KLEIN ROAD

Phase 2

Summary of Needs Study

August 2018

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EXECUTIVE SUMMARY

Pape-Dawson Engineers, Inc. (Pape-Dawson) was contracted to perform preliminary engineering services in support of developing a bond level estimate for Klein Road Phase 2 (Project). The subject roadway is in Guadalupe County south of IH-35, west of Lake Dunlap in the City of New Braunfels (City). Project limits are from S Walnut Ave to FM 725. The parcels along the 0.96-mile corridor include residential low density and open land uses with zoning consisting of single-family, two-family, and agricultural/pre-development districts.

Project development will proceed through schematic phase with an estimated construction cost. PS&E and Construction phases are pending voter approval of the May 2019 Proposed Bond Program.

The City is holding a public meeting on September 11, 2018 to engage the community and agency stakeholders. Feedback from this meeting may establish additional Project needs and will be incorporated where possible into the schematic design.

Detailed survey, environmental, and geotechnical services were deferred to PS&E phase at the request of the City until additional funding for those activities becomes available. Assumptions related to those disciplines are documented in the Summary of Needs Study based on field observations and information provided by the City from Klein Road Phase 1. Pape-Dawson has identified risks in proceeding with schematic design in these areas, including possible typical section element modification or elimination at PS&E phase if factors detrimental to the Project cost, schedule, or permitting become known at that time.

The Summary of Needs Study includes detailed analysis for roadway, temporary traffic control plan, drainage, and traffic operations along Klein Road. See below for a summary of the key findings:

Roadway

- Apparent right of way (ROW) is narrow (60-75 feet) relative to the roadway's Minor Arterial designation, which requires a 70' ROW. The City's standard Minor Arterial typical section cannot be met without ROW acquisition
- ROW acquisition is needed to the east side
- Multiple overhead and underground utilities are anticipated to conflict with proposed improvements due to narrow ROW and sidewalk/shared-use path locations

Temporary Traffic Control

- Road closure at an existing low water crossing will be required during construction. Detour routes will have minimal impacts on emergency service response times when dispatched from area emergency service stations
- Detour routes will affect a small subset of school-bound roadway users within the attendance zones of Klein Road Elementary and New Braunfels Middle Schools

Drainage

- A storm sewer system is needed to replace the existing drainage swales and provide relief to the Ranch Estates community along Bonnies Way, an area of noted offsite flooding
- An existing low water crossing needs to be replaced due to safety concerns during inclement weather. Two alternatives are presented to replace the crossing: a bridge-class multi-box culvert or a span bridge on drilled shafts

Traffic

- Each roadway intersection studied (S Walnut Ave, Roadrunner Ave/Stoeger Dr, Dove Crossing Dr, and FM 725) currently operates at an acceptable level of service C or better
- Projected annual traffic growth is estimated to be 5% per year, causing each intersection to operate at an unacceptable level of service by 2040
- A 4-lane roadway section with a median for left turn channels is needed to meet 2040 projected traffic demands, which is incompatible with existing ROW
- Alternative lane configurations and innovative intersection designs have been identified to maximize capacity improvements in areas of feasible ROW acquisition

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1 INTRODUCTION

Pape-Dawson Engineers, Inc. (Pape-Dawson) was contracted to perform preliminary engineering services in support of developing a bond level estimate for Klein Road Phase 2 (Project). The subject roadway is in Guadalupe County south of IH-35, west of Lake Dunlap in the City of New Braunfels (City). Project limits of the 0.96-mile study corridor are from S Walnut Ave to FM 725, which serves as the northern extension of Klein Road Phase 1—a project under construction at time of study from FM 1044 to S Walnut Ave.

1.1 Purpose

The Project is under consideration for inclusion in the City's 2019 Proposed Bond Program – a funding mechanism (pending voter approval) that will enable regional infrastructure improvements to address current and expected community growth. The 2012 New Braunfels Regional Transportation Plan (RTP, see **Appendix A1**) indicates ultimate configuration of Klein Road as a 'Minor Arterial,' a City designation for a roadway with 70' right of way (ROW), 4~12' lanes, curb, and sidewalk on both sides (see **Appendix A2**). Existing Klein Road consists of 2~12' lanes, no curb, drainage swales, and an isolated sidewalk segment not connected with the area's broader pedestrian facility network. Significant infrastructure investment is needed to meet the vision for Klein Road established in the RTP, the timing of which will be critical to keeping up with traffic demand. Although existing intersections perform at level of service C or better (see **Section 5.1 Existing Conditions**), future annual traffic growth is estimated at 5% -- an indication that existing roadway infrastructure will quickly become undersized relative to demand if no action is taken.

If funded, the Project will include the expansion of Klein Road, utility adjustments/relocations, traffic control, drainage, signing, pavement marking, illumination, sidewalk and shared use path improvements.

In addition to serving adjacent residential and commercial land uses, Klein Road provides access to an existing elementary school, middle school, school district transportation center, three churches, and a planned major sports complex. These factors establish Klein Road as a key north-south link in the area's transportation network to distribute high traffic volumes during peak hours and special events. Klein Road Phase 1 improvements are currently under construction and address current and expected traffic demand through additional roadway capacity and intersection improvements at FM 1044 and S Walnut Ave, defined in the RTP as Parkway and Principal Arterial respectively. Klein Road Phase 2 extends Phase 1 improvements to the next Principal Arterial north, FM 725. This provides an extended and continuous Minor Arterial typical section between three major east-west roadways that provide regional access to IH-35. When completed, Klein Road Phases 1 and 2 will address current and growing traffic demand, primarily driven by residential development of existing agricultural/pre-development districts.

According to the RTP, a new location roadway (Mary Blvd) will extend Klein Road's Minor Arterial section north from FM 725 across the Guadalupe River, terminating at SH 46. Once realized, the Klein/Mary corridor will serve as a 5-mile long parallel north-south alternative to County Line Road and IH-35, providing regional traffic congestion relief. While the Mary corridor is currently unfunded, constructing Klein Road Phase 2 is the logical next step for the City to address current and expected growth.

2 ROADWAY

Comprehensive roadway improvement needs are examined with respect to existing land use and right of way acquisition; zoning and future land use; bicycle and pedestrian facilities, community involvement, pavement evaluation, and utilities.

2.1 Existing Land Use and Right Of Way Acquisition

Existing land uses of parcels adjacent to the Project corridor include: Residential Low Density (less than 5 units/acre), Open, Drainage, Commercial, Institution, and Schools. The apparent

ROW established by these parcels, based on observed features and publicly available parcel data from the Guadalupe County Appraisal District, varies in width from approximately 60-75 feet. ROW widths are inconsistent and can be attributed to asymmetric development, or ROW dedication, along the corridor. Most development has occurred to the west, creating a uniform ROW limit (ie, a nearly constant offset west of existing Klein Road's centerline). In contrast, the eastern ROW line is an inconsistent offset from existing Klein Road's centerline: ~60' offset from the western ROW limit at undeveloped eastern parcels, ~70' where development has occurred on both sides of the roadway.

The path of least resistance for potential ROW acquisition lies on the east side of the road due to fewer affected owners and lower property values. Acquiring approximately 10' of additional ROW from 11 open, commercial, and institutional parcels would provide a uniform 70' ROW to accommodate the Minor Arterial typical section. Acquiring additional ROW beyond 70' is infeasible as doing so would require acquisition from an additional 16 developed parcels if acquired on the east side only (48 parcels if acquisition is done symmetrically about the existing Klein Road centerline). Additionally, acquisition of ROW from developed parcels would greatly increase the cost of acquisition and impact of the Project on the community it serves. Thus, the Minor Arterial typical section is the largest feasible for the corridor and requires ROW acquisition.

An existing Klein Road schematic was developed for the entire Klein Road Phase 1 and Phase 2 limits as part of the Klein Road Phase 1 project. Pape-Dawson examined the portion of the schematic covering the Project limits for a comparison of ROW acquisition needs with the following observations:

- The existing schematic does not propose ROW acquisition where development has occurred on both sides of the roadway between Benneli Dr and Roadrunner Ave/Stoeger Dr – this is consistent with Pape-Dawson's determination that ROW acquisition at this location is infeasible.

  - ROW acquisition was proposed along the east and west sides of the road from S Walnut Ave to Wise Owl for a total ROW width of 78'-102'. Due to the maximum 70' ROW available between Benneli Dr and Roadrunner Ave/Stoeger Dr, acquisition of ROW to the west provides little additional benefit.
- "Corner Clips" at Quail Ridge Dr and Benneli Dr are non-standard, rectangular in shape that may limit available intersection sight distance. Larger, chamfered ROW "corner clips" are needed at these locations.

Apparent ROW will establish the boundary for concept design alternatives and schematic design, as conventional survey of actual ROW and easement limits has been deferred until the PS&E phase (see **Section 7 SURVEY**). Using apparent ROW is a concern for the schematic phase, as design is based on approximated ROW limits. If existing ROW is determined at PS&E phase to be more restrictive than apparent ROW (or outside stakeholders control easements within areas to be acquired), schematic design features may be subject to adjustment or elimination at PS&E phase.

2.2 Zoning and Future Land Use

The zoning of parcels adjacent to the Project corridor include: APD (Agricultural/Pre-Development), C-1B (General Business), C-3 (Commercial), PD (Planned Development), R-1A-6.6 (Single-Family), and R-2A (Single-Family and Two-Family) districts. The City's future land use maps indicate residential low density to the east for nearly the entire corridor limits, with commercial development expected near the project's termini (S Walnut Ave and FM 725). These observations form the basis for expected development and associated traffic projections further detailed in **Section 5.2 Traffic Projections**.

2.3 Bicycle and Pedestrian Facilities

An isolated 5-foot wide sidewalk segment exists on the east side of Klein Road from Benelli Dr to Roadrunner Ave/Stoeger Dr (see **Figure 1**). No other existing pedestrian or bicycle facilities exist

within the project limits. Prior City direction has been to explore opportunities to bring connectivity to isolated bicycle or pedestrian facilities where possible.

***Figure 1**: Klein Road Existing Pedestrian Facilities*

The 2010 City of New Braunfels Hike and Bike Trail Plan (**Appendix A6**) identifies the Project corridor for a future hike and bike trail. If constructed, the Project's bicycle and pedestrian improvements will extend an existing shared use path along S Walnut Ave, similar facilities currently under construction within Klein Road Phase 1, and provide future connectivity with off-street trails envisioned along an existing drainage channel Guadalupe River Tributary 22 (see

Section 4 DRAINAGE) and FM 725. Additionally, the Project will connect the isolated internal pedestrian facility networks of the White Wing, Dove Crossing, Ranch Estates, and Whispering Valley subdivisions enabling a fully walkable community.

Due to restrictive ROW between Benelli Dr and Roadrunner Ave/Stoeger Dr, separate off-street bicycle and pedestrian facilities are not considered feasible. However, a 10' shared use path offers the most compact solution to fulfilling the Hike and Bike Plan vision and connecting existing pedestrian facility networks. This is consistent with the existing schematic prepared during Klein Road Phase 1 development – a 10' shared use path is indicated on the east side of the road with 6' sidewalk on the west (see **Appendix A5**).

Key criteria governing the horizontal layout of sidewalk and shared use paths relates to the clear width provided along the route. Above-ground features such as mailboxes, utility poles or pedestals, or traffic signal equipment commonly present obstructions to or restrictions on the clear width that can be achieved. The Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) and the AASHTO Guide for the Planning, Design, and Operation of Bicycle Facilities (PDOBF) will govern the areas viable for above-ground feature placement relative to sidewalks and shared use paths.

Based on the AASHTO criteria review, a 5' minimum separation of the shared use path from the back of curb is required, otherwise a physical barrier is needed to separate the vehicular and bicycle/pedestrian facilities. No above-ground feature may be placed within the shared use path or within a 2' buffer zone either side of the shared use path. Thus the 3' of space remaining between the back of curb and the buffer zone may contain above-ground features. Conversely, sidewalks offer more flexibility for reduced clear width than shared use paths in that the minimum clear width is 4 feet exclusive of the width of the curb. If ROW determinations during PS&E phase present a challenge to fitting the standard 10' shared use path with 5' separation from back of curb, the 6' wide western sidewalk may be subject to width reduction (4' minimum) or

elimination if utility placement dictates or ROW cannot be acquired. Existing utilities and their placement relative to these facilities is discussed further in **Section 2.6 Utilities**.

2.4 Community Involvement

Klein Road Phase 1 design included a public meeting to obtain community input regarding concerns along Klein Road and suggestions for proposed improvements. Comments received from the public focused on drainage and traffic issues such as:

- Downstream flooding at the cross culvert under S Walnut Ave
- Design Speed and Marked Speed Limit perceived as being too low
- Traffic control (access to emergency services, area schools, and increased delays during construction)

Public comments from Phase 1 design will be considered for Phase 2 design where applicable. Pape-Dawson will participate in a City-led public meeting to be held on September 11, 2018 and present the Project schematic design to receive additional input from the public.

2.5 Pavement Evaluation

Existing pavement conditions within the Project limits are similar to those described in the Klein Road Phase 1 Geotechnical Engineering Study, where noted pavement deficiencies included rutting, longitudinal and edge cracking in the outer tire paths in both directions of travel. The sources of pavement deficiencies were examined through soil borings at 12 locations within the Klein Road Phase 1 limits. The geotechnical engineer's findings cited significant swell/heave potential of the pavement (2.5-6.25 inches) due to the subsurface stratigraphy "generally described as highly plastic, dark brown clay overlying hard, plastic to highly plastic tan clay," soil types known for high susceptibility for swell/heave in the presence of water. Swell/heave mitigation strategies recommended in the Klein Road Phase 1 Geotechnical Engineering Study included: "soil treatment with lime or other chemicals, removal and replacement of high plasticity index soils,

and drains or barriers to collect or inhibit moisture infiltration." Of these strategies, the Klein Road Phase 1 project adopted 12" of lime treated subgrade, 9" flexible base, Tensar TX-5 geogrid, and 4" of hot mixed asphalt concrete. The Project will match Klein Road Phase 1 pavement section elements to develop a bond-level estimate of construction cost of pavement elements, however, the soil stratigraphy and recommended mitigation for swell/heave may change after more detailed geotechnical investigation is performed at PS&E phase.

2.6 Utilities

Klein Road Phase 2 utility locations were obtained through a Quality Level D investigation utilizing field observations of surface features, utility maps provided by the City, and Texas 811 One Call utility location services. Quality Level D data establishes the utility providers in the area and their general line locations but is not intended to serve as design level information. See **Appendix A7** for an existing utility base map indicating Quality Level D approximate utility locations. **Table 1** includes a summary of the utility types and owners known to exist within the project limits. The Project's schematic design will avoid as many utility conflicts as feasible, identify specific areas of concern, affected owners, and recommended relocation/mitigation strategies.

***Table 1**: Existing Utility Types and Owners*

Utility Type	Utility Owner	Notes
Underground Communications	AT&T	Along east and west side of road
Gas	CenterPoint Energy	Existing stub just north of S Walnut Ave
Overhead Communications	Green Valley Electric Cooperative	Along east side of road on GVEC poles with various crossings west
Overhead Electric		Along east side of road
Water	Green Valley SUD	12" PVC, runs along east side of road with some crossings to west, some water easements exist
Sanitary Sewer	Guadalupe-Blanco River Authority	East side of road, outside of ROW (not within project limits)
Sanitary Sewer	New Braunfels Utilities	West side of road, outside of ROW (not within project limits)
Overhead Communications	Spectrum	Along east side of road on GVEC poles with various crossings west
Underground Communications		Crossing from east side to west at various locations with small segments on west side of road
Underground Communications	ZAYO	Intersection of W Klein Road & FM 725

Pape-Dawson anticipates multiple utility conflicts with the Project improvements. Conflicts are listed by type, including:

Pole mounted utilities

- Utility poles and pole mounted utilities (overhead electric and communications) will conflict with bicycle and pedestrian facilities primarily on the east side of the roadway due to existing pole placement relative apparent ROW. Based on the Minor Arterial typical section, the travel lanes will be widened within 1-2' of the existing eastern ROW limit, leaving little room for the bicycle and pedestrian facilities envisioned for the corridor (see **Section 2.3 Bicycle and Pedestrian Facilities**). Bicycle and pedestrian facilities on the east side of the road will generally occupy the portion of ROW to be acquired. Allowing pole mounted utilities to remain in areas of ROW acquisition would violate PDOBF criteria for shared use path width, clearance, and lateral buffer zones. Therefore, utility poles will need to be relocated to the eastern acquired ROW limits to avoid conflict with bicycle and pedestrian facilities. An alternative would be to relocate those conflicting facilities to the west side of the roadway where utility poles may encroach on the sidewalk up to a minimum of 4' clear width provided at the narrowest locations. Secondly, existing pole mounted utilities could be relocated underground to avoid conflict with bicycle and pedestrian facilities altogether. Consolidation of existing overhead and underground electric and telecommunications utilities in an underground utility corridor (ie, duct banks) offers the most compact solution to mitigating conflicts with bicycle and pedestrian facilities but are typically more costly to construct than pole mounted utilities.

Underground utilities

- Underground communication lines will conflict with storm sewer, pavement section, shared-use path, and sidewalk improvements. Existing underground telecommunications lines run parallel to the roadway on both sides, limiting potential horizontal placement of storm sewer facilities outside the roadway. Additionally, lateral underground

communication lines consist of coaxial lines with 24" cover and fiber lines with 36" cover. If the pavement section adopted for the Project closely matches that of Klein Road Phase 1, the minimum depth of excavation is 25", excluding profile adjustments that may raise or lower the roadway at these locations. Thus, the depth of pavement section over existing lateral communication lines establishes a need to lower those lines to avoid potential disruption due to construction activities. Existing utility pedestals serving underground telecommunication utilities north of Ranch Estates Blvd will conflict with the clear width requirements for sidewalk improvements in the area if not relocated. The proposed design will also widen the roadway or add sidewalk/shared-use path facilities above existing underground communication lines, which will lead to costly future maintenance if these underground utilities are not relocated to grass parkway portions of the typical section.

- The existing 12" water main runs parallel to Klein Road on the east side but has lateral connections to the west side at multiple locations. While the depth of the water main is unknown, it is assumed to conflict with storm sewer improvements at a minimum of 5 lateral crossing locations (1 per residential subdivision street intersecting Klein Road from the west) and 5 service taps for lots with Klein Road frontage. Lateral and service tap connections will need to be relocated deeper underground to avoid conflicts with the proposed storm sewer system. The water main east of the road is far enough removed from the road that it should not conflict with proposed improvements. However, Klein Road Phase 1 improvements included relocating and increasing the size of an existing water main. These same improvements will be considered for Phase 2 if the existing 12" water line is nearing end of life cycle or if the utility owner indicates future upgrades are needed to meet demand of adjacent development.

- Sanitary sewer utilities were identified within existing residential subdivisions on both sides of Klein Road, but no lines were observed within the apparent ROW. Klein Road serves as the "sewer divide" for the area, meaning two different sanitary sewer service

providers (New Braunfels Utilities and Guadalupe-Blanco River Authority) maintain separate sanitary sewer service areas on either side of Klein Road. There were no observed sanitary sewer crossings beneath Klein Road as these two providers have no need to connect lines with each other. Thus, there are no anticipated sanitary sewer conflicts for the Project. Sanitary sewer locations were confirmed through correspondence with New Braunfels Utilities and Guadalupe-Blanco River Authority.

Additional coordination with local utility owners will be required to determine if any utility projects, including planned upgrades or new utility line construction, is planned within Phase 2 project limits.

3 TEMPORARY TRAFFIC CONTROL PLAN

Construction of Klein Road from S Walnut Ave to just north of Roadrunner Ave / Stoeger Dr and from just south of Dove Crossing Dr to FM 725 will be conducted with two-lane two-way traffic control. Removal of an existing low water crossing will be conducted with full roadway closure.

3.1 Two-Lane, Two-Way Traffic

Under a two-lane, two-way traffic control configuration the roadway will be constructed in halves, starting on the east side. The sequence of construction for this traffic control scheme includes:

1. Clear ROW
2. Relocate utilities to ultimate configuration
3. Temporary pavement widening to the west (approx. 15')
4. Install Low-profile concrete traffic barrier (LPCTB) using 10' lane widths measured from the western temporary pavement, divert traffic to the west side
5. Construct the eastern side of the roadway up to, but not including the final asphalt course
6. Shift traffic to the east, construct the western side of the roadway up to, but not including the final asphalt course

7. Remove LPCTB, construct final asphalt course
8. Install permanent pavement markings, medians, illumination, and landscaping

The primary benefit of this traffic control alternative is that traffic remains open during construction. However, a key disadvantage is diminished ride quality, particularly on the temporary widening, which could generate negative feedback from the public. Additionally, placing and removing the temporary widening is considered a sunk cost, or expense incurred but not directly reflected in the ultimate improvements.

3.3 Road Closure at Guadalupe River Tributary 22 (Low Water Crossing)

Replacing the low water crossing will require a road closure between Roadrunner Ave and Dove Crossing Dr. The proposed structure will be constructed at a significantly higher elevation than the existing crossing, requiring material and equipment staging areas adjacent to the work area and thus making it infeasible to keep the road open to traffic during construction. A viable detour route was selected based on minimal additional distance and time delay added to local trips due to road closure while avoiding the use of local residential roads for through traffic. Specific analysis of the detour impacts relative to the following trip generators was conducted:

<u>Emergency Services</u>

The detour route will have minimal impacts on emergency service response times for fire, EMS, and police dispatched from nearest service stations because those stations are all located west of the project limits. The most efficient routes for dispatched emergency vehicles to the Project limits already utilize S Walnut Ave and FM 725 to access Klein Road, thus emergency response times are not anticipated to increase because of a closure at the Tributary 22. See **Figure 2** for the emergency service stations and proposed detour route. Although not preferred due to their local street classification, Dove Crossing Dr and Divine Way offer parallel route alternatives to FM 725 and W County Line Rd respectively and could be utilized by emergency services to access the Project limits if conditions warrant.

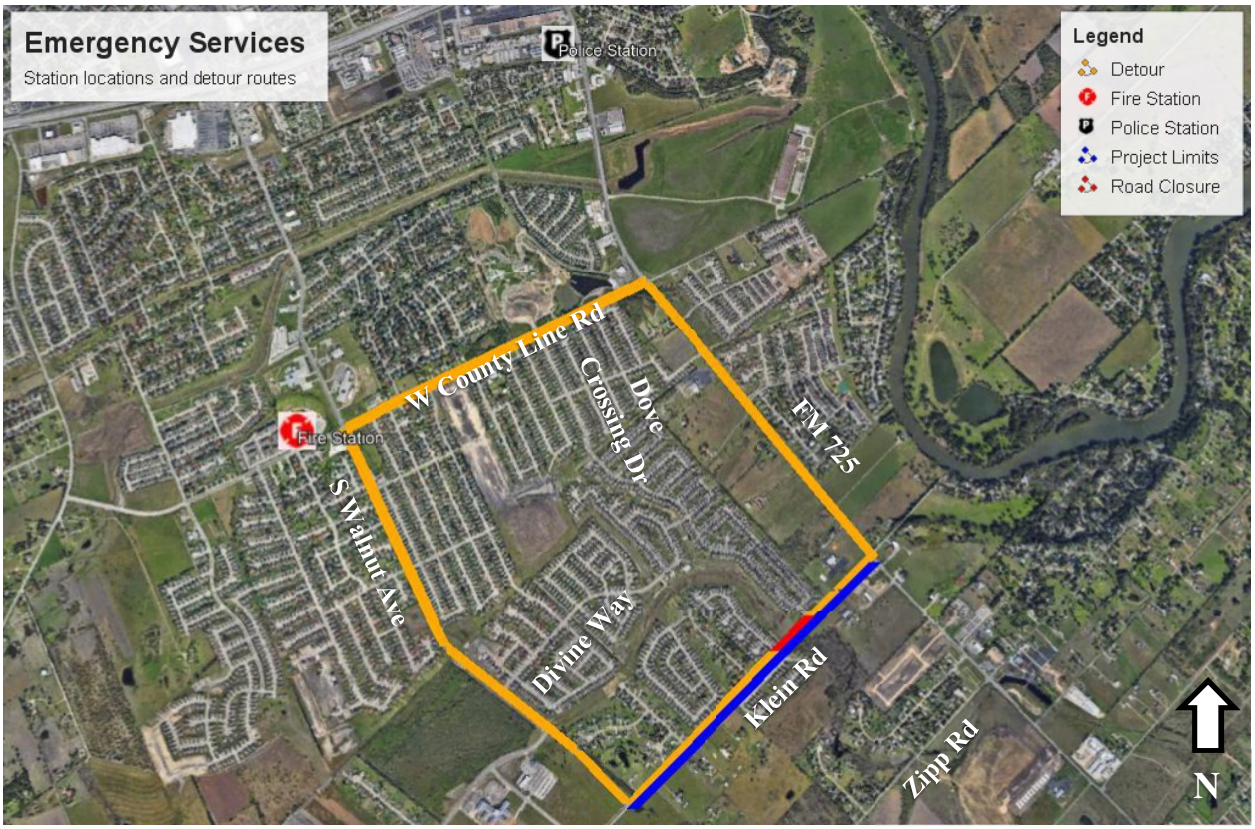


***Figure 2**: Emergency Service Stations and Phase 2 Detour Routes*

Klein Road Elementary School

Pape-Dawson determined the detour route will cause some delay for trips to/from Klein Road Elementary School. A majority of the Klein Road Elementary School attendance zone is located south and east of the school. The most efficient existing route to the elementary school is to travel west on FM 725 and south on Klein Road until reaching the school. Traffic that currently accesses the school using Klein Road will need to be detoured as shown in **Figure 3**. The detour will add approximately 1.9 miles for most vehicles to reach the school, however, an alternative route utilizing local streets Dove Crossing Dr and Divine Way can reduce the added travel distance to approximately 0.5 miles, or minimal delay. While the local street alternative route is more direct than the detour route indicated in **Figure 3**, it would not be an ideal marked detour due to the increase in traffic on local streets.

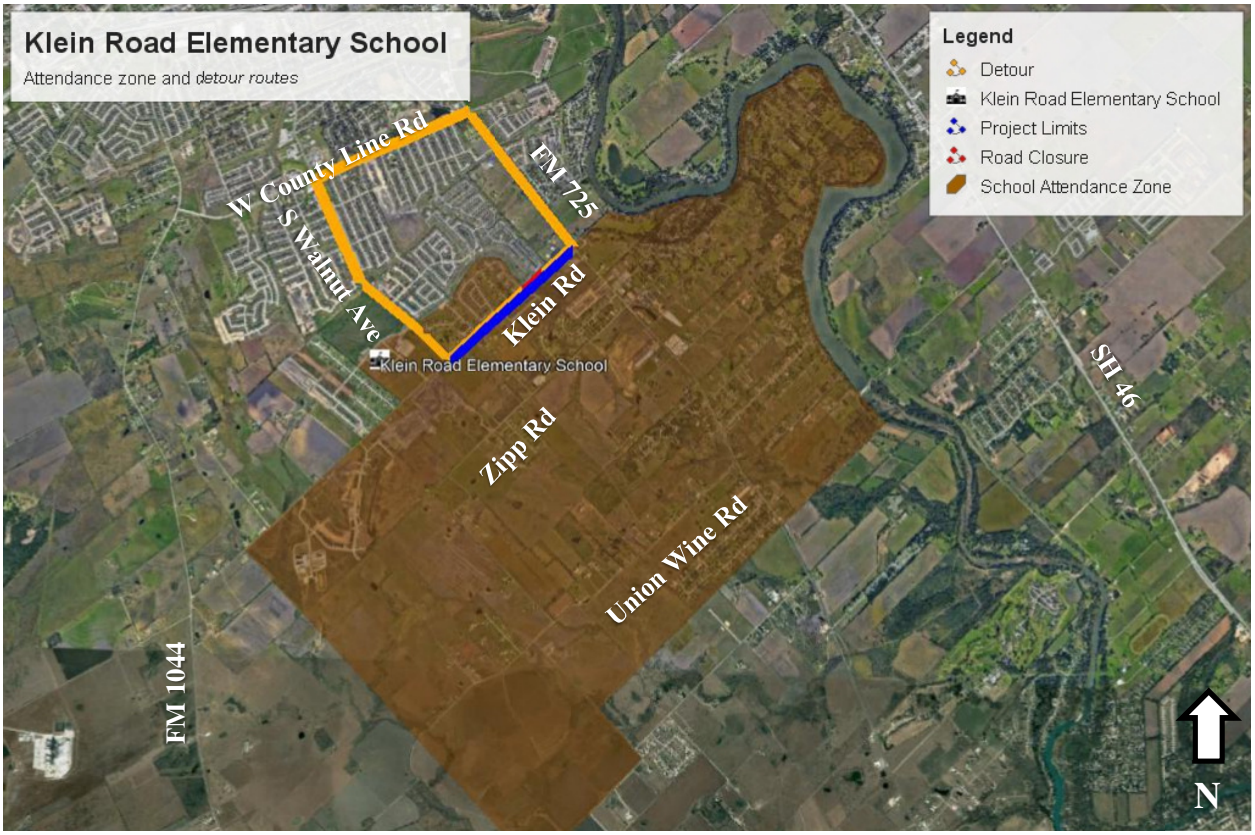


***Figure 3**: Klein Road Elementary School and Phase 2 Detour Routes*

New Braunfels Middle School

Pape-Dawson determined the proposed detour routes will have similar delay for trips to/from New Braunfels Middle School. The New Braunfels Middle School attendance zone is located east and south of the school. The most efficient existing route to the middle school is to travel west on FM 725 and south on Klein Road until reaching the school. Traffic that currently accesses the school using Klein Road will need to be detoured as shown in **Figure 4**. Delay due to the detour is similar to that of trips to/from Klein Road Elementary School discussed in the previous section.

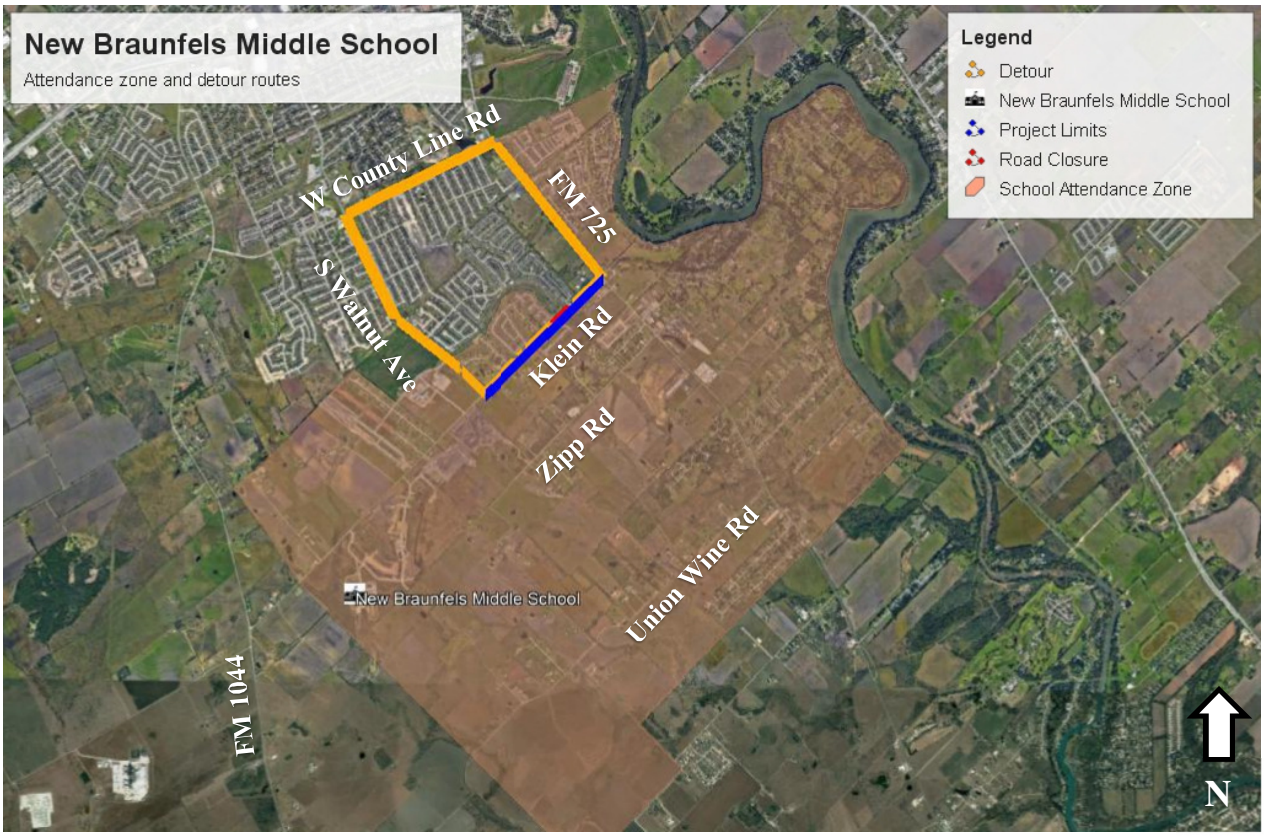


***Figure 4**: New Braunfels Middle School and Phase 2 Detour Routes*

Construction sequencing of the drainage improvements at Tributary 22 should begin at the end of school session to minimize the impact of delays on school-bound trips. Public information campaigns, portable changeable message signs, and highly visible detour signing will also assist in notifying the public to expect delays during the construction process. Additionally, other City departments should be notified of the closure internally for solid waste collection route modifications. Impacts to postal services are considered negligible as there is sufficient local road connectivity surrounding the closure.

