 = 1.45717577 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 1.69032389 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.96	LF
Total Length =	15.98	LF

INITIAL DATA

Initial Sta. =	11+00.00
Final Sta. =	12+00.00
Ground elev. =	522.1
Sand Strata elev. =	517.5
Shale Strata elev. =	498.05
Water elevation =	512
Bottom trench =	513.085

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

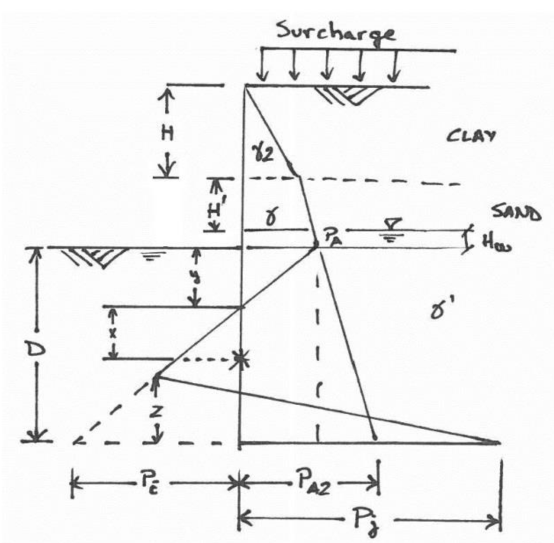
H =	4.6	LF
H' =	4.415	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 6.3290746 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	424.504725	psf
Pa2 =	559.988679	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2222.18239	psf
Pj =	5881.30566	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.17276013 LF

Moment equilibrium

Mo = -4.56331E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.01512644	LF
ΣPa at y=	1152.55717	Lb

x = 2.34782132 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 4280.17299 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 1.46748788 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 1.60506487 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 1.60506487 in^3

USS MARINER STEEL

S4 = 1.77110607 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 2.05448304 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	8.54	LF
Total Length =	17.56	LF

INITIAL DATA

Initial Sta. =	12+00.00
Final Sta. =	13+00.00
Ground elev. =	523.3
Sand Strata elev. =	518.25
Shale Strata elev. =	501.5
Water elevation =	512
Bottom trench =	512.945

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

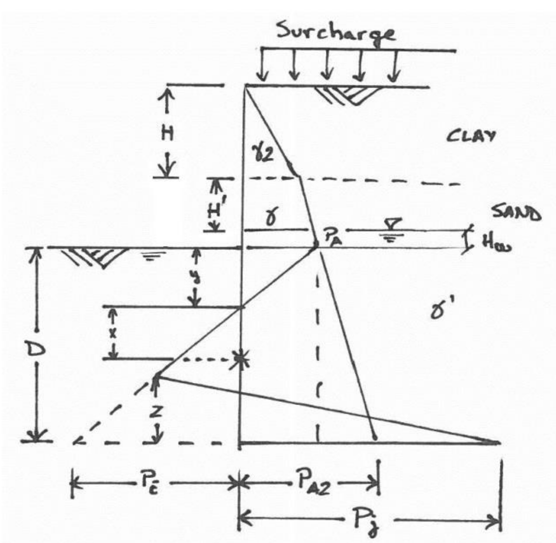
H =	5.05	LF
H' =	5.305	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 7.2524888 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	473.650706	psf
Pa2 =	628.901815	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2559.18897	psf
Pj =	6919.51043	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.33062832 LF

Moment equilibrium

Mo = 3.01032E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.13265019	LF
ΣPa at y=	1524.59878	Lb

x = 2.70029733 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 6591.80357 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 2.26004694 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 2.47192634 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 2.47192634 in^3

USS MARINER STEEL

S4 = 2.72764286 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 3.16406572 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	9.79	LF
Total Length =	20.15	LF

INITIAL DATA

Initial Sta. =	13+00.00
Final Sta. =	14+00.00
Ground elev. =	523.6
Sand Strata elev. =	520.7
Shale Strata elev. =	505.25
Water elevation =	512
Bottom trench =	512.805

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

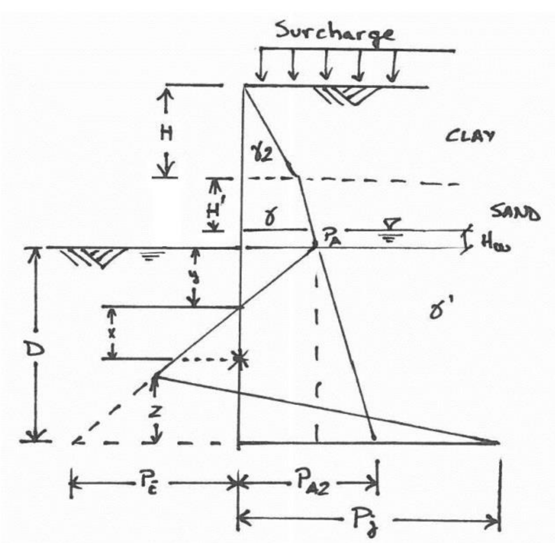
H =	2.9	LF
H' =	7.895	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 8.5481719 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	482.95663	psf
Pa2 =	665.943906	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	3091.71071	psf
Pj =	9358.8833	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.48483965 LF

Moment equilibrium

Mo = 3.18893E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.15490362	LF
ΣPa at y=	2185.35548	Lb

x = 3.23291919 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 12143.7622 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 4.16357563 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 4.55391084 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 4.55391084 in^3

USS MARINER STEEL

S4 = 5.02500507 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 5.82900588 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	11.54	LF
Total Length =	22.34	LF

INITIAL DATA

Initial Sta. =	14+00.00
Final Sta. =	15+00.00
Ground elev. =	523.9
Sand Strata elev. =	517.5
Shale Strata elev. =	502.25
Water elevation =	512
Bottom trench =	512.665

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

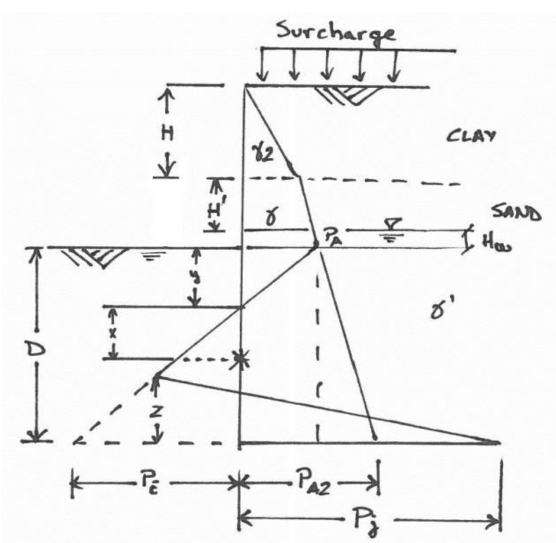
H =	6.4	LF
H' =	4.835	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 7.352019 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	509.060786	psf
Pa2 =	666.442499	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	2565.40034	psf
Pj =	6616.78971	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 1.37842262 LF

Moment equilibrium

Mo = 2.21683E-03 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.217327	LF
ΣPa at y=	1540.50117	Lb

x = 2.71434359 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 6520.60316 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 2.23563537 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 2.44522618 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 2.44522618 in^3

USS MARINER STEEL

S4 = 2.69818062 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 3.12988951 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	9.93	LF
Total Length =	21.16	LF

INITIAL DATA

Initial Sta. =	15+00.00
Final Sta. =	16+00.00
Ground elev. =	524.25
Sand Strata elev. =	514.35
Shale Strata elev. =	499.25
Water elevation =	512
Bottom trench =	512.525

FORCES

Pa =	536.948826	psf
Pa2 =	660.701242	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1880.56199	psf
Pj =	3754.58416	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	9.9	LF
H' =	1.825	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	5.7810408	LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z =	1.20450309	LF

Moment equilibrium

Mo =	6.24658E-04	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

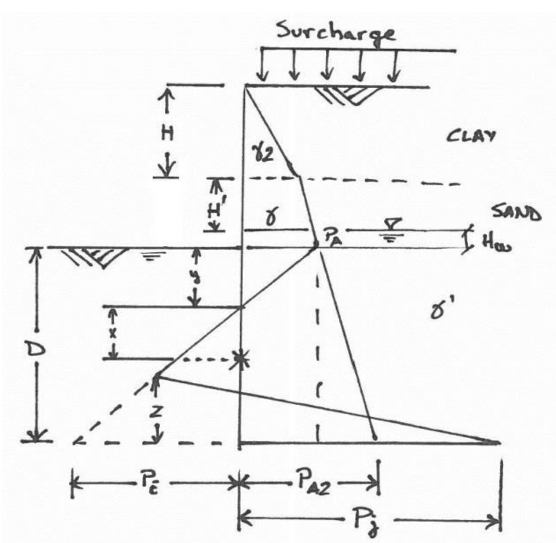
y =	1.28401622	LF
ΣPa at y=	834.691304	Lb
x =	1.99800582	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	2334.08738	Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 =	0.80025853	in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 =	0.87528277	in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 =	0.87528277	in^3

USS MARINER STEEL

S4 =	0.96582926	in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 =	1.12036194	in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	7.80	LF
Total Length =	19.53	LF

INITIAL DATA

Initial Sta. =	16+00.00
Final Sta. =	17+00.00
Ground elev. =	524.05
Sand Strata elev. =	512
Shale Strata elev. =	497
Water elevation =	512
Bottom trench =	512.385

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

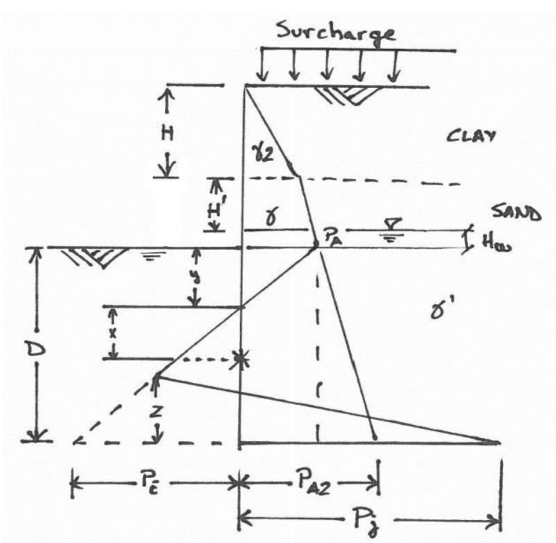
H =	11.665	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.2653552 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	540.055756	psf
Pa2 =	631.362499	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1243.6269	psf
Pj =	1783.68266	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.99130293 LF

Moment equilibrium

Mo = 6.52967E-04 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.29144588	LF
ΣPa at y=	348.726391	Lb

x = 1.29144588 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 600.481681 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.20587943 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.22518063 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.22518063 in^3

USS MARINER STEEL

S4 = 0.24847518 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.28823121 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.76	LF
Total Length =	17.42	LF

INITIAL DATA

Initial Sta. =	17+00.00
Final Sta. =	18+00.00
Ground elev. =	523.7
Sand Strata elev. =	512
Shale Strata elev. =	497
Water elevation =	512
Bottom trench =	512.245

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

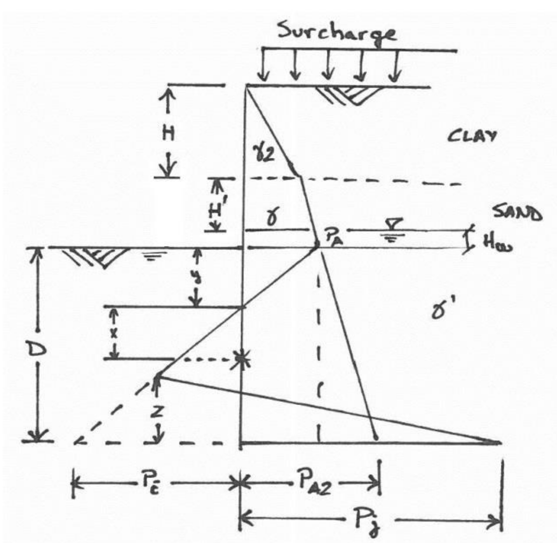
ϕ =	30	º
δ =	20	º
β =	0	º
Ka =	0.2973139	
Kp =	6.1053578	
kp-ka =	5.8080439	
H =	11.455	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	4.2012506	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	531.939088	psf
Pa2 =	621.873569	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1224.93636	psf
Pj =	1756.87545	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	0.97640474	LF

Moment equilibrium

Mo =	2.21882E-05	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.27203633	LF
ΣPa at y=	338.322923	Lb
x =	1.27203633	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	573.812067	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.19673557 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.21517953 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.21517953 in^3

USS MARINER STEEL

S4 = 0.23743948 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.27542979 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.67	LF
Total Length =	17.13	LF

INITIAL DATA

Initial Sta. =	18+00.00
Final Sta. =	19+00.00
Ground elev. =	523.3
Sand Strata elev. =	512
Shale Strata elev. =	498.08
Water elevation =	511.28
Bottom trench =	512.66099

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

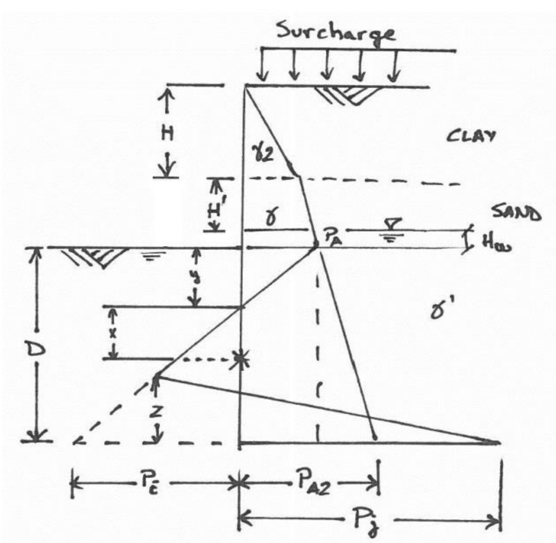
Ka =	0.2973139	
Kp =	6.1053578	
kp-ka =	5.8080439	
H =	10.639012	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.9521591 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	500.400497	psf
Pa2 =	585.002777	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1152.31007	psf
Pj =	1652.71057	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.91851386 LF

Moment equilibrium

Mo = 6.17804E-07 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.19661749	LF
ΣPa at y=	299.393993	Lb
x =	1.19661749	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 477.680116 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.16377604 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.17913004 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.17913004 in^3

USS MARINER STEEL

S4 = 0.19766074 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.22928646 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.34	LF
Total Length =	15.97	LF

INITIAL DATA

Initial Sta. =	19+00.00
Final Sta. =	20+00.00
Ground elev. =	522.925
Sand Strata elev. =	512
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.965

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

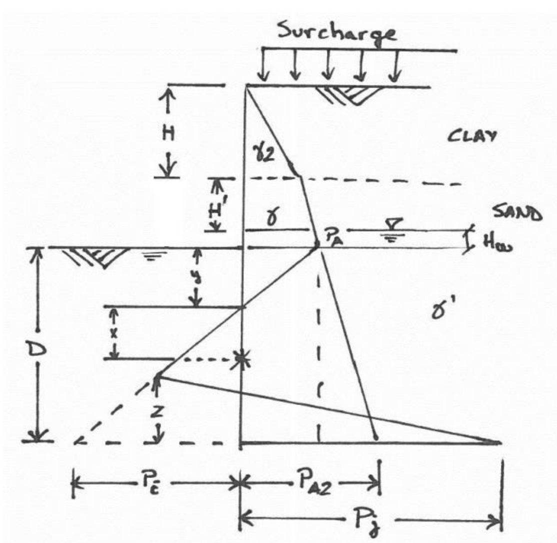
H =	10.925	LF
H' =	0.035	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 4.085716 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	512.702881	psf
Pa2 =	600.164161	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1195.85843	psf
Pj =	1734.20381	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.94647648 LF

Moment equilibrium

Mo = 1.66016E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.22603642	LF
ΣPa at y=	323.268502	Lb

x = 1.24341327 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 535.968334 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.18376057 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.20098813 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.20098813 in^3

USS MARINER STEEL

S4 = 0.22178 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.2572648 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.52	LF
Total Length =	16.48	LF

INITIAL DATA

Initial Sta. =	20+00.00
Final Sta. =	21+00.00
Ground elev. =	522.145
Sand Strata elev. =	512
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.825

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

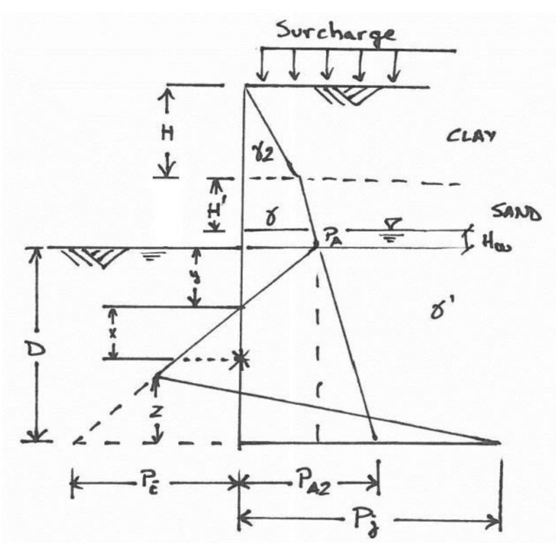
H =	10.145	LF
H' =	0.175	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	4.0281379	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	487.550129	psf
Pa2 =	573.778856	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1196.93319	psf
Pj =	1812.69583	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	0.92110073	LF

Moment equilibrium

Mo =	2.82092E-05	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.16588815	LF
ΣPa at y=	326.875095	Lb
x =	1.2503302	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	545.602114	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.18706358 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.20460079 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.20460079 in^3

USS MARINER STEEL

S4 = 0.22576639 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.26188901 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.44	LF
Total Length =	15.76	LF

INITIAL DATA

Initial Sta. = 21+00.00
Final Sta. = 22+00.00
Ground elev. = 521.365
Sand Strata elev. = 512
Shale Strata elev. = 497.81
Water elevation = 511.46
Bottom trench = 511.685

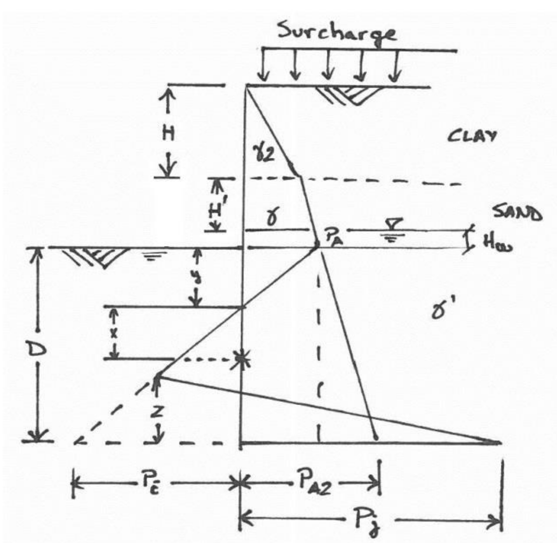
PARAMETERS

γ = 120 PCF
γ2 = 130 PCF
γ' = 72 PCF
Note: All soil is considered saturated
ϕ = 30 º
δ = 20 º
β = 0 º

Ka = 0.2973139
Kp = 6.1053578
kp-ka = 5.8080439

H = 9.365 LF
H' = 0.315 LF
Hw = 0 LF
Note: if Hw>0, Siphon study needed
D = 3.9634196 LF
Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa = 462.397376 psf
Pa2 = 547.240704 psf
Note: Active forces / Added 300 PSF Surcharge

Pe = 1195.02209 psf
Pj = 1888.20199 psf
Note: Pasive forces

DISTANCE Z

Force Equilibrium
Z = 0.89453243 LF

Moment equilibrium
Mo = 2.25204E-05 Ft-Lb
Note: Correct if equal to 0

MAXIMUM MOMENT

y = 1.10573988 LF
ΣPa at y= 328.473197 Lb

x = 1.25338292 LF
Note: where ΣPa = ΣPp
Note2: Plane of zero shear

Mx = 551.095424 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.188947 in^3
USS-EX-TEN 55 (ASTM A572 GR 55)
S2 = 0.20666078 in^3
USS EX-TEN 50 (ASTM A572 GR 50)
S3 = 0.20666078 in^3
USS MARINER STEEL
S4 = 0.22803949 in^3
USS EX-TEN 45 (ASTM A572 GR 45)
S5 = 0.2645258 in^3
Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D = 5.35 LF
Total Length = 15.03 LF

INITIAL DATA

Initial Sta. =	22+00.00
Final Sta. =	23+00.00
Ground elev. =	520.585
Sand Strata elev. =	512
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.545

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

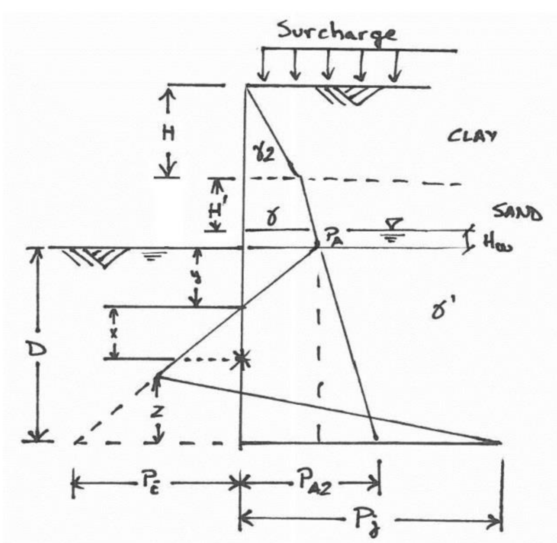
H =	8.585	LF
H' =	0.455	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.891576 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	437.244624	psf
Pa2 =	520.550027	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1190.13138	psf
Pj =	1960.72854	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.86673792 LF

Moment equilibrium

Mo = 3.82619E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.04559161	LF
ΣPa at y=	328.062808	Lb

x = 1.2525997 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 552.390255 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.18939094 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.20714635 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.20714635 in^3

USS MARINER STEEL

S4 = 0.22857528 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.26514732 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.25	LF
Total Length =	14.29	LF

INITIAL DATA

Initial Sta. =	23+00.00
Final Sta. =	24+00.00
Ground elev. =	519.805
Sand Strata elev. =	512
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.405

FORCES

Pa =	411.306963	psf
Pa2 =	491.776578	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1160.67175	psf
Pj =	1967.6059	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	7.805	LF
H' =	0.54	LF
Hw =	0.055	LF

Note: if Hw>0, Siphon study needed

D = 3.7591034 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.82947687 LF

Moment equilibrium

Mo = 3.26815E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.98356638	LF
ΣPa at y=	313.32673	Lb

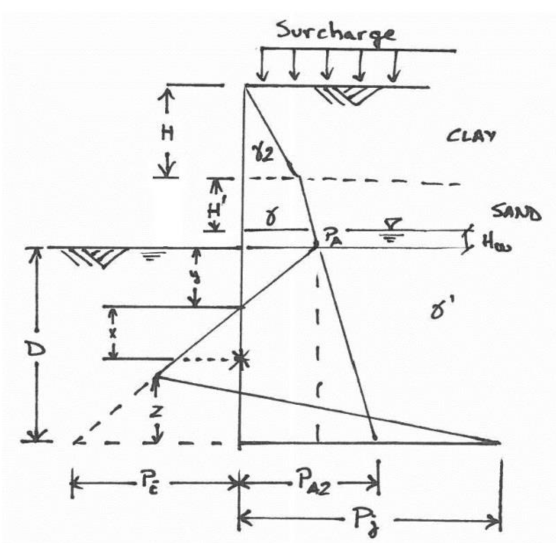
x = 1.22414405 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 517.555271 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.17744752 in^3
USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.19408323 in^3
USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.19408323 in^3
USS MARINER STEEL

S4 = 0.2141608 in^3
USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.24842653 in^3
Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.07	LF
Total Length =	13.47	LF

INITIAL DATA

Initial Sta. =	24+00.00
Final Sta. =	25+00.00
Ground elev. =	519.025
Sand Strata elev. =	512
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.265

FORCES

Pa =	384.156262	psf
Pa2 =	459.969827	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1096.86625	psf
Pj =	1876.64969	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	7.025	LF
H' =	0.54	LF
Hw =	0.195	LF

Note: if Hw>0, Siphon study needed

D = 3.5415981 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.77910728 LF

Moment equilibrium

Mo = 3.69712E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

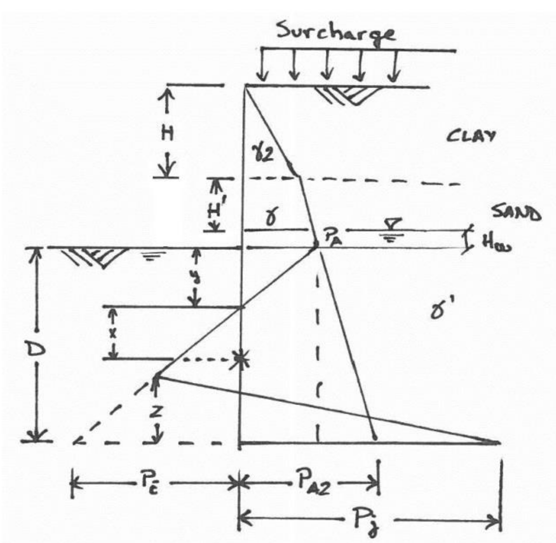
y =	0.91864037	LF
ΣPa at y=	280.172917	Lb
x =	1.15756898	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 438.229545 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.15025013 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.16433608 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.16433608 in^3

USS MARINER STEEL

S4 = 0.18133636 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.21035018 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.78	LF
Total Length =	12.54	LF

INITIAL DATA

Initial Sta. =	25+00.00
Final Sta. =	26+00.00
Ground elev. =	518.245
Sand Strata elev. =	512
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.125

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

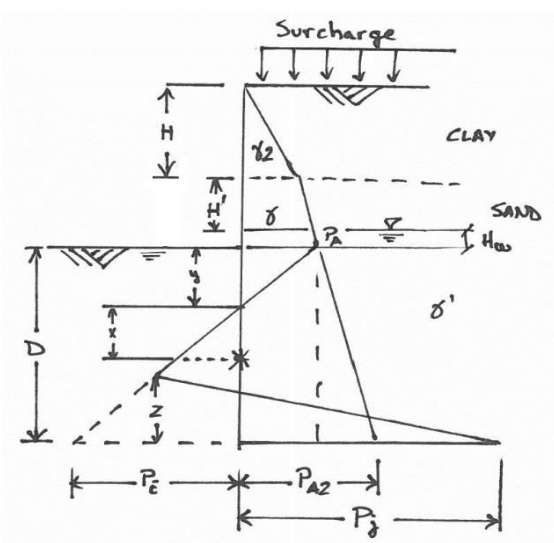
H =	6.245	LF
H' =	0.54	LF
Hw =	0.335	LF

Note: if Hw>0, Siphon study needed

D = 3.3237202 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	357.00556	psf
Pa2 =	428.155101	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1032.90496	psf
Pj =	1785.5377	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.72867101 LF

Moment equilibrium

Mo = 5.62348E-05 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.85371437	LF
ΣPa at y=	248.78189	Lb

x = 1.09079512 LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 367.286571 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.12592682 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.13773246 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.13773246 in^3

USS MARINER STEEL

S4 = 0.15198065 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.17629755 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	4.49	LF
Total Length =	11.61	LF

INITIAL DATA

Initial Sta. =	26+00.00
Final Sta. =	26+18.97
Ground elev. =	517.3
Sand Strata elev. =	512
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	512.67672

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	°
δ =	20	°
β =	0	°

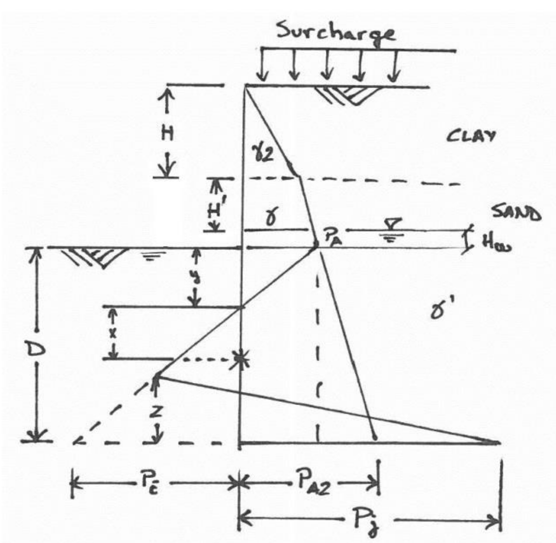
Ka =	0.2973139	
Kp =	6.1053578	
kp-ka =	5.8080439	
H =	4.623279	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 2.1157741 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	267.887596	psf
Pa2 =	313.17912	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	616.885029	psf
Pj =	884.772625	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.49172307 LF

Moment equilibrium

Mo = 1.69393E-11 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	0.64060484	LF
ΣPa at y=	85.8050454	Lb
x =	0.64060484	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 73.2895034 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.02512783 in^3
USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.02748356 in^3
USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.02748356 in^3
USS MARINER STEEL

S4 = 0.03032669 in^3
USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.03517896 in^3
Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	2.86	LF
Total Length =	7.48	LF

INITIAL DATA

Initial Sta. =	0+00.00
Final Sta. =	1+00.00
Ground elev. =	524.8
Sand Strata elev. =	512.69
Shale Strata elev. =	500.625
Water elevation =	510
Bottom trench =	514.185

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

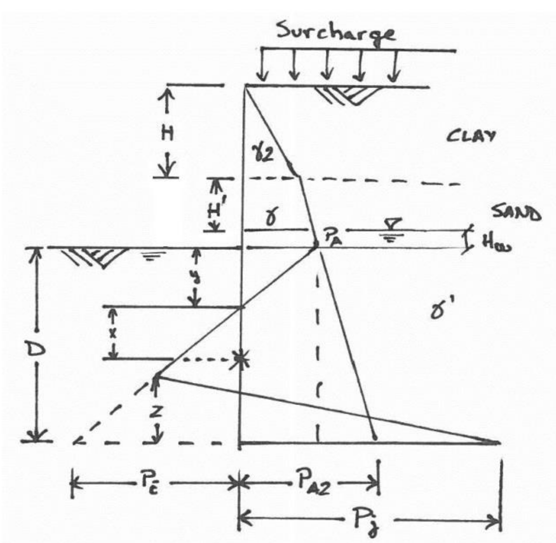
H =	10.615	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	1.0276358	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	499.472414	psf
Pa2 =	521.470601	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	-69.7365341	psf
Pj =	429.73588	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	-1.62483489	LF

Moment equilibrium

Mo =	3.46499E+02	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.19439814	LF
ΣPa at y=	298.284462	Lb
x =	1.19439814	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	475.02721	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.16286647 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.1781352 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.1781352 in^3

USS MARINER STEEL

S4 = 0.19656298 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.22801306 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	1.39	LF
Total Length =	12.00	LF

Mony Street Alternative (LATERAL)

INITIAL DATA

Initial Sta. =	1+00.00
Final Sta. =	2+00.00
Ground elev. =	524.4
Sand Strata elev. =	512
Shale Strata elev. =	499.565
Water elevation =	510.29
Bottom trench =	513.765

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

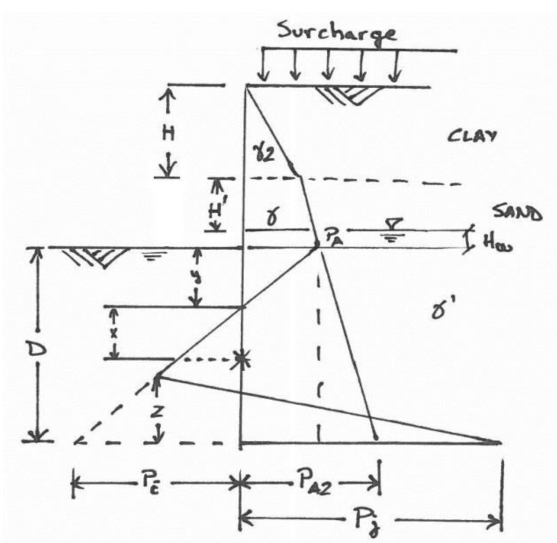
H =	10.635	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	3.9509344	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	500.24543	psf
Pa2 =	584.821493	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1151.95299	psf
Pj =	1652.19842	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	0.91822923	LF

Moment equilibrium

Mo =	6.02131E-08	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.19624667	LF
ΣPa at y=	299.208465	Lb
x =	1.19624667	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx =	477.236174	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.16362383 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.17896357 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.17896357 in^3

USS MARINER STEEL

S4 = 0.19747704 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.22907336 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.33	LF
Total Length =	15.97	LF

INITIAL DATA

Initial Sta. =	2+00.00
Final Sta. =	3+00.00
Ground elev. =	524
Sand Strata elev. =	512
Shale Strata elev. =	499.025
Water elevation =	510.65
Bottom trench =	513.345

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

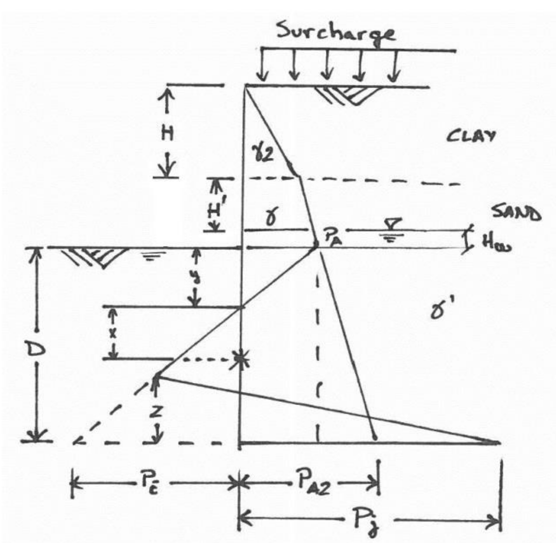
H =	10.655	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D =	3.9570107	LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	501.018446	psf
Pa2 =	585.724584	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1153.72099	psf
Pj =	1654.73944	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z =	0.91963232	LF

Moment equilibrium

Mo =	2.02768E-02	Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.1980952	LF
ΣPa at y=	300.133898	Lb
x =	1.1980952	LF

Note: where ΣPa = ΣPp
Note2: Plane of zero shear

Mx =	479.451976	Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.16438353 in^3
USS-EX-TEN 55 (ASTM A572 GR 55)
S2 = 0.17979449 in^3
USS EX-TEN 50 (ASTM A572 GR 50)
S3 = 0.17979449 in^3
USS MARINER STEEL
S4 = 0.19839392 in^3
USS EX-TEN 45 (ASTM A572 GR 45)
S5 = 0.23013695 in^3
Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.34	LF
Total Length =	16.00	LF

Mony Street Alternative (LATERAL)

INITIAL DATA

Initial Sta. =	3+00.00
Final Sta. =	4+00.00
Ground elev. =	523.6
Sand Strata elev. =	512
Shale Strata elev. =	498.485
Water elevation =	511.01
Bottom trench =	512.925

FORCES

Pa =	501.791462	psf
Pa2 =	586.628911	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1155.51316	psf
Pj =	1657.30462	psf

Note: Pasive forces

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

ϕ =	30	º
δ =	20	º
β =	0	º

Ka =	0.2973139
Kp =	6.1053578
kp-ka =	5.8080439

H =	10.675	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.9631449 LF

Note: Obtained using Solver (Mo = 0)

DISTANCE Z

Force Equilibrium

Z = 0.92106706 LF

Moment equilibrium

Mo = -8.00393E-07 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

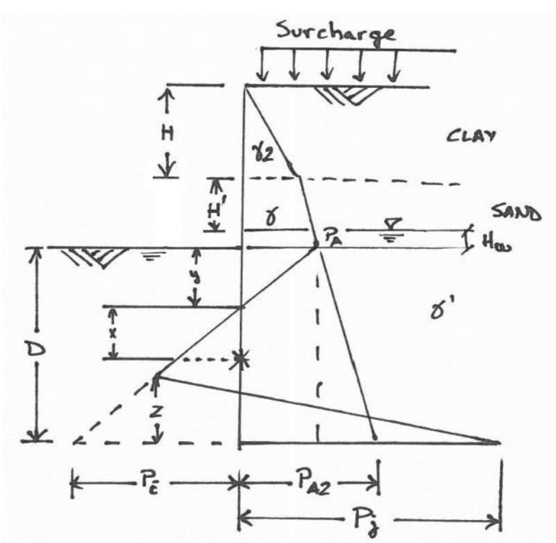
y =	1.19994373	LF
ΣPa at y=	301.060759	Lb
x =	1.19994373	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 481.674626 Ft-Lb

DIAGRAM



STEEL SHEET PILING SECTIONS

S1 = 0.16514559 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.18062798 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.18062798 in^3

USS MARINER STEEL

S4 = 0.19931364 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.23120382 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.35	LF
Total Length =	16.03	LF

Mony Street Alternative (LATERAL)

INITIAL DATA

Initial Sta. =	4+00.00
Final Sta. =	4+37.86
Ground elev. =	523.3
Sand Strata elev. =	512
Shale Strata elev. =	498.08
Water elevation =	511.28
Bottom trench =	512.66099

PARAMETERS

γ =	120	PCF
γ2 =	130	PCF
γ' =	72	PCF

Note: All soil is considered saturated

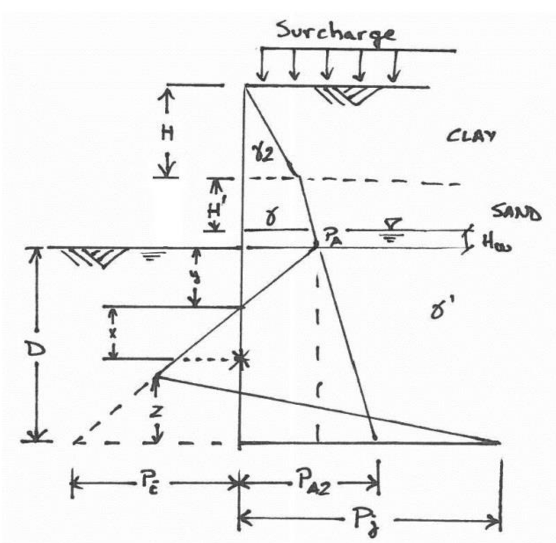
ϕ =	30	º
δ =	20	º
β =	0	º
Ka =	0.2973139	
Kp =	6.1053578	
kp-ka =	5.8080439	
H =	10.639012	LF
H' =	0	LF
Hw =	0	LF

Note: if Hw>0, Siphon study needed

D = 3.9521591 LF

Note: Obtained using Solver (Mo = 0)

DIAGRAM



FORCES

Pa =	500.400497	psf
Pa2 =	585.002777	psf

Note: Active forces / Added 300 PSF Surcharge

Pe =	1152.31007	psf
Pj =	1652.71057	psf

Note: Pasive forces

DISTANCE Z

Force Equilibrium

Z = 0.91851386 LF

Moment equilibrium

Mo = 6.17804E-07 Ft-Lb

Note: Correct if equal to 0

MAXIMUM MOMENT

y =	1.19661749	LF
ΣPa at y=	299.393993	Lb
x =	1.19661749	LF

Note: where ΣPa = ΣPp

Note2: Plane of zero shear

Mx = 477.680116 Ft-Lb

STEEL SHEET PILING SECTIONS

S1 = 0.16377604 in^3

USS-EX-TEN 55 (ASTM A572 GR 55)

S2 = 0.17913004 in^3

USS EX-TEN 50 (ASTM A572 GR 50)

S3 = 0.17913004 in^3

USS MARINER STEEL

S4 = 0.19766074 in^3

USS EX-TEN 45 (ASTM A572 GR 45)

S5 = 0.22928646 in^3

Regular Carbon Grade (ASTM A 328)

SAFETY FACTOR (35%)

Final D =	5.34	LF
Total Length =	15.97	LF

Appendix No. 8:

<u>Hydrology</u>

INDEX - APPENDIX NO. 8: HYDROLOGY

INDEX - FIGURE AND TABLE

8. Hydrology

On this appendix we will study the effects of de-watering on the construction of our project under an objective view. Improvement on construction or nearby building affection will result on the feasibility of using this method on our case. De-watering might not be needed on every station of our alignments and this will be considered in this appendix as well.

It will emphasized the difference between our two remaining project alignment and the consequences on both of them.

8.1. De-watering Theory

Construction of buildings, powerhouses, dams, locks and many other structures requires excavation below the water table into water-bearing soils. Such excavations require lowering the water table below the slopes and bottom of the excavation to prevent raveling or sloughing of the slope and to ensure dry, firm working conditions for construction operations.

Groundwater can be controlled by means of one or more types of dewatering systems appropriate to the size and depth of the excavation, geological conditions, and characteristics of the soil.

Lowering the water table can also be utilized to increase the effective weight of the soil and consolidate the soil layers. Reducing lateral loads on sheeting and bracing is another way of use. This is the most important quality on de-watering due to the construction with shoring boxes which on the practice is quite the same as sheet pilling.

There are a high variety of de-watering methods as:

a) Surface water control like ditches, training walls, embankments. Simple methods of diverting surface water, open excavations. Simple pumping equipment.

b) Gravity drainage. Relatively impermeable soils. Open excavations especially on sloping sites. Simple pumping equipment.

c) Sump pumping.

d) Wellpoint systems with suction pumps.

e) Shallow (bored) wells with pumps.

f) Deep (bored) wells with pumps.

g) Eductor system.

For our construction, the most suitable one is the wellpoint system with suction pumps.

8.1.1. Wellpoint systems

A wellpoint is 2 – 3 inch diameter metal or plastic pipe 2 – 4 feet long which is perforated and covered with a screen. The lower end of the pipe has a driving head with water holes for jetting (Fig. 1 and 2). Wellpoints are connected to 2 – 3 inch diameter pipes known as riser pipes and are inserted into the ground by driving or jetting. The upper ends of the riser pipes lead to a header pipe which, in turn, connected to a pump. The ground water is drawn by the pump into the wellpoints through the header pipe and discharged (Fig. 3). The wellpoints are usually installed with 2.5 – 10 feet spacing (See Table 1). This type of dewatering system is effective in soils constituted primarily of sand fraction or other soil containing seams of such materials. In gravels spacing required may be too close and impracticable. In clays it is also not used because it is too slow. In silts and silt – clay mixtures the use of well points are aided by upper (2 – 3 feet long) compacted clay seals and sand-filtered boreholes (8 – 24 inch diameter). Upper clay seals help to maintain higher suction (vacuum) pressures and sand filters increase the amount of discharge. Filtered boreholes are also functional in layered soil profiles (Fig. 4, 5, 6 and 7).

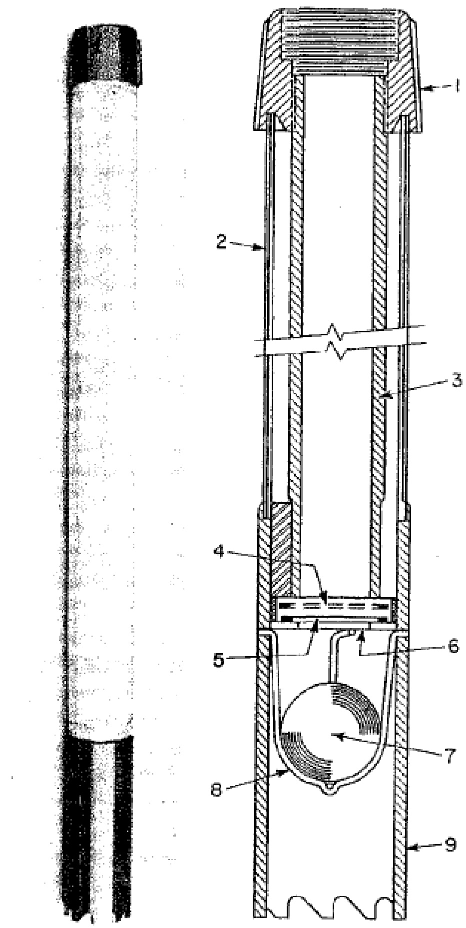


Figure 1. Well point: (1) coupling; (2) screen cylinder; (3) center tube; (4) ring valve; (5) ring valve at rest position; (6) ball seat; (7) ball valve; (8) retainer basket – clamps the ball seat in place and keeps the ball valve in the center of the tip during jetting, providing a streamlined oversize exit for the full force of the jetting water; (9) jetting tip.

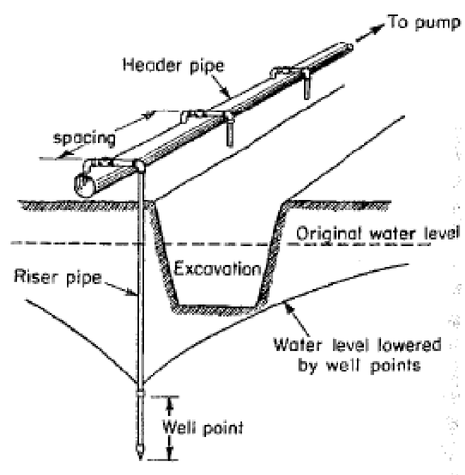


Figure 2. Well Point system.

