Airway Boulevard Extension

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The University of Texas at El Paso cares about preparing their students at their best, as part of this process the University not only concentrates on preparing engineering students on the classroom but also focuses on trying to make students face real-life situations. As a part of this preparation civil engineering students are required to work on different real-life projects for two semesters. This course is named Senior Engineering Design and its primary objective is to expose the students to a real-world design or analysis experience.

Erick Faudoa, Ivan Olivas, Guillermo Ovies, Rodolfo Morales and Carlos Rodriguez conformed group “A” and worked on a street extension for the Airway Boulevard to Market Street and Industrial Avenue, the objective of this design will be to improve traffic and facilitate heavy traffic flow on the commercial/industrial development. The design will meet all the standards required by the City of El Paso.

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1.0 Background

Working alongside Moreno Cardenas Inc.(MC*i*) the Senior Design Group conformed by Erick Faudoa, Ivan Olivas, Guillermo Ovies, Rodolfo Morales and Carlos Rodriguez must develop a Senior Project Proposal presenting a design given by Dr. Walton, professor of Senior Design I, the report will state all the criteria followed and data gathered, to develop a design trying to meet real life requirements.

The group shall prepare a report and oral presentation on providing a connection to Airway Boulevard from the intersection of Airway Boulevard and Interstate Highway 10 to Market Avenue and Industrial Avenue. Different options were analyzed to obtain the best roadway alignment. Information used in the study included a geotechnical engineering report, existing topographic survey, site visit and City of El Paso Design Standards. The report considered the following analysis for the roadway improvements: hydrologic and hydraulic analysis, traffic analysis, and roadway geometric alignment. The design of the road must be presented considering heavy traffic and shall provide specification needed for the road expansion.

2.0 Approach

The objective of the project is to design a roadway that will benefit the area adjacent to the commercial/industrial development; the actual streets are reduced in size and the primary type of traffic that passes through the area is heavy traffic (commercial trucks), the construction of the roadway will relieve traffic and facilitate heavy traffic to enter the zone, helping businesses in the area adjacent to the roadway to have an easy access.

For the geotechnical study, results were provided by a local engineering firm specialized in soil studies, the reports showed the different types of soil in the land down to 50 feet depth, the results will be interpreted and used to see the actual compaction needed for the road to be placed on top of the subgrade and also see the requirements needed to choose the base course, sub-base course thickness and material. For the hydraulic concerns, the group must present a detailed analysis on the hydraulics needed to maintain everything under city regulations, drainage and run off created by the modification of the actual site conditions must be taken into account to get the required specifications. A traffic analysis shall be placed to observe the traffic flow created by different minor and major arterials in the vicinities of the area benefitted by the expansion of the road, also to have a specific traffic volume to have the appropriate requirements for the design of the road, and thickness and material needed for the surface. The design will be based on the analysis of all previous areas to meet the appropriate criteria to design a roadway which will be based on quality, cost and safety under the city regulations.

The proposed route is to continue from Airway Boulevard to Industrial Avenue on a north to south direction and from Market Street to Airway Boulevard from a south to north direction. The one-way roads will merge into a two-way 4 lane street connecting with Airway Boulevard.

3.0 Geotechnical Study

Geotechnical data was gathered from El Paso City office. The information given is shown in figure one in Appendix A. According to the information provided, the type of soil in the zone is mostly sand. Since the information was too broad, a geotechnical study was requested from a local company. The information provided by the local company is not exactly from the project zone but it is close enough to assume that the soil is the same (Appendix A). The American Association of State Highway and Transportation Officials (ASSHTO, 1993) soil classification system was used to classify the type of soil in the area, according to that study the soil ended up to be silty sand (SM). The geotechnical report did not shown any abnormality or problem on the soil profile, which means that there is no need for any stabilizer.

Once earthwork has been completed (see Roadway geometry) compaction needs to take place. Compaction is really important because it will improve some engineering properties. Compaction will increase shear strength which will improve the ability of the road to hold heavy loads such as the loads produced by big trucks. Moisture needs to be maintained under optimum conditions in order to achieve the maximum dry unit weight. Earthwork, moisture conditioning and compaction is going to get done using heavy equipment such as excavators, bulldozers, backhoes, water trucks, rollers among other.

4.0 Existing Site Conditions

The project is located at a private property owned by Western Refining. In terms of existing conditions, the information was very limited. In order to gather information a failed attempt to contact Western Refining was made.

The information shown in this Technical Report (T.R) was collected by visiting the site, Moreno Cardenas Inc. and El Paso´s City office. The total area of the land is 60.75 acres according to the Geographic Information System. The topographic information used for this project was given by Moreno Cardenas Inc. From the contour lines and topographic profiles (Appendix B), it is shown that there is a difference in elevation of 37 ft in on the Airway-Market profile and 22 ft in the Industrial-Airway profile. By inspection, the perimeter is surrounded by main sewer lines coming from the adjacent business and stores. A water line exists in the southwest portion of the property which can be used to drain the water. In the southeast corner of the landfill there is a railroad track. The underground installations and services are not available but some might exist.

5.0 Hydraulic Analysis

The following section of the report evaluates the drainage requirements for the project study area. The criteria used for the design of the drainage structures are in conformance to the City of El Paso Drainage Design Manual. All the results for the design of the different components are attached at the end of the report under Appendix C.

The drainage system was designed by taking advantage of the existing topographic conditions. There is an arroyo on the south-west section of the project site; the proposed improvements include directing all the runoff to this natural depression. The new drainage system will be handling the runoff generated by the roadway improvements and draining into the natural depression.

Any drainage structure is sized according to the probability of occurrence of an expected peak discharge during the design life of the installation. Based on the City of El Paso Drainage Design Manual drainage improvements/requirements for roadway, streets are required to be designed for the 25 Years or 100 Years storms (2008). Also, since the drainage area is less than 200 acres, all requirements were calculated using the Rational Method. This method is based on the principle that the maximum rate of runoff from a given drainage area for an assumed rainfall intensity occurs when all parts of the area are contributing to the flow at the point of discharge.

The method is expressed by the equation:

$$Q=CIA$$

where:

Q= Discharge, in cubic feet per second

C= Runoff Coefficient

I= Rainfall intensity, in inches per hour

A=Drainage area, in acres

According to the City of El Paso Drainage Design Manual, intensity for 25 Year and 100 Year design frequencies were determine from the formulas:

$$I = \frac{b}{(Tc + d)^{e}}$$

Where:

I = Rainfall intensity in inches per hour (in/hr)

Tc = Time of concentration, in minutes

e, b, d = Coefficients for specific frequencies. The coefficients used for the 25 Year frequency for El Paso are 0.8915, 70.95 and 19.798, respectively. The coefficients used for the 100 Year design frequency are 0.9177, 111.04 and 26.09, respectively.

It is important to mention that in El Paso, precipitation does not occur that often the average annual rainfall is only about 9 inches; however the 9 inches as an intensity value is considered high since the city has intense summer monsoonal thunderstorms that could cause flash flooding.

The time of concentration Tc is determined from the overland length and an assumed velocity for each drainage area. For watershed areas, a minimum value of 10 minutes is assumed.

For the roadway, a runoff coefficient C of 0.9 is to be used. The soil areas were the discharge will be calculated; require a runoff coefficient of 0.33.

The runoff computations calculated by the Rational Method are tabulated in Table C.1

A ponding area was also designed in order to retain runoff created by the road. The design of the ponding area and the location on the project site are shown in Table C.3 and Figure C.1.

Improvements for the road were also proposed. The road has a slope of 2%; it was conclude a ditch in the median is the best option in order to drain the runoff generated by the roadway. The ditch will be located before the two roads merge. To design this element, the discharge the road will create is to be known. Ditches were sized to handle the peak runoff. The design was made by using all of the standards for a triangular channel. To calculate the velocity and discharge the ditch will create the Manning equation was used:

$$V=\frac{1.49}{n}R^{\frac{2}{3}}S^{\frac{1}{2}}$$

Where:

n= Gauckler–Manning coefficient ($T/L^{1/3}$; $s/m^{1/3}$)

R=hydraulic radius (ft)

S=slope of the water surface or the linear hydraulic head loss (L/L)

V=cross-sectional average velocity (ft/s)

All calculations for the ditch design are presented on Table C.4 and Figure C.2.

In order to reduce the runoff accumulated in the north-east area of the project, culverts are to be included. The culverts will take the water under the roadway from the east side to the southwest where the arroyo is located. To design this elements software from the Texas Department of Transportation was used. Calculations, location of the culverts and screenshots of the software are presented on Table C.5 and Figures C.3- C.5.

6.0 Traffic Analysis

The traffic flow was determined by making traffic counts at peak hours, the traffic was counted in person using a traffic counter tally. Two persons were assigned to measure the traffic flow at each intersection, the measurements were taken at morning and evening. The morning peak hours considered was from 7 - 9 AM and in the evening form 4-6 PM. The intersections analyzed were selected based on the amount of traffic they would contribute to the industrial park. The intersections taken in to account were I-10 and Airway, Humble Pl and Gateway Blvd. East, Hawkins and Gateway Blvd. East, and Hawkins and Tony Lama St. It was considered that those four locations would provide a reliable estimation on the traffic generated in the industrial park. The reasoning for selecting those intersections was that these four intersections were located at what we considered would be the main points of access to the industrial park, they cover the westbound traffic coming from Gateway East Blvd. (Gateway and Humble Pl.), the traffic generated by the commercial developments north to the industrial park (Airway and Gateway), the west bound traffic incoming from the west (Hawkins and Gateway), and the southbound traffic towards the industrial park (Tony Lama and Hawkins).

Using a traffic counter, the volume of traffic was recorded and downloaded to create a traffic volume data table which can be referred to in the appendix, as Table D.1-.8. The traffic count included the number of trucks and large commercial vehicles that arrived at the intersection, the direction of the trucks was not considered, only the amount of trucks arriving at the intersection. The percent of truck traffic was determined by dividing the total volume of cars arriving at the intersection divided by the total amount of trucks arriving at each intersection. The percent of trucks of total traffic was calculated into two separate categories, morning and peak hours traffic volume. The results are shown in tables 4.9-.12. It was found to be 7.0% and 6.0% for Humble Pl and Gateway Blvd for evening and morning peak hours respectively. For the Gateway and Airway intersection it was 3.44% for morning peak hours and 2.57% for the evening peak hours. In the Gateway Blvd and Airway intersection the morning and evening results were 3.44% and

2.57% respectively. The intersection which has a higher truck percent in traffic flow is the Hawkins and Tony Lama St. with an 8.79% for the evening peak hours and 10.56% for the morning peak hours. This information will be utilized for the road design; it will serve as a parameter to justify the design of the paved road in terms of asphalt and concrete thickness, lane width and other related design factors.

The percent of trucks in the total traffic volume was considered as the main parameter for the design of the paved surface of the connecting roads between Airway - Commerce and Industrial Rd. The need for a connecting road between the above mentioned streets is validated by the traffic volume analysis. The large volume of traffic created by the industrial park and the surrounding commercial developments suggests that if the connecting road were to be built, the traffic and travel times would significantly be lowered. This will have a positive impact for the commercial vehicles as well as the commuters and occasional users. Also it will increase the level of service for the mentioned intersections.

The projected traffic for trucks and cars was calculated by the equation found in Trip Generation 7th Edition (2001). This equation provides an estimate for the amount of trips an industrial park will generate. Based on the amount of employees, the square feet gross floor area, and vehicle occupancy it can predict the amount of trips an industrial park will generate. This model suggests that trucks account for 1 to 22 percent of the weekday traffic at the sites surveyed, generally an average of 8% was considered for the sites surveyed. The vehicle occupancy ranged from 1.2 to 1.8 persons per automobile with an average of 1.37 occupants. The sites were surveyed in the late 1960’s, the early 1970’s and the mid-1980’s. At the time it is still the model used to predict trip generation in an industrial park. Any other mathematical model to calculate the projected traffic for an industrial park was not found.