4 DRAINAGE

4.1 Existing Conditions

A low water crossing exists on Klein Road located between the Roadrunner Ave and Dove Crossing Dr intersections at Guadalupe Tributary 22 (see **Appendix B1**). Two preliminary alternative improvements for the low water crossing have been analyzed:

- Bridge-class multi-box culvert
- Span bridge with drilled shafts

Each alternative will remove the low water crossing to improve safety, emergency response capabilities during adverse and extreme weather, and commute delays. Both alternatives also meet the 2016 TxDOT Hydraulic Drainage Manual (HDM) requirements that the project "will not cause adverse impacts to adjacent properties" (HDM 5-8) and that raising the water surface elevation "will not cause any adverse impacts" (HDM 5-14) to adjacent properties.

The existing low water crossing is the drainage low point for the Project, meaning all runoff is conveyed to this tributary. Existing roadside ditches and driveway culverts exist on both sides of Klein Road providing runoff conveyance.

The project area soils from the Klein Road Phase 1 Geotechnical Engineering Study (see **Section 9 GEOTECHNICAL STUDY** for a more detailed discussion) were analyzed based on runoff potential, percentage of clay, and other various material properties described in Part 630 of the USDA National Engineering Handbook, Chapter 7. Phase 1 soils were determined to be Type D because the soil contains greater than 40% clay with a high shrink-swell potential. Soil characteristics, which influence the curve number utilized for the NRCS Hydrograph Method, are assumed to be consistent with Klein Road Phase 1 and will be confirmed with further geotechnical study during the PS&E phase.

Hydrologic and hydraulic analysis for the existing and proposed drainage design is typically performed utilizing elevation and slope data provided by conventional survey. However, the drainage analysis conducted for the Project schematic design is based on LiDAR topography, as conventional survey was deferred until the PS&E phase. LiDAR topography is not detailed enough to design and construct safe, appropriately sized drainage improvements. However, the analysis conducted is satisfactory for the purpose of order-of-magnitude structure sizing and preliminary estimating. Detailed drainage design will be modified at the PS&E phase to address any inconsistencies between LiDAR and conventional survey topography and fine tune construction cost estimates.

4.2 Storm Sewer System

As stated in **Section 2.1 Existing Land Use and Right Of Way Acquisition**, ROW is a restrictive factor for Project elements. The proposed roadway, bicycle and pedestrian improvements will require all available existing ROW plus approximately 10' along the eastern ROW limit to be acquired from undeveloped parcels. Consequently, roadside ditches are not viable to convey runoff towards Guadalupe Tributary 22 due to their horizontal space requirements. A storm sewer system will be required to replace drainage conveyance provided by existing roadside ditches, as is common for urban corridors. Per the City of New Braunfels – 2016 Drainage and Erosion Control Design Manual 2018-1 (DECDM) 2018-1 Section 7.2, "storm drain systems shall be designed for the 25-year design storm and evaluated for the 100-year design storm." The storm sewer will include two separate systems each draining toward Guadalupe Tributary 22, one from S Walnut Ave and the other from FM 725. The storm sewer system should not be located beneath proposed pavement, shared-use path, or sidewalk to prevent high future maintenance costs and road closures.

4.3 Hydrologic Analysis – Low Water Crossing

A hydrologic analysis was conducted to determine the peak discharges for the existing low water crossing. The contributing area was delineated for the low water crossing using ArcGIS (v.10.2.2) and LiDAR topography. Total contributing area was found to be 1.75 square miles with boundaries

extending from the intersection of McCrae and Klein Road to the intersection of FM 725 and Klein Road (see **Appendix B2**).

Using HEC-HMS (v. 4.2) and the NRCS Hydrograph method, existing flows were calculated at the tributary crossing. Rainfall depth and intensities (**Table 2** and **Table 3**) were sourced from the DECDM. Per the DECDM, flow information was analyzed for ultimate development conditions. Information on the calculated flows are summarized in **Table 4**.

***Table 2**: New Braunfels Rainfall Intensity Constants*

Year	Intensity Constants		
	b	d	e
2	69.7	12.03	0.857
5	61.2	9.61	0.762
10	59.8	7.69	0.720
25	64.6	7.14	0.691
50	68.4	6.40	0.673
100	74.9	5.95	0.663

***Table 3**: New Braunfels Area Depth-Duration Values*

Year	Area Depth-Duration (inches)									
	5-Min	15-Min	1-Hr	2-Hr	3-Hr	6-Hr	12-Hr	24-Hr	2-Day	3-Day
2	0.51	1.05	1.65	2.19	2.44	2.87	3.10	3.34	3.98	4.31
5	0.66	1.34	2.33	3.08	3.48	4.17	4.45	4.83	5.66	6.20
10	0.80	1.58	2.84	3.72	4.23	5.11	5.49	6.06	7.00	7.72
25	0.96	1.89	3.56	4.61	5.26	6.41	7.07	8.06	9.08	10.11
50	1.11	2.16	4.17	5.32	6.10	7.47	8.50	9.96	10.99	12.34
100	1.28	2.47	4.84	6.08	6.99	8.61	10.18	12.30	13.30	15.04

***Table 4**: Guadalupe Tributary 22 Flows*

Drainage Area ID	Area (Sq mi)	Method	Percent Impervious	NRCS CN	Lag Time (min)	AEP Storm Event Flows (CFS)	
						2%	1%
A	1.75	NRCS	40.3%	88	23.6	5,021	6,260

The existing tributary is identified as Tributary 22 on FEMA FIRM Panel 48187C0115F (see **Appendix B1**)**.** The project location is designated as Zone A, representing the area subject to flooding by the 1% annual chance flood, and no base flood elevations have been determined.

4.4 Hydraulic Analysis – Overview of Low Water Crossing

A hydraulic analysis was conducted for the existing low water crossing and two proposed alternatives to assess the performance of each under existing and ultimate development conditions. HEC-RAS (v. 5.0.3) was used to create models and perform hydraulic calculations. Cross sections were taken upstream and downstream of the low water crossing (see **Appendix B3**).

According to Section 9.1 of the DECDM, the cross structure at the project location must meet the following requirements:

- 2% Annual Exceedance Probability (AEP) event runoff with headwater one foot below the top of the structure
- 1% AEP event water surface shall not encroach through half of roadway lanes

All results from the hydraulic analysis can be found in **Appendix B4**.

4.5 Hydraulic Analysis – Existing Low Water Crossing

The existing low water crossing (see **Figure 5**) consists of three 24-inch corrugated metal pipes (CMPs) with the roadway functioning as a weir. Pipe sizes were field verified on 7/10/2018.

The existing culverts are undersized as their capacity is less than the discharge reaching the crossing. Hydraulic analysis of the existing conditions showed the 2% AEP storm event overtops the low water crossing by 3.73' and showed the 1% AEP storm event overtops by 4.04'. Storm runoff overtopping the road renders Klein Road impassable to traffic, creates unsafe driving conditions, and degrades the existing roadway structure. There are no active measures (such as lockable traffic gates) prohibiting vehicles from attempting to cross the tributary during roadway inundation, which can lead to dangerous (including fatal) outcomes.

***Figure 5**: Klein Road Existing Low Water Crossing*

4.6 Hydraulic Analysis - Proposed Bridge-Class Multi-Box Culvert

A bridge-class multi-box culvert is the first proposed design alternative to replace the low water crossing. Box culverts were analyzed to determine the sizes needed to provide enough capacity for flows reaching the crossing. Pape-Dawson determined sixteen 12'x9' box culverts are needed to prevent overtopping during the 1% AEP event and provide required freeboard during the 2% AEP event, as described in **Section 4.3 Hydrologic Analysis – Low Water Crossing**. The calculated existing and proposed 2% AEP water surface elevations (WSELs) are shown in **Table 5**.

Table 5: Klein Road – 2% AEP WSEL Culvert Analysis

River Station	Existing 2% AEP WSEL (ft)	Proposed 2% AEP WSEL (ft)	ΔWSEL (Prop-Exist) (ft)
5301	631.27	631.27	0.00
4940	630.09	630.09	0.00
4745	629.62	629.62	0.00
4533	629.15	629.16	0.01
4333	628.14	628.16	0.02
4125	627.50	627.53	0.03
3928	627.03	627.08	0.05
3720	626.63	626.72	0.09
3533	626.38	626.50	0.12
3329	625.99	624.62	-1.37
3296	Crossing		
3251	624.15	624.38	0.23
3050	623.61	623.61	0.00
2842	622.21	622.21	0.00
2637	621.41	621.41	0.00
2425	620.61	620.61	0.00
2217	619.99	619.99	0.00

The calculated existing and proposed 1% AEP WSELs are shown in **Table 6.**

***Table 6**: Klein Road – 1% AEP WSEL Culvert Analysis*

River Station	Existing 1% AEP WSEL (ft)	Proposed 1% AEP WSEL (ft)	ΔWSEL (Prop-Exist) (ft)
5301	631.75	631.75	0.00
4940	630.55	630.55	0.00
4745	630.10	630.11	0.01
4533	629.68	629.69	0.01
4333	628.58	628.61	0.03
4125	627.92	627.99	0.07
3928	627.43	627.55	0.12
3720	627.00	627.18	0.18
3533	626.75	627.00	0.25
3329	626.30	625.37	-0.93
3296	Crossing		
3251	624.49	624.79	0.30
3050	623.95	623.95	0.00
2842	622.51	622.51	0.00
2637	621.71	621.71	0.00
2425	620.95	620.95	0.00
2217	620.34	620.34	0.00

In both 1% and 2% AEP events, proposed WSELs are greater than existing WSELs directly upstream and downstream of the crossing. This increase is not a concern at time of study as it does not impact any structures or private property downstream. Topography obtained by conventional survey will examine the changes to calculates WSELs at the 1% and 2% AEP events to confirm this model result. If zero rise in calculated WSELs is required, regardless of impact to structures

or private property, channel grading may alleviate these local increases in WSELs. Review of the environmental assessment, to be completed in the PS&E phase, will be required to ensure channel grading avoids impacts to jurisdictional waters, endangered species, and other sensitive environmental features.

Due to the proposed increase in culvert size, Klein Road is proposed to be elevated approximately 10' to implement the bridge class multi-box culvert alternative – a significant change to the roadway profile anticipated between the intersection with Roadrunner Ave/Stoeger Dr to the south and the intersection with Dove Crossing Dr to the north. Roadway profile changes will require storm sewer improvements to ensure runoff from the roadway reaches Tributary 22.

The box culverts will be precast and future maintenance will be required to prevent cracking and degradation of the boxes and wingwalls due to the high number of boxes needed.

4.7 Hydraulic Analysis - Proposed Span Bridge with Drilled Shafts

A span bridge with drilled shafts is the second design alternative analyzed to replace the low water crossing. The bridge would span 315' and include 30" diameter piers spaced 50' apart. Hydraulic analysis confirmed this alternative would prevent overtopping during the 1% AEP event and provide required freeboard during the 2% AEP event, as described in **Section 4.3 Hydrologic Analysis – Low Water Crossing**. The calculated existing and proposed 2% AEP WSELs are shown in **Table 7**.

***Table 7**: Klein Road – 2% AEP WSEL Bridge Analysis*

River Station	Existing 2% AEP WSEL (ft)	Proposed 2% AEP WSEL (ft)	ΔWSEL (Prop-Exist) (ft)
5301	631.27	631.27	0.00
4940	630.09	630.09	0.00
4745	629.62	629.62	0.00
4533	629.15	629.15	0.00
4333	628.14	628.14	0.00
4125	627.50	627.47	-0.03
3928	627.03	626.98	-0.05
3720	626.63	626.55	-0.08
3533	626.38	626.27	-0.11
3329	625.99	625.60	-0.39
3296	Crossing		
3251	624.15	624.19	0.04
3050	623.61	623.61	0.00
2842	622.21	622.21	0.00
2637	621.41	621.41	0.00
2425	620.61	620.61	0.00
2217	619.99	619.99	0.00

The calculated existing and proposed 1% AEP WSELs are shown in **Table 8.**

***Table 8**: Klein Road – 1% AEP WSEL Bridge Analysis*

River Station	Existing 1% AEP WSEL (ft)	Proposed 1% AEP WSEL (ft)	ΔWSEL (Prop-Exist) (ft)
5301	631.75	631.75	0.00
4940	630.55	630.55	0.00
4745	630.10	630.10	0.00
4533	629.68	629.68	0.00
4333	628.58	628.58	0.00
4125	627.92	627.92	0.00
3928	627.43	627.43	0.00
3720	627.00	626.99	-0.01
3533	626.75	626.74	-0.01
3329	626.30	626.23	-0.07
3296	Crossing		
3251	624.49	624.53	0.04
3050	623.95	623.95	0.00
2842	622.51	622.51	0.00
2637	621.71	621.71	0.00
2425	620.95	620.95	0.00
2217	620.34	620.34	0.00

A marginal decrease in WSEL is observed directly upstream of the crossing and a marginal increase in WSEL is seen directly downstream of the crossing. The increase in WSEL downstream does not result in any adverse impacts to surrounding structures. The minimal change in WSEL downstream indicates channel grading should not be needed for this alternative. Correction of

topography assumed in the model using conventional survey data will confirm this conclusion at PS&E phase.

4.8 Drainage Criteria

As previously stated, analysis regarding the proposed alternative designs for the low water crossing use criteria set by the DCEDM. The DECDM provides more restrictive drainage criteria than the TxDOT HDM. For example, the DCEDM uses the 2% AEP event as the basis for design with a strict requirement for the 1% AEP event: the "100-year water surface shall not encroach through half of roadway lanes". For the multi-box culvert design, these requirements caused the need for an approximate 10' rise in roadway profile elevation and the necessity for sixteen proposed boxes to achieve drainage capacity. In the case of the bridge design, these requirements led to the 315' long proposed span length.

In contrast, the HDM uses the 4% AEP event as the basis for design with the 1% AEP event used as a check for arterial roadways. The less-restrictive criteria mandated by the TxDOT HDM allows for multiple design benefits. While the roadway will still require an elevation increase to meet HDM requirements, this elevation increase would be smaller than that needed using DCEDM criteria. Also, the proposed number of culvert boxes or proposed bridge span would be decreased because capacity requirements would be less restrictive under the HDM. The City should consider using alternative criteria such as the HDM rather than the DCEDM if cost or constructability become a concern for the project.

4.9 Flooding at S Walnut Ave and Settlers Crossing

During a Klein Road Phase 1 public meeting, comments were received regarding increased instances of flooding occurring in the Ranch Estates community along Bonnies Way (approximately 0.3 miles northwest of the intersection of Klein Road and S Walnut Ave). Though this flooding occurs outside the project limits, Pape-Dawson conducted hydraulic analysis for S Walnut Ave and Klein Road to determine if Phase 2 drainage improvements could alleviate offsite flooding.

An existing drainage cross culvert, consisting of two corrugated metal arch pipes, exists just north of the intersection of Klein Road and S Walnut Ave. The cross culvert conveys drainage from the east heading northwest through a ditch parallel to S Walnut Ave, then turns through a private homestead and the Ranch Estates community until reaching an existing concrete-lined drainage channel, Tributary 22 (see **Figure 6**).

***Figure 6**: Flooding Location Map*

Resizing or replacing the cross culvert at Klein Road and S Walnut Ave will not resolve the flooding issue noted at Bonnies Way – any increased capacity at the Klein Road cross culvert could allow drainage to reach Tributary 22 more quickly via the existing drainage path through the Ranch Estates community; decreased capacity will restrict drainage conveyance and possibly shift the flooding

upstream of Klein Road. Drainage must be conveyed to Tributary 22 by a different route so that the overall drainage conveyed through Bonnies Way is reduced. Pape-Dawson considered two potential solutions to address flooding at Bonnies Way by conveying drainage along Klein Road north to Tributary 22:

- Utilize roadside ditches and driveway culverts
- Utilize a storm sewer system

Both alternatives divert water north through the Project to reach Tributary 22 at a different location than utilized today. This would alleviate flooding at Bonnies Way, conveying drainage further downstream along Tributary 22, but possibly create a similar flooding issue at the low water crossing. The new design to replace the existing low water crossing, whether bridge class multi-box culverts or a span bridge on drilled shafts, must account for the additional drainage to ensure no flooding will occur.

Roadside ditches and driveway culverts

The first proposed alternative is to convey drainage north using roadside ditches and driveway culverts along the east side of Klein Road until reaching Tributary 22 near the existing low water crossing. Hydraulic analysis was conducted to determine the required driveway culvert sizes to handle the 4% AEP event flow (as mandated by the DECDM). Using existing slopes, Pape-Dawson determined that driveway box culverts ranging in size from a 5'x4' box to a 6'x5' box would be required. Drainage velocities through the 5'x4' box culverts, however, would be greater than 12 fps. Per the TxDOT Hydraulic Manual, velocities should be maintained between 3 fps to 12 fps. To reduce velocities to acceptable levels, adjustments can be made to the slope of these culverts.

Roadside ditches were also hydraulically analyzed for this alternative. To provide enough capacity for the 4% AEP event, a ditch with minimum 3:1 side slopes and bottom width of 6' is required. Drainage would be conveyed at a depth of 3.4' and would require a slope of 0.008 ft/ft to provide a shear stress below1 lb/sf. If shear stress rises above this level, due to an increased drainage velocity from using a

differing ditch section than that described above, soil retention blankets, riprap, or gabion mattresses will be needed to prevent erosion of the ditch.

Under this alternative, drainage would be conveyed at a higher velocity than drainage under existing conditions. This increase in velocity is anticipated to result in a rise in WSEL directly downstream of the existing low water crossing location. To prevent this rise in WSEL, drainage detention would need to be considered in the design, such as a detention pond. This alternative is not feasible for multiple reasons. Klein Road lacks the ROW to fit the proposed roadside ditches (as described in **Section 4.2 Storm Sewer System**) and to fit a proposed detention pond. ROW acquisition for the detention pond would not be feasible due to the adjacent residential developments (as described in **Section 2.1 Existing Land Use and Right Of Way Acquisition**). In addition, the driveway culvert sizes are too large to maintain the same flowline as the 3.4' deep roadside ditches.

Storm sewer improvements

The second proposed alternative is to convey drainage north using a proposed underground storm sewer system parallel to Klein Road until reaching Tributary 22 near the existing low water crossing. Pape-Dawson conducted hydraulic analysis for this alternative and concluded that the proposed storm sewer is anticipated to be an 8'x4' size box culvert. This box culvert could also serve as the trunkline for the proposed storm sewer system already envisioned for the Project (see **Section 4.2 Storm Sewer System**). The benefit of using a storm drain system rather than a ditch is that a storm drain's trunkline size and slope can be modified to reduce drainage velocities, whereas a ditch slope cannot be heavily modified and increasing the size uses more of the available ROW. Adjusting the slope of the storm sewer system allows the velocity to be better controlled, and in-line detention measures are available, meaning a substantial rise in the WSEL downstream of the low water crossing is not anticipated.

Pape-Dawson concluded this alternative is feasible but would involve a large cost due to the size of pipe and the amount of soil excavation needed. It would, however, reduce flooding reported at Bonnies Way.

5 TRAFFIC OPERATIONS

The schematic developed for the Project limits under Klein Road Phase 1 proposed a three-lane typical section including 40' of pavement for 2~14' lanes, a 12' center two-way left-turn lane, a 6' sidewalk to the west and a 10' shared use path to the east. One important observation is that the typical section prepared during Phase 1 does not meet the Minor Arterial requirements for 48' of pavement, or 4 travel lanes, and violates the AASHTO PDOBF for separation of side paths from the back of curb. The Project schematic will be an update to the Phase 1 schematic based on AASHTO and PROWAG criteria, new traffic counts, projections, and alternatives not previously examined.

5.1 Existing Conditions

Klein Road is a primary access roadway to the Dove Crossing, White Wing, Whispering Valley, and Ranch Estates residential communities. Klein Road is referred to as a north-south roadway in this analysis. The posted speed limit on Klein Road is 30 miles per hour.

Turning Movement Counts (TMC) were collected along the Project limits at the intersections of Klein Road at Walnut Ave, Klein Road at Roadrunner Ave/Stoeger Dr, Klein Road at Dove Crossing Dr, and Klein Road at FM 725 from 7:00 AM to 9:00 AM, 11:00 AM to 1:00 PM, and 4:00 PM to 6:00 PM on Tuesday, May 22nd, 2018 (see **Appendices C1 and C2**). The existing intersection geometries are shown in **Table 9**.

***Table 9**: Intersection Geometry - Existing Conditions (2018)*

Intersection	Approach	Lane Designation*	Traffic Control
Klein at Walnut			One-Way Stop-Controlled
	NB	L-T	
	SB	TR	
	EB	L-R	
Klein at Roadrunner/Stoeger			Two-Way Stop-Controlled (TWSC)
	NB		
	SB	LTR	
	EB	LTR	
	WB	LTR	
Klein at Dove Crossing			One-Way Stop-Controlled
	NB	LT	
	SB	TR	
	EB	L-R	
Klein at FM 725			Traffic Signal
	NB	L-TR	
	SB	L-TR	
	EB	L-T-R	
	WB	L-TR	
*L = Left-turn lane; T = Through lane; R = Right-turn lane; LT = Shared Left/Thru lane; TR = Shared Thru/Right lane; LTR = Shared Left/Through/Right-turn lane; U = Turn around Lane			

The TMC data confirms that AM, Midday, and PM peak hours on the corridor are 7:15 AM – 8:15 AM, 12:00 PM to 1:00 PM, and 5:00 PM to 6:00 PM, respectively. An existing conditions model was developed using Synchro traffic analysis software Version 9.2. Existing Measures of Effectiveness for each peak hour, including level of service (LOS), delays, and queueing along the project limits, are reported in **Appendix C3**. A summary of the levels of service and delays is shown in **Table 10** and **Table 11**.

Table 10: *Signalized Intersection Capacity - Existing Conditions (2018)*

		AM Peak Hour		MID Peak Hour		PM Peak Hour	
Intersection	Condition	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)
Klein at FM 725	Existing	C	24.2	B	11.4	C	20.5

Table 11*: Unsignalized Intersection Capacity - Existing Conditions (2018)*

Intersection			AM Peak Hour		MID Peak Hour		PM Peak Hour	
Condition	Approach	Mvmt	LOS	Approach Delay (sec/veh)	LOS	Approach Delay (sec/veh)	LOS	Approach Delay (sec/veh)
Klein at Walnut								
Existing	NB	LT	A	3.9	A	2.6	A	2.5
Existing	SB	TR	A	0.0	A	0.0	A	0.0
Existing	EB	LR	C	23.4	B	10.2	B	14.1
Klein at Roadrunner/Stoeger								
Existing	NB	LTR	A	0.3	A	0.4	A	0.6
Existing	SB	LTR	A	0.6	A	0.7	A	0.7
Existing	EB	LTR	C	22.1	B	11.3	B	13.5
Existing	WB	LTR	B	13.5	A	9.8	B	12.4
Klein at Dove Crossing								
Existing	NB	LT	A	1.1	A	0.6	A	0.7
Existing	SB	TR	A	0.0	A	0.0	A	0.0
Existing	EB	LR	C	15.5	B	10.9	B	13.1

The results in **Table 10** and **Table 11** confirm that all intersections operate at LOS C or better, therefore, no traffic improvements are required at this time.

5.2 Traffic Projections

The following is a summary of the data used for traffic analysis and how it was applied to assume growth rates and projected turning movement counts for the Project corridor.

- Design Years**:** Base Year is 2018 and Forecasted Year is 2040
- Historic Counts**:** these relevant historic counts were obtained from the Traffic Count Database System (TCDS)
    - Four annual Accumulative Count Recorder (ACR) traffic stations, which provide 24-hour axle counts across an entire roadway section, were available outside the project limits:
        - 95H113 – FM 725, just west of Klein Road
        - 95H114 – FM 725, 1.5 miles east of Klein Road
        - 95H112 – FM 1044, 1.5 miles east of Klein Road
        - 46D5 – FM 1044, 2 miles east of Klein Road

    These counts all occur in areas of similar development and should reflect the growth on Klein Road.
- Future Projection**:** Forecasted Year counts were obtained from the San Antonio Bexar County Metropolitan Planning Organization (SABCMPO) 2040 Travel Demand Model. Projections were taken from the locations of the four annual ACR count stations previously listed.
- Growth Rate and Factors: **Table 12** shows the exponential growth rates derived from the SABCMPA 2040 Travel Demand Model projected counts at the pertinent TCDS count locations.

***Table 12**: Historic Count Growth Rates*

Historic Count	Exponential Growth Rate (%)
95H113	4
95H114	5
95H112	5
46D5	6

- After reviewing SABCMPO's 2040 Travel Demand Model assignments and historic growth, an average annual growth rate of 5% was selected for Klein Road. Both the east and west legs on the FM 725 intersection, Stoeger Dr, and Walnut Ave also used a 5% growth rate to reflect

the possibility for adjacent development. Roadrunner Ave and Dove Crossing Dr used a 2% growth rate to reflect the areas already mostly developed. The diagram in **Appendix C4** summarizes the annual growth percentages and the total growth rate factors applied throughout the corridor.

- A single family residential development is currently in the design phase south of the Klein Road at Benelli Dr intersection. A TIA was proposed for this development in 2017. The trips generated from this development were distributed throughout the network and added to the ADT for the forecast year of 2040. In total, the proposed development generates 1038 trips per day (190 peak hour trips) and will obtain access to Klein Road via Benelli Dr.

5.3 Future (No Build) Traffic Model

A future conditions model using the current roadway geometry was developed using existing turning movement counts with the applied growth rate factors and trip generation from future development. Measures of Effectiveness for each peak hour including LOS, delays, and queueing along the project limits are reported in **Appendix C5**. A summary of the levels of service and delays is shown in **Table 13** and **Table 14**.

***Table 13**: Signalized Intersection Capacity - Future (No Build) Conditions (2040)*

		AM Peak Hour		MID Peak Hour		PM Peak Hour	
Intersection	Condition	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)
Klein at FM 725	Fut. (No Build)	**F**	**476.9**	**F**	**224.6**	**F**	**590.1**

The results in **Table 13** confirm that the intersection of Klein at FM 725 will operate at LOS F under existing conditions by 2040.

***Table 14**: Unsignalized Intersection Capacity - Future (No Build) Conditions (2040)*

Intersection			AM Peak Hour		MID Peak Hour		PM Peak Hour	
Condition	Approach	Mvmt	LOS	Approach Delay (sec/veh)	LOS	Approach Delay (sec/veh)	LOS	Approach Delay (sec/veh)
Klein at Walnut								
Fut. (No Build)	NB	LT	**F**	**196.2**	A	3.0	A	3.7
Fut. (No Build)	SB	TR	A	0.0	A	0.0	A	0.0
Fut. (No Build)	EB	LR	**F**	**ERR**	**D**	**28.0**	**F**	**4466.4**
Klein at Roadrunner/Stoeger								
Fut. (No Build)	NB	LTR	A	1.7	A	0.3	A	1.2
Fut. (No Build)	SB	LTR	A	5.0	A	1.1	A	3.6
Fut. (No Build)	EB	LTR	**F**	**ERR**	**D**	**27.0**	**F**	**359.6**
Fut. (No Build)	WB	LTR	**F**	**ERR**	C	15.6	**F**	**50.8**
Klein at Dove Crossing								
Fut. (No Build)	NB	LT	A	4.7	A	0.5	A	1.3
Fut. (No Build)	SB	TR	A	0.0	A	0.0	A	0.0
Fut. (No Build)	EB	LR	**F**	**ERR**	C	22.4	**F**	**120.8**

The results in **Table 14** confirm that the intersection of Klein Road at S Walnut Ave, Klein Road at Roadrunner Ave/Stoeger Dr, and Klein Road at Dove Crossing Dr will operate at LOS F under existing conditions by 2040. The values displayed as "ERR" indicate approach delays so high, they could not be analyzed.

5.4 Future (Proposed) Traffic Model

A future conditions model was developed using a proposed roadway geometric configuration, existing turning movement counts, applied growth rate factors, and trip generation from future development. The proposed roadway geometry was developed to mitigate the operational issues at the intersections identified in **Table 14**. A four-lane section (two 12-foot lanes each direction) with a 12-foot median for left turn channels and changes to intersection geometry is required to provide acceptable LOS in 2040. Incorporating the same bicycle and pedestrian facilities considered in the schematic developed under Phase 1, with appropriate parkways and buffers as

established in the AASHTO PDOBF, the proposed typical section would require a 90' ROW for the entire Project limits. The proposed changes to intersection geometry are shown in **Table 15.**

***Table 15**: Intersection Geometry - Future (Proposed) Conditions (2040)*

Intersection	Approach	Lane Designation*	Traffic Control
Klein at Walnut			Traffic Signal
	NB	L-T-T	
	SB	T-T-R	
	EB	L-LR-R	
Klein at Roadrunner/Stoeger			Two-Way Stop-Controlled (TWSC)
	NB	L-T-TR	
	SB	L-T-TR	
	EB	LTR	
	WB	LTR	
Klein at Dove Crossing			One-Way Stop-Controlled
	NB	L-T-T	
	SB	T-TR	
	EB	L-R	
Klein at FM 725			Traffic Signal
	NB	L-L-TR-R	
	SB	L-TR	
	EB	L-T-T-T-R	
	WB	L-L-T-T-TR	
*L = Left-turn lane; T = Through lane; R = Right-turn lane; LT = Shared Left/Thru lane; TR = Shared Thru/Right lane; LTR = Shared Left/Through/Right-turn lane; U = Turn around Lane			

Measures of Effectiveness for each peak hour including LOS, delays, and queueing along the project limits are reported in **Appendix C6**. A summary of the levels of service and delays is shown in **Table 16** and **Table 17**.