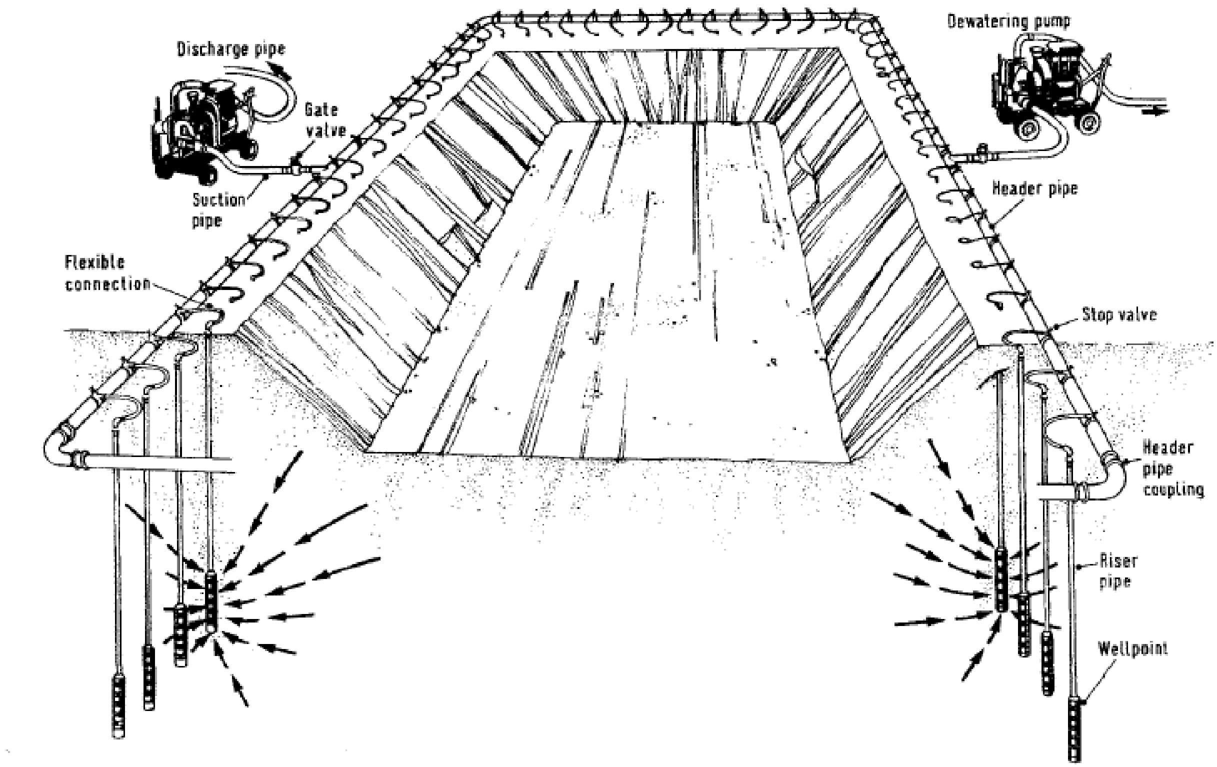


Figure 3. Wellpoint dewatering system components.

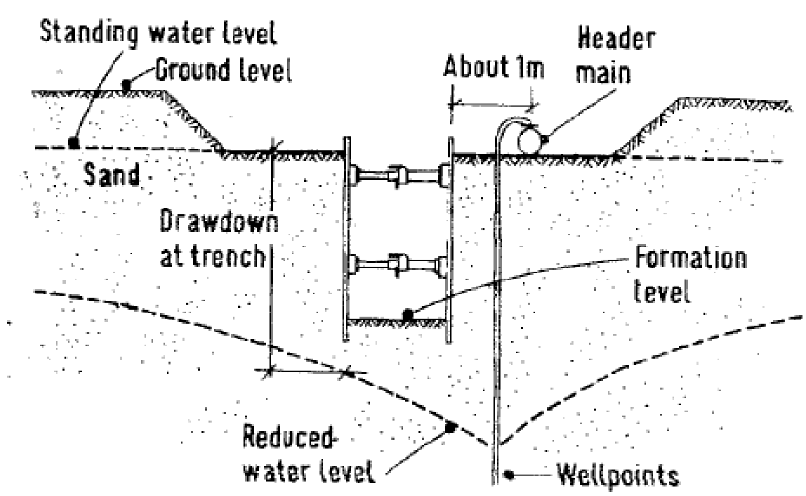


Figure 4. Single-sided wellpoint system.

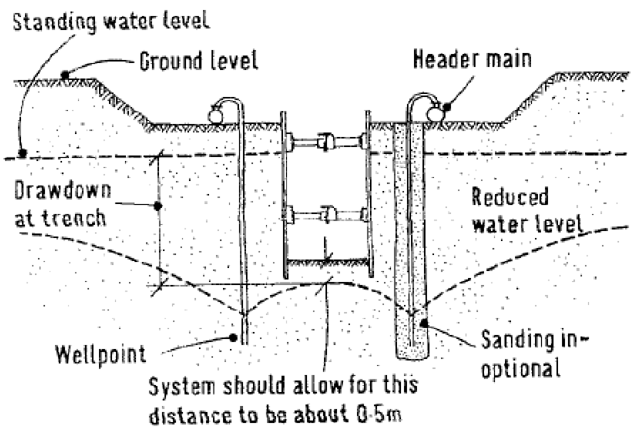


Figure 5. Single-sided wellpoint system.

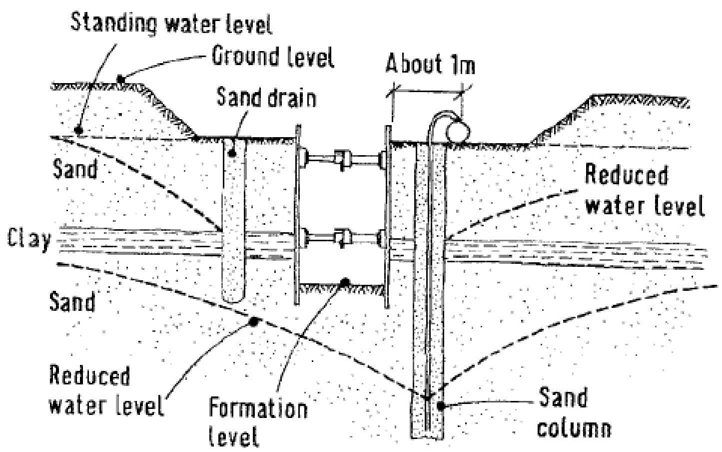


Figure 6. Single-sided wellpoint system with sand column.

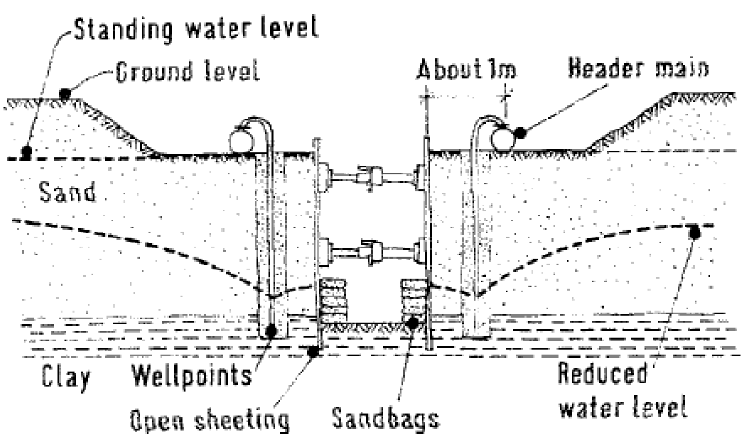


Figure 7. Double-sided wellpoint system with sand column.

Soil	Typical Spacing (FT)	Time (days)
Silty Sand	5 – 6.5	7 – 21 (Could be longer)
Clean fine to coarse sand and sandy gravel	3 – 5	3 – 10
Fine to coarse gravel	1.5 – 3	1 – 2

Table 1. Typical spacing for some common soil types and the approximate time required for effective drawdown

The header pipe (15-30 cm diameter, connecting all wellpoints) is connected to a vacuum (Suction assisted self – priming centrifugal or piston) pump. The wellpoints can lower a water level to a maximum of 5.5 m below the centerline of the header pipe. In silty fine sands this limit is 3-4 m. Multiple stage system of wellpoints are used for lowering water level to a greater depth.

Nomograms for selecting preliminary wellpoint spacing in clean uniform sand and gravel, and stratified clean sand and gravel are shown in Figures 8 and 9.

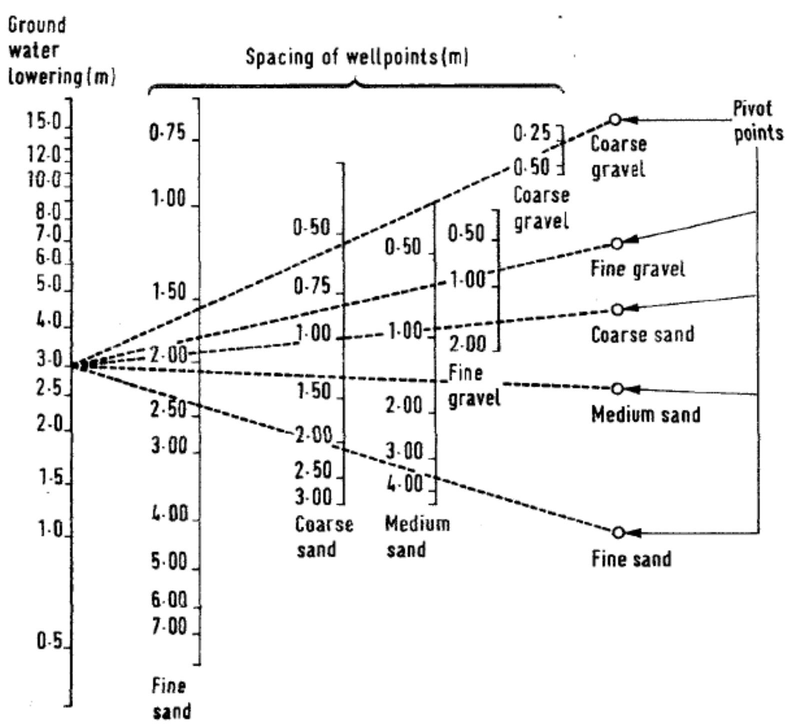


Figure 8. Nomogram for wellpoint spacing (m) in clean, uniform sand and gravel.

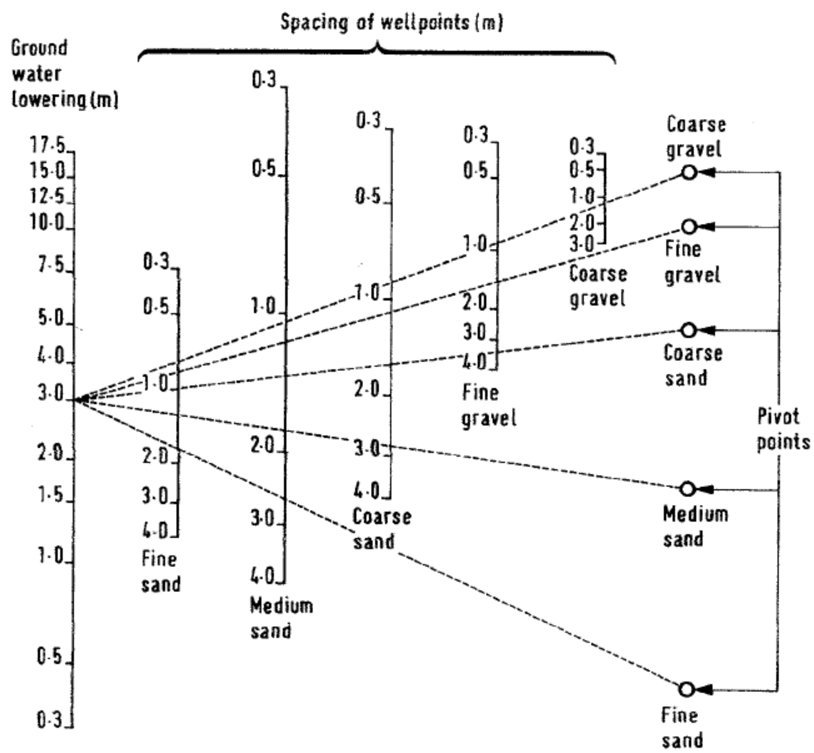


Figure 9. Nomogram for wellpoint spacing (m) in stratified clean sand and gravel. (Note 1 - Design should be based on the most permeable of the strata. Note 2 - The lower the permeability if the ground, the steeper the drawdown curves becomes.)

Horizontal wellpoints are used mainly for pipeline water. They consist of perforated pipes laid horizontally in a trench and connected to a suitable pump.

8.2. Mathematical and Model Analysis

To do such analysis, first we need to show the exact depth of the proposed sewer lines every 50 feet, the water table elevation, sand strata and shale elevation so we can make an exhaustive analysis of both cases at any point.

8.2.1. Greenfield avenue alternative de-watering length

As we can see on the Annex 2, this alternative is underneath the water table from station 12+50.00 until 20+50.00 (800LF Approx.) where it come out again due to the lowering of the water level itself. Although we find our sewer design under the clay strata, ergo in the sand one, from station 4+50.00 until the very end at 27+25.13 (2275.13 LF Approx.). With previous excavations on the area (Drainage installation at Pharr street), once the sand strata is broken the ground becomes highly instable and dewatering becomes a must. In this case that would be de-water the whole length of the project but the one where the sewer is at the clay strata which would be form station 0+00 to 4+50 (450LF Approx.).

This sets the de-watering length at, as stated before, 2275.13LF approximately.

If dewatering is done the recently installed sewer pipe won't sink overnight as happened with other utilities in the area. Such utilities are not as concerned as the grade to maintain but on sewer grade is key and must be maintained at all times to be accepted by the city for its use.

I would like to emphasis that such de-watering will provide a safer environmental while executing the project and the setting of the trenching boxes will be much safer and there should not be any caving between the trench and the box. Siphoning won't occur as well.

Even though we are drying the area, a solid embedment must be used so it doesn't sink the whole facility after the de-watering is done. This topic will be taken care while designing the final chosen alignment.

8.2.2. De-watering system calculation – Greenfield Alternative

Now that we know the total length to be de-watered an engineered solution must be find. The following parameters are meant to be find:

a) One or double sided well points
b) Distance from edge of the trench to well points
c) Depth of the well points
d) Distance between well points

Usually, when performing trenching de-watering, a leap-frogging operation is done. This means that only between 400-1000LF are installed at all times and as long as the sewer installation progresses, the de-watering installation advances with it (Usually once a week).

As we expect to be installing 75LF of sewer pipe a day (Working day), around 400LF must be replaced every week.

Although, to maintain a buffer spacing between the end of the wellpoints and the head of the trench, we will consider that we leap-frog 500LF at a time.

On the other hand, we must consider the time to lower the water table. The bore logs that can be found at Appendix 3 show that the sand is quite silty and clayey. This means that we may face dewatering times between 7 and 21 days as per table 1.

Either way, no more that 1000LF will be set at the same time an as per the calculations, this won't affect the results of spacing between wellpoints.

To find out the conductivity of our silty sand we will use the following figure (from Heath 1983):

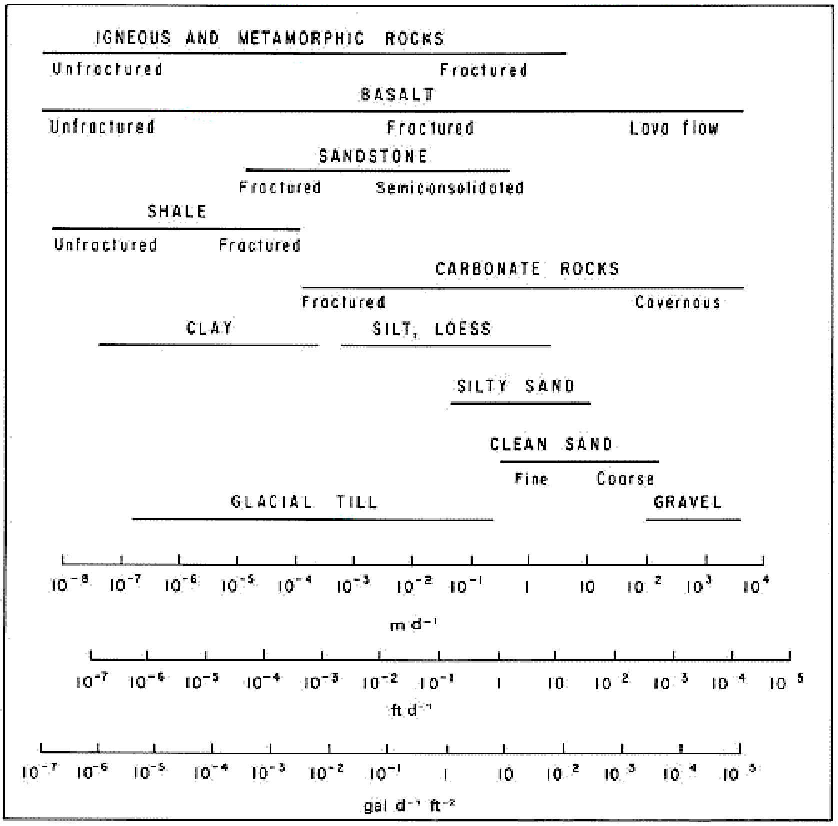


Figure 10. Hydraulic conductivity of selected consolidated and unconsolidated geologic materials.

The silty sand permeability goes between 10^{-1} - 10 m/day. Converted to m/s we will have the following range:

$$K = 1.15 \times 10^{-6} - 1.15 \times 10^{-4} \text{ m/sec}$$

To be fair and due to the uncertainty of this values, the average permeability factor will be chosen as a moderate safety factor as-well ($K = 1.15 \times 10^{-5}$ m/sec).

Our calculation case is as shown below:

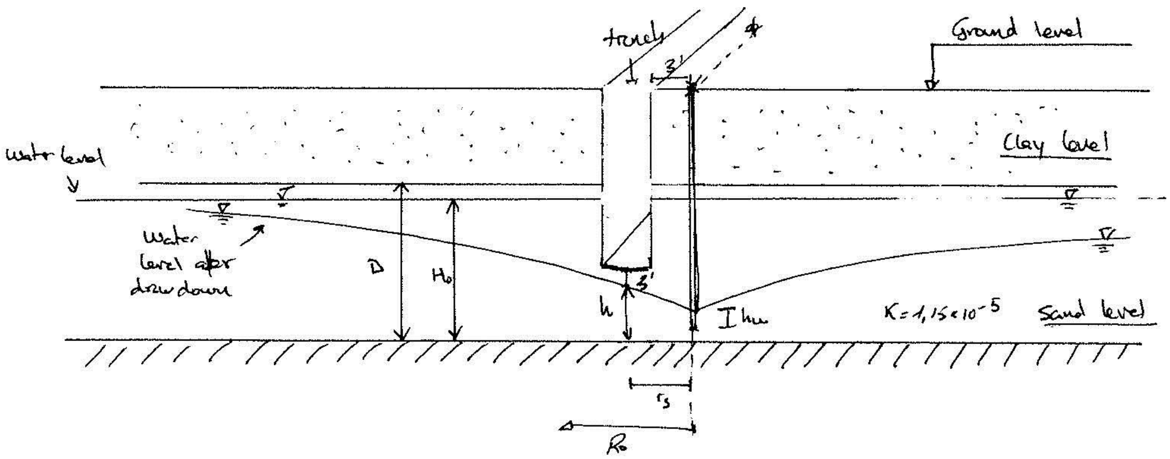


Figure 11. Trench de-watering description.

Where;

D = height of piezometric level above base of aquifer (m). (Can be equal to H if aquifer isn't confined or is found at the bottom of the clay strata elevation).

h_W= height of water at outside edge of pumping wells after drawdown (m).

R_o = radius of influence (m).

r_s = equivalent radius of assumed single well (m).

The ground level through the project varies between 519.3 and 524.9. The goal of de-watering is to set the underground water table 3 feet beneath the bottom of the trench (ergo 3 feet below flow line due to the 1 foot embedment).

From the tables on annex 2 we can obtain the following information:

	Ground Level	WL target under trench	Water Level	Begin Sand	Begin Shale	InFlow - WL	InFlow-sand	InFlow-Shale	Max Drawdown
MAX	524.9	17.7	512.5	521.5	506.0	1.2	1.2	20.7	(2.8)
MIN	519.3	9.7	510.0	512.0	493.0	(0.7)	(9.6)	5.0	(4.0)
AVERAGE	522.9	14.4	511.6	514.8	498.7	0.2	(3.0)	13.1	(3.5)

Table 2. Max, Min and Average elevations of Greenfield Ave. Alternative.

To do all our calculations we must choose first our initial data. Due to the length of the case we will choose the elevations that will keep us on the safe side but we cannot be too conservative, if so we may fall under a very expensive installation.

Ground elevation: As ground level we will chose the **average** elevation as the range isn't too wide. (522.9)

Water elevation: On this parameter we will set it as its **maximum** elevation. The area is very unstable and is reasonable to take this factor as the main one. (512.5)

Top Sand Strata elevation: This strata varies a lot from station 0+00 to the last one. We will consider it at the **same elevation as the water level**. Any higher elevation wouldn't affect the result of the calculations and a lower one will lead us to shallower wells. (512.5)

Top Shale Strata: This parameter will be taken as the **average** one. The shale strata will limit our well length and condition its diameter. (498.7)

Maximum drawdown elevation: This elevation comes from subtracting to the water level the maximum drawdown that is 4 feet. (508.5)

The first thing we need to calculate is the radius of influence:

$$R_0 = C \cdot h \cdot \sqrt{k}$$

Where;

C ≈ 1500 to 2000 for line flow to trenches (Factor for radial flow)

h = H – Maximum drawdown elevation = 4.0 LF (1.25 m)

k = coefficient of permeability (m/s).

$$R_0 = 2000 \cdot 1.25 \cdot \sqrt{1.15 \text{ x } 10^{-5}} = 8.48\, m\ (27.82\, LF)$$

As we can see, due to the silty sand, the influence radius is quite small. The next step is to know how deep we must set the well point and what distance they must be placed to achieve such drawdown. Here we have 2 different incognita. We could set the wellpoints deeper to place them more spaced or we can set more well points and set them shallower. To discern and optimize the depth and distance a first case must be achieve and from then onwards set the optimal values due to trials.

8.2.2.1. Case 1 – Spacing between wellpoints at 5 LF (1.524 m)

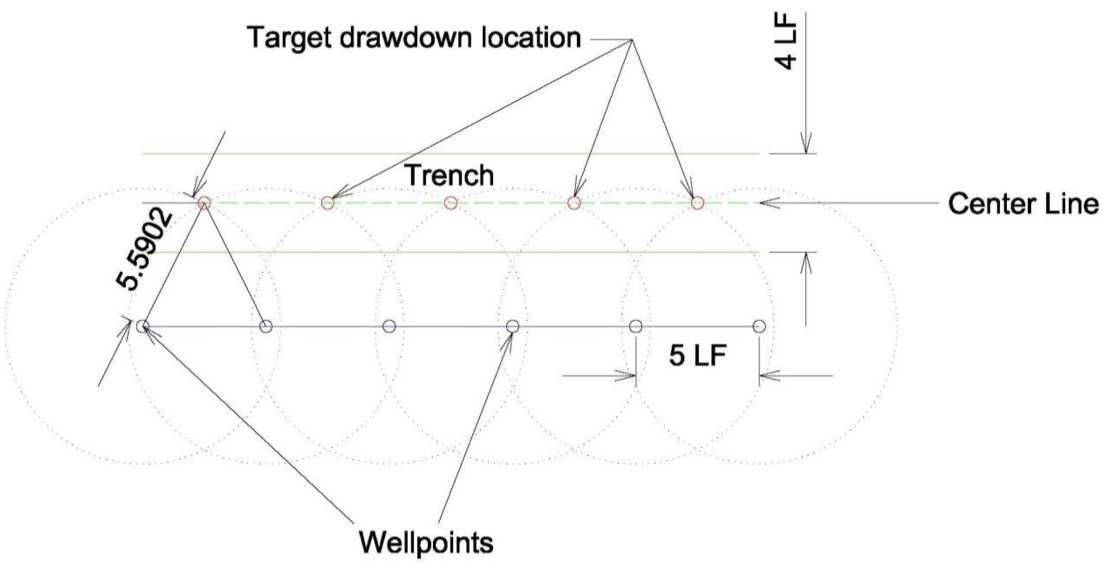


Figure 12. Detail Case 1.

As we can see on the detail above, the target distance is not the perpendicular distance from the center of the wellpoint up to the center line of the trench but where both consecutives wellpoints influence radius intersect. This distance is easily found by the Pythagoras theorem.

The percent drawdown of the water table at any distance from the center of cone can be obtained from the following figure.

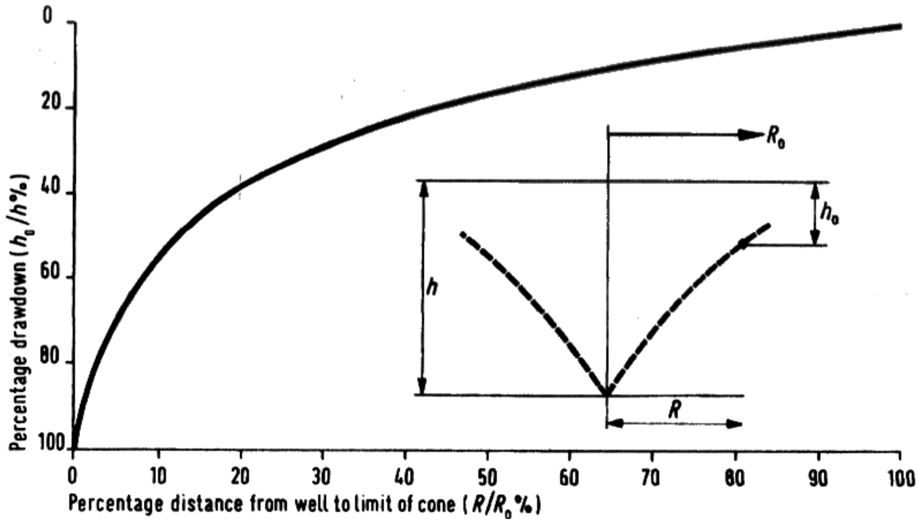


Figure 13. Relation of drawdown to distance from center of cone of depression.

In our case, the distance to the perimeter to the center is 5.5902 LF (1.7 m) and its percentage respect the influence radius is:

$$\frac{1.7\ m}{8.48\ m} \cdot 100 = 20.10\% \ \rightarrow From\ the\ above\ figure\ \%\ drawdown\ is\ 39\%$$

Therefore, required drawdown at wells to obtain 1.25 m drawdown at center of the trench will be ${}^{1.25}/_{0.408} = 3.20\ m\ (10.51\ LF)$. In practice since each line of wells will contribute to the drawdown, a somewhat lesser drawdown at the wells will be required. Alternatively, assuming a full 10.51 LF drawdown will allow a margin of error.

Even though we know there is clay strata on top of the sandy clay, the water table level never gets inside it and usually stays way underneath the strata transition. Therefore we will use a non-confined aquifer to calculate the flow (or yield) using the following formula:

$$Q = \frac{2\pi kD(H - h_{w(max)})}{\ln({}^{R_0}/_{r_s})}$$

To be able to calculate this formula, we need to determine the lowest level of the well. We must allow an extra head (h_w) of around 3 LF or up to the shale strata for velocity and friction losses (Whichever is less).

$$Q = 1.7 \cdot 10^{-4} \frac{m^3}{s} = 0.046 \frac{gal}{s}$$

Assuming 18 inch (460 mm) diameter wells find the area of wetted depth (hw) of wells for calculated yield using the following graph for k = 1.15 x 10^{-5} m/s: Yield per meter of wetted depth = 0.38 lt/s or 0.1 gal/s.

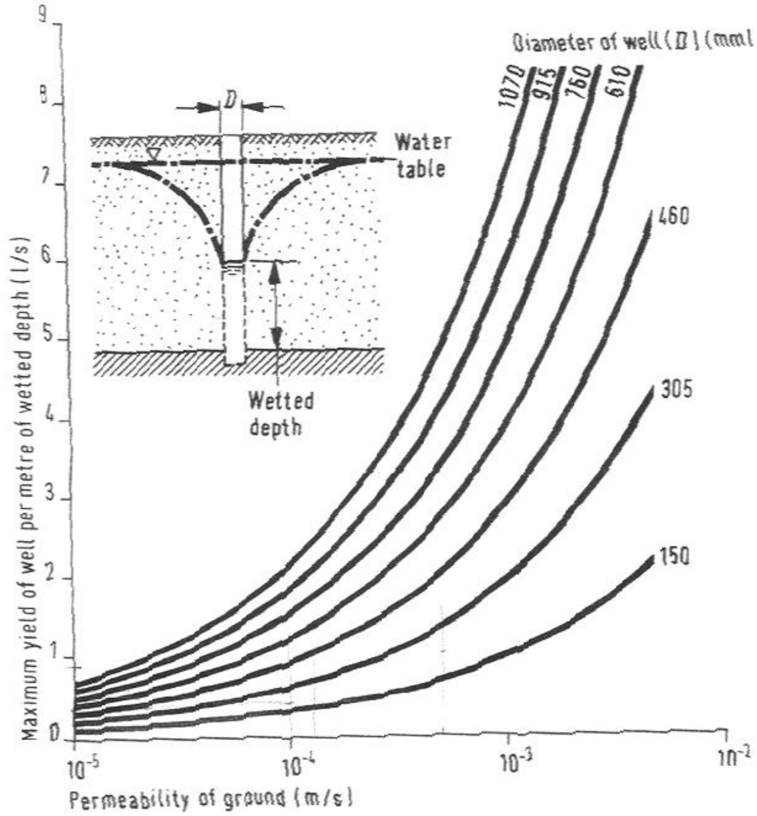


Figure 14. Maximum yield of wells.

Then, the total wetted depth required is:

$$h_w = \frac{0.046}{0.1} = 0.46\ m\ approx.\ or\ 1.50\ LF$$

This leave us with enough space to set the well without arriving to shale depth. To sum up, the well length sill be the difference between the ground elevation and the shale strata extracting the difference between $h_{w(max)}$ and the actual h_w.

$$Wellpoint\ Depth = 25.7\ LF$$

With this final depth we conclude this first case.

Out from this case various concerns may arise. The main one is what if the drawdown level at the center line is not enough and at the edge of the trench some water breaks through. On the following case we will take this into account.

8.2.2.2. Case 2 – r_s distance to the edge of the trench – 7LF (2.1336 m)

With this new distance, the new target drawdown distance will be at 7.433 LF (2.27m).

$$^{r_s}/_{R_0} = 26.73\% \ \rightarrow From\ figure\ 13\ \%\ drawdown\ is\ 33\%$$

Such distance will be 12.42 LF. This means a longer well as could be predicted. This brings us closer to the shale strata which is only at 1.38 LF from this new elevation.

Due to this elevation, the flow will be at 6.5 x 10^{-4} m^3/s or 0.172 gal/s. This will lead a wetted distance at a 18 inch diameter well of 5.6 LF. This distance is higher that the distance to the shale strata making this option not feasible. The wetted area is very important because is the only part of the well that suctions the water. If it gets into the shale strata, the whole system would be compromised. To avoid this problem we will try to diminish the distance between wells.

8.2.2.3. Case 3 – r_s distance at the edge of the trench – 7 LF (2.1336 m) and wells separated within 3 feet.

Keeping the same steps on this case than the previous ones we obtain the following information:

R_s/R_0 = 25.75%

H_0/h = 36% → H_o = 11.38 (Distance to shale: 2.41)

Required h_w = 3.47 LF (Not feasible)

8.2.2.4. Case 4 - r_s distance at the edge of the trench – 6.5 LF (1.98 m) and wells separated within 4 feet.

Another way to solve this situation is setting the wells closer to the trench. This option would make the whole excavation operation more complex due to the proximity of the wells to the tracks of the trackhoe. Taken this into account, we will set the wellpoints half foot closer to the trench at a 2.5 LF. At the same time, we will reset the pumps at a distance between each other of 4 feet reducing therefore the cost of such activity.

R_s/R_0 = 24.46%

H_0/h = 37.5% → H_o = 10.93 (Distance to shale: 2.87)

Required h_w = 2.49 LF (Feasible)

$$Wellpoint\ Depth = 26.7\ LF$$

The rest of the relevant information can be found below:

H_o = 10.93 LF

Q = 0.076 gal/s

With this last case we have found a limit case that will work for our project. It is on the safe side and it is feasible. Also we've achieved not to set a double sided wellpoint system. Further down on the paper we will take a look on the building affection on both alternatives due to the de-watering operations.

8.2.3. Mony street alternative de-watering length

This time the analysis of the alternative is on Annex 3. This alternative is underneath the water table from station 12+50.00 until 26+18.97 (1368.97LF Approx.) . The lateral coming from north of Mony Street isn't under the water table at all. As explain previously, we will keep dewatering on every place where we hit the sand strata. This means that the total length dewatering will be from station 4+50 until the very end adding the last 37 LF of the lateral coming south north of Mony street. The de-watered length will be 2206.83 approx.

8.2.4. De-watering system calculation – Greenfield Alternative

On this case we will apply all we have applied already on the previous cases but the initial data will vary. Please find below relevant information that can be extracted from tables at Annex 3.

	Ground Level	WL target under trench	Water Level	Begin Sand	Begin Shale	InFlow - WL	InFlow-sand	InFlow-Shale	Max Drawdown
MAX	524.9	15.8	512.5	521.5	506.0	3.3	1.2	20.7	0.7
MIN	517.3	9.7	510.0	512.0	493.0	(1.4)	(9.7)	5.8	(4.0)
AVERAGE	522.3	13.4	511.7	514.0	497.9	0.2	(2.0)	14.1	(3.1)

To do all our calculations, as we did on the prior case we must choose first our initial data.

<u>Ground elevation</u>: As ground level we will chose the **average** elevation as the range isn't too wide. (522.3)

<u>Water elevation</u>: On this parameter we will set it as its **maximum** elevation and it coincides to the prior case. (512.5)

Top Sand Strata elevation: We will consider it at the **same elevation as the water level**. (512.5)

Top Shale Strata: This parameter will be taken as the **average** one. The shale strata will limit our well length and condition its diameter. (497.9)

Maximum drawdown elevation: This elevation comes from subtracting to the water level the maximum drawdown that is 4 feet. (508.5)

As final consideration, our influence radius R_o won't change due to different initial data and therefore will be as the Greenfield alternative case.

$$R_0 = 2000 \cdot 1.25 \cdot \sqrt{1.15 \text{ x } 10^{-5}} = 8.48\, m\ (27.82\ LF)$$

8.2.4.1. Case 1 – r_s distance at the edge of the trench – 7LF (2.1336 m) and wellpoints separated 5 LF between each other (1.524 m).

R_s/R_0 = 26.73%

H_0/h = 34.5% → H_o = 11.88 (Distance to shale: 2.72)

Required h_w = 3.65 LF (Not Feasible)

$$Wellpoint\ Depth = 28.98\ LF\ \approx 29\ LF$$

This first approach isn't feasible. Distance to the maximum drawdown is too long. We will consider on our next case the same distance from the wellpoints up to the farther edge of the trench as case 4 on Greenfield Ave alternative. We will keep the original distance from wellpoint to wellpoint.

8.2.4.2. Case 2 – r_s distance at the edge of the trench – 6.5LF (1.98 m) and wellpoints separated 5 LF between each other (1.524 m).

R_s/R_0 = 25.04%

H_0/h = 36.25% → H_o = 11.31 (Distance to shale: 3.29)

Required h_w = 2.9 LF (Feasible)

$$Wellpoint\ Depth = 27.3\ LF$$

Thanks to this casuistic we have obtained two feasible de-watering systems to apply to our projects. A comparative between both cases can be found below this lines:

8.3. Building affection due to de-watering operations

The main concern of de-watering is how it will affect the existing buildings in the area nearby. We are studying a mainly industrial neighborhood with big buildings and heavy traffic. We could provide an approximate settlement of such buildings but it would be less than accurate and therefore not reliable. Instead of assuming the damage a countermeasure can be applied to avoid such settlements.

The recharge of the groundwater next to the wellpoints can prevent any settlement and assure the integrity of the building nearby. The following figure explains how the water table gets recharged due to an infiltrating wellpoint:

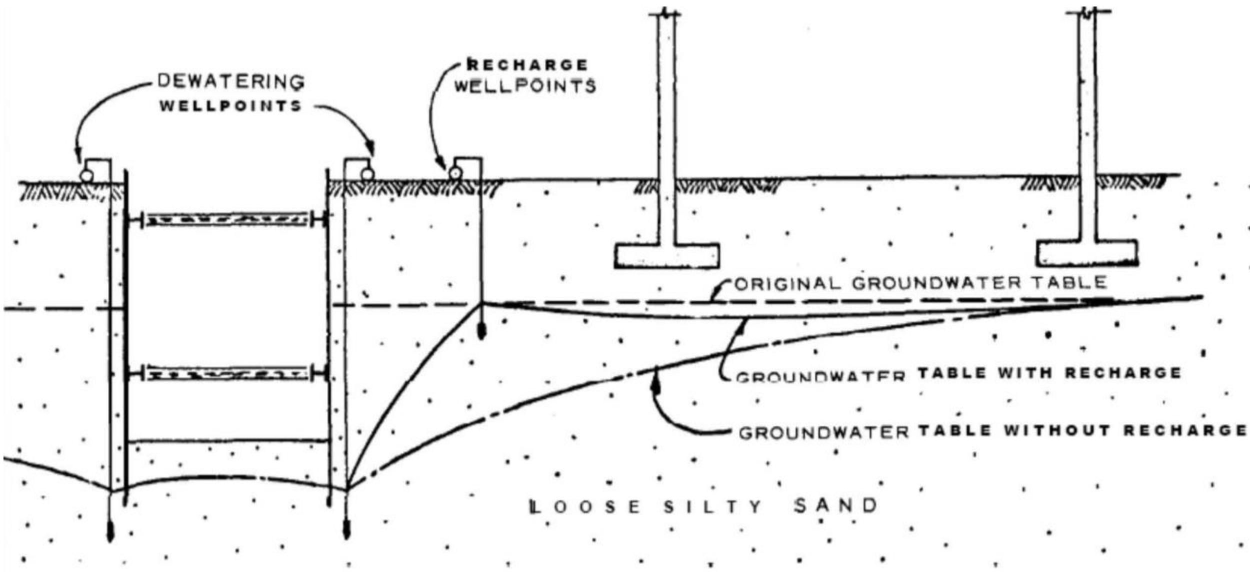


Figure 15. Recharge groundwater to prevent settlement.

There will be an extra cost for both alternatives at relevant locations as greenfield Ave. for alternative 1 or at Mony street on the other.

Both alternatives will provide such reinforcing wellpoints at Pharr street as-well.

Well points will have the same spacing and flow rates as the ones pumping water out from the subsurface.

8.4. Comparative Greenfield - Mony

	Distance Wellpoint - Trench (LF)	Wellpoint Separation (LF)	Wellpoint Depth (LF)	Application Length (LF)	Recharge Length (LF)	Wellpoints / 1000LF
Greenfield Ave Alternative	2.50	4.00	26.7	2275.13	575.00	250
Mony Street Alternative	2.50	5.00	27.3	2606.86	1069.00	200

Table 3. De-watering System comparative.

If we apply this data to the case where all the de-watering system is installed at the same time, a percentage different can be obtained between both alternatives.

Greenfield alternative would have installed 569 wellpoints plus 144 due to the recharge at Pharr and Greenfield Ave. In total there will be 713 wellpoints shafted and installed.

Mony alternative would set to function 442 wellpoints with the addition of 214 more due to the recharging operations. This will sum up to 656 wellpoints installed.

With this information, **Mony street alternative** should be almost up to **10% cheaper** (92% of Greenfield's cost) de-watering wise. It will depend of how cost is priced by subcontractor and the time applied.

8.5. De-watering Cost

Local construction company specialized in de-watering offered the following prices for an average setup according to the following terms:

- The system will be installed to provide up to 1,000 lineal feet of dewatered trench at any time.
- The system will be pulled and advanced by our forces as the job progresses.
- The systems will be installed in your sub cut trench at a depth of ±5' below existing grade, or within approximately ±2' of the current static water level, whichever is lower.
- The vacuum points will be installed to a depth of 23' below bench elevation, or to jetting refusal whichever comes first.
- Subcontractor will provide up to 100' of discharge pipe or hose per operating pump.
- Discharge piping from wellpoint pumps to final discharge location will be by the contractor.
- All work performed by Subcontractor will be with our non-union crews at prevailing wages.
- Upon completion of the dewatering , contractor to remove and return all dewatering equipment to the Subcontractor Yard

8.5.1. Proposed Services and Pricing

Subcontractor will provide labor, materials, tools, supervision and equipment except as specifically excluded below. Subcontractor will install a minimum of 2,000 feet of operable trench dewatering system as described above. Upon completion of the dewatering, the system will be removed by contractor and returned to Subcontractor's yard for the sum price $68.00 / linear foot of trench.

Should additional footage require dewatering beyond the base amount of 2,000 feet, add$ 58.00 / linear foot of trench.

The above pricing includes up to six (6) weeks rental of the dewatering equipment. Rental of the associated dewatering equipment including up to four (4) primary Subcontractor Diesel driven vacuum wellpoint pumps, two (2) standby wellpoint pumps, up to 1,000' of Subcontractor header pipe, ±450 vacuum wellpoints and up to ±400' of discharge pipe from the wellpoint pumps. Rental beyond the initial six (6) weeks will be $1,125.00 /day.

Other considerations:

- Rental of the dewatering equipment will commence upon mobilization to the job site, and cease when the system is return to Subcontractor yard.
- The above price is based on one mobilization and one de-mobilization only. Any additional mobilizations will be billed accordingly. Subcontractor forces will require up to 1-2 weeks of advance installation time prior to the contractor beginning line installation.
- The fuel requirement (and fuel tanks) for this system are not included in this pricing. The estimated fuel requirement for the installed system is approximately 75 - 90 gallons / 24 day / operating pump depending on RPM.
- Subcontractor will perform the agreed upon dewatering services in a timely and workmanlike manner. Subcontractor intends to perform its installation work in a continual and uninterrupted manner. If the system cannot be installed or leap- frogged in a

continuous manner for reasons that are not the fault of Subcontractor, our stand by rate will be $5,800.00 per day/ crew or $725.00 per hour/ crew.

- The Contractor will be required to provide any additional labor that may be required as well as any and/or all equipment that may be required for any service call or repair.

8.5.2. *Cost Summary Template*

TRENCH DEWATERING COST SUMMARY

Item	Quantity	UM	Unit	Amount
1 - Sided (First 2000')		LF	$ 68.00	
1 - Sided (After 2000')		LF	$ 58.00	
Equipment Rental (First 6 weeks)		Month	$ -	
Equipment Rental (After 6 weeks)		Month	$ 33,750.00	
Equipment Rental (After 6 weeks)		Day	$ 1,125.00	
Stand by Crew		Day	$ 5,800.00	
Stand by Crew		HR	$ 725.00	

Table 4. Trench dewatering cost summary

This prices doesn't have into account the number of dwells performed along the trench but the time they are used. This means that the last statement on the page 27 above is false. Greenfield will be then less expensive than Mony option.

8.6. De-watering Comparative

A table as the previous one will be used to finally compare in a quantitative manner the difference between implementing this de-watering system in both alternatives. Due to the failed study of pilling sheets along the trench, de-watering will be a must, even though, the bottom of the trench must be ensured and filled with 3 by 5 inch rock or concrete grout. Either way the initial assumption that the trench would go at a pace of 75 LF per day is too aggressive. In order to find a more conservative solution and probably more accurate to the reality of the area, the new construction pace will be diminished up to 50LF of trench per day. This means more time with the de-watering subcontractor on-site. (Consider 5 working days per week as well)

8.6.1. Greenfield Avenue De-watering Cost

Greenfield Avenue Alternative				
Item	Quantity	UM	Unit	Amount
1 - Sided (First 2000')	2000	LF	$ 68.00	$ 136,000.00
1 - Sided (After 2000')	275.13	LF	$ 58.00	$ 15,957.54
Recharge 1 - sided	575	LF	$ 58.00	$ 33,350.00
Equipment Rental (First 6 weeks)	1	Month	$ -	$ -
Equipment Rental (After 6 weeks)	56.25	Day	$ 1,125.00	$ 63,274.91
Stand by Crew	9.1	Day	$ 5,800.00	$ 52,783.02
Stand by Crew	0	Hr	$ 725.00	$ -
			TOTAL	$ 301,365.47

Table 5. Greenfield Avenue De-watering Cost

To compute this alternative, a 7 days prior dewatering to the start of works was used and also a 20% of the time will be set as downtime due to unpredictable and unknown factors as weather or machinery breakdown. The same preferences has been used for the Mony alternative.