For the industrial park in question an area was estimated by using computer software that through satellite imaging can provide a very close estimate of land dimensions. Using the software the measurements were taken and an area of 18,657,908 square feet was calculated. It was calculated by estimating as close as possible through satellite imaging and assuming it the area for the industrial park was a rectangle. The area was considered from Humble Pl. to Hawkins Blvd. The numbers of employees were also assumed in order to calculate the number of trips according to the mathematical model. The model provides an equation to calculate the projected trips for the area.

The traffic count will also be utilized to create a simulation in SYNCHRO software. It will provide a graphical representation of the volume of traffic at the intersections considered. With the software a traffic optimization will be obtained. The software will be also utilized to provide visual support for the presentation.

7.0 Roadway Geometry

The roadway design is based on the policy on geometric design of highways and streets (ASSHTO, 2004) and El Paso design standards for construction manual (2008).

The typical asphalt and concrete section for this project will have 70 ft long and will have four 12 ft lines, two 8ft shoulders and a 6 ft median to meet city specifications as Figure E-1 and Figure E-2 show.

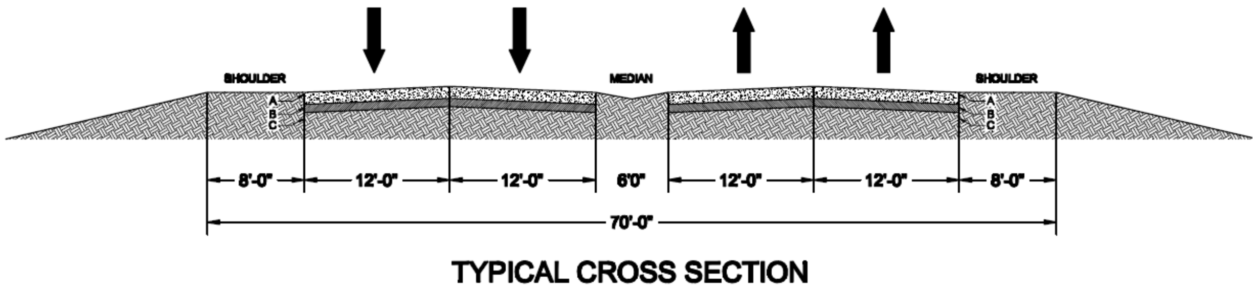

Figure E-1. Propose Concrete Cross Sections.

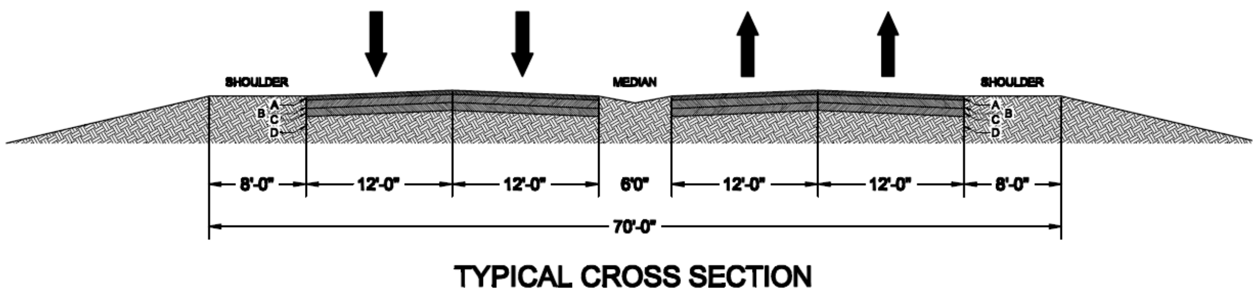

Figure E-2. Propose Asphalt Cross Sections.

The proposed concrete section will consist of 3 in. of Portland cement concrete (PCC) in segment A, and 10 in. of base on segment B and 12 in. of subgrade (soil) on segment C on figure E-1.

The proposed asphalt section will consist of 4 in. of Asphaltic concrete in segment A, 11 in. of Base in segment B, 12 in. of subbase on segment C, over a subgrade (soil) on segment D in figure E-2.

The assumed design speed for this minor arterial is expected to be 30 mph and according to table E-1 taken from the *Policy on geometric design of highways and streets* (ASSHTO, 2004), the maximum radius for the curve would be 456 ft. This velocity was determined by a logical analysis taking in to account the speed limit coming out from the Airway, the topography and the functional classification of the highway.

Table E-1. Maximums Radius for Curves.

Metric		US Customary	
Design speed (km/h)	Maximum radius (m)	Design speed (mph)	Maximum radius (ft)
20	24	15	114
30	54	20	203
40	95	25	317
50	148	30	456
60	213	35	620
70	290	40	810
80	379	45	1025
90	480	50	1265
100	592	55	1531
110	716	60	1822
120	852	65	2138
130	1000	70	2479
		75	2846
		80	3238

Note: The safety benefits of spiral curve transitions are likely to be negligible for larger radii.

The central angles for each of the curves are 91°29´33´´ and 91°50´9´´. Having the angle of curve and the previously mentioned radius it was possible to obtain parameter such as: tangent length, length of curve, middle ordinate, point of curve (PT), point of tangent intersection (PI) and point of tangent (PT) (Appendix E).

The maximum grade for this project according to the description of the terrain which is rolling and the design velocity, it would be 9% as table E-2 taken from the policy on geometric design of highways and streets (ASSHTO, 2004) shows. However since the traffic on this area is going to be mostly heavy trucks, it is recommended to use a 1.5 % and 1.2 % slope each to avoid any problem and to facilitate the final grading.

Table E-2. Maximum Grade for Arterial.

	Metric						US Customary						
	Maximum grade (%) for specified design speed (km/h)						Maximum grade (%) for specified design speed (mph)						
Type of terrain	50	60	70	80	90	100	30	35	40	45	50	55	60
Level	8	7	6	6	5	5	8	7	7	6	6	5	5
Rolling	9	8	7	7	6	6	9	8	8	7	7	6	6
Mountainous	11	10	9	9	8	8	11	10	10	9	9	8	8

On the other hand, since there was no access to the land to perform a proper survey. The total Earthwork for the project was approximated using AutoCad. The earthwork volume was estimated by calculating the areas over the final grade line and the areas under the final grade line. Once those areas were calculated and multiplied by the road width, the embankment and cut volumes were known. As a result, the total embankment volume is 32,600 cu yards and for the cut 16, 600 cu yard approximately. Since the embankment volume is almost double than the cut, some imported material is going to be needed..

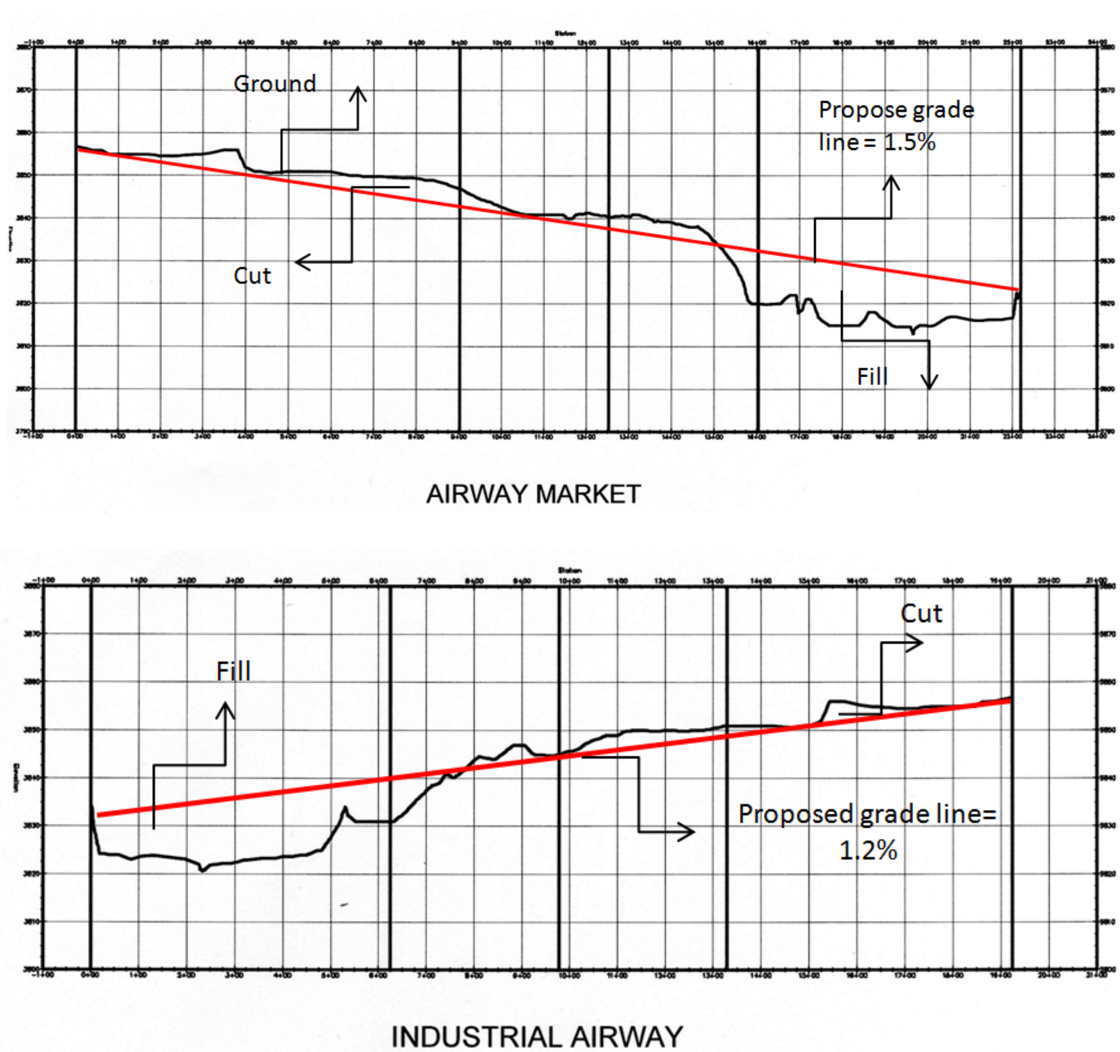

Figure E-3. Mass Diagrams.

8.0 Asphalt Considerations

For the pavement thickness design different considerations must be taken into account, the criteria followed was under the design standards for construction for the city of El Paso, which follows ASTM standards(1993), all the procedures will be used for all city of El Paso street paving projects and all of those projects within 5 miles of distance. To follow the requirements needed, a geotechnical study must be made to obtain the classification of subgrade soils, in order to get the results for the geotechnical study a minimum of 2 boring holes with standard penetration tests must be excavated to 6.5 ft. below paving and the location of the boring holes shall be placed at intervals not exceeding 800 ft. between the drillings. From the report obtained for the soil study, the properties of the soil should be established and the index properties for the soil, the strength of the subgrade soils, the results for the 2 boring holes dug on a nearby area shown the soil that the soil on the land was a silty sand (SM) (A-3), a non-plastic material with a water content of 6% , and a liquid limit of 35.

The thickness of base materials and pavement must be determined in accordance with the manual minimum requirements for the surface, base course and the sub-base course. The surface of the design will be constituted of Hot Mixed Asphalt (HMA), and the necessary data for the HMA must be obtained getting different values, these values given by the city manual, considered are the terminal serviceability index (PT) must be 2.0, equivalent 18-kip single-axle load (E.A.L), these tables and figures are attached on the appendix F, table 1 sheet No. 3-25, soil support value (s) which for sand is 7 obtained from a table 2 sheet 3-28, regional factor (R) must be 0.5, the structural number (SN) must be determined from the figure 1, sheet 3-29A attached on Appendix F. The layer coefficient (A1, A2, A3) with the following equation:

$$SN = A_1 D_1 + A_2 D_2 + A_3 D_3$$

Where:

D_1= Thickness of surface course.