***Table 16**: Signalized Intersection Capacity - Future (Proposed) Conditions (2040)*

		AM Peak Hour		MID Peak Hour		PM Peak Hour	
Intersection	Condition	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)
Klein at Walnut	Future (Proposed)	C	34.2	B	12.7	B	16.7
Klein at FM 725	Future (Proposed)	D	36.4	B	15.8	D	45.1

***Table 17**: Unsignalized Intersection Capacity - Future (Proposed) Conditions (2040)*

Intersection			AM Peak Hour		MID Peak Hour		PM Peak Hour	
Condition	Approach	Movement	LOS	Approach Delay (sec/veh)	LOS	Approach Delay (sec/veh)	LOS	Approach Delay (sec/veh)
Klein at Roadrunner/Stoeger								
Future (Proposed)	NB	LTR	A	0.2	A	0.2	A	0.4
Future (Proposed)	SB	LTR	A	0.6	A	0.8	A	0.6
Future (Proposed)	EB	LTR	**F**	**91.1**	B	13.6	C	23.5
Future (Proposed)	WB	LTR	D	33.5	B	11.4	C	16.3
Klein at Dove Crossing								
Future (Proposed)	NB	LT	A	0.6	A	0.3	A	0.4
Future (Proposed)	SB	TR	A	0.0	A	0.0	A	0.0
Future (Proposed)	EB	LR	C	22.4	B	12.5	C	20.7

While the intersection of Klein Road at Roadrunner Ave/Stoeger Dr still operates at LOS F at the design year, volumes are not anticipated to warrant a traffic signal. An alternative design option was analyzed for this intersection that included a Flying-T configuration for Roadrunner Ave (thus forcing right-in, right-out movements at Stoeger Dr). However, the system performance was not improved. The proposed geometry minimizes delay at this intersection, maintains volume to capacity ratio < 1 (ie, demand less than capacity), and is therefore still considered viable.

5.5 Alternative Design Options

Due to ROW restrictions (discussed in **Section 2.1 Existing Land Use and Right Of Way Acquisition**) a four-lane section is not attainable throughout the corridor due to existing development restricting feasible ROW acquisition to 70'. If a two-lane section (one 12-foot lane each direction) with a 12-foot median for left turn channels is the only attainable roadway geometry, then the following alternative design configurations should be considered to re-route turns and improve traffic operations:

Alternative 1**:** Constructing U-turns near the northern and southern project limits would allow for the restriction of left turns from Roadrunner Ave/Stoeger Dr, Dove Crossing Dr, and other stop-controlled intersections, minimizing delay and queue lengths from these minor roads. These trips would be re-routed through the U-turns to return to their desired path with minimal delay. A summary of the levels of service and delays is shown in **Table 18** and **Table 19**.

Table 18*: Signalized Intersection Capacity - Future (Alternative 1) Conditions (2040)*

		AM Peak Hour		MID Peak Hour		PM Peak Hour	
Intersection	Condition	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)
Klein at Walnut	Future (Alt 1)	D	39.7	B	14.0	B	19.0
Klein at FM 725	Future (Alt 1)	D	37.9	B	15.8	D	45.1

***Table 19**: Unsignalized Intersection Capacity - Future (Alternative 1) Conditions (2040)*

				AM Peak Hour		MID Peak Hour		PM Peak Hour	
Intersection	Condition	Approach	Mvmt	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)
Klein at Roadrunner/ Stoeger	Fut. (Alt 1)	NB	LTR	A	0.4	A	0.2	A	0.8
	Fut. (Alt 1)	SB	LTR	A	1.6	A	0.9	A	1.5
	Fut. (Alt 1)	EB	R	E	45.4	B	11.0	D	27.1
	Fut. (Alt 1)	WB	R	F	178.6	B	13.5	C	15.6
Klein at Dove Crossing	Fut. (Alt 1)	NB	LT	A	1.0	A	0.3	A	0.9
	Fut. (Alt 1)	SB	TR	A	0.0	A	0.0	A	0.0
	Fut. (Alt 1)	EB	R	E	45.7	B	11.9	E	47.4

Alternative 2**:** Constructing a Flying-T intersection at Dove Crossing would provide more direct access to and from Klein Road. Left turns from Roadrunner/Stoeger would still be restricted to minimize queue lengths and delays, and therefore, U-turns near the northern and southern limits of the project would have to be constructed. A summary of the levels of service and delays is shown in **Table 20** and **Table 21**.

***Table 20**: Signalized Intersection Capacity - Future (Alternative 2) Conditions (2040)*

		AM Peak Hour		MID Peak Hour		PM Peak Hour	
Intersection	Condition	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)
Klein at Walnut	Future (Alt 2)	D	43.2	B	14.7	B	18.9
Klein at FM 725	Future (Alt 2)	D	38.1	B	16.1	D	45.0

***Table 21**: Unsignalized Intersection Capacity - Future (Alternative 2) Conditions (2040)*

				AM Peak Hour		MID Peak Hour		PM Peak Hour	
Intersection	Condition	Approach	Mvmt	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)
Klein at Roadrunner /Stoeger	Fut. (Alt 2)	NB	LTR	A	0.4	A	0.2	A	0.7
	Fut. (Alt 2)	SB	LTR	A	1.3	A	1.0	A	1.4
	Fut. (Alt 2)	EB	R	E	35.5	B	10.7	C	23.4
	Fut. (Alt 2)	WB	R	F	105.7	B	12.6	B	14.5
Klein at Dove Crossing	Fut. (Alt 2)	NB	LT	A	2.5	A	0.9	A	2.5
	Fut. (Alt 2)	SB	TR	A	1.5	A	0.7	A	2.8
	Fut. (Alt 2)	EB	R	D	31.4	A	7.6	F	87.8

Examples of these alternatives are shown in **Appendix C7**. While these alternative methods may be considered in spaces of limited ROW, intersection geometries for the intersections of Klein Road at S Walnut Ave and Klein Road at FM 725 should adhere to the proposed geometries in **Table 15** to address the projected volumes on all approaches.

5.6 Traffic Conclusions

Traffic analysis included evaluations of existing and projected traffic conditions, as well as proposed changes to roadway geometry in response to anticipated future operational issues. Based on traffic projections, the three-lane section developed at Klein Road Phase 1 schematic phase (see **Appendix A5**) will be insufficient to support the projected traffic volumes. A four-lane section (two 12-foot lanes each direction) with a 12-foot median for left turn channels and changes to intersection geometry to provide acceptable LOS in 2040. If this recommended geometry is not attainable due to ROW restrictions, the alternatives provided must be considered to re-route turns and improve traffic operations to the maximum extent feasible.

6 DEFERRED PROFESSIONAL SERVICES

The City deferred conventional survey, environmental assessment, and geotechnical study until PS&E phase pending project funding from the 2019 Proposed Bond Program. Deferring these services imposes some risk of proceeding with specific cost and schedule assumptions that could be adversely impacted if items related to these disciplines are found to be detrimental to the cost or schedule for the Project.

7 SURVEY

Sources of existing feature information supporting schematic design include aerial imagery, LiDAR topography, and field observations. Schematic design will be conducted in state plane grid coordinates as no conventional survey-grade input data was gathered to support the schematic. Design will be converted to surface coordinates at PS&E phase once survey data has been received.

8 ENVIRONMENTAL ASSESSMENT

The Project environmental assessment will identify sensitive environmental areas within project limits. If sensitive environmental areas are located within Phase 2 project limits, PS&E design must be modified to avoid or mitigate any conflicts with sensitive areas.

The 'Phase 1 Environmental Site Assessment' conducted by Raba Kistner in 2014 identified no sensitive environmental areas within Phase 1 project limits. Pape-Dawson identified two potential Phase 2 sensitive environmental areas from field observations:

- Potential wetland southeast of the low water crossing
- Possible soil contamination from underground petroleum storage tanks at the project's northern terminus

The full environmental assessment will fully vet these specific concerns and investigate additional environmental constraints.

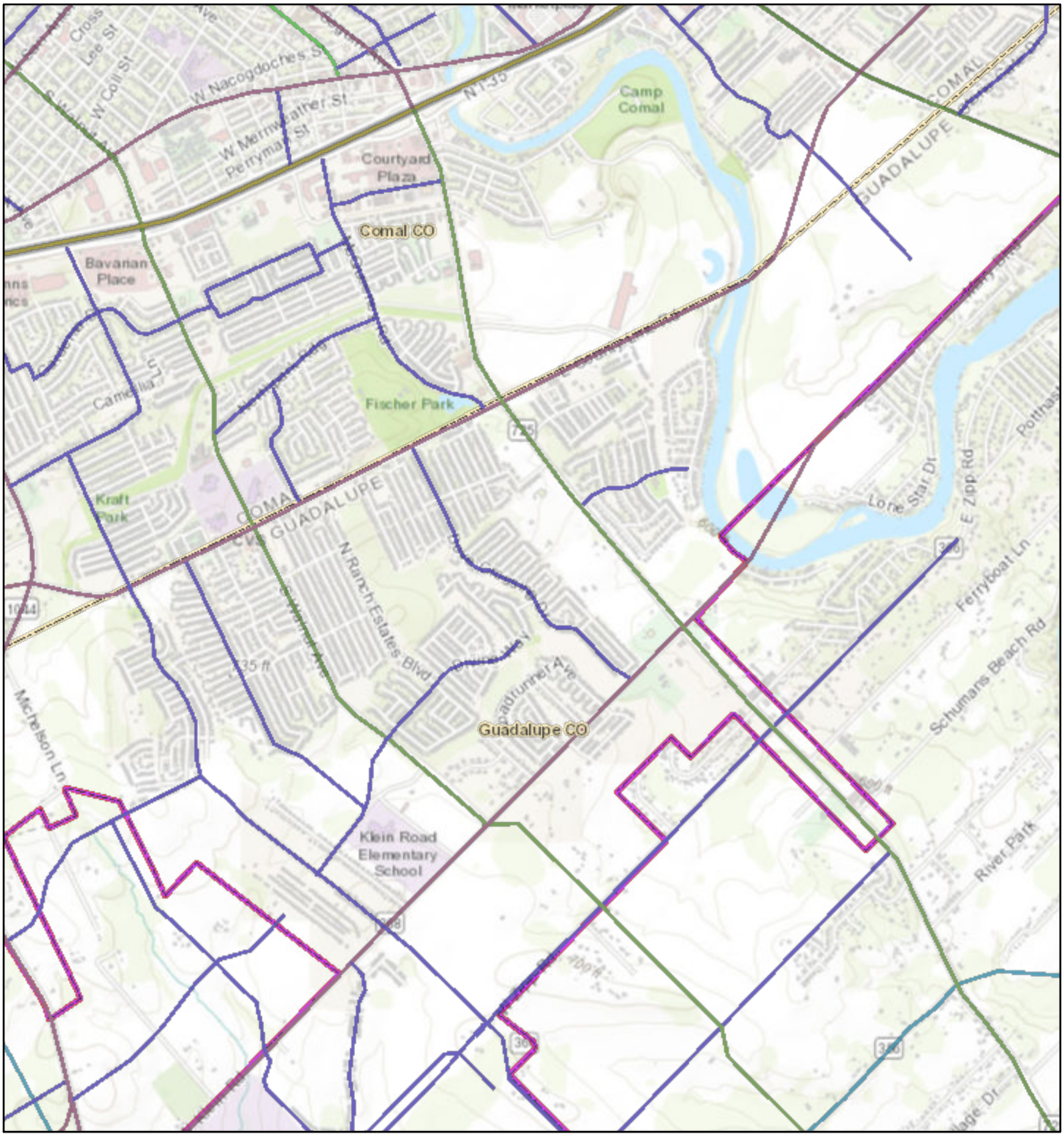
9 GEOTECHNICAL STUDY

The Project geotechnical study will determine soil conditions within project limits and propose pavement section alternatives, similar to the Phase 1 'Geotechnical Engineering Study' conducted by Raba Kistner in 2014. The Phase 1 geotechnical study provides the basis for the Project geotechnical assumptions until more detailed study can be conducted during the PS&E phase.

One concern with the adopted pavement section is that lime treatment requires road closure for several days to allow the subgrade lime-soil mixture to cure. Additionally, the process of mixing the lime can be disruptive to nearby residences and through traffic due to fine dust. Alternatives to lime treatment will be considered at PS&E phase for potential improvements to the traffic control plan or reduction in disruption to nearby residences.

APPENDIX A1

Klein Road Phase 2 Regional Transportation Plan Map



7/31/2018 1:17:14 PM

1:36,112

0 0.28 0.55 1.1 mi

0 0.42 0.85 1.7 km

Regional Transportation Plan

- Couplet
- Enhanced Intersection
- Expressway
- Future
- Interstate
- Major Collector
- Minor Arterial
- Minor Collector
- Parkway
- Principal Arterial
- ETJ
- County Boundaries (Outline)
- City Limits (Outline)
- Addresses

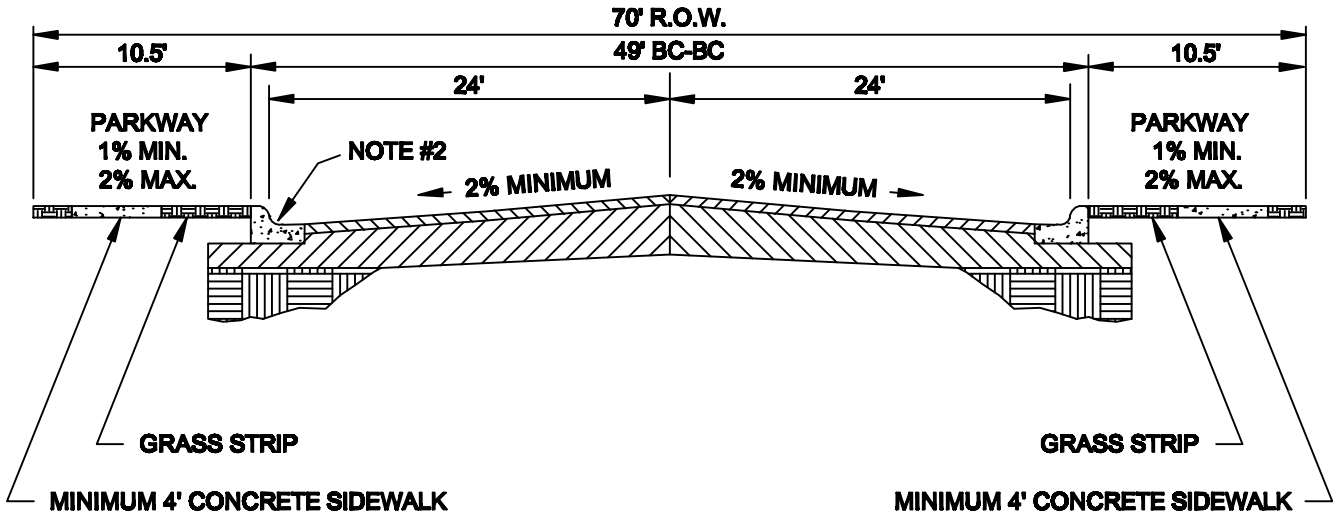
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

GIS User

City of New Braunfels, Comal County, Texas Parks & Wildlife, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA |

APPENDIX A2

MINOR ARTERIAL
FOUR LANES - NO PARKING



NOTES:

1. STRUCTURAL SECTION REQUIRES DETAILED ENGINEERING DESIGN, SUBJECT TO THE APPROVAL OF THE CITY ENGINEER. CITY WILL ACCEPT DESIGNS THAT INCORPORATE BIAXIAL GEOGRID.

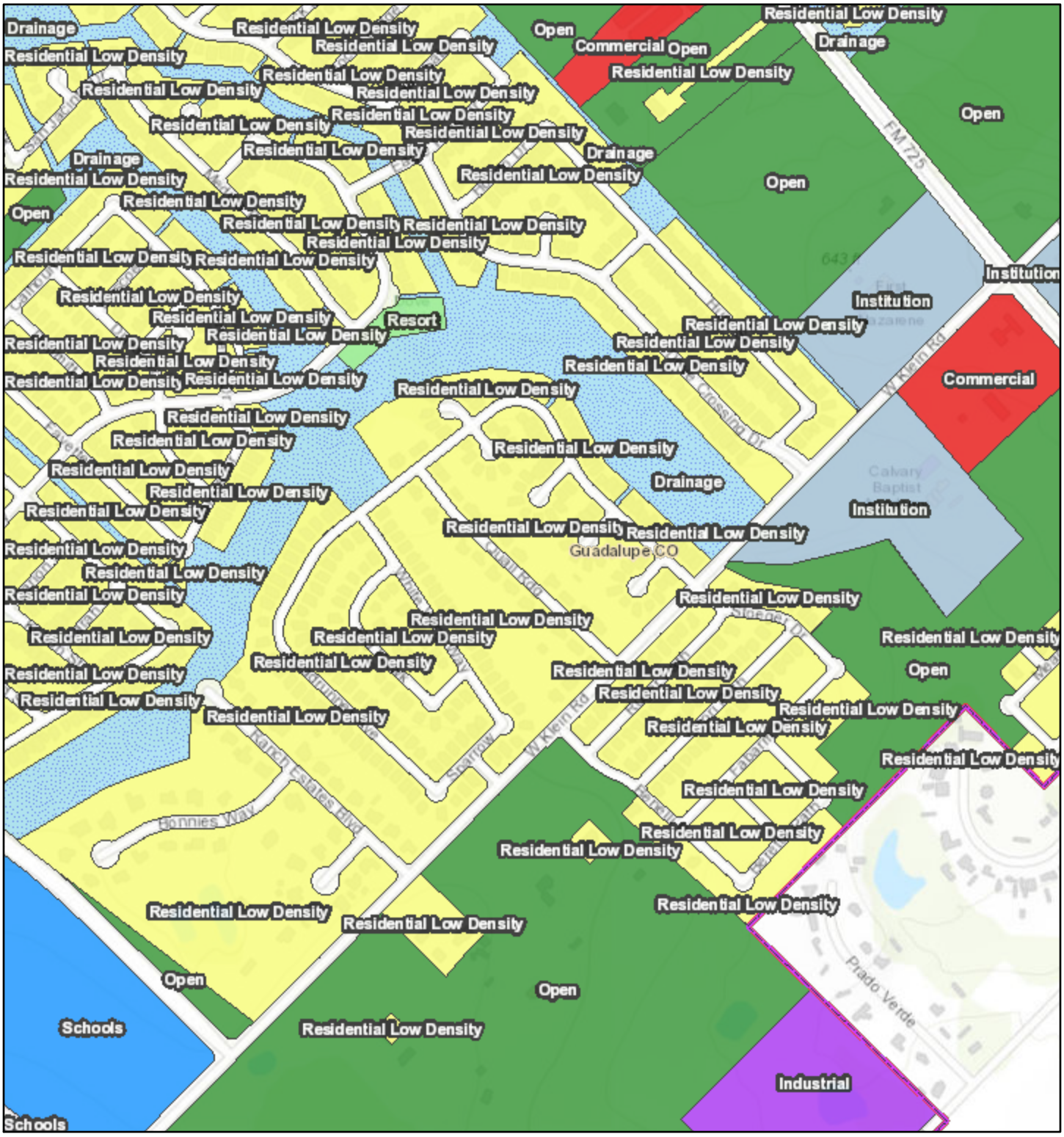
2. SEE CURB DETAIL ST-013.

3. BASE MUST EXTEND 1' BEYOND BACK OF CURB, 6" MINIMUM THICKNESS

DATE APPROVED: 7/08	DWG. NO: ST-006	SCALE: N.T.S.	City of New Braunfels ENGINEERING DEPARTMENT
DRAWN BY: RAS	SHEET: 1 OF 1		
FILENAME: Minor Arterial (4) Lanes			
P:\CURRENT NEW BRAUNFELS DETAILS\2006\			

APPENDIX A3

Klein Road Phase 2 Existing Land Use Map



7/31/2018 1:14:13 PM

1:9,028

0 0.05 0.1 0.2 mi

0 0.1 0.2 0.4 km

Existing Land Use (Shaded)

- Residential Low Density (Less than 5 Units/Acre)
- Residential Medium (6-12 Units/Acre)
- Manufactured Homes
- Residential High Density (12+ Units/Acre)
- Mobile Home Park
- Commercial
- Industrial
- Schools
- Government
- Institution

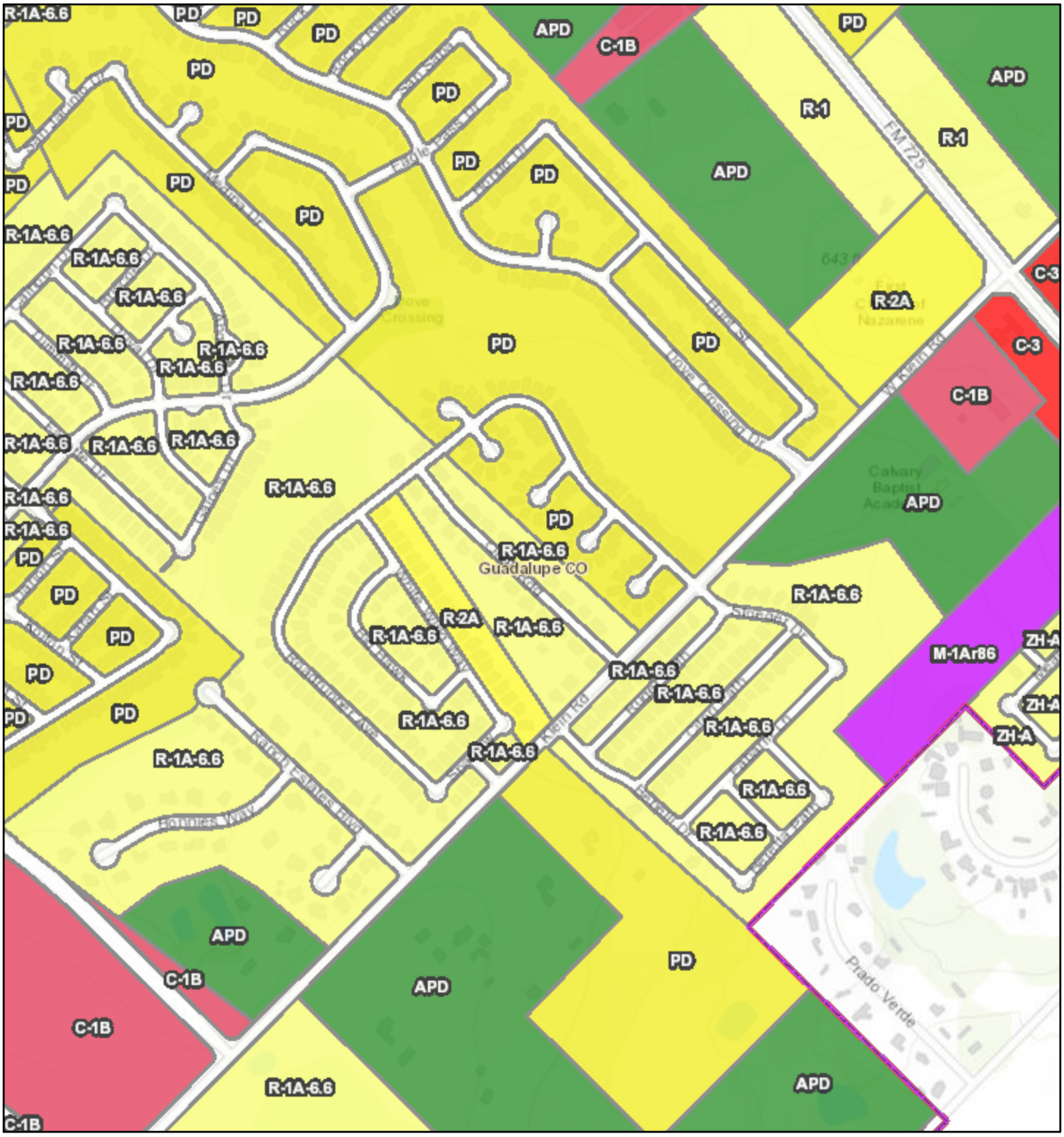
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

GIS User

City of New Braunfels, Comal County, Texas Parks & Wildlife, Esri, HERE, Garmin, INCREMENT P, Intermap, USGS, METI/NASA, EPA, USDA |

APPENDIX A4

Klein Road Phase 2 Zoning Map



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1:9,028

0 0.05 0.1 0.2 mi

0 0.1 0.2 0.4 km

Zoning (Shaded)

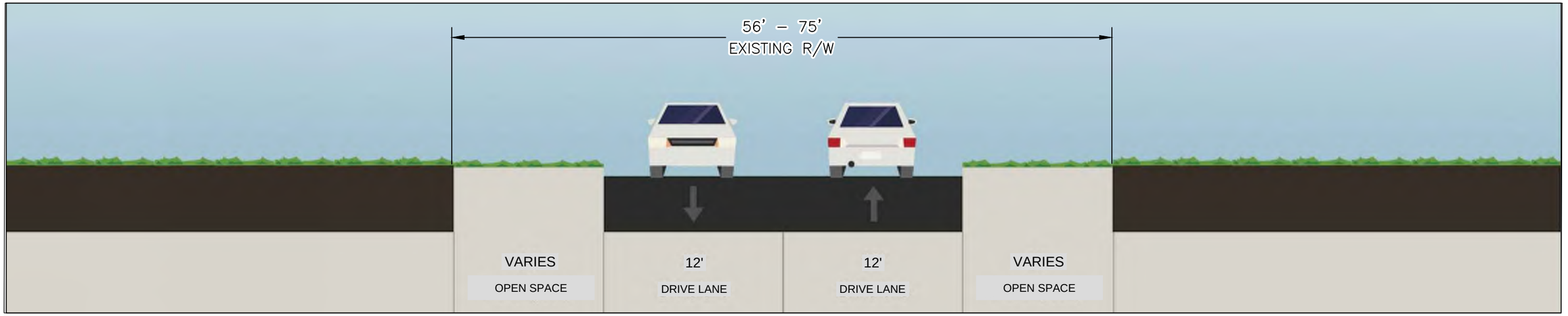
- APD
- B-1
- B-1A
- B-1B
- C-1
- C-1A
- C-1B
- C-2
- C-2A
- C-3

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

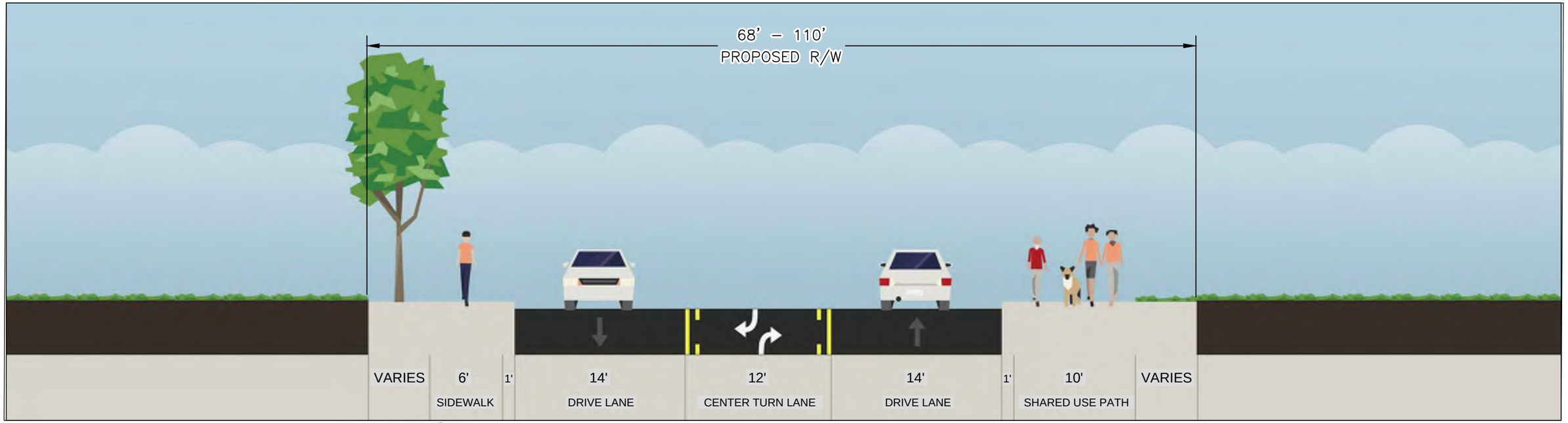
GIS User

City of New Braunfels, Comal County, Texas Parks & Wildlife, Esri, HERE, Garmin, INCREMENT P, Intermap, USGS, METI/NASA, EPA, USDA |

APPENDIX A5



A **EXISTING TYPICAL ROADWAY CROSS SECTION (FACING NORTHEAST)**
NOT TO SCALE



B **PROPOSED TYPICAL ROADWAY CROSS SECTION (FACING NORTHEAST)**
NOT TO SCALE

NOTES:

ASSUMED SURFACING THICKNESS TO MATCH PHASE 1 PAVEMENT SECTION:

- 9" FLEX BASE (CMP IN PLC) (TYPE A GR 1) (FINAL POS)
- 12" LIME TREATED SUBGRADE
- 2" HMAC - Type C (PG 70-22 BINDER)
- 2" HMAC - Type D (PG 76-22 BINDER)
- TENSAR TX-5 GEOGRID
- PRIME COAT (MC-30)
- TACK COAT

STATE OF TEXAS
PATRICK A. LACKEY
56363
LICENSED
PROFESSIONAL ENGINEER
11-22-17

Trihydro CORPORATION
New Braunfels Branch Office
Texas Engineering Firm F-131
Texas Survey Firm 10194320
1011 West County Line Road
New Braunfels, Texas 78130
(P) 830/626.3588 (F) 830/626.3601

SHEET 1 OF 5

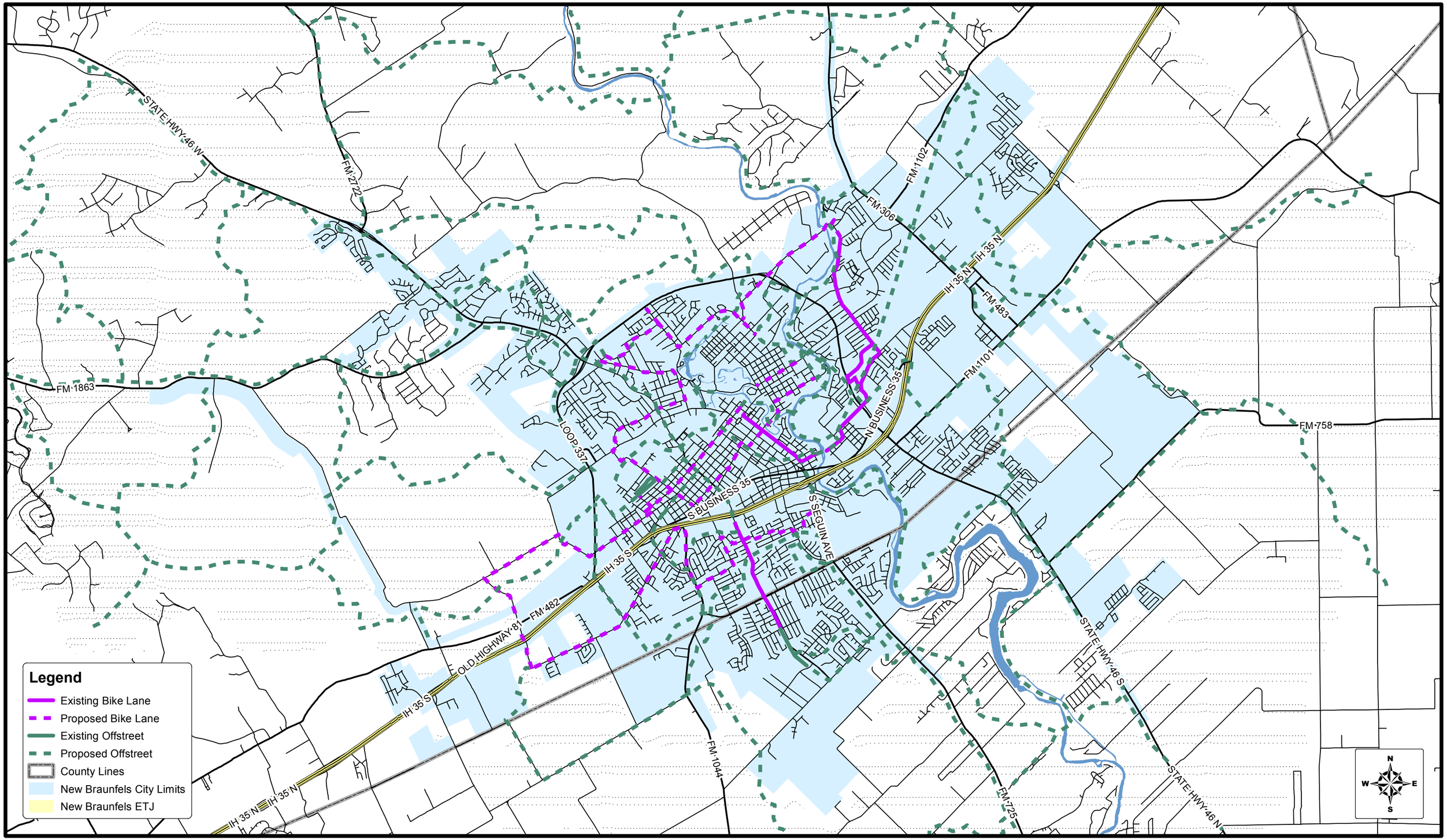
EXISTING AND PROPOSED TYPICAL SECTIONS
W. KLEIN ROAD - WALNUT AVENUE TO FM 725
CONCEPTUAL DESIGN

CITY OF NEW BRAUNFELS
NEW BRAUNFELS, TEXAS

Drawn By: TM	Checked By: TR	Scale: AS SHOWN	Date: 11/21/2017

M:\CTOF\CITYOFNEWBRAUNFELS\CADD\KLEINRDPH2APP\XREFS\PROPROAD

APPENDIX A6



City of New Braunfels

Hike and Bike Trail Plan

Adopted by City Council on November 8, 2010

Adopted as part of the Regional Transportation Plan on March 12, 2012

APPENDIX A7

Plotted on: 8/9/2018

Design File Name: \\pape-dawson\gis\projects\510\50025\civil\utility\510050025UTIL01.dgn

WALNUT AVE

BEGIN PROJECT

W KLEIN ROAD

EXISTING ℄ W KLEIN RD

RANCH ESTATES BLVD

MATCH LINE STA "A"

WISE OWL

QUAIL RIDGE

ROADRUNNER AVE

MATCH LINE STA "A"

MATCH LINE STA "B"

BENELLI DR

SOCCER DR

DOVE CROSSING DR

FM 725

END PROJECT

N.T.S.