8.6.2. Mony Street De-watering Cost

Mony Avenue Alternative				
Item	Quantity	UM	Unit	Amount
1 - Sided (First 2000')	2000	LF	$ 68.00	$ 136,000.00
1 - Sided (After 2000')	206.83	LF	$ 58.00	$ 11,996.14
Recharge 1 - sided	1069	LF	$ 58.00	$ 62,002.00
Equipment Rental (First 6 weeks)	1	Month	$ -	$ -
Equipment Rental (After 6 weeks)	67.39	Day	$ 1,125.00	$ 75,814.31
Stand by Crew	10.43	Day	$ 5,800.00	$ 60,479.15
Stand by Crew	0	Hr	$ 725.00	$ -
			TOTAL	$ 369,493.34

Table 6. Mony Street De-watering Cost

ANNEX 8.1 – Alignment through Greenfield Ave. Analysis

Station		Distance (LF)	Diameter (FT)	Design		Slope	Water Level	Begin Sand	Begin Shale	Out-Flow - WL	Out-Flow -sand	Out-Flow -Shale	Comments
Begin	End			Out-Flow	In-Flow								
00+00.00	00+50.00	50	1.5	513.73	513.66	0.14%	512.5	512.5	493.0	1.2	1.2	20.7	Starting Point
00+50.00	01+00.00	50	1.5	513.66	513.59	0.14%	512.5	512.5	493.0	1.2	1.2	20.7	
01+00.00	01+50.00	50	1.5	513.59	513.52	0.14%	512.5	512.5	493.0	1.1	1.1	20.6	
01+50.00	02+00.00	50	1.5	513.52	513.46	0.14%	512.5	512.5	493.0	1.0	1.0	20.5	
02+00.00	02+50.00	50	1.5	513.46	513.39	0.14%	512.5	512.5	493.0	1.0	1.0	20.5	
02+50.00	03+00.00	50	1.5	513.39	513.32	0.14%	512.5	512.5	493.0	0.9	0.9	20.4	
03+00.00	03+50.00	50	1.5	513.32	513.25	0.14%	512.5	512.5	493.0	0.8	0.8	20.3	
03+50.00	04+00.00	50	1.5	513.25	513.18	0.14%	512.5	512.5	493.0	0.8	0.8	20.3	
04+00.00	04+50.00	50	1.5	513.18	513.11	0.14%	512.5	512.5	493.0	0.7	0.7	20.2	Pharr Street - Lateral
04+50.00	05+00.00	50	1.5	513.11	513.05	0.14%	512.3	514.0	494.5	0.9	(0.9)	18.6	
05+00.00	05+50.00	50	1.5	513.05	512.98	0.14%	512.0	516.5	496.0	1.0	(3.5)	17.0	
05+50.00	06+00.00	50	1.5	512.98	512.91	0.14%	512.0	517.0	498.5	1.0	(4.0)	14.5	
06+00.00	06+50.00	50	1.5	512.91	512.84	0.14%	512.0	517.0	500.5	0.9	(4.1)	12.4	
06+50.00	07+00.00	50	1.5	512.84	512.77	0.14%	512.0	517.0	502.0	0.8	(4.2)	10.8	
07+00.00	07+50.00	50	1.5	512.77	512.70	0.14%	512.0	516.6	501.3	0.8	(3.8)	11.5	End Pharr Street
07+50.00	08+00.00	50	1.5	512.70	512.63	0.14%	512.0	516.3	500.6	0.7	(3.6)	12.1	
08+00.00	08+50.00	50	1.5	512.63	512.57	0.14%	512.0	516.0	500.0	0.6	(3.4)	12.6	
08+50.00	09+00.00	50	1.5	512.57	512.50	0.14%	512.0	516.4	498.8	0.6	(3.8)	13.8	
09+00.00	09+50.00	50	1.5	512.50	512.43	0.14%	512.0	516.8	497.3	0.5	(4.3)	15.2	
09+50.00	10+00.00	50	1.5	512.43	512.36	0.14%	512.0	517.2	495.8	0.4	(4.8)	16.6	
10+00.00	10+50.00	50	1.5	512.36	512.29	0.14%	512.0	517.5	494.5	0.4	(5.1)	17.9	
10+50.00	11+00.00	50	1.5	512.29	512.22	0.14%	512.0	517.5	495.8	0.3	(5.2)	16.5	
11+00.00	11+50.00	50	1.5	512.22	512.15	0.14%	512.0	517.5	497.3	0.2	(5.3)	14.9	
11+50.00	12+00.00	50	1.5	512.15	512.09	0.14%	512.0	517.5	498.8	0.2	(5.3)	13.4	
12+00.00	12+50.00	50	1.5	512.09	512.02	0.14%	512.0	517.5	500.0	0.1	(5.4)	12.1	
12+50.00	13+00.00	50	1.5	512.02	511.95	0.14%	512.0	519.0	503.0	0.0	(7.0)	9.0	
13+00.00	13+50.00	50	1.5	511.95	511.88	0.14%	512.0	521.5	506.0	(0.1)	(9.6)	5.9	Mid Point Pharr - Mony
13+50.00	14+00.00	50	1.5	511.88	511.81	0.14%	512.0	519.9	504.5	(0.1)	(8.0)	7.4	
14+00.00	14+50.00	50	1.5	511.81	511.74	0.14%	512.0	518.3	503.0	(0.2)	(6.5)	8.8	
14+50.00	15+00.00	50	1.5	511.74	511.68	0.14%	512.0	516.7	501.5	(0.3)	(5.0)	10.2	
15+00.00	15+50.00	50	1.5	511.68	511.61	0.14%	512.0	515.1	500.0	(0.3)	(3.4)	11.7	
15+50.00	16+00.00	50	1.5	511.61	511.54	0.14%	512.0	513.6	498.5	(0.4)	(2.0)	13.1	

16+00.00	16+50.00	50	1.5	511.54	511.47	0.14%	512.0	512.0	497.0	(0.5)	(0.5)	14.5	
16+50.00	17+00.00	50	1.5	511.47	511.40	0.14%	512.0	512.0	497.0	(0.5)	(0.5)	14.5	
17+00.00	17+50.00	50	1.5	511.40	511.33	0.14%	512.0	512.0	497.0	(0.6)	(0.6)	14.4	
17+50.00	18+00.00	50	1.5	511.33	511.26	0.14%	512.0	512.0	497.0	(0.7)	(0.7)	14.3	
18+00.00	18+50.00	50	1.5	511.26	511.20	0.14%	511.8	512.0	497.3	(0.6)	(0.7)	14.0	
18+50.00	19+00.00	50	1.5	511.20	511.13	0.14%	511.6	512.0	497.5	(0.4)	(0.8)	13.7	
19+00.00	19+50.00	50	1.5	511.13	511.06	0.14%	511.5	512.0	497.8	(0.3)	(0.9)	13.3	Mony Street - Lateral
19+50.00	20+00.00	50	1.5	511.06	510.99	0.14%	511.3	512.0	498.1	(0.2)	(0.9)	13.0	
20+00.00	20+50.00	50	1.5	510.99	510.92	0.14%	511.1	512.0	498.4	(0.1)	(1.0)	12.6	
20+50.00	21+00.00	50	1.5	510.92	510.85	0.14%	510.9	512.0	498.6	0.0	(1.1)	12.3	
21+00.00	21+50.00	50	1.5	510.85	510.78	0.14%	510.7	512.0	498.9	0.1	(1.1)	12.0	
21+50.00	22+00.00	50	1.5	510.78	510.72	0.14%	510.6	512.0	499.2	0.2	(1.2)	11.6	
22+00.00	22+50.00	50	1.5	510.72	510.65	0.14%	510.4	512.0	499.4	0.3	(1.3)	11.3	Mid Point Mony - Greenfield
22+50.00	23+00.00	50	1.5	510.65	510.58	0.14%	510.2	512.0	499.7	0.4	(1.4)	10.9	
23+00.00	23+50.00	50	1.5	510.58	510.51	0.14%	510.0	512.0	500.0	0.6	(1.4)	10.6	
23+50.00	24+00.00	50	1.5	510.51	510.44	0.14%	510.0	513.4	501.3	0.5	(2.9)	9.3	
24+00.00	24+50.00	50	1.5	510.44	510.37	0.14%	510.0	514.8	502.5	0.4	(4.3)	7.9	
24+50.00	25+00.00	50	1.5	510.37	510.31	0.14%	510.0	516.1	503.8	0.4	(5.8)	6.6	
25+00.00	25+50.00	50	1.5	510.31	510.24	0.14%	510.0	517.5	505.0	0.3	(7.2)	5.3	Begin Greenfield Ave.
25+50.00	26+00.00	50	1.5	510.24	510.17	0.14%	510.0	517.5	505.0	0.2	(7.3)	5.2	
26+00.00	26+50.00	50	1.5	510.17	510.10	0.14%	510.0	517.5	505.0	0.2	(7.3)	5.2	
26+50.00	27+00.00	50	1.5	510.10	510.03	0.14%	510.0	517.5	505.0	0.1	(7.4)	5.1	
27+00.00	27+25.13	25	1.5	510.03	510.00	0.14%	510.0	517.5	505.0	0.0	(7.5)	5.0	End Point

Station		Distance (LF)	Diameter (FT)	Design		Slope	Ground Level	WL target under trench
Begin	End			Out-Flow	In-Flow			
00+00.00	00+50.00	50	1.5	513.73	513.66	0.14%	522.7	N/A
00+50.00	01+00.00	50	1.5	513.66	513.59	0.14%	522.5	N/A
01+00.00	01+50.00	50	1.5	513.59	513.52	0.14%	522.7	N/A
01+50.00	02+00.00	50	1.5	513.52	513.46	0.14%	522.8	N/A
02+00.00	02+50.00	50	1.5	513.46	513.39	0.14%	523.0	N/A
02+50.00	03+00.00	50	1.5	513.39	513.32	0.14%	523.1	N/A
03+00.00	03+50.00	50	1.5	513.32	513.25	0.14%	523.3	N/A
03+50.00	04+00.00	50	1.5	513.25	513.18	0.14%	523.4	N/A
04+00.00	04+50.00	50	1.5	513.18	513.11	0.14%	523.6	N/A
04+50.00	05+00.00	50	1.5	513.11	513.05	0.14%	523.7	13.7
05+00.00	05+50.00	50	1.5	513.05	512.98	0.14%	523.9	13.9
05+50.00	06+00.00	50	1.5	512.98	512.91	0.14%	524.2	14.3
06+00.00	06+50.00	50	1.5	512.91	512.84	0.14%	522.6	12.8
06+50.00	07+00.00	50	1.5	512.84	512.77	0.14%	521.1	11.3
07+00.00	07+50.00	50	1.5	512.77	512.70	0.14%	519.5	9.8
07+50.00	08+00.00	50	1.5	512.70	512.63	0.14%	519.3	9.7
08+00.00	08+50.00	50	1.5	512.63	512.57	0.14%	519.3	9.7
08+50.00	09+00.00	50	1.5	512.57	512.50	0.14%	519.7	10.2
09+00.00	09+50.00	50	1.5	512.50	512.43	0.14%	520.2	10.7
09+50.00	10+00.00	50	1.5	512.43	512.36	0.14%	520.6	11.2
10+00.00	10+50.00	50	1.5	512.36	512.29	0.14%	521.0	11.7
10+50.00	11+00.00	50	1.5	512.29	512.22	0.14%	521.5	12.2
11+00.00	11+50.00	50	1.5	512.22	512.15	0.14%	521.9	12.7
11+50.00	12+00.00	50	1.5	512.15	512.09	0.14%	522.3	13.2
12+00.00	12+50.00	50	1.5	512.09	512.02	0.14%	523.2	14.2
12+50.00	13+00.00	50	1.5	512.02	511.95	0.14%	523.4	14.4
13+00.00	13+50.00	50	1.5	511.95	511.88	0.14%	523.5	14.6
13+50.00	14+00.00	50	1.5	511.88	511.81	0.14%	523.7	14.9
14+00.00	14+50.00	50	1.5	511.81	511.74	0.14%	523.8	15.1
14+50.00	15+00.00	50	1.5	511.74	511.68	0.14%	524.0	15.3
15+00.00	15+50.00	50	1.5	511.68	511.61	0.14%	524.2	15.6
15+50.00	16+00.00	50	1.5	511.61	511.54	0.14%	524.3	15.8
16+00.00	16+50.00	50	1.5	511.54	511.47	0.14%	524.1	15.7
16+50.00	17+00.00	50	1.5	511.47	511.40	0.14%	524.0	15.6
17+00.00	17+50.00	50	1.5	511.40	511.33	0.14%	523.8	15.5
17+50.00	18+00.00	50	1.5	511.33	511.26	0.14%	523.6	15.4

18+00.00	18+50.00	50	1.5	511.26	511.20	0.14%	523.5	15.3
18+50.00	19+00.00	50	1.5	511.20	511.13	0.14%	523.3	15.2
19+00.00	19+50.00	50	1.5	511.13	511.06	0.14%	523.1	15.0
19+50.00	20+00.00	50	1.5	511.06	510.99	0.14%	523.2	15.2
20+00.00	20+50.00	50	1.5	510.99	510.92	0.14%	523.4	15.5
20+50.00	21+00.00	50	1.5	510.92	510.85	0.14%	523.5	15.7
21+00.00	21+50.00	50	1.5	510.85	510.78	0.14%	523.7	15.9
21+50.00	22+00.00	50	1.5	510.78	510.72	0.14%	523.8	16.1
22+00.00	22+50.00	50	1.5	510.72	510.65	0.14%	523.9	16.3
22+50.00	23+00.00	50	1.5	510.65	510.58	0.14%	524.1	16.5
23+00.00	23+50.00	50	1.5	510.58	510.51	0.14%	524.2	16.7
23+50.00	24+00.00	50	1.5	510.51	510.44	0.14%	524.4	16.9
24+00.00	24+50.00	50	1.5	510.44	510.37	0.14%	524.5	17.1
24+50.00	25+00.00	50	1.5	510.37	510.31	0.14%	524.6	17.3
25+00.00	25+50.00	50	1.5	510.31	510.24	0.14%	524.9	17.7
25+50.00	26+00.00	50	1.5	510.24	510.17	0.14%	524.0	16.9
26+00.00	26+50.00	50	1.5	510.17	510.10	0.14%	523.1	16.0
26+50.00	27+00.00	50	1.5	510.10	510.03	0.14%	522.3	15.2
27+00.00	27+25.13	25	1.5	510.03	510.00	0.14%	521.4	14.4

ANNEX 8.2 – Alignment through Mony St. Analysis

tation		Distance (LF)	Diameter (FT)	Design		Slope	Water Level	Begin Sand	Begin Shale	Out-Flow - WL	Out-Flow -sand	Out-Flow -Shale	Comments
Begin	End			Out-Flow	In-Flow								
00+00.00	00+50.00	50	1.5	513.73	513.63	0.20%	512.5	512.5	493.0	1.2	1.2	20.7	Starting Point
00+50.00	01+00.00	50	1.5	513.63	513.53	0.20%	512.5	512.5	493.0	1.1	1.1	20.6	
01+00.00	01+50.00	50	1.5	513.53	513.43	0.20%	512.5	512.5	493.0	1.0	1.0	20.5	
01+50.00	02+00.00	50	1.5	513.43	513.33	0.20%	512.5	512.5	493.0	0.9	0.9	20.4	
02+00.00	02+50.00	50	1.5	513.33	513.23	0.20%	512.5	512.5	493.0	0.8	0.8	20.3	
02+50.00	03+00.00	50	1.5	513.23	513.13	0.20%	512.5	512.5	493.0	0.7	0.7	20.2	
03+00.00	03+50.00	50	1.5	513.13	513.03	0.20%	512.5	512.5	493.0	0.6	0.6	20.1	
03+50.00	04+00.00	50	1.5	513.03	512.93	0.20%	512.5	512.5	493.0	0.5	0.5	20.0	
04+00.00	04+50.00	50	1.5	512.93	512.83	0.20%	512.5	512.5	493.0	0.4	0.4	19.9	Pharr Street - Lateral
04+50.00	05+00.00	50	1.5	512.83	512.73	0.20%	512.3	514.0	494.5	0.6	(1.2)	18.3	
05+00.00	05+50.00	50	1.5	512.73	512.63	0.20%	512.0	516.5	496.0	0.7	(3.8)	16.7	
05+50.00	06+00.00	50	1.5	512.63	512.53	0.20%	512.0	517.0	498.5	0.6	(4.4)	14.1	
06+00.00	06+50.00	50	1.5	512.53	512.43	0.20%	512.0	517.0	500.5	0.5	(4.5)	12.0	
06+50.00	07+00.00	50	1.5	512.43	512.33	0.20%	512.0	517.0	502.0	0.4	(4.6)	10.4	
07+00.00	07+50.00	50	1.5	512.33	512.23	0.20%	512.0	516.6	501.3	0.3	(4.3)	11.0	End Pharr Street
07+50.00	08+00.00	50	1.5	512.23	512.13	0.20%	512.0	516.3	500.6	0.2	(4.1)	11.6	
08+00.00	08+50.00	50	1.5	512.13	512.03	0.20%	512.0	516.0	500.0	0.1	(3.9)	12.1	
08+50.00	09+00.00	50	1.5	512.03	511.93	0.20%	512.0	516.4	498.8	0.0	(4.4)	13.2	
09+00.00	09+50.00	50	1.5	511.93	511.83	0.20%	512.0	516.8	497.3	(0.1)	(4.9)	14.7	
09+50.00	10+00.00	50	1.5	511.83	511.73	0.20%	512.0	517.2	495.8	(0.2)	(5.4)	16.0	
10+00.00	10+50.00	50	1.5	511.73	511.63	0.20%	512.0	517.5	494.5	(0.3)	(5.8)	17.2	
10+50.00	11+00.00	50	1.5	511.63	511.53	0.20%	512.0	517.5	495.8	(0.4)	(5.9)	15.8	
11+00.00	11+50.00	50	1.5	511.53	511.43	0.20%	512.0	517.5	497.3	(0.5)	(6.0)	14.2	
11+50.00	12+00.00	50	1.5	511.43	511.33	0.20%	512.0	517.5	498.8	(0.6)	(6.1)	12.6	
12+00.00	12+50.00	50	1.5	511.33	511.23	0.20%	512.0	517.5	500.0	(0.7)	(6.2)	11.3	
12+50.00	13+00.00	50	1.5	511.23	511.13	0.20%	512.0	519.0	503.0	(0.8)	(7.8)	8.2	
13+00.00	13+50.00	50	1.5	511.13	511.03	0.20%	512.0	521.5	506.0	(0.9)	(10.4)	5.1	Mid Point Pharr - Mony
13+50.00	14+00.00	50	1.5	511.03	510.93	0.20%	512.0	519.9	504.5	(1.0)	(8.9)	6.5	
14+00.00	14+50.00	50	1.5	510.93	510.83	0.20%	512.0	518.3	503.0	(1.1)	(7.4)	7.9	
14+50.00	15+00.00	50	1.5	510.83	510.73	0.20%	512.0	516.7	501.5	(1.2)	(5.9)	9.3	
15+00.00	15+50.00	50	1.5	510.73	510.63	0.20%	512.0	515.1	500.0	(1.3)	(4.4)	10.7	
15+50.00	16+00.00	50	1.5	510.63	510.53	0.20%	512.0	513.6	498.5	(1.4)	(3.0)	12.1	

16+00.00	16+50.00	50	1.5	510.53	510.43	0.20%	512.0	512.0	497.0	(1.5)	(1.5)	13.5	
16+50.00	17+00.00	50	1.5	510.43	510.33	0.20%	512.0	512.0	497.0	(1.6)	(1.6)	13.4	
17+00.00	17+50.00	50	1.5	510.33	510.23	0.20%	512.0	512.0	497.0	(1.7)	(1.7)	13.3	
17+50.00	18+00.00	50	1.5	510.23	510.13	0.20%	512.0	512.0	497.0	(1.8)	(1.8)	13.2	
18+00.00	18+50.00	50	1.5	510.13	510.03	0.20%	511.8	512.0	497.3	(1.7)	(1.9)	12.9	
18+50.00	19+00.00	50	1.5	510.03	509.93	0.20%	511.6	512.0	497.5	(1.6)	(2.0)	12.5	
19+00.00	19+50.00	50	1.5	509.93	509.83	0.20%	511.5	512.0	497.8	(1.5)	(2.1)	12.1	Mony Street - Lateral
19+50.00	20+00.00	50	1.5	509.83	509.73	0.20%	511.5	512.0	497.8	(1.6)	(2.2)	12.0	
20+00.00	20+50.00	50	1.5	509.73	509.63	0.20%	511.5	512.0	497.8	(1.7)	(2.3)	11.9	
20+50.00	21+00.00	50	1.5	509.63	509.53	0.20%	511.5	512.0	497.8	(1.8)	(2.4)	11.8	
21+00.00	21+50.00	50	1.5	509.53	509.43	0.20%	511.5	512.0	497.8	(1.9)	(2.5)	11.7	
21+50.00	22+00.00	50	1.5	509.43	509.33	0.20%	511.5	512.0	497.8	(2.0)	(2.6)	11.6	
22+00.00	22+50.00	50	1.5	509.33	509.23	0.20%	511.5	512.0	497.8	(2.1)	(2.7)	11.5	Mid Point Mony
22+50.00	23+00.00	50	1.5	509.23	509.13	0.20%	511.5	512.0	497.8	(2.2)	(2.8)	11.4	
23+00.00	23+50.00	50	1.5	509.13	509.03	0.20%	511.5	512.0	497.8	(2.3)	(2.9)	11.3	
23+50.00	24+00.00	50	1.5	509.03	508.93	0.20%	511.5	512.0	497.8	(2.4)	(3.0)	11.2	
24+00.00	24+50.00	50	1.5	508.93	508.83	0.20%	511.5	512.0	497.8	(2.5)	(3.1)	11.1	
24+50.00	25+00.00	50	1.5	508.83	508.73	0.20%	511.5	512.0	497.8	(2.6)	(3.2)	11.0	
25+00.00	25+50.00	50	1.5	508.73	508.63	0.20%	511.5	512.0	497.8	(2.7)	(3.3)	10.9	
25+50.00	26+00.00	50	1.5	508.63	508.53	0.20%	511.5	512.0	497.8	(2.8)	(3.4)	10.8	
26+00.00	26+18.97	19	1.5	508.53	508.4	0.20%	511.5	512.0	497.8	(2.9)	(3.5)	10.7	End Point Mony
00+00.00	00+50.00	50	0.7	513.5	513.29	0.42%	510.0	513.4	501.3	3.5	0.1	12.3	Begin Greenfield
00+50.00	01+00.00	50	0.7	513.29	513.08	0.42%	510.0	512.0	500.0	3.3	1.3	13.3	
01+00.00	01+50.00	50	0.7	513.08	512.87	0.42%	510.2	512.0	499.7	2.9	1.1	13.4	
01+50.00	02+00.00	50	0.7	512.87	512.66	0.42%	510.4	512.0	499.4	2.5	0.9	13.4	
02+00.00	02+50.00	50	0.7	512.66	512.45	0.42%	510.6	512.0	499.2	2.1	0.7	13.5	
02+50.00	03+00.00	50	0.7	512.45	512.24	0.42%	510.7	512.0	498.9	1.7	0.4	13.6	
03+00.00	03+50.00	50	0.7	512.24	512.03	0.42%	510.9	512.0	498.6	1.3	0.2	13.6	
03+50.00	04+00.00	50	0.7	512.03	511.82	0.42%	511.1	512.0	498.4	0.9	0.0	13.7	
04+00.00	04+37.86	38	0.7	511.82	511.66	0.42%	511.3	512.0	498.1	0.5	(0.2)	13.7	Mony Street - Lateral

Station		Distance (LF)	Diameter (FT)	Design		Slope	Ground level	WL target under trench
Begin	End			Out-Flow	In-Flow			
00+00.00	00+50.00	50	1.5	513.73	513.66	0.14%	522.7	N/A
00+50.00	01+00.00	50	1.5	513.66	513.59	0.14%	522.5	N/A
01+00.00	01+50.00	50	1.5	513.59	513.52	0.14%	522.7	N/A
01+50.00	02+00.00	50	1.5	513.52	513.45	0.14%	522.8	N/A
02+00.00	02+50.00	50	1.5	513.45	513.38	0.14%	523.0	N/A
02+50.00	03+00.00	50	1.5	513.38	513.31	0.14%	523.1	N/A
03+00.00	03+50.00	50	1.5	513.31	513.24	0.14%	523.3	N/A
03+50.00	04+00.00	50	1.5	513.24	513.17	0.14%	523.4	N/A
04+00.00	04+50.00	50	1.5	513.17	513.1	0.14%	523.6	N/A
04+50.00	05+00.00	50	1.5	513.1	513.03	0.14%	523.7	13.7
05+00.00	05+50.00	50	1.5	513.03	512.96	0.14%	523.9	13.9
05+50.00	06+00.00	50	1.5	512.96	512.89	0.14%	524.2	14.3
06+00.00	06+50.00	50	1.5	512.89	512.82	0.14%	522.6	12.8
06+50.00	07+00.00	50	1.5	512.82	512.75	0.14%	521.1	11.4
07+00.00	07+50.00	50	1.5	512.75	512.68	0.14%	519.5	9.8
07+50.00	08+00.00	50	1.5	512.68	512.61	0.14%	519.3	9.7
08+00.00	08+50.00	50	1.5	512.61	512.54	0.14%	519.3	9.8
08+50.00	09+00.00	50	1.5	512.54	512.47	0.14%	519.7	10.2
09+00.00	09+50.00	50	1.5	512.47	512.4	0.14%	520.2	10.8
09+50.00	10+00.00	50	1.5	512.4	512.33	0.14%	520.6	11.3
10+00.00	10+50.00	50	1.5	512.33	512.26	0.14%	521.0	11.7
10+50.00	11+00.00	50	1.5	512.26	512.19	0.14%	521.5	12.3
11+00.00	11+50.00	50	1.5	512.19	512.12	0.14%	521.9	12.8
11+50.00	12+00.00	50	1.5	512.12	512.05	0.14%	522.3	13.3
12+00.00	12+50.00	50	1.5	512.05	511.98	0.14%	523.2	14.2
12+50.00	13+00.00	50	1.5	511.98	511.91	0.14%	523.4	14.5
13+00.00	13+50.00	50	1.5	511.91	511.84	0.14%	523.5	14.7
13+50.00	14+00.00	50	1.5	511.84	511.77	0.14%	523.7	14.9
14+00.00	14+50.00	50	1.5	511.77	511.7	0.14%	523.8	15.1
14+50.00	15+00.00	50	1.5	511.7	511.63	0.14%	524.0	15.4
15+00.00	15+50.00	50	1.5	511.63	511.56	0.14%	524.2	15.6
15+50.00	16+00.00	50	1.5	511.56	511.49	0.14%	524.3	15.8
16+00.00	16+50.00	50	1.5	511.49	511.42	0.14%	524.1	15.7
16+50.00	17+00.00	50	1.5	511.42	511.35	0.14%	524.0	15.7
17+00.00	17+50.00	50	1.5	511.35	511.28	0.14%	523.8	15.5

17+50.00	18+00.00	50	1.5	511.28	511.21	0.14%	523.6	15.4
18+00.00	18+50.00	50	1.5	511.21	511.14	0.14%	523.5	15.4
18+50.00	19+00.00	50	1.5	511.14	511.07	0.14%	523.3	15.2
19+00.00	19+50.00	50	1.5	511.07	511	0.14%	523.1	15.1
19+50.00	20+00.00	50	1.5	511	510.93	0.14%	522.7	14.8
20+00.00	20+50.00	50	1.5	510.93	510.86	0.14%	522.3	14.5
20+50.00	21+00.00	50	1.5	510.86	510.79	0.14%	522.0	14.2
21+00.00	21+50.00	50	1.5	510.79	510.72	0.14%	521.6	13.8
21+50.00	22+00.00	50	1.5	510.72	510.65	0.14%	521.2	13.5
22+00.00	22+50.00	50	1.5	510.65	510.58	0.14%	520.8	13.2
22+50.00	23+00.00	50	1.5	510.58	510.51	0.14%	520.4	12.9
23+00.00	23+50.00	50	1.5	510.51	510.44	0.14%	520.0	12.6
23+50.00	24+00.00	50	1.5	510.44	510.37	0.14%	519.6	12.2
24+00.00	24+50.00	50	1.5	510.37	510.3	0.14%	519.2	11.9
24+50.00	25+00.00	50	1.5	510.3	510.23	0.14%	518.8	11.6
25+00.00	25+50.00	50	1.5	510.23	510.16	0.14%	518.4	11.3
25+50.00	26+00.00	50	1.5	510.16	510.09	0.14%	518.1	11.0
26+00.00	26+18.97	19	1.5	510.09	510.06	0.14%	517.3	10.2
00+00.00	00+50.00	50	0.7	513.5	513.29	0.42%	524.9	14.6
00+50.00	01+00.00	50	0.7	513.29	513.08	0.42%	524.7	N/A
01+00.00	01+50.00	50	0.7	513.08	512.87	0.42%	524.5	N/A
01+50.00	02+00.00	50	0.7	512.87	512.66	0.42%	524.3	N/A
02+00.00	02+50.00	50	0.7	512.66	512.45	0.42%	524.1	N/A
02+50.00	03+00.00	50	0.7	512.45	512.24	0.42%	523.9	N/A
03+00.00	03+50.00	50	0.7	512.24	512.03	0.42%	523.7	N/A
03+50.00	04+00.00	50	0.7	512.03	511.82	0.42%	523.5	14.7
04+00.00	04+37.86	38	0.7	511.82	511.66	0.42%	523.3	14.6

Appendix No. 9:

Structural Analysis

INDEX - APPENDIX NO. 9: STRUCTURAL ANALYSIS

INDEX - FIGURE AND TABLE

9. Structural Analysis

Usually, a sewer line installation has no need of any structural component to be installed. In our case instead, due to the loose silty sands in the area, the possibility of the proposed manholes to sink is high. Therefore this paper proposes to install a drill shaft foundation beneath every manholes that must be set in the sand strata. Such foundation will set as a support and won't be connected to the manholes in order to comply with city specifications, otherwise the city may not agree on such design. To avoid a possible displacement laterally, a concrete pad with curb will be constructed on top of the foundation once the manhole is installed.

9.1. Manhole support design

To design the drill shafts beneath the manholes, the publication No. FHWA-NHI-10-016 (May 2010) from the U.S. Department of Transportation Federal Highway Administration (Drilled Shafts: Construction procedures and Load and Resistance Factor Design (LRFD) Design Methods) was used.

Such publication has been developed following:

- AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007 with 2088 and 2009 Interims.

9.1.1. AASHTO Limit States and Load Combinations

The AASHTO Specifications (AASHTO, 2007), Article 3.4, identify twelve potential limit states that may require evaluation for design of a bridge. As summarized in Table 1, these include five limit states pertaining to strength, two pertaining to extreme events, four pertaining to serviceability, and one pertaining to fatigue. A unique combination of loads is specified for each of the twelve limit states. A general description of each load combination is given in

Table 1, and the specific loads included in each category along with applicable load factors are presented in Table 2.

The most common limit states for which drilled shaft foundations are designed include: Strength I, Strength IV, Extreme Event I (earthquake), Extreme Event II (ice, vessel and vehicle collision), and Service I. Although in our case we will only use Limit state Strength I.

Limit State Type	Case	Load Combination
Strength	I	Normal vehicular use of the bridge without wind
	II	Use of the bridge by Owner-specified special vehicles, evaluation permit vehicles, or both, without wind
	III	Bridge exposed to wind velocity exceeding 55 mph
	IV	Very high dead load to live load force effect ratios
	V	Normal vehicular use of the bridge with wind of 55 mph
Extreme Event	I	Load combination including earthquake
	II	Ice load, collision by vessels and vehicles, and certain hydraulic events with a reduced live load other than that which is part of the vehicular Collision load, *CT*
Service	I	I Normal operational use of the bridge with a 55 mph wind and all loads taken at their nominal values
	II	Intended to control yielding of steel structures and slip of slip-critical connections due to vehicular live load
	III	Longitudinal analysis relating to tension in prestressed concrete superstructures with the objective of crack control and to principal tension in the webs of segmental concrete girders
	IV	Tension in prestressed concrete columns with the objective of crack control
Fatigue		Repetitive gravitational vehicular live load and dynamic responses under the effects of a single design truck

Table 1. AASHTO (2007) Limit states for bridge design.

For drilled shafts, the reactions are resolved into vertical, horizontal, and moment components, and these are taken as the factored values of axial, lateral, and moment force effects, respectively.

Load Combination Limit State	*PL*	*LL*	*WA*	*WS*	*W;*	*FR*	*TCS*	*TG*	*SE*	*EQ**	*IC**	*CT**	*CV**
Strength I	1.30	1.75	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-
Strength I	γ_p	1.35	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-
Strength I	γ_p	-	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-
Strength I	γ_p	-	1.00	-	-	1.00	0.50/1.20	-	-	-	-	-	-
Strength I	γ_p	1.35	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-
Extreme Event I	γ_p	γ_{EQ}	1.00	-	-	1.00	-	-	-	1.00	-	-	-
Extreme Event I	γ_p	0.50	1.00	-	-	1.00	-	-	-	-	1.00	1.00	1.00
Service I	1.00	1.00	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-
Service II	1.00	1.30	1.00	-	-	1.00	0.50/1.20	-	-	-	-	-	-
Service II	1.00	0.80	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-
Service II	1.00	-	1.00	-	-	1.00	0.50/1.20	-	1.00	-	-	-	-
Fatigue	-	0.75	-	-	-	-	-	-	-	-	-	-	-

Table 2. Load combinations and load factors (After AASHTO 2007, Table 3.4.1-1) (*Use one of these at a time)

Where;

- PL permanent load
- LL live load
- WA water load and stream pressure
- WS wind load on structure
- WL wind on live load
- FR friction
- TG temperature gradient
- SE settlement
- EQ earthquake
- IC ice load
- CT vehicular collision force
- CV vessel collision force

In our case, we will only consider axial reaction as for underground structures centered in the center of the manhole, no moment or lateral reaction should take place. Multiple iterations are often performed in order to obtain agreement between deformations and forces at the structure/foundation interface as calculated by the structural analysis and those based on geotechnical analysis.

The load for the manholes foundations will be the following:

- Dimension of the Manhole:
  - Outer diameter: 5.33'
  - Inner diameter: 4'
  - Height (Variable): i.e. 15'
- Weight
  - Concrete: 150 lb/ft^3
  - Water: 62.43 lb/ft^3
- Dead Load (DL)
  - Concrete Structure + MH full of water
    - Concrete Structure: 29,648.78 lb
    - Water: 27,534.42 lb
- Live Load (LL)
  - As per AASHTO 3.7.3 and 3.7.6A, a moving truck on top of the manholes will weight: 32,000 lb

- LOAD on footing (Strength I)
  - 1.3DL + 1.75LL = 130,338.16 lb (or 130.34 K [Kips], common weight in US customary units)

9.1.2. Design for Axial Load Procedure

9.1.2.1. At each foundation location, divide the subsurface into a finite number of geomaterial layers; assign one of the following geomaterial types to each layer:

- Cohesionless soil
- Cohesive soil
- Rock
- Cohesive Intermediate Geomaterial

9.1.2.2. Review the strength and service limit states to be satisfied and the corresponding axial load combinations and load factors for each foundation.

9.1.2.3. For each geomaterial layer established in Step 9.1.2.1. and for each limit state identified in Step 9.1.2.2., assign the appropriate geomaterial properties needed for evaluation of axial resistances. Identify the loading mode(s) to be analyzed for each geomaterial layer, i.e., fully-drained or undrained.

9.1.2.4. For each drilled shaft, select trial lengths and diameters for initial analyses.

9.1.2.5. Compute values of nominal unit side resistance for all geomaterial layers through which the trial shaft extends and the nominal unit base resistance at the trial tip elevation.

9.1.2.6. Select appropriate resistance factors. Iterating from Step 9.1.2.4. as necessary, adjust the trial design to satisfy the following LRFD requirement for each strength limit state (Equation 1-1):

$$\sum \eta_i \gamma_i F_i \leq \sum \varphi_i R_i$$

Equation 1-1 can be stated as: the summation of factored axial loads may not exceed the summation of factored axial resistances. As the reader can note, the first part of the equation is well explained at the end of paragraph 9.1.1. In consequence, only the second part is missing and must be found.

9.1.2.7. Conduct load-deformation analysis for each trial design and iterate from Step 9.1.2.4. as necessary to satisfy the LRFD requirement for each service limit state. Service limit state evaluation for axial loading requires analysis of side and bases resistances that are mobilized at axial displacement corresponding to the tolerable deformation established for the structure being designed.

The picture below represents an idealized geomaterial layering for computation of compression resistances. Layer one would be our clay strata, layer 2 the silty sandy and finally layer 3, our shale rock where the drill shaft must be embedded to ensure the efficiency and long-term functionality of such foundations.

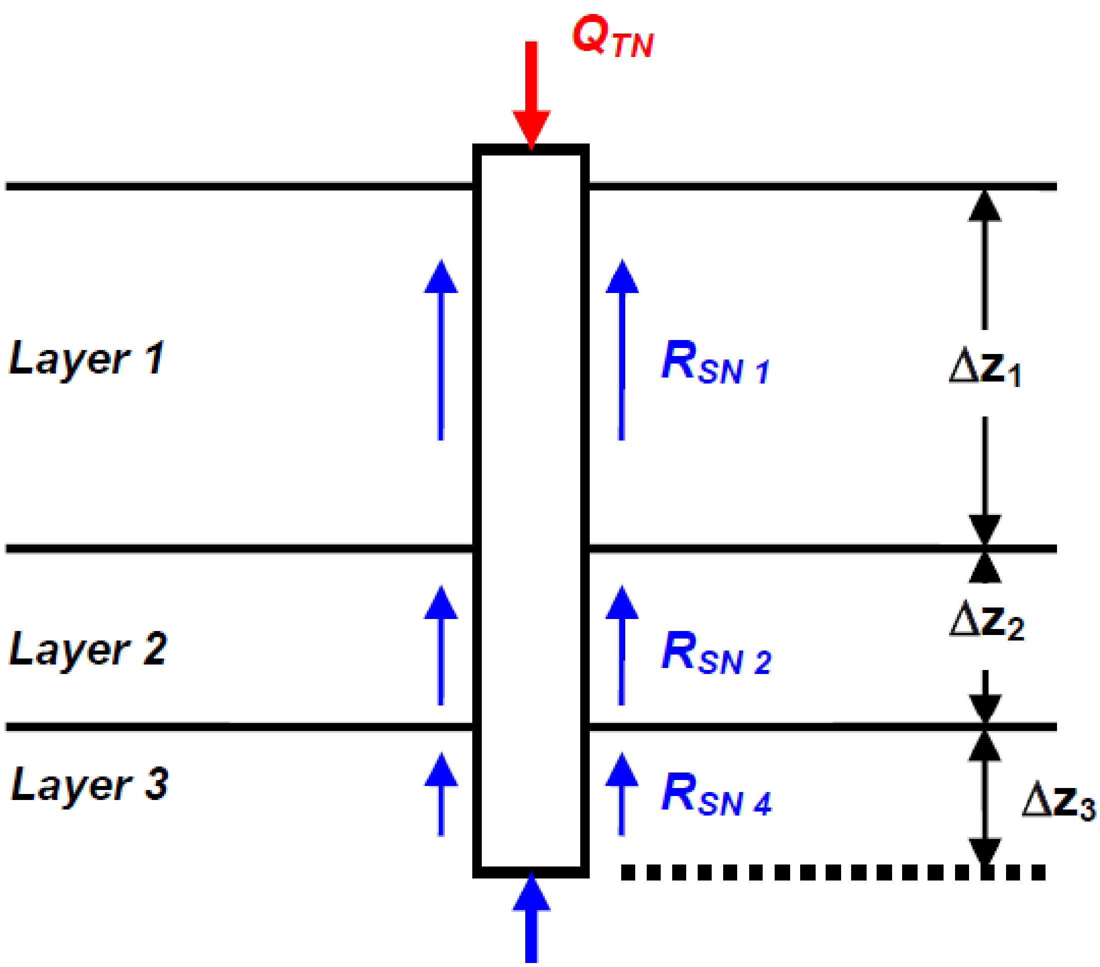


Figure 1. Idealized Geomaterial Layering for Computation of Compression Resistances

9.1.3. Nominal Side and Base Resistances Calculation

The calculation of the geotechnical resistances for axial compression loads. The methods presented herein were selected to be consistent with those presented in Article 10.8 of the 2007 AASHTO LRFD Bridge Design Specifications.

Considering the two components of resistance for axial compression loading (side and base), the summation of factored resistances (right side of Equation 1-1) for evaluation of LRFD strength limit states is given by (Equation 1-2):

$$\sum \varphi_i R_i = \sum_{i=1}^{n} \varphi_{S,i} R_{SN,i} + \varphi_B R_{BN}$$

Where;

- $R_{SN,i}$ = nominal side resistance for layer i,
- $\varphi_{S,i}$ = resistance factor for side resistance in layer i,
- n = number of layers providing side resistance,
- R_{BN} = nominal base resistance, and
- φ_B = resistance factor for base resistance.

Nominal side resistance for a specific geomaterial layer is the product of the nominal unit side resistance (f_{SN}) and the cylindrical surface area over which side resistance develops, expressed as the product of the layer thickness (Δz_i) and the shaft circumference, or (Equation 1-3):

$$R_{SN} = \pi B \Delta z_i f_{SN}$$

Where;

- B = shaft diameter,
- Δz_i = thickness of layer i, and

- f_{SN} = nominal unit side resistance.

Nominal unit side resistance is evaluated in terms of effective stress for cohesionless soil layers. Nominal unit side resistance in cohesive soil layers and cohesive IGMs is evaluated in terms of total stress for end-of-construction (undrained) conditions. If the long-term (fully-drained) side resistance in cohesive soil is deemed to be important, effective stress analysis should be conducted. Nominal unit side resistance in rock is evaluated in terms of uniaxial compressive strength.

Nominal base resistance is the product of the nominal unit base resistance (q_{BN}) and the cross-sectional area of bearing at the shaft base (Abase), or (Equation 1-4):

$$R_{BN} = \frac{\pi B^2}{4} q_{BN}$$

9.1.4. Clay Layer (Cohesive Soil) – Side Resistance (Alpha Method)

Short-term undrained side resistance in cohesive soil layers is evaluated in terms of undrained shear strength. Equation 1-3 then becomes (Equation 2-1):

$$R_{SN} = \pi B \Delta z f_{SN} = \pi B \Delta z (\alpha s_u)_i$$

Where;

- R_{SN} = nominal side resistance,
- B = shaft diameter,
- Δz = thickness of the soil layer over which resistance is calculated,
- s_u = average undrained shear strength over the depth interval Δz,
- α = coefficient relating unit side resistance to undrained shear strength (hence the term "alpha method"), and
- f_{SN} = nominal unit side resistance.

Key terms to evaluate in Equation 13-15 are the mean undrained shear strength of the cohesive soil layer and the coefficient α.

Evaluation of α is as follows:

α = 0 between the ground surface and a depth of 5 ft or to the depth of seasonal moisture change, whichever is greater

α = 0.55 along remaining portions of the shaft for $\frac{s_u}{p_a} \leq 1.5$

α = 0.55 – $0.1\left(\frac{s_u}{p_a} - 1.5\right)$ along remaining portions of the shaft for $1.5 \leq \frac{s_u}{p_a} \leq 2.5$

α = 0.45 along remaining portions of the shaft for $2.5 \leq \frac{s_u}{p_a}$

p_a = atmospheric pressure in the same units as s_u (2,116 psf or 14.7 psi in U.S. customary units).

The resistance factor for application to the side resistance calculated using the α-method as presented above is φ = 0.45. The basis of this recommendation (Allen, 2005) is a combination of fitting to the ASD factor of safety (FS = 2.5) and taking into account the reliability-based analysis conducted by Paikowsky et al. (2004).

The practice of neglecting side resistance over the top 5 feet or depth of seasonal moisture change accounts for the potential loss of side resistance as soil expands and contracts in response to wetting and drying, freezing and thawing, "gapping" caused by cyclic lateral loading, or any process occurring near the ground surface having the potential to soften the soil or eliminate contact between the shaft and soil.

9.1.5. Sand Layer (Cohesionless Soil) – Side Resistance (Beta Method)

The nominal side resistance of a drilled shaft in cohesionless soil can be expressed as the frictional resistance that develops over a cylindrical shear surface defined by the soil-shaft interface. As illustrated in Figure 2, the unit side resistance is directly proportional to the normal stress acting on the interface.

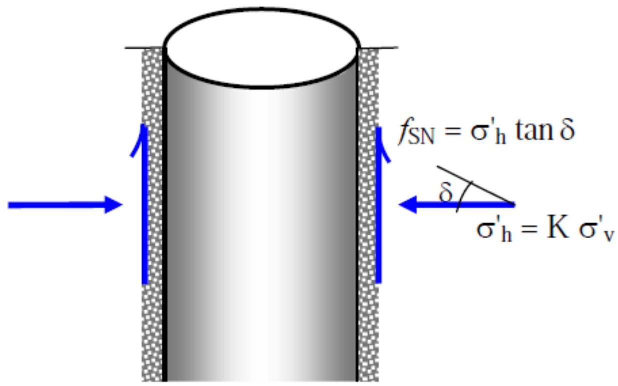


Figure 2. Frictional Model of Unit Side Resistance, Drilled Shaft in Cohesionless Soil.