D_2= Thickness of base course.

D_3= Thickness of sub-base course.

Following Figure F-3 in the section for pavement thickness design procedure we obtained the CBR (California Bearing Ratio) 17 from the soil support value. All data being analyzed the software Spectra Pave 4 PRO two sections were calculated for reinforced and unreinforced pavement:

Unreinforced Pavement

Layer	Di	ai	mi	SN
ACC1	4.00	0.440	N/A	1.76
ABC	11.00	0.140	1.0	1.54
SBC	12.00	0.110	1.0	1.32
Overall Structural Number (SN)				4.62

Reinforced Pavement

Layer	Di	ai	mi	SN
ACC1	3.00	0.440	N/A	1.32
MSL:	10.00	0.209	1.0	2.09
SBC	12.00	0.110	1.0	1.32
Overall Structural Number (SN)				4.73

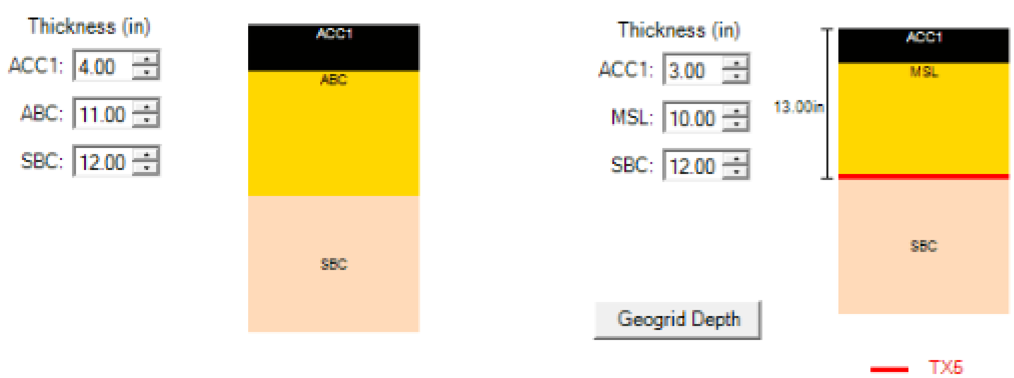

Figure F-3. Thickness for the Different Reinforced and Unreinforced Sections

The thickness of each section are shown above on the different sections for unreinforced and reinforced pavement. For the unreinforced pavement, the wearing surface will be 4in. thick and the material would be hot mixed asphalt (HMA). The base course would consist of compacted gravel 11 in. thick and the subbase course would consist of the same soil found on site which would be compacted sand 12 in. thick. For the reinforced section the wearing surface would be a continously reinforced concrete slab 3 in. thick, the base course and subbase materials used would be compacted gravel and compacted sand, the thickness of the base course would be 10 in. thick and the subbase 12 in. thick. This results are the minimum required for the E.A.L for 20 years which are 2 200 00 and the designed E.A.L used for both section is greater than the minimum requirement.

9.0 Construction Permits

In order for a construction of any type to start, within the civil engineering field, many different regulations are imposed upon the project depending on its location. In this case it is located in El Paso, TX; and because of this certain protocols must be followed from El Paso district and the State of Texas. The majority of these regulations are imposed by the Texas Department of Transportation (TxDot). For the construction project of Airway-Industrial Park, there were several permits that apply to the construction site, but overall there are three permits which are the most important for the project since they hold the primary objective in order to construct the street. These three permits are the grading permit, drainage permit, and the SW3P or Storm Water Pollution prevention plans.

A grading permit is required when the volume of cut and fills soil materials equals or exceeds certain amount of material excavated. The amount is defined depending on the regulation for the construction sites. The process as is name states it’s divided into two parts:

1. Cut - soil materials that are removed from an area of land, such as an excavation

2. Fill - soil materials that are added to an area of land, such as the placement of soil for an embankment or fill slope.

The amount obtained for the cut and fill was 16 600 cubic yards. In order to obtain the permit, applications forms must be completed. First contact a contractor who in most of the cases would be the one in charge of getting all the permits and their subdivisions. The representatives in charge of handling the entire city permits would be the office of City of El Paso where all the application forms and additional documents can be found. The specific application required will be determined by the scope of the project. Most of the time a grading permit application requires different sets of grading and drainage plans which include a site plan in each set. Additional information may include in-site specific soils or geotechnical report for structures. Additional documents may include geological reports, compactions reports, surveys to establish grades, property lines and location of structure, erosion control plans, Best Management Practices (BMPs), maps and diagrams used to produce your calculations to help prevent any delays in processing your grading permit application. After having a detailed plan for drainage and grading, it has to be submitted to the El Paso City office for revision and the permit to be accepted. All documents that are submitted have to be signed by a professional engineer and have to follow the guidelines provided by the city law.

The Drainage Permit must be included among the grading permit since both are deeply associated with each other. A drainage plan has to be drawn and shown to the city. These plans of the drainage have to show boundaries of subdivision and contributing drainage areas, limits of contributing watershed areas, tables to include times of concentration, intensities, coefficient values, etc. Location and sizes of all proposed and existing drainage structures must be shown. Existing and proposed drainage flow patterns, high and low points of street with flow patterns.

The most important elements for this permit and the design in this case would be the storage facilities. The proposed plans have to show maximum capacity, expected runoff, bottom elevation, high water surface, free board, soil tests to determine slopes, existing water table elevation during off peak period, among other that are related to all those assets. In this design we used on-site ponding which differ, a little from all the other structures used. For on-site ponding there are different requisites that have to be shown in the design which are preliminary soil tests, cross section showing storage capacity, drainage computations based on a 100-year storm, a minimum of 2% cross slope, accommodations for street runoff, and 50 % of residential lot area shall remain without structures.

The purpose of a Storm Water Pollution Prevention Plan (SW3P) prepared for a construction project is to specify the design and planning of environmental protection control procedures during highway construction projects, to ensure the minimum impact possible on the environment from highway projects by preventing runoff from discharging from a construction site, and minimizing construction activity pollutants from entering waters of the US. This was put into action because the practices of specifying that the contractor would be responsible for the soil related accidents such as erosion and sediment control are no longer suitable. In this case the design to provides adequate information, control measures, and guidance in the specifications to achieve a practical, economic, and reliable plan in order to control erosion and sedimentation in the project. A SW3P should be taken into action for any project where the soil has disturbing activities occurring. Following TxDot regulations if the project disturbs more than 5 acres of land, an EPA NPDES general permit will be required to meet the guidelines. All forms should describe and ensure the application of practices that will lessen the contaminants contained in storm water related with the construction site.

At a minimum any SW3P developed for a construction activity should include the following information:

• A description of the nature of the construction activity and the intended sequence of major soil disturbing activities.

• A site map indicating: drainage patterns, areas not to be disturbed, locations of major controls measures, locations of areas that will be stabilized, surface waters (including wetlands), locations where storm water is discharged to a surface water, limits of construction and disturbed areas erosion control BMPs, sediment control BMPs.

References:

- American Association of State Highway and Transportation Officials. (2004). *A Policy on Geometric Design of Highways and Streets* (5th Ed.). Washington, D.C.: ASSHTO
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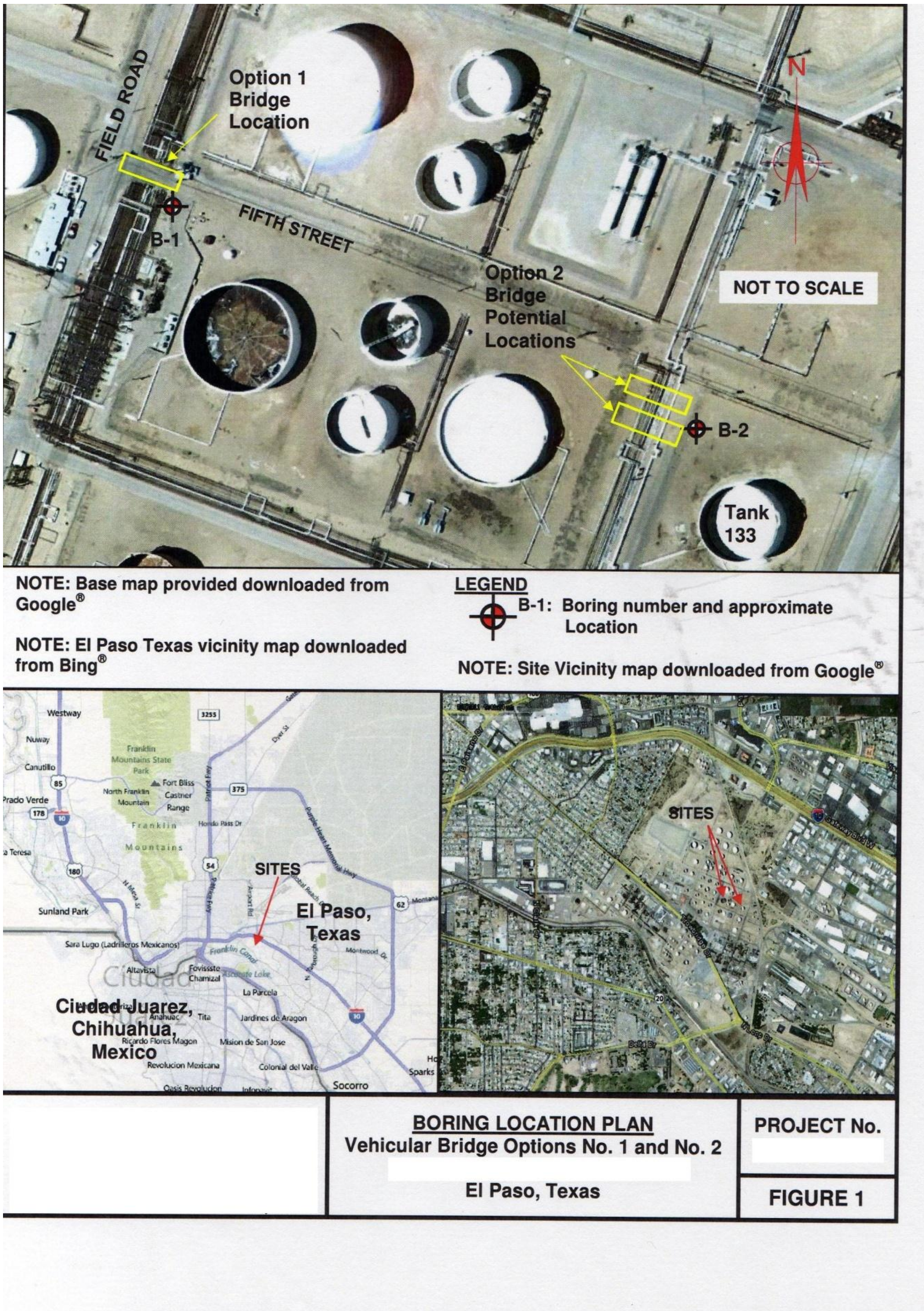
- *Trip Generation*. (2002). Houston, TX: Institute of Transportation Engineers.