REV. NO.	DATE	DESCRIPTION	BY

PAPE-DAWSON ENGINEERS

SAN ANTONIO | AUSTIN | HOUSTON | FORT WORTH | DALLAS
2000 NW LOOP 410 | SAN ANTONIO, TX 78213 | 210.375.9000
TBPE FIRM REGISTRATION #470 | TBPLS FIRM REGISTRATION #100288-00

NEW BRAUNFELS, TX

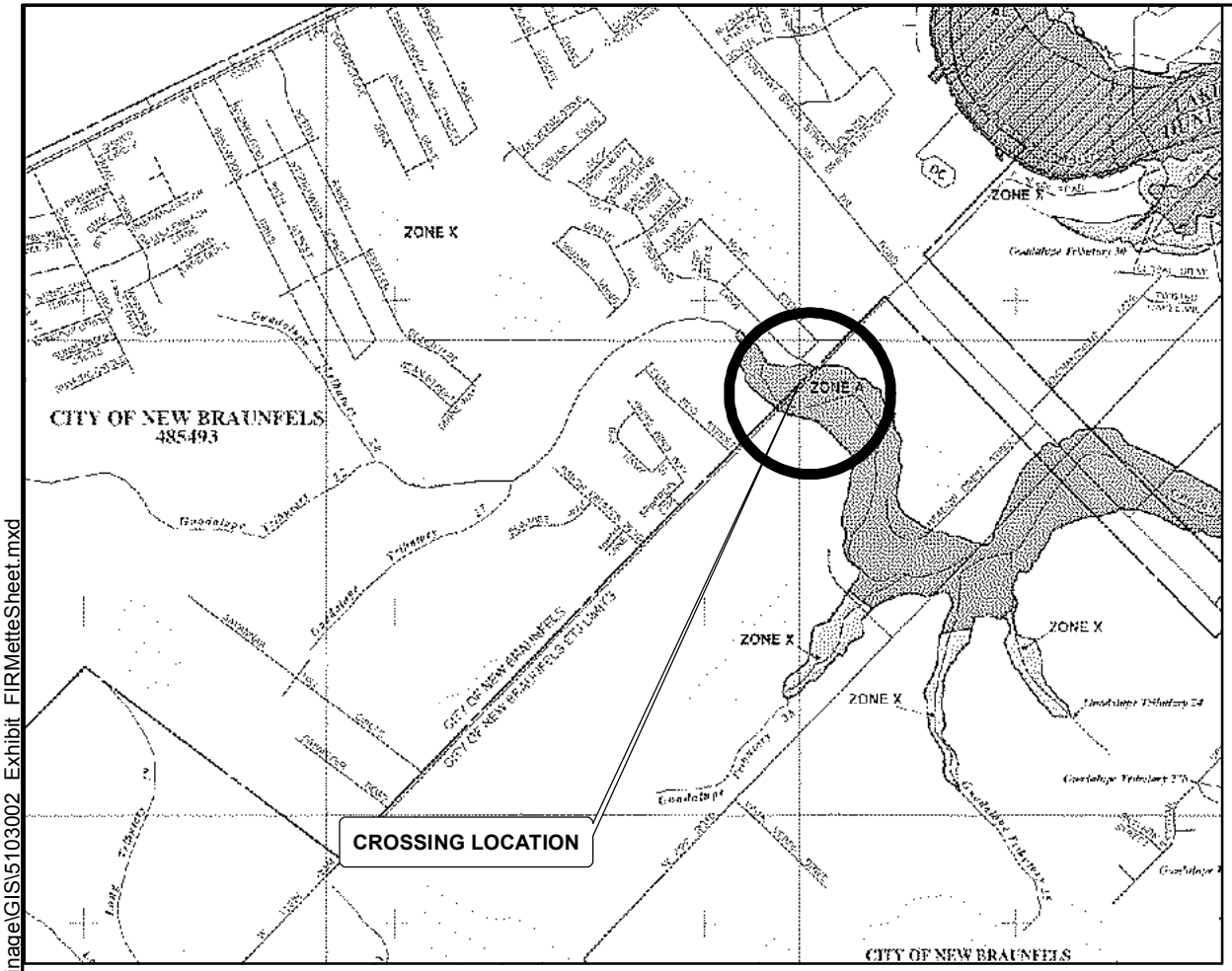
W KLEIN ROAD

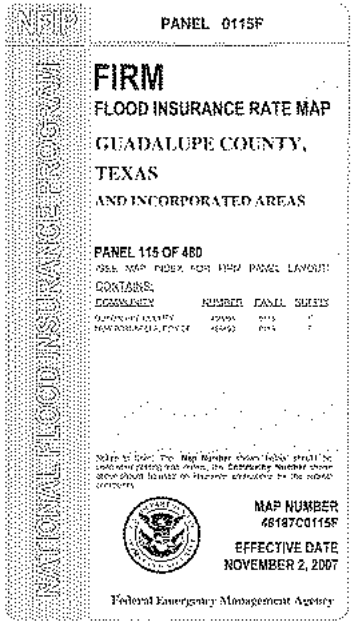
EXISTING UTILITY BASE MAP

LEGEND

POWER POLE	EXISTING ℄ W KLEIN RD
TRAFFIC SIGNAL BOX	RIGHT OF WAY
TRAFFIC SIGNAL POLE	PROPERTY LINE
COMMUNICATIONS SIGN	OH E — OVERHEAD ELECTRIC
COMMUNICATIONS MANHOLE	UGT — UNDERGROUND COMM (AT&T)
UTILITY VAULT	UGT — UNDERGROUND COMM (SPECTRUM)
UTILITY PEDESTAL	F/O — UNDERGROUND FIBER OPTIC LINE (AT&T)
WATER VALVE	W — WATERLINE
FIRE HYDRANT	G — GAS LINE

APPENDIX B1





N

NTS

PAPE-DAWSON ENGINEERS

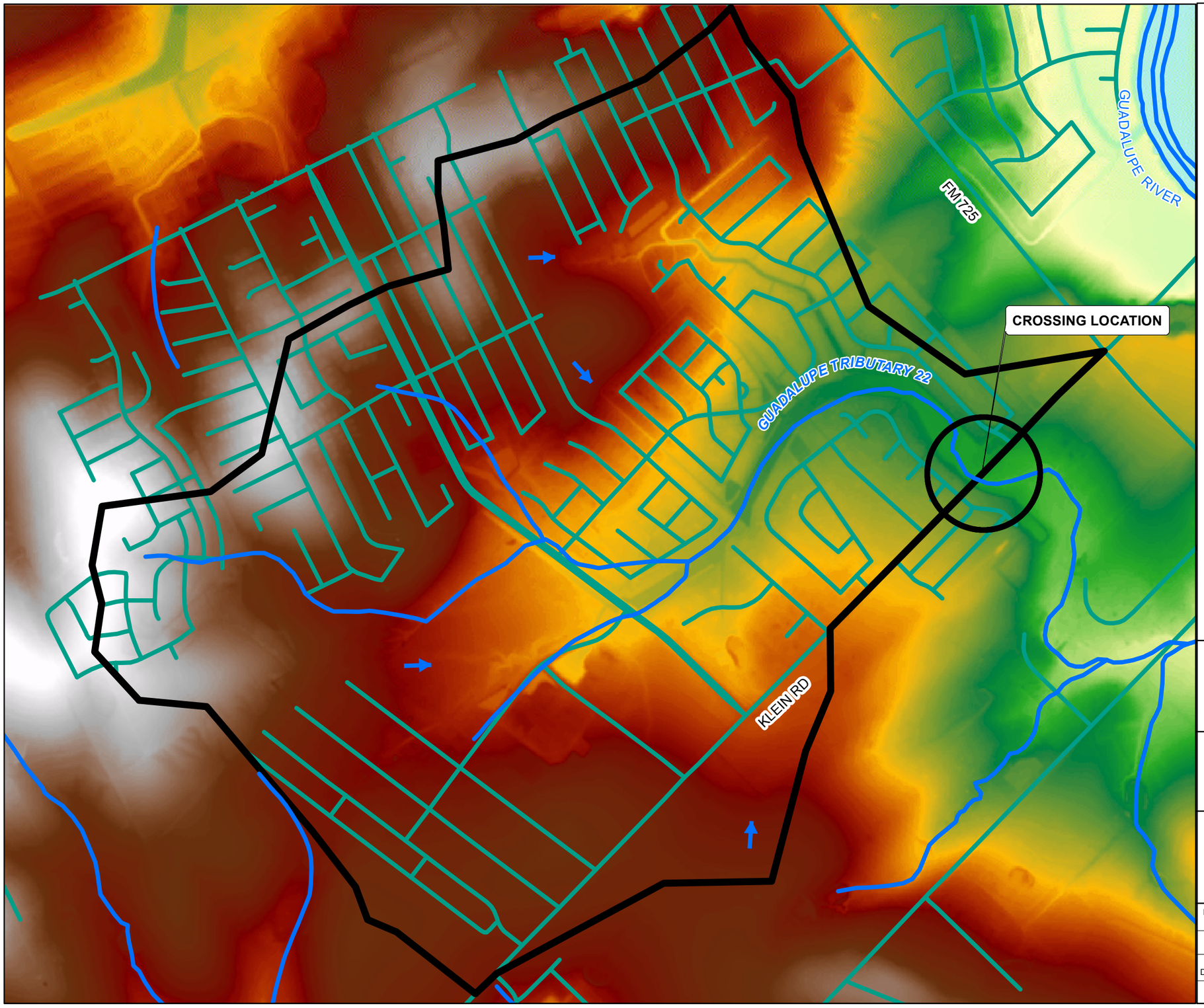
San Antonio | Austin | Houston | Fort Worth | Dallas
TBPE Firm Reg. #470

KLEIN ROAD DRAINAGE STUDY FIRMette

FED. RD. DIV. NO.	STATE	PAPE-DAWSON PROJECT NO.			HIGHWAY NO.
-	TEXAS	51030-02			KLEIN
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	APPENDIX NO.
-	GUADALUPE	-	-	-	

\\pape-dawson\pd\H\projects\51030\02\design\Civil\Drainage\GIS\51030002_Exhibit_FIRMetteSheet.mxd

APPENDIX B2



N

1,000 500 0 1,000
Feet

Legend

- STREAM LINE
- DRAINAGE AREA BOUNDARY
- STREETS

ELEVATION

FEET

High : 755.48

Low : 574.28

- FLOW ARROW

SOURCE:
LIDAR DATA OBTAINED FROM FEMA, 2013, NAVD88

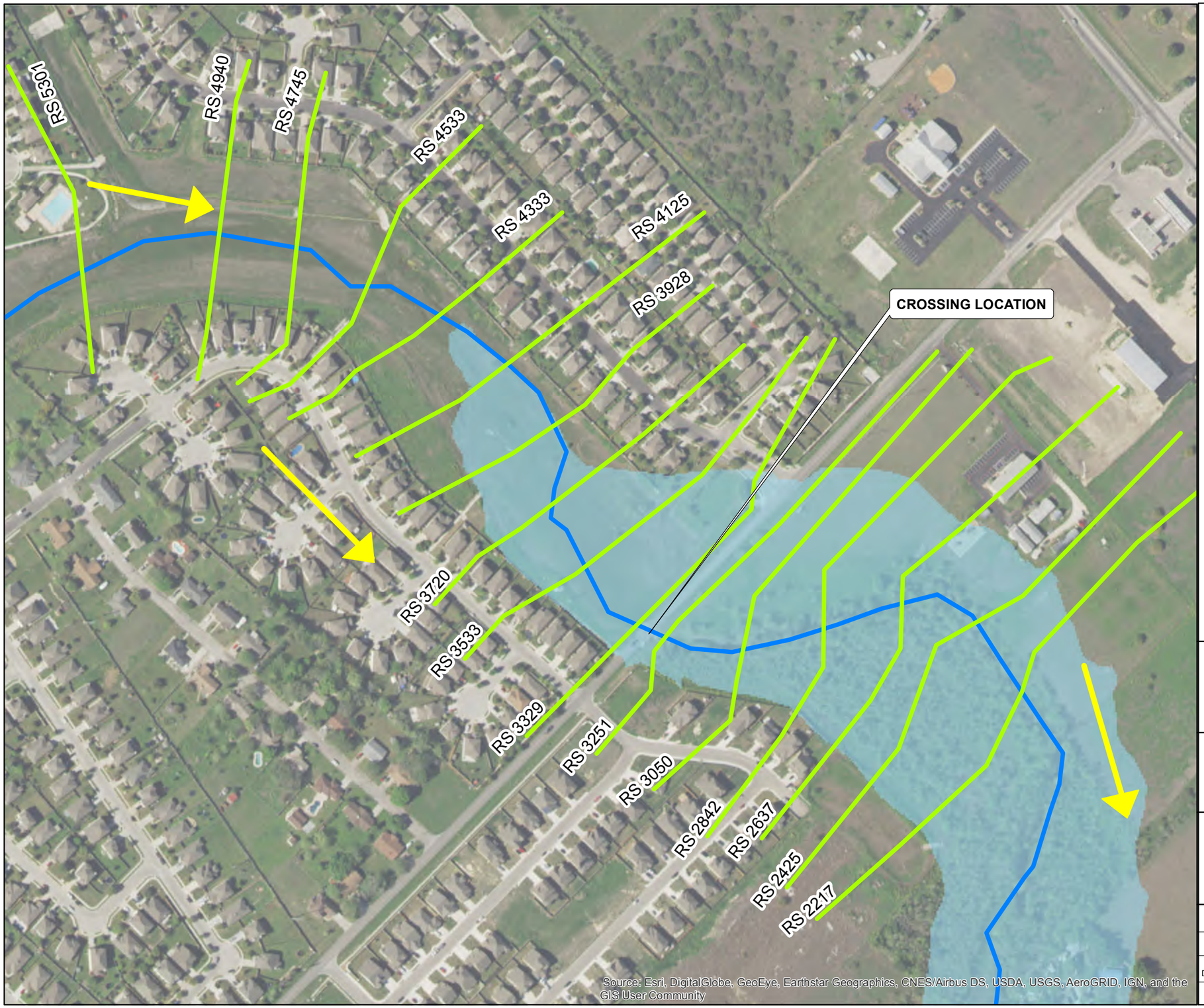
PAPE-DAWSON ENGINEERS
San Antonio | Austin | Houston | Fort Worth | Dallas
TBPE Firm Reg. #470

KLEIN ROAD
DRAINAGE STUDY
DRAINAGE AREA MAP

FED. RD. DIV. NO.	STATE	PAPE-DAWSON PROJECT NO.			HIGHWAY NO.
-	TEXAS	51030-02			KLEIN
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	APPENDIX NO.
-	GUADALUPE	-	-	-	

\\pape-dawson\pd\H\projects\51030\02\design\Civil\DrainageGIS\5103002_Exhibit_DrainageAreaMap.mxd

APPENDIX B3



N

250 125 0 250 500

Feet

Legend

- STREAM LINE
- **FLOOD HAZARD ZONE**
  - A
- HEC-RAS CROSS SECTIONS
- FLOW ARROW

PAPE-DAWSON ENGINEERS
San Antonio | Austin | Houston | Fort Worth | Dallas
TBPE Firm Reg. #470

KLEIN ROAD
DRAINAGE STUDY
HEC-RAS CROSS SECTION LAYOUT

FED. RD. DIV. NO.	STATE	PAPE-DAWSON PROJECT NO.			HIGHWAY NO.
-	TEXAS	51030-02			KLEIN
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	APPENDIX NO.
-	GUADALUPE	-	-	-	

\\pape-dawson\pd\H\projects\51030\02\design\Civil\Drainage\GIS\5103002_Exhibit_CrossSectionLayout.mxd

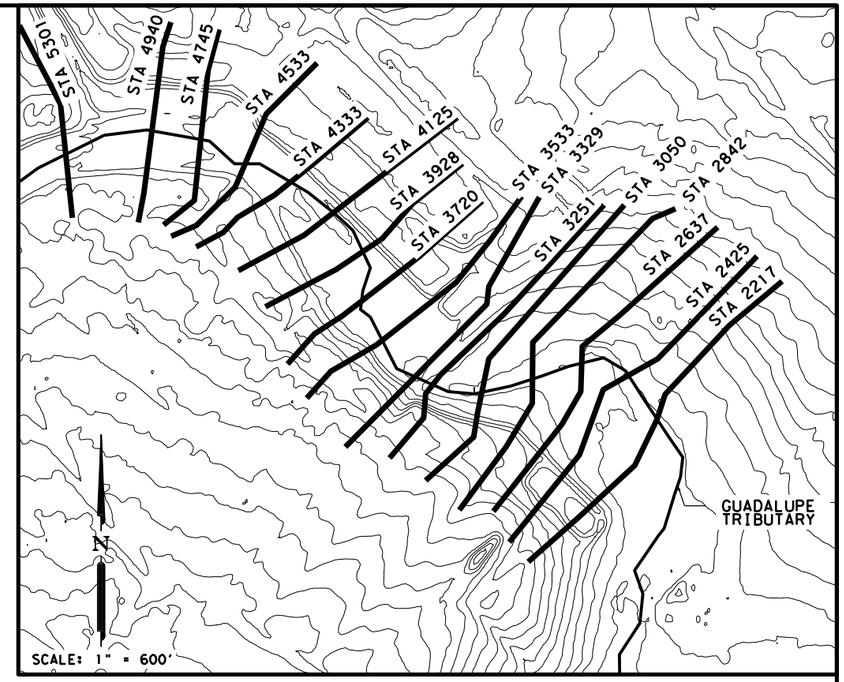
APPENDIX B4

Plotted on: 7/30/2018

Design Filename: \\pape-dawson\pdVHprojects\5103002\design\Civil\Drainage\5103002*hds01.dgn

CULVERT HYDRAULIC DATA

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude #
Trib	5301	50-YR	EX	5021	628.00	631.27	631.26	632.69	0.011795	9.64	536.40	198.35	0.98
Trib	5301	50-YR	PR CV	5021	628.00	631.27	631.26	632.69	0.011799	9.64	536.33	198.34	0.98
Trib	5301	100-YR	EX	6260	628.00	631.75	631.75	633.36	0.011068	10.30	634.11	211.17	0.97
Trib	5301	100-YR	PR CV	6260	628.00	631.75	631.75	633.36	0.011068	10.30	634.11	211.17	0.97
Trib	4940	50-YR	EX	5021	626.40	630.09		630.47	0.003000	4.92	1038.13	377.08	0.49
Trib	4940	50-YR	PR CV	5021	626.40	630.09		630.47	0.002997	4.92	1038.43	377.18	0.49
Trib	4940	100-YR	EX	6260	626.40	630.55		630.98	0.002908	5.30	1221.85	433.34	0.50
Trib	4940	100-YR	PR CV	6260	626.40	630.55		630.98	0.002901	5.30	1222.88	433.57	0.50
Trib	4745	50-YR	EX	5021	625.80	629.62		629.94	0.002302	4.54	1142.97	438.47	0.44
Trib	4745	50-YR	PR CV	5021	625.80	629.62		629.94	0.002299	4.53	1143.64	438.65	0.44
Trib	4745	100-YR	EX	6260	625.80	630.10		630.46	0.002217	4.87	1366.59	495.39	0.44
Trib	4745	100-YR	PR CV	6260	625.80	630.11		630.46	0.002208	4.86	1368.68	495.94	0.44
Trib	4533	50-YR	EX	5021	624.89	629.15		629.47	0.002156	4.79	1242.52	483.23	0.43
Trib	4533	50-YR	PR CV	5021	624.89	629.16		629.47	0.002149	4.79	1243.88	483.32	0.43
Trib	4533	100-YR	EX	6260	624.89	629.68		630.01	0.001965	4.99	1502.04	499.12	0.42
Trib	4533	100-YR	PR CV	6260	624.89	629.69		630.02	0.001952	4.98	1505.51	499.32	0.42
Trib	4333	50-YR	EX	5021	624.21	628.14		628.81	0.004762	6.58	777.79	268.30	0.63
Trib	4333	50-YR	PR CV	5021	624.21	628.16		628.82	0.004708	6.56	780.84	268.69	0.63
Trib	4333	100-YR	EX	6260	624.21	628.58		629.38	0.004866	7.21	897.49	283.31	0.65
Trib	4333	100-YR	PR CV	6260	624.21	628.61		629.39	0.004748	7.16	905.15	284.24	0.64
Trib	4125	50-YR	EX	5021	623.44	627.50		627.96	0.003104	5.46	937.44	300.44	0.51
Trib	4125	50-YR	PR CV	5021	623.44	627.53		627.98	0.003013	5.41	946.75	302.23	0.51
Trib	4125	100-YR	EX	6260	623.44	627.92		628.48	0.003259	6.04	1070.26	324.35	0.54
Trib	4125	100-YR	PR CV	6260	623.44	627.99		628.53	0.003070	5.93	1092.52	328.00	0.52
Trib	3928	50-YR	EX	5021	623.23	627.03		627.38	0.002479	4.80	1061.52	332.55	0.46
Trib	3928	50-YR	PR CV	5021	623.23	627.08		627.43	0.002345	4.72	1080.35	333.73	0.45
Trib	3928	100-YR	EX	6260	623.23	627.43		627.87	0.002630	5.33	1198.65	341.02	0.48
Trib	3928	100-YR	PR CV	6260	623.23	627.55		627.96	0.002369	5.16	1239.41	343.50	0.46
Trib	3720	50-YR	EX	5021	622.63	626.63		626.91	0.001902	4.30	1188.94	360.67	0.40
Trib	3720	50-YR	PR CV	5021	622.63	626.72		626.99	0.001748	4.19	1221.17	362.20	0.39
Trib	3720	100-YR	EX	6260	622.63	627.00		627.36	0.002099	4.83	1325.56	367.96	0.43
Trib	3720	100-YR	PR CV	6260	622.63	627.18		627.51	0.001796	4.61	1393.34	372.08	0.40
Trib	3533	50-YR	EX	5021	622.42	626.38		626.58	0.001407	3.83	1512.73	559.00	0.35
Trib	3533	50-YR	PR CV	5021	622.42	626.50		626.69	0.001242	3.67	1580.84	565.38	0.33
Trib	3533	100-YR	EX	6260	622.42	626.75		627.00	0.001510	4.23	1724.12	577.78	0.37
Trib	3533	100-YR	PR CV	6260	622.42	627.00		627.20	0.001207	3.93	1865.82	590.17	0.33
Trib	3329	50-YR	EX	5021	621.25	625.99	624.54	626.28	0.001515	4.45	1270.68	543.66	0.42
Trib	3329	50-YR	PR CV	5021	621.25	624.62	624.62	625.83	0.009621	8.82	570.20	336.92	0.99
Trib	3329	100-YR	EX	6260	621.25	626.30	624.90	626.66	0.001701	4.99	1446.38	589.76	0.45
Trib	3329	100-YR	PR CV	6260	621.25	625.37	625.02	626.46	0.006122	8.41	748.89	484.89	0.83
Trib	3296			Culvert									
Trib	3251	50-YR	EX	5021	619.25	624.15		624.69	0.004690	7.12	999.54	570.09	0.72
Trib	3251	50-YR	PR CV	5021	619.25	624.38	624.38	625.67	0.007827	9.65	584.96	592.38	0.94
Trib	3251	100-YR	EX	6260	619.25	624.49		625.06	0.004430	7.43	1199.76	601.56	0.71
Trib	3251	100-YR	PR CV	6260	619.25	624.79	624.79	626.28	0.007763	10.40	678.59	627.92	0.95
Trib	3050	50-YR	EX	5021	619.11	623.61		623.95	0.002560	5.82	1227.97	569.90	0.55
Trib	3050	50-YR	PR CV	5021	619.11	623.61		623.95	0.002560	5.82	1227.97	569.90	0.55
Trib	3050	100-YR	EX	6260	619.11	623.95		624.33	0.002604	6.24	1426.26	594.31	0.56
Trib	3050	100-YR	PR CV	6260	619.11	623.95		624.33	0.002604	6.24	1426.26	594.31	0.56
Trib	2842	50-YR	EX	5021	618.69	622.21	622.20	623.04	0.007879	8.20	788.35	486.92	0.91
Trib	2842	50-YR	PR CV	5021	618.69	622.21	622.20	623.04	0.007879	8.20	788.35	486.92	0.91
Trib	2842	100-YR	EX	6260	618.69	622.51	622.49	623.42	0.007676	8.72	939.36	522.44	0.91
Trib	2842	100-YR	PR CV	6260	618.69	622.51	622.49	623.42	0.007676	8.72	939.36	522.44	0.91
Trib	2637	50-YR	EX	5021	618.12	621.41		621.81	0.003859	6.09	1069.82	541.42	0.64
Trib	2637	50-YR	PR CV	5021	618.12	621.41		621.81	0.003859	6.09	1069.82	541.42	0.64
Trib	2637	100-YR	EX	6260	618.12	621.71		622.18	0.004004	6.64	1233.78	564.70	0.67
Trib	2637	100-YR	PR CV	6260	618.12	621.71		622.18	0.004004	6.64	1233.78	564.70	0.67
Trib	2425	50-YR	EX	5021	617.81	620.61		621.00	0.003778	5.13	1060.32	605.39	0.61
Trib	2425	50-YR	PR CV	5021	617.81	620.61		621.00	0.003778	5.13	1060.32	605.39	0.61
Trib	2425	100-YR	EX	6260	617.81	620.95		621.37	0.003492	5.42	1268.73	635.13	0.60
Trib	2425	100-YR	PR CV	6260	617.81	620.95		621.37	0.003492	5.42	1268.73	635.13	0.60
Trib	2217	50-YR	EX	5021	616.95	619.99	619.10	620.34	0.002602	4.83	1097.70	524.03	0.52
Trib	2217	50-YR	PR CV	5021	616.95	619.99	619.10	620.34	0.002602	4.83	1097.70	524.03	0.52
Trib	2217	100-YR	EX	6260	616.95	620.34	619.37	620.75	0.002600	5.24	1282.59	548.21	0.53
Trib	2217	100-YR	PR CV	6260	616.95	620.34	619.37	620.75	0.002600	5.24	1282.59	548.21	0.53



NOTES:
1. DATA PRESENTED FROM DRAINAGE SUMMARY FOR KLEIN ROAD PREPARED BY PAPE-DAWSON ENGINEERS. DATED JULY 2018.

2. GUADALUPE TRIBUTARY 22 IS IDENTIFIED ON FEMA FIRM PANEL 48187C0115F. DATED NOVEMBER 2. 2007. THE UPSTREAM/DOWNSTREAM AREA AND EXISTING CROSSING ARE WITHIN A ZONE "A".

HYDRAULIC METHOD

WATER SURFACE ELEVATIONS COMPUTED USING A HEC-RAS (V.5.0.3) MODEL CREATED FOR GUADALUPE TRIBUTARY 22.
FILE NAME: "5103002_KLEINRD.PRJ"

EFFECTIVE AND PROPOSED MODELS WERE DEVELOPED USING LIDAR DATA AND FIELD DATA.

EFFECTIVE CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "EXISTING" NAMED "5103002_KLEINRD.P01".

PROPOSED CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "PROP CULVERT" NAMED "5103002_KLEINRD.P03".

HYDROLOGIC METHOD

FLOWS USED FOR MODELS WERE CALCULATED FROM THE SCS HYDROGRAPH METHOD AND INFORMATION FROM THE CITY OF NEW BRAUNFELS - DRAINAGE AND EROSION CONTROL DESIGN MANUAL.