By Equation 1-3, nominal side resistance is then given by equation 3-1:

$$R_{SN} = \pi B \Delta z f_{SN} = \pi B \Delta z (\sigma'_v K\ tan\delta)$$

Where;

- R_{SN} = nominal side resistance
- B = shaft diameter
- Δz = thickness of the soil layer over which resistance is calculated
- σ'_v = average vertical effective stress over the depth interval Δz
- K = coefficient of horizontal soil stress ($K = \sigma'_h / \sigma'_v$)
- σ'_h = horizontal effective stress
- δ = effective stress angle of friction for the soil-shaft interface

For convenience, the following terms may be combined (Equation 3-2):

$$\beta = K\ tan\delta$$

And (Equation 3-3)

$$f_{SN} = \sigma'_v\ \beta$$

in which β = side resistance coefficient (hence the term "beta method") and f_{SN} = nominal unit side resistance. Several design models have been proposed for evaluating the β term in Equation 3-3. The approach currently recommended in AASHTO (2007) is the "O'Neill and Reese (1999)" method.

In this approach, β is calculated solely as a function of depth below the ground surface, without explicit consideration of soil strength or the in-situ state of stress.

The operative value of K, coefficient of horizontal soil stress, is a function of the in-situ (at-rest) value, K_o, and changes in horizontal stress that occur in response to drilled shaft construction, given by the ratio K/K_o. K_o can be obtained using the equation below (Equation 3-4 and 3-5)

$$K_0 = (1 - sin\varphi')OCR^{sin\varphi'} \leq K_p$$

$$OCR = \frac{\sigma'_p}{\sigma'_v}$$

where σ'_p = effective vertical pre consolidation stress. Note that the value of K_o as given by Equation 13-8 is limited to an upper-bound value corresponding to the coefficient of passive earth pressure, which, for a cohesionless soil, is given by (Equation 3-6):

$$K_p = tan^2\left(45^0 + \frac{\varphi'}{2}\right)$$

A variety of methods have been proposed for evaluation of either K_o or σ'_p by correlations with in-situ test results. For a practical estimate based on the most commonly used in-situ test (SPT) the following correlation is suggested by Mayne (2007) and is the one we will be using on this paper (Equation 3-7):

$$\frac{\sigma'_p}{p_a} \approx 0.47(N_{60})^m$$

where m = 0.6 for clean quartzitic sands and m = 0.8 for silty sands to sandy silts (e.g., Piedmont residual soils), and pa = atmospheric pressure in the same units as σ'p (for example, 2,116 psf).

Substituting Equations 3-5 through 3-7 into Equation 3-2 leads to the following approximation of β for cohesionless soils (Equation 3-8):

$$\beta \approx (1 - sin\varphi')\left(\frac{\sigma'_p}{\sigma'_v}\right)^{sin\varphi'} tan\varphi' \leq K_p tan\varphi'$$

Calibration to allowable stress design (ASD) using a factor of safety of FS = 2.5 yields a resistance factor for side resistance in cohesionless soils of φ_S = 0.55.

9.1.6. *Rock Layer – Side Resistance*

Unit side resistance for shafts in rock may be evaluated on the basis of mean uniaxial compressive strength of the rock, as follows (Equation 4-1):

$$\frac{f_{SN}}{p_a} = C\sqrt{\frac{q_u}{p_a}}$$

in which q_u = mean value of uniaxial compressive strength for the rock layer, p_a = atmospheric pressure in the same units as q_u, and C = a regression coefficient used to analyze load test results. Studies relating side resistance to rock compressive strength include those of Horvath and Kenney (1979), Rowe and Armitage (1987), Kulhawy and Phoon (1993), and others. The most recent regression analysis of available load test data is reported by Kulhawy et al. (2005) and demonstrates that the mean value of the coefficient C is approximately equal to 1.0.

9.1.7. Rock Layer – Base Resistance

Base resistance in rock is more complex than in soil because of the wide range of possible rock mass conditions. Various failure modes are possible depending upon whether rock mass strength is governed by intact rock, fractured rock mass, or structurally controlled by shearing along dominant discontinuity surfaces. In practice, it is common to have information on the uniaxial compressive strength of intact rock (q_u) and the general condition of rock at the base of a shaft. Empirical relationships between nominal unit base resistance (q_{BN}) and rock compressive strength can be expressed in the form (Equation 5-1):

$$q_{BN} = N^*{}_{cr} q_u$$

where N^*_{cr} is an empirical bearing capacity factor for rock. The value of N^*_{cr} = 2.5 is recommended for design when q_u is the sole parameter used for establishing q_{BN} and the following conditions are met:

- The drilled shaft base is bearing on rock which is either massive or tightly jointed (no compressible seams or joints) to a depth of at least one diameter beneath the base,
- It can be verified that no solution cavities or voids exist beneath the base, and
- A clean base can be achieved and verified using conventional clean-out equipment.

The parameter q_u can be correlated to the SPT test with the following formula (equation 5-2) expressed in pounds per square foot:

$$q_u = 0.19 \cdot M' \cdot 1000$$

The LRFD resistance factor specified in AASHTO (2007) for use of Equation 5-1 with N^*_{cr} = 2.5 is φ = 0.55, based on fitting to an ASD factor of safety FS = 2.5.

9.1.8. *Uplift Resistance*

Resistance to uplift may develop at the base of a drilled shaft, as negative porewater pressure (suction) develops in response to the void created between the base of the shaft and underlying ground. In cohesionless soils, any suction would dissipate rapidly, but in cohesive soils (clay), tip suction could be substantial under short-term undrained loading.

drilled shaft loaded in uplift is resisted by the weight of the shaft and the side resistance that develops over the cylindrical surface at the interface between the concrete shaft and the geomaterial layers along the sides.

AASHTO Specifications (2007) require the "uplift resistance of a single straight-sided drilled shaft to be estimated in a manner similar to that for determining side resistance for drilled shafts in compression". Therefore, nominal unit side resistances are computed by the same methods presented in Section 13.3.5 for axial compression loading.

In the current LRFD specifications (AASHTO, 2007) this issue is addressed by applying lower resistance factors to the computed nominal side resistances for uplift than for compression. The recommended resistance factors are 0.10 less than those for compression, as described by Allen (2005).

For design purposes the weight of the drilled shaft is treated as a (negative) force effect on the left side of Equation 6-1, rather than as a component of resistance. Accordingly, resistance to axial uplift loading consists only of side resistance and evaluation of the LRFD strength limit state is given by (Equation 6-1):

$$\sum \varphi_i R_i = \sum_{i=1}^{n} \varphi_{S,i} R_{SN,i}$$

The trial design is then evaluated for each applicable strength limit state, using the general form of the LRFD equation 6-2:

$$\sum \eta_i \gamma_i F_i \leq \sum \varphi_i R_i$$

where the term on the left-hand side of Equation 13-1 represents the summation of factored uplift force effects, including the buoyant weight of the drilled shaft, and the term on the right-hand side represents the summation of factored resistances.

9.2. Greenfield Avenue Alternative Drill shaft summary

As per TCEQ regulations an owner must include manholes in a wastewater collection system at:

(1) all points of change in alignment, grade, or size;

(2) at the intersection of all pipes; and

(3) at the end of all pipes that may be extended at a future date.

Also, Manholes may be spaced no further apart than the distances specified in the following table for a wastewater collection system with straight alignment and uniform grades, unless a variance based on the availability of cleaning equipment that is capable of servicing greater distances is granted by the executive director.

Pipe Diameter **(inches)**	Maximum Manhole Spacing **(feet)**
6-15	500
18-30	800
36-48	1000
54 or larger	2000

Table 3. Maximum Manhole Spacing.

For this project we will stick on the 500 feet maximum distance between manholes due to the slight curvature of the line along the south bound frontage road. It makes theoretical points where there is a change on the alignment and the city will ask for such extra manholes.

9.2.1. Drill shaft length summary (Greenfield)

SEWER SYSTEM ESTIMATED D.S. LENGTH					
MH No.	MH STATION	D.S. DIAMETER (in)	D.S. LENGTH (FT)	MH LENGTH (FT)	TOTAL LENGTH (FT)
1	3+81.46	24”	24.18	9.22	33.40
2	4+16.35	24”	24.11	9.44	33.55
3	4+48.89	24”	22.55	9.65	32.20
4	7+06.03	36”	15.4	5.80	21.20
5	11+00.00	36”	18.85	8.73	27.58
6	15+00.00	36”	18.11	11.55	29.66
7	19+07.20	36”	19.25	11.04	30.29
8	22+00.00	36”	15.22	12.39	27.51
9	24+94.59	36”	9.24	13.66	22.90
10	25+60.55	36”	9.17	12.85	22.02

Table 4. (Greenfield) Sewer System estimated D.S. length.

Notes:

- Bottom of the drilled shaft shall be a minimum of 3 feet into rock (Shale) material.
- Top of the drilled shaft to be perfectly level, for the placement of manholes on top of drilled shafts.
- Drilled shafts construction per project specification.
- Concrete shall be class C – 3600PSI
- Drilled shafts must have minimal reinforcing steel to comply with TxDOT specifications (8 - #7 and #3 Spiral at 6” pitch).
- Drilled shaft reinforcing bars (Vertical) shall stop 2” from top of drilled shaft surface.

9.3. Mony Street Alternative Drill shaft summary

This case is really similar to the previous one but the frequency of drilled shafts at Mony street is higher because the terrain is the most unstable one and they are spaced at an average distance of 200 feet. This shorter distance, added to the dewatering will lead to be able to set the sewer pipe at grade without settling.

9.3.1. Drill shaft length summary (Mony)

SEWER SYSTEM ESTIMATED D.S. LENGTH

MH No.	MH STATION	D.S. DIAMETER (in)	D.S. LENGTH (FT)	MH LENGTH (FT)	TOTAL LENGTH (FT)
1	3+78.46	24”	24.17	9.23	33.40
2	4+16.35	24”	24.10	9.50	33.60
3	4+48.89	24”	22.53	9.67	32.20
4	7+05.93	24”	16.38	5.82	22.20
5	11+00.00	24”	20.82	8.78	29.60
6	15+00.00	36”	17.06	11.64	28.70
7	19+00.00	36”	19.69	11.12	30.81
8	20+00.00	36”	19.05	10.48	29.53
9	21+93.29	36”	18.77	9.20	27.97
10	23+59.21	36”	18.06	8.24	26.30
11	1+00 (LAT)	36”	17.17	10.63	27.80

Table 5. (Mony) Sewer System estimated D.S. length.

Notes:

- Bottom of the drilled shaft shall be a minimum of 3 feet into rock (Shale) material.
- Top of the drilled shaft to be perfectly level, for the placement of manholes on top of drilled shafts.
- Drilled shafts construction per project specification.
- Concrete shall be class C – 3600PSI

- Drilled shafts must have minimal reinforcing steel to comply with TxDOT specifications (8 - #7 and #3 Spiral at 6" pitch).
- Drilled shaft reinforcing bars (Vertical) shall stop 2" from top of drilled shaft surface.

9.4. Drill Shafts Comparative

GREENFIELD AVENUE ALTERNATIVE								
D.S. LENGTH (FT)	**MH LENGTH (FT)**	**Price DS 24"**	**Price DS 36"**	**Price DS – no Concrete**	**Cost A**	**Mob**	**Cost B**	**Total**
24.18	9.2	$161.62	$167.73	($85.00)	$5,394.88	$4,500.00	($782.00)	$9,112.88
24.11	9.4	$161.62	$167.73	($85.00)	$5,415.89	$4,500.00	($799.00)	$9,116.89
22.55	9.7	$161.62	$167.73	($85.00)	$5,212.25	$4,500.00	($824.50)	$8,887.75
15.4	5.8	$161.62	$167.73	($85.00)	$3,555.88	$4,500.00	($493.00)	$7,562.88
18.85	8.7	$161.62	$167.73	($85.00)	$4,620.96	$4,500.00	($739.50)	$8,381.46
18.11	11.6	$161.62	$167.73	($85.00)	$4,983.26	$4,500.00	($986.00)	$8,497.26
19.25	11	$161.62	$167.73	($85.00)	$5,073.83	$4,500.00	($935.00)	$8,638.83
15.22	12.3	$161.62	$167.73	($85.00)	$4,615.93	$4,500.00	($1,045.50)	$8,070.43
9.24	13.7	$161.62	$167.73	($85.00)	$3,847.73	$4,500.00	($1,164.50)	$7,183.23
9.17	12.9	$161.62	$167.73	($85.00)	$3,701.80	$4,500.00	($1,096.50)	$7,105.30
					TOTAL Greenfield Alt.			$82,556.89

Table 6. Greenfield Avenue Alternative D.S. Cost.

MONY STREET ALTERNATIVE								
D.S. LENGTH (FT)	**MH LENGTH (FT)**	**Price DS 24"**	**Price DS 36"**	**Price DS – no Concrete**	**Cost A**	**Mob**	**Cost B**	**Total**
24.17	9.2	$161.62	$167.73	($85.00)	$5,393.26	$4,500.00	($782.00)	$9,111.26
24.1	9.5	$161.62	$167.73	($85.00)	$5,430.43	$4,500.00	($807.50)	$9,122.93
22.53	9.7	$161.62	$167.73	($85.00)	$5,209.01	$4,500.00	($824.50)	$8,884.51
16.38	5.8	$161.62	$167.73	($85.00)	$3,584.73	$4,500.00	($493.00)	$7,591.73
20.82	8.8	$161.62	$167.73	($85.00)	$4,968.16	$4,500.00	($748.00)	$8,720.16
17.06	11.6	$161.62	$167.73	($85.00)	$4,807.14	$4,500.00	($986.00)	$8,321.14
19.69	11	$161.62	$167.73	($85.00)	$5,147.63	$4,500.00	($935.00)	$8,712.63
19.05	10.5	$161.62	$167.73	($85.00)	$4,956.42	$4,500.00	($892.50)	$8,563.92
18.77	9.2	$161.62	$167.73	($85.00)	$4,691.41	$4,500.00	($782.00)	$8,409.41
18.06	8.2	$161.62	$167.73	($85.00)	$4,404.59	$4,500.00	($697.00)	$8,207.59
17.17	10.6	$161.62	$167.73	($85.00)	$4,657.86	$4,500.00	($901.00)	$8,256.86
					TOTAL Mony Alt.			$93,902.16

Table 7. Mony Street Alternative D.S. Cost.

Concrete prices in Texas as back charge to drilling companies average low bid of $85 per linear feet.

As we can appreciate on the tables above, Greenfield alternative is $11,345.26 cheaper than Mony alternative. Also, this last one has less drill shafts to be performed on the street than the first one.

A usual mobilization cost for this kind of contractor rounds up to $4,500.00 but as long as the NT3A Project stills building bridges, obtaining a contractor on site will lead to a cheaper prices. Although a mobilization per drilled shaft can be charged because of the distance between every shaft. The pace of this machine will be one drilled shaft per day. Maybe the first 3 that are at Pharr street grouped could be done in a day but this price is conservative and acceptable.

ANNEX 9.1 – Greenfield Avenue Drill Shaft Report

MANHOLE SUPPORT

Design Load (Cast in place MH)

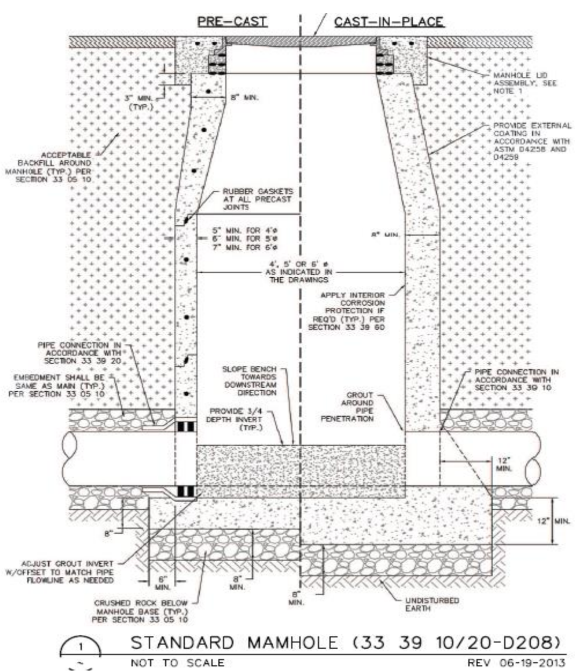
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	9.2	FT	8.2	FT	
Weight (Wc)	150.0	PCF	15.4	K	(kips)
Filled Water	62.4	PCF	11.5	K	(kips)

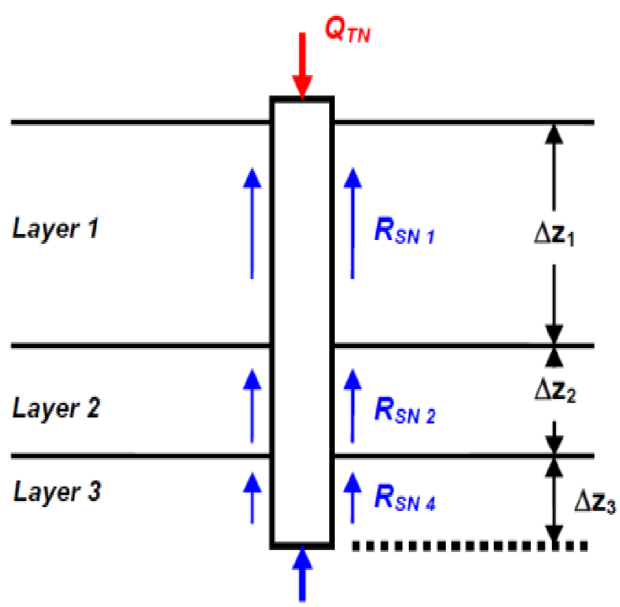
DL	Dead Load	26.87	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	90.93	K	(kips)





INITIAL DATA

Initial Sta. =	3+81.46	
Final Sta. =	3+81.46	
Ground elev. =	523.40	
Sand Strata elev. =	512.50	
Shale Strata elev. =	493.00	
Water elevation =	512.50	
Bottom trench =	514.18	

PARAMETERS

D.S. Length =	24.18	LF
D.S. Diameter =	2	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	12	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	10.9	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0	LF
H'w (sand + w) =	19.5	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 119.23 K
Total vertical Load on shaft
P = 90.93 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 81.23
Weight of the Shaft
P = 14.81

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.4637051	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	2318.52552	psf
R_Unit_clay =	2.31852552	KSF
Nominal side Resistance Clay		
Rs_clay =	11.0132005	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2821	
σ'p =	7260.36606	
OCR =	2.57368524	
Ko=	0.86093679	
β =	0.40146142	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	1132.52266	psf
R_Unit_sand =	1.13252266	KSF
Nominal side Resistance Sand		
Rs_Sand =	76.3174885	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	12.26	K

Rock (Shale) - Base Resistance (Layer 3)

N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	19.63	K

MANHOLE SUPPORT

Design Load (Cast in place MH)

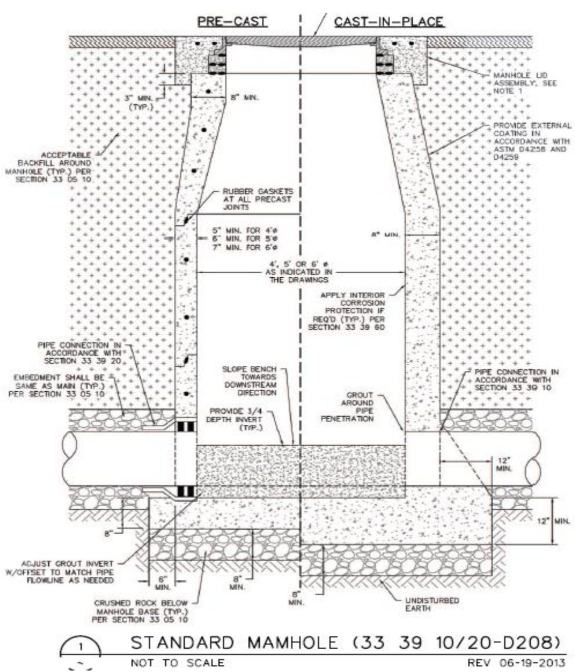
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	9.4	FT	8.4	FT	
Weight (Wc)	150.0	PCF	15.7	K	(kips)
Filled Water	62.4	PCF	11.8	K	(kips)

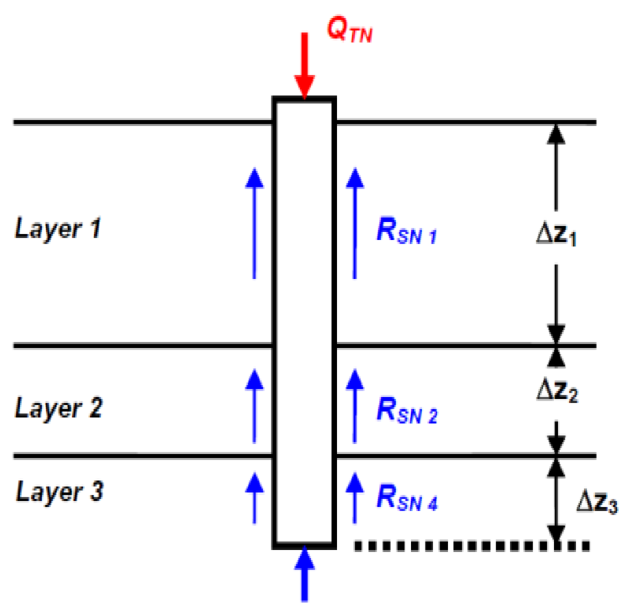
DL	Dead Load	27.50	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	91.74	K	(kips)





INITIAL DATA

Initial Sta. =	4+16.35	
Final Sta. =	4+16.35	
Ground elev. =	523.55	
Sand Strata elev. =	512.50	
Shale Strata elev. =	493.00	
Water elevation =	512.50	
Bottom trench =	514.11	

PARAMETERS

D.S. Length =	24.11	LF
D.S. Diameter =	2	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	12	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	11.05	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0	LF
H'w (sand + w) =	19.5	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 119.07 K
Total vertical Load on shaft
P = 91.74 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 81.12
Weight of the Shaft
P = 14.77

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 10.5543171 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v = 2840.5
σ'p = 7260.36606
OCR = 2.55601692
Ko= 0.85843401
β = 0.40029435
Kp tanϕ = 1.14894141
note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 1137.03611 psf
R_Unit_sand = 1.13703611 KSF

Nominal side Resistance Sand
Rs_Sand = 76.6216372 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 12.26 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 19.63 K

MANHOLE SUPPORT

Design Load (Cast in place MH)

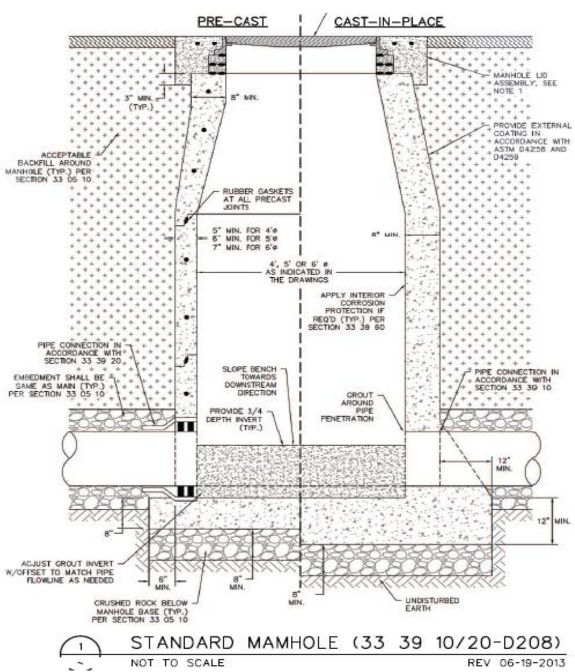
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	9.7	FT	8.7	FT	
Weight (Wc)	150.0	PCF	16.0	K	(kips)
Filled Water	62.4	PCF	12.1	K	(kips)

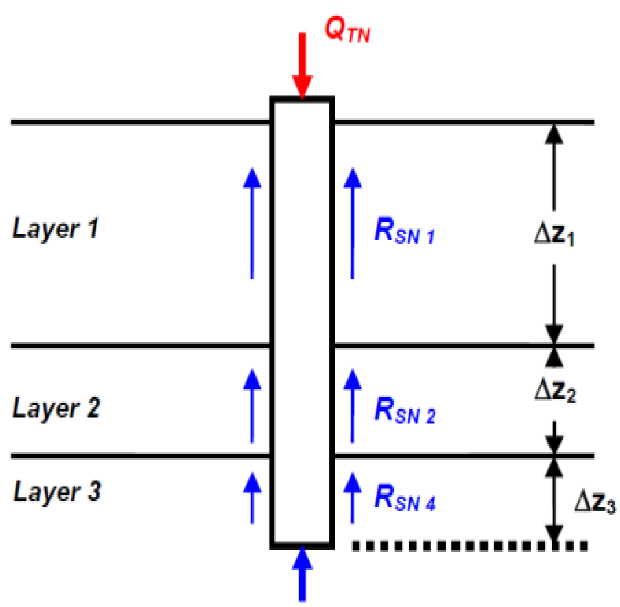
DL	Dead Load	28.10	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	92.53	K	(kips)





INITIAL DATA

Initial Sta. =	4+48.89	
Final Sta. =	4+48.89	
Ground elev. =	523.70	
Sand Strata elev. =	514.00	
Shale Strata elev. =	494.50	
Water elevation =	512.25	
Bottom trench =	514.05	

PARAMETERS

D.S. Length =	22.55	LF
D.S. Diameter =	2	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	12	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	9.7	LF
Hw (Clay + w)=	0	LF
H' (sand) =	1.75	LF
H'w (sand + w) =	17.75	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 107.41 K
Total vertical Load on shaft
P = 92.53 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 71.99
Weight of the Shaft
P = 13.81

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 0.32777382 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2749	
σ'p =	7260.36606	
OCR =	2.64109351	
Ko=	0.87039537	
β =	0.40587203	
Kp tanϕ =	1.14894141	

note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 1115.7422 psf
R_Unit_sand = 1.1157422 KSF

Nominal side Resistance Sand
Rs_Sand = 75.1867007 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 12.26 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

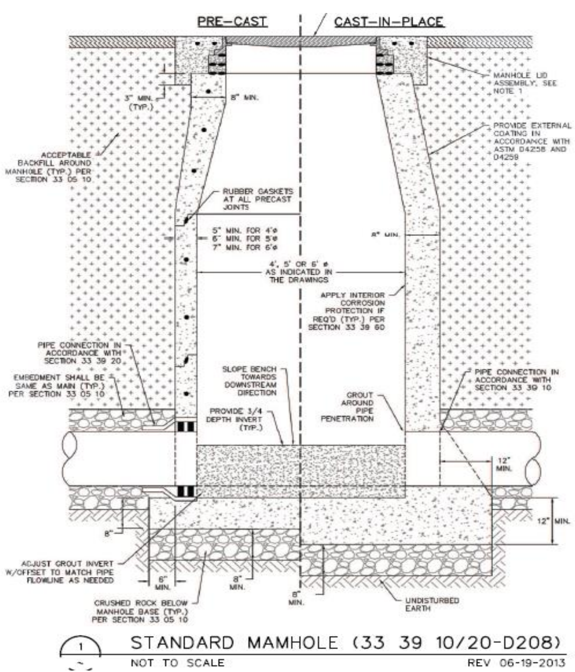
Nominal Base Resistance Clay
Rb_Rock = 19.63 K

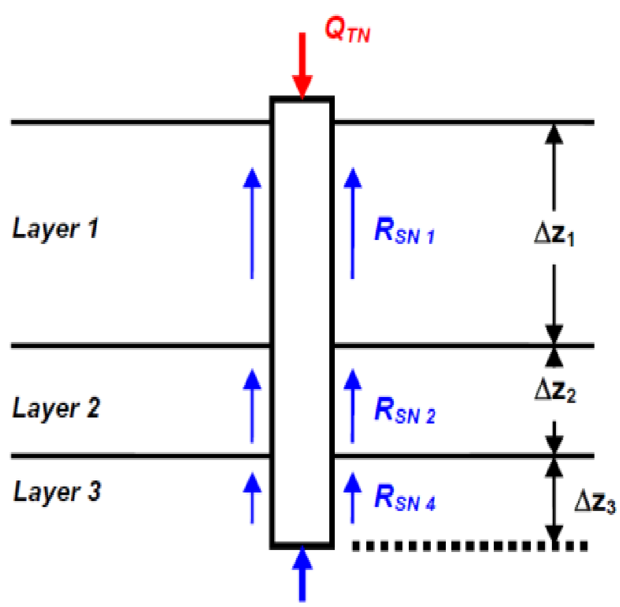
MANHOLE SUPPORT

Design Load (Cast in place MH)

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	5.8	FT	4.8	FT	
Weight (Wc)	150.0	PCF	10.4	K	(kips)
Filled Water	62.4	PCF	6.7	K	(kips)

DL	Dead Load	17.08	K	(kips)
LL	HS20	32.00	K	(kips)
	(AASHTO 3.7.3 & 3.7.6A)			
Load on footing 1.3DL + 1.75LL		78.21	K	(kips)





INITIAL DATA

Initial Sta. =	7+06.03	
Final Sta. =	7+06.03	
Ground elev. =	519.50	
Sand Strata elev. =	516.60	
Shale Strata elev. =	501.30	
Water elevation =	512.00	
Bottom trench =	513.70	

PARAMETERS

D.S. Length =	15.4	LF
D.S. Diameter =	3	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	9	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	2.9	LF
Hw (Clay + w)=	0	LF
H' (sand) =	4.6	LF
H'w (sand + w) =	10.7	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 123.39 K
Total vertical Load on shaft
P = 78.21 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 65.09
Weight of the Shaft
P = 21.23

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.4637051	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	2318.52552	psf
R_Unit_clay =	2.31852552	KSF
Nominal side Resistance Clay		
Rs_clay =	0	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	1699.4	
σ'p =	5767.76462	
OCR =	3.3940006	
Ko=	0.96772418	
β =	0.45125719	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	766.866475	psf
R_Unit_sand =	0.76686648	KSF
Nominal side Resistance Sand		
Rs_Sand =	60.8198018	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	18.39	K

Rock (Shale) - Base Resistance (Layer 3)

N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	44.18	K

MANHOLE SUPPORT

Design Load (Cast in place MH)

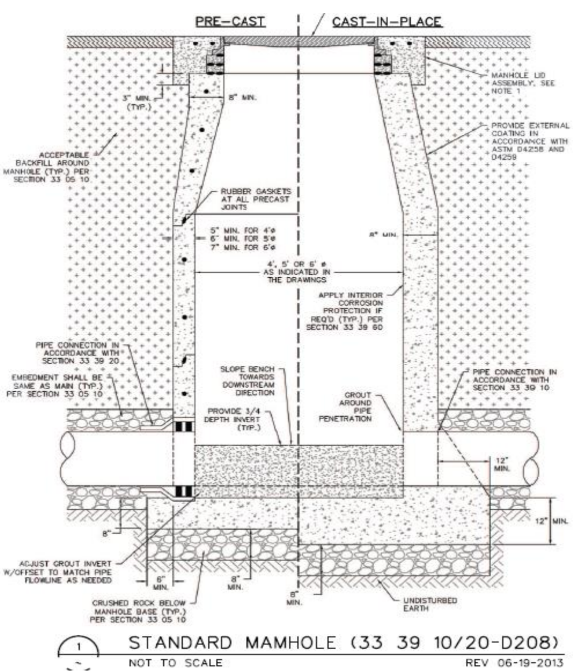
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	8.7	FT	7.7	FT	
Weight (Wc)	150.0	PCF	14.7	K	(kips)
Filled Water	62.4	PCF	10.8	K	(kips)

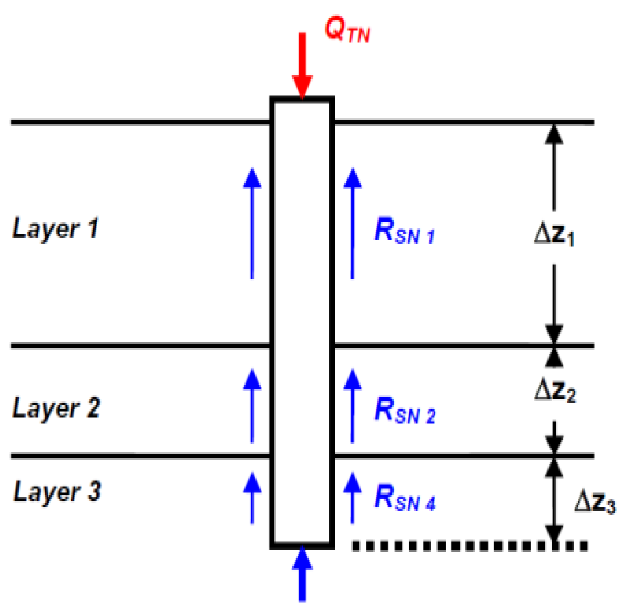
DL	Dead Load	25.46	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	89.10	K	(kips)





INITIAL DATA

Initial Sta. =	11+00.00	
Final Sta. =	11+00.00	
Ground elev. =	521.88	
Sand Strata elev. =	517.50	
Shale Strata elev. =	497.30	
Water elevation =	512.00	
Bottom trench =	513.15	

PARAMETERS

D.S. Length =	18.85	LF
D.S. Diameter =	3	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	2	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	4.38	LF
Hw (Clay + w)=	0	LF
H' (sand) =	5.5	LF
H'w (sand + w) =	14.7	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 119.91 K
Total vertical Load on shaft
P = 89.10 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 62.24
Weight of the Shaft
P = 25.98

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.51096408	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	2043.85633	psf
R_Unit_clay =	2.04385633	KSF
Nominal side Resistance Clay		
Rs_clay =	0	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2287.8	
σ'p =	1731.55989	
OCR =	0.75686681	
Ko=	0.5132565	
β =	0.23933544	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	547.551613	psf
R_Unit_sand =	0.54755161	KSF
Nominal side Resistance Sand		
Rs_Sand =	57.3337369	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	18.39	K

Rock (Shale) - Base Resistance (Layer 3)

N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	44.18	K

MANHOLE SUPPORT

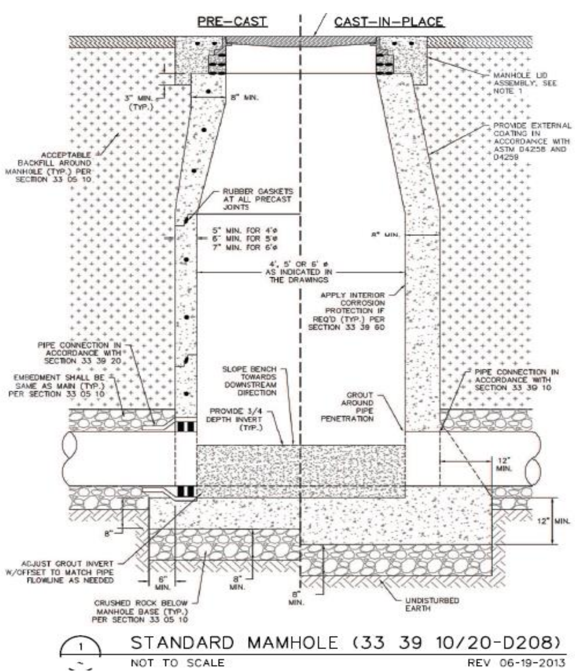
Design Load (Cast in place MH)

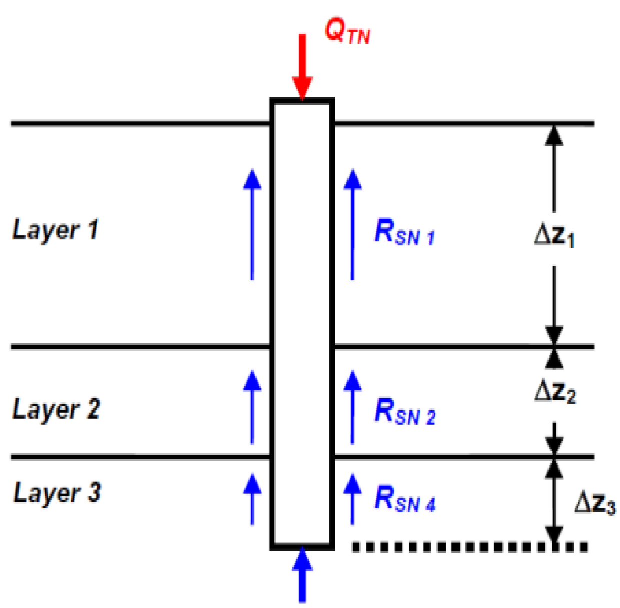
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	11.6	FT	10.6	FT	
Weight (Wc)	150.0	PCF	18.8	K	(kips)
Filled Water	62.4	PCF	14.7	K	(kips)

DL	Dead Load	33.53	K	(kips)
LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	99.59	K	(kips)





INITIAL DATA

Initial Sta. =	15+00.00
Final Sta. =	15+00.00
Ground elev. =	524.16
Sand Strata elev. =	515.10
Shale Strata elev. =	500.00
Water elevation =	512.00
Bottom trench =	512.61

PARAMETERS

D.S. Length =	18.11	LF
D.S. Diameter =	3	LF
Socket Length =	5.5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.25	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	0	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	9.06	LF
Hw (Clay + w)=	0	LF
H' (sand) =	3.1	LF
H'w (sand + w) =	12	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 108.56 K
Total vertical Load on shaft
P = 99.59 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 53.65
Weight of the Shaft
P = 24.96

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.55	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	1375	psf
R_Unit_clay =	1.375	KSF
Nominal side Resistance Clay		
Rs_clay =	0	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2413.8	
σ'p =	0	
OCR =	0	
Ko=	0	
β =	0	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	0	psf
R_Unit_sand =	0	KSF
Nominal side Resistance Sand		
Rs_Sand =	0	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	64.38	K

Rock (Shale) - Base Resistance (Layer 3)

N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	44.18	K

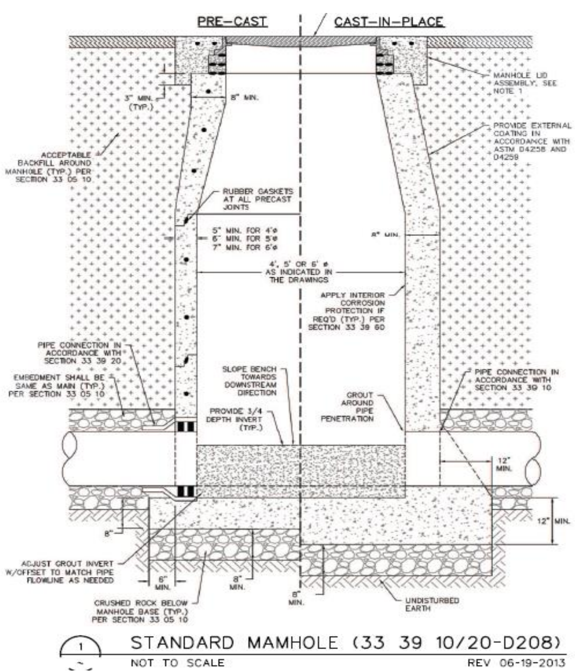
MANHOLE SUPPORT

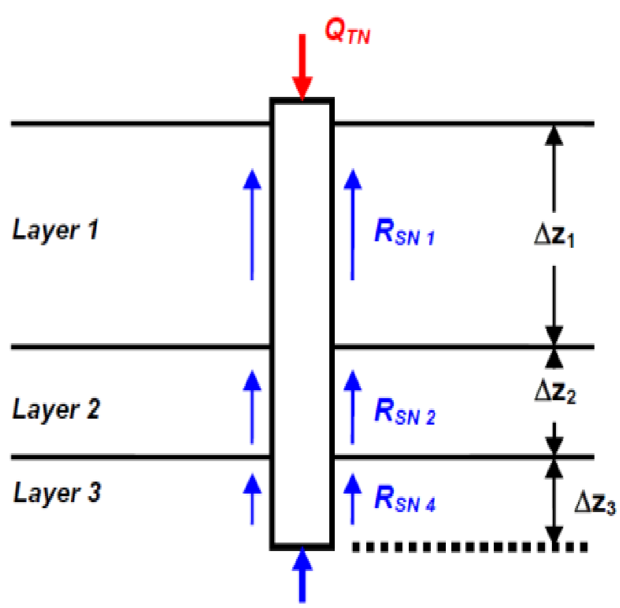
Design Load (Cast in place MH)

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	11.0	FT	10.0	FT	
Weight (Wc)	150.0	PCF	18.1	K	(kips)
Filled Water	62.4	PCF	14.0	K	(kips)

DL	Dead Load	32.07	K	(kips)
LL	HS20	32.00	K	(kips)
	(AASHTO 3.7.3 & 3.7.6A)			

Load on footing 1.3DL + 1.75LL	97.70	K	(kips)





INITIAL DATA

Initial Sta. =	19+07.20
Final Sta. =	19+07.20
Ground elev. =	523.10
Sand Strata elev. =	512.00
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	512.06

PARAMETERS

D.S. Length =	19.25	LF
D.S. Diameter =	3	LF
Socket Length =	5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.25	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	0	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	11.1	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0.54	LF
H'w (sand + w) =	13.65	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 99.71 K
Total vertical Load on shaft
P = 97.70 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 46.26
Weight of the Shaft
P = 26.53

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.55
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 1375 psf
R_Unit_clay = 1.375 KSF

Nominal side Resistance Clay
Rs_clay = 0.34989488 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2490.6	
σ'p =	0	
OCR =	0	
Ko=	0	
β =	0	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	

Unit Side Resistance Sand
R_Unit_sand = 0 psf
R_Unit_sand = 0 KSF

Nominal side Resistance Sand
Rs_Sand = 0 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 55.18 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 44.18 K

MANHOLE SUPPORT

Design Load (Cast in place MH)

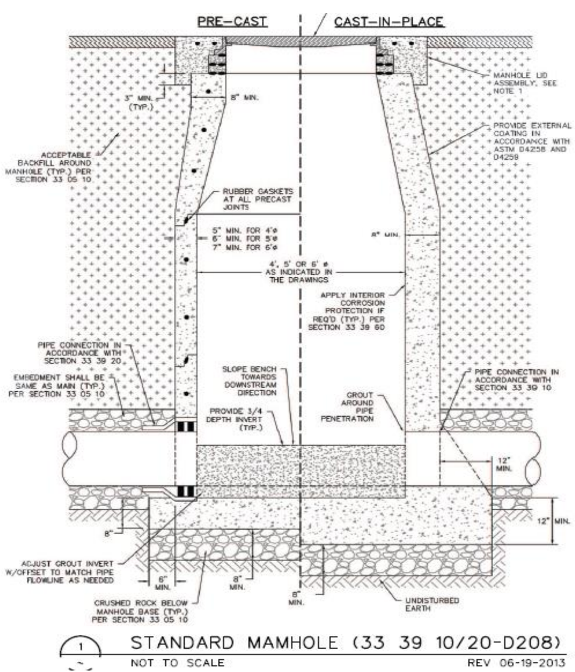
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	12.3	FT	11.3	FT	
Weight (Wc)	150.0	PCF	19.9	K	(kips)
Filled Water	62.4	PCF	15.7	K	(kips)

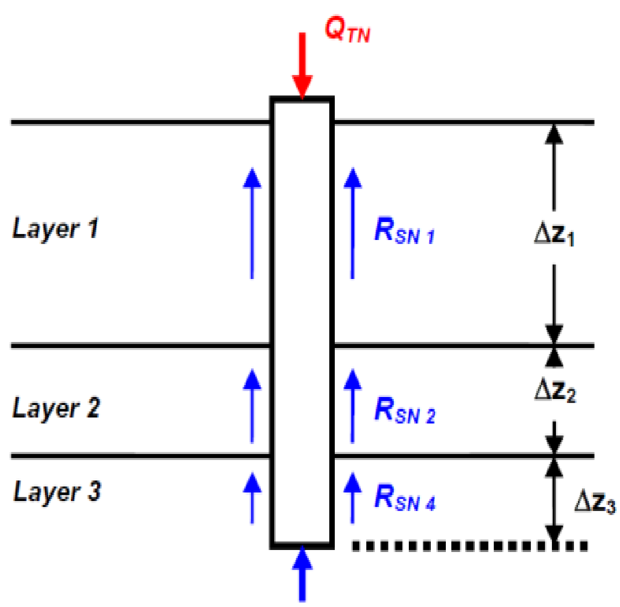
DL	Dead Load	35.65	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	102.34	K	(kips)





INITIAL DATA

Initial Sta. =	22+00.00
Final Sta. =	22+00.00
Ground elev. =	523.94
Sand Strata elev. =	512.00
Shale Strata elev. =	499.43
Water elevation =	510.38
Bottom trench =	511.65