APPENDIX A

Geotechnical Study



LOG OF BORING NO. B-2

El Paso, Texas

DRILLING METHOD: Vacuum (0-11 ft); CME 75, 3¼" (I.D.) H.S. Auger (11-50 ft)

LOCATION: Option No. 2 (See Figure 1)

SHEAR STRENGTH, TONS/FT^2: 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT: 10 20 30 40 50 60 70 80

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	PLASTICITY INDEX	% -200
0	**FILL: SILTY SAND (SM)** light brown, slightly moist				
	SILTY SAND (SM) (A-3) medium dense, light brown, slightly moist, with trace gravel				
		15			
15	**CLAYEY SAND (SC) (A-6)** medium dense to dense, dark gray, moist	29			
	LEAN CLAY with SAND (CL) (A-7) very stiff, gray, moist				
20		17		25	75
	SANDY SILTY CLAY (CL-ML) (A-4) hard, gray, moist				
25	- dark gray below 24 feet	50/ 7"		4	50
30	**SILTY CLAYEY SAND (SC-SM) (A-2-4 or A-4)** very dense, dark gray, moist	50/ 11"		4	31
35		50/ 6"			38
	POORLY GRADED SAND (SP) (A-3) very dense, dark gray, slightly moist,				
40		50/ 8"			
45		50/ 6"			
50		50/ 9"			
50	Boring Terminated				

NOTES:
1. Free water was not observed during drilling operations.
2. Backfilled with soil cuttings and lean grout.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 50.0 ft	**DEPTH TO WATER:** Dry	**PROJ. No.:**	
DATE DRILLED: 10/17/2011	**DATE MEASURED:** 10/17/2011	**FIGURE:** 3	

LOG OF BORING NO. B-1

Vehicular Bridge Option Nos. 1 and 2

El Paso, Texas

DRILLING METHOD: Vacuum (0-11 ft); CME 75, 3¼" (I.D.) H.S. Auger (11-50 ft)

LOCATION: Option No. 1 (See Figure 1)

Depth, ft	Description of Material	Blows per ft	Plasticity Index	% -200
0–0.1	**ASPHALT** (approx. 1-1/2 inches)			
0.1–0.4	**BASE COURSE** (approx. 3-1/2 inches)			
0.4–6	**FILL: SILTY SAND (SM) (A-3)** light brown, slightly moist with trace gravel and black debris			
6–11	**SILTY SAND (SM) (A-3)** light brown, moist with trace gravel			
11–16	**POORLY GRADED SAND (SP) (A-3)** medium dense, light gray, slightly moist	25		3
		25		
16–23	**SANDY LEAN CLAY (CL) (A-4)** very stiff, brown, moist - with trace gravel from 16 to 17 feet	16	9	53
23–27	**CLAYEY SAND (SC) (A-6)** medium dense, gray, moist with interbedded clay lenses	16		40
27–38	**SANDY SILTY CLAY (CL-ML) (A-4)** dark gray, stiff, moist	33	4	64
		12		
38–50	**SILTY SAND (SM) (A-3)** very dense, brown to grayish-brown	50/6"		
		50/7"		16
		50/5"		
50	Boring Terminated			

Shear strength, tons/ft²: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0

Plastic limit — Water content — Liquid limit: 10, 20, 30, 40, 50, 60, 70, 80

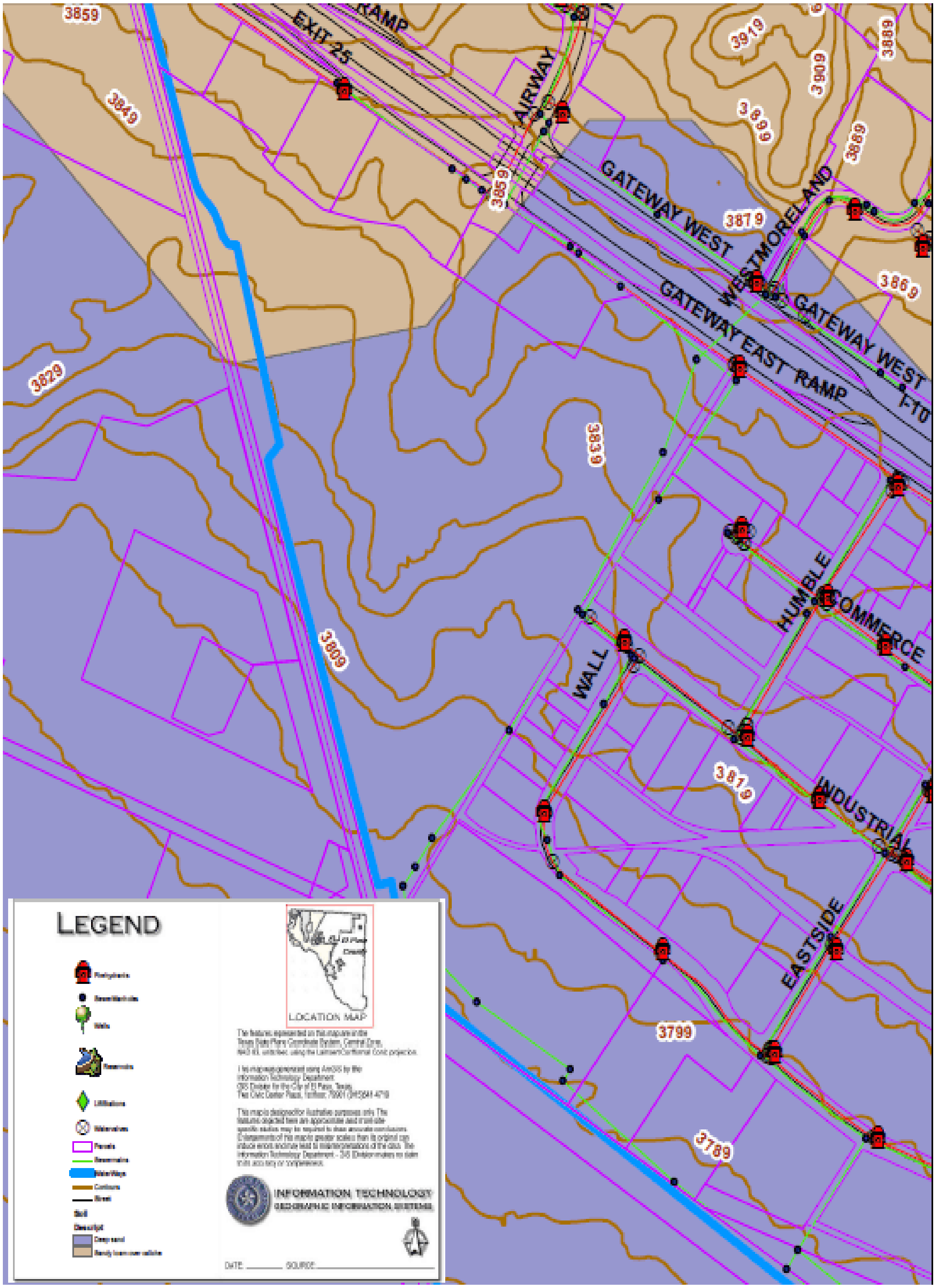
NOTES:
1. Free water was not observed during drilling operations.
2. Backfilled with soil cuttings and lean grout.

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT

DEPTH DRILLED: 50.0 ft
DATE DRILLED: 9/2/2011
DEPTH TO WATER: Dry
DATE MEASURED: 9/2/2011
PROJ. No.:
FIGURE: 2

APPENDIX B

City Map Contour Lines




CONTOUR LINES
OBSCURED
AIRWAY
INDUSTRIAL
MARKET

APPENDIX C

Table C.1 – Runoff Determination by Rational Method

DA	A'	C	C	CXA (0.90)	CXA (0.33)	Tc	I_{25}	I_{100}	Q_{25} (0.9)	Q_{100} (0.9)	Q_{25} (0.33)	Q_{100} (0.33)
No.	(ac.)					min.	(in/hr)	(in/hr)	(cfs)	(cfs)	(cfs)	(cfs)
1	23.30	0.90	0.33	20.97	7.69	10.0	3.44	4.13	72.16	86.67	26.46	31.78
2	14.38	0.90	0.33	12.94	4.75	10.0	3.44	4.13	44.54	53.49	16.33	19.61
3	9.26	0.90	0.33	8.33	3.06	10.0	3.44	4.13	28.68	34.44	10.52	12.63

Table C.2 – Roadway Dimensions and Areas

Road Width Industrial Av.	Road Width Market St.	Road Length Industrial Av.	Road Length Market St.
(ft)	(ft)	(ft)	(ft)
32	32	1509.2716	1835.4938

Area		
Road	(sqft.)	(ac.)
Industrial Av.	48296.69	1.11
Market St.	58735.80	1.35
	Total Area	2.46

Ponding Area

Table C.3 – Ponding Area Design

$Q = \frac{ARC}{12}$	Area	
	ft^3	Acre-ft
	32109.748	0.737

Where:
A=Road Total Area (2.46 ac.)
R= 4
C= 0.9

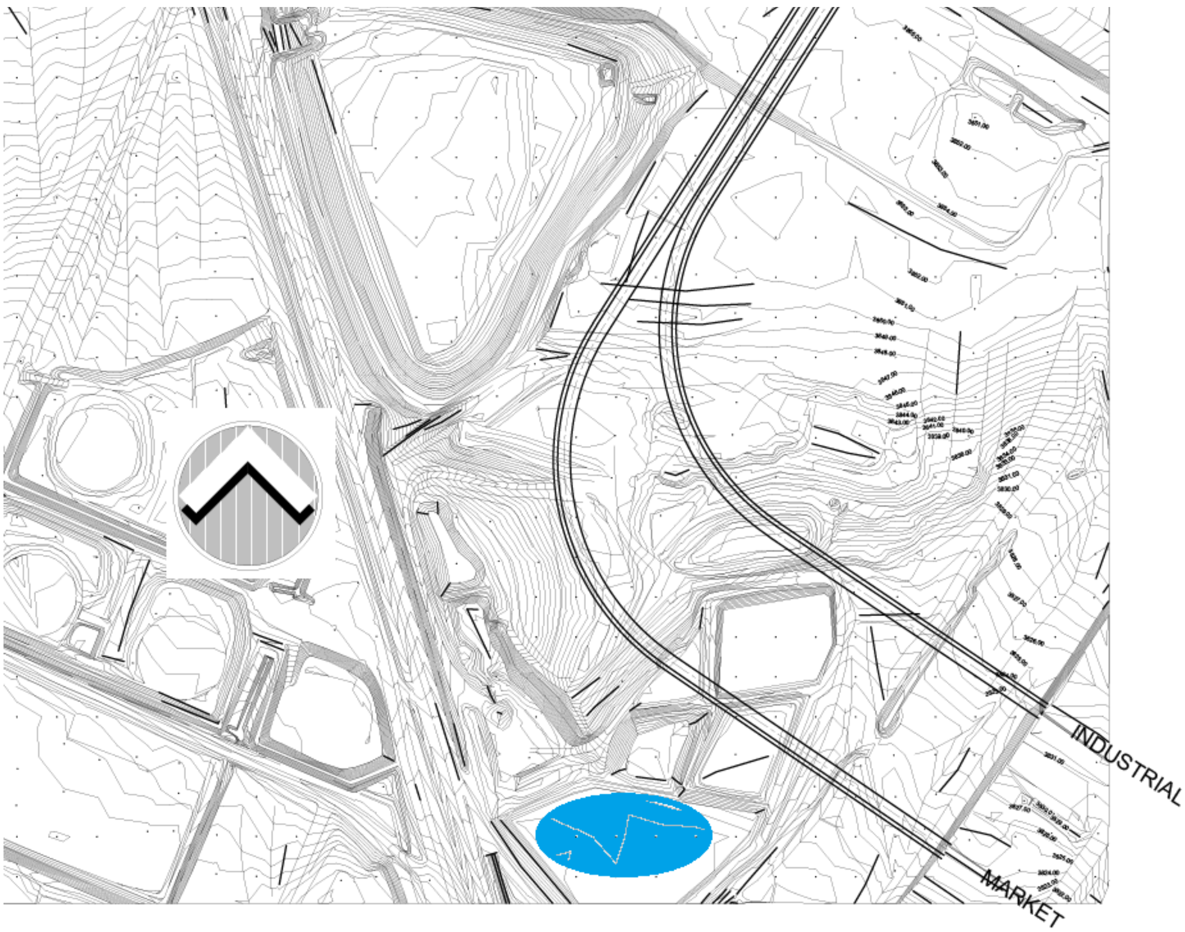


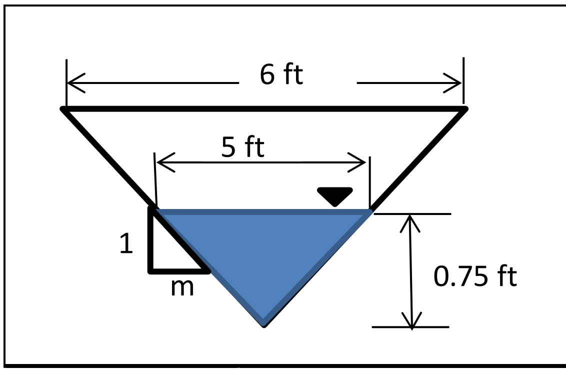
Figure C.1 – Ponding Area Location along the Proposed Route