REV. NO.	DATE	DESCRIPTION	BY

PAPE-DAWSON ENGINEERS

SAN ANTONIO | AUSTIN | HOUSTON | FORT WORTH | DALLAS
2000 NW LOOP 410 | SAN ANTONIO, TX 78213 | 210.375.9000
TBPE FIRM REGISTRATION #470 | TBPLS FIRM REGISTRATION #10028800

KLEIN ROAD

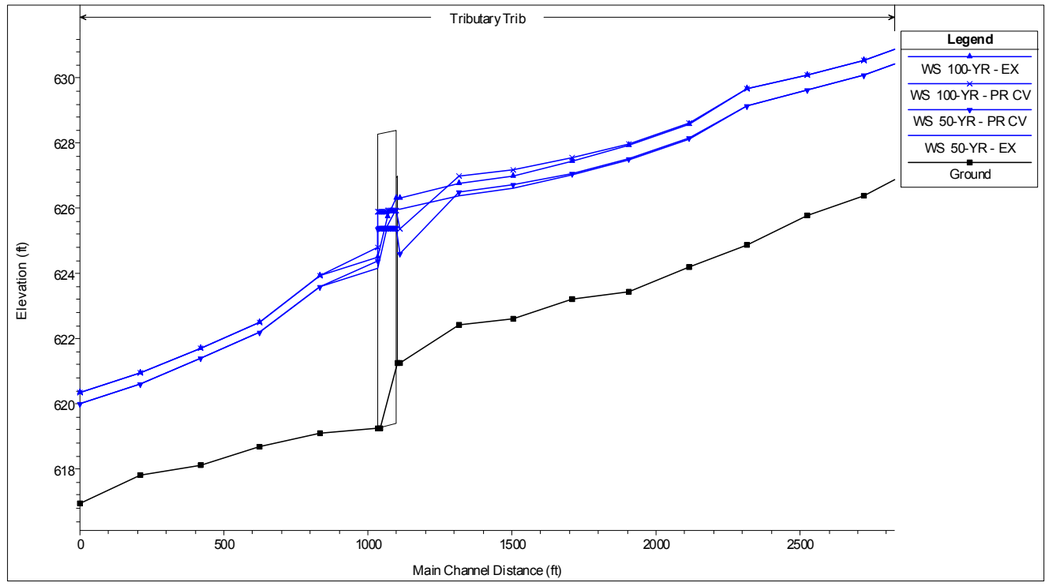
PROPOSED CULVERT HYDRAULIC DATA SHEET

SHEET 1 OF 4

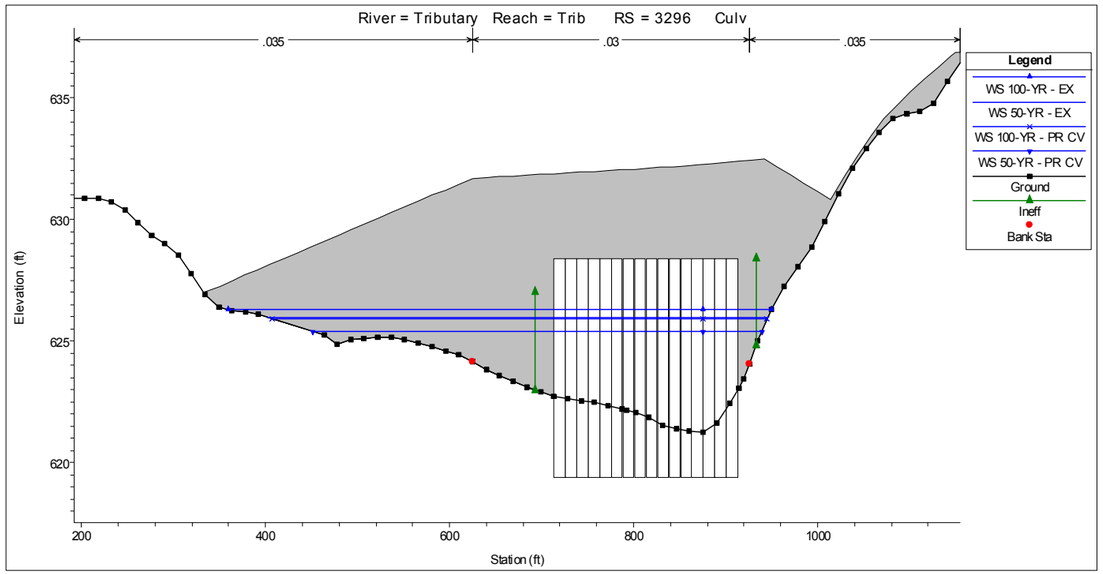
Plotted on: 7/30/2018

Design Filename: \\pape-dawson\pdfs\projects\5103\002\design\Civil\Drainage\5103002-hds02.dgn

HEC-RAS CHANNEL PROFILE



HEC-RAS CULVERT UPSTREAM



HEC-RAS CULVERT OUTPUT

Trib RS: 3296 Culv Group: Culvert #1 Profile: 50-YR					
Plan	EX	PR CV		EX	PR CV
Q Culv Group (cfs)	63.97	5021.00	Culv Full Len (ft)	30.00	60.00
# Barrels	3	16	Culv Vel US (ft/s)	6.79	4.36
Q Barrel (cfs)	21.32	313.81	Culv Vel DS (ft/s)	6.79	4.27
E.G. US. (ft)	626.28	625.81	Culv Inv El Up (ft)	619.40	619.40
W.S. US. (ft)	625.99	624.62	Culv Inv El Dn (ft)	619.26	619.26
E.G. DS (ft)	624.69	625.67	Culv Frctn Ls (ft)	0.91	0.00
W.S. DS (ft)	624.15	624.38	Culv Exit Loss (ft)	0.18	0.00
Delta EG (ft)	1.59	0.14	Culv Entr Loss (ft)	0.50	0.12
Delta WS (ft)	1.84	0.25	Q Weir (cfs)	4961.35	
E.G. IC (ft)	626.26	623.77	Weir Sta Lft (ft)	361.67	
E.G. OC (ft)	626.28	625.81	Weir Sta Rgt (ft)	947.24	
Culvert Control	Outlet	Outlet	Weir Submerg	0.26	
Culv WS Inlet (ft)	621.40	625.40	Weir Max Depth (ft)	4.01	
Culv WS Outlet (ft)	621.26	625.39	Weir Avg Depth (ft)	2.03	
Culv Nml Depth (ft)		3.31	Weir Flow Area (sq ft)	1188.40	
Culv Crt Depth (ft)	1.65	2.77	Min El Weir Flow (ft)	622.27	627.01

Trib RS: 3296 Culv Group: Culvert #1 Profile: 100-YR					
Plan	EX	PR CV		EX	PR CV
Q Culv Group (cfs)	64.56	6260.00	Culv Full Len (ft)	30.00	60.00
# Barrels	3	16	Culv Vel US (ft/s)	6.85	5.00
Q Barrel (cfs)	21.52	391.25	Culv Vel DS (ft/s)	6.85	4.90
E.G. US. (ft)	626.66	626.47	Culv Inv El Up (ft)	619.40	619.40
W.S. US. (ft)	626.30	625.37	Culv Inv El Dn (ft)	619.26	619.26
E.G. DS (ft)	625.06	626.28	Culv Frctn Ls (ft)	0.93	0.00
W.S. DS (ft)	624.49	624.79	Culv Exit Loss (ft)	0.16	0.00
Delta EG (ft)	1.60	0.19	Culv Entr Loss (ft)	0.51	0.16
Delta WS (ft)	1.81	0.58	Q Weir (cfs)	6195.44	
E.G. IC (ft)	626.64	624.49	Weir Sta Lft (ft)	341.77	
E.G. OC (ft)	626.66	626.47	Weir Sta Rgt (ft)	952.74	
Culvert Control	Outlet	Outlet	Weir Submerg	0.30	
Culv WS Inlet (ft)	621.40	625.93	Weir Max Depth (ft)	4.39	
Culv WS Outlet (ft)	621.26	625.91	Weir Avg Depth (ft)	2.32	
Culv Nml Depth (ft)		3.86	Weir Flow Area (sq ft)	1415.00	
Culv Crt Depth (ft)	1.66	3.21	Min El Weir Flow (ft)	622.27	627.01

NOTES:
1. DATA PRESENTED FROM DRAINAGE SUMMARY FOR KLEIN ROAD PREPARED BY PAPE-DAWSON ENGINEERS. DATED JULY 2018.

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HYDRAULIC METHOD

WATER SURFACE ELEVATIONS COMPUTED USING A HEC-RAS (V.5.0.3) MODEL CREATED FOR GUADALUPE TRIBUTARY 22.
FILE NAME: "5103002_KLEINRD.PRJ"

EFFECTIVE AND PROPOSED MODELS WERE DEVELOPED USING LIDAR DATA AND FIELD DATA.

EFFECTIVE CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "EXISTING" NAMED "5103002_KLEINRD.P01".

PROPOSED CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "PROP CULVERT" NAMED "5103002_KLEINRD.P03".

HYDROLOGIC METHOD

FLOWS USED FOR MODELS WERE CALCULATED FROM THE SCS HYDROGRAPH METHOD AND INFORMATION FROM THE CITY OF NEW BRAUNFELS - DRAINAGE AND EROSION CONTROL DESIGN MANUAL.

REV. NO.	DATE	DESCRIPTION	BY

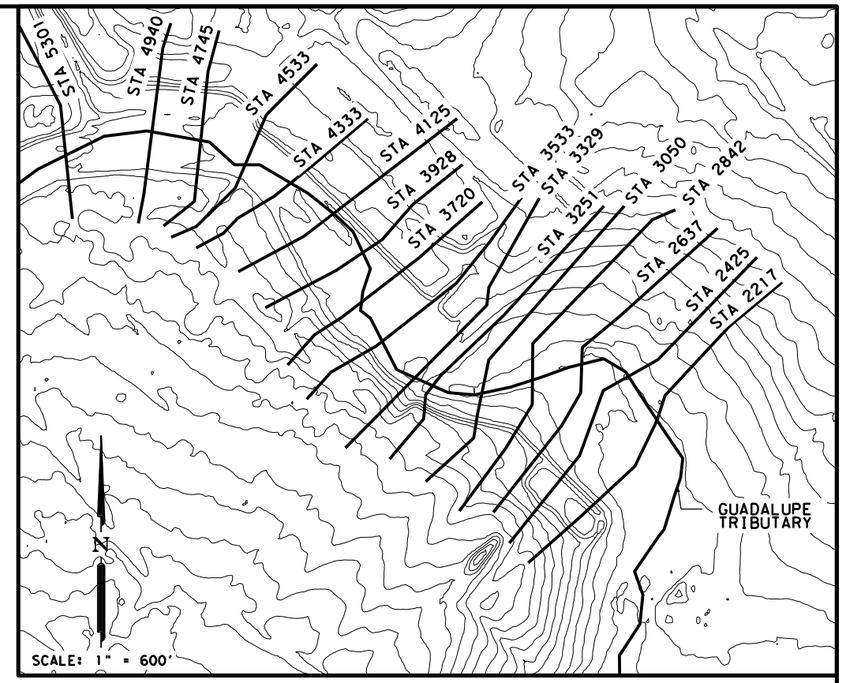
PAPE-DAWSON ENGINEERS
SAN ANTONIO | AUSTIN | HOUSTON | FORT WORTH | DALLAS
2000 NW LOOP 410 | SAN ANTONIO, TX 78213 | 210.375.9000
TBPE FIRM REGISTRATION #470 | TBPLS FIRM REGISTRATION #10028800

KLEIN ROAD

PROPOSED CULVERT HYDRAULIC DATA SHEET

BRIDGE HYDRAULIC DATA

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude #
Trib	5301	50-YR	EX	5021	628.00	631.27	631.26	632.69	0.011795	9.64	536.40	198.35	0.98
Trib	5301	50-YR	PRBR	5021	628.00	631.27	631.26	632.69	0.011790	9.64	536.48	198.36	0.98
Trib	5301	100-YR	EX	6260	628.00	631.75	631.75	633.36	0.011068	10.30	634.11	211.17	0.97
Trib	5301	100-YR	PRBR	6260	628.00	631.75	631.75	633.36	0.011068	10.30	634.11	211.17	0.97
Trib	4940	50-YR	EX	5021	626.40	630.09		630.47	0.003000	4.92	1038.13	377.08	0.49
Trib	4940	50-YR	PRBR	5021	626.40	630.09		630.47	0.003002	4.92	1037.90	377.01	0.49
Trib	4940	100-YR	EX	6260	626.40	630.55		630.98	0.002908	5.30	1221.85	433.34	0.50
Trib	4940	100-YR	PRBR	6260	626.40	630.55		630.98	0.002908	5.30	1221.80	433.33	0.50
Trib	4745	50-YR	EX	5021	625.80	629.62		629.94	0.002302	4.54	1142.97	438.47	0.44
Trib	4745	50-YR	PRBR	5021	625.80	629.62		629.94	0.002305	4.54	1142.46	438.34	0.44
Trib	4745	100-YR	EX	6260	625.80	630.10		630.46	0.002217	4.87	1366.59	495.39	0.44
Trib	4745	100-YR	PRBR	6260	625.80	630.10		630.46	0.002217	4.87	1366.47	495.36	0.44
Trib	4533	50-YR	EX	5021	624.89	629.15		629.47	0.002156	4.79	1242.52	483.23	0.43
Trib	4533	50-YR	PRBR	5021	624.89	629.15		629.46	0.002161	4.79	1241.46	483.16	0.43
Trib	4533	100-YR	EX	6260	624.89	629.68		630.01	0.001965	4.99	1502.04	499.12	0.42
Trib	4533	100-YR	PRBR	6260	624.89	629.68		630.01	0.001966	4.99	1501.85	499.11	0.42
Trib	4333	50-YR	EX	5021	624.21	628.14		628.81	0.004762	6.58	777.79	268.30	0.63
Trib	4333	50-YR	PRBR	5021	624.21	628.14		628.81	0.004806	6.60	775.40	267.99	0.63
Trib	4333	100-YR	EX	6260	624.21	628.58		629.38	0.004866	7.21	897.49	283.31	0.65
Trib	4333	100-YR	PRBR	6260	624.21	628.58		629.38	0.004872	7.22	897.13	283.26	0.65
Trib	4125	50-YR	EX	5021	623.44	627.50		627.96	0.003104	5.46	937.44	300.44	0.51
Trib	4125	50-YR	PRBR	5021	623.44	627.47		627.94	0.003180	5.50	929.92	298.98	0.52
Trib	4125	100-YR	EX	6260	623.44	627.92		628.48	0.003259	6.04	1070.26	324.35	0.54
Trib	4125	100-YR	PRBR	6260	623.44	627.92		628.48	0.003268	6.04	1069.23	324.18	0.54
Trib	3928	50-YR	EX	5021	623.23	627.03		627.38	0.002479	4.80	1061.52	332.55	0.46
Trib	3928	50-YR	PRBR	5021	623.23	626.98		627.34	0.002600	4.87	1045.59	331.56	0.47
Trib	3928	100-YR	EX	6260	623.23	627.43		627.87	0.002630	5.33	1198.65	341.02	0.48
Trib	3928	100-YR	PRBR	6260	623.23	627.43		627.87	0.002643	5.34	1196.71	340.90	0.48
Trib	3720	50-YR	EX	5021	622.63	626.63		626.91	0.001902	4.30	1188.94	360.67	0.40
Trib	3720	50-YR	PRBR	5021	622.63	626.55		626.85	0.002056	4.40	1160.23	359.31	0.42
Trib	3720	100-YR	EX	6260	622.63	627.00		627.36	0.002099	4.83	1325.56	367.96	0.43
Trib	3720	100-YR	PRBR	6260	622.63	626.99		627.35	0.002116	4.84	1322.17	367.76	0.43
Trib	3533	50-YR	EX	5021	622.42	626.38		626.58	0.001407	3.83	1512.73	559.00	0.35
Trib	3533	50-YR	PRBR	5021	622.42	626.27		626.49	0.001588	3.98	1448.83	552.62	0.37
Trib	3533	100-YR	EX	6260	622.42	626.75		627.00	0.001510	4.23	1724.12	577.78	0.37
Trib	3533	100-YR	PRBR	6260	622.42	626.74		626.99	0.001529	4.24	1716.65	577.17	0.37
Trib	3329	50-YR	EX	5021	621.25	625.99	624.54	626.28	0.001515	4.45	1270.68	543.66	0.42
Trib	3329	50-YR	PRBR	5021	621.25	625.60	624.55	626.02	0.002492	5.27	973.07	506.60	0.53
Trib	3329	100-YR	EX	6260	621.25	626.30	624.90	626.66	0.001701	4.99	1446.38	589.76	0.45
Trib	3329	100-YR	PRBR	6260	621.25	626.23	624.89	626.60	0.001824	5.10	1405.46	575.85	0.46
Trib	3296			Bridge									
Trib	3251	50-YR	EX	5021	619.25	624.15		624.69	0.004690	7.12	999.54	570.09	0.72
Trib	3251	50-YR	PRBR	5021	619.25	624.19	624.19	625.24	0.007480	9.07	666.98	576.02	0.91
Trib	3251	100-YR	EX	6260	619.25	624.49		625.06	0.004430	7.43	1199.76	601.56	0.71
Trib	3251	100-YR	PRBR	6260	619.25	624.53	624.53	625.75	0.007548	9.78	770.12	604.87	0.93
Trib	3050	50-YR	EX	5021	619.11	623.61		623.95	0.002560	5.82	1227.97	569.90	0.55
Trib	3050	50-YR	PRBR	5021	619.11	623.61		623.95	0.002560	5.82	1227.97	569.90	0.55
Trib	3050	100-YR	EX	6260	619.11	623.95		624.33	0.002604	6.24	1426.26	594.31	0.56
Trib	3050	100-YR	PRBR	6260	619.11	623.95		624.33	0.002604	6.24	1426.26	594.31	0.56
Trib	2842	50-YR	EX	5021	618.69	622.21	622.20	623.04	0.007879	8.20	788.35	486.92	0.91
Trib	2842	50-YR	PRBR	5021	618.69	622.21	622.20	623.04	0.007879	8.20	788.35	486.92	0.91
Trib	2842	100-YR	EX	6260	618.69	622.51	622.49	623.42	0.007676	8.72	939.36	522.44	0.91
Trib	2842	100-YR	PRBR	6260	618.69	622.51	622.49	623.42	0.007676	8.72	939.36	522.44	0.91
Trib	2637	50-YR	EX	5021	618.12	621.41		621.81	0.003859	6.09	1069.82	541.42	0.64
Trib	2637	50-YR	PRBR	5021	618.12	621.41		621.81	0.003859	6.09	1069.82	541.42	0.64
Trib	2637	100-YR	EX	6260	618.12	621.71		622.18	0.004004	6.64	1233.78	564.70	0.67
Trib	2637	100-YR	PRBR	6260	618.12	621.71		622.18	0.004004	6.64	1233.78	564.70	0.67
Trib	2425	50-YR	EX	5021	617.81	620.61		621.00	0.003778	5.13	1060.32	605.39	0.61
Trib	2425	50-YR	PRBR	5021	617.81	620.61		621.00	0.003778	5.13	1060.32	605.39	0.61
Trib	2425	100-YR	EX	6260	617.81	620.95		621.37	0.003492	5.42	1268.73	635.13	0.60
Trib	2425	100-YR	PRBR	6260	617.81	620.95		621.37	0.003493	5.42	1268.69	635.13	0.60
Trib	2217	50-YR	EX	5021	616.95	619.99	619.10	620.34	0.002602	4.83	1097.70	524.03	0.52
Trib	2217	50-YR	PRBR	5021	616.95	619.99	619.10	620.34	0.002602	4.83	1097.70	524.03	0.52
Trib	2217	100-YR	EX	6260	616.95	620.34	619.37	620.75	0.002600	5.24	1282.59	548.21	0.53
Trib	2217	100-YR	PRBR	6260	616.95	620.34	619.37	620.75	0.002600	5.24	1282.59	548.21	0.53



NOTES:
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HYDRAULIC METHOD

WATER SURFACE ELEVATIONS COMPUTED USING A HEC-RAS (V.5.0.3) MODEL CREATED FOR GUADALUPE TRIBUTARY 22.
FILE NAME: "5103002_KLEINRD.PRJ"

EFFECTIVE AND PROPOSED MODELS WERE DEVELOPED USING LIDAR DATA AND FIELD DATA.

EFFECTIVE CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "EXISTING" NAMED "5103002_KLEINRD.P01".

PROPOSED CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "PROP BRIDGE" NAMED "5103002_KLEINRD.P02".

HYDROLOGIC METHOD

FLOWS USED FOR MODELS WERE CALCULATED FROM THE SCS HYDROGRAPH METHOD AND INFORMATION FROM THE CITY OF NEW BRAUNFELS - DRAINAGE AND EROSION CONTROL DESIGN MANUAL.

REV. NO.	DATE	DESCRIPTION	BY

PAPE-DAWSON ENGINEERS
SAN ANTONIO | AUSTIN | HOUSTON | FORT WORTH | DALLAS
2000 NW LOOP 410 | SAN ANTONIO, TX 78213 | 210.375.9000
TBPE FIRM REGISTRATION #470 | TBPLS FIRM REGISTRATION #10028800

KLEIN ROAD

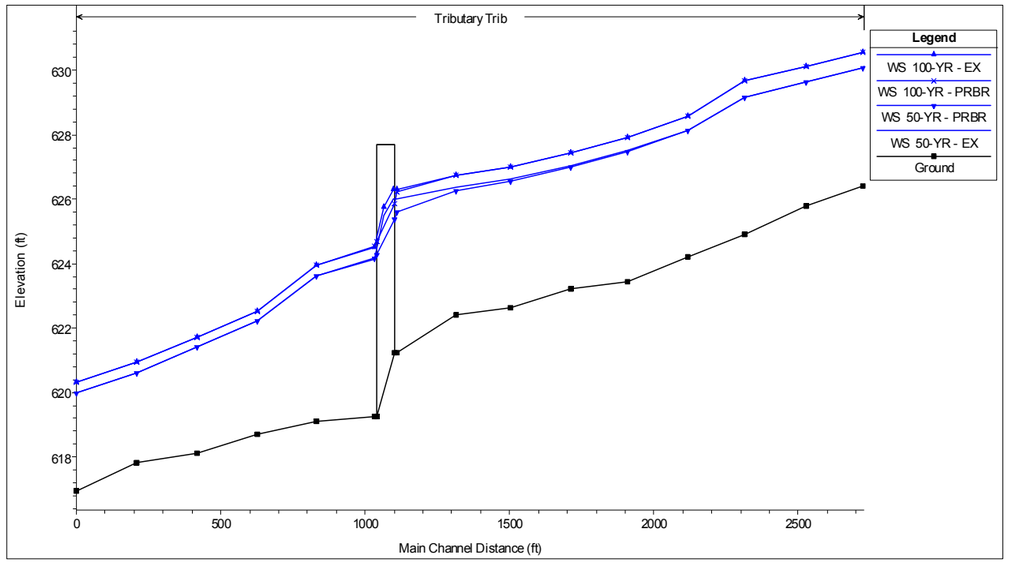
PROPOSED BRIDGE HYDRAULIC DATA SHEET

Plotted on: 7/30/2018

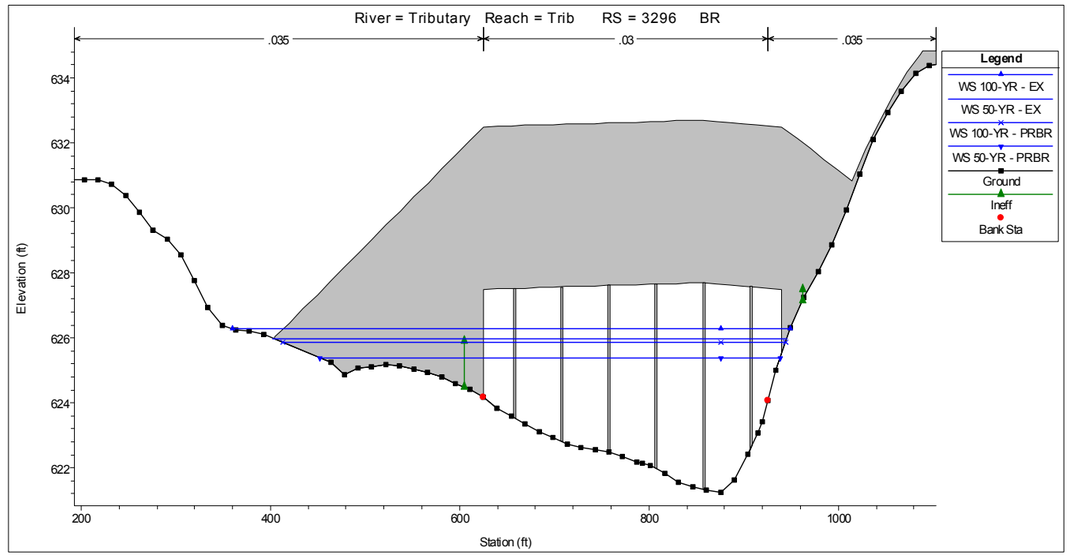
Design Filename: \\pape-dawson\pdfs\projects\5103002\design\Civil\Drainage\5103002hds03.dgn

Plotted on: 7/30/2018
Design Filename: \\pape-dawson\pdfs\projects\5103002\design\Civil\Drainage\5103002rhds04.dgn

HEC-RAS CHANNEL PROFILE



HEC-RAS BRIDGE UPSTREAM



HEC-RAS BRIDGE OUTPUT

Plan: PRBR	Tributary	Trib RS: 3296	Profile: 50-YR		
E.G. US. (ft)	626.02	Element		Inside BR US	Inside BR DS
W.S. US. (ft)	625.60	E.G. Elev (ft)		625.95	625.42
Q Total (cfs)	5021.00	W.S. Elev (ft)		625.38	624.29
Q Bridge (cfs)	5021.00	Crit W.S. (ft)		624.61	624.29
Q Weir (cfs)		Max Chl Dpth (ft)		4.13	5.04
Weir Sta Lft (ft)		Vel Total (ft/s)		6.00	7.94
Weir Sta Rgt (ft)		Flow Area (sq ft)		837.34	632.67
Weir Submerg		Froude # Chl		0.52	0.67
Weir Max Depth (ft)		Specif Force (cu ft)		2238.57	2216.99
Min El Weir Flow (ft)	625.98	Hydr Depth (ft)		2.80	2.38
Min El Prs (ft)	627.70	W.P. Total (ft)		335.09	293.46
Delta EG (ft)	0.78	Conv. Total (cfs)		77412.00	52759.20
Delta WS (ft)	1.41	Top Width (ft)		298.62	266.07
BR Open Area (sq ft)	1501.84	Frctn Loss (ft)		0.36	
BR Open Vel (ft/s)	7.94	C & E Loss (ft)		0.17	
BR Sluice Coef		Shear Total (lb/sq ft		0.66	1.22
BR Sel Method	Energy only	Power Total (lb/ft s		3.94	9.67

Plan: PRBR	Tributary	Trib RS: 3296	Profile: 100-YR		
E.G. US. (ft)	626.60	Element		Inside BR US	Inside BR DS
W.S. US. (ft)	626.23	E.G. Elev (ft)		626.50	625.96
Q Total (cfs)	6260.00	W.S. Elev (ft)		625.85	624.67
Q Bridge (cfs)	6260.00	Crit W.S. (ft)		624.95	624.67
Q Weir (cfs)		Max Chl Dpth (ft)		4.60	5.42
Weir Sta Lft (ft)		Vel Total (ft/s)		6.40	8.52
Weir Sta Rgt (ft)		Flow Area (sq ft)		978.15	735.07
Weir Submerg		Froude # Chl		0.53	0.69
Weir Max Depth (ft)		Specif Force (cu ft)		2976.60	2909.61
Min El Weir Flow (ft)	625.98	Hydr Depth (ft)		3.26	2.71
Min El Prs (ft)	627.70	W.P. Total (ft)		342.96	302.41
Delta EG (ft)	0.86	Conv. Total (cfs)		98459.00	65547.20
Delta WS (ft)	1.70	Top Width (ft)		300.03	270.81
BR Open Area (sq ft)	1501.84	Frctn Loss (ft)		0.35	
BR Open Vel (ft/s)	8.52	C & E Loss (ft)		0.19	
BR Sluice Coef		Shear Total (lb/sq ft		0.72	1.38
BR Sel Method	Energy only	Power Total (lb/ft s		4.61	11.79

NOTES:
1. DATA PRESENTED FROM DRAINAGE SUMMARY FOR KLEIN ROAD PREPARED BY PAPE-DAWSON ENGINEERS. DATED JULY 2018.

2. GUADALUPE TRIBUTARY 22 IS IDENTIFIED ON FEMA FIRM PANEL 48187C0115F. DATED NOVEMBER 2, 2007. THE UPSTREAM/DOWNSTREAM AREA AND EXISTING CROSSING ARE WITHIN A ZONE "A".

HYDRAULIC METHOD

WATER SURFACE ELEVATIONS COMPUTED USING A HEC-RAS (V.5.0.3) MODEL CREATED FOR GUADALUPE TRIBUTARY 22.
FILE NAME: "5103002_KLEINRD.PRJ"

EFFECTIVE AND PROPOSED MODELS WERE DEVELOPED USING LIDAR DATA AND FIELD DATA.

EFFECTIVE CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "EXISTING" NAMED "5103002_KLEINRD.P01".

PROPOSED CONDITION WATER SURFACE ELEVATIONS COMPUTED FROM HEC-RAS MODEL PLAN "PROP BRIDGE" NAMED "5103002_KLEINRD.P02".

HYDROLOGIC METHOD

FLOWS USED FOR MODELS WERE CALCULATED FROM THE SCS HYDROGRAPH METHOD AND INFORMATION FROM THE CITY OF NEW BRAUNFELS - DRAINAGE AND EROSION CONTROL DESIGN MANUAL.

REV. NO.	DATE	DESCRIPTION	BY

PAPE-DAWSON ENGINEERS
SAN ANTONIO | AUSTIN | HOUSTON | FORT WORTH | DALLAS
2000 NW LOOP 410 | SAN ANTONIO, TX 78213 | 210.375.9000
TBPE FIRM REGISTRATION #470 | TBPLS FIRM REGISTRATION #10028800

KLEIN ROAD

PROPOSED BRIDGE HYDRAULIC DATA SHEET

APPENDIX C1

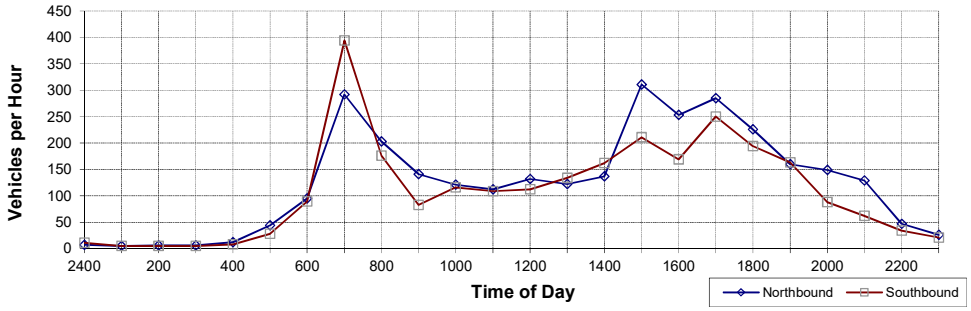
Pape-Dawson Engineers, Inc. **Automatic Traffic Counts**

Average Daily Traffic

Project No. : 51030-01
Station No. :
Counter No. : 1

Location: Klein Rd, N of Walnut Ave
City/State: New Braunfels, TX
Date: May 22, 2018
Day of Week: Tuesday

Site:



Time	Peak	Northbound	TMC	Southbound	TMC	Time	Peak	Northbound	TMC	Southbound	TMC
24:00		1		2		12:00		35		29	
0:15		4		4		12:15		37		27	
0:30		0		2		12:30		22		22	
0:45		2	7	3	11	12:45		38	132	34	112
1:00		4		1		13:00		28		34	
1:15		1		0		13:15		33		23	
1:30		0		0		13:30		28		33	
1:45		0	5	4	5	13:45		33	122	44	134
2:00		3		0		14:00	*	24		29	
2:15		1		2		14:15	*	32		29	
2:30		2		3		14:30	*	30		38	
2:45		0	6	0	5	14:45	*	51	137	66	162
3:00		2		1		15:00		100		59	
3:15		1		1		15:15		47		51	
3:30		3		1		15:30		53		50	
3:45		0	6	2	5	15:45		111	311	51	211
4:00		3		1		16:00		70		62	
4:15		1		3		16:15		66		30	
4:30		2		2		16:30		58		47	
4:45		6	12	2	8	16:45		59	253	30	169
5:00		4		5		17:00		68		47	
5:15		11		3		17:15	*	85		60	
5:30		18		11		17:30	*	56		57	
5:45		11	44	9	28	17:45	*	76	285	86	250
6:00		16		13		18:00	*	60		74	
6:15		20		11		18:15		69		45	
6:30		25		23		18:30		47		39	
6:45		34	95	42	89	18:45		50	226	36	194
7:00		45		57		19:00		48		51	
7:15	*	72		136		19:15		42		42	
7:30	*	110		131		19:30		31		38	
7:45	*	65	292	70	394	19:45		39	160	32	163
8:00	*	75		86		20:00		24		21	
8:15		64		30		20:15		32		21	
8:30		29		29		20:30		32		25	
8:45		35	203	31	176	20:45		61	149	21	88
9:00		37		20		21:00		71		17	
9:15		32		25		21:15		16		16	
9:30		46		18		21:30		23		17	
9:45		26	141	20	83	21:45		19	129	12	62
10:00		19		28		22:00		12		11	
10:15		42		23		22:15		18		10	
10:30		35		36		22:30		8		8	
10:45		25	121	29	116	22:45		9	47	5	34
11:00		26		25		23:00		9		6	
11:15		24		30		23:15		10		5	
11:30		32		27		23:30		2		4	
11:45		30	112	27	109	23:45		5	26	6	21

AM Peak Hour	7:15-8:15	Directional Volumes	3,021	2,629
% of ADT	13.2%		**24-Hour Volume**	5,650
PM Peak Hour	17:15-18:15			
% of ADT	9.8%			

APPENDIX C2

North/South Street:	Klein Rd											
East/West Street:	Walnut Ave /											
TOD:	AM	Date:	22-May-18		Synchro Node:	1	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Walnut Ave					
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
7:00 AM	9	45	0	0	56	8	8	0	13	0	0	0
7:15 AM	25	69	0	0	124	32	13	0	26	0	0	0
7:30 AM	40	86	0	0	83	25	11	0	45	0	0	0
7:45 AM	55	43	0	0	62	22	10	0	48	0	0	0
8:00 AM	48	70	0	0	49	9	4	0	40	0	0	0
8:15 AM	29	46	0	0	12	8	5	0	14	0	0	0
8:30 AM	13	18	0	0	14	13	8	0	8	0	0	0
8:45 AM	8	26	0	0	13	7	9	0	10	0	0	0
Total	227	403	0	0	413	124	68	0	204	0	0	0
Peak Hour	168	268	0	0	318	88	38	0	159	0	0	0