PARAMETERS

D.S. Length =	15.22	LF
D.S. Diameter =	3	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	5	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	11.94	LF
Hw (Clay + w)=	0	LF
H' (sand) =	1.62	LF
H'w (sand + w) =	10.95	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 114.17 K
Total vertical Load on shaft
P = 102.34 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 57.55
Weight of the Shaft
P = 20.98

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.55
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 1650 psf
R_Unit_clay = 1.65 KSF

Nominal side Resistance Clay
Rs_clay = 0 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2535	
σ'p =	3604.03936	
OCR =	1.42171178	
Ko=	0.66995248	
β =	0.31240397	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	

Unit Side Resistance Sand
R_Unit_sand = 791.944071 psf
R_Unit_sand = 0.79194407 KSF

Nominal side Resistance Sand
Rs_Sand = 51.6016521 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 18.39 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 44.18 K

MANHOLE SUPPORT

Design Load (Cast in place MH)

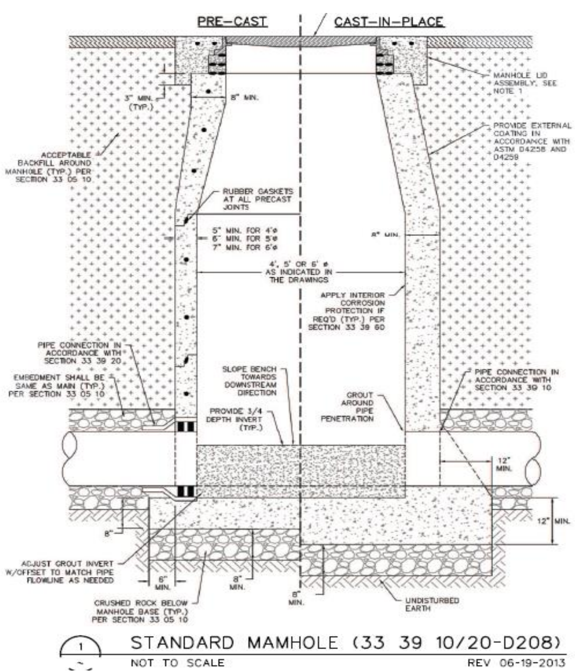
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	13.7	FT	12.7	FT	
Weight (Wc)	150.0	PCF	21.9	K	(kips)
Filled Water	62.4	PCF	17.7	K	(kips)

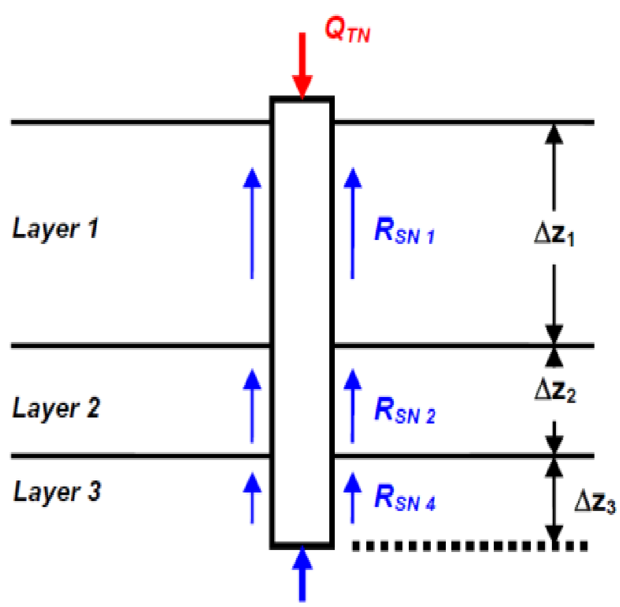
DL	Dead Load	39.57	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	107.44	K	(kips)





INITIAL DATA

Initial Sta. =	24+94.59
Final Sta. =	24+94.59
Ground elev. =	524.90
Sand Strata elev. =	517.50
Shale Strata elev. =	505.00
Water elevation =	510.00
Bottom trench =	511.24

PARAMETERS

D.S. Length =	9.24	LF
D.S. Diameter =	3	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	11	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	7.4	LF
Hw (Clay + w)=	0	LF
H' (sand) =	7.5	LF
H'w (sand + w) =	5	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 124.65 K
Total vertical Load on shaft
P = 107.44 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 66.12
Weight of the Shaft
P = 12.74

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 0 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2222
σ'p =	6772.16716
OCR =	3.04778
Ko=	0.92470532
β =	0.43119717
Kp tanϕ =	1.14894141

note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 958.12012 psf
R_Unit_sand = 0.95812012 KSF

Nominal side Resistance Sand
Rs_Sand = 62.0817271 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 18.39 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 44.18 K

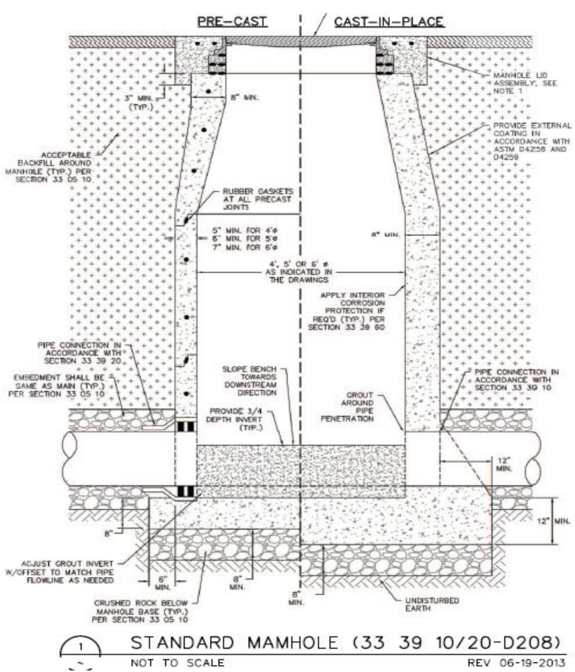
MANHOLE SUPPORT

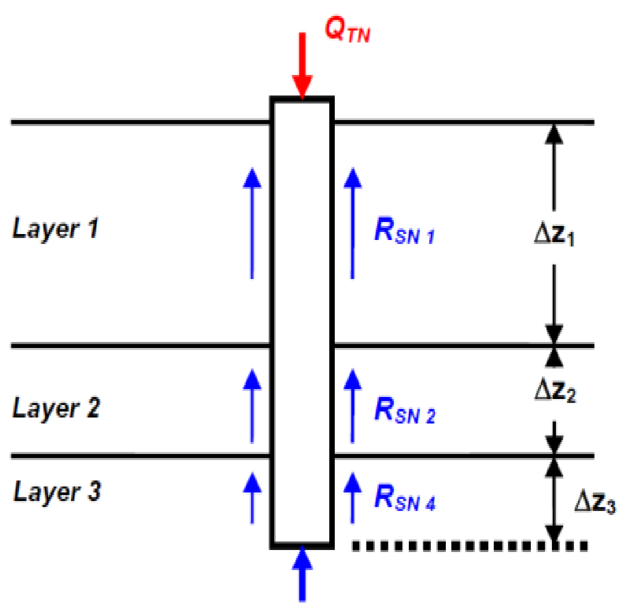
Design Load (Cast in place MH)

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	13.7	FT	12.7	FT	
Weight (Wc)	150.0	PCF	21.9	K	(kips)
Filled Water	62.4	PCF	17.7	K	(kips)

DL	Dead Load	39.57	K	(kips)
LL	HS20 (AASHTO 3.7.3 & 3.7.6A)	32.00	K	(kips)

Load on footing 1.3DL + 1.75LL	107.44	K	(kips)





INITIAL DATA

Initial Sta. =	25+60.55
Final Sta. =	25+60.55
Ground elev. =	524.90
Sand Strata elev. =	517.50
Shale Strata elev. =	505.00
Water elevation =	510.00
Bottom trench =	511.24

PARAMETERS

D.S. Length =	9.24	LF
D.S. Diameter =	3	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	11	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	7.4	LF
Hw (Clay + w)=	0	LF
H' (sand) =	7.5	LF
H'w (sand + w) =	5	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 124.65 K
Total vertical Load on shaft
P = 107.44 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 66.12
Weight of the Shaft
P = 12.74

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 0 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2222	
σ'p =	6772.16716	
OCR =	3.04778	
Ko=	0.92470532	
β =	0.43119717	
Kp tanϕ =	1.14894141	

note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 958.12012 psf
R_Unit_sand = 0.95812012 KSF

Nominal side Resistance Sand
Rs_Sand = 62.0817271 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 18.39 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 44.18 K

ANNEX 9.2 – Mony Street Drill Shaft Report

MANHOLE SUPPORT

Design Load (Cast in place MH) **3+81.46**

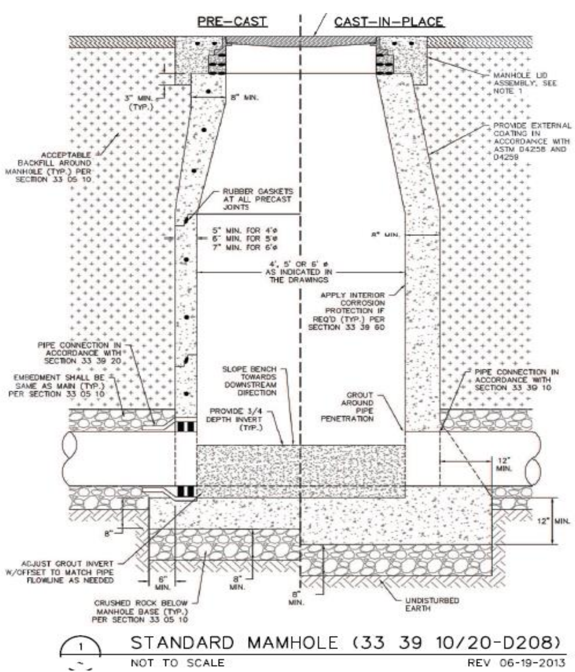
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	9.2	FT	8.2	FT	
Weight (Wc)	150.0	PCF	15.4	K	(kips)
Filled Water	62.4	PCF	11.5	K	(kips)

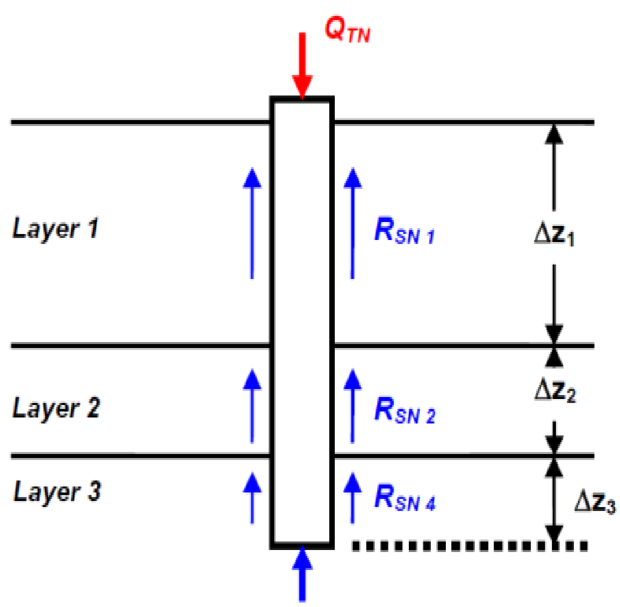
DL	Dead Load	26.90	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	90.96	K	(kips)





INITIAL DATA

Initial Sta. =	3+81.46	
Final Sta. =	3+81.46	
Ground elev. =	523.40	
Sand Strata elev. =	512.50	
Shale Strata elev. =	493.00	
Water elevation =	512.50	
Bottom trench =	514.17	

PARAMETERS

D.S. Length =	24.17	LF
D.S. Diameter =	2	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	12	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	10.9	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0	LF
H'w (sand + w) =	19.5	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 119.16 K
Total vertical Load on shaft
P = 90.96 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 81.18
Weight of the Shaft
P = 14.81

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 10.947646 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2821	
σ'p =	7260.36606	
OCR =	2.57368524	
Ko=	0.86093679	
β =	0.40146142	
Kp tanϕ =	1.14894141	

note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 1132.52266 psf
R_Unit_sand = 1.13252266 KSF

Nominal side Resistance Sand
Rs_Sand = 76.317489 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 12.262356 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 19.634953 K

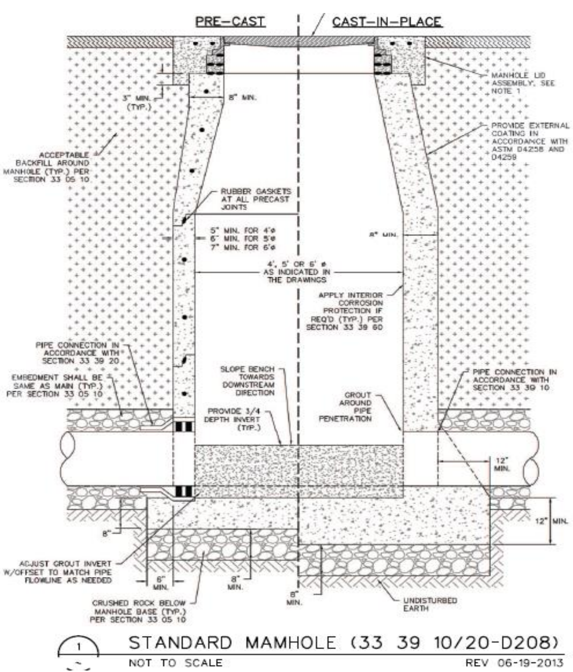
MANHOLE SUPPORT

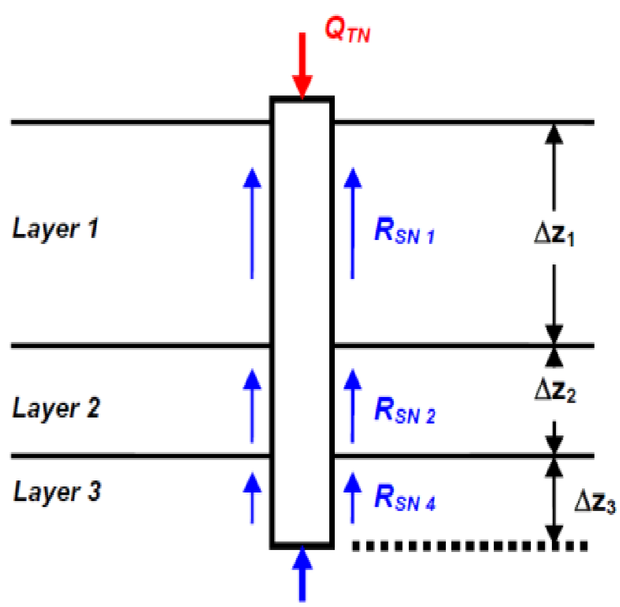
Design Load (Cast in place MH) **4+16.35**

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	9.5	FT	8.5	FT	
Weight (Wc)	150.0	PCF	15.8	K	(kips)
Filled Water	62.4	PCF	11.9	K	(kips)

DL	Dead Load	27.67	K	(kips)
LL	HS20	32.00	K	(kips)
	(AASHTO 3.7.3 & 3.7.6A)			

Load on footing 1.3DL + 1.75LL	91.97	K	(kips)





INITIAL DATA

Initial Sta. =	4+16.35
Final Sta. =	4+16.35
Ground elev. =	523.60
Sand Strata elev. =	512.50
Shale Strata elev. =	493.00
Water elevation =	512.50
Bottom trench =	514.10

PARAMETERS

D.S. Length =	24.1	LF
D.S. Diameter =	2	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	12	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	11.1	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0	LF
H'w (sand + w) =	19.5	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 119.11 K
Total vertical Load on shaft
P = 91.97 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 81.15
Weight of the Shaft
P = 14.76

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 10.488762 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v = 2847
σ'p = 7260.36606
OCR = 2.55018127
Ko= 0.85760518
β = 0.39990786
Kp tanϕ = 1.14894141
note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 1138.53768 psf
R_Unit_sand = 1.13853768 KSF

Nominal side Resistance Sand
Rs_Sand = 76.722824 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 12.262356 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 19.634953 K

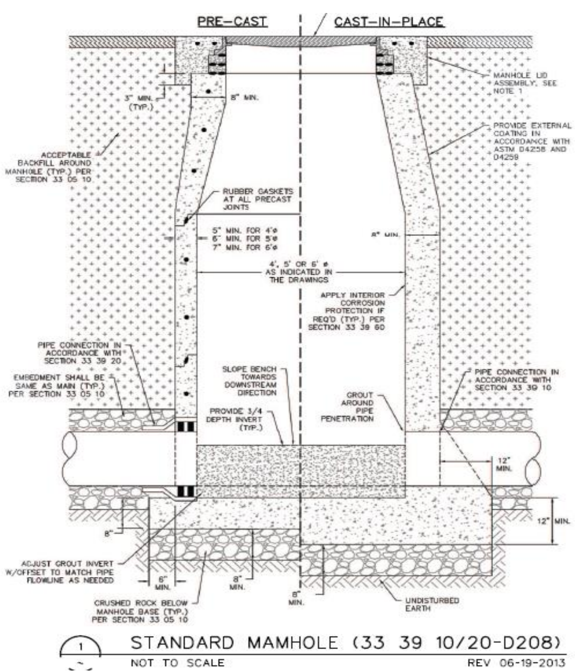
MANHOLE SUPPORT

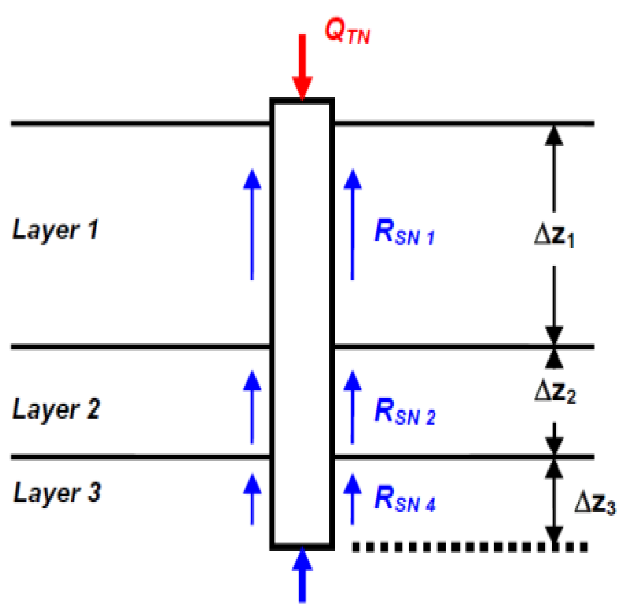
Design Load (Cast in place MH) **4+48.89**

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	9.7	FT	8.7	FT	
Weight (Wc)	150.0	PCF	16.1	K	(kips)
Filled Water	62.4	PCF	12.1	K	(kips)

DL	Dead Load	28.15	K	(kips)
LL	HS20	32.00	K	(kips)
	(AASHTO 3.7.3 & 3.7.6A)			

Load on footing 1.3DL + 1.75LL	92.60	K	(kips)





INITIAL DATA

Initial Sta. =	4+48.89	
Final Sta. =	4+48.89	
Ground elev. =	523.70	
Sand Strata elev. =	514.00	
Shale Strata elev. =	494.50	
Water elevation =	512.25	
Bottom trench =	514.03	

PARAMETERS

D.S. Length =	22.53	LF
D.S. Diameter =	2	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	12	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	9.7	LF
Hw (Clay + w)=	0	LF
H' (sand) =	1.75	LF
H'w (sand + w) =	17.75	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 107.28 K
Total vertical Load on shaft
P = 92.60 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 71.89
Weight of the Shaft
P = 13.80

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 0.196664 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v = 2749
σ'p = 7260.36606
OCR = 2.64109351
Ko= 0.87039537
β = 0.40587203
Kp tanϕ = 1.14894141
note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 1115.7422 psf
R_Unit_sand = 1.1157422 KSF

Nominal side Resistance Sand
Rs_Sand = 75.186701 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 12.262356 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 19.634953 K

MANHOLE SUPPORT

Design Load (Cast in place MH) **7+06.03**

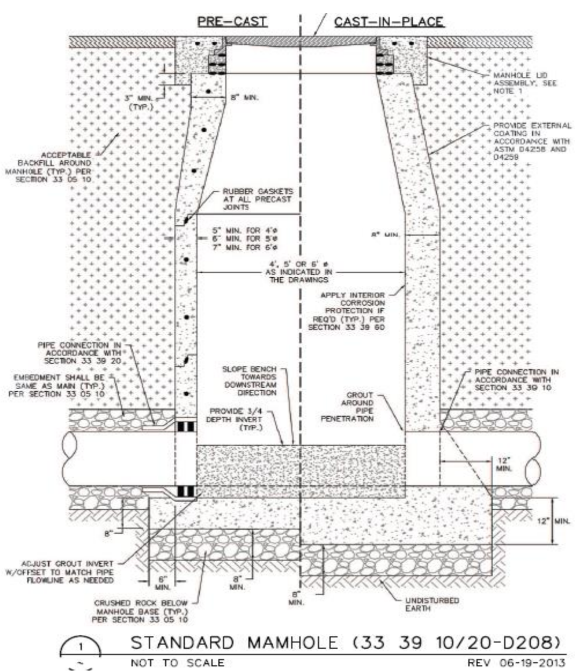
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	5.8	FT	4.8	FT	
Weight (Wc)	150.0	PCF	10.4	K	(kips)
Filled Water	62.4	PCF	6.7	K	(kips)

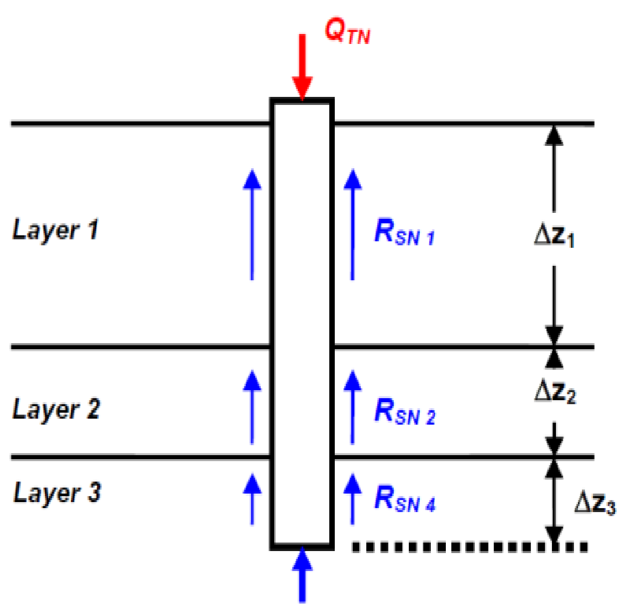
DL	Dead Load	17.14	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	78.28	K	(kips)





INITIAL DATA

Initial Sta. =	7+06.03
Final Sta. =	7+06.03
Ground elev. =	519.50
Sand Strata elev. =	516.60
Shale Strata elev. =	501.30
Water elevation =	512.00
Bottom trench =	513.68

PARAMETERS

D.S. Length =	16.38	LF
D.S. Diameter =	2	LF
Socket Length =	4	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	9	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	2.9	LF
Hw (Clay + w)=	0	LF
H' (sand) =	4.6	LF
H'w (sand + w) =	10.7	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 84.71 K
Total vertical Load on shaft
P = 78.28 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 53.61
Weight of the Shaft
P = 10.03

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 0.000000 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	1699.4
σ'p =	5767.76462
OCR =	3.3940006
Ko=	0.96772418
β =	0.45125719
Kp tanϕ =	1.14894141

note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 766.866475 psf
R_Unit_sand = 0.76686648 KSF

Nominal side Resistance Sand
Rs_Sand = 40.546535 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 24.524713 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 19.634953 K

MANHOLE SUPPORT

Design Load (Cast in place MH) **11+00.00**

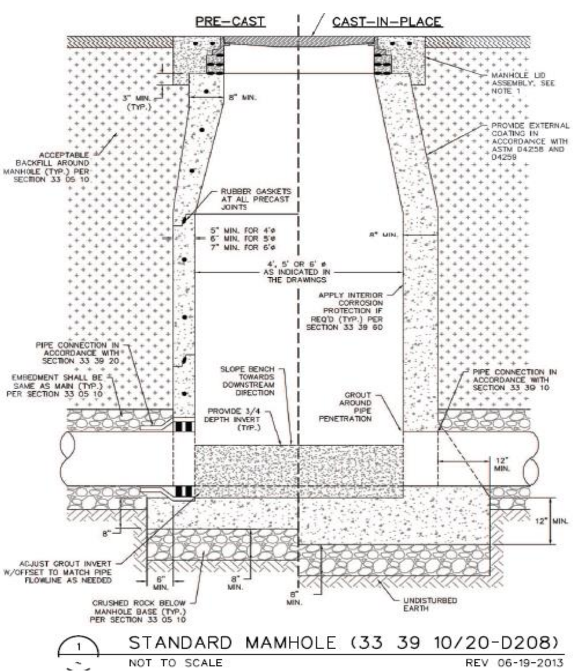
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	8.8	FT	7.8	FT	
Weight (Wc)	150.0	PCF	14.8	K	(kips)
Filled Water	62.4	PCF	10.9	K	(kips)

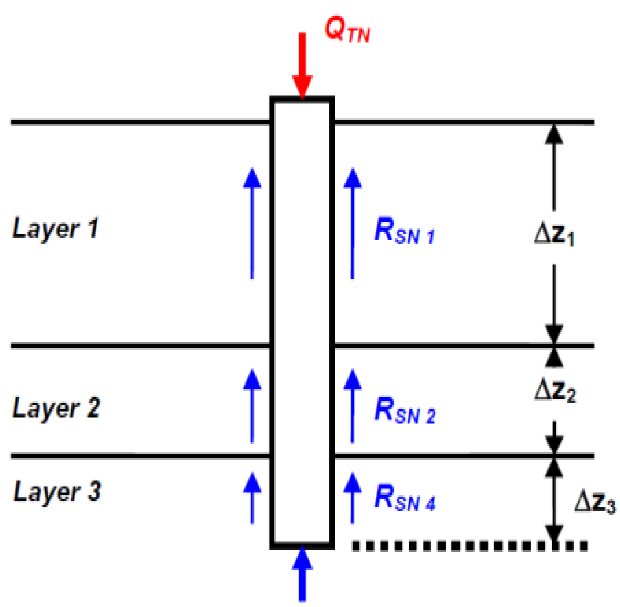
DL	Dead Load	25.61	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	89.29	K	(kips)





INITIAL DATA

Initial Sta. =	11+00.00	
Final Sta. =	11+00.00	
Ground elev. =	521.90	
Sand Strata elev. =	517.50	
Shale Strata elev. =	497.30	
Water elevation =	512.00	
Bottom trench =	513.12	

PARAMETERS

D.S. Length =	20.82	LF
D.S. Diameter =	2	LF
Socket Length =	5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	2	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	4.4	LF
Hw (Clay + w)=	0	LF
H' (sand) =	5.5	LF
H'w (sand + w) =	14.7	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 94.67 K
Total vertical Load on shaft
P = 89.29 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 61.95
Weight of the Shaft
P = 12.75

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.51096408	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	2043.85633	psf
R_Unit_clay =	2.04385633	KSF
Nominal side Resistance Clay		
Rs_clay =	0.000000	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2290.4	
σ'p =	1731.55989	
OCR =	0.75600764	
Ko=	0.51301019	
β =	0.23922058	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	547.910815	psf
R_Unit_sand =	0.54791082	KSF
Nominal side Resistance Sand		
Rs_Sand =	38.247566	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	36.787069	K

Rock (Shale) - Base Resistance (Layer 3)

N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	19.634953	K

MANHOLE SUPPORT

Design Load (Cast in place MH) **15+00.00**

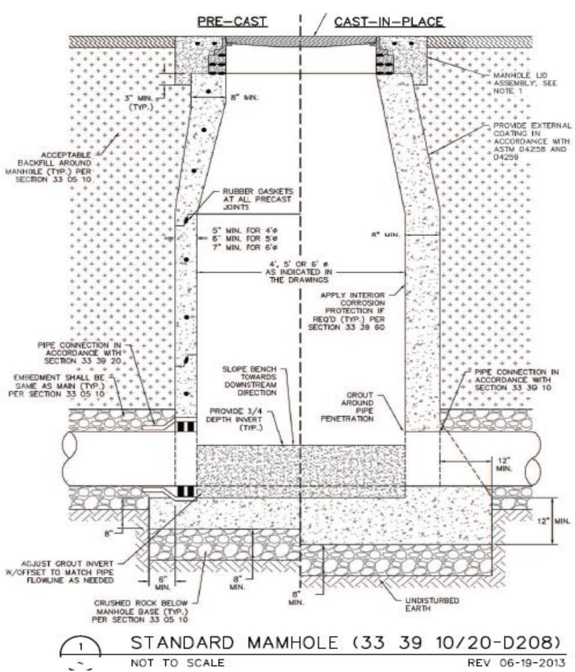
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	8.8	FT	7.8	FT	
Weight (Wc)	150.0	PCF	14.8	K	(kips)
Filled Water	62.4	PCF	10.9	K	(kips)

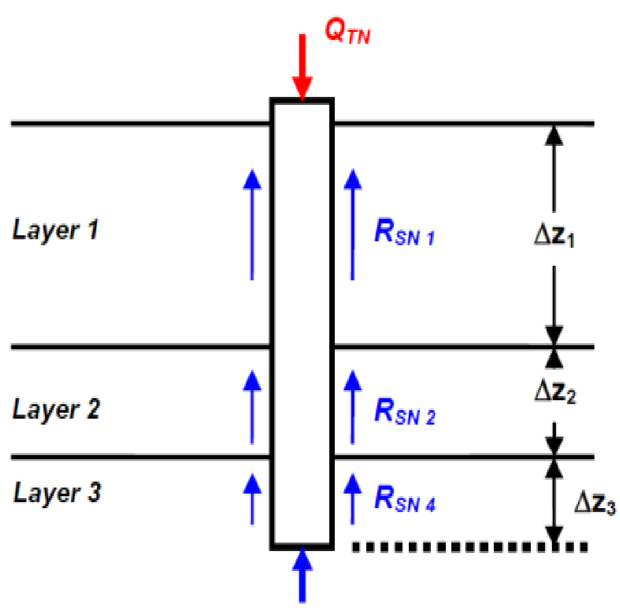
DL	Dead Load	25.61	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	89.29	K	(kips)





INITIAL DATA

Initial Sta. =	15+00.00	
Final Sta. =	15+00.00	
Ground elev. =	521.90	
Sand Strata elev. =	517.50	
Shale Strata elev. =	497.30	
Water elevation =	512.00	
Bottom trench =	513.12	

PARAMETERS

D.S. Length =	20.32	LF
D.S. Diameter =	3	LF
Socket Length =	4.5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.25	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	0	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	4.4	LF
Hw (Clay + w)=	0	LF
H' (sand) =	5.5	LF
H'w (sand + w) =	14.7	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 90.16 K
Total vertical Load on shaft
P = 89.29 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 38.32
Weight of the Shaft
P = 28.01

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.55	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	1375	psf
R_Unit_clay =	1.375	KSF
Nominal side Resistance Clay		
Rs_clay =	0.000000	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2290.4	
σ'p =	0	
OCR =	0	
Ko=	0	
β =	0	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	0	psf
R_Unit_sand =	0	KSF
Nominal side Resistance Sand		
Rs_Sand =	0.000000	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	45.983837	K

Rock (Shale) - Base Resistance (Layer 3)

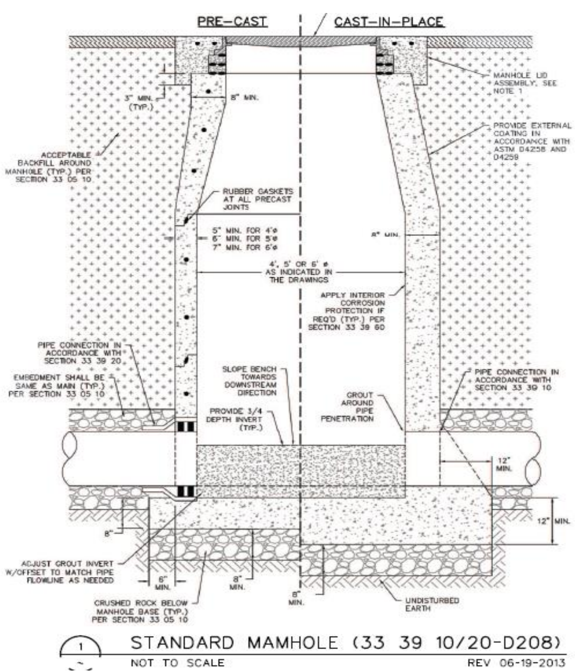
N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	44.178644	K

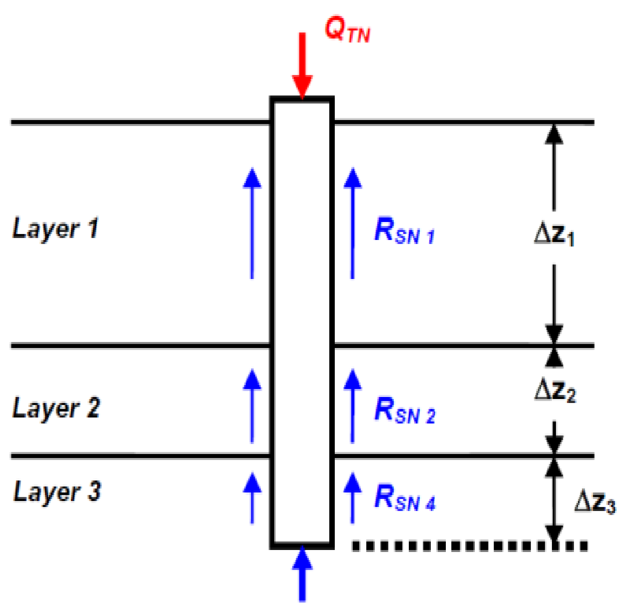
MANHOLE SUPPORT

Design Load (Cast in place MH) **19+07.20**

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	11.6	FT	10.6	FT	
Weight (Wc)	150.0	PCF	19.0	K	(kips)
Filled Water	62.4	PCF	14.8	K	(kips)

DL	Dead Load	33.79	K	(kips)
LL	HS20 (AASHTO 3.7.3 & 3.7.6A)	32.00	K	(kips)
Load on footing 1.3DL + 1.75LL		99.93	K	(kips)





INITIAL DATA

Initial Sta. =	19+07.20
Final Sta. =	19+07.20
Ground elev. =	524.20
Sand Strata elev. =	515.10
Shale Strata elev. =	500.00
Water elevation =	512.00
Bottom trench =	512.56

PARAMETERS

D.S. Length =	18.06	LF
D.S. Diameter =	3	LF
Socket Length =	5.5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.25	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	0	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	9.1	LF
Hw (Clay + w)=	0	LF
H' (sand) =	3.1	LF
H'w (sand + w) =	12	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 108.56 K
Total vertical Load on shaft
P = 99.93 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 53.65
Weight of the Shaft
P = 24.89

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.55	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	1375	psf
R_Unit_clay =	1.375	KSF
Nominal side Resistance Clay		
Rs_clay =	0.000000	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2419	
σ'p =	0	
OCR =	0	
Ko=	0	
β =	0	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	0	psf
R_Unit_sand =	0	KSF
Nominal side Resistance Sand		
Rs_Sand =	0.000000	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	64.377372	K

Rock (Shale) - Base Resistance (Layer 3)

N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	44.178644	K

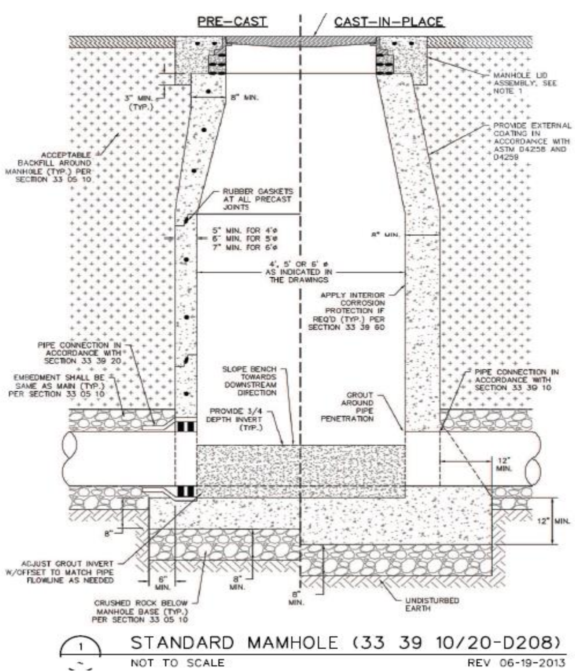
MANHOLE SUPPORT

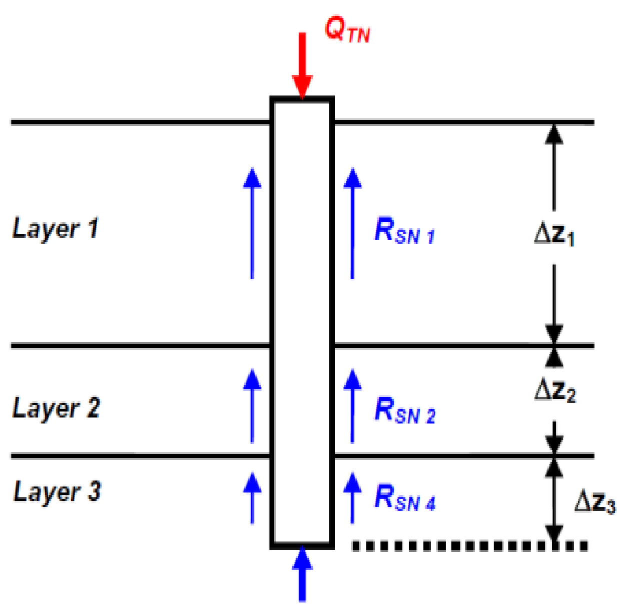
Design Load (Cast in place MH) **20+00.00**

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	10.5	FT	9.5	FT	
Weight (Wc)	150.0	PCF	17.2	K	(kips)
Filled Water	62.4	PCF	13.2	K	(kips)

DL	Dead Load	30.47	K	(kips)
LL	HS20	32.00	K	(kips)
	(AASHTO 3.7.3 & 3.7.6A)			

Load on footing 1.3DL + 1.75LL	95.61	K	(kips)





INITIAL DATA

Initial Sta. =	20+00.00
Final Sta. =	20+00.00
Ground elev. =	522.34
Sand Strata elev. =	512.00
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.86

PARAMETERS

D.S. Length =	19.05	LF
D.S. Diameter =	3	LF
Socket Length =	5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.25	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	0	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	10.34	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0.54	LF
H'w (sand + w) =	13.65	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 99.36 K
Total vertical Load on shaft
P = 95.61 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 45.98
Weight of the Shaft
P = 26.26

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.55
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 1375 psf
R_Unit_clay = 1.375 KSF

Nominal side Resistance Clay
Rs_clay = 0.000000 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2391.8	
σ'p =	0	
OCR =	0	
Ko=	0	
β =	0	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	

Unit Side Resistance Sand
R_Unit_sand = 0 psf
R_Unit_sand = 0 KSF

Nominal side Resistance Sand
Rs_Sand = 0.000000 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 55.180604 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

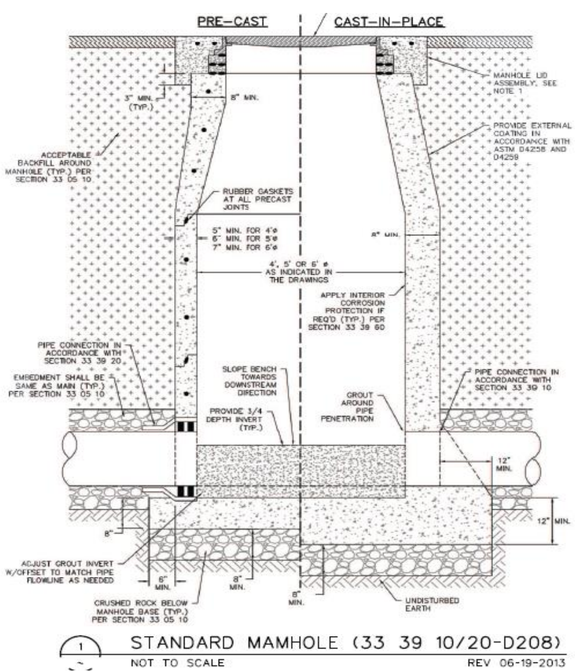
Nominal Base Resistance Clay
Rb_Rock = 44.178644 K

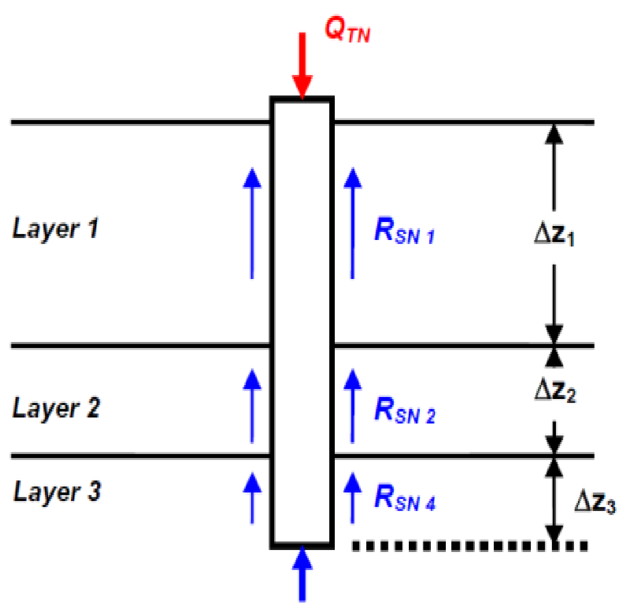
MANHOLE SUPPORT

Design Load (Cast in place MH) **21+93.29**

Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	9.2	FT	8.2	FT	
Weight (Wc)	150.0	PCF	15.4	K	(kips)
Filled Water	62.4	PCF	11.4	K	(kips)

DL	Dead Load	26.81	K	(kips)
LL	HS20 (AASHTO 3.7.3 & 3.7.6A)	32.00	K	(kips)
Load on footing 1.3DL + 1.75LL		90.85	K	(kips)





INITIAL DATA

Initial Sta. =	21+93.29
Final Sta. =	21+93.29
Ground elev. =	520.78
Sand Strata elev. =	512.00
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.58

PARAMETERS

D.S. Length =	18.77	LF
D.S. Diameter =	3	LF
Socket Length =	5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.25	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	0	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	8.78	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0.54	LF
H'w (sand + w) =	13.65	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 99.36 K
Total vertical Load on shaft
P = 90.85 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 45.98
Weight of the Shaft
P = 25.87

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.55
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 1375 psf
R_Unit_clay = 1.375 KSF

Nominal side Resistance Clay
Rs_clay = 0.000000 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v = 2189
σ'p = 0
OCR = 0
Ko= 0
β = 0
Kp tanϕ = 1.14894141
note: β < Kp tanϕ
Red. Factor = 0.55

Unit Side Resistance Sand
R_Unit_sand = 0 psf
R_Unit_sand = 0 KSF

Nominal side Resistance Sand
Rs_Sand = 0.000000 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 55.180604 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 44.178644 K

MANHOLE SUPPORT

Design Load (Cast in place MH) **23+59.21**

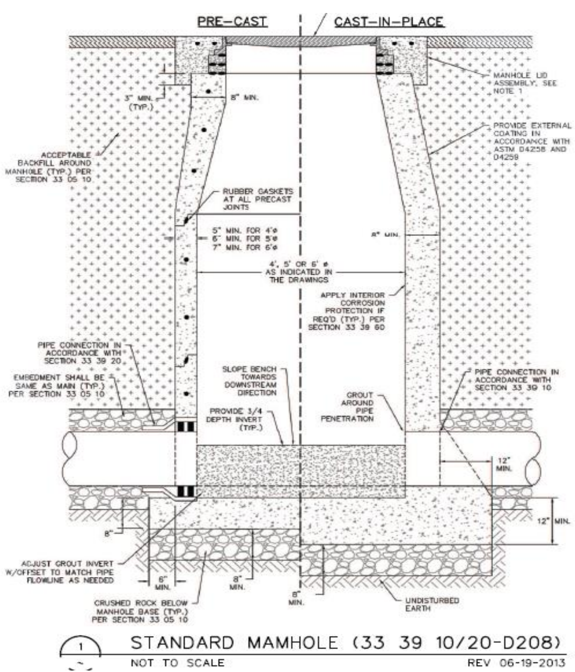
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	8.2	FT	7.2	FT	
Weight (Wc)	150.0	PCF	14.0	K	(kips)
Filled Water	62.4	PCF	10.1	K	(kips)