Ditch

Table C.4 - Discharge Calculated for Inner Road Lanes (Rational Method)

Lane Width Industrial Av. (ft)	LaneWidth Market St. (ft)	Road Length Industrial Av. (ft)	Road Length Market St. (ft)
12	12	1509.2716	1835.4938

	Area (sqft.)	Area (ac.)	Q_{100} (cfs)
Industrial Av.	18111.26	0.42	1.55
Market St.	22025.93	0.51	1.88
			3.43



m		3.33
Area (A)	sqft.	1.87
Perimeter (P)	ft.	5.22
Hydraulic Radius (R)	ft.	0.35
Slope		0.003
n		0.013
Velocity (V)	ft/s	2.84
Discharge (Q)	cfs.	5.32

Figure C.2 Ditch Design

Culverts Design

Table C.5 - Discharge Required for Culvert Design

DA	A'	C soil	C road	Total Area, 1 Lane and A'	Industrial Av .1 Lane Total Area	C weighted value	Q25 (C weighted)	Q100 (C weighted)
No.	(ac.)			(ac.)	(ac.)		(cfs)	(cfs)
1.00	14.38	0.33	0.90	15.07	0.69	0.36	18.48	22.19

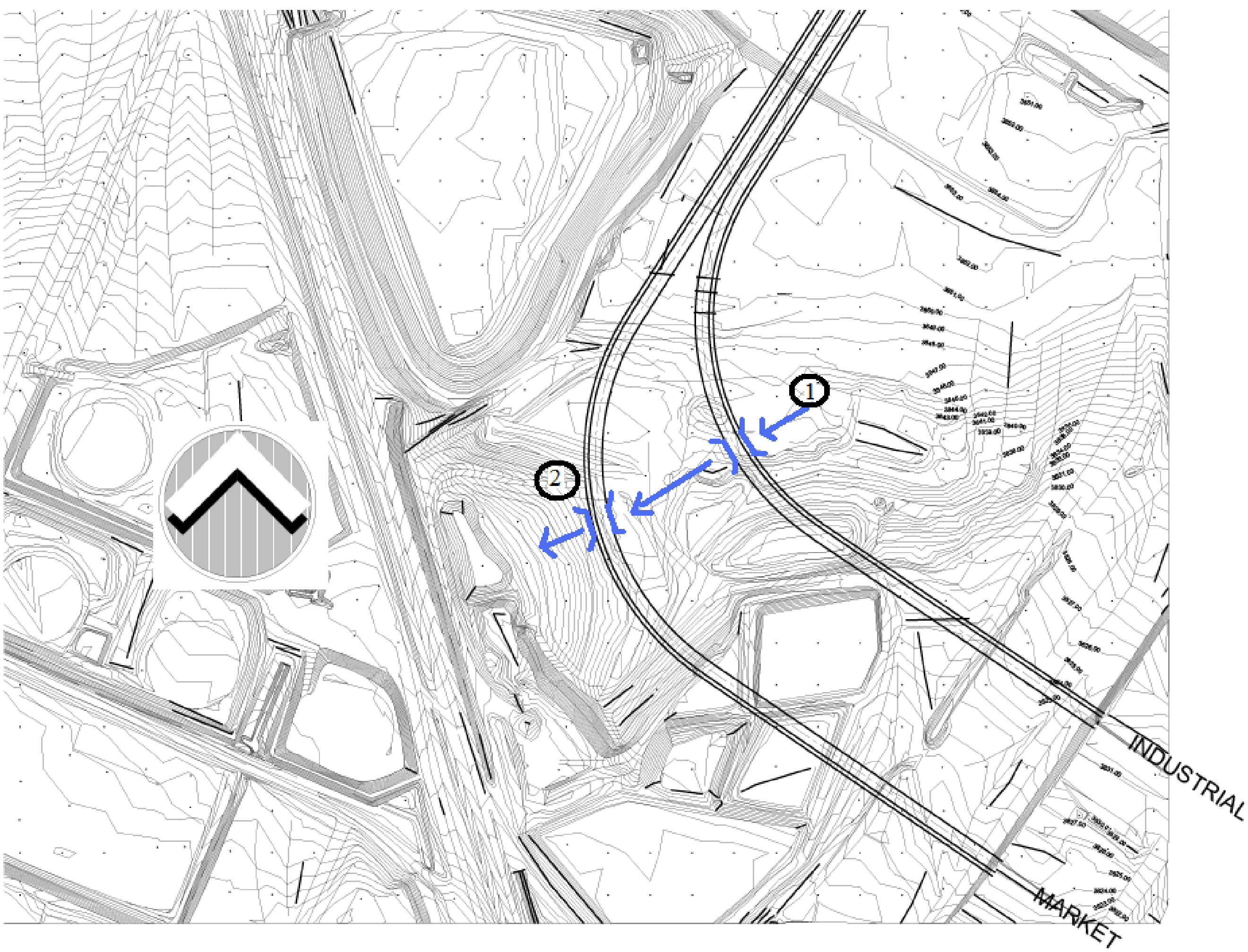
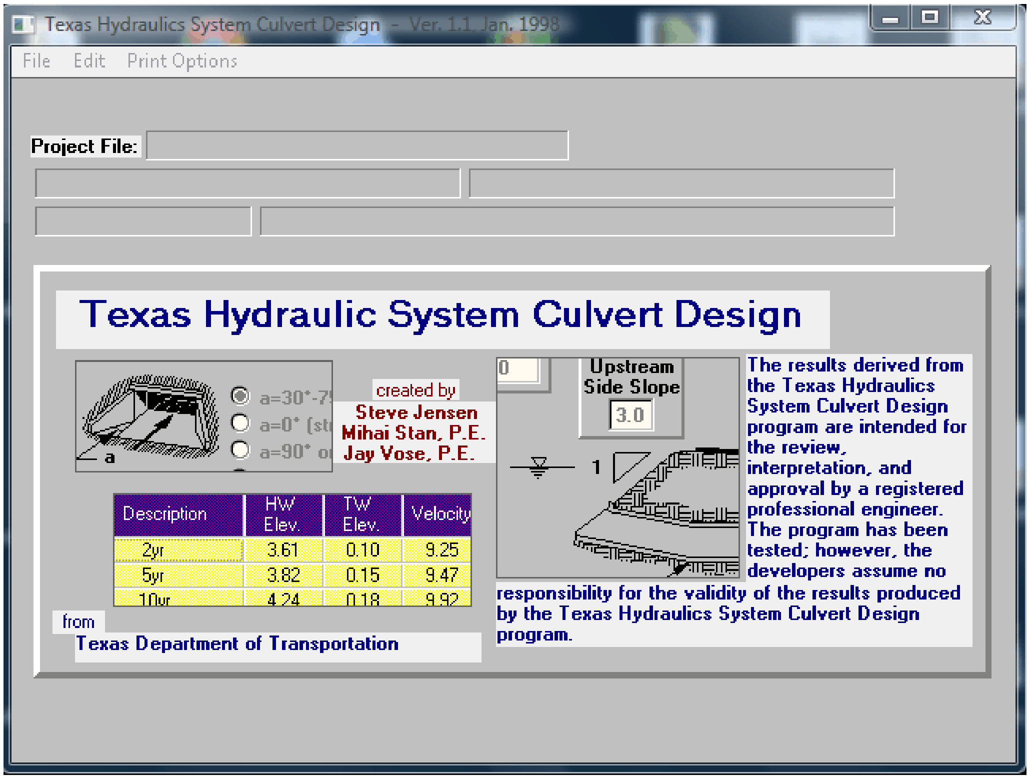
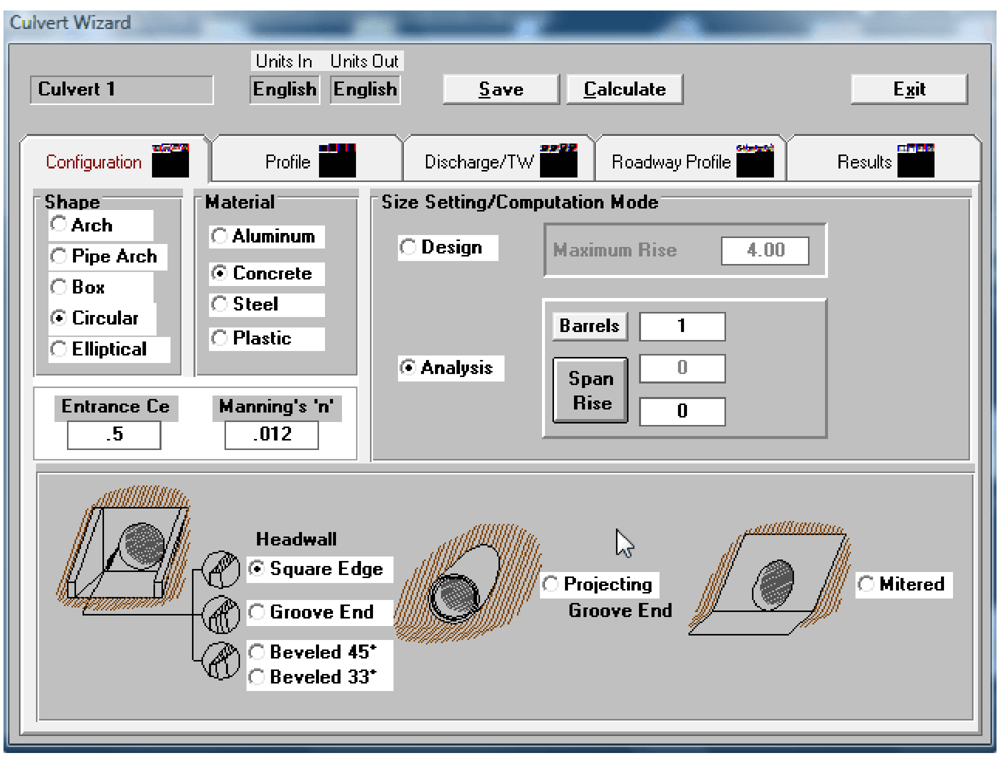