Pedestrians				
	NB	SB	EB	WB
7:00 AM				
7:15 AM				
7:30 AM				
7:45 AM				
8:00 AM				
8:15 AM				
8:30 AM				
8:45 AM				

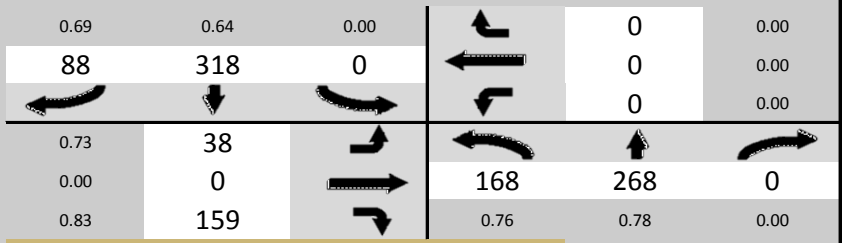


Diagram for: Peak Hour

Peak Hour: 07:15 AM-08:15 AM

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	Walnut Ave /											
TOD:	Midday	Date:	22-May-18		Synchro Node:	1	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Walnut Ave					
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
11:00 AM	15	14	0	0	18	6	8	0	8	0	0	0
11:15 AM	9	14	0	0	16	3	15	0	17	0	0	0
11:30 AM	13	13	0	0	13	12	9	0	16	0	0	0
11:45 AM	17	21	0	0	13	8	10	0	6	0	0	0
12:00 PM	13	22	0	0	19	14	10	0	12	0	0	0
12:15 PM	8	17	0	0	11	11	13	0	8	0	0	0
12:30 PM	9	18	0	0	12	10	4	0	11	0	0	0
12:45 PM	4	25	0	0	26	5	10	0	14	0	0	0
Total	88	144	0	0	128	69	79	0	92	0	0	0
Peak Hour	52	70	0	0	61	37	44	0	51	0	0	0

Pedestrians				
	NB	SB	EB	WB
11:00 AM				
11:15 AM				
11:30 AM				
11:45 AM				
12:00 PM				
12:15 PM				
12:30 PM				
12:45 PM				

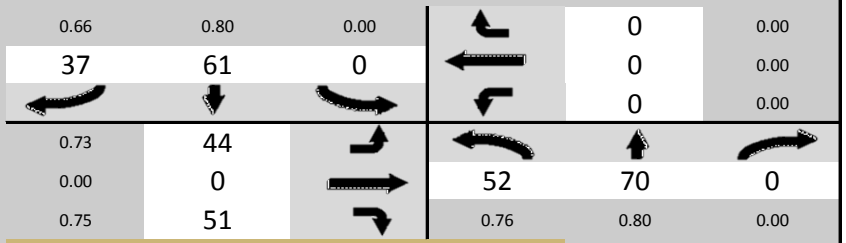


Diagram for:	Peak Hour
Peak Hour:	**11:15 AM-12:15 PM**

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	Walnut Ave /											
TOD:	PM	Date:	22-May-18		Synchro Node:	1	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Walnut Ave					
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
4:00 PM	31	40	0	0	37	16	25	0	28	0	0	0
4:15 PM	19	28	0	0	24	12	26	0	16	0	0	0
4:30 PM	16	26	0	0	23	12	34	0	30	0	0	0
4:45 PM	12	29	0	0	19	13	23	0	16	0	0	0
5:00 PM	15	34	0	0	30	16	41	0	19	0	0	0
5:15 PM	11	32	0	0	35	22	32	0	23	0	0	0
5:30 PM	15	28	0	0	45	22	30	0	27	0	0	0
5:45 PM	13	33	0	0	64	13	35	0	62	0	0	0
Total	132	250	0	0	277	126	246	0	221	0	0	0
Peak Hour	54	127	0	0	174	73	138	0	131	0	0	0

Pedestrians				
	NB	SB	EB	WB
4:00 PM				
4:15 PM				
4:30 PM				
4:45 PM				
5:00 PM				
5:15 PM				
5:30 PM				
5:45 PM				

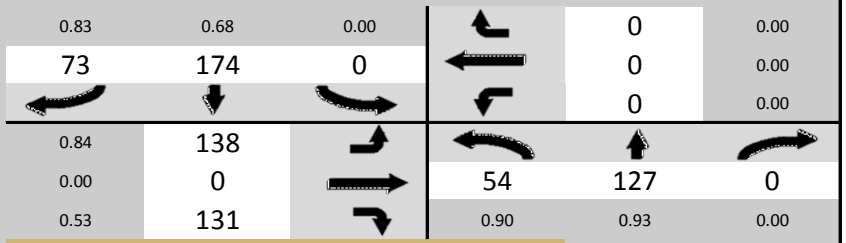


Diagram for:	Peak Hour
Peak Hour:	**05:00 PM-06:00 PM**

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	Roadrunner Ave / Stoeger Dr											
TOD:	AM	Date:	22-May-18		Synchro Node:	2	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Roadrunner Ave			Stoeger Dr		
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
7:00 AM	0	59	0	1	47	0	8	0	2	0	0	10
7:15 AM	1	68	1	0	93	0	9	0	4	3	0	12
7:30 AM	1	104	2	1	99	1	4	0	3	1	0	6
7:45 AM	2	76	0	5	62	2	12	0	5	3	0	4
8:00 AM	3	79	1	3	61	2	8	0	1	0	0	2
8:15 AM	1	76	0	4	25	4	8	0	0	0	0	2
8:30 AM	0	35	0	1	24	3	3	0	1	0	0	6
8:45 AM	0	34	0	3	26	2	7	0	0	0	0	1
Total	8	531	4	18	437	14	59	0	16	7	0	43
Peak Hour	7	327	4	9	315	5	33	0	13	7	0	24

Pedestrians				
	NB	SB	EB	WB
7:00 AM				
7:15 AM				
7:30 AM				
7:45 AM				
8:00 AM				
8:15 AM				
8:30 AM				
8:45 AM				

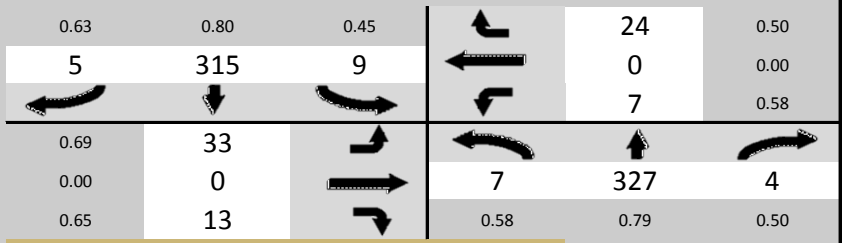


Diagram for: Peak Hour

Peak Hour: 07:15 AM-08:15 AM

PAPE-DAWSON ENGINEERS

North/South Street:	**Klein Rd**											
East/West Street:	**Roadrunner Ave / Stoeger Dr**											
TOD:	**Midday**	Date:	22-May-18		Synchro Node:	2	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Roadrunner Ave			Stoeger Dr		
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
11:00 AM	0	33	0	2	19	0	4	0	0	0	0	2
11:15 AM	0	24	1	0	18	1	3	0	0	0	0	1
11:30 AM	0	29	0	2	23	4	2	0	1	2	0	6
11:45 AM	1	28	1	1	28	1	3	0	0	0	0	2
12:00 PM	2	25	0	2	30	1	3	1	0	0	0	3
12:15 PM	1	29	1	2	26	3	1	0	1	0	0	6
12:30 PM	0	21	0	3	17	0	5	0	1	0	0	3
12:45 PM	0	42	1	1	29	2	2	0	0	1	1	2
Total	4	231	4	13	190	12	23	1	3	3	1	25
Peak Hour	4	111	2	7	107	9	9	1	2	2	0	17

Pedestrians				
	NB	SB	EB	WB
11:00 AM				
11:15 AM				
11:30 AM				
11:45 AM				
12:00 PM				
12:15 PM				
12:30 PM				
12:45 PM				

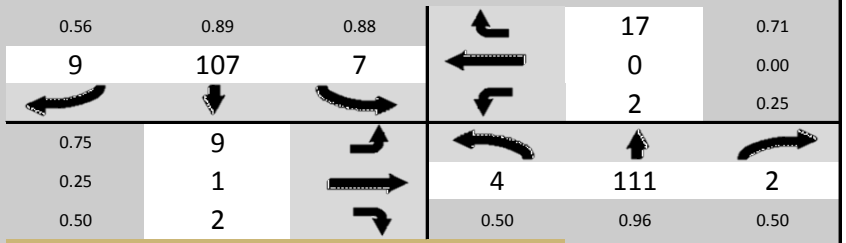


Diagram for: Peak Hour

Peak Hour: 11:30 AM-12:30 PM

PAPE-DAWSON ENGINEERS

North/South Street:	**Klein Rd**											
East/West Street:	**Roadrunner Ave / Stoeger Dr**											
TOD:	**PM**	Date:	22-May-18		Synchro Node:	2	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Roadrunner Ave			Stoeger Dr		
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
4:00 PM	0	67	2	3	47	6	6	0	1	2	0	4
4:15 PM	5	61	0	5	40	6	5	0	0	1	0	1
4:30 PM	1	45	0	7	45	6	7	0	2	1	0	4
4:45 PM	1	47	0	6	40	6	5	0	1	0	0	2
5:00 PM	3	55	1	4	50	8	2	0	0	0	2	1
5:15 PM	4	61	0	6	68	3	3	0	1	0	0	2
5:30 PM	1	48	1	7	59	14	2	0	0	0	0	1
5:45 PM	1	55	1	5	92	11	4	0	7	0	0	3
Total	16	439	5	43	441	60	34	0	12	4	2	18
Peak Hour	9	219	3	22	269	36	11	0	8	0	2	7

Pedestrians				
	NB	SB	EB	WB
4:00 PM				
4:15 PM				
4:30 PM				
4:45 PM				
5:00 PM				
5:15 PM				
5:30 PM				
5:45 PM				

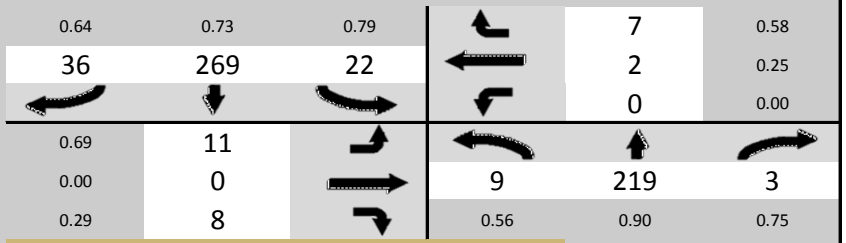


Diagram for: Peak Hour

Peak Hour: 05:00 PM-06:00 PM

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	Dove Crossing Dr /											
TOD:	AM	Date:	22-May-18		Synchro Node:	3	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Dove Crossing Dr					
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
7:00 AM	3	76	0	0	49	4	11	0	3	0	0	0
7:15 AM	3	93	0	0	84	4	13	0	10	0	0	0
7:30 AM	5	108	0	0	83	3	16	0	16	0	0	0
7:45 AM	11	76	0	0	55	9	10	0	15	0	0	0
8:00 AM	10	72	0	0	47	3	17	0	13	0	0	0
8:15 AM	15	72	0	0	27	3	10	0	3	0	0	0
8:30 AM	4	37	0	0	30	6	7	0	2	0	0	0
8:45 AM	2	40	0	0	24	7	3	0	4	0	0	0
Total	53	574	0	0	399	39	87	0	66	0	0	0
Peak Hour	29	349	0	0	269	19	56	0	54	0	0	0

Pedestrians				
	NB	SB	EB	WB
7:00 AM				
7:15 AM				
7:30 AM				
7:45 AM				
8:00 AM				
8:15 AM				
8:30 AM				
8:45 AM				

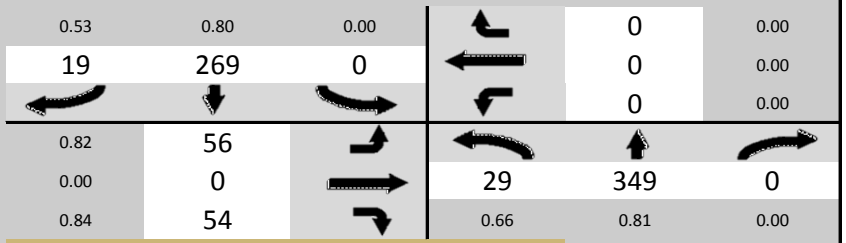


Diagram for: Peak Hour

Peak Hour: 07:15 AM-08:15 AM

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	Dove Crossing Dr /											
TOD:	Midday	Date:	22-May-18		Synchro Node:	3	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Dove Crossing Dr					
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
11:00 AM	3	34	0	0	25	2	6	0	0	0	0	0
11:15 AM	0	29	0	0	17	2	2	0	2	0	0	0
11:30 AM	0	38	0	0	30	5	5	0	0	0	0	0
11:45 AM	0	32	0	0	25	6	6	0	1	0	0	0
12:00 PM	1	33	0	0	34	4	5	0	1	0	0	0
12:15 PM	1	38	0	0	29	6	3	0	1	0	0	0
12:30 PM	0	30	0	0	22	3	14	0	0	0	0	0
12:45 PM	3	42	0	0	28	13	4	0	2	0	0	0
Total	8	276	0	0	210	41	45	0	7	0	0	0
Peak Hour	5	143	0	0	113	26	26	0	4	0	0	0

Pedestrians				
	NB	SB	EB	WB
11:00 AM				
11:15 AM				
11:30 AM				
11:45 AM				
12:00 PM				
12:15 PM				
12:30 PM				
12:45 PM				

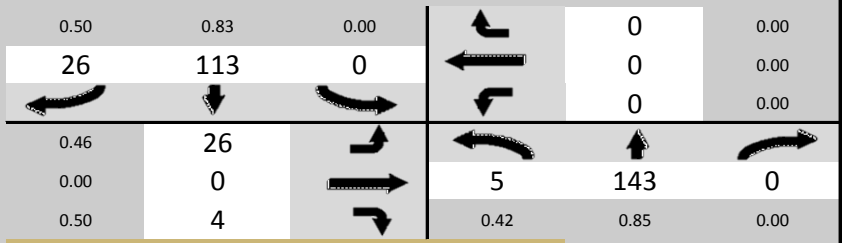


Diagram for:	Peak Hour
Peak Hour:	**12:00 PM-01:00 PM**

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	Dove Crossing Dr /											
TOD:	PM	Date:	22-May-18		Synchro Node:	3	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			Dove Crossing Dr					
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
4:00 PM	5	64	0	0	55	3	5	0	2	0	0	0
4:15 PM	6	57	0	0	54	9	4	0	6	0	0	0
4:30 PM	4	51	0	0	46	13	15	0	7	0	0	0
4:45 PM	5	54	0	0	50	16	10	0	4	0	0	0
5:00 PM	4	56	0	0	56	12	12	0	4	0	0	0
5:15 PM	4	59	0	0	73	18	7	0	8	0	0	0
5:30 PM	2	49	0	0	76	16	12	0	9	0	0	0
5:45 PM	4	54	0	0	91	27	11	0	12	0	0	0
Total	34	444	0	0	501	114	76	0	52	0	0	0
Peak Hour	14	218	0	0	296	73	42	0	33	0	0	0

Pedestrians				
	NB	SB	EB	WB
4:00 PM				
4:15 PM				
4:30 PM				
4:45 PM				
5:00 PM				
5:15 PM				
5:30 PM				
5:45 PM				

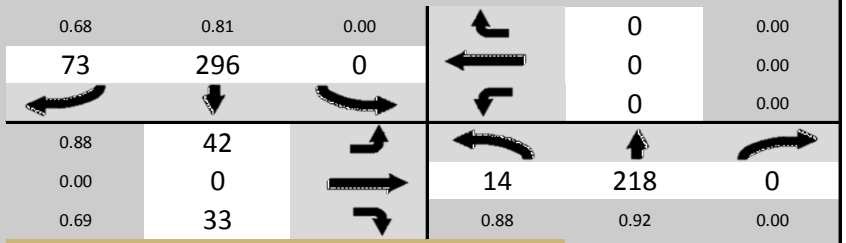


Diagram for:	Peak Hour
Peak Hour:	**05:00 PM-06:00 PM**

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	FM 725											
TOD:	AM	Date:	22-May-18		Synchro Node:	4	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit				
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			FM 725			FM 725		
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
7:00 AM	53	0	32	0	1	3	1	65	20	45	158	0
7:15 AM	59	1	54	0	1	3	0	67	23	67	181	0
7:30 AM	63	0	43	1	0	2	1	81	29	32	201	1
7:45 AM	53	0	32	0	0	3	1	82	33	33	161	1
8:00 AM	55	1	26	0	1	0	0	67	29	11	105	0
8:15 AM	60	0	17	0	0	3	0	71	13	5	157	1
8:30 AM	30	0	13	0	0	1	1	78	16	17	122	0
8:45 AM	20	0	4	1	0	1	1	75	20	9	137	0
Total	393	2	221	2	3	16	5	586	183	219	1222	3
Peak Hour	228	1	161	1	2	11	3	295	105	177	701	2

Pedestrians				
	NB	SB	EB	WB
7:00 AM				
7:15 AM				
7:30 AM				
7:45 AM				
8:00 AM				
8:15 AM				
8:30 AM				
8:45 AM				

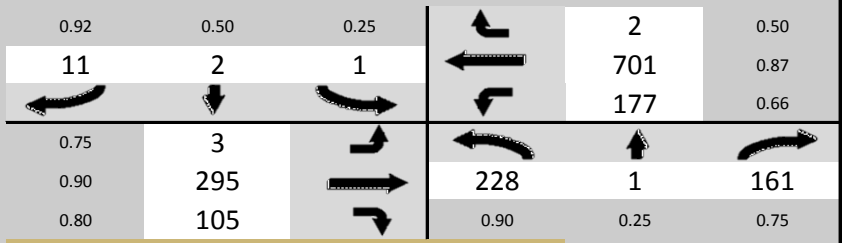


Diagram for: Peak Hour

Peak Hour: 07:00 AM-08:00 AM

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	FM 725											
TOD:	Midday	Date:	22-May-18		Synchro Node:		4	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit			
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			FM 725			FM 725		
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
11:00 AM	27	1	11	0	0	0	4	83	13	6	113	2
11:15 AM	22	0	9	0	0	4	1	88	17	8	116	0
11:30 AM	26	1	11	2	1	0	0	106	19	6	100	0
11:45 AM	24	0	11	1	0	2	1	114	25	9	87	1
12:00 PM	28	0	9	0	0	0	1	108	26	8	98	1
12:15 PM	31	1	12	0	0	2	2	97	23	10	99	1
12:30 PM	33	0	12	0	0	1	2	97	26	6	121	0
12:45 PM	28	0	13	1	0	2	4	113	30	6	111	1
Total	219	3	88	4	1	11	15	806	179	59	845	6
Peak Hour	120	1	46	1	0	5	9	415	105	30	429	3

Pedestrians				
	NB	SB	EB	WB
11:00 AM				
11:15 AM				
11:30 AM				
11:45 AM				
12:00 PM				
12:15 PM				
12:30 PM				
12:45 PM				

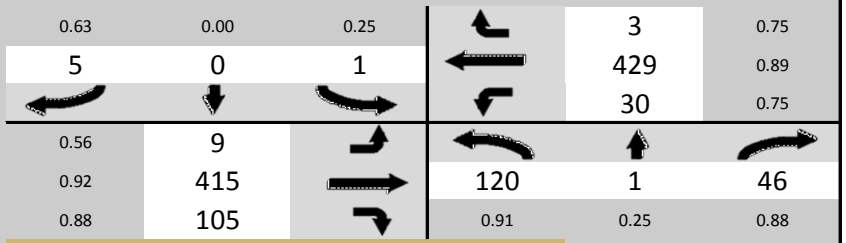


Diagram for: Peak Hour

Peak Hour: 12:00 PM-01:00 PM

PAPE-DAWSON ENGINEERS

North/South Street:	Klein Rd											
East/West Street:	FM 725											
TOD:	PM	Date:	22-May-18		Synchro Node:		4	Raw Data:	H:\projects\510\30\01\Traffic\Data\RAW\Sit			
	Northbound			Southbound			Eastbound			Westbound		
	Klein Rd			Klein Rd			FM 725			FM 725		
Time	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right
4:00 PM	46	0	22	0	0	1	2	144	26	15	132	0
4:15 PM	34	0	18	0	0	0	4	150	43	15	130	0
4:30 PM	34	2	33	0	1	1	2	179	37	21	129	0
4:45 PM	22	0	21	0	0	0	0	178	46	16	114	1
5:00 PM	39	2	32	2	0	3	4	162	41	32	153	1
5:15 PM	24	1	28	1	0	2	6	195	55	33	162	2
5:30 PM	28	0	33	0	1	1	3	158	54	42	147	1
5:45 PM	33	1	29	0	0	0	1	163	54	41	141	0
Total	260	6	216	3	2	8	22	1329	356	215	1108	5
Peak Hour	124	4	122	3	1	6	14	678	204	148	603	4

Pedestrians				
	NB	SB	EB	WB
4:00 PM				
4:15 PM				
4:30 PM				
4:45 PM				
5:00 PM				
5:15 PM				
5:30 PM				
5:45 PM				

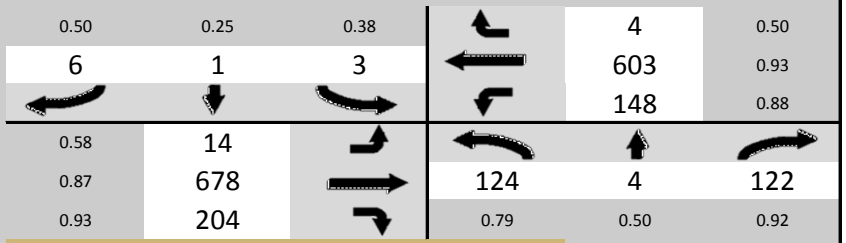
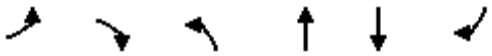


Diagram for: Peak Hour

Peak Hour: 05:00 PM-06:00 PM

PAPE-DAWSON ENGINEERS

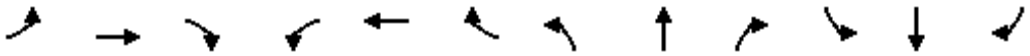
APPENDIX C3



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	38	159	168	268	318	88
Future Volume (Veh/h)	38	159	168	268	318	88
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.73	0.83	0.76	0.78	0.64	0.69
Hourly flow rate (vph)	52	192	221	344	497	128
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1347	561	625			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1347	561	625			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	59	63	77			
cM capacity (veh/h)	127	525	947			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1
Volume Total	52	192	221	344	625
Volume Left	52	0	221	0	0
Volume Right	0	192	0	0	128
cSH	127	525	947	1700	1700
Volume to Capacity	0.41	0.37	0.23	0.20	0.37
Queue Length 95th (ft)	44	42	23	0	0
Control Delay (s)	51.7	15.8	10.0	0.0	0.0
Lane LOS	F	C	A		
Approach Delay (s)	23.4		3.9		0.0
Approach LOS	C				

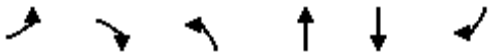
Intersection Summary			
Average Delay	5.5		
Intersection Capacity Utilization	44.7%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	33	0	13	7	0	24	7	327	4	9	315	5
Future Volume (Veh/h)	33	0	13	7	0	24	7	327	4	9	315	5
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.69	1.00	0.65	0.58	1.00	0.50	0.58	0.79	0.50	0.45	0.80	0.63
Hourly flow rate (vph)	48	0	20	12	0	48	12	414	8	20	394	8
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	928	884	398	900	884	418	402			422		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	928	884	398	900	884	418	402			422		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	79	100	97	95	100	92	99			98		
cM capacity (veh/h)	225	276	652	246	276	635	1157			1137		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	68	60	434	422
Volume Left	48	12	12	20
Volume Right	20	48	8	8
cSH	278	483	1157	1137
Volume to Capacity	0.24	0.12	0.01	0.02
Queue Length 95th (ft)	23	11	1	1
Control Delay (s)	22.1	13.5	0.3	0.6
Lane LOS	C	B	A	A
Approach Delay (s)	22.1	13.5	0.3	0.6
Approach LOS	C	B		

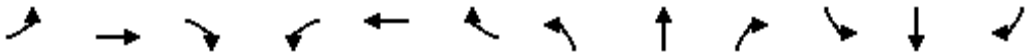
Intersection Summary				
Average Delay	2.7			
Intersection Capacity Utilization	34.9%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	56	54	29	349	269	19
Future Volume (Veh/h)	56	54	29	349	269	19
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.82	0.84	0.66	0.81	0.80	0.53
Hourly flow rate (vph)	68	64	44	431	336	36
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		6				
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	873	354	372			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	873	354	372			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	78	91	96			
cM capacity (veh/h)	309	690	1186			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	132	475	372
Volume Left	68	44	0
Volume Right	64	0	36
cSH	599	1186	1700
Volume to Capacity	0.22	0.04	0.22
Queue Length 95th (ft)	21	3	0
Control Delay (s)	15.5	1.1	0.0
Lane LOS	C	A	
Approach Delay (s)	15.5	1.1	0.0
Approach LOS	C		

Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	48.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	2	297	114	143	648	2	230	2	155	1	2	8
Future Volume (vph)	2	297	114	143	648	2	230	2	155	1	2	8
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.89	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1776	1482	1719	1775		1752	1573		1770	1653	
Flt Permitted	0.28	1.00	1.00	0.43	1.00		0.75	1.00		0.47	1.00	
Satd. Flow (perm)	514	1776	1482	770	1775		1378	1573		880	1653	
Peak-hour factor, PHF	0.50	0.91	0.86	0.53	0.81	0.50	0.91	0.50	0.72	0.25	0.50	0.67
Adj. Flow (vph)	4	326	133	270	800	4	253	4	215	4	4	12
RTOR Reduction (vph)	0	0	69	0	0	0	0	169	0	0	9	0
Lane Group Flow (vph)	4	326	64	270	804	0	253	50	0	4	7	0
Heavy Vehicles (%)	2%	7%	9%	5%	7%	2%	3%	2%	3%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2		2	6			8	8		4	4	
Actuated Green, G (s)	44.1	43.6	43.6	50.9	50.9		19.2	19.2		19.2	19.2	
Effective Green, g (s)	44.1	43.6	43.6	50.9	50.9		19.2	19.2		19.2	19.2	
Actuated g/C Ratio	0.49	0.48	0.48	0.57	0.57		0.21	0.21		0.21	0.21	
Clearance Time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	304	860	717	552	1003		293	335		187	352	
v/s Ratio Prot	0.00	c0.18		0.06	c0.45			0.03			0.00	
v/s Ratio Perm	0.01		0.04	0.22			c0.18			0.00		
v/c Ratio	0.01	0.38	0.09	0.49	0.80		0.86	0.15		0.02	0.02	
Uniform Delay, d1	17.2	14.7	12.5	10.8	15.5		34.1	28.8		28.0	28.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	1.3	0.2	0.7	6.7		22.2	0.2		0.0	0.0	
Delay (s)	17.2	15.9	12.8	11.5	22.3		56.3	29.0		28.0	28.0	
Level of Service	B	B	B	B	C		E	C		C	C	
Approach Delay (s)		15.0			19.6			43.6			28.0	
Approach LOS		B			B			D			C	

Intersection Summary			
HCM 2000 Control Delay	24.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	16.1
Intersection Capacity Utilization	70.4%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Klein & Walnut

Movement	EB	EB	NB
Directions Served	L	R	L
Maximum Queue (ft)	50	68	160
Average Queue (ft)	23	42	38
95th Queue (ft)	45	63	81
Link Distance (ft)	336	336	
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			260
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	56	31	29	50
Average Queue (ft)	24	14	1	5
95th Queue (ft)	49	38	10	28
Link Distance (ft)	532	456	2995	665
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Klein & Dove Crossing

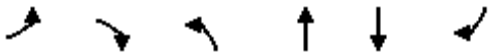
Movement	EB	EB	NB
Directions Served	L	R	LT
Maximum Queue (ft)	71	68	77
Average Queue (ft)	31	30	7
95th Queue (ft)	54	56	34
Link Distance (ft)	556		665
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)		150	
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 10: Klein & FM 725/FM725

Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	T	R	L	TR	L	TR	TR
Maximum Queue (ft)	162	72	95	407	224	289	51
Average Queue (ft)	72	25	58	139	142	58	8
95th Queue (ft)	143	55	96	308	231	145	32
Link Distance (ft)	508			545		1243	403
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)		150	70		200		
Storage Blk Time (%)	2		4	14	4		
Queuing Penalty (veh)	2		26	20	7		

Network Summary

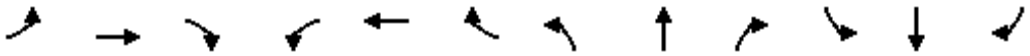
Network wide Queuing Penalty: 54



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	37	45	34	82	68	40
Future Volume (Veh/h)	37	45	34	82	68	40
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.71	0.80	0.65	0.82	0.65	0.71
Hourly flow rate (vph)	52	56	52	100	105	56
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	337	133	161			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	337	133	161			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	92	94	96			
cM capacity (veh/h)	630	911	1412			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1
Volume Total	52	56	52	100	161
Volume Left	52	0	52	0	0
Volume Right	0	56	0	0	56
cSH	630	911	1412	1700	1700
Volume to Capacity	0.08	0.06	0.04	0.06	0.09
Queue Length 95th (ft)	7	5	3	0	0
Control Delay (s)	11.2	9.2	7.6	0.0	0.0
Lane LOS	B	A	A		
Approach Delay (s)	10.2		2.6		0.0
Approach LOS	B				

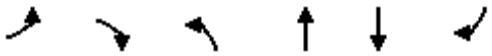
Intersection Summary			
Average Delay	3.6		
Intersection Capacity Utilization	18.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	11	1	2	1	1	14	3	117	2	8	102	6
Future Volume (Veh/h)	11	1	2	1	1	14	3	117	2	8	102	6
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.55	0.25	0.50	0.25	0.25	0.58	0.38	0.70	0.50	0.67	0.85	0.50
Hourly flow rate (vph)	20	4	4	4	4	24	8	167	4	12	120	12
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	361	337	126	341	341	169	132			171		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	361	337	126	341	341	169	132			171		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	96	99	100	99	99	97	99			99		
cM capacity (veh/h)	569	576	924	601	573	875	1453			1406		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	28	32	179	144
Volume Left	20	4	8	12
Volume Right	4	24	4	12
cSH	603	779	1453	1406
Volume to Capacity	0.05	0.04	0.01	0.01
Queue Length 95th (ft)	4	3	0	1
Control Delay (s)	11.3	9.8	0.4	0.7
Lane LOS	B	A	A	A
Approach Delay (s)	11.3	9.8	0.4	0.7
Approach LOS	B	A		

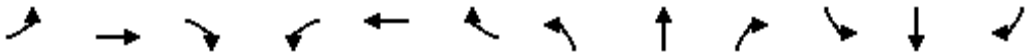
Intersection Summary				
Average Delay	2.1			
Intersection Capacity Utilization	21.3%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	26	4	5	143	113	26
Future Volume (Veh/h)	26	4	5	143	113	26
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.46	0.50	0.42	0.85	0.83	0.50
Hourly flow rate (vph)	57	8	12	168	136	52
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		6				
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	354	162	188			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	354	162	188			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	91	99	99			
cM capacity (veh/h)	638	883	1386			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	65	180	188
Volume Left	57	12	0
Volume Right	8	0	52
cSH	728	1386	1700
Volume to Capacity	0.09	0.01	0.11
Queue Length 95th (ft)	7	1	0
Control Delay (s)	10.9	0.6	0.0
Lane LOS	B	A	
Approach Delay (s)	10.9	0.6	0.0
Approach LOS	B		