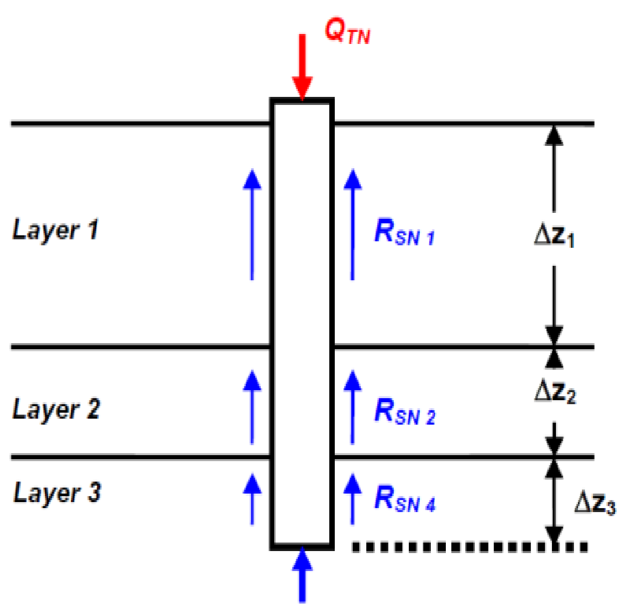
DL	Dead Load	24.06	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	87.28	K	(kips)





INITIAL DATA

Initial Sta. =	23+59.21	
Final Sta. =	23+59.21	
Ground elev. =	519.61	
Sand Strata elev. =	512.00	
Shale Strata elev. =	497.81	
Water elevation =	511.46	
Bottom trench =	511.37	

PARAMETERS

D.S. Length =	18.06	LF
D.S. Diameter =	3	LF
Socket Length =	4.5	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	1.25	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	0	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	º
δ (sand) =	25	º
H (clay) =	7.61	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0.54	LF
H'w (sand + w) =	13.65	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 90.16 K
Total vertical Load on shaft
P = 87.28 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 38.32
Weight of the Shaft
P = 24.89

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α =	0.55	
note: α > 0 for H-5LF		
Red. Factor =	0.45	
Unit Side Resistance Clay		
R_Unit_clay =	1375	psf
R_Unit_clay =	1.375	KSF
Nominal side Resistance Clay		
Rs_clay =	0.000000	K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2036.9	
σ'p =	0	
OCR =	0	
Ko=	0	
β =	0	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	
Unit Side Resistance Sand		
R_Unit_sand =	0	psf
R_Unit_sand =	0	KSF
Nominal side Resistance Sand		
Rs_Sand =	0.000000	K

Rock (Shale) - Side Resistance (Layer 3)

C =	1.00	
(Kulhawy, 2005)		
Red. Factor =	0.60	
Unit Side Resistance Rock		
R_Unit_Rock =	3252.69	psf
R_Unit_Rock =	3.25	KSF
Nominal side Resistance Rock		
Rs_Rock =	45.983837	K

Rock (Shale) - Base Resistance (Layer 3)

N*cr =	2.50	
(Rowe & Armitage, 1987)		
Red. Factor =	0.50	
Unit base Resistance Rock		
Rb_Unit_Rock =	12500.00	psf
Rb_Unit_Rock =	12.50	KSF
Nominal Base Resistance Clay		
Rb_Rock =	44.178644	K

MANHOLE SUPPORT

Design Load (Cast in place MH) **1+00.00**

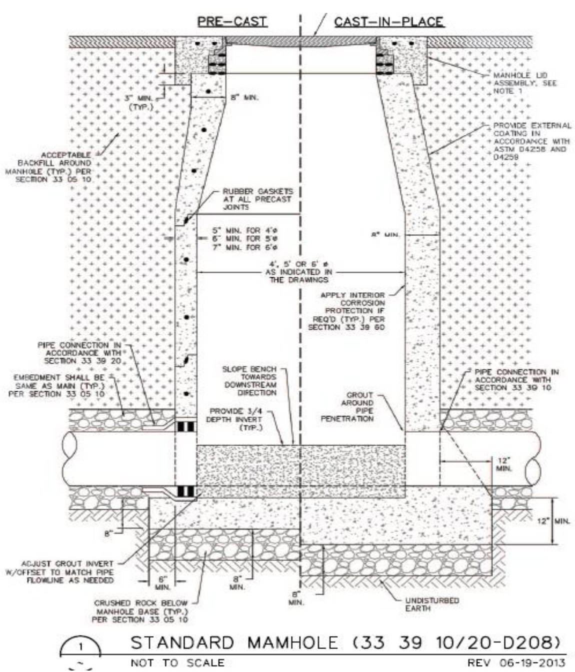
Dimension	Outside		Inside		
Diameter	5.3	FT	4.0	FT	
Height (Variable)	8.2	FT	7.2	FT	
Weight (Wc)	150.0	PCF	14.0	K	(kips)
Filled Water	62.4	PCF	10.1	K	(kips)

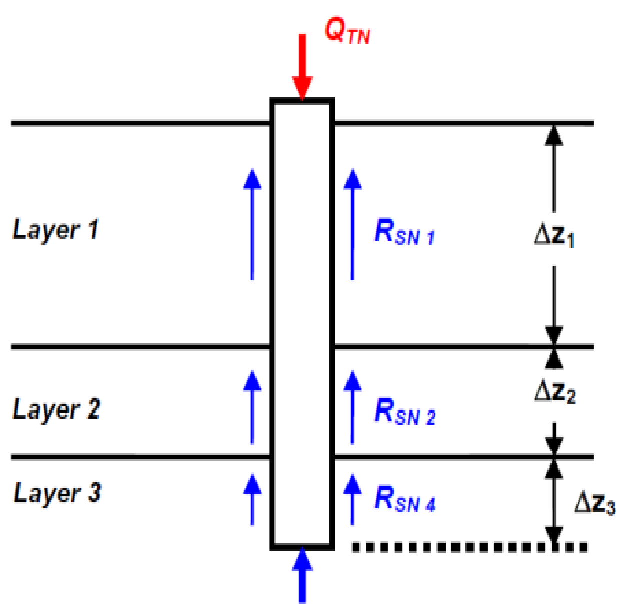
DL	Dead Load	24.06	K	(kips)

LL	HS20	32.00	K	(kips)

(AASHTO 3.7.3 & 3.7.6A)

Load on footing 1.3DL + 1.75LL	87.28	K	(kips)





INITIAL DATA

Initial Sta. =	1+00.00
Final Sta. =	1+00.00
Ground elev. =	519.61
Sand Strata elev. =	512.00
Shale Strata elev. =	497.81
Water elevation =	511.46
Bottom trench =	511.37

PARAMETERS

D.S. Length =	16.56	LF
D.S. Diameter =	3	LF
Socket Length =	3	LF
γ2 (Clay) =	130	PCF
PP (Clay) =	2.5	tsf
γ (sand) =	120	PCF
γ' (sand) =	72	PCF
N (sand) =	11	
m (sand) =	0.8	
Qu (shale) =	5000	psf
N60 (shale) =	26.32	
ϕ (sand) =	25	o
δ (sand) =	25	o
H (clay) =	7.61	LF
Hw (Clay + w)=	0	LF
H' (sand) =	0.54	LF
H'w (sand + w) =	13.65	LF
Pa (Atmos) =	2116	psf

Final Checkout - Bearing Capacity Check
Axial Loading Only

Allowable Compression Shaft Resistance
P_Allow = 126.62 K
Total vertical Load on shaft
P = 87.28 K

P_Allow > P ? YES

Final Checkout - Uplift Resistance

Allowable Uplift Side Shaft Resistance
P_Allow = 67.73
Weight of the Shaft
P = 22.83

P_Allow > P ? YES

Cohesive Soil (Clay) - Side Resistance (Layer 1)

α = 0.4637051
note: α > 0 for H-5LF
Red. Factor = 0.45

Unit Side Resistance Clay
R_Unit_clay = 2318.52552 psf
R_Unit_clay = 2.31852552 KSF

Nominal side Resistance Clay
Rs_clay = 0.000000 K

Cohesive Soil (Clay) - Side Resistance (Layer 2)

σ'v =	2036.9	
σ'p =	6772.16716	
OCR =	3.32474209	
Ko=	0.95932881	
β =	0.44734237	
Kp tanϕ =	1.14894141	
note: β < Kp tanϕ		
Red. Factor =	0.55	

Unit Side Resistance Sand
R_Unit_sand = 911.191673 psf
R_Unit_sand = 0.91119167 KSF

Nominal side Resistance Sand
Rs_Sand = 64.047657 K

Rock (Shale) - Side Resistance (Layer 3)

C = 1.00
(Kulhawy, 2005)
Red. Factor = 0.60

Unit Side Resistance Rock
R_Unit_Rock = 3252.69 psf
R_Unit_Rock = 3.25 KSF

Nominal side Resistance Rock
Rs_Rock = 18.393535 K

Rock (Shale) - Base Resistance (Layer 3)

N*cr = 2.50
(Rowe & Armitage, 1987)
Red. Factor = 0.50

Unit base Resistance Rock
Rb_Unit_Rock = 12500.00 psf
Rb_Unit_Rock = 12.50 KSF

Nominal Base Resistance Clay
Rb_Rock = 44.178644 K

Appendix No. 10:

Final Study of Alternatives

INDEX - APPENDIX NO. 10: FINAL STUDY OF ALTERNATIVES

INDEX - FIGURE AND TABLE

On this appendix a last study of alternatives will be done between the Greenfield Avenue and Mony Street alignments. As we have been study them thoroughly in the previous 3 appendix there will be a solid base to discern between the two possible solutions to the problem is faced in this paper.

Not only the economical factor will be balanced but other main ones will be faced as well as done in the preliminary study of alternatives.

This decision won't be taken with the SPECTRE I Method because there are only 2 different alternatives to discern from. Therefore, a basic weighted study will be enough to know which one of both alternatives is going to be the one. The procedure will be quite the same but without the last steps (Only from Matrix I through III).

The alternatives will be considered in the same way as they were considered before in a more accurate manner. That means that the criteria and the parameters will remain the same as in Appendix 6.

Criteria	Parameters
Execution	Execution Term Earth Hauled off-site
Functionality	Population adjustment Maintenance Cost
Environmental Impact	Length Easements Social Impact
Economical cost	Initial Investment

Table 1. Criteria and Parameters for the Multi-criteria election.

10. Study of Alternatives

10.1. Greenfield Avenue Alternative Attributes

The first alignment to be considered in this appendix is the one that was on first place in the previous study: The Greenfield Avenue alignment.

10.1.1. Execution

- **Execution Term:**

As commented in Appendix 8, as long as we won't be able to relay on the sheet pilling construction method, once all the area is de-watered and the trench excavated, we would need to stabilize the bottom of the trench to ensure that when we pull the trench box out, anything caves in and propitiate the settling of the recently installed pipe. Therefore the new construction pace using de-watering plus a trench shield will be up to 50LF a day.

With this new parameter let's estimate the execution term.

- Traffic Control to be set at Greenfield and Pharr to start the Drill shafts and the de-watering process at Greenfield (The lowest point is usually the starting point of every sewer installation).
    - 2 Days
- Drill shaft execution will be 10 working days plus 2 (As a 20%) breakdown time. 7 days must rest the first drilled shaft so a Manhole can be set upon it. If the contractors are well coordinated, upon day 8th the utility contractor should be ready to start. Time until start of sewer works:
    - 7 days (Also the same time needed for the first de-watering system installed to work)

- Utility installation as commented on the dewatering appendix will be adding a 20% time of breakdown as well:
  - 87 days
- Testing the facility
  - 7 days (Pressure test + Video Camera the whole new line)
- De-mobilizing and traffic control removal
  - 2 days

The final computation of all this dates will be further commented and presented on the work plan.

Total execution term = 105 days (around 3 and a half months).

- **Earth Hauled off-site:**

This parameter will remain the same one as used in the previous preliminary alternative analysis adding only the earth hauled from the manhole installation that wasn't accounted on first place. Knowing now how many and how deep they are will be easy to compute this quantity.

Trench spoils: 1236.40 CY

Manhole spoils: 86.25 CY

Total spoils: 1322.65 CY

10.1.2. Functionality

- **Population Adjustment:**

As on the previous appendix study, this parameter will remain the same as before. Either way, once decided what alternative will be finally designed, a study of the lift station must be done as well.

Population adjustment: High

- **Maintenance Cost:**

This parameter will remain the same as well. There has been no change in the diameter, grade or alignment to this alternative.

Maintenance Cost: $44,030.23

10.1.3. Environmental Impact

- **Length:**

Total Trench Length = 2725.13 LF

- **Easements:**

Easements crossed = 1 Parcels

- **Social Impact:**

This impact will be considered among the linear footage that the works affects to existing roads and streets. A industrial Street will have a factor of 1 and a residential on a factor of 0.8 on the footage.

Total LF of Alternative 3 performed in a road = 511.78 LF

10.1.4. Economical Cost

This time a more accurate budget will be generated with the cost of all geotechnical provisions already studied in previous appendix and sewer parts.

Greenfield Avenue Alternative Budget						
Item	**Quantity**	**Unit**	**Unit Cost**		**Total**	
18" PVC Sewer Pipe	2695.13	LF	$	65.00	$	175,183.45
18" DIP Sewer Carrier Pipe	30.00	LF	$	145.00	$	4,350.00
30" Casing by Open Cut	30.00	LF	$	200.00	$	6,000.00
4' Manhole	10.00	EA	$	4,300.00	$	43,000.00
Sewer Service, Reconnection	7.00	EA	$	650.00	$	4,550.00
10' Wide Asphalt Pvmt Repair, Residential	200.00	LF	$	80.00	$	16,000.00
6" Conc Curb and Gutter	100.00	LF	$	22.00	$	2,200.00
Concrete Pavement Repair	434.00	SY	$	110.00	$	47,740.00
Concrete Sidewalk Repair	45.00	SY	$	54.00	$	2,430.00
Trench Safety	2725.13	LF	$	4.04	$	11,009.53
Exploratory Excavation of Existing Utilities	15.00	EA	$	750.00	$	11,250.00
Utility Markers	1.00	EA	$	750.00	$	750.00
Bypass Pumping	1.00	LS	$	20,000.00	$	20,000.00
Epoxy Coat 4' Dia WWMH	87.00	VF	$	225.00	$	19,575.00
CCTV	2725.13	LF	$	3.25	$	8,856.67
Dewatering (Subcontractor up to 87 days)	1.00	LS	$	301,365.47	$	301,365.47
Drill Shaft (At every Manhole)	1.00	LS	$	81,368.71	$	81,368.71
			TOTAL Cost		$	755,628.83

Table 2. Greenfield Avenue Alternative Budget.

*Economical Cost = **$755,628.83** (Cost includes all Geotechnical provision and actions)*

10.2. Mony Street Alternative Attributes

The second alignment and last to be considered in this appendix is: The Mony Street alignment.

10.2.1. Execution

- **Execution Term:**

No sheet pilling will be used to build this new sewer line through this alignment. As commented before we will use de-watering plus a trench shield and the new construction pace will be increased up to 50LF a day.

With this new parameter let's estimate the execution term.

- Traffic Control to be set at Mony and Pharr to start the Drill shafts and the de-watering process at Mony (The lowest point is usually the starting point of every sewer installation).
    - 3 Days
- Drill shaft execution will be 11 working days plus 2 (As a 20%) breakdown time. 7 days must rest the first drilled shaft so a Manhole can be set upon it. If the contractors are well coordinated, upon day 8th the utility contractor should be ready to start. Time until start of sewer works:
    - 7 days (Also the same time needed for the first de-watering system installed to work)
- Utility installation as commented on the dewatering appendix will be adding a 20% time of breakdown as well:
    - 98 days
- Testing the facility

- 7 days (Pressure test + Video Camera the whole new line)

- De-mobilizing and traffic control removal
  - 2 days

The final computation of all this dates will be further commented and presented on the work plan.

Total execution term = 117 days (around 4 months).

- **Earth Hauled off-site:**

Trench spoils: 1386.91 CY

Manhole spoils: 86.30 CY

Total spoils: 1473.22 CY

10.2.2. Functionality

- **Population Adjustment:**

Population adjustment: High

- **Maintenance Cost:**

This parameter will remain the same as well. There has been no change in the diameter, grade or alignment to this alternative.

Maintenance Cost: $49,103.00

10.2.3. Environmental Impact

- **Length:**

Total Trench Length = 3056.86 LF

- **Easements:**

Easements crossed = 1 Parcels

- **Social Impact:**

This impact will be considered among the linear footage that the works affects to existing roads and streets. A industrial Street will have a factor of 1 and a residential on a factor of 0.8 on the footage.

Total LF of Alternative 3 performed in a road = 1,053.00 LF

10.2.4. Economical Cost

This time a more accurate budget will be generated with the cost of all geotechnical provisions already studied in previous appendix and sewer parts.

Mony Street Alternative Budget						
Item	**Quantity**	**Unit**		**Unit Cost**		**Total**
8" PVC Sewer Pipe	437.86	LF	$	65.00	$	28,460.90
18" PVC Sewer Pipe	2619.00	LF	$	48.00	$	125,712.00
18" DIP Sewer Carrier Pipe	30.00	LF	$	145.00	$	4,350.00
30" Casing by Open Cut	30.00	LF	$	200.00	$	6,000.00
4' Manhole	11.00	EA	$	4,300.00	$	47,300.00
Sewer Service, Reconnection	7.00	EA	$	650.00	$	4,550.00
10' Wide Asphalt Pvmt Repair, Residential	0.00	LF	$	80.00	$	-
6" Conc Curb and Gutter	90.00	LF	$	22.00	$	1,980.00
Concrete Pavement Repair	743.30	SY	$	110.00	$	81,763.00
Concrete Sidewalk Repair	35.00	SY	$	54.00	$	1,890.00
Trench Safety	3056.86	LF	$	4.04	$	12,349.71
Exploratory Excavation of Existing Utilities	20.00	EA	$	750.00	$	15,000.00
Utility Markers	1.00	EA	$	750.00	$	750.00
Bypass Pumping	1.00	LS	$	20,000.00	$	20,000.00
Epoxy Coat 4' Dia WWMH	104.31	VF	$	225.00	$	23,469.75
CCTV	3056.86	LF	$	3.25	$	9,934.80
Dewatering (Subcontractor up to 98 days)	1.00	LS	$	369,493.34	$	369,493.34
Drill Shaft (At every Manhole)	1.00	LS	$	92,282.63	$	92,282.63
				TOTAL Cost	$	816,825.23

Table 3. Mony Street Alternative Budget.

Economical Cost = ***$816,825.23*** *(Cost includes all Geotechnical provision and actions)*

10.3. Alternative Analysis

Please find below the parameter values for each criteria.

10.3.1. EXECUTION

	Alt. 1		Alt. 2	
	Value	Cost	Value	Cost
Execution Term	**105**	**1**	**117**	**10**
Earth removal	**1236.4**	1	1,473.22	10
Total Cost	2		20	

Table 4. Execution parameter values.

10.3.2. FUNCTIONALITY

	Alt. 1		Alt. 2	
	Value	Cost	Value	Cost
Poblation adjustment	**High**	**1**	**High**	**1**
Maintenance Cost	**44,030.23**	1	49,103.00	10
Total Cost	2		11	

Table 5. Functionality parameter values.

10.3.3. ENVIRONMENTAL IMPACT

	Alt. 1		Alt. 2	
	Value	Cost	Value	Cost
Length (LF)	**2725.13**	**1**	**3056.86**	**10**
Easements (EA)	**1**	**1**	**1**	**1**
Social Impact (LF)	**511.78**	1	1,053.00	10
Total Cost	3		21	

Table 6. Environmental Impact parameter values.

10.3.4. ECONOMICAL COST

	Alt. 1		Alt. 2	
	Value	**Cost**	**Value**	**Cost**
Initial Investment ($)	**755,628.83**	1.00	816,825.23	10.00
Total Cost	**1**		10	

Table 7. Economical cost parameter values.

10.4. Conclusion

At this point, it is not even worthy to go through all the Matrix I to Matrix III process because Greenfield alternative outnumber or even Mony alternative in all criteria parameters. This makes an easy final decision.

The Alignment to be designed will be the **GREENFIELD AVENUE ALTERNATIVE.**

Appendix No. 11:

<u>Lift Station Flow Calculation</u>

Appendix No. 11: Lift Station Flow Calculation

INDEX - APPENDIX NO. 11: LIFT STATION FLOW CALCULATION

INDEX - FIGURE AND TABLE

11. Greenway Place Lift Station Analysis

The purpose of this Appendix is to analyze if the existing Greenway Place Lift Station has the capacity to handle the additional flow from the area shown in yellow at annex 11.1. There is an existing 24" sewer main (M-267, X-18382) that crosses IH-35W near Greenfield Ave. and currently handles the flow from the area shown in yellow in Figure 1. As part of the utility relocation related to the IH-35W expansion, the existing 24" sewer main (M-267, X-18382) is proposed to be taken out of service. In order to do this, additional flow will be routed to the Greenway Place Lift Station.

South of Pharr Street, a 6" sewer lateral (L-3484, X-3484) and 10" sewer main (M-2332, X-2332) will be redirected as well towards the Lift Station and therefore.

11.1. Potential Flow

In order to determine the potential flow that would be conveyed into the existing Greenway Place Lift Station, a sewer basin analysis was performed (see Annex 11.1). According to the 2012 Wastewater Master Plan Hydraulic Model, peak flow values were taken at four locations. The first location modeled the wastewater flow just upstream of the existing Greenway Place Lift Station. The second location modeled the wastewater flow going through the existing 24" sewer main (M-267, X-18382) just before entering into the existing 68" sewer main (M-245-B, X-14471). Third and fourth location modeled the flow that would flow through existing 42" sewer main (M-1-I-1, X-13685) through 6" sewer lateral (L-3484, X-3484) and 10" sewer main (M-2332, X-2332).

Existing Peak Flow into Greenway Place Lift Station		**Peak Flow through 24" Sewer Main (M-267, X-18382)**		**Peak Flow through 6" Sewer Lateral (L-3484, X-3484)**	
Planning Period	Flow	Planning Period	Flow	Planning Period	Flow
Existing	0.53 MGD	Existing	0.145 MGD	Existing	0.045 MGD
2030	1.22 MGD	2030	0.173 MGD	2030	0.054 MGD

Table 1. 2012 Wastewater Master Hydraulic Model Peak Wet Weather Flow (Part 1).

Peak Flow through 10" Sewer Main (M-2332, X-2332)		Combined Peak Flow into Greenway Place Lift Station	
Planning Period	Flow	Planning Period	Flow
Existing	0.034 MGD	Existing	0.754 MGD
2030	0.041 MGD	2030	1.488 MGD

Table 2. 2012 Wastewater Master Hydraulic Model Peak Wet Weather Flow (Part 2).

Based on the hydraulic model, the design peak wet-weather flow with the additional M-267 and upper M-1-I-1 drainage area is 1.488 million gallons a day (MGD).

11.2. Pump Capacity

According to the record drawings (X-18585), Greenway Place Lift Station has two existing 1,300 gallons per minute (gpm) submersible pumps (see Record Drawing at annex 11.2). With one pump out of service, the firm capacity of the lift station is 1,300 gpm or 1.87 MGD. This pump capacity is more than the projected 2030 design peak wet weather flow of 1.488 MGD.

11.3. Wet Well Size

The wet well size (5.78' H X 15' W X 12' D) of the existing Greenway Place Lift Station has an active storage volume capacity of 1,040.4 cubic feet. The vertical component of the active volume storage was determined by taking the difference between the 18" pipe invert (FL=502.28) and the pump off elevation (EL=496.50).

Vertical Component of Active Storage Volume, 502.28 - 496.50 = 5.78

Based on the Greenway Place Lift Station pump capacity of 1,300 gpm and a minimum cycle run time of 6 minutes, the active volume required according to TCEQ 217.60 is 261 cubic feet. See equation below:

$$V = \frac{T \cdot Q}{4 \cdot 7.48}$$

Where: V = Active Volume (Cubic feet)
Q = Pump Capacity (Gallons per minute)
T = Cycle time (minutes)
7.48 = Conversion factor (gallons/cubic foot)

The wet well volume currently provide by the Greenway Place Lift Station meets the minimum requirements per TCEQ 217.60.

11.4. Conclusion

After looking at the pump and wet well capacity, the Greenway Place Lift Station has the capacity to handle the additional wastewater flow from the proposed wastewater system changes.

ANNEX 11.1 – ADDITIONAL FLOW INFLUENCE AREA

Kimley-Horn and Associates, Inc.

No.	Revision	By	Date

THIS DOCUMENT IS INCOMPLETE AND RELEASED TEMPORARILY FOR INTERIM REVIEW ONLY. IT IS NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES
RYAN D. OWEN P.E.
SERIAL NO. 109586
DATE: MARCH 2012

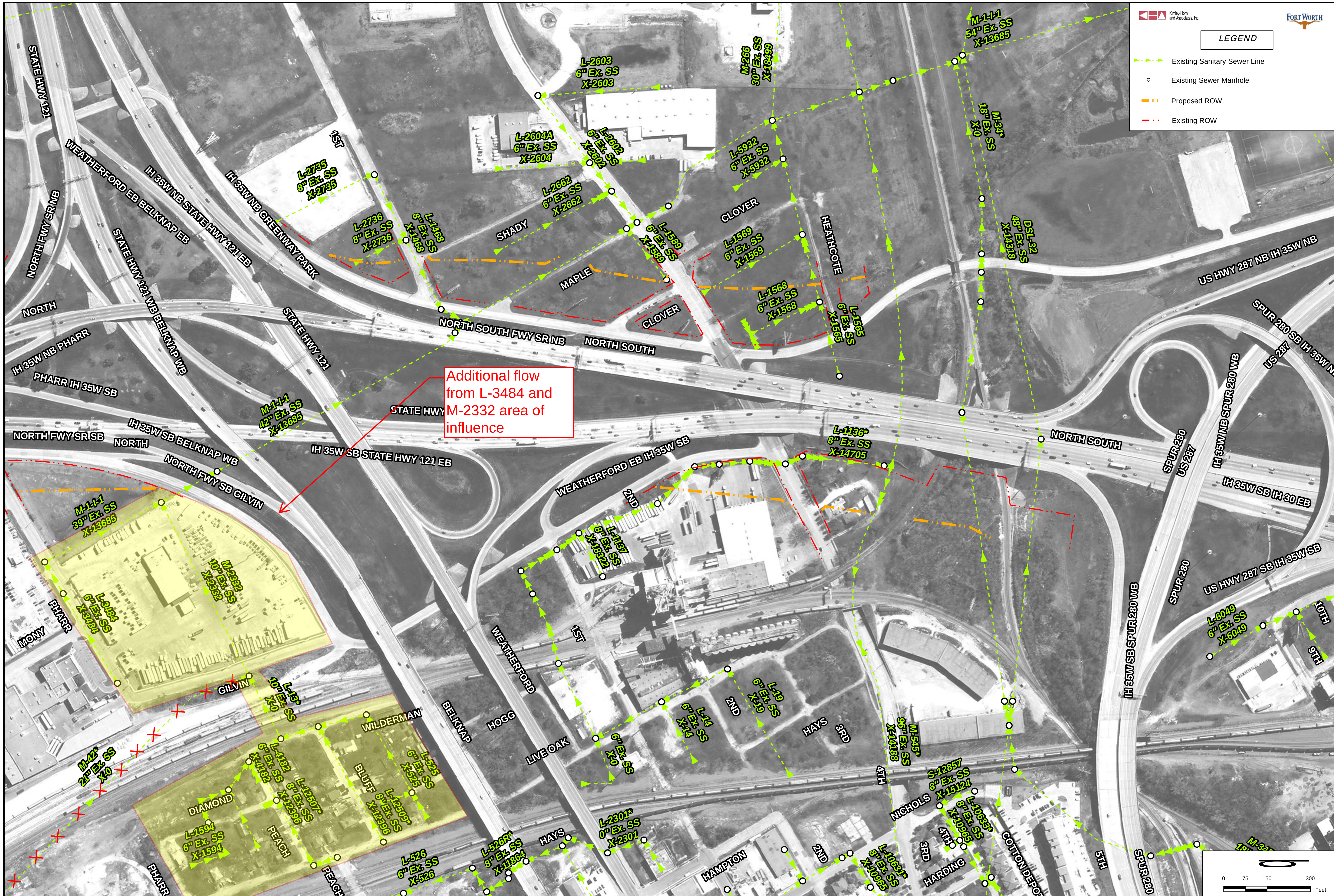
CITY OF FORT WORTH
NORTH TARRANT EXPRESS
SEGMENT 3A
WATER AND SANITARY SEWER CONFLICT ANALYSIS

CONCEPTUAL
PART 3A-9-TRINITY RIVER
EXISTING SEWER

DATE:	MAR 2012
DESIGN:	RDO
DRAWN:	CPI
CHECKED:	CTD
KHA NO.:	061018090

SHEET
9

K:\FTW_Utilities\061018090\GIS\MAPS\SEG_3A\FW-Water-Sewer-SEG3A- PART 3A-9.mxd



Kimley-Horn and Associates, Inc.

No.	Revision	By	Date

THIS DOCUMENT IS INCOMPLETE AND RELEASED TEMPORARILY FOR INTERIM REVIEW ONLY. IT IS NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES
RYAN D. OWEN P.E.
SERIAL NO. 109586
DATE: MARCH 2012

CITY OF FORT WORTH
NORTH TARRANT EXPRESS SEGMENT 3A
WATER AND SANITARY SEWER CONFLICT ANALYSIS

CONCEPTUAL
PART 3A-10-4th STREET
EXISTING SEWER

DATE:	MAR 2012
DESIGN:	RDO
DRAWN:	CPI
CHECKED:	CTD
KHA NO.:	061018090

SHEET
10

K:\FTW_Utilities\061018090\GIS\MAPS\SEG_3A\FW-Water-Sewer-SEG3A- PART 3A-10.mxd

ANNEX 11.2 – LIFT STATION RECORD DRAWINGS (PARTIAL)

X-18585

S-13005

(9)

THE CITY OF FORT WORTH, TEXA

DEPARTMENT OF ENGINEERING

FORT WORTH

WATER

PLANS FOR THE CONSTRUCTION OF SANITARY SEWER LIFT STATION TO SERVE GREENWAY PLACE ADDITION

RECORD [illegible] INGS

Job Foreman had field [illegible] ngs.
Recommend these drawings [illegible] turned ov [illegible]

MIKE MONCRIEF
MAYOR

GARY W. JACKSON
CITY MANAGER

DALE A. FISSELER, P.E.
WATER DEPARTMENT DIRECTOR

ROBERT D. GOODE, P.E.
TRANSPORTATION AND PUBLIC WORKS DIRECTOR

LOCATION MAP

7/1/03
S. FRANK CRUMB, P.E.
[illegible]SISTANT DIRECTOR, WATER DEPARTMENT

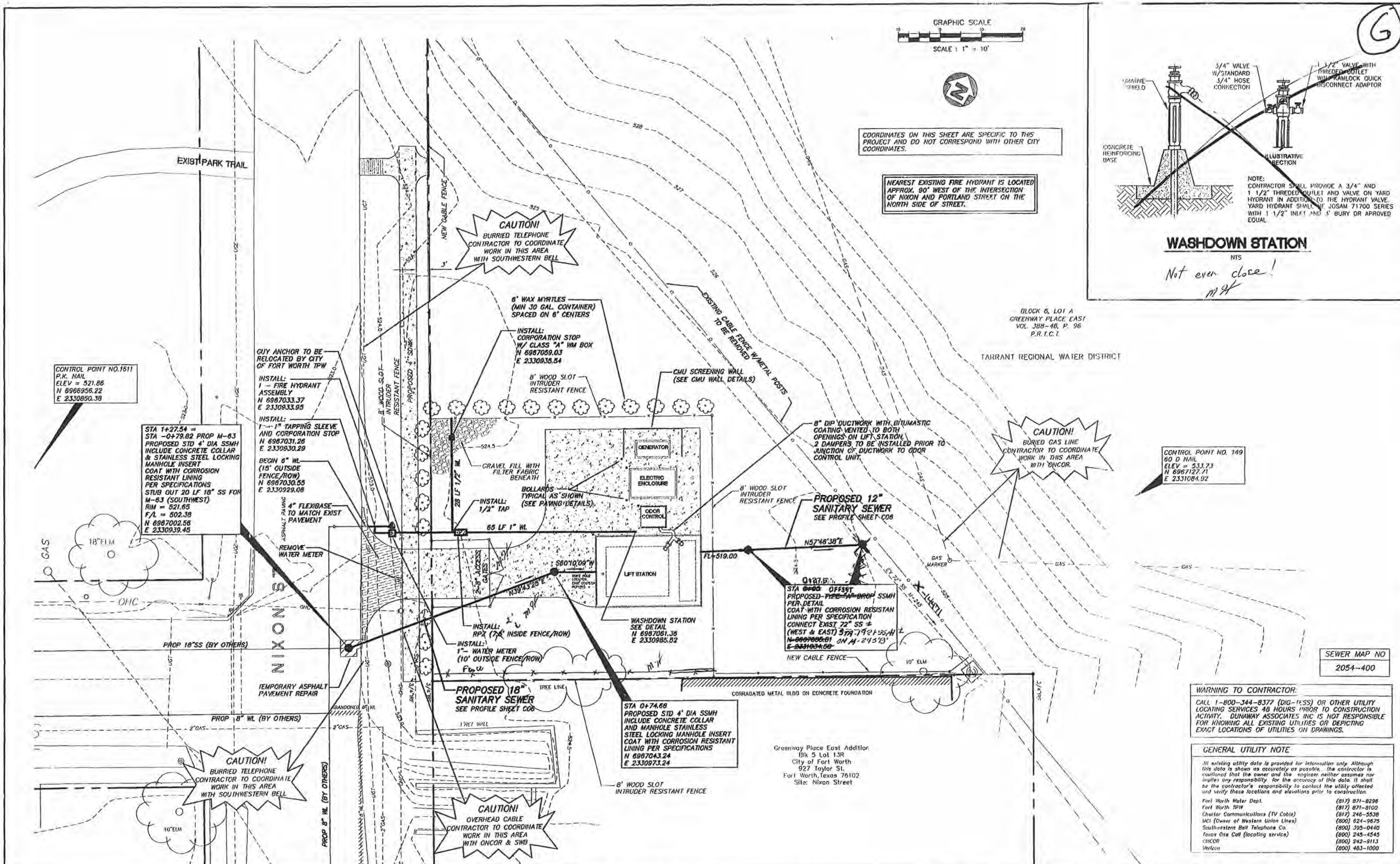
PROJECT NUMBER PS58 - 070580175450

Dunaway Associates, Inc. | Engineers Planners Surveyors Landscape Architects

STATE OF TEXAS
BRIAN S. DARBY
82623
REGISTERED PROFESSIONAL ENGINEER
6/5/3
RECORD DRAWING

2003

X-18585 40



NO	REVISION	BY	DATE

IPV DESIGNED
IPV DRAWN
BSD CHECKED

FORT WORTH WATER

Scale	Date
HORIZ 1"= 10' VERT NA	2003
Project Number P558-070580175450	

Dunaway Associates, Inc. — Engineers, Planners, Surveyors, Landscape Architects

1801 Merrimac Circle, Ste. 100 Fort Worth, TX 76107 Ph: 817.335.1121 Metro: 817.429.2136 Fax: 817.335.7437

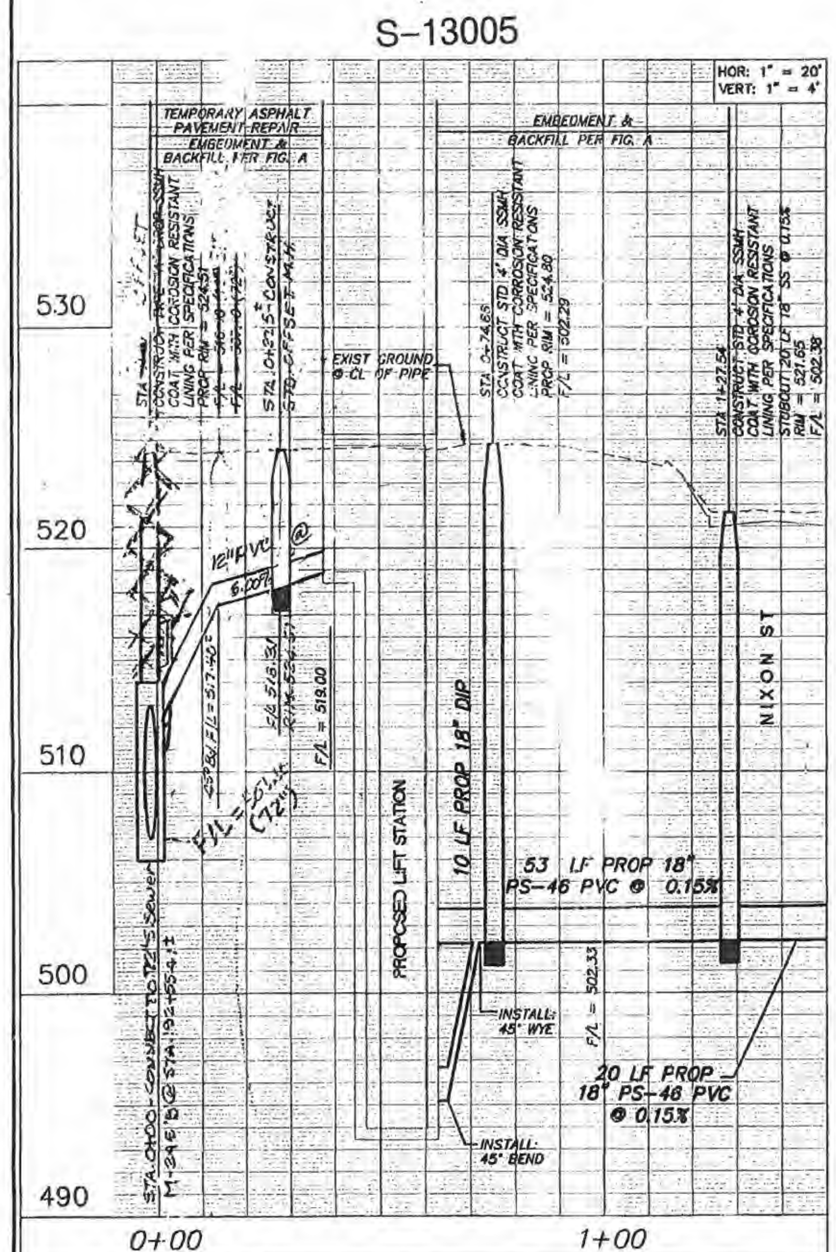
STATE OF TEXAS — BRIAN S. DARBY — 82623 — REGISTERED PROFESSIONAL ENGINEER

PROJECT ENGINEER
DATE 7/14/3

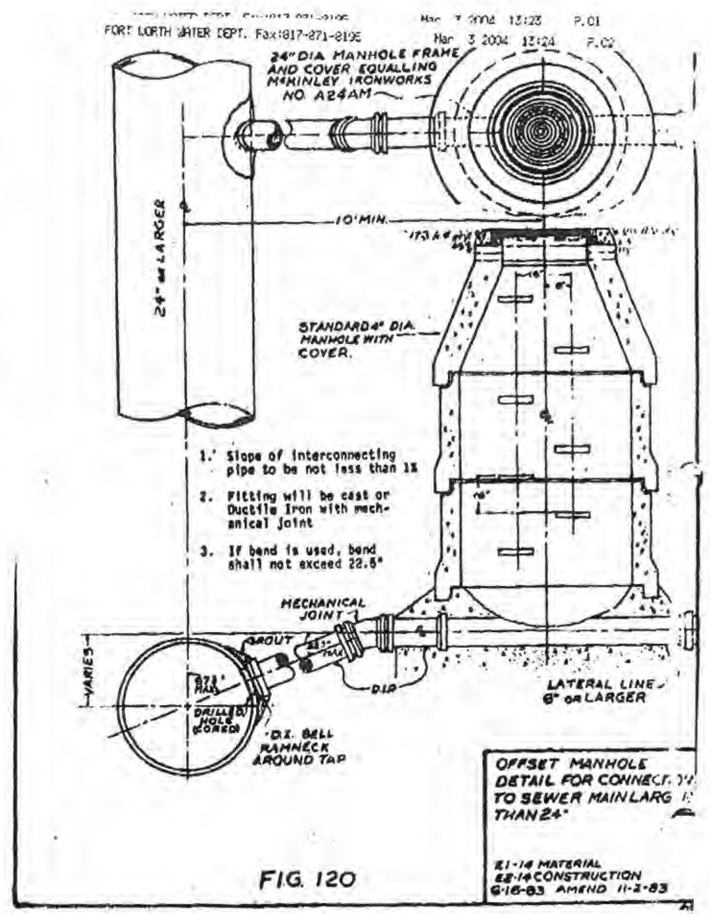
CITY OF FORT WORTH, TEXAS
GREENWAY PLACE ADDITION LIFT STATION
SITE PLAN

DAI PROJECT 2001089-02
SHEET C04

(6)

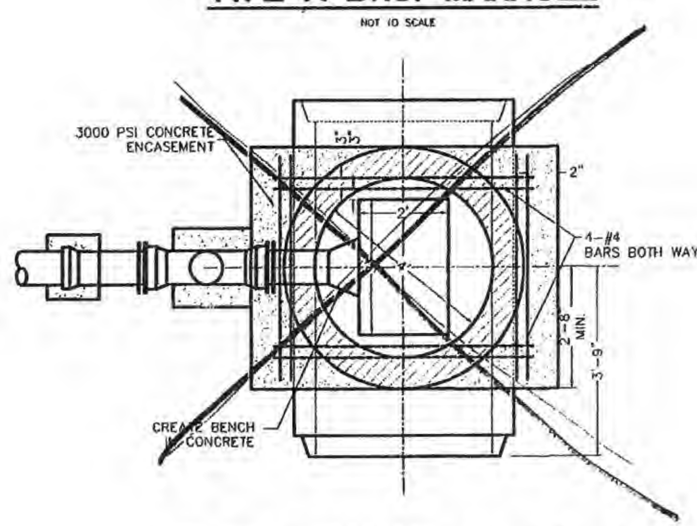


SANITARY SEWER LINE PROFILE



TYPE "A" DROP MANHOLE

NOT TO SCALE

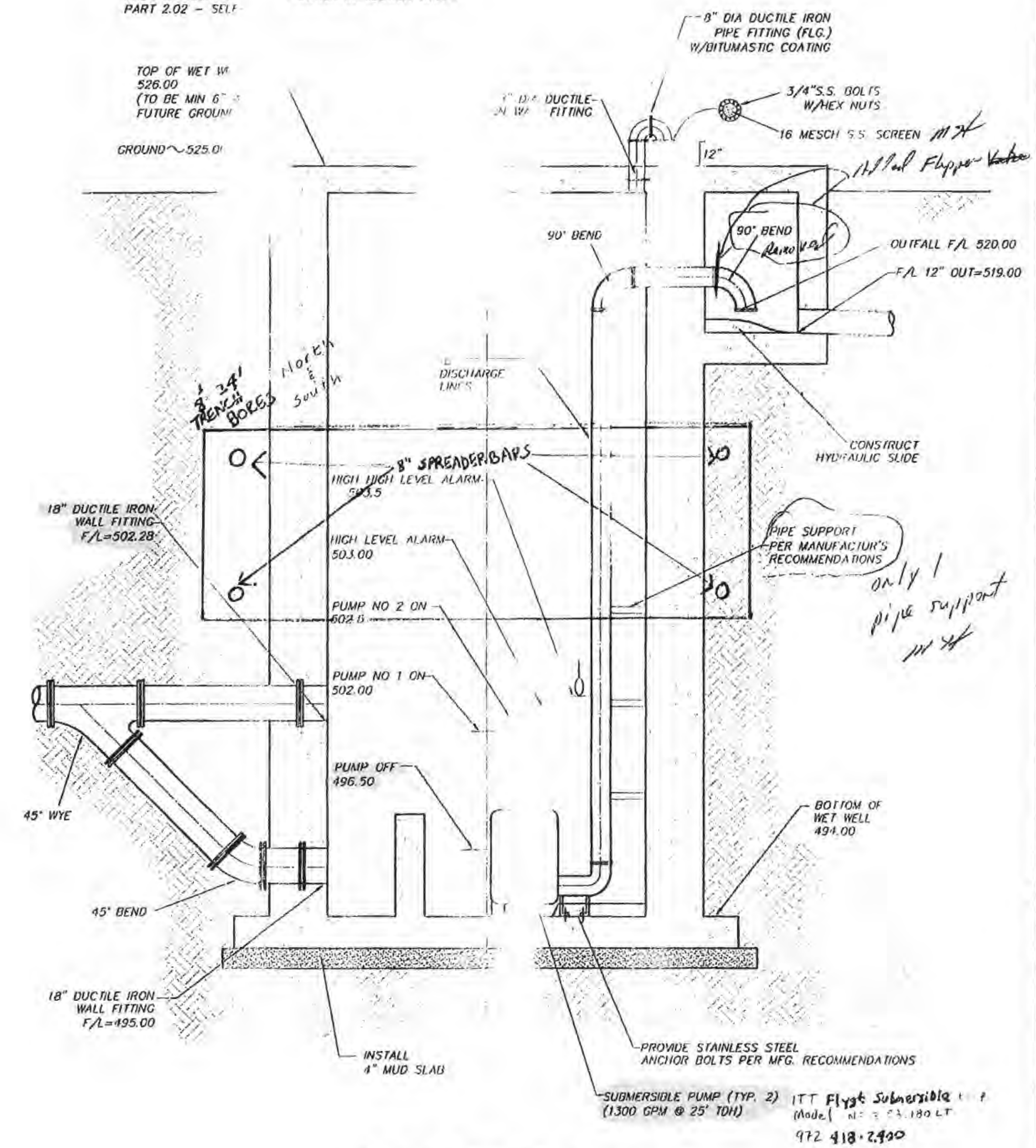


PLAN VIEW MANHOLE ACCESS

NOT TO SCALE

NOTES:

1. THE CONTRACTOR SH... RESPONSIBLE FOR FINISHING ITEMS FOR A COMPLETE INSTALLATION OF THE LIFT STATION
2. COAT ALL INTERIOR WA... WET WELL AND DISCHARGE ... CORROSION RESISTAN...
3. THE CONTRACTOR SHA... USE FLANGED PIPING WITHIN ... PIPING SHALL BE HIGH... SUPPORTED TO THE WET WELL ... MOVEMENT.
4. THE CONTRACTOR SHALL INCORPORATE AN OSHA COMP... TRENCH SAFETY SYSTEM FOR ...ERATIONS ASSOCIATED WITH ... CONSTRUCTION OF ... STATION WET WELL.
5. BACKFILL TO BE PE... ...CIFICATIONS IN GEOTECHNICAL PART 5.0 EARTHW... 5.2 PLACEMENT AND COM... AND PER TECHNICA... ...CATION IN SECTION 02220 PART 2.02 – SEL...
6. MANHOLE FRAME AND COVER F... DISCHARGE CHAMBER TO BE PER CITY OF F... WORTH STANDARD MATERIALS AND CONSTRUCTION. CASTING AND REINFORCING PER STRUCTURAL DETAILS IN PLANS.