Figure C.3 – Culverts Location along the Proposed Route

Figures C.4 Software Used for Culvert Design





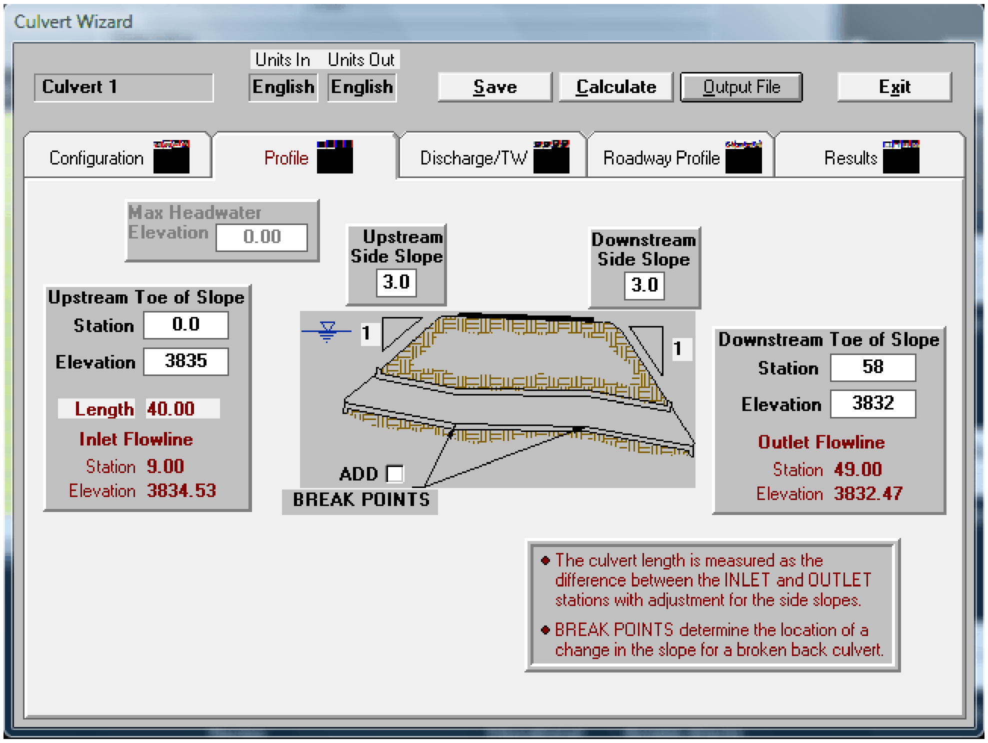

Culvert Wizard
Culvert 1
Units In Units Out
English English
Save
Calculate
Output File
Exit
Configuration
Profile
Discharge/TW
Roadway Profile
Results
Max Headwater Elevation 0.00
Upstream Side Slope 3.0
Downstream Side Slope 3.0
Upstream Toe of Slope
Station 0.0
Elevation 3835
Length 40.00
Inlet Flowline
Station 9.00
Elevation 3834.53
Downstream Toe of Slope
Station 58
Elevation 3832
Outlet Flowline
Station 49.00
Elevation 3832.47
ADD
BREAK POINTS
The culvert length is measured as the difference between the INLET and OUTLET stations with adjustment for the side slopes.
BREAK POINTS determine the location of a change in the slope for a broken back culvert.

Figure C.5 Software Culverts Analysis

Culvert 1

```
                     CULVERT HYDRAULIC COMPUTATIONS
                     ------------------------------
CULVERT NAME:    Culvert 1                      Input Units:  English
PROJECT NAME:    Culvert 1                      Output Units: English
PROJECT CONTROL: CSJ:
COUNTY:          El Paso
DESCRIPTION:     Description

ANALYZE   SINGLE    OPENING   CULVERT

MATERIAL: CONCRETE
SHAPE:    RCP CIRCULAR PIPE.
ENTRANCE: HEADWALL
PROFILE:  STRAIGHT CULVERT

FREQUENCY: Q100      DISCHARGE:    22.19 cfs  TAILWATER:     3.50 ft


n value:  0.0120      Ke value:  0.5000

CULVERT DIAM. =  3.00 ft   BARRELS =  1

INLET  station:       0.00      elevation:    3835.00 ft
OUTLET station:      58.00      elevation:    3832.00 ft

-----------------------------------------------------------------------------

-----------------------------------------------------------------------------
       CULVERT  OUTPUT      RUN NO =>  1
-----------------------------------------------------------------------------
ANALYSIS for discharge frequency of :   Q100

Barls. Qpb  Rise  Span  Length  Max.HW  Calc.HW  HW  Control  Veloc. Out.deptł
                                 elev    elev
       cfs   ft    ft     ft     ft      ft     ft           ft/s     ft
-----------------------------------------------------------------------------
  1  22.19  3.00  0.00   40.00   0.00 3836.70  2.16 Inlet    13.14    0.87

Inlet control depth  =      2.16 ft
Outlet control depth =      6.88 ft

Normal depth   =     0.74 ft   Culvert slope  =     0.05179
Critical depth =     1.52 ft   Critical slope =     0.00364
-----------------------------------------------------------------------------


 RUNING MESSAGES LIST:

*Computation: Hydraulic jump occurs at culvert outlet.
*Computation: Outlet velocity is based on the outlet water depth.

 NORMAL TERMINATION OF THYSYS,  CULVERT.
```

Culvert 2

$Q_{Culvert2} = Q_{culvert1} + Q_{ditch}$

= 22.19 + 3.43 = 25.62

```
CULVERT NAME:     Culvert 2                          Input Units:  English
PROJECT NAME:     Culvert 2                          Output Units: English
PROJECT CONTROL:  CSJ:
COUNTY:           El Paso
DESCRIPTION:      Description

ANALYZE   SINGLE    OPENING   CULVERT

MATERIAL: CONCRETE
SHAPE:    RCP CIRCULAR PIPE.
ENTRANCE: HEADWALL
PROFILE:  STRAIGHT CULVERT

FREQUENCY: Q100       DISCHARGE:    25.62 cfs

Tailwater not provided for    25.62 cfs.
       Minimum of normal or critical depth used as tailwater.

n value:  0.0120       Ke value:  0.5000

CULVERT DIAM. =  3.00 ft   BARRELS =  1

INLET  station:      0.00      elevation:    3830.00 ft
OUTLET station:     58.00      elevation:    3827.00 ft

------------------------------------------------------------------------------

------------------------------------------------------------------------------
       CULVERT  OUTPUT      RUN NO =>  1
------------------------------------------------------------------------------
ANALYSIS for discharge frequency of :   Q100

Barls. Qpb  Rise  Span  Length  Max.HW  Calc.HW  HW  Control  Veloc. Out.depth
                                 elev    elev
       cfs   ft    ft     ft      ft      ft     ft            ft/s     ft
------------------------------------------------------------------------------
  1  25.62  3.00  0.00  40.00    0.00 3831.90  2.37 Inlet    13.45    0.94

Inlet control depth  =      2.37 ft
Outlet control depth =      7.47 ft

Normal depth   =     0.80 ft    Culvert slope  =     0.05179
Critical depth =     1.63 ft    Critical slope =     0.00378
------------------------------------------------------------------------------


 RUNING MESSAGES LIST:

*Computation: Tailwater elevation lower than outlet elevation.
*Computation: Minimum of normal/critical depth used.
*Computation: Hydraulic jump occurs at culvert outlet.

 NORMAL TERMINATION OF THYSYS,  CULVERT.
```

APPENDIX D

Unit Type:	MICROTALLY V3.08
Serial Number:	7111404
ID:	
Location:	TONY LAMA & HAWKINS
Comments:	
Measurements:	English

Table D.1

Time	SBL	SBT	SBR	NBL	NBT	NBR	WBL	WBT	WBR	EBL	EBT	EBR	
10/27/2011 16:00	15	5	1	11	20	3	1	50	14	8	103	14	
10/27/2011 16:15	12	8	3	10	15	4	2	63	17	9	120	11	
10/27/2011 16:30	14	6	1	8	11	2	4	62	17	9	165	12	
10/27/2011 16:45	23	5	2	9	13	3	2	56	17	8	102	14	
10/27/2011 16:56	11	3	0	5	10	2	0	11	3	1	39	3	
10/27/2011 17:00	36	9	0	17	30	1	2	81	21	12	215	15	
10/27/2011 17:15	18	11	2	6	34	1	3	86	19	6	168	21	
10/27/2011 17:30	16	9	2	7	19	2	2	70	20	4	113	17	
10/27/2011 17:45	16	12	1	8	22	0	0	35	15	5	111	20	
10/27/2011 18:00	12	8	3	11	14	5	3	27	12	9	98	14	
TOTAL	173	76	15	92	188	23	19	541	155	71	1234	141	2728

Table D.2

10/27/2011 7:00	12	4	4	12	22	2	2	56	12	9	102	12	
10/27/2011 7:15	14	6	3	10	24	3	3	51	10	7	115	14	
10/27/2011 7:30	15	3	2	15	19	1	4	62	16	8	123	11	
10/27/2011 7:45	16	4	2	13	17	0	2	65	18	6	135	10	
10/27/2011 8:00	18	9	5	16	18	3	1	72	19	7	142	16	
10/27/2011 8:15	14	7	4	14	20	3	2	77	22	9	146	13	
10/27/2011 8:30	22	7	3	15	25	2	3	80	25	8	152	10	
10/27/2011 8:45	19	11	2	13	20	1	1	83	24	10	135	11	
10/27/2011 9:00	17	10	1	10	21	3	4	89	31	11	137	15	
TOTAL	147	61	26	118	186	18	22	635	177	75	1187	112	2764

Unit Type:	MICROTALLY V3.08
Serial Number:	7111404
ID:	
Location:	AIRWAY & GATEWAY
Comments:	
Measurements:	English
Start Date:	11/11/2011

Table D.3

	SBL	SBT	SBR	NBL	NBT	NBR	WBL	WBT	WBR	EBL	EBT	EBR	
11/26/2011 4:00	45	2	95	22	3	5	32	126	86	70	119	2	
11/26/2011 4:15	50	4	87	24	2	6	30	132	79	68	132	3	
11/26/2011 4:30	46	2	98	26	3	4	34	141	91	74	128	1	
11/26/2011 4:45	62	1	110	30	1	3	38	135	89	79	135	2	
11/26/2011 5:00	55	4	90	24	2	2	41	136	79	80	124	3	
11/26/2011 5:15	47	1	94	22	1	5	35	137	81	82	126	4	
11/26/2011 5:30	56	2	110	26	3	4	36	140	84	86	132	2	
11/26/2011 6:00	53	1	114	24	1	2	41	141	83	82	140	3	
TOTAL	414	17	798	198	16	31	287	1088	672	621	1036	20	5198

Table D.4

	SBL	SBT	SBR	NBL	NBT	NBR	WBL	WBT	WBR	EBL	EBT	EBR	
11/10/2011 7:00	52	95	56	114	132	65	40	156	42	65	165	89	
11/10/2011 7:15	54	90	72	100	156	70	49	174	56	77	184	96	
11/10/2011 7:30	50	110	82	98	162	82	65	165	62	74	195	87	
11/10/2011 7:45	49	93	88	120	163	90	52	181	42	69	201	91	
11/10/2011 8:00	47	88	96	112	170	75	58	165	48	85	178	98	
11/10/2011 8:15	53	95	79	98	134	85	63	142	55	66	196	87	
11/10/2011 8:30	55	102	95	120	149	96	54	170	72	92	179	85	
11/10/2011 8:45	60	123	105	132	160	110	66	182	65	90	198	92	
11/10/2011 9:00	62	99	98	142	152	114	68	195	50	96	179	105	
TOTAL	482	895	771	1036	1378	787	515	1530	492	714	1675	830	11105

Unit Type:	MICROTALLY V3.04
Serial Number:	7041208
ID:	
Location:	HUMBLE & GATEWAY
Comments:	
Measurements:	English
Start Date:	10/27/2011

Table D.5

Time	SBL	SBT	SBR	NBL	NBT	NBR	WBL	WBT	WBR	EBL	EBT	EBR	
10/27/2011 15:57	0	0	0	0	0	2	0	0	0	0	60	3	
10/27/2011 16:00	0	0	0	1	0	13	0	0	0	0	326	14	
10/27/2011 16:15	0	0	0	0	0	20	0	0	0	0	513	4	
10/27/2011 16:30	0	0	0	0	0	10	0	0	0	0	607	9	
10/27/2011 16:45	0	0	0	0	0	21	0	0	0	0	544	9	
10/27/2011 17:00	0	0	0	0	0	17	0	0	0	0	630	7	
10/27/2011 17:15	0	0	0	0	0	17	0	0	0	0	556	4	
10/27/2011 17:30	0	0	0	0	0	10	0	0	0	0	511	14	
10/27/2011 17:45	0	0	0	0	0	16	0	0	0	0	254	4	
10/27/2011 18:00	0	0		0	0	15	0	0	0	0	260	5	
TOTAL	0	0	0	1	0	141	0	0	0	0	4261	73	4476