Intersection Summary			
Average Delay	1.9		
Intersection Capacity Utilization	21.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	9	415	105	30	429	3	120	1	46	1	0	5
Future Volume (vph)	9	415	105	30	429	3	120	1	46	1	0	5
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.86		1.00	0.85	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1687	1792	1524	1671	1758		1703	1589		1770	1583	
Flt Permitted	0.43	1.00	1.00	0.41	1.00		0.75	1.00		0.72	1.00	
Satd. Flow (perm)	759	1792	1524	727	1758		1349	1589		1342	1583	
Peak-hour factor, PHF	0.56	0.92	0.88	0.75	0.89	0.75	0.91	0.25	0.88	0.25	1.00	0.63
Adj. Flow (vph)	16	451	119	40	482	4	132	4	52	4	0	8
RTOR Reduction (vph)	0	0	62	0	1	0	0	43	0	0	7	0
Lane Group Flow (vph)	16	451	57	40	485	0	132	13	0	4	1	0
Heavy Vehicles (%)	7%	6%	6%	8%	8%	2%	6%	2%	3%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2		2	6			8	8		4	4	
Actuated Green, G (s)	26.3	25.4	25.4	28.5	26.5		9.7	9.7		9.7	9.7	
Effective Green, g (s)	26.3	25.4	25.4	28.5	26.5		9.7	9.7		9.7	9.7	
Actuated g/C Ratio	0.49	0.48	0.48	0.54	0.50		0.18	0.18		0.18	0.18	
Clearance Time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	390	855	727	424	875		245	289		244	288	
v/s Ratio Prot	0.00	0.25		c0.00	c0.28			0.01			0.00	
v/s Ratio Perm	0.02		0.04	0.05			c0.10			0.00		
v/c Ratio	0.04	0.53	0.08	0.09	0.55		0.54	0.05		0.02	0.01	
Uniform Delay, d1	7.0	9.7	7.5	6.1	9.3		19.7	17.9		17.8	17.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.6	0.0	0.1	0.8		2.3	0.1		0.0	0.0	
Delay (s)	7.0	10.3	7.6	6.2	10.0		22.0	18.0		17.9	17.8	
Level of Service	A	B	A	A	B		C	B		B	B	
Approach Delay (s)		9.7			9.7			20.8			17.8	
Approach LOS		A			A			C			B	

Intersection Summary			
HCM 2000 Control Delay	11.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	53.2	Sum of lost time (s)	16.1
Intersection Capacity Utilization	47.3%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Klein & Walnut

Movement	EB	EB	NB
Directions Served	L	R	L
Maximum Queue (ft)	31	77	31
Average Queue (ft)	24	29	4
95th Queue (ft)	43	59	21
Link Distance (ft)	336	336	
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			260
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB
Directions Served	LTR	LTR
Maximum Queue (ft)	54	31
Average Queue (ft)	15	11
95th Queue (ft)	42	35
Link Distance (ft)	532	456
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 8: Klein & Dove Crossing

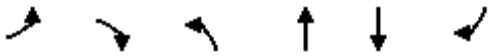
Movement	EB	EB
Directions Served	L	R
Maximum Queue (ft)	49	31
Average Queue (ft)	21	5
95th Queue (ft)	45	23
Link Distance (ft)	608	
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		150
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 10: Klein & FM 725/FM725

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	TR	L	TR	L	TR
Maximum Queue (ft)	30	242	174	48	135	152	69	28	30
Average Queue (ft)	5	76	23	16	59	57	24	1	6
95th Queue (ft)	21	174	74	40	116	117	51	9	25
Link Distance (ft)		381			374		1243		403
Upstream Blk Time (%)									
Queuing Penalty (veh)									
Storage Bay Dist (ft)	120		150	70		200		120	
Storage Blk Time (%)		2	0		4				
Queuing Penalty (veh)		2	0		1				

Network Summary

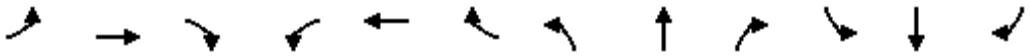
Network wide Queuing Penalty: 3



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	138	131	54	127	174	73
Future Volume (Veh/h)	138	131	54	127	174	73
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.84	0.53	0.90	0.93	0.68	0.83
Hourly flow rate (vph)	164	247	60	137	256	88
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	557	300	344			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	557	300	344			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	65	67	95			
cM capacity (veh/h)	467	740	1215			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1
Volume Total	164	247	60	137	344
Volume Left	164	0	60	0	0
Volume Right	0	247	0	0	88
cSH	467	740	1215	1700	1700
Volume to Capacity	0.35	0.33	0.05	0.08	0.20
Queue Length 95th (ft)	39	37	4	0	0
Control Delay (s)	16.8	12.3	8.1	0.0	0.0
Lane LOS	C	B	A		
Approach Delay (s)	14.1		2.5		0.0
Approach LOS	B				

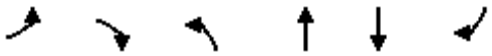
Intersection Summary			
Average Delay	6.6		
Intersection Capacity Utilization	34.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	11	0	8	0	2	7	9	219	3	22	269	36
Future Volume (Veh/h)	11	0	8	0	2	7	9	219	3	22	269	36
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.69	1.00	0.29	1.00	0.25	0.58	0.56	0.90	0.75	0.79	0.73	0.64
Hourly flow rate (vph)	16	0	28	0	8	12	16	243	4	28	368	56
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	745	731	396	757	757	245	424			247		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	745	731	396	757	757	245	424			247		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.2			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.3			2.2		
p0 queue free %	95	100	96	100	98	98	99			98		
cM capacity (veh/h)	310	336	653	302	325	794	1114			1319		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	44	20	263	452
Volume Left	16	0	16	28
Volume Right	28	12	4	56
cSH	466	503	1114	1319
Volume to Capacity	0.09	0.04	0.01	0.02
Queue Length 95th (ft)	8	3	1	2
Control Delay (s)	13.5	12.4	0.6	0.7
Lane LOS	B	B	A	A
Approach Delay (s)	13.5	12.4	0.6	0.7
Approach LOS	B	B		

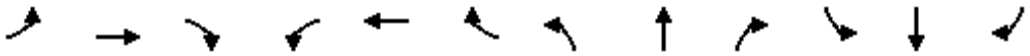
Intersection Summary				
Average Delay	1.7			
Intersection Capacity Utilization	39.6%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	42	33	14	218	296	73
Future Volume (Veh/h)	42	33	14	218	296	73
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.88	0.69	0.88	0.92	0.81	0.68
Hourly flow rate (vph)	48	48	16	237	365	107
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		6				
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	688	418	472			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	688	418	472			
tC, single (s)	6.4	6.3	4.2			
tC, 2 stage (s)						
tF (s)	3.5	3.4	2.3			
p0 queue free %	88	92	98			
cM capacity (veh/h)	406	626	1054			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	96	253	472
Volume Left	48	16	0
Volume Right	48	0	107
cSH	812	1054	1700
Volume to Capacity	0.12	0.02	0.28
Queue Length 95th (ft)	10	1	0
Control Delay (s)	13.1	0.7	0.0
Lane LOS	B	A	
Approach Delay (s)	13.1	0.7	0.0
Approach LOS	B		

Intersection Summary			
Average Delay	1.7		
Intersection Capacity Utilization	33.0%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	14	678	204	148	603	4	124	4	122	3	1	6
Future Volume (vph)	14	678	204	148	603	4	124	4	122	3	1	6
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.86		1.00	0.89	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1736	1810	1583	1736	1824		1770	1570		1770	1653	
Flt Permitted	0.41	1.00	1.00	0.11	1.00		0.75	1.00		0.62	1.00	
Satd. Flow (perm)	753	1810	1583	205	1824		1392	1570		1148	1653	
Peak-hour factor, PHF	0.58	0.87	0.93	0.88	0.93	0.50	0.79	0.50	0.92	0.38	0.25	0.50
Adj. Flow (vph)	24	779	219	168	648	8	157	8	133	8	4	12
RTOR Reduction (vph)	0	0	58	0	0	0	0	111	0	0	10	0
Lane Group Flow (vph)	24	779	161	168	656	0	157	30	0	8	6	0
Heavy Vehicles (%)	4%	5%	2%	4%	4%	2%	2%	2%	4%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2		2	6			8	8		4	4	
Actuated Green, G (s)	49.6	49.1	49.1	53.6	53.6		15.2	15.2		15.2	15.2	
Effective Green, g (s)	49.6	49.1	49.1	53.6	53.6		15.2	15.2		15.2	15.2	
Actuated g/C Ratio	0.55	0.55	0.55	0.60	0.60		0.17	0.17		0.17	0.17	
Clearance Time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	470	987	863	285	1086		235	265		193	279	
v/s Ratio Prot	0.00	c0.43		0.06	c0.36			0.02			0.00	
v/s Ratio Perm	0.03		0.10	0.29			c0.11			0.01		
v/c Ratio	0.05	0.79	0.19	0.59	0.60		0.67	0.11		0.04	0.02	
Uniform Delay, d1	9.5	16.3	10.3	15.1	11.5		35.0	31.7		31.3	31.2	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	6.4	0.5	3.1	2.5		7.0	0.2		0.1	0.0	
Delay (s)	9.6	22.7	10.8	18.2	14.0		42.0	31.9		31.4	31.2	
Level of Service	A	C	B	B	B		D	C		C	C	
Approach Delay (s)		19.9			14.8			37.2			31.3	
Approach LOS		B			B			D			C	

Intersection Summary			
HCM 2000 Control Delay	20.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.76		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	16.1
Intersection Capacity Utilization	70.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Klein & Walnut

Movement	EB	EB	NB
Directions Served	L	R	L
Maximum Queue (ft)	74	94	53
Average Queue (ft)	44	36	8
95th Queue (ft)	67	58	32
Link Distance (ft)	336	336	
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			260
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	31	31	27	70
Average Queue (ft)	14	9	1	3
95th Queue (ft)	39	32	9	25
Link Distance (ft)	532	456	2995	664
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Klein & Dove Crossing

Movement	EB	EB	NB	SB
Directions Served	L	R	LT	TR
Maximum Queue (ft)	76	31	55	22
Average Queue (ft)	19	23	10	1
95th Queue (ft)	50	44	42	7
Link Distance (ft)	608		664	1243
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)		150		
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 10: Klein & FM 725/FM725

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	TR	L	TR	L	TR
Maximum Queue (ft)	51	415	175	95	389	198	112	29	31
Average Queue (ft)	8	194	96	66	130	90	50	2	7
95th Queue (ft)	31	374	204	106	289	157	92	11	27
Link Distance (ft)		381			374		1243		403
Upstream Blk Time (%)		4			1				
Queuing Penalty (veh)		0			0				
Storage Bay Dist (ft)	120		150	70		200		120	
Storage Blk Time (%)		15	0	10	10	1			
Queuing Penalty (veh)		32	0	62	15	1			

Network Summary

Network wide Queuing Penalty: 111

APPENDIX C4

Plotted on: 7/31/2018

N

NTS

WALNUT AVENUE
ANNUAL GROWTH = 5%
GROWTH FACTOR = 2.93

ROADRUNNER AVENUE
ANNUAL GROWTH = 2%
GROWTH FACTOR = 1.55

DOVE CROSSING DRIVE
ANNUAL GROWTH = 2%
GROWTH FACTOR = 1.55

KLEIN ROAD
ANNUAL GROWTH = 5%
GROWTH FACTOR = 2.93

STOEGER DRIVE
ANNUAL GROWTH = 5%
GROWTH FACTOR = 2.93

FM 725
ANNUAL GROWTH = 5%
GROWTH FACTOR = 2.93

Design Filename: P:\112\01\02\design\Civil\Working\Klein Growth.dgn

PAPE-DAWSON ENGINEERS
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2000 NW LOOP 410 | SAN ANTONIO, TX 78213 | 210.375.9000
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Texas Department of Transportation
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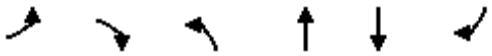
KLEIN ROAD
GROWTH RATE SUMMARY

WALNUT AVE TO FM 725

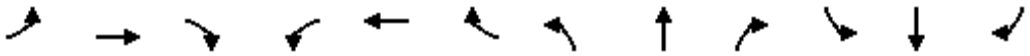
APPENDIX C5



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	119	465	491	785	930	281
Future Volume (Veh/h)	119	465	491	785	930	281
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.73	0.83	0.76	0.78	0.64	0.68
Hourly flow rate (vph)	163	560	646	1006	1453	413
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	3958	1660	1866			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	3958	1660	1866			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	0	0	0			
cM capacity (veh/h)	0	120	318			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1
Volume Total	163	560	646	1006	1866
Volume Left	163	0	646	0	0
Volume Right	0	560	0	0	413
cSH	0	120	318	1700	1700
Volume to Capacity	Err	4.68	2.03	0.59	1.10
Queue Length 95th (ft)	Err	Err	1156	0	0
Control Delay (s)	Err	Err	501.6	0.0	0.0
Lane LOS	F	F	F		
Approach Delay (s)	Err		196.2		0.0
Approach LOS	F				

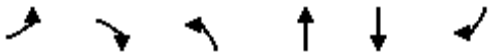
Intersection Summary			
Average Delay	Err		
Intersection Capacity Utilization	109.8%	ICU Level of Service	H
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	51	0	21	21	0	71	12	993	12	27	933	8
Future Volume (Veh/h)	51	0	21	21	0	71	12	993	12	27	933	8
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.67	1.00	0.66	0.58	1.00	0.51	0.60	0.79	0.50	0.45	0.79	0.67
Hourly flow rate (vph)	76	0	32	36	0	139	20	1257	24	60	1181	12
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	2755	2628	1187	2648	2622	1269	1193			1281		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	2755	2628	1187	2648	2622	1269	1193			1281		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	0	100	86	0	100	32	97			89		
cM capacity (veh/h)	4	20	230	12	21	205	585			542		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	108	175	1301	1253
Volume Left	76	36	20	60
Volume Right	32	139	24	12
cSH	5	47	585	542
Volume to Capacity	20.87	3.76	0.03	0.11
Queue Length 95th (ft)	Err	Err	3	9
Control Delay (s)	Err	Err	1.7	5.0
Lane LOS	F	F	A	A
Approach Delay (s)	Err	Err	1.7	5.0
Approach LOS	F	F		

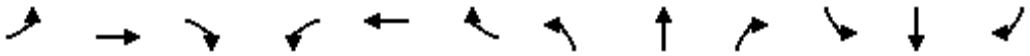
Intersection Summary				
Average Delay	1000.4			
Intersection Capacity Utilization	83.0%	ICU Level of Service	E	
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	86	83	45	1021	787	30
Future Volume (Veh/h)	86	83	45	1021	787	30
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.83	0.83	0.66	0.81	0.80	0.54
Hourly flow rate (vph)	104	100	68	1260	984	56
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		6				
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	2408	1012	1040			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2408	1012	1040			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	0	66	90			
cM capacity (veh/h)	33	290	669			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	204	1328	1040
Volume Left	104	68	0
Volume Right	100	0	56
cSH	59	669	1700
Volume to Capacity	3.47	0.10	0.61
Queue Length 95th (ft)	Err	8	0
Control Delay (s)	Err	4.7	0.0
Lane LOS	F	A	
Approach Delay (s)	Err	4.7	0.0
Approach LOS	F		

Intersection Summary			
Average Delay	795.5		
Intersection Capacity Utilization	101.7%	ICU Level of Service	G
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	6	869	344	421	1895	6	704	6	460	3	6	24
Future Volume (vph)	6	869	344	421	1895	6	704	6	460	3	6	24
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.85		1.00	0.89	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1776	1482	1719	1775		1752	1573		1770	1653	
Flt Permitted	0.11	1.00	1.00	0.11	1.00		0.73	1.00		0.19	1.00	
Satd. Flow (perm)	201	1776	1482	198	1775		1339	1573		358	1653	
Peak-hour factor, PHF	0.50	0.91	0.86	0.53	0.81	0.50	0.91	0.50	0.72	0.25	0.50	0.67
Adj. Flow (vph)	12	955	400	794	2340	12	774	12	639	12	12	36
RTOR Reduction (vph)	0	0	117	0	0	0	0	262	0	0	28	0
Lane Group Flow (vph)	12	955	283	794	2352	0	774	389	0	12	20	0
Heavy Vehicles (%)	2%	7%	9%	5%	7%	2%	3%	2%	3%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2		2	6			8	8		4	4	
Actuated Green, G (s)	40.8	40.3	40.3	49.3	49.3		20.8	20.8		20.8	20.8	
Effective Green, g (s)	40.8	40.3	40.3	49.3	49.3		20.8	20.8		20.8	20.8	
Actuated g/C Ratio	0.45	0.45	0.45	0.55	0.55		0.23	0.23		0.23	0.23	
Clearance Time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	157	795	663	324	972		309	363		82	382	
v/s Ratio Prot	0.00	c0.54		0.35	c1.33			0.25			0.01	
v/s Ratio Perm	0.03		0.19	c0.99			c0.58			0.03		
v/c Ratio	0.08	1.20	0.43	2.45	2.42		2.50	1.07		0.15	0.05	
Uniform Delay, d1	36.3	24.9	17.0	26.4	20.4		34.6	34.6		27.5	26.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.2	102.5	2.0	662.0	642.0		686.7	67.4		0.8	0.1	
Delay (s)	36.5	127.4	19.0	688.4	662.4		721.3	102.0		28.4	27.0	
Level of Service	D	F	B	F	F		F	F		C	C	
Approach Delay (s)		94.8			669.0			438.4			27.3	
Approach LOS		F			F			F			C	

Intersection Summary			
HCM 2000 Control Delay	476.9	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	2.42		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	16.1
Intersection Capacity Utilization	162.5%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Klein & Walnut

Movement	EB	EB	NB	NB
Directions Served	L	R	L	T
Maximum Queue (ft)	351	399	285	410
Average Queue (ft)	338	246	258	344
95th Queue (ft)	354	496	360	501
Link Distance (ft)	336	336		347
Upstream Blk Time (%)	97	66		56
Queuing Penalty (veh)	0	0		0
Storage Bay Dist (ft)			260	
Storage Blk Time (%)			19	45
Queuing Penalty (veh)			150	219

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	548	471	3005	94
Average Queue (ft)	360	344	2316	12
95th Queue (ft)	691	597	4074	49
Link Distance (ft)	532	456	2995	664
Upstream Blk Time (%)	44	42	15	
Queuing Penalty (veh)	0	0	134	
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Klein & Dove Crossing

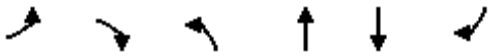
Movement	EB	EB	NB
Directions Served	L	R	LT
Maximum Queue (ft)	624	175	679
Average Queue (ft)	460	55	651
95th Queue (ft)	814	177	784
Link Distance (ft)	608		664
Upstream Blk Time (%)	52		33
Queuing Penalty (veh)	0		365
Storage Bay Dist (ft)		150	
Storage Blk Time (%)	76	0	
Queuing Penalty (veh)	63	0	

Intersection: 10: Klein & FM 725/FM725

Movement	EB	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	T	R	L	TR	L	TR	TR
Maximum Queue (ft)	30	433	175	95	437	225	1260	53
Average Queue (ft)	3	405	150	87	403	224	1252	17
95th Queue (ft)	18	425	223	107	429	225	1261	43
Link Distance (ft)		381			374		1243	403
Upstream Blk Time (%)		43			50		37	
Queuing Penalty (veh)		0			0		408	
Storage Bay Dist (ft)	120		150	70		200		
Storage Blk Time (%)		43	0	35	29	80	3	
Queuing Penalty (veh)		150	3	659	122	374	24	

Network Summary

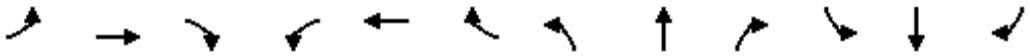
Network wide Queuing Penalty: 2672



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	108	131	99	240	199	117
Future Volume (Veh/h)	108	131	99	240	199	117
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.71	0.80	0.65	0.82	0.65	0.71
Hourly flow rate (vph)	152	164	152	293	306	165
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	986	388	471			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	986	388	471			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	35	75	86			
cM capacity (veh/h)	234	655	1086			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1
Volume Total	152	164	152	293	471
Volume Left	152	0	152	0	0
Volume Right	0	164	0	0	165
cSH	234	655	1086	1700	1700
Volume to Capacity	0.65	0.25	0.14	0.17	0.28
Queue Length 95th (ft)	100	25	12	0	0
Control Delay (s)	44.9	12.3	8.9	0.0	0.0
Lane LOS	E	B	A		
Approach Delay (s)	28.0		3.0		0.0
Approach LOS	D				

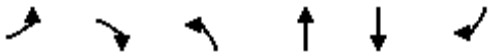
Intersection Summary			
Average Delay	8.3		
Intersection Capacity Utilization	39.1%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	18	2	4	3	2	42	5	342	6	24	299	10
Future Volume (Veh/h)	18	2	4	3	2	42	5	342	6	24	299	10
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.56	0.25	0.50	0.25	0.25	0.58	0.42	0.70	0.50	0.67	0.85	0.50
Hourly flow rate (vph)	32	8	8	12	8	72	12	489	12	36	352	20
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	1029	959	362	965	963	495	372			501		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1029	959	362	965	963	495	372			501		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	82	97	99	95	97	87	99			97		
cM capacity (veh/h)	175	246	683	218	244	575	1186			1063		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	48	92	513	408
Volume Left	32	12	12	36
Volume Right	8	72	12	20
cSH	211	432	1186	1063
Volume to Capacity	0.23	0.21	0.01	0.03
Queue Length 95th (ft)	21	20	1	3
Control Delay (s)	27.0	15.6	0.3	1.1
Lane LOS	D	C	A	A
Approach Delay (s)	27.0	15.6	0.3	1.1
Approach LOS	D	C		

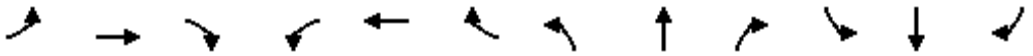
Intersection Summary				
Average Delay	3.1			
Intersection Capacity Utilization	45.3%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	41	7	9	419	330	40
Future Volume (Veh/h)	41	7	9	419	330	40
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.47	0.58	0.45	0.85	0.83	0.50
Hourly flow rate (vph)	87	12	20	493	398	80
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		6				
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	971	438	478			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	971	438	478			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	68	98	98			
cM capacity (veh/h)	275	619	1084			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	99	513	478
Volume Left	87	20	0
Volume Right	12	0	80
cSH	313	1084	1700
Volume to Capacity	0.32	0.02	0.28
Queue Length 95th (ft)	33	1	0
Control Delay (s)	22.4	0.5	0.0
Lane LOS	C	A	
Approach Delay (s)	22.4	0.5	0.0
Approach LOS	C		

Intersection Summary			
Average Delay	2.3		
Intersection Capacity Utilization	39.3%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	27	1215	307	88	1256	9	352	3	134	3	0	15
Future Volume (vph)	27	1215	307	88	1256	9	352	3	134	3	0	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.86		1.00	0.85	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1687	1792	1524	1671	1758		1703	1589		1770	1583	
Flt Permitted	0.09	1.00	1.00	0.08	1.00		0.74	1.00		0.61	1.00	
Satd. Flow (perm)	163	1792	1524	147	1758		1329	1589		1140	1583	
Peak-hour factor, PHF	0.56	0.92	0.87	0.76	0.89	0.75	0.91	0.25	0.88	0.25	1.00	0.63
Adj. Flow (vph)	48	1321	353	116	1411	12	387	12	152	12	0	24
RTOR Reduction (vph)	0	0	69	0	0	0	0	110	0	0	17	0
Lane Group Flow (vph)	48	1321	284	116	1423	0	387	54	0	12	7	0
Heavy Vehicles (%)	7%	6%	6%	8%	8%	2%	6%	2%	3%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2		2	6			8	8		4	4	
Actuated Green, G (s)	47.7	43.5	43.5	56.5	47.9		25.8	25.8		25.8	25.8	
Effective Green, g (s)	47.7	43.5	43.5	56.5	47.9		25.8	25.8		25.8	25.8	
Actuated g/C Ratio	0.51	0.46	0.46	0.60	0.51		0.27	0.27		0.27	0.27	
Clearance Time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	150	829	705	227	895		364	436		312	434	
v/s Ratio Prot	0.01	0.74		c0.05	c0.81			0.03			0.00	
v/s Ratio Perm	0.15		0.19	0.26			c0.29			0.01		
v/c Ratio	0.32	1.59	0.40	0.51	1.59		1.06	0.12		0.04	0.02	
Uniform Delay, d1	20.3	25.2	16.7	19.0	23.1		34.1	25.6		25.0	24.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	1.2	272.8	0.4	1.9	270.5		64.9	0.1		0.1	0.0	
Delay (s)	21.5	298.0	17.1	21.0	293.6		99.0	25.7		25.1	24.9	
Level of Service	C	F	B	C	F		F	C		C	C	
Approach Delay (s)		232.7			273.0			77.2			24.9	
Approach LOS		F			F			E			C	

Intersection Summary			
HCM 2000 Control Delay	224.6	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.37		
Actuated Cycle Length (s)	94.0	Sum of lost time (s)	16.1
Intersection Capacity Utilization	108.4%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Klein & Walnut

Movement	EB	EB	NB
Directions Served	L	R	L
Maximum Queue (ft)	75	56	53
Average Queue (ft)	39	35	13
95th Queue (ft)	62	50	40
Link Distance (ft)	336	336	
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			260
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	SB
Directions Served	LTR	LTR	LTR
Maximum Queue (ft)	31	56	29
Average Queue (ft)	14	32	5
95th Queue (ft)	39	60	23
Link Distance (ft)	532	456	664
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 8: Klein & Dove Crossing

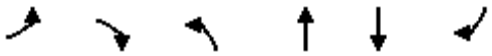
Movement	EB	EB	NB
Directions Served	L	R	LT
Maximum Queue (ft)	51	31	77
Average Queue (ft)	27	7	5
95th Queue (ft)	47	28	30
Link Distance (ft)	608		664
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)		150	
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 10: Klein & FM 725/FM725

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	TR	L	TR	L	TR
Maximum Queue (ft)	145	444	175	94	437	224	371	30	53
Average Queue (ft)	26	408	127	52	401	170	121	2	8
95th Queue (ft)	86	427	239	101	426	243	298	14	32
Link Distance (ft)		381			374		1243		403
Upstream Blk Time (%)		44			47				
Queuing Penalty (veh)		0			0				
Storage Bay Dist (ft)	120		150	70		200		120	
Storage Blk Time (%)		40	0	6	39	8			
Queuing Penalty (veh)		135	3	75	34	11			

Network Summary

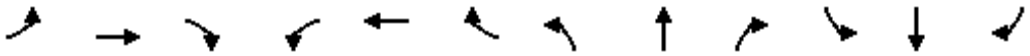
Network wide Queuing Penalty: 259



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	432	383	158	372	509	229
Future Volume (Veh/h)	432	383	158	372	509	229
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.84	0.53	0.90	0.94	0.68	0.83
Hourly flow rate (vph)	514	723	176	396	749	276
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1635	887	1025			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1635	887	1025			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	0	0	74			
cM capacity (veh/h)	82	343	677			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	SB 1
Volume Total	514	723	176	396	1025
Volume Left	514	0	176	0	0
Volume Right	0	723	0	0	276
cSH	82	343	677	1700	1700
Volume to Capacity	6.25	2.11	0.26	0.23	0.60
Queue Length 95th (ft)	Err	1316	26	0	0
Control Delay (s)	Err	533.1	12.2	0.0	0.0
Lane LOS	F	F	B		
Approach Delay (s)	4466.4		3.7		0.0
Approach LOS	F				

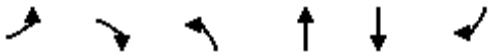
Intersection Summary			
Average Delay	1950.3		
Intersection Capacity Utilization	83.4%	ICU Level of Service	E
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	17	0	13	0	3	21	15	664	9	65	828	56
Future Volume (Veh/h)	17	0	13	0	3	21	15	664	9	65	828	56
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.71	1.00	0.30	1.00	0.25	0.58	0.63	0.90	0.75	0.81	0.73	0.64
Hourly flow rate (vph)	24	0	43	0	12	36	24	738	12	80	1134	88
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	2172	2136	1178	2173	2174	744	1222			750		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	2172	2136	1178	2173	2174	744	1222			750		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.2			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.3			2.2		
p0 queue free %	0	100	81	100	70	91	96			91		
cM capacity (veh/h)	21	43	232	25	40	415	557			859		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	67	48	774	1302
Volume Left	24	0	24	80
Volume Right	43	36	12	88
cSH	51	125	557	859
Volume to Capacity	1.31	0.38	0.04	0.09
Queue Length 95th (ft)	152	40	3	8
Control Delay (s)	359.6	50.8	1.2	3.6
Lane LOS	F	F	A	A
Approach Delay (s)	359.6	50.8	1.2	3.6
Approach LOS	F	F		

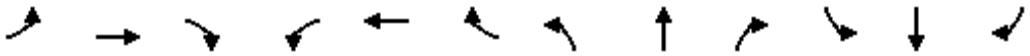
Intersection Summary				
Average Delay	14.7			
Intersection Capacity Utilization	95.6%	ICU Level of Service	F	
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	66	51	21	638	866	114
Future Volume (Veh/h)	66	51	21	638	866	114
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.87	0.67	0.88	0.92	0.81	0.68
Hourly flow rate (vph)	76	76	24	693	1069	168
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)		6				
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1894	1153	1237			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1894	1153	1237			
tC, single (s)	6.4	6.3	4.2			
tC, 2 stage (s)						
tF (s)	3.5	3.4	2.3			
p0 queue free %	0	68	96			
cM capacity (veh/h)	73	236	540			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	152	717	1237
Volume Left	76	24	0
Volume Right	76	0	168
cSH	147	540	1700
Volume to Capacity	1.04	0.04	0.73
Queue Length 95th (ft)	197	3	0
Control Delay (s)	120.8	1.3	0.0
Lane LOS	F	A	
Approach Delay (s)	120.8	1.3	0.0
Approach LOS	F		

Intersection Summary			
Average Delay	9.1		
Intersection Capacity Utilization	62.8%	ICU Level of Service	B
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	42	1983	632	443	1764	12	383	12	362	9	3	18
Future Volume (vph)	42	1983	632	443	1764	12	383	12	362	9	3	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.86		1.00	0.89	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1736	1810	1583	1736	1824		1770	1570		1770	1653	
Flt Permitted	0.16	1.00	1.00	0.17	1.00		0.73	1.00		0.19	1.00	
Satd. Flow (perm)	297	1810	1583	303	1824		1352	1570		358	1653	
Peak-hour factor, PHF	0.58	0.87	0.93	0.88	0.93	0.50	0.80	0.50	0.92	0.38	0.25	0.50
Adj. Flow (vph)	72	2279	680	503	1897	24	479	24	393	24	12	36
RTOR Reduction (vph)	0	0	84	0	1	0	0	302	0	0	28	0
Lane Group Flow (vph)	72	2279	596	503	1920	0	479	115	0	24	20	0
Heavy Vehicles (%)	4%	5%	2%	4%	4%	2%	2%	2%	4%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2		2	6			8	8		4	4	
Actuated Green, G (s)	34.8	34.3	34.3	42.9	42.9		20.8	20.8		20.8	20.8	
Effective Green, g (s)	34.8	34.3	34.3	42.9	42.9		20.8	20.8		20.8	20.8	
Actuated g/C Ratio	0.39	0.38	0.38	0.48	0.48		0.23	0.23		0.23	0.23	
Clearance Time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2		5.2	5.2	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	277	689	603	443	869		312	362		82	382	
v/s Ratio Prot	0.03	c1.26		0.24	c1.05			0.07			0.01	
v/s Ratio Perm	0.07		0.38	0.30			c0.35			0.07		
v/c Ratio	0.26	3.31	0.99	1.14	2.21		1.54	0.32		0.29	0.05	
Uniform Delay, d1	32.3	27.9	27.7	24.9	23.6		34.6	28.7		28.5	26.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.5	1042.2	34.1	85.3	548.3		256.4	0.5		2.0	0.1	
Delay (s)	32.8	1070.0	61.8	110.2	571.8		291.0	29.2		30.5	27.0	
Level of Service	C	F	E	F	F		F	C		C	C	
Approach Delay (s)		819.2			476.0			169.2			28.2	
Approach LOS		F			F			F			C	