LIFT STATION - SECTION

NOT TO SCALE

NO	REVISION	BY	DATE

DESIGNED: IPV
DRAWN: BSD
CHECKED

FORT WORTH WATER

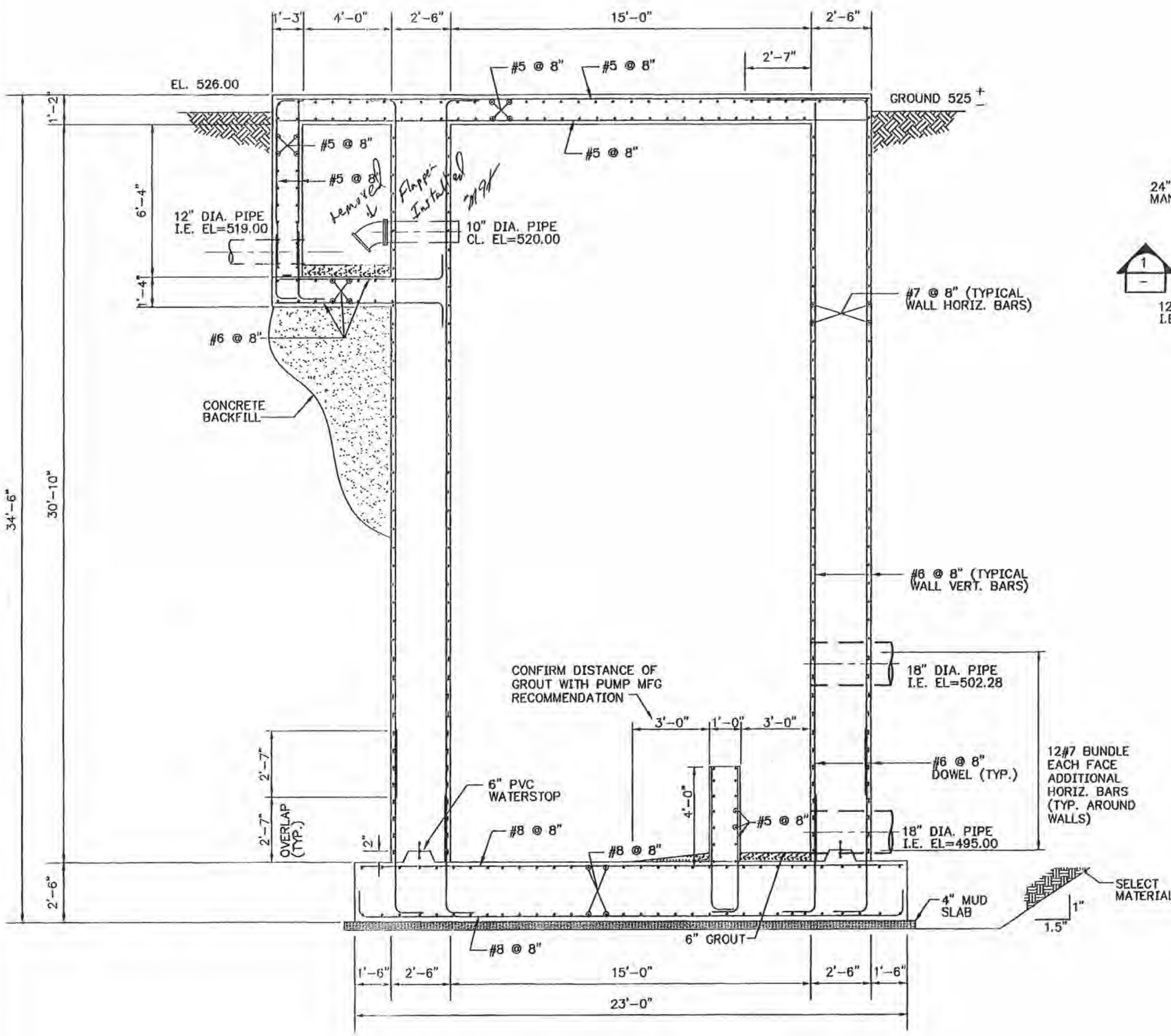
Scale	Date
HORIZ 1"= 5' VERT NA	2003
Project Number PS58-070580175450	

Dunaway Associates, Inc. — Engineers, Planners, Surveyors, Landscape Architects
1501 Merrimac Circle, Ste. 100 Fort Worth, TX 76107 Ph: 817.335.1121 Metro: 817.429.2135 Fax: 817.335.7437

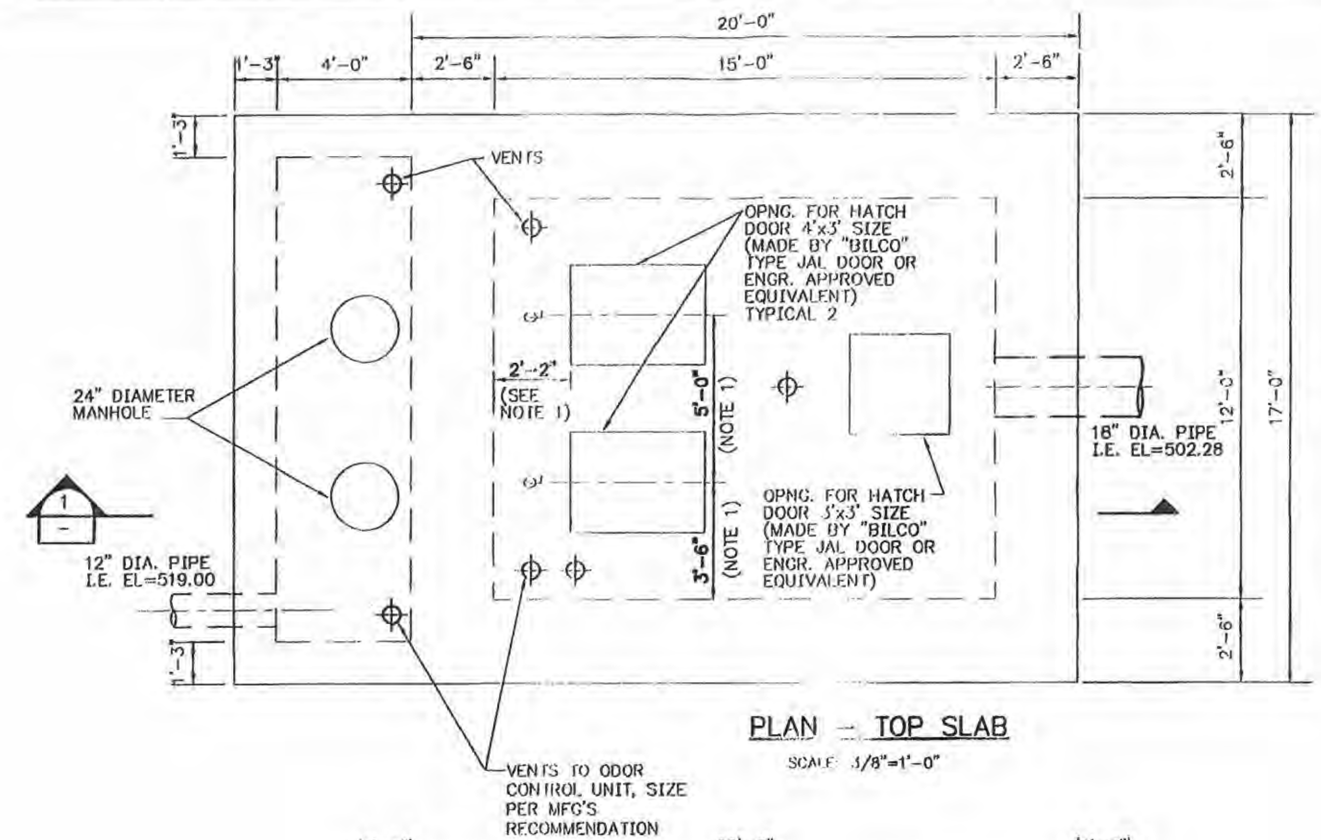
STATE OF TEXAS — BRIAN S. DARBY — 82623 — REGISTERED PROFESSIONAL ENGINEER
PROJECT ENGINEER
DATE 7/14/3

CITY OF FORT WORTH, TEXAS
GREENWAY PLACE ADDITION LIFT STATION
SANITARY SEWER PROFILE AND DETAILS

DAI PROJECT 2001089-02
SHEET C06

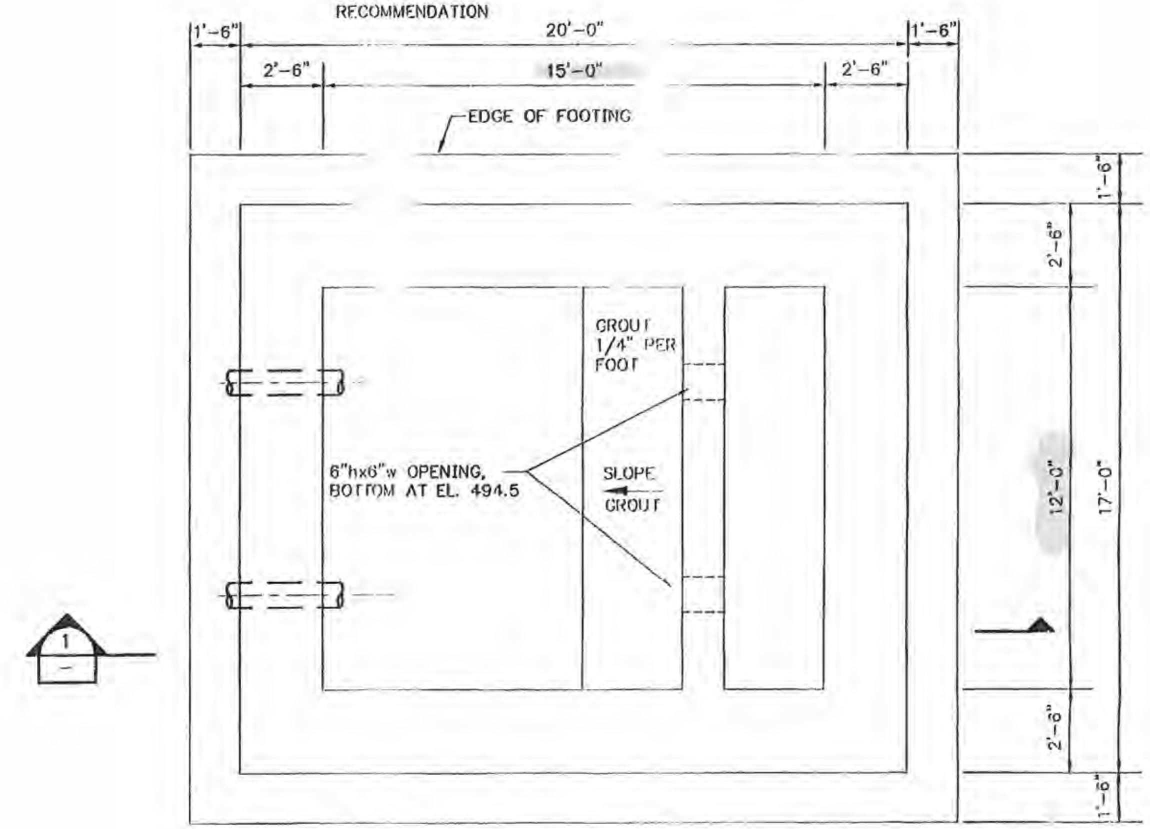


1 SECTION



PLAN – TOP SLAB

SCALE: 3/8"=1'-0"



PLAN – BOTTOM SLAB

SCALE: 3/8"=1'-0"

NOTES:

1. DIMENSION FOR PUMP ACCESS HATCH DOOR SHALL BE LOCATED PER PUMP MANUFACTURER SHOP DWGS.

STATE OF TEXAS
JASON L. HO
84469
LICENSED
PROFESSIONAL ENGINEER
7-15-03

CP&Y
Chiang, Patel & Yerby, Inc.

NO	REVISION	BY	DATE

DGS DESIGNED
DGS DRAWN
PNM CHECKED

FORT WORTH WATER

Scale	Date
HORIZ NONE VERT NONE	MAY 2003
Project Number P558-070580176480	

Dunaway Associates, Inc.
Engineers
Planners
Surveyors
Landscape Architects

1601 Merrimac Circle, Ste. 100 Fort Worth, TX 76107 Ph: 817.335.1121 Metro: 817.429.2138 Fax: 817.335.7437

CITY OF FORT WORTH, TEXAS
GREENWAY PLACE ADDITION LIFT STATION
STRUCTURAL LIFT STATION PLAN

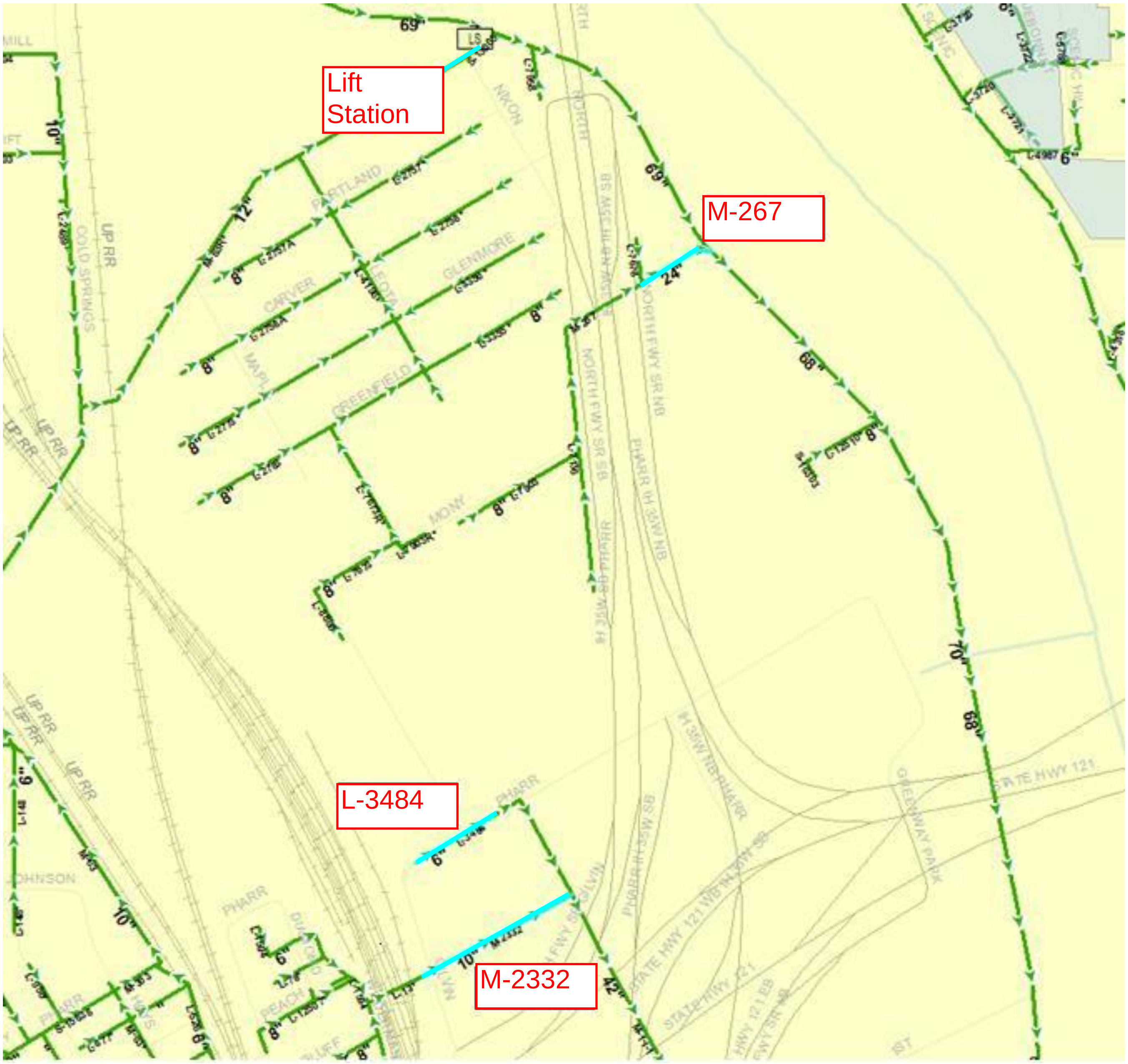
DAI PROJECT 2001089-02

SHEET S-1

ANNEX 11.3 – INFORMATION REQUESTED TO CITY OF FORT WORTH

Casals 47607 Response.

Lift Station (2012) – 0.53 MGD | 368 gpm	&	Lift Station (2030) – 1.22 MGD | 847 gpm
M-2267 (2012) - 0.1448 MGD | 101 gpm	&	M-2267 (2030) - 0.173 MGD | 120 gpm
M-2332 (2012) – 0.0342 MGD | 24 gpm	&	M-2332 (2030) – 0.041 MGD | 28 gpm
L-3484 (2012) – 0.0447 MGD | 31 gpm	&	L-3484 (2030) – 0.054 MGD | 38 gpm



Appendix No. 12:

Quality Control

INDEX - APPENDIX NO. 12: QUALITY CONTROL

INDEX - FIGURE AND TABLE

11. Quality Plan

There are a lot of quality controls to be implemented any construction work. In regards a sewer installation, concrete, pipe quality and soil compaction are the most important ones. Although, every specification might have a specific quality control assurance prior to implementation or while in the field that must be considered as well.

A Quality Plan must be provided by awarded subcontractor in reference of their willing to build in a good quality manner assuming his client specifications. A sample of quality plan can be found at Annex 11.1 – Contractor Quality assurance and quality control Manual.

11.1. Concrete Quality Assurance

Concrete is controlled basically when comes on-site. It is then a field quality control. City of Fort Worth usually will engage a special inspector and qualified testing agency to perform field test and inspections. In our case, as long as this is a TxDOT Project, General contractor is in charge of taking care of all quality assurance inspector and testing agencies.

11.1.1. Inspections

- Steel reinforcement placement.
- Headed bolts and studs.
- Verification of use of required design mixture.
- Concrete placement, including conveying and depositing.
- Curing procedures and maintenance of curing temperature.
- Verification of concrete strength before removal of shores and forms from beams and slabs

11.1.2. Concrete Test

Perform testing of composite samples of fresh concrete obtained according to ASTM C172 according to the following requirements:

1. Testing Frequency: Obtain 1 composite sample for each day's pour of each concrete mixture exceeding 5 cubic yard, but less

than 25 cubic yard, plus 1 set for each additional 50 cubic yard or fraction thereof.

2. Slump: ASTM C143; 1 test at point of placement for each composite sample, but not less than 1 test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C231, pressure method, for normal-weight concrete; 1 test for each composite sample, but not less than 1 test for each day's pour of each concrete mixture.

4. Concrete Temperature: ASTM C1064; 1 test hourly when air temperature is 40 degrees Fahrenheit and below and when 80 degrees Fahrenheit and above, and 1 test for each composite sample.

5. Compression Test Specimens: ASTM C31. (Cast and laboratory cure 4 cylinders for each composite sample)

6. Compressive-Strength Tests: ASTM C39;

    a. Test 1 cylinder at 7 days.

    b. Test 2 cylinder at 28 days.

    c. Hold 1 cylinder for testing at 56 days as needed.

7. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate operations and provide corrective procedures for protecting and curing in-place concrete.

8. Strength of each concrete mixture will be satisfactory if every average of any 3 consecutive compressive-strength tests equals or

exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

9. Report test results in writing to Engineer, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

10. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Engineer. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42 or by other methods as directed by Engineer.

    a. When the strength level of the concrete for any portion of the structure, as indicated by cylinder tests, falls below the specified requirements, provide improved curing conditions and/or adjustments to the mix design as required to obtain the required strength. If the average strength of the laboratory control cylinders falls so low as to be deemed unacceptable, follow the core test procedure set forth in ACI 301, Chapter 17. Locations of core tests shall be approved by the Engineer. Core sampling and testing shall be at Contractors expense.

b. If the results of the core tests indicate that the strength of the structure is inadequate, any replacement, load testing, or strengthening as may be ordered by the Engineer shall be provided by the Contractor without cost to the City.

11. Measure floor and slab flatness and levelness according to ASTM E1155 within 48 hours of finishing.

11.2. Sewer and Manhole Testing

There are three kind of test that must be perform to new sewer pipes and manholes: Low Pressure Air Test (Pipe), Deflection test (Pipe) and Vacuum test (Manhole).

11.2.1. Low Pressure Air Test (Pipe)

First of all, as a preparation for this test, Clean the sewer main before testing, as outlined in Section 33 04 50 and plug ends of all branches, laterals, tees, wyes, and stubs to be included in test. The end plug must have an inlet tap.

Connect air hose to inlet tap and a portable air control source and After the stabilization period (3.5 psig minimum pressure) start the stop watch. Determine time in seconds that is required for the internal air pressure to reach 2.5 psig. Minimum permissible pressure holding time per diameter per length of pipe is computed from the following equation:

$$T = \frac{(0.085 * D * K)}{Q}$$

Where;

T = shortest time, seconds, allowed for air pressure to drop to 1.0 psig.

K = 0.000419*D*L, but not less than 1.0.

D = nominal pipe diameter, inches.

L = length of pipe being tested (by pipe size), feet.

Q = 0.0015, cubic feet per minute per square foot of internal surface.

Stop test if no pressure loss has occurred during the first 25 percent of the calculated testing time.

11.2.2. Deflection (or Mandrel) Test (Pipe)

This test is to performed as last work item before final inspection. Clean the sewer main and inspect for offset and obstruction prior to testing.

The materials used to do this test are:

- Use of an uncertified mandrel or a mandrel altered or modified after certification will invalidate the deflection test.
- Mandrel Requirements:
  - Odd number of legs with 9 legs minimum
  - Effective length not less than its nominal diameter
  - Fabricated of rigid and nonadjustable steel
  - Fitted with pulling rings and each end
  - Stamped or engraved on some segment other than a runner indicating the following:
    - Pipe material specification
    - Nominal size
    - Mandrel outside diameter (OD)
  - Mandrel diameter must be 95 percent of inside diameter (ID) of pipe.

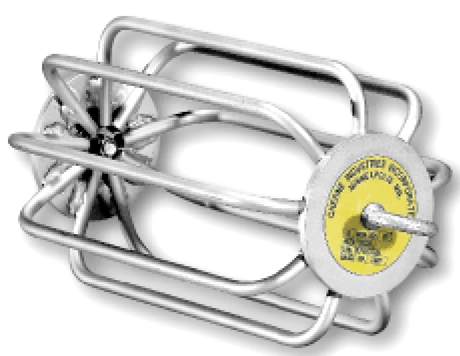


Figure 1. Steel Deflection Gauge - Mandrel Test.

For pipe 36 inches and smaller, the mandrel is pulled through the pipe by hand to ensure that maximum allowable deflection is not exceeded.

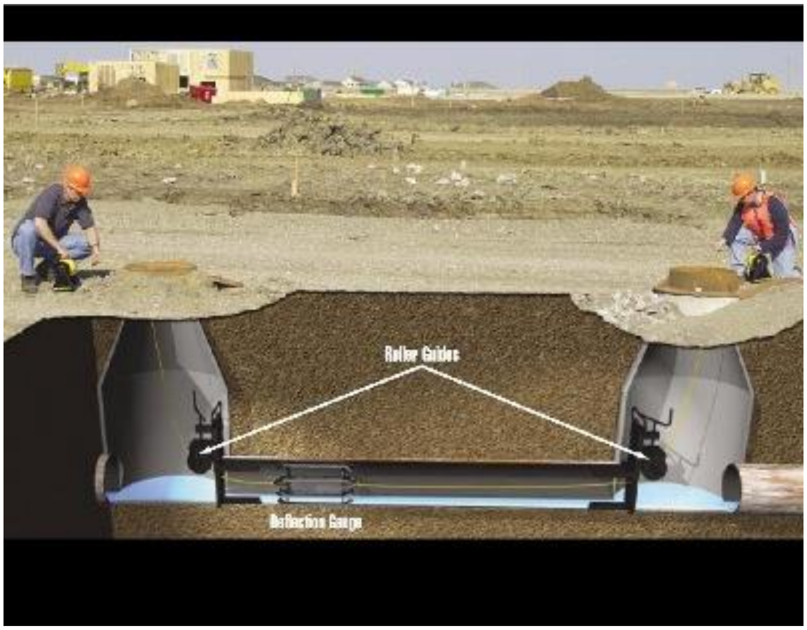


Figure 2. Test Execution - Mandrel Test.

Maximum percent deflection by pipe size is as follows:

Nominal Pipe Size Inches	Percent Deflection Allowed
12 and smaller	5.0
15 through 30	4.0
Greater than 30	3.0

Table 1. Maximum percent deflection - Mandrel Test.

11.2.3. Vacuum test (Manholes)

Prior to start this test plug lifting holes and exterior joints. Plug pipes and stub outs entering the manhole. Secure stub outs, manhole boots, and pipe plugs to prevent movement while vacuum is drawn.

Plug pipes with drop connections beyond drop. Place test head inside the frame at the top of the manhole.

Draw a vacuum of 10 inches of mercury and turn off the pump. With the valve closed, read the level vacuum level after the required test time. The minimum time required for vacuum drop of 1 inch of mercury is as follows:

Depth of Manhole, feet	4-foot Dia Seconds	5-foot Dia Seconds	6-foot Dia Seconds
8	8	8	8
10	10	10	10
12	12	12	12
14	14	14	14
16	16	16	16
18	18	18	18
**	T=5	T=6.5	T=8

Table 2. Minimum time required for Vacuum drop - Vacuum Test.

** For manholes over 18 feet deep, add "T" seconds as shown for each respective diameter for each 2 feet of additional depth of manhole to the time shown for 18 foot depth. (Example: A 30 foot deep, 4-foot diameter. Total test time would be 70 seconds. 40+6*5=70 seconds)

Manhole vacuum levels observed to drop greater than 1 inch of mercury will have failed the test.

11.3. Backfill Quality Control

There are three existing testing methods that must be applied when backfilling the excavation trench.

11.3.1. Proctors

The City will perform Proctors in accordance with ASTM D698. Test results will generally be available to within 4 calendar days and distributed to:

a. Contractor

b. City Project Manager

c. City Inspector

d. Engineer

Contractor must Notify the City if the characteristic of the soil changes and the City will perform new proctors for varying soils:

e. When indicated in the geotechnical investigation

f. If notified by the Contractor

g. At the convenience of the City

Trenches where different soil types are present at different depths, the proctors shall be based on the mixture of those soils.

11.3.2. Density Testing of Backfill

Density Test Shall be in conformance with ASTM D2922. Provide a testing trench protection for trenches deeper than 5 feet. Place, move and remove testing trench protection as necessary to facilitate all test conducted by the City.

For final backfill depths less than 15 feet and trenches of any depth not under existing or future pavement:

a. The City will perform density testing twice per working day when backfilling operations are being conducted.

b. The testing lab shall take a minimum of 3 density tests of the current lift in the available trench.

For final backfill depths greater than 15 feet deep:

c. The City will perform density testing twice per working day when backfilling operations are being conducted.

d. The testing lab shall take a minimum of 3 density tests of the current lift in the available trench.

e. The testing lab will remain onsite sufficient time to test 2 additional lifts.

Contractor has to make the excavation available for testing and the City will determine the location of the test. The City testing lab will provide results to Contractor and the City's Inspector upon completion of the testing. A formal report will be posted to the City's Buzzsaw site within 48 hours. Test reports shall include:

1) Location of test by station number

2) Time and date of test

3) Depth of testing

4) Field moisture

5) Dry density

6) Proctor identifier

7) Percent Proctor Density

11.3.3. Density of Embedment

Storm sewer boxes that are embedded with acceptable backfill material, blended backfill material, cement modified backfill material or select material will follow the same testing procedure as backfill. The City may test fine crushed rock or crushed rock embedment in accordance with ASTM D2922 or ASTM 1556.

ANNEX 11.1 – CONTRACTOR QUALITY ASSURANCE AND QUALITY CONTROL MANUAL

QUALITY ASSURANCE

And

QUALITY CONTROL
MANUAL

Section 1

QUALITY POLICY

AND

AUTHORITY

QUALITY POLICY and AUTHORITY

CONTRACTOR recognizes that in today's competitive marketplace, effective quality systems are essential when providing quality cost effective services to our clients. Management is total committed to providing Public and Private General Contracting Services that comply fully with the specifications and expectations of our valued clients. Therefore, it is the policy of CONTRACTOR to adhere strictly to this quality control program and to insure that this program and the requirements of our customers are met on each and every project we execute.

Full authority for the implementation and administration of the quality controls described in this manual has been delegated to the Quality Control Manager ("QCM"). The QCM has the responsibility and organizational freedom to identify quality control problems, stop work, recommend solutions and verify resolution of such problems. The QCM shall also have the responsibility of documenting the established Quality Assurance/Quality Control Programs in a manner that strives to comply with applicable Quality Systems. The ultimate objective of this company's QA/QC program is to comply fully or surpass the quality standards established by applicable Quality System.

Project Managers are responsible for their assigned project's QA/QC activities. They may delegate the performance of their assigned duties to qualified individuals, but they shall full responsibility for completing their projects in strict accordance with established quality control policies and the client's specifications.

The quality of all subcontractors and vendors shall be the joint responsibility of the QCM and applicable Project Manager. All projects will be executed in a manner that emphasizes safety, quality, schedule and maximum cost effectiveness.

Any commitment, conflicts, or non-conformance issues not resolved using current established Quality Assurance/Quality Control Procedures shall be brought to the attention of the undersigned for final resolution.

President

Section 2

MANGEMENT

RESPONSIBILTY

MANAGEMENT RESPONSIBILITY

2.1 RESPONSIBILITY

Management has the responsibility to define and document its policy and objectives for, and commitment to, quality. Management will ensure that its policy is understood, implemented, and maintained at all levels of the organization.

All employees have the responsibility and authority for implementation of established QA/QC activities. Resolution of conflicts in QA/QC policies shall flow through the organizational chain of command as follows:

1. Field Employees
2. Foreman
3. Superintendents
4. Project Manager (Project QA/QC Manager)
5. President

It is the responsibility of any employee that manages, performs, or verifies work affecting quality to;

a. Initiate action to prevent the occurrence of work or service nonconformity;
b. Identify and record any quality problems;
c. Initiate, recommend, or provide solutions through designated channels;
d. Verify the implementation of solutions;
e. Control further processing, delivery, or installation of non-conforming work until the deficiency or unsatisfactory condition has been corrected.

2.2 ALLOCATION OF RESOURCES AND PERSONNEL

Management shall identify in-house requirements and provide adequate resources and trained personnel as needed to support required QA/QC verification activities. Verification activities shall include inspection, testing and monitoring of the construction / installation processes and audits of the quality systems. These activities shall be carried out by personnel independent of those having direct responsibility for the project being executed.

2.3 MANAGEMENT REVIEW

The established QA/QC policies and procedures shall be reviewed at appropriate intervals by management to ensure continuing suitability and effectiveness. These reviews will include assessment of the results of internal audits and shall assess overa!l conformance to client's requirements and expectations. Records of such reviews and audits shall be maintained.

Section 3

QUALITY SYSTEMS

QUALITY SYSTEMS

CONTRACTOR Contracting Services' staff has established and shall maintain and document this QA/QC system as a means of ensuring that the services we provide our clients conform to specified requirements. This QA/QC system will include:

a) Documented quality system procedures and instructions to ensure that all activities are performed in accordance with established requirements;
b) Effective management support to ensure compliance and the use of the QA/QC procedures and instructions.

All employees of CONTRACTOR Contracting Services shall strive to improve the quality of our services to our clients. The QA/QC program is a process of continuous improvement which requires input from everyone in our organization. Everyone in our organization shall comply and endeavor to improve the process where possible. An effective QA/QC program consists of the following key components:

a) Established QA/QC procedures and instruction that comply with generally accepted industry standards , Federal, State, and Local regulating authorities, and the project specifications and standards established by the client;
b) The identification and timely issuance to the project team any required controls, processes , inspection equipment, fixtures, tools, materials and labor skills needed to properly execute the project;
c) Updating, as necessary, of quality control, inspection, and testing techniques, including the development of new methods and procedures;
d) Identification of any commitments made which exceeds available resources in sufficient time to properly acquire the resources;
e) Clarification of the standards of acceptability as required to support the overall QA/QC program and our client's objectives;
f) Review of the project process, construction , installation, inspection, and test procedures to ensure that the applicable documentation reflects how activities are actually performed;
g) Effective maintenance of quality records to document and track performance and improvement.

The QA/QC manual is not a controlled document. A copy is available to all employees though their immediate supervisor. **The QA/QC manual is designed to convey basic QA/QC procedures and instructions that must be followed by all employees and subcontractors of CONTRACTOR Contracting Services.**

Specific QA/QC procedures and instructions for individual activities are maintained by the QCM/Project Manager as controlled documents. It is the Project Manager's responsibility to ensure specific activity QA/QC procedures and instructions are conveyed to the individuals or subcontractors performing the specified activities.

Section 4

PROJECT REVIEW

and

SETUP

PROJECT REVIEW and SETUP

4.1 PROPOSAL SUBMISSION

Management will review projects to bid and determine if a proposal will be submitted to perform the work. The proposal must include all costs related to completing the work in accordance with the client's specifications.

4.2 RESPONSIBILY ASSIGNMENT AND CONTRACTUAL REVIEW

Once the project proposal has been accepted by the client and a contract has been received by CONTRACTOR Contracting Services a Project Manager is assigned. The Project Manger shall review the contract documents and establish and maintain procedures to ensure that:

a) The requirements and acceptance specifications of the client are adequately defined and documented;
b) Any requirements daggering from those included in the proposal are resolved or clarified in the proposal;
c) That CONTRACTOR Contracting Services has the capability to meet all contractual requirements of the contract.

4.3 PROJECT SETUP

Upon award, the Project Manager shall immediately setup the project in accordance with the execution and staffing plan established during the proposal. All key staff members shall be notified and sent as much information concerning their responsibilities to the project as soon as possible.

The Project Manager shall develop a project file containing all related specific activities.

Section 5

DOCUMENT

CONTROL

DOCUMENT CONTROL

5.1 CONTROL OF QA/QC MANUALS, PROCEDURES and INSRUCTIONS

Specific QA/QC procedures and instructions for individual activities are maintained by the Project Manager as controlled documents. It is the Project Manger's responsibility to ensure specific activity QA/QC procedures and instructions are conveyed to the individuals or subcontractors performing the specific activities.

The Project Manager shall ensure that:

a) All pertinent issues of appropriate QA/QC documents are available at all locations where operations essential to the effective functioning of the quality system are performed:
b) All obsolete documents are promptly removed from all points of issue or use.

A master list or equivalent document control procedure shall be established to identify the current revision of documents in order to preclude the use of non-applicable documents . Documents shall be re-issued after a practical number of changes have been made.

5.2 CONTROL OF PROJECT RELATED DOCUMENTS

Upon award, each project is assigned a project number and the Project Manager establishes a "Project Job File". This file shall contain a complete set of all project related contract documents, specifications, drawings, etc. All information generated during the life of the project shall be maintained in this job file.

A listing shall be made of all submittals that are to be submitted to the client for review and approval. A copy of all documents returned by the client approved, or approved as noted, shall be maintained in the job file.

Any revisions to the contract documents shall be date stamped on the date received and reviewed by the Project Manager for any possible impact to the project. All changes after the contract award shall be properly documented and any associated addition or deduction to the contract price shall be immediately identified and submitted to the client for review and approval.

A complete set of all documents required for proper execution of the work shall be maintained at the project site. Any revisions received shall be immediately forwarded to the project site for use while executing the project. Any field changes to the work shall be properly noted on the project site set of drawings . The project site set of the drawings shall show the work as exactly as the work was built.(Hereinafter referred to as the "As-Built" set of drawings).

Section 6

PURCHAING
and
MATERIAL CONTROL

PURCHASING and DOCUMENT CONTROL

6.1 GENERAL PURCHASING REQUIREMENTS

The Project Manager has the overall responsibility to ensure that all materials and services purchased are in accordance with the QA/QC procedures, the project specifications, and drawings.

6.2 SUBCONTRACTING REQUIREMENTS

All subcontractors shall be selected on the basis of their ability to meet subcontract requirements, including established quality requirements. CONTRACTOR Contracting Services has established a list of qualified subcontractors for services typically subcontracted.

The selection of subcontractors and material vendors are controlled by the Project Manager. The Superintendent shall ensure that applicable QA/QC procedures are followed by all subcontractors performing services for CONTRACTOR Contracting.

6.3 MAINTENANCE OF PURCHASING DATA

All purchasing documents shall contain data clearly describing the material service ordered.

Section 7

PROCESS

CONTROLS

PROCESS CONTROLS

7.1 MANAGEMENT OF PROCESS CONTROLS

During project setup the Project Manager develops the project QA/QC plan covering all construction activities and applicable processes which directly affect quality. The Superintendent shall ensure that these processes are carried out under controlled conditions.

7.2 SPECIFIC ACTIVITY PROCESS CONTROLS

Specific Activity Process Controls are for activities where the results cannot be fully verified by subsequent inspection and testing. Accordingly, continuous monitoring and/or compliance with documented procedures are required to ensure that the specified requirements are met.

Management shall continue review of established QA/QC procedures to ensure ongoing suitability and effectiveness. As the need for new activity QA/QC process procedures is identified they will be created and implemented. Records shall be maintained for qualified processes, equipment, and personnel, as appropriate.

Appendix No. 13:

Environmental

INDEX - APPENDIX NO. 13: ENVIRONMENTAL

INDEX - FIGURE AND TABLE

NO TABLE OF FIGURES ENTRIES FOUND.

13. Environmental Documentation

13.1. Environmental Plan

The awarded contractor in charge to build the new sewer line has to be committed to the health and safety personnel and the environment. Also has to strive to prevent any accident, spill, or hazard that could potentially harm the environment or employee.

Contractor will comply with any and all state and federal laws pertaining to environmental regulations and will implement and practice procedures to ensure compliance is upheld and maintained.

These practices will assist in minimizing the risk and help to protect their employees and the environment in which the work is done. Contractor will strive to prevent any leak, spill, or other release to the atmosphere, land, or water. Contractor will ensure that all waste is disposed of in a safe, proper manner, in accordance with the appropriate waste management procedure.

Though environmental harm is never planned, Contractor will address procedures in the event that a hazard is created. Contractor will conduct daily verbal and written meetings discussing Job Hazard assessments (JHA's), inspections of machinery and equipment, daily excavation, and general housekeeping to ensure that trash/debris is picked up and placed in the proper trash receptacle.

The necessary permits and Safety Data Sheets will be updated when needed, and kept on file for reference.

All Contractor employees that will be involved in working with the general contractor, will attend General's contractor safety and environmental orientation. Contractor employees will follow all site-specific environmental regulations at worksite.

Contractor will take the necessary steps and precautions to minimize any environmental risk associated with this jobsite. Environmental protection is no small task, but, with proper adherence to federal, state, and local regulatory requirements, it can be achieved.

In the event of a spill or leak, Contractor will implement the appropriate controls to ensure that the leak is controlled and cleaned in the proper manner (Hazardous Communication Plan). Each Contractor employee on site will be responsible to ensure that this task is completed promptly and correctly. Each Contractor employee will strive to reduce all waste by identifying and eliminating wasteful practices and products.

13.2. Hazardous Communication Plan

Awarded Contractor, as a whole, is committed to preventing accidents and ensuring the safety and health of our employees. It will comply with all applicable federal and state health and safety rules and provide a safe, environmentally conscious worksite for all employees.

13.2.1. Identifying hazardous chemicals

Hazardous chemicals with a potential for employee exposure at this workplace are Diesel, Gasoline, Hydraulic fluid, and Chlorine. Detailed information about the product's use, classification, hazards, and first aid measures for each chemical is included in a Safety Data Sheet (SDS); the product identifier for each chemical on the list matches and can be easily cross-referenced with the product identifier on its label and on its Safety Data Sheet.

13.2.2. Identifying containers of hazardous chemicals

All hazardous chemical containers used at this workplace will either have the original manufacturer's label --that includes a product identifier, an appropriate signal word, hazard statement(s), pictogram(s), precautionary statement(s) and the name, address, and telephone number of the chemical manufacturer, importer, or other responsible party -- OR a label with the appropriate label elements just described; OR workplace labeling that includes the product identifier and words, pictures, symbols, or combination that provide at least general information regarding the hazards of the chemicals.

No container will be released for use until this information is verified. Workplace labels must be legible and in English.

Information in other languages is available upon General Contractor request.

13.2.3. Keeping Safety Data Sheets

Safety Data Sheets must be readily available to all employees during their work shifts. Employees can review Safety Data Sheets for all hazardous chemicals used at this workplace. Each employee will have a hard copy of this information.

13.2.4. Informing employees who does special tasks

Before employees perform special (non-routine) tasks that may expose them to hazardous chemicals, their supervisors will inform them about the chemicals' hazards. Their supervisors also will inform them about how to control exposure and what to do in an emergency. The employer will evaluate the hazards of these tasks and provide appropriate controls including Personal Protective Equipment all additional training as required.

Examples of special tasks that may expose employees to hazardous chemicals include the following:

1. Fueling equipment and trucks
2. Cleaning/Disinfecting utility lines
3. Refilling/Changing hydraulic lines on equipment

13.2.5. Informing contractors and other employers about our hazardous chemicals

If employees of other employer(s) may be exposed to hazardous chemicals at our workplace (for example, employees of a construction contractor working on-site) It is the responsibility of a contractor manager to provide General contractors and their employees with the following information:

• The identity of the chemicals, how to review our Safety Data Sheets, and an explanation of the container and pipe labeling system.

• Safe work practices to prevent exposure.

13.3. Material Safety Data Sheets

Usually, in utility works, the material exposed to spill are basically petroleum base products used as fuel, engine oil or lubricants. In that case, please find in Annex 11.1 the material safety data sheets used in a sewer line installation to keep machinery as a trackhoe or backhoe working.

13.4. Temporary Facilities and Controls

Contractor must provide temporary facilities and controls needed for the Work. Among them, temporary utilities as water, electricity and lightning, telephone or heat/AC must be acquired as per city specifications 01 50 00. Such regulation also controls the sanitary facilities to be provided to comply with State and local departments of health.

13.4.1. Storage Sheds and Buildings

Contractor must Provide adequately ventilated, watertight, weatherproof storage facilities with floor above ground level for materials and equipment susceptible to weather damage. Storage of materials not susceptible to weather damage may be on blocks off ground.

Fill and grade site for temporary structures to provide drainage away from temporary and existing buildings. Provide and maintain Temporary fencing for the duration of the construction.

13.4.2. Dust Control

Contractor is responsible for maintaining dust control through the duration of the project. This means to have a person on-call at all times that must respond in a timely manner.

13.4.3. Temporary Protection of Construction

Contractor is responsible for protecting Work from damage due to weather so no spills are created during a bad weather event.

13.5. Erosion and Sediment control

It is very important to implement the project's Storm Water Pollution Prevention Plan (SWPPP or SW3P) and installation, maintenance and removal of erosion and sediment control devices.

Every construction in the state of Texas Must have a SW3P Permit and an also all the environmental permits, issues and commitments (EPIC Sheets) that can be found at the drawings of this project related to the NT3A TxDOT overall project.