Table D.6

Time	SBL	SBT	SBR	NBL	NBT	NBR	WBL	WBT	WBR	EBL	EBT	EBR	
10/27/2011 7:00	0	0	0	0	0	12	0	0	0	0	320	12	
10/27/2011 7:15	0	0	0	0	0	15	0	0	0	0	450	10	
10/27/2011 7:30	0	0	0	0	0	18	0	0	0	0	472	9	
10/27/2011 7:45	0	0	0	0	0	14	0	0	0	0	500	13	
10/27/2011 8:00	0	0	0	0	0	16	0	0	0	0	498	17	
10/27/2011 8:15	0	0	0	0	0	17	0	0	0	0	530	11	
10/27/2011 8:30	0	0	0	0	0	10	0	0	0	0	520	13	
10/27/2011 8:45	0	0	0	0	0	10	0	0	0	0	519	16	
10/27/2011 9:00	0	0	0	0	0	18	0	0	0	0	504	9	
TOTAL	0	0	0	0	0	130	0	0	0	0	4313	110	4553

Unit Type:	MICROTALLY V3.08
Serial Number:	7111404
ID:	
Location:	HAWKINS & GAETWAY
Comments:	
Measurements:	English
Start Date:	11/11/2011

Table D.7

	SBL	SBT	SBR	NBL	NBT	NBR	WBL	WBT	WBR	EBL	EBT	EBR	
11/26/2011 4:00	45	2	95	22	3	5	32	126	86	70	119	2	
11/26/2011 4:15	50	4	87	24	2	6	30	132	79	68	132	3	
11/26/2011 4:30	46	2	98	26	3	4	34	141	91	74	128	1	
11/26/2011 4:45	62	1	110	30	1	3	38	135	89	79	135	2	
11/26/2011 5:00	55	4	90	24	2	2	41	136	79	80	124	3	
11/26/2011 5:15	47	1	94	22	1	5	35	137	81	82	126	4	
11/26/2011 5:30	56	2	110	26	3	4	36	140	84	86	132	2	
11/26/2011 6:00	53	1	114	24	1	2	41	141	83	82	140	3	
TOTALS	414	17	798	198	16	31	287	1088	672	621	1036	20	5198

Table D.8

	SBL	SBT	SBR	NBL	NBT	NBR	WBL	WBT	WBR	EBL	EBT	EBR	
11/10/2011 7:00	52	95	56	114	132	65	40	156	42	65	165	89	
11/10/2011 7:15	54	90	72	100	156	70	49	174	56	77	184	96	
11/10/2011 7:30	50	110	82	98	162	82	65	165	62	74	195	87	
11/10/2011 7:45	49	93	88	120	163	90	52	181	42	69	201	91	
11/10/2011 8:00	47	88	96	112	170	75	58	165	48	85	178	98	
11/10/2011 8:15	53	95	79	98	134	85	63	142	55	66	196	87	
11/10/2011 8:30	55	102	95	120	149	96	54	170	72	92	179	85	
11/10/2011 8:45	60	123	105	132	160	110	66	182	65	90	198	92	
11/10/2011 9:00	62	99	98	142	152	114	68	195	50	96	179	105	
TOTAL	482	895	771	1036	1378	787	515	1530	492	714	1675	830	11105

Table D.9

HUMBLE & GATEWAY	
TOTAL VEHICLES A.M.	4476
TOTAL TRUCKS A.M	308
TRUC PERCENTAGE A.M.	6.881143878
TOTAL VEHICLES P.M.	4553
TOTAL TRUCKS P.M	254
TOTAL PERCENTAGE P.M	5.578739293

Table D.10

AIRWAY & GATEWAY	
TOTAL VEHICLES A.M.	5196
TOTAL TRUCKS A.M	196
TRUC PERCENTAGE A.M.	3.77213241
TOTAL VEHICLES P.M.	6363
TOTAL TRUCKS P.M	164
TOTAL PERCENTAGE P.M	2.577400597

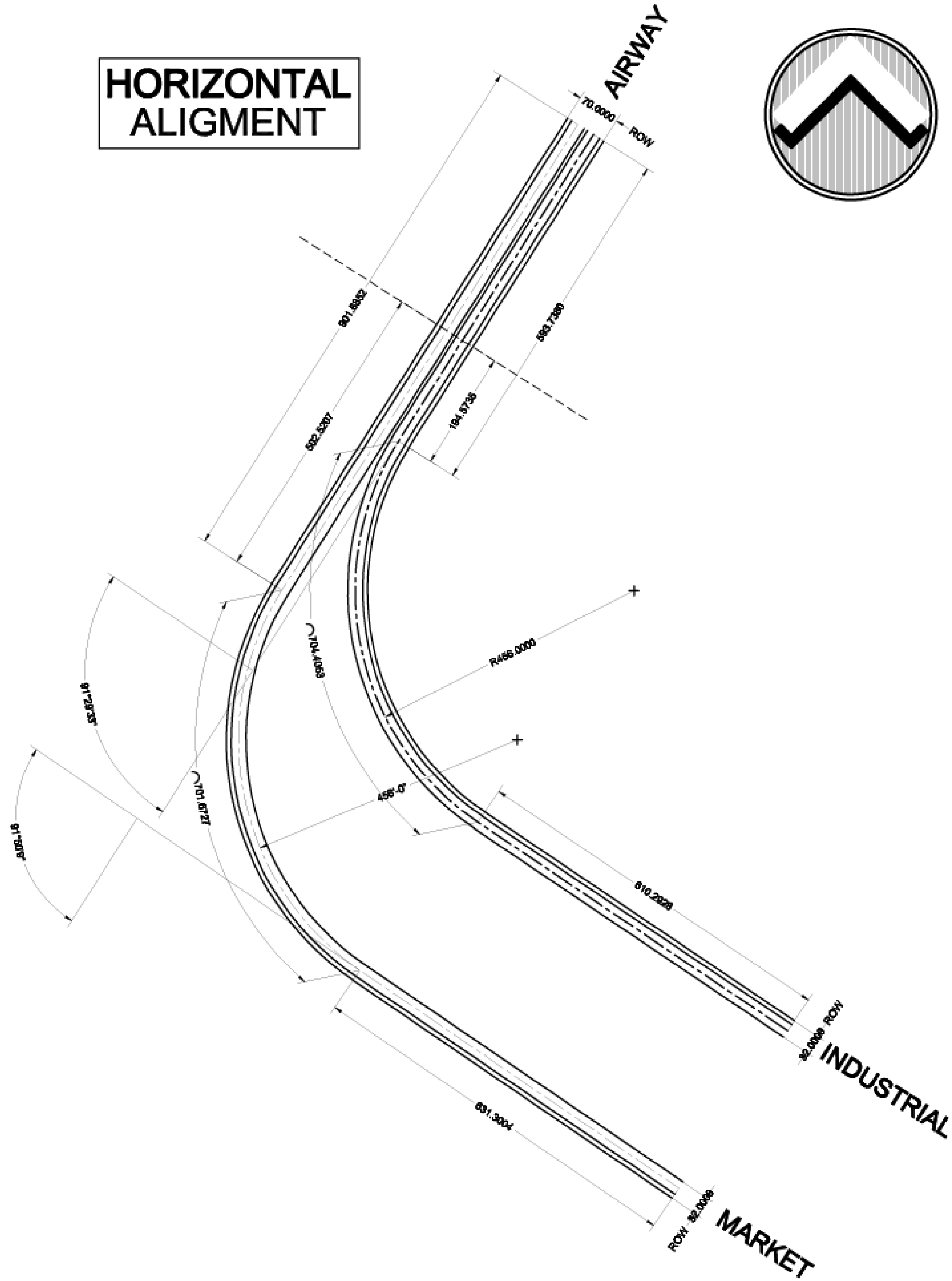
Table D.11

GATEWAY & HAWKINS	
TOTAL VEHICLES A.M.	11105
TOTAL TRUCKS A.M	298
TRUC PERCENTAGE A.M.	2.683475912
TOTAL VEHICLES P.M.	8542
TOTAL TRUCKS P.M	276
TOTAL PERCENTAGE P.M	3.231093421

Table D.12

TONY LAMA & HAWKINS	
TOTAL VEHICLES A.M.	2764
TOTAL TRUCKS A.M	240
TRUC PERCENTAGE A.M.	8.683068017
TOTAL VEHICLES P.M.	2764
TOTAL TRUCKS P.M	292
TOTAL PERCENTAGE P.M	10.56439942

APPENDIX E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ALIGMENT
AIRWAY
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ROW
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593.7380
502.5207
194.5735
R456.0000
704.4063
701.6727
456'-0"
810.2928
ROW
92.0000
INDUSTRIAL
891.3004
ROW
92.0000
MARKET

APPENDIX F

City Manual Design Standards for Construction

PAVEMENT THICKNESS DESIGN CHART

STREET CLASSIFICATION	AVERAGE DAILY TRAFFIC	ROADWAY WIDTH (FT.)	ROW WIDTH (FT.)	MINIMUM PAVEMENT THICKNESS (IN.) ** HMAC
E.A.L.	CSB (20 YRS)			SUBGRADE
ALLEY	200 45,000	14 OR 20	14 OR 20	1-1/2 4-1/2 6
TWENTY FOOT (20') RESIDENTIAL LANE - NO PARKING	200 45,000	20	40	1-1/2 6 8
THIRTY-TWO FOOT (32') RESIDENTIAL LANE - NO PARKING	500 45,000	32	50	1-1/2 6 8
THIRTY-SIX FOOT (36') RESIDENTIAL 1 LANE	3,000 269,000	36	56	1-1/2 6 8
TWENTY-EIGHT FOOT (28') RESIDENTIAL 2 LANE	3,000 269,000	28	46	1-1/2 6 8
RESIDENTIAL COLLECTOR - WITH PARKING	3,000 269,000	36	54	1-1/2 6 8
RESIDENTIAL COLLECTOR WITH MEDIAN	3,000 269,000	36	54	1-1/2 6 8
MOUNTAIN RESIDENTIAL	500 * 45,000	20	23	1-1/2 4-1/2 6
DIVIDED MOUNTAIN RESIDENTIAL	500 * 45,000	20	VARIES	1-1/2 4-1/2 6
MULTI-FAMILY/ COMMERCIAL/ INDUSTRIAL LOCAL STREET 1	6,000 * 630,000	44	64	2 8 10