There are a lot of materials that can be used to prevent storm water pollution due to the earth erosion during a rain event compiled at city of Fort Worth specification 31 25 00:

- Rock Filter Dams
- Geotextile Fabric
- Sandbag Material
- Stabilized Construction Entrances
- Embankment for Erosion Control
- Sandbags
- Temporary Sediment Control Fence

All related to SW3P can be found at the specification Section of this very project. Other important specifications involving environmental control are the following and must be in compliance during the whole duration of the Work:

- 01 57 13 Storm Water Pollution Prevention
- 01 60 00 Product Requirements
- 01 66 00 Product Storage and Handling Requirements
- 01 74 23 Cleaning
- 02 41 13 Selective Site Demolition
- 02 41 14 Utility removal or abandonment

- 02 41 15 Paving Removal
- 31 10 00 Site Clearing
- 31 23 23 Borrow Materials
- 32 92 13 Hydro mulching, Seeding and Sodding

13.6. Environmental Legislation Priority

There are many regulations regarding environmental control. In our project, specifications must be meet in the following order. If a regulation doesn't apply to a situation, the following legislation will be active and so on.

- Federal Regulations,
- Texas Commission on Environmental Quality,
- City of Fort Worth Specifications,
- TxDOT Specifications.

ANNEX 11.1 – SAFETY MATERIAL DATA SHEETS

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

MANUFACTURER:	*Universal Lubricants, Inc.* *2824 N. Ohio, Wichita, KS 67219*	*PRODUCT CODE:* *REV. DATE:*	*C0010* *11/01/13*
EMERGENCY PHONE:	*(316) 832-0151*		

TRADE NAME: ***DYNA-PLEX 21C SHPD SAE 10W, 20W, 30, 40, 50***
SYNONYMS: *Petroleum Lubricant*
CAS REG. NO.: *Mixture*

NFPA Hazard Classification: *HEALTH - 1; FLAMMABILITY - 1; REACTIVITY - 0;*
(Least=0; Slight=1; Moderate=2; High=3; Extreme=4)

SECTION II - INGREDIENTS

Component Name *CAS Number*	*Hazardous in Blend*	*Approx. %*	*OSHA/ACGIH PEL/TLV*
Base Lubricating Oils *Mixture*	*No*	*80-90*	*None*
Detergent/Inhibitor System *Trade Secret*	*No*	*10-15*	*None*
Pour Point Depressant *Trade Secret*	*No*	*<1.0*	*None*
Anti-Foam Agent *Trade Secret*	*No*	*<1.0*	*None*

SECTION III - PHYSICAL DATA

-Specific Gravity (H_20=1):	*.8800*
-Appearance:	*Clear, Amber*
-Odor:	*Lubricating Oil*
-Solubility in Water:	*Soluble in hydrocarbons, emulsifies in water*
-Vapor Pressure:	*N/A*
-Boiling Point:	*800°F*
-Percent Volatile:	*N/A*
-Molecular Weight:	*Variable*

SECTION IV - FIRE PROTECTION INFORMATION

-Flash Point (C.O.C.): 216°C, (420°F)
-Flammable Limits in Air, % by volume: Lower-N/A; Upper-N/A
-Extinguishing Media: Use dry chemical, foam or carbon dioxide.
-Unusual Fire and Explosion Conditions: Do not weld, heat or drill containers. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.
-Special Fire Fighting Procedures: Do not enter confined fire space without proper protective equipment. Cool fire exposed containers with water. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

SECTION V - REACTIVITY DATA

-Stability: Stable.
-Conditions to Avoid: Heat, open flames, oxidizing materials and mist.
-Incompatibility: May react strong with oxidizing agents.
-Hazardous Polymerization: Will not occur.
-Hazardous Decomposition Products: None (see Unusual Fire and Explosive Conditions in Section IV).

SECTION VI - PERSONAL HEALTH PROTECTION INFORMATION

Threshold Limit Value:	*5.00 mg/m^3 suggested for oil mist.*
Eye Protection:	*If material is handled such that it could be splashed into eyes, wear plastic face shield or splash-proof safety goggles.*
Skin Protection:	*For prolonged or repeated exposures, use impervious clothing (boots, gloves, aprons, etc.) over parts of the body subject to exposure. If handling hot material, use insulated protective clothing. Launder soiled clothes. Properly dispose of contaminated leather articles, including shoes, which cannot be decontaminated.*
Respiratory Protection:	*If vapor or mist is generated when the material is heated or handled, use an organic vapor respirator with a dust and mist filter. All respirators must be NIOSH certified. Do not use compressed oxygen in hydrocarbon atmospheres. Adequate ventilation in accordance with good engineering practices must be provided to maintain concentrations below the specified exposure or flammable limits.*
Ingestion:	*Food and beverage consumption should be avoided in work areas where hydrocarbons are present.*

SECTION VII - EMERGENCY AND FIRST AID PROCEDURES

Eye Contact:	*Immediately flush eyes with large amounts of water and continue flushing until irritation subsides. Seek medical attention.*
Skin Contact:	*Remove contaminated clothing. Wash contaminated area with soap and water. Do not reuse clothing until thoroughly cleaned. Seek medical attention for persistent irritation.*
Inhalation:	*If breathing difficulty exists, remove victim to fresh air. Seek medical attention.*
Ingestion:	*Do not induce vomiting. Seek medical attention.*
Skin Injection:	*If product is injected into or under skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.*

SECTION VIII - ENVIRONMENTAL PRECAUTIONS

-Steps to be taken if material is released or spilled: Consult Personal Health Protection Information (SECTION VI), Fire Protection Information (SECTION IV), and Reactivity Data (SECTION V). Notify appropriate authorities of spill. Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert materials, such as sand, clay, etc. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or suitable containers.
-Disposal of waste: All disposals must comply with Federal, state and local regulations. Spilled or discarded material may be a regulated waste. Refer to state and local regulations. If regulated solvents are used to clean up spilled material, the resulting waste mixture may be regulated. Department of Transportation regulations may apply for transporting of this material.

SECTION IX - HANDLING AND STORAGE

-Store only in properly marked containers. Store in closed containers away from heat, sparks, flame or oxidizing materials.
-This product is not classified as hazardous under DOT regulations. See NFPA 30 and OSHA 1910.106 --- flammable and combustible liquids.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

MANUFACTURER: *Universal Lubricants, Inc.*
2824 N. Ohio, Wichita, KS 67219
EMERGENCY PHONE: (316) 832-0151

PRODUCT CODE: *C0110*
REV. DATE: *11/01/13*

TRADE NAME: ***DYNA-PLEX 21C SHPD SAE 10W30, 15W40, 20W50***
SYNONYMS: *Petroleum Lubricant*
CAS REG. NO.: Mixture

NFPA Hazard Classification: *HEALTH - 1; FLAMMABILITY - 1; REACTIVITY - 0;*
(Least=0; Slight=1; Moderate=2; High=3; Extreme=4)

SECTION II - INGREDIENTS

Component Name *CAS Number*	*Hazardous in Blend*	*Approx. %*	*OSHA/ACGIH PEL/TLV*
Base Lubricating Oils *Mixture*	*No*	*75-85*	*None*
Detergent/Inhibitor System *Trade Secret*	*No*	*10-20*	*None*
Viscosity Index Improver *Trade Secret*	*No*	*5-10*	*None*

SECTION III - PHYSICAL DATA

-Specific Gravity (H_20=1):	*0.8866*
-Appearance:	*Clear, Amber*
-Odor:	*Lubricating Oil*
-Solubility in Water:	*Soluble in hydrocarbons, emulsifies in water*
-Vapor Pressure:	*N/A*
-Boiling Point:	*>800°F*
-Percent Volatile:	*N/A*
-Molecular Weight:	*Variable*

SECTION IV - FIRE PROTECTION INFORMATION

-Flash Point (C.O.C.): 232°C, (450°F)
-Flammable Limits in Air, % by volume: Lower-N/A; Upper-N/A
-Extinguishing Media: Use dry chemical, foam or carbon dioxide.
-Unusual Fire and Explosion Conditions: Do not weld, heat or drill containers. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.
-Special Fire Fighting Procedures: Do not enter confined fire space without proper protective equipment. Cool fire exposed containers with water. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

SECTION V - REACTIVITY DATA

-Stability: Stable.
-Conditions to Avoid: Heat, open flames, oxidizing materials and mist.
-Incompatibility: May react strong with oxidizing agents.
-Hazardous Polymerization: Will not occur.
-Hazardous Decomposition Products: None (see Unusual Fire and Explosive Conditions in Section IV).

SECTION VI - PERSONAL HEALTH PROTECTION INFORMATION

Threshold Limit Value: *5.00 mg/m^3 suggested for oil mist.*

Eye Protection: *If material is handled such that it could be splashed into eyes, wear plastic face shield or splash-proof safety goggles.*

Skin Protection: *For prolonged or repeated exposures, use impervious clothing (boots, gloves, aprons, etc.) over parts of the body subject to exposure. If handling hot material, use insulated protective clothing. Launder soiled clothes. Properly dispose of contaminated leather articles, including shoes, which cannot be decontaminated.*

Respiratory Protection: *If vapor or mist is generated when the material is heated or handled, use an organic vapor respirator with a dust and mist filter. All respirators must be NIOSH certified. Do not use compressed oxygen in hydrocarbon atmospheres. Adequate ventilation in accordance with good engineering practices must be provided to maintain concentrations below the specified exposure or flammable limits.*

Ingestion: *Food and beverage consumption should be avoided in work areas where hydrocarbons are present.*

SECTION VII - EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: *Immediately flush eyes with large amounts of water and continue flushing until irritation subsides. Seek medical attention.*

Skin Contact: *Remove contaminated clothing. Wash contaminated area with soap and water. Do not reuse clothing until thoroughly cleaned. Seek medical attention for persistent irritation.*

Inhalation: *If breathing difficulty exists, remove victim to fresh air. Seek medical attention.*

Ingestion: *Do not induce vomiting. Seek medical attention.*

Skin Injection: *If product is injected into or under skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.*

SECTION VIII - ENVIRONMENTAL PRECAUTIONS

-Steps to be taken if material is released or spilled: Consult Personal Health Protection Information (SECTION VI), Fire Protection Information (SECTION IV), and Reactivity Data (SECTION V). Notify appropriate authorities of spill. Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert materials, such as sand, clay, etc. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or suitable containers.
-Disposal of waste: All disposals must comply with Federal, state and local regulations. Spilled or discarded material may be a regulated waste. Refer to state and local regulations. If regulated solvents are used to clean up spilled material, the resulting waste mixture may be regulated. Department of Transportation regulations may apply for transporting of this material.

SECTION IX - HANDLING AND STORAGE

-Store only in properly marked containers. Store in closed containers away from heat, sparks, flame or oxidizing materials.
-This product is not classified as hazardous under DOT regulations. See NFPA 30 and OSHA 1910.106 --- flammable and combustible liquids.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

MANUFACTURER: *Universal Lubricants, Inc.*
2824 N. Ohio, Wichita, KS 67219
EMERGENCY PHONE: (316) 832-0151

PRODUCT CODE: *D0610*
REV. DATE: *06/13/02*

TRADE NAME: ***DYNA-PLEX 21C TO-4 TRANSMISSION OIL SAE 10W, 30, 50, 60***
SYNONYMS: *Petroleum Lubricant*
CAS REG. NO.: *Mixture*

NFPA Hazard Classification: *HEALTH - 1; FLAMMABILITY - 1; REACTIVITY - 0;*
(Least=0; Slight=1; Moderate=2; High=3; Extreme=4)

SECTION II - INGREDIENTS

Component Name / CAS Number	*Hazardous in Blend*	*Approx. %*	*OSHA/ACGIH PEL/TLV*
Base Lubricating Oils / *Mixture*	*No*	*90-95*	*None*
Detergent/Inhibitor System / *Trade Secret*	*No*	*5-8*	*None*
Pour Point Depressant / *Trade Secret*	*No*	*<1.0*	*None*

SECTION III - PHYSICAL DATA

-Specific Gravity (H_20=1): *.8681*
-Appearance: *Clear, Amber*
-Odor: *Lubricating Oil*
-Solubility in Water: *Soluble in hydrocarbons, emulsifies in water*
-Vapor Pressure: *N/A*
-Boiling Point: *No Data Available*
-Percent Volatile: *N/A*
-Molecular Weight: *Variable*

SECTION IV - FIRE PROTECTION INFORMATION

-Flash Point (C.O.C.): 210°C, (410°F)
-Flammable Limits in Air, % by volume: Lower-N/A; Upper-N/A
-Extinguishing Media: Use dry chemical, foam or carbon dioxide.
-Unusual Fire and Explosion Conditions: Do not weld, heat or drill containers. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.
-Special Fire Fighting Procedures: Do not enter confined fire space without proper protective equipment. Cool fire exposed containers with water. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

SECTION V - REACTIVITY DATA

-Stability: Stable.
-Conditions to Avoid: Heat, open flames, oxidizing materials and mist.
-Incompatibility: May react strong with oxidizing agents.
-Hazardous Polymerization: Will not occur.
-Hazardous Decomposition Products: None (see Unusual Fire and Explosive Conditions in Section IV).

SECTION VI - PERSONAL HEALTH PROTECTION INFORMATION

Threshold Limit Value:	*5.00 mg/m^3 suggested for oil mist.*
Eye Protection:	*If material is handled such that it could be splashed into eyes, wear plastic face shield or splash-proof safety goggles.*
Skin Protection:	*For prolonged or repeated exposures, use impervious clothing (boots, gloves, aprons, etc.) over parts of the body subject to exposure. If handling hot material, use insulated protective clothing. Launder soiled clothes. Properly dispose of contaminated leather articles, including shoes, which cannot be decontaminated.*
Respiratory Protection:	*If vapor or mist is generated when the material is heated or handled, use an organic vapor respirator with a dust and mist filter. All respirators must be NIOSH certified. Do not use compressed oxygen in hydrocarbon atmospheres. Adequate ventilation in accordance with good engineering practices must be provided to maintain concentrations below the specified exposure or flammable limits.*
Ingestion:	*Food and beverage consumption should be avoided in work areas where hydrocarbons are present.*

SECTION VII - EMERGENCY AND FIRST AID PROCEDURES

Eye Contact:	*Immediately flush eyes with large amounts of water and continue flushing until irritation subsides. Seek medical attention.*
Skin Contact:	*Remove contaminated clothing. Wash contaminated area with soap and water. Do not reuse clothing until thoroughly cleaned. Seek medical attention for persistent irritation.*
Inhalation:	*If breathing difficulty exists, remove victim to fresh air. Seek medical attention.*
Ingestion:	*Do not induce vomiting. Seek medical attention.*
Skin Injection:	*If product is injected into or under skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.*

SECTION VIII - ENVIRONMENTAL PRECAUTIONS

-Steps to be taken if material is released or spilled: Consult Personal Health Protection Information (SECTION VI), Fire Protection Information (SECTION IV), and Reactivity Data (SECTION V). Notify appropriate authorities of spill. Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert materials, such as sand, clay, etc. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or suitable containers.
-Disposal of waste: All disposals must comply with Federal, state and local regulations. Spilled or discarded material may be a regulated waste. Refer to state and local regulations. If regulated solvents are used to clean up spilled material, the resulting waste mixture may be regulated. Department of Transportation regulations may apply for transporting of this material.

SECTION IX - HANDLING AND STORAGE

-Store only in properly marked containers. Store in closed containers away from heat, sparks, flame or oxidizing materials.
-This product is not classified as hazardous under DOT regulations. See NFPA 30 and OSHA 1910.106 --- flammable and combustible liquids.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

MANUFACTURER: *Universal Lubricants, Inc.*
2824 N. Ohio, Wichita, KS 67219
EMERGENCY PHONE: (316) 832-0151

PRODUCT CODE: *D2310*
REV. DATE: *06/13/02*

TRADE NAME: ***UNIVERSAL RIGEL 456 90, 85W140***
SYNONYMS: *Petroleum Lubricant*
CAS REG. NO.: *Mixture*

NFPA Hazard Classification: *HEALTH - 1; FLAMMABILITY - 1; REACTIVITY - 0;*
(Least=0; Slight=1; Moderate=2; High=3; Extreme=4)

SECTION II - INGREDIENTS

Component Name CAS Number	*Hazardous in Blend*	*Approx. %*	*OSHA/ACGIH PEL/TLV*
Base Lubricating Oils			
Mixture	*No*	*90-95*	*None*
Extreme Pressure Additive			
Trade Secret	*No*	*5-10*	*None*
Tackifier Agent			
Trade Secret	*No*	*<1.0*	*None*
Anti-Foam Agent			
Trade Secret	*No*	*<1.0*	*None*

SECTION III - PHYSICAL DATA

-Specific Gravity (H_20=1): *.8956*
-Appearance: *Clear, Amber*
-Odor: *Lubricating Oil*
-Solubility in Water: *Soluble in hydrocarbons, emulsifies in water*
-Vapor Pressure: *N/A*
-Boiling Point: *No data available*
-Percent Volatile: *N/A*
-Molecular Weight: *Variable*

SECTION IV - FIRE PROTECTION INFORMATION

-Flash Point (C.O.C.): 216°C, (420°F)
-Flammable Limits in Air, % by volume: Lower-N/A; Upper-N/A
-Extinguishing Media: Use dry chemical, foam or carbon dioxide.
-Unusual Fire and Explosion Conditions: Do not weld, heat or drill containers. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.
-Special Fire Fighting Procedures: Do not enter confined fire space without proper protective equipment. Cool fire exposed containers with water. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

SECTION V - REACTIVITY DATA

-Stability: Stable.
-Conditions to Avoid: Heat, open flames, oxidizing materials and mist.
-Incompatibility: May react strong with oxidizing agents.
-Hazardous Polymerization: Will not occur.
-Hazardous Decomposition Products: None (see Unusual Fire and Explosive Conditions in Section IV).

SECTION VI - PERSONAL HEALTH PROTECTION INFORMATION

Threshold Limit Value:	*5.00 mg/m^3 suggested for oil mist.*
Eye Protection:	*If material is handled such that it could be splashed into eyes, wear plastic face shield or splash-proof safety goggles.*
Skin Protection:	*For prolonged or repeated exposures, use impervious clothing (boots, gloves, aprons, etc.) over parts of the body subject to exposure. If handling hot material, use insulated protective clothing. Launder soiled clothes. Properly dispose of contaminated leather articles, including shoes, which cannot be decontaminated.*
Respiratory Protection:	*If vapor or mist is generated when the material is heated or handled, use an organic vapor respirator with a dust and mist filter. All respirators must be NIOSH certified. Do not use compressed oxygen in hydrocarbon atmospheres. Adequate ventilation in accordance with good engineering practices must be provided to maintain concentrations below the specified exposure or flammable limits.*
Ingestion:	*Food and beverage consumption should be avoided in work areas where hydrocarbons are present.*

SECTION VII - EMERGENCY AND FIRST AID PROCEDURES

Eye Contact:	*Immediately flush eyes with large amounts of water and continue flushing until irritation subsides. Seek medical attention.*
Skin Contact:	*Remove contaminated clothing. Wash contaminated area with soap and water. Do not reuse clothing until thoroughly cleaned. Seek medical attention for persistent irritation.*
Inhalation:	*If breathing difficulty exists, remove victim to fresh air. Seek medical attention.*
Ingestion:	*Do not induce vomiting. Seek medical attention.*
Skin Injection:	*If product is injected into or under skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.*

SECTION VIII - ENVIRONMENTAL PRECAUTIONS

-Steps to be taken if material is released or spilled: Consult Personal Health Protection Information (SECTION VI), Fire Protection Information (SECTION IV), and Reactivity Data (SECTION V). Notify appropriate authorities of spill. Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert materials, such as sand, clay, etc. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or suitable containers.
-Disposal of waste: All disposals must comply with Federal, state and local regulations. Spilled or discarded material may be a regulated waste. Refer to state and local regulations. If regulated solvents are used to clean up spilled material, the resulting waste mixture may be regulated. Department of Transportation regulations may apply for transporting of this material.

SECTION IX - HANDLING AND STORAGE

-Store only in properly marked containers. Store in closed containers away from heat, sparks, flame or oxidizing materials.
-This product is not classified as hazardous under DOT regulations. See NFPA 30 and OSHA 1910.106 --- flammable and combustible liquids.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

MANUFACTURER: *Universal Lubricants, Inc.*
2824 N. Ohio, Wichita, KS 67219
EMERGENCY PHONE: (316) 832-0151

PRODUCT CODE: *D2700*
REV. DATE: *03/04/02*

TRADE NAME: ***DYNA-PLEX 21C HIGH PERFORMANCE HYDRAULIC OIL***
SYNONYMS: *Petroleum Lubricant*
CAS REG. NO.: *Mixture*

NFPA Hazard Classification: *HEALTH - 1; FLAMMABILITY - 1; REACTIVITY - 0;*
(Least=0; Slight=1; Moderate=2; High=3; Extreme=4)

SECTION II - INGREDIENTS

Component Name *CAS Number*	*Hazardous* *in Blend*	*Approx.* *%*	*OSHA/ACGIH* *PEL/TLV*
Base Lubricating Oil *Mixture*	*No*	*80-90*	*None*
Detergent/Inhibitor System *Trade Secret*	*No*	*10-15*	*None*
Pour Point Depressant *Trade Secret*	*No*	*<1.0*	*None*
Anti-Foam Agent *Trade Secret*	*No*	*<1.0*	*None*
Purple Dye *Trade Secret*	*No*	*<1.0*	*None*

SECTION III - PHYSICAL DATA

-Specific Gravity (H_20=1): *.8735*
-Appearance: *Clear, Purple*
-Odor: *Lubricating Oil*
-Solubility in Water: *Soluble in hydrocarbons, emulsifies in water*
-Vapor Pressure: *N/A*
-Boiling Point: *800°F*
-Percent Volatile: *N/A*
-Molecular Weight: *Variable*

SECTION IV - FIRE PROTECTION INFORMATION

-Flash Point (C.O.C.): 204°C, (400°F)
-Flammable Limits in Air, % by volume: Lower-N/A; Upper-N/A
-Extinguishing Media: Use dry chemical, foam or carbon dioxide.
-Unusual Fire and Explosion Conditions: Do not weld, heat or drill containers. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.
-Special Fire Fighting Procedures: Do not enter confined fire space without proper protective equipment. Cool fire exposed containers with water. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

SECTION V - REACTIVITY DATA

-Stability: Stable.
-Conditions to Avoid: Heat, open flames, oxidizing materials and mist.
-Incompatibility: May react strong with oxidizing agents.
-Hazardous Polymerization: Will not occur.
-Hazardous Decomposition Products: None (see Unusual Fire and Explosive Conditions in Section IV).

SECTION VI - PERSONAL HEALTH PROTECTION INFORMATION

Threshold Limit Value:	*5.00 mg/m^3 suggested for oil mist.*
Eye Protection:	*If material is handled such that it could be splashed into eyes, wear plastic face shield or splash-proof safety goggles.*
Skin Protection:	*For prolonged or repeated exposures, use impervious clothing (boots, gloves, aprons, etc.) over parts of the body subject to exposure. If handling hot material, use insulated protective clothing. Launder soiled clothes. Properly dispose of contaminated leather articles, including shoes, which cannot be decontaminated.*
Respiratory Protection:	*If vapor or mist is generated when the material is heated or handled, use an organic vapor respirator with a dust and mist filter. All respirators must be NIOSH certified. Do not use compressed oxygen in hydrocarbon atmospheres. Adequate ventilation in accordance with good engineering practices must be provided to maintain concentrations below the specified exposure or flammable limits.*
Ingestion:	*Food and beverage consumption should be avoided in work areas where hydrocarbons are present.*

SECTION VII - EMERGENCY AND FIRST AID PROCEDURES

Eye Contact:	*Immediately flush eyes with large amounts of water and continue flushing until irritation subsides. Seek medical attention.*
Skin Contact:	*Remove contaminated clothing. Wash contaminated area with soap and water. Do not reuse clothing until thoroughly cleaned. Seek medical attention for persistent irritation.*
Inhalation:	*If breathing difficulty exists, remove victim to fresh air. Seek medical attention.*
Ingestion:	*<u>Do not induce vomiting</u>. Seek medical attention.*
Skin Injection:	*If product is injected into or under skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.*

SECTION VIII - ENVIRONMENTAL PRECAUTIONS

-Steps to be taken if material is released or spilled: Consult Personal Health Protection Information (SECTION VI), Fire Protection Information (SECTION IV), and Reactivity Data (SECTION V). Notify appropriate authorities of spill. Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert materials, such as sand, clay, etc. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or suitable containers.
-Disposal of waste: All disposals must comply with Federal, state and local regulations. Spilled or discarded material may be a regulated waste. Refer to state and local regulations. If regulated solvents are used to clean up spilled material, the resulting waste mixture may be regulated. Department of Transportation regulations may apply for transporting of this material.

SECTION IX - HANDLING AND STORAGE

-Store only in properly marked containers. Store in closed containers away from heat, sparks, flame or oxidizing materials.
-This product is not classified as hazardous under DOT regulations. See NFPA 30 and OSHA 1910.106 --- flammable and combustible liquids.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

Universal Lubricants, Inc.
2824 N. Ohio, Wichita, KS 67219
EMERGENCY PHONE: (316) 832-0151

PRODUCT CODE: G870
REV. DATE: 10/11/02

TRADE NAME: ***DYNA-PLEX 21C HI-TEMP 500+ MOLY #2***
SYNONYMS: Petroleum Lubricant
CAS REG. NO.: Mixture

NFPA Hazard Classification: HEALTH - 0; FLAMMABILITY - 1; REACTIVITY - 0;
(Least=0; Slight=1; Moderate=2; High=3; Extreme=4)

SECTION II - INGREDIENTS

Component Name CAS Number	*Hazardous in Blend*	*Approx. %*	*OSHA/ACGIH PEL/TLV*
Base Lubricating Oils Mixture	*No*	*90-100*	*None*
Lithium Soap Thickener Trade Secret	*No*	*1-5*	*None*
Molybdenum Disulfide Trade Secret	*No*	*1-3*	*None*
Additive Package Trade Secret	*No*	*1-5*	*None*

SECTION III - PHYSICAL DATA

-Specific Gravity (H_20=1):	*0.93*
-Appearance:	*Black, Tacky*
-Odor:	*Mineral Oil*
-Solubility in Water:	*Negligible @25°C*
-Vapor Pressure:	*N/A*
-Boiling Point:	*N/A*
-Percent Volatile:	*N/A*
-Molecular Weight:	*Variable*

SECTION IV - FIRE PROTECTION INFORMATION

-Flash Point (C.O.C.): 220°C, (430°F)
-Flammable Limits in Air, % by volume: Lower-N/A; Upper-N/A
-Extinguishing Media: Use dry chemical, foam or carbon dioxide.
-Unusual Fire and Explosion Conditions: Do not weld, heat or drill containers. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.
-Special Fire Fighting Procedures: Do not enter confined fire space without proper protective equipment. Cool fire exposed containers with water. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

SECTION V - REACTIVITY DATA

-Stability: Stable.
-Conditions to Avoid: Heat, open flames, oxidizing materials and mist.
-Incompatibility: May react strong with oxidizing agents.
-Hazardous Polymerization: Will not occur.
-Hazardous Decomposition Products: Carbon monoxide and carbon dioxide from burning.

SECTION VI - PERSONAL HEALTH PROTECTION INFORMATION

Threshold Limit Value: *5.00 mg/m^3 suggested for 8 hour exposure.*

Eye Protection: *If material is handled such that it could be splashed into eyes, wear plastic face shield or splash-proof safety goggles.*

Skin Protection: *For prolonged or repeated exposures, use impervious clothing (boots, gloves, aprons, etc.) over parts of the body subject to exposure. If handling hot material, use insulated protective clothing. Launder soiled clothes. Properly dispose of contaminated leather articles, including shoes, which cannot be decontaminated.*

Respiratory Protection: *If vapor or mist is generated when the material is heated or handled, use an organic vapor respirator with a dust and mist filter. All respirators must be NIOSH certified. Do not use compressed oxygen in hydrocarbon atmospheres. Adequate ventilation in accordance with good engineering practices must be provided to maintain concentrations below the specified exposure or flammable limits.*

Ingestion: *Food and beverage consumption should be avoided in work areas where hydrocarbons are present.*

SECTION VII - EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: *Immediately flush eyes with large amounts of water and continue flushing until irritation subsides. Seek medical attention.*

Skin Contact: *Remove contaminated clothing. Wash contaminated area with soap and water. Do not reuse clothing until thoroughly cleaned. Seek medical attention for persistent irritation.*

Inhalation: *If breathing difficulty exists, remove victim to fresh air. Seek medical attention.*

Ingestion: *Do not induce vomiting. Seek medical attention.*

Skin Injection: *If product is injected into or under skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.*

SECTION VIII - ENVIRONMENTAL PRECAUTIONS

-Steps to be taken if material is released or spilled: Consult Personal Health Protection Information (SECTION VI), Fire Protection Information (SECTION IV), and Reactivity Data (SECTION V). Notify appropriate authorities of spill. Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert materials, such as sand, clay, etc. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or suitable containers.
-Disposal of waste: All disposals must comply with Federal, state and local regulations. Spilled or discarded material may be a regulated waste. Refer to state and local regulations. If regulated solvents are used to clean up spilled material, the resulting waste mixture may be regulated. Department of Transportation regulations may apply for transporting of this material.

SECTION IX - HANDLING AND STORAGE

-Store only in properly marked containers. Store in closed containers away from heat, sparks, flame or oxidizing materials.
-This product is not classified as hazardous under DOT regulations. See NFPA 30 and OSHA 1910.106 --- flammable and combustible liquids.

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

Universal Lubricants, Inc.
2824 N. Ohio, Wichita, KS 67219
EMERGENCY PHONE: (316) 832-0151

PRODUCT CODE: G890
REV. DATE: 10/11/02

TRADE NAME: ***DYNA-PLEX 21C HI-TAC #1***
SYNONYMS: Petroleum Lubricant
CAS REG. NO.: Mixture

NFPA Hazard Classification: HEALTH - 0; FLAMMABILITY - 1; REACTIVITY - 0;
(Least=0; Slight=1; Moderate=2; High=3; Extreme=4)

SECTION II - INGREDIENTS

Component Name CAS Number	*Hazardous in Blend*	*Approx. %*	*OSHA/ACGIH PEL/TLV*
Base Lubricating Oils Mixture	*No*	*80-90*	*None*
Additive Trade Secret	*No*	*10-20*	*None*

SECTION III - PHYSICAL DATA

-Specific Gravity (H_20=1): 0.9110
-Appearance: Buttery, Red
-Odor: Mineral Oil
-Solubility in Water: Negligible @25°C
-Vapor Pressure: N/A
-Boiling Point: N/A
-Percent Volatile: N/A
-Molecular Weight: Variable

SECTION IV - FIRE PROTECTION INFORMATION

-Flash Point (C.O.C.): 160°C, (320°F)
-Flammable Limits in Air, % by volume: Lower-N/A; Upper-N/A
-Extinguishing Media: Use dry chemical, foam or carbon dioxide.
-Unusual Fire and Explosion Conditions: Do not weld, heat or drill containers. Dense smoke may be generated while burning. Carbon monoxide, carbon dioxide and other oxides may be generated as products of combustion.
-Special Fire Fighting Procedures: Do not enter confined fire space without proper protective equipment. Cool fire exposed containers with water. Caution should be exercised when using water or foam as frothing may occur, especially if sprayed into containers of hot, burning liquid.

SECTION V - REACTIVITY DATA

-Stability: Stable.
-Conditions to Avoid: Heat, open flames, oxidizing materials and mist.
-Incompatibility: May react strong with oxidizing agents.
-Hazardous Polymerization: Will not occur.
-Hazardous Decomposition Products: Carbon monoxide and carbon dioxide from burning.

SECTION VI - PERSONAL HEALTH PROTECTION INFORMATION

Threshold Limit Value: *5.00 mg/m^3 suggested for 8 hour exposure.*

Eye Protection: *If material is handled such that it could be splashed into eyes, wear plastic face shield or splash-proof safety goggles.*

Skin Protection: *For prolonged or repeated exposures, use impervious clothing (boots, gloves, aprons, etc.) over parts of the body subject to exposure. If handling hot material, use insulated protective clothing. Launder soiled clothes. Properly dispose of contaminated leather articles, including shoes, which cannot be decontaminated.*

Respiratory Protection: *If vapor or mist is generated when the material is heated or handled, use an organic vapor respirator with a dust and mist filter. All respirators must be NIOSH certified. Do not use compressed oxygen in hydrocarbon atmospheres. Adequate ventilation in accordance with good engineering practices must be provided to maintain concentrations below the specified exposure or flammable limits.*

Ingestion: *Food and beverage consumption should be avoided in work areas where hydrocarbons are present.*

SECTION VII - EMERGENCY AND FIRST AID PROCEDURES

Eye Contact: *Immediately flush eyes with large amounts of water and continue flushing until irritation subsides. Seek medical attention.*

Skin Contact: *Remove contaminated clothing. Wash contaminated area with soap and water. Do not reuse clothing until thoroughly cleaned. Seek medical attention for persistent irritation.*

Inhalation: *If breathing difficulty exists, remove victim to fresh air. Seek medical attention.*

Ingestion: *Do not induce vomiting. Seek medical attention.*

Skin Injection: *If product is injected into or under skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.*

SECTION VIII - ENVIRONMENTAL PRECAUTIONS

-Steps to be taken if material is released or spilled: Consult Personal Health Protection Information (SECTION VI), Fire Protection Information (SECTION IV), and Reactivity Data (SECTION V). Notify appropriate authorities of spill. Contain spill immediately. Do not allow spill to enter sewers or watercourses. Remove all sources of ignition. Absorb with appropriate inert materials, such as sand, clay, etc. Large spills may be picked up using vacuum pumps, shovels, buckets, or other means and placed in drums or suitable containers.
-Disposal of waste: All disposals must comply with Federal, state and local regulations. Spilled or discarded material may be a regulated waste. Refer to state and local regulations. If regulated solvents are used to clean up spilled material, the resulting waste mixture may be regulated. Department of Transportation regulations may apply for transporting of this material.

SECTION IX - HANDLING AND STORAGE

-Store only in properly marked containers. Store in closed containers away from heat, sparks, flame or oxidizing materials.
-This product is not classified as hazardous under DOT regulations. See NFPA 30 and OSHA 1910.106 --- flammable and combustible liquids.

Appendix No. 14:

Traffic Control

INDEX - APPENDIX NO. 14: TRAFFIC CONTROL

INDEX - FIGURE AND TABLE

14. Traffic Control Analysis

14.1. Traffic Control Introduction

To build the proposed 18" and 8" wastewater pipe, traffic control must be set in order to cross or go along existing streets. Therefore, traffic control plans must be designed and implemented in a timely fashion so the contractor do not suffer delay while constructing such sewer system.

The proposed traffic control plans can be found at the drawing set and it involves specific street closures that cannot be closed for more than 9 days in a row. There are also specific low profile barrier setting that must meet the engineer expectations once implemented. This traffic control doesn't have a limit of time but can be subject to re-opening if the city of Fort Worth asks for.

If a street must be completely closed for more than 9 days, city council has to approve it. That means a process of 45 days must be done to be able to obtain such closures and there is no approval guarantee from the city council. That's why all work plan must be try to be set in order to avoid such processes.

Finally, there will be sporadically lane closures along the project with flaggers in case the street is two-way condition. This traffic control will be used to unload or load heavy machinery as well as materials. This resources can only be set from 9am to 3pm as per TxDOT requirements unless the city differs and grants a longer period of time. Nightly closure can as well be implemented from 9pm to 5am with the same provisions as the daily ones.

If nigh closures are done, proper illumination must be acquire to provide enough safety to the operation being held. Field engineer, TxDOT inspector or City inspector has the power to stop works as soon as they consider, under reasonable reasons, that the work being done is unsafe, traffic control devices are not well place/in good conditions or such traffic control is not necessary to perform the work.

14.2. Street Closures

As commented above, many street must be traffic control in order to build the proposed sewer line maintaining a safe traffic environment. Listed below are all the street affected to such traffic control and why.

14.2.1. Greenway/Pharr Area Traffic Control

Also considered as North Area at the drawings set, there will be 3 streets mainly affected (Greenfield Avenue, Mony Street and Pharr Street) as well as the I-35W South Bound Frontage Road.

14.2.1.1. Greenfield Avenue Traffic Control

Two different traffic control plans are to be set in this street.

The first of all an also first to be set as per our schedule (Sewer lines are built from the lowest point up to the highest) will be the setup of Low profile concrete barriers along the WB lane to provide a safe area in the street to trench and perform as well all the drilled shafts on this area.

There is a sensible matter with this traffic control. There are many residential driveways along this closure that will be deprived from their access. Usually, if driveways are enough spaced and are big enough, barrier can be set in order to allow traffic to go through and when construction works arrive to it, half closures are done with competent personnel as flaggers to control the traffic and steel plates are to be set every night or when works are not taking place. In this case this is not possible due to the number of driveways, the small amount of traffic and the cost that would require. City and contractor must work together to enforce a full closure of the driveways for at least 10 to 15 working days.

The second traffic control to be set in Greenfield Avenue will be a full closure by the I-35 South Bound Frontage Road to cross the street and remove the existing sewer line that used to go up to the SBFR. This closures, as stated before, only can be set for a period of 9 days or shorter if contractor doesn't want to involve city council.

14.2.1.2. Mony Street Traffic Control

This second street only needs to be crossed. There are no manholes nor drilled shafts to be set on the street. If pace of works is as it should, contractor should have no problems crossing such street in less than 9 days. If necessary, Saturday and Sunday works must occur.

14.2.1.3. Pharr Street Traffic Control

Pharr St. as Greenfield Ave will have a similar closures. The main difference is that in this case, only one business (Truck Company) will be affected and the TCP must be accommodated to keep free access to such parcel. Business and contractor must agree upon commencement of works how construction will be done across its driveway.

The second traffic control will be done once the first one is finished and will close Pharr street completely. This traffic control will need more than 9 days and therefore city council will be involved. There are 2 drill shafts, 2 manholes and a junction box to be set as well as casing and carried cast iron pipe.

14.2.2. 1st Street Area Traffic Control

Also known as South at the drawings, this traffic control must be set to finish the works up to the end of the proposed 8" wastewater line to be installed.

Street is wide enough to leave one lane open protected with low profile concrete barriers from construction site. When only one lane can remain open, caution must be taken to decide what bound can stay open. In this case it's been decided that the east bound must stay open in order to provide an easier detour to drivers. Otherwise, oncoming traffic from the North Bound Frontage Road would require a much longer detour to arrive to the same place.

14.3. Common Traffic Control Devices/Operations.

There are many traffic control devices/operations but the most common ones to be used on this project are the following:

14.3.1. Low Profile Concrete Barrier

This portable concrete barrier is called Low Profile due to its height. It is meant to be set in low speed streets as the ones we are setting them.

This kind of barriers doesn't need a crash cushion attenuator, only what it is called a "nose piece" is enough to redirect traffic from the construction area without having any blunt end.

Each piece is mutually connected by 2 rods to keep a continuum structure meant to work together. If trench works are placed closer than 2 feet from the edge of the barrier, such barrier must be pinned in order to grant not only the drivers safety but the workers as well.

Please find below an actual picture of such protection devices:

Figure 1. Low Profile Concrete Barrier.

14.3.2. Channelizing Devices

Also shown in the picture above, an example of such devices are the drums. This big cones are very common in Texas due to its powerful inclement weather. Other devices used are the barricades which keeps upcoming traffic from entering the construction areas.

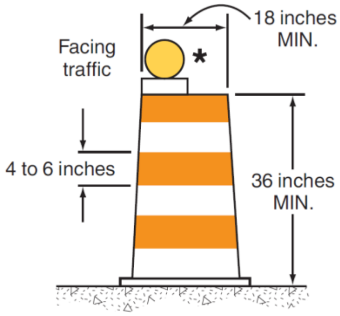


Figure 2. DRUM (Warning lights are optional)

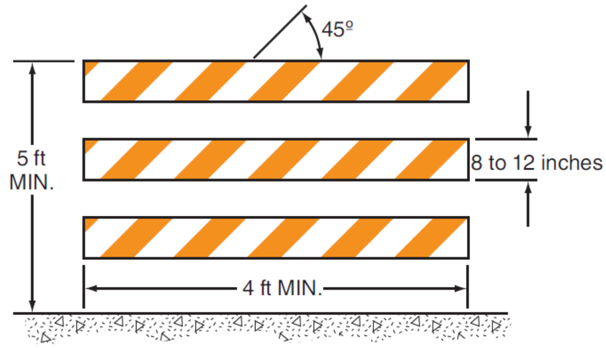


Figure 3. Type 3 Barricade.

14.3.3. Hand-Signaling Devices by Flaggers.

As commented before, flaggers may be needed to close lanes to provide a safe area in existing and currently working streets to load or unload big machinery and materials. Flaggers must be certificate to operate in the State of Texas.

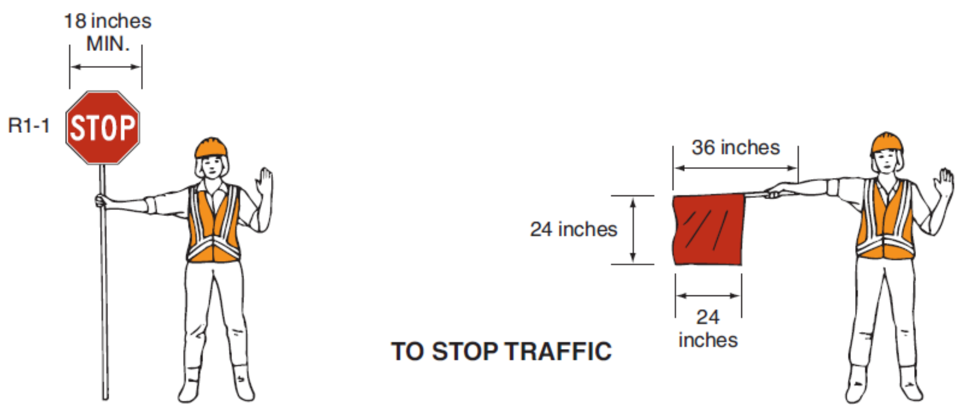


Figure 4. Typical Flagging operation to stop traffic.

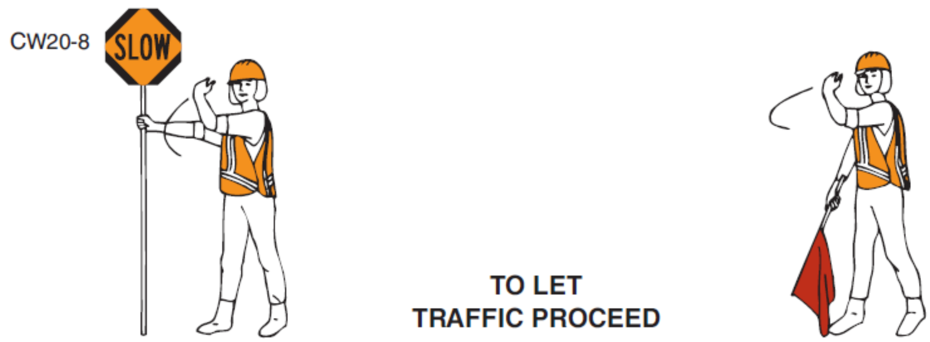


Figure 5. Typical Flagging operation to let traffic proceed.

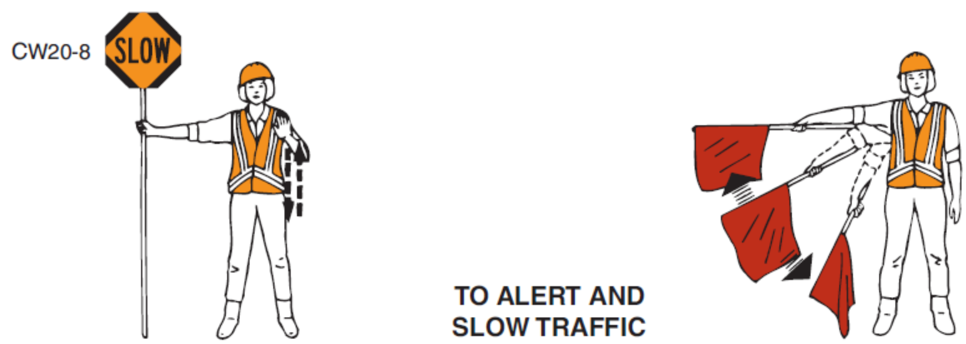


Figure 6. Typical Flagging operation to alert and slow traffic.

14.3.4. Escorting Operation

Escorting means that a traffic control vehicle properly signalized can follow a wheel mounted machinery that is certified to go through Texas streets. Machinery and escorting vehicle must follow as any other vehicle the traffic signals. This means, per example, that if the wheeled machinery crosses an intersection with a traffic signals that after it turns red, the escort vehicle must stop and wait for it to be green again. Escorted vehicle must stop by the shoulder or in a safe place until escorting vehicle can resume its duties. This can be applied to any other traffic signs as Stops or Yields.