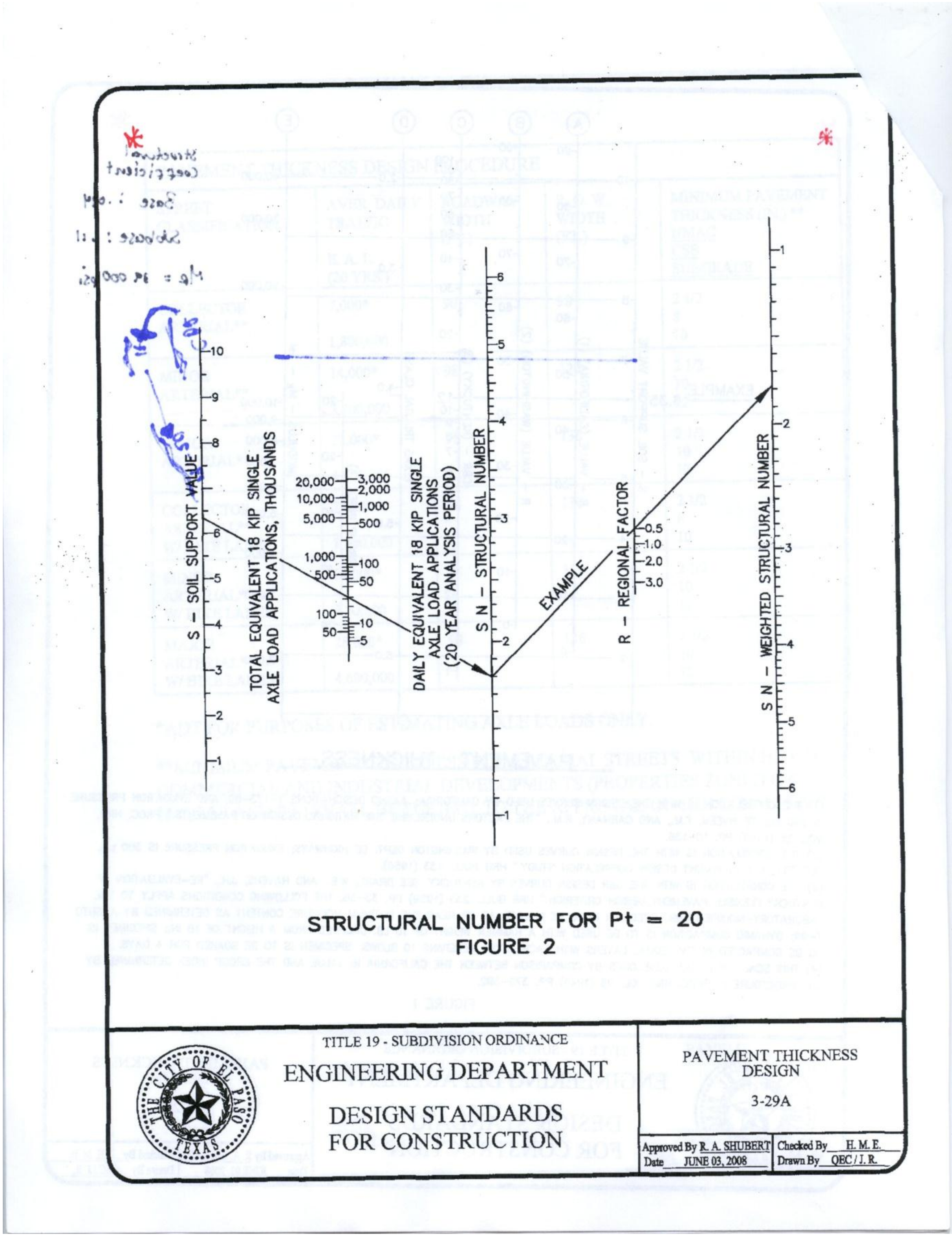
TITLE 19 - SUBDIVISION ORDINANCE

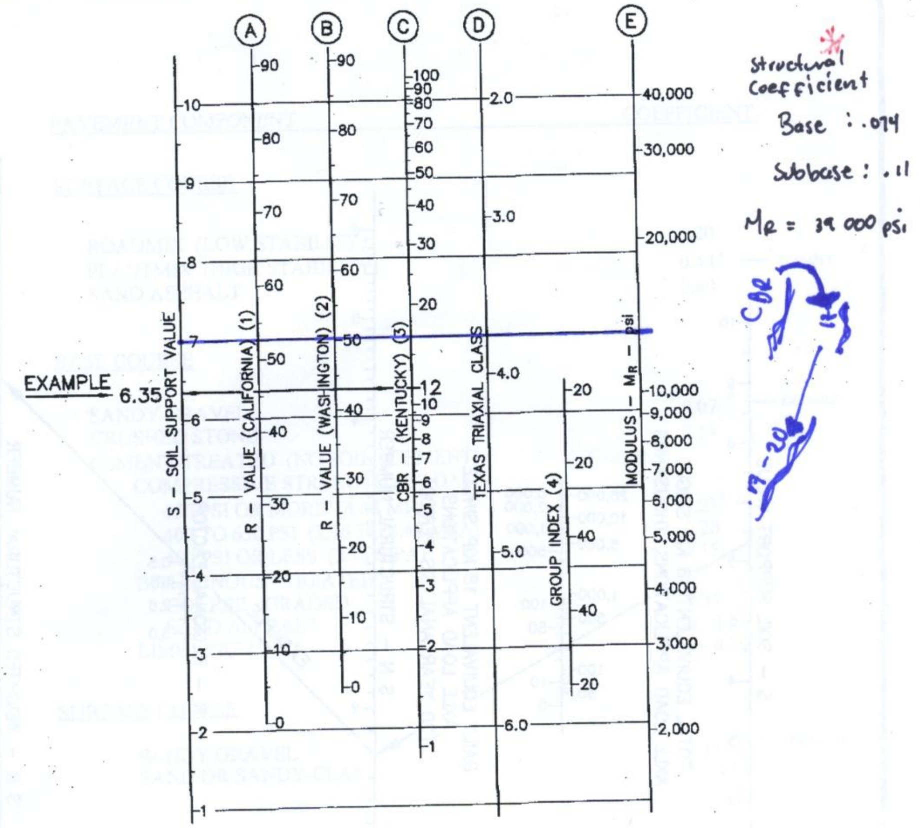
ENGINEERING DEPARTMENT

DESIGN STANDARDS FOR CONSTRUCTION

PAVEMENT THICKNESS DESIGN CHART 3-25

Approved By R. A. SHUBERT Checked By H. M. E.
Date JUNE 03, 2008 Drawn By QEC / J. R.


S – SOIL SUPPORT VALUE
TOTAL EQUIVALENT 18 KIP SINGLE AXLE LOAD APPLICATIONS, THOUSANDS
DAILY EQUIVALENT 18 KIP SINGLE AXLE LOAD APPLICATIONS (20 YEAR ANALYSIS PERIOD)
S N – STRUCTURAL NUMBER
EXAMPLE
R – REGIONAL FACTOR
S N – WEIGHTED STRUCTURAL NUMBER
STRUCTURAL NUMBER FOR Pt = 20
FIGURE 2
TITLE 19 - SUBDIVISION ORDINANCE
ENGINEERING DEPARTMENT
DESIGN STANDARDS FOR CONSTRUCTION
PAVEMENT THICKNESS DESIGN
3-29A
Approved By R. A. SHUBERT
Date JUNE 03, 2008
Checked By H. M. E.
Drawn By OEC / J. R.
THE CITY OF EL PASO TEXAS



PAVEMENT THICKNESS

(1) THE CORRELATION IS WITH THE DESIGN CURVES USED BY CALIFORNIA; AASHO DESIGNATIONS T–173–60, AND EXUDATION PRESSURE IS 240 psi. SE HVEEM, F.M., AND CARMANY, R.M., "THE FACTORS UNDERLYING THE RATIONAL DESIGN OF PAVEMENTS." PROC. HRB, VOL. 28 (1948) PP. 10–136.

(2) THE CORRELATION IS WITH THE DESIGN CURVES USED BY WASHINGTON DEPT. OF HIGHWAYS; EXUDATION PRESSURE IS 300 psi. SEE "FLEXIBLE PAVEMENT DESIGN CORRELATION STUDY." HRB BULL. 133 (1956).

(3) THE CORRELATION IS WITH THE CBR DESIGN CURVES BY KENTUCKY. SEE DRAKE, W.B., AND HAVENS, J.H., "RE–EVALUATION OF KENTUCKY FLEXIBLE PAVEMENT DESIGN CRITERION." HRB BULL. 233 (1959) PP. 33–56. THE FOLLOWING CONDITIONS APPLY TO THE LABORATORY–MODIFIED CBR: SPECIMEN IS TO BE MOLDED AT OR NEAR THE OPTIMUM MOISTURE CONTENT AS DETERMINED BY AASHTO T–99; DYNAMIC COMPACTION IS TO BE USED WITH A HAMMER WEIGHT OF 10 LB. DROPPED FROM A HEIGHT OF 18 IN.; SPECIMEN IS TO BE COMPACTED IN FIVE EQUAL LAYERS WITH EACH LAYER RECEIVING 10 BLOWS; SPECIMEN IS TO BE SOAKED FOR 4 DAYS.

(4) THIS SCALE HAS BEEN DEVELOPED BY COMPARISON BETWEEN THE CALIFORNIA R–VALUE AND THE GROUP INDEX DETERMINED BY THE PROCEDURE IN PROC. HRB VOL. 25 (1945) PP. 376–392.

FIGURE I

THE CITY OF EL PASO TEXAS	TITLE 19 - SUBDIVISION ORDINANCE ENGINEERING DEPARTMENT DESIGN STANDARDS FOR CONSTRUCTION	PAVEMENT THICKNESS DESIGN 3-28
	Approved By R. A. SHUBERT Date JUNE 03, 2008	Checked By H. M. E. Drawn By QEC / J. R.

*

PAVEMENT THICKNESS DESIGN PROCEDURE

STREET CLASSIFICATION	AVER. DAILY TRAFFIC E. A. L. (20 YRS.)	ROADWAY WIDTH (FT.)	R. O. W. WIDTH (FT.)	MINIMUM PAVEMENT THICKNESS (IN.) ** HMAC CSB SUBGRADE
COLLECTOR ARTERIAL**	7,000* 1,800,000	90	98	2 1/2 8 10
MINOR ARTERIAL**	14,000* [2,200,000]	98	120	2 1/2 10 12
MAJOR ARTERIAL**	28,000* 4,600,000	98	136	2 1/2 10 12
COLLECTOR ARTERIAL** W/ BIKE LANES	7,000* 1,800,000	98	136	2 1/2 8 10
MINOR ARTERIAL** W/ BIKE LANES	14,000* 2,200,00	98	136	2 1/2 10 12
MAJOR ARTERIAL** W/ BIKE LANES	28,000* 4,600,000	98	136	2 1/2 10 12

*ADT FOR PURPOSES OF ESTIMATING AXLE LOADS ONLY.

**MINIMUM PAVEMENT THICKNESS FOR ARTERIAL STREETS, WITHIN HEAVY COMMERCIAL AND INDUSTRIAL DEVELOPMENTS (PROPERTIES ZONED C-4, M-1, M-2, M-3 AND P.I.) SHALL BE SUBJECT TO THE APPROVAL OF THE CITY ENGINEER.

THE CITY OF EL PASO TEXAS

TITLE 19 - SUBDIVISION ORDINANCE

ENGINEERING DEPARTMENT

DESIGN STANDARDS FOR CONSTRUCTION

PAVEMENT THICKNESS DESIGN CHART (HEAVY) 3-27

Approved By R. A. SHUBERT | Checked By H. M. E.
Date JUNE 03, 2008 | Drawn By QEC / J. R.

PAVEMENT THICKNESS DESIGN CHART
(continued)

STREET CLASSIFICATION	AVERAGE DAILY TRAFFIC E.A.L. (20 YRS)	ROADWAY WIDTH (FT.)	ROW WIDTH (FT.)	MINIMUM PAVEMENT THICKNESS (IN.) ** HMAC CSB SUBGRADE
MULTI-FAMILY/ COMMERCIAL/ INDUSTRIAL LOCAL STREET 2	6,000 * 630,000	36	56	2 8 10
NON-RESIDENTIAL COLLECTOR	6,000 * 630,000	50	70	2 8 10
NON-RESIDENTIAL COLLECTOR WITH BIKE LANES	6,000 * 630,000	62	82	2-1/2 8 10
BOULEVARD	14,000 * 1,300,000	44	120	2-1/2 10 12
MINOR ARTERIAL	14,000 * 1,500,000	58	78	2-1/2 8 10
MINOR ARTERIAL W/BIKE LANES	14,000 * 1,500,000	58	88	2-1/2 8 10
MAJOR ARTERIAL	26,000 * 3,100,000	66	110	2-1/2 10 12
MAJOR ARTERIAL W/BIKE LANES	26,000 * 3,100,000	66	120	2-1/2 10 12

* ADT FOR PURPOSES OF ESTIMATING AXLE LOADS ONLY

** IF THE RESULTS FOR "CBR" VALUES ARE HIGHER THAN THE MINIMUM PAVEMENT THICKNESS, THE HIGHER VALUES SHALL BE USED.

TITLE 19 - SUBDIVISION ORDINANCE

ENGINEERING DEPARTMENT

DESIGN STANDARDS FOR CONSTRUCTION

PAVEMENT THICKNESS DESIGN CHART

3-26

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Date JUNE 03, 2008 | Drawn By QEC / J. R.