Intersection Summary			
HCM 2000 Control Delay	590.1	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	2.61		
Actuated Cycle Length (s)	90.0	Sum of lost time (s)	16.1
Intersection Capacity Utilization	170.2%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Klein & Walnut

Movement	EB	EB	NB
Directions Served	L	R	L
Maximum Queue (ft)	388	388	53
Average Queue (ft)	354	354	29
95th Queue (ft)	368	369	57
Link Distance (ft)	336	336	
Upstream Blk Time (%)	95	73	
Queuing Penalty (veh)	0	0	
Storage Bay Dist (ft)			260
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	LTR	LTR
Maximum Queue (ft)	56	52	75	97
Average Queue (ft)	26	16	10	20
95th Queue (ft)	50	42	49	68
Link Distance (ft)	532	456	2995	664
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Klein & Dove Crossing

Movement	EB	EB	NB
Directions Served	L	R	LT
Maximum Queue (ft)	74	79	114
Average Queue (ft)	30	32	9
95th Queue (ft)	60	58	50
Link Distance (ft)	608		664
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)		150	
Storage Blk Time (%)			
Queuing Penalty (veh)			

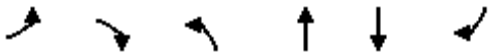
Intersection: 10: Klein & FM 725/FM725

Movement	EB	EB	EB	WB	WB	NB	NB	SB	SB
Directions Served	L	T	R	L	TR	L	TR	L	TR
Maximum Queue (ft)	140	420	175	95	426	225	756	71	52
Average Queue (ft)	18	400	132	91	397	205	338	8	12
95th Queue (ft)	75	414	240	107	417	255	648	34	39
Link Distance (ft)		381			374		1243		403
Upstream Blk Time (%)		51			53				
Queuing Penalty (veh)		0			0				
Storage Bay Dist (ft)	120		150	70		200		120	
Storage Blk Time (%)		48	0	40	28	36	8		
Queuing Penalty (veh)		324	4	710	126	133	32		

Network Summary

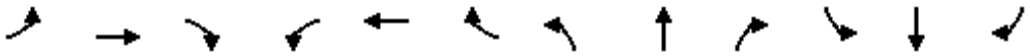
Network wide Queuing Penalty: 1329

APPENDIX C6



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	119	465	491	785	930	281
Future Volume (vph)	119	465	491	785	930	281
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.5	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.95	0.95	1.00
Frt	0.91	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.98	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3181	1427	1736	3471	3471	1568
Flt Permitted	0.98	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3181	1427	1736	3471	3471	1568
Peak-hour factor, PHF	0.73	0.83	0.76	0.78	0.64	0.68
Adj. Flow (vph)	163	560	646	1006	1453	413
RTOR Reduction (vph)	255	255	0	0	0	78
Lane Group Flow (vph)	188	25	646	1006	1453	335
Heavy Vehicles (%)	3%	3%	4%	4%	4%	3%
Turn Type	Prot	Prot	Prot	NA	NA	Perm
Protected Phases	2	2	3	8	4	
Permitted Phases						4
Actuated Green, G (s)	10.7	10.7	43.5	101.3	53.3	53.3
Effective Green, g (s)	10.7	10.7	43.5	101.3	53.3	53.3
Actuated g/C Ratio	0.09	0.09	0.36	0.84	0.44	0.44
Clearance Time (s)	4.0	4.0	4.5	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	283	127	629	2930	1541	696
v/s Ratio Prot	c0.06	0.02	c0.37	0.29	c0.42	
v/s Ratio Perm						0.21
v/c Ratio	0.66	0.20	1.03	0.34	0.94	0.48
Uniform Delay, d1	52.9	50.7	38.2	2.1	31.9	23.6
Progression Factor	1.00	1.00	1.00	1.00	0.61	0.51
Incremental Delay, d2	5.8	0.8	43.0	0.1	11.4	0.5
Delay (s)	58.7	51.4	81.2	2.1	30.9	12.4
Level of Service	E	D	F	A	C	B
Approach Delay (s)	55.9			33.0	26.8	
Approach LOS	E			C	C	

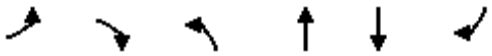
Intersection Summary			
HCM 2000 Control Delay	34.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.95		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	12.5
Intersection Capacity Utilization	71.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	51	0	21	21	0	71	12	993	12	27	933	8
Future Volume (Veh/h)	51	0	21	21	0	71	12	993	12	27	933	8
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.67	1.00	0.66	0.58	1.00	0.51	0.60	0.79	0.50	0.45	0.79	0.67
Hourly flow rate (vph)	76	0	32	36	0	139	20	1257	24	60	1181	12
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								TWLTL			TWLTL	
Median storage veh)								2			2	
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	2114	2628	596	2052	2622	640	1193			1281		
vC1, stage 1 conf vol	1307	1307		1309	1309							
vC2, stage 2 conf vol	808	1321		742	1313							
vCu, unblocked vol	2114	2628	596	2052	2622	640	1193			1281		
tC, single (s)	7.5	6.5	6.9	7.5	6.5	6.9	4.1			4.1		
tC, 2 stage (s)	6.5	5.5		6.5	5.5							
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	28	100	93	74	100	67	97			89		
cM capacity (veh/h)	106	121	446	139	135	418	581			538		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	108	175	20	838	443	60	787	406
Volume Left	76	36	20	0	0	60	0	0
Volume Right	32	139	0	0	24	0	0	12
cSH	137	295	581	1700	1700	538	1700	1700
Volume to Capacity	0.79	0.59	0.03	0.49	0.26	0.11	0.46	0.24
Queue Length 95th (ft)	120	88	3	0	0	9	0	0
Control Delay (s)	91.1	33.5	11.4	0.0	0.0	12.5	0.0	0.0
Lane LOS	F	D	B			B		
Approach Delay (s)	91.1	33.5	0.2			0.6		
Approach LOS	F	D						

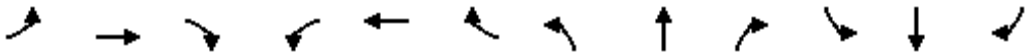
Intersection Summary				
Average Delay	5.9			
Intersection Capacity Utilization	45.0%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	86	83	45	1021	787	30
Future Volume (Veh/h)	86	83	45	1021	787	30
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.83	0.83	0.66	0.81	0.80	0.54
Hourly flow rate (vph)	104	100	68	1260	984	56
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				TWLTL	TWLTL	
Median storage veh)				2	2	
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1778	520	1040			
vC1, stage 1 conf vol	1012					
vC2, stage 2 conf vol	766					
vCu, unblocked vol	1778	520	1040			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)	5.8					
tF (s)	3.5	3.3	2.2			
p0 queue free %	57	80	90			
cM capacity (veh/h)	242	501	664			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	104	100	68	630	630	656	384
Volume Left	104	0	68	0	0	0	0
Volume Right	0	100	0	0	0	0	56
cSH	242	501	664	1700	1700	1700	1700
Volume to Capacity	0.43	0.20	0.10	0.37	0.37	0.39	0.23
Queue Length 95th (ft)	51	18	9	0	0	0	0
Control Delay (s)	30.6	14.0	11.0	0.0	0.0	0.0	0.0
Lane LOS	D	B	B				
Approach Delay (s)	22.4		0.6			0.0	
Approach LOS	C						

Intersection Summary			
Average Delay	2.1		
Intersection Capacity Utilization	40.8%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	6	869	344	421	1895	6	704	6	460	3	6	24
Future Volume (vph)	6	869	344	421	1895	6	704	6	460	3	6	24
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.5	4.0	4.0	4.5	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.91	1.00	0.97	0.91		0.97	0.95	0.95	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.86	0.85	1.00	0.89	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	4848	1482	3335	4845		3400	1500	1490	1770	1653	
Flt Permitted	0.11	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	200	4848	1482	3335	4845		3400	1500	1490	1770	1653	
Peak-hour factor, PHF	0.50	0.91	0.86	0.53	0.81	0.50	0.91	0.50	0.72	0.25	0.50	0.67
Adj. Flow (vph)	12	955	400	794	2340	12	774	12	639	12	12	36
RTOR Reduction (vph)	0	0	276	0	0	0	0	234	244	0	35	0
Lane Group Flow (vph)	12	955	124	794	2352	0	774	91	82	12	13	0
Heavy Vehicles (%)	2%	7%	9%	5%	7%	2%	3%	2%	3%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	Prot	NA		Split	NA	Perm	Split	NA	
Protected Phases	5	2		1	6		8	8		4	4	
Permitted Phases	2		2						8			
Actuated Green, G (s)	39.2	37.2	37.2	31.5	66.7		30.1	30.1	30.1	4.7	4.7	
Effective Green, g (s)	39.2	37.2	37.2	31.5	66.7		30.1	30.1	30.1	4.7	4.7	
Actuated g/C Ratio	0.33	0.31	0.31	0.26	0.56		0.25	0.25	0.25	0.04	0.04	
Clearance Time (s)	4.5	4.0	4.0	4.5	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	91	1502	459	875	2693		852	376	373	69	64	
v/s Ratio Prot	0.00	0.20		c0.24	c0.49		c0.23	0.06		0.01	c0.01	
v/s Ratio Perm	0.04		0.08						0.05			
v/c Ratio	0.13	0.64	0.27	0.91	0.87		0.91	0.24	0.22	0.17	0.21	
Uniform Delay, d1	28.4	35.6	31.2	42.8	23.0		43.6	35.8	35.6	55.8	55.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		0.95	0.71	0.73	1.00	1.00	
Incremental Delay, d2	0.7	2.1	1.4	12.9	3.4		13.1	0.3	0.3	1.2	1.6	
Delay (s)	29.1	37.6	32.6	55.8	26.4		54.6	25.8	26.2	57.0	57.5	
Level of Service	C	D	C	E	C		D	C	C	E	E	
Approach Delay (s)		36.1			33.8			41.5			57.4	
Approach LOS		D			C			D			E	

Intersection Summary			
HCM 2000 Control Delay	36.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	16.5
Intersection Capacity Utilization	78.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Walnut & Klein

Movement	EB	EB	EB	NB	NB	NB	SB	SB	SB
Directions Served	L	LR	R	L	T	T	T	T	R
Maximum Queue (ft)	314	360	175	174	392	320	449	449	125
Average Queue (ft)	111	294	172	173	324	165	296	312	108
95th Queue (ft)	264	372	183	177	448	298	401	415	159
Link Distance (ft)	312	312			340	340	1098	1098	
Upstream Blk Time (%)	2	29			17	0			
Queuing Penalty (veh)	0	0			0	0			
Storage Bay Dist (ft)			150	150					100
Storage Blk Time (%)		61	17	38	0			43	1
Queuing Penalty (veh)		143	49	148	2			122	4

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	L	L
Maximum Queue (ft)	160	78	50	29
Average Queue (ft)	62	38	5	10
95th Queue (ft)	123	66	24	33
Link Distance (ft)	514	438		
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)			150	150
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Klein & Dove Crossing

Movement	EB	EB	NB	SB
Directions Served	L	R	L	T
Maximum Queue (ft)	227	94	55	48
Average Queue (ft)	87	37	17	2
95th Queue (ft)	183	64	46	16
Link Distance (ft)	596	596		1217
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)			150	
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 10: Klein & FM 725

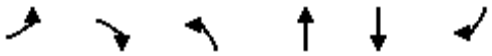
Movement	EB	EB	EB	EB	EB	WB	WB	WB	WB	WB	NB	NB
Directions Served	L	T	T	T	R	L	L	T	T	TR	L	L
Maximum Queue (ft)	29	386	333	295	275	262	274	567	491	329	275	444
Average Queue (ft)	4	276	216	67	116	178	214	212	212	122	216	252
95th Queue (ft)	20	386	318	192	211	261	291	368	333	222	302	375
Link Distance (ft)		371	371	371				552	552	552		1217
Upstream Blk Time (%)		2						0				
Queuing Penalty (veh)		0						0				
Storage Bay Dist (ft)	150				250	250	250				250	
Storage Blk Time (%)		30			1	0	3	1			2	9
Queuing Penalty (veh)		2			2	1	18	6			8	33

Intersection: 10: Klein & FM 725

Movement	NB	NB	SB	SB
Directions Served	TR	R	L	TR
Maximum Queue (ft)	76	106	31	72
Average Queue (ft)	50	55	2	21
95th Queue (ft)	81	86	14	52
Link Distance (ft)	1217			375
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)		150	120	
Storage Blk Time (%)				
Queuing Penalty (veh)				

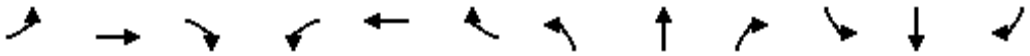
Network Summary

Network wide Queuing Penalty: 537



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	108	131	99	240	199	117
Future Volume (vph)	108	131	99	240	199	117
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.5	4.0	4.0	4.0
Lane Util. Factor	0.97	0.91	1.00	0.95	0.95	1.00
Frt	0.96	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.97	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3272	1413	1752	3438	3343	1524
Flt Permitted	0.97	1.00	0.95	1.00	1.00	1.00
Satd. Flow (perm)	3272	1413	1752	3438	3343	1524
Peak-hour factor, PHF	0.71	0.80	0.65	0.82	0.65	0.71
Adj. Flow (vph)	152	164	152	293	306	165
RTOR Reduction (vph)	46	71	0	0	0	107
Lane Group Flow (vph)	170	29	152	293	306	58
Heavy Vehicles (%)	4%	4%	3%	5%	8%	6%
Turn Type	Prot	Prot	Prot	NA	NA	Perm
Protected Phases	2	2	3	8	4	
Permitted Phases						4
Actuated Green, G (s)	17.3	17.3	9.1	34.7	21.1	21.1
Effective Green, g (s)	17.3	17.3	9.1	34.7	21.1	21.1
Actuated g/C Ratio	0.29	0.29	0.15	0.58	0.35	0.35
Clearance Time (s)	4.0	4.0	4.5	4.0	4.0	4.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	943	407	265	1988	1175	535
v/s Ratio Prot	c0.05	0.02	c0.09	0.09	c0.09	
v/s Ratio Perm						0.04
v/c Ratio	0.18	0.07	0.57	0.15	0.26	0.11
Uniform Delay, d1	16.0	15.5	23.6	5.8	13.9	13.1
Progression Factor	1.00	1.00	1.00	1.00	0.88	0.50
Incremental Delay, d2	0.1	0.1	3.0	0.0	0.1	0.1
Delay (s)	16.1	15.6	26.6	5.9	12.3	6.7
Level of Service	B	B	C	A	B	A
Approach Delay (s)	16.0			13.0	10.3	
Approach LOS	B			B	B	

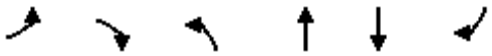
Intersection Summary			
HCM 2000 Control Delay	12.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.29		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.5
Intersection Capacity Utilization	25.9%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	18	2	4	3	2	42	5	342	6	24	299	10
Future Volume (Veh/h)	18	2	4	3	2	42	5	342	6	24	299	10
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.56	0.25	0.50	0.25	0.25	0.58	0.42	0.70	0.50	0.67	0.85	0.50
Hourly flow rate (vph)	32	8	8	12	8	72	12	489	12	36	352	20
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								TWLTL			TWLTL	
Median storage veh)								2			2	
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	778	959	186	779	963	250	372			501		
vC1, stage 1 conf vol	434	434		519	519							
vC2, stage 2 conf vol	344	525		260	444							
vCu, unblocked vol	778	959	186	779	963	250	372			501		
tC, single (s)	7.5	6.5	6.9	7.5	6.5	6.9	4.1			4.1		
tC, 2 stage (s)	6.5	5.5		6.5	5.5							
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	93	98	99	97	98	90	99			97		
cM capacity (veh/h)	432	416	824	451	426	749	1183			1059		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	48	92	12	326	175	36	235	137
Volume Left	32	12	12	0	0	36	0	0
Volume Right	8	72	0	0	12	0	0	20
cSH	466	650	1183	1700	1700	1059	1700	1700
Volume to Capacity	0.10	0.14	0.01	0.19	0.10	0.03	0.14	0.08
Queue Length 95th (ft)	9	12	1	0	0	3	0	0
Control Delay (s)	13.6	11.4	8.1	0.0	0.0	8.5	0.0	0.0
Lane LOS	B	B	A			A		
Approach Delay (s)	13.6	11.4	0.2			0.8		
Approach LOS	B	B						

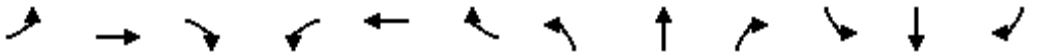
Intersection Summary				
Average Delay	2.0			
Intersection Capacity Utilization	31.0%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	41	7	9	419	330	40
Future Volume (Veh/h)	41	7	9	419	330	40
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.47	0.58	0.45	0.85	0.83	0.50
Hourly flow rate (vph)	87	12	20	493	398	80
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				TWLTL	TWLTL	
Median storage veh)				2	2	
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	724	239	478			
vC1, stage 1 conf vol	438					
vC2, stage 2 conf vol	286					
vCu, unblocked vol	724	239	478			
tC, single (s)	6.8	6.9	4.1			
tC, 2 stage (s)	5.8					
tF (s)	3.5	3.3	2.2			
p0 queue free %	84	98	98			
cM capacity (veh/h)	544	762	1081			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	87	12	20	246	246	265	213
Volume Left	87	0	20	0	0	0	0
Volume Right	0	12	0	0	0	0	80
cSH	544	762	1081	1700	1700	1700	1700
Volume to Capacity	0.16	0.02	0.02	0.14	0.14	0.16	0.13
Queue Length 95th (ft)	14	1	1	0	0	0	0
Control Delay (s)	12.9	9.8	8.4	0.0	0.0	0.0	0.0
Lane LOS	B	A	A				
Approach Delay (s)	12.5		0.3			0.0	
Approach LOS	B						

Intersection Summary			
Average Delay	1.3		
Intersection Capacity Utilization	21.6%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	27	1215	307	88	1256	9	352	3	134	3	0	15
Future Volume (vph)	27	1215	307	88	1256	9	352	3	134	3	0	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.5	4.0	4.0	4.5	4.0		4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.91	1.00	0.97	0.91		0.97	0.95	0.95	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.87	0.85	1.00	0.85	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1687	4893	1524	3242	4799		3303	1530	1490	1770	1583	
Flt Permitted	0.16	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	277	4893	1524	3242	4799		3303	1530	1490	1770	1583	
Peak-hour factor, PHF	0.56	0.92	0.87	0.76	0.89	0.75	0.91	0.25	0.88	0.25	1.00	0.63
Adj. Flow (vph)	48	1321	353	116	1411	12	387	12	152	12	0	24
RTOR Reduction (vph)	0	0	202	0	1	0	0	58	67	0	23	0
Lane Group Flow (vph)	48	1321	151	116	1422	0	387	25	14	12	1	0
Heavy Vehicles (%)	7%	6%	6%	8%	8%	2%	6%	2%	3%	2%	2%	2%
Turn Type	pm+pt	NA	Perm	Prot	NA		Split	NA	Perm	Split	NA	
Protected Phases	5	2		1	6		8	8		4	4	
Permitted Phases	2		2						8			
Actuated Green, G (s)	28.6	25.6	25.6	4.9	27.5		10.6	10.6	10.6	2.4	2.4	
Effective Green, g (s)	28.6	25.6	25.6	4.9	27.5		10.6	10.6	10.6	2.4	2.4	
Actuated g/C Ratio	0.48	0.43	0.43	0.08	0.46		0.18	0.18	0.18	0.04	0.04	
Clearance Time (s)	4.5	4.0	4.0	4.5	4.0		4.0	4.0	4.0	4.0	4.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	202	2087	650	264	2199		583	270	263	70	63	
v/s Ratio Prot	0.01	0.27		c0.04	c0.30		c0.12	0.02		c0.01	0.00	
v/s Ratio Perm	0.10		0.10						0.01			
v/c Ratio	0.24	0.63	0.23	0.44	0.65		0.66	0.09	0.05	0.17	0.02	
Uniform Delay, d1	15.5	13.5	10.9	26.2	12.5		23.0	20.7	20.5	27.8	27.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00		0.97	1.04	1.00	1.00	1.00	
Incremental Delay, d2	0.6	1.5	0.8	1.2	0.7		2.8	0.1	0.1	1.2	0.1	
Delay (s)	16.1	15.0	11.8	27.4	13.2		25.2	21.7	20.6	29.0	27.8	
Level of Service	B	B	B	C	B		C	C	C	C	C	
Approach Delay (s)		14.4			14.2			24.0			28.2	
Approach LOS		B			B			C			C	

Intersection Summary			
HCM 2000 Control Delay	15.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.62		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	16.5
Intersection Capacity Utilization	55.8%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Walnut & Klein

Movement	EB	EB	NB	NB	NB	SB	SB	SB
Directions Served	L	LR	L	T	T	T	T	R
Maximum Queue (ft)	88	103	96	108	79	55	133	125
Average Queue (ft)	37	41	44	34	15	16	53	45
95th Queue (ft)	67	79	74	73	50	47	95	85
Link Distance (ft)	312	312		340	340	1095	1095	
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)			150					100
Storage Blk Time (%)							1	0
Queuing Penalty (veh)							1	0

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	L	L
Maximum Queue (ft)	31	54	28	52
Average Queue (ft)	18	27	2	8
95th Queue (ft)	42	51	13	31
Link Distance (ft)	515	438		
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)			150	150
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Klein & Dove Crossing

Movement	EB	EB	NB
Directions Served	L	R	L
Maximum Queue (ft)	53	30	29
Average Queue (ft)	26	2	2
95th Queue (ft)	51	14	14
Link Distance (ft)	596	596	
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			150
Storage Blk Time (%)			
Queuing Penalty (veh)			

Intersection: 10: Klein & FM 725

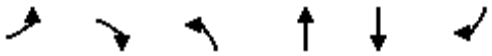
Movement	EB	EB	EB	EB	EB	WB	WB	WB	WB	WB	NB	NB
Directions Served	L	T	T	T	R	L	L	T	T	TR	L	L
Maximum Queue (ft)	97	253	208	89	100	123	130	367	213	114	114	158
Average Queue (ft)	33	165	106	32	54	10	54	120	77	22	73	92
95th Queue (ft)	72	243	186	73	88	50	92	237	165	62	114	137
Link Distance (ft)		371	371	371				352	352	352		1216
Upstream Blk Time (%)								0				
Queuing Penalty (veh)								0				
Storage Bay Dist (ft)	150				250	250	250				250	
Storage Blk Time (%)		8						1				
Queuing Penalty (veh)		2						1				

Intersection: 10: Klein & FM 725

Movement	NB	NB	SB	SB
Directions Served	TR	R	L	TR
Maximum Queue (ft)	56	101	31	31
Average Queue (ft)	28	24	2	7
95th Queue (ft)	46	61	14	28
Link Distance (ft)	1216			375
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)		150	120	
Storage Blk Time (%)				
Queuing Penalty (veh)				

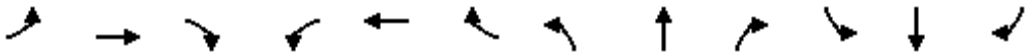
Network Summary

Network wide Queuing Penalty: 4



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	404	383	158	372	509	213
Future Volume (vph)	404	383	158	372	509	213
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.5	4.5	4.5	4.5	4.5	4.5
Lane Util. Factor	0.97	0.91	1.00	0.95	0.95	1.00
Frt	0.94	0.85	1.00	1.00	1.00	0.85
Flt Protected	0.97	1.00	0.95	1.00	1.00	1.00
Satd. Flow (prot)	3293	1441	1770	3471	3539	1482
Flt Permitted	0.97	1.00	0.20	1.00	1.00	1.00
Satd. Flow (perm)	3293	1441	374	3471	3539	1482
Peak-hour factor, PHF	0.84	0.53	0.90	0.94	0.68	0.83
Adj. Flow (vph)	481	723	176	396	749	257
RTOR Reduction (vph)	170	235	0	0	0	152
Lane Group Flow (vph)	651	148	176	396	749	105
Heavy Vehicles (%)	2%	2%	2%	4%	2%	9%
Turn Type	Prot	Prot	pm+pt	NA	NA	Perm
Protected Phases	2	2	3	8	4	
Permitted Phases			8			4
Actuated Green, G (s)	26.5	26.5	39.5	39.5	25.9	25.9
Effective Green, g (s)	26.5	26.5	39.5	39.5	25.9	25.9
Actuated g/C Ratio	0.35	0.35	0.53	0.53	0.35	0.35
Clearance Time (s)	4.5	4.5	4.5	4.5	4.5	4.5
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	1163	509	366	1828	1222	511
v/s Ratio Prot	c0.20	0.10	c0.06	0.11	c0.21	
v/s Ratio Perm			0.19			0.07
v/c Ratio	0.56	0.29	0.48	0.22	0.61	0.21
Uniform Delay, d1	19.5	17.5	11.0	9.5	20.4	17.3
Progression Factor	1.00	1.00	1.00	1.00	0.73	0.67
Incremental Delay, d2	1.9	1.4	1.0	0.3	1.9	0.7
Delay (s)	21.5	18.9	12.0	9.8	16.7	12.4
Level of Service	C	B	B	A	B	B
Approach Delay (s)	20.7			10.5	15.6	
Approach LOS	C			B	B	

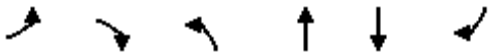
Intersection Summary			
HCM 2000 Control Delay	16.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	13.5
Intersection Capacity Utilization	49.6%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	17	0	13	0	3	21	15	640	9	65	787	56
Future Volume (Veh/h)	17	0	13	0	3	21	15	640	9	65	787	56
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.71	1.00	0.30	1.00	0.25	0.58	0.63	0.90	0.75	0.81	0.73	0.64
Hourly flow rate (vph)	24	0	43	0	12	36	24	711	12	80	1078	88
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								TWLTL			TWLTL	
Median storage veh)								2			2	
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	1728	2053	583	1507	2091	362	1166			723		
vC1, stage 1 conf vol	1282	1282		765	765							
vC2, stage 2 conf vol	446	771		742	1326							
vCu, unblocked vol	1728	2053	583	1507	2091	362	1166			723		
tC, single (s)	7.5	6.5	6.9	7.5	6.5	6.9	4.2			4.1		
tC, 2 stage (s)	6.5	5.5		6.5	5.5							
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.3			2.2		
p0 queue free %	84	100	91	100	93	94	96			91		
cM capacity (veh/h)	148	176	456	224	162	635	573			875		

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	NB 3	SB 1	SB 2	SB 3
Volume Total	67	48	24	474	249	80	719	447
Volume Left	24	0	24	0	0	80	0	0
Volume Right	43	36	0	0	12	0	0	88
cSH	261	367	573	1700	1700	875	1700	1700
Volume to Capacity	0.26	0.13	0.04	0.28	0.15	0.09	0.42	0.26
Queue Length 95th (ft)	25	11	3	0	0	8	0	0
Control Delay (s)	23.5	16.3	11.6	0.0	0.0	9.5	0.0	0.0
Lane LOS	C	C	B			A		
Approach Delay (s)	23.5	16.3	0.4			0.6		
Approach LOS	C	C						

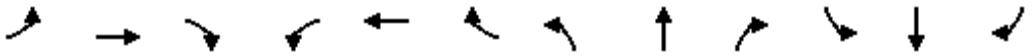
Intersection Summary				
Average Delay	1.6			
Intersection Capacity Utilization	45.3%	ICU Level of Service		A
Analysis Period (min)	15			



Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (veh/h)	66	51	21	638	866	114
Future Volume (Veh/h)	66	51	21	638	866	114
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.87	0.67	0.88	0.92	0.81	0.68
Hourly flow rate (vph)	76	76	24	693	1069	168
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				TWLTL	TWLTL	
Median storage veh)				2	2	
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1548	618	1237			
vC1, stage 1 conf vol	1153					
vC2, stage 2 conf vol	394					
vCu, unblocked vol	1548	618	1237			
tC, single (s)	6.8	7.0	4.3			
tC, 2 stage (s)	5.8					
tF (s)	3.5	3.4	2.3			
p0 queue free %	69	82	95			
cM capacity (veh/h)	245	422	522			

Direction, Lane #	EB 1	EB 2	NB 1	NB 2	NB 3	SB 1	SB 2
Volume Total	76	76	24	346	346	713	524
Volume Left	76	0	24	0	0	0	0
Volume Right	0	76	0	0	0	0	168
cSH	245	422	522	1700	1700	1700	1700
Volume to Capacity	0.31	0.18	0.05	0.20	0.20	0.42	0.31
Queue Length 95th (ft)	32	16	4	0	0	0	0
Control Delay (s)	26.1	15.4	12.2	0.0	0.0	0.0	0.0
Lane LOS	D	C	B				
Approach Delay (s)	20.7		0.4			0.0	
Approach LOS	C						

Intersection Summary			
Average Delay	1.6		
Intersection Capacity Utilization	37.9%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	42	1983	597	434	1764	12	363	12	358	9	3	18
Future Volume (vph)	42	1983	597	434	1764	12	363	12	358	9	3	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2	5.2	5.2	5.2	
Lane Util. Factor	1.00	0.91	1.00	0.97	0.91		0.97	0.95	0.95	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.87	0.85	1.00	0.89	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	4940	1583	3367	4979		3433	1509	1475	1770	1653	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	4940	1583	3367	4979		3433	1509	1475	1770	1653	
Peak-hour factor, PHF	0.58	0.87	0.93	0.88	0.93	0.50	0.80	0.50	0.92	0.38	0.25	0.50
Adj. Flow (vph)	72	2279	642	493	1897	24	454	24	389	24	12	36
RTOR Reduction (vph)	0	0	201	0	1	0	0	150	169	0	34	0
Lane Group Flow (vph)	72	2279	441	493	1920	0	454	57	37	24	14	0
Heavy Vehicles (%)	4%	5%	2%	4%	4%	2%	2%	2%	4%	2%	2%	2%
Turn Type	Prot	NA	Perm	Prot	NA		Split	NA	Perm	Split	NA	
Protected Phases	5	2		1	6		8	8		4	4	
Permitted Phases			2					8	8		4	
Actuated Green, G (s)	10.8	71.8	71.8	23.2	84.2		27.1	27.1	27.1	6.6	6.6	
Effective Green, g (s)	10.8	71.8	71.8	23.2	84.2		27.1	27.1	27.1	6.6	6.6	
Actuated g/C Ratio	0.07	0.48	0.48	0.15	0.56		0.18	0.18	0.18	0.04	0.04	
Clearance Time (s)	5.2	5.7	5.7	5.2	5.7		5.2	5.2	5.2	5.2	5.2	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	124	2364	757	520	2794		620	272	266	77	72	
v/s Ratio Prot	0.04	c0.46		c0.15	0.39		c0.13	0.04		c0.01	0.01	
v/s Ratio Perm			0.28						0.03			
v/c Ratio	0.58	0.96	0.58	0.95	0.69		0.73	0.21	0.14	0.31	0.19	
Uniform Delay, d1	67.4	37.9	28.3	62.8	23.5		58.0	52.3	51.7	69.5	69.1	
Progression Factor	1.00	1.00	1.00	1.00	1.00		0.98	0.99	1.10	1.00	1.00	
Incremental Delay, d2	6.8	11.8	3.3	26.7	1.4		4.3	0.4	0.2	2.3	1.3	
Delay (s)	74.2	49.7	31.5	89.5	24.9		61.0	52.2	57.1	71.8	70.4	
Level of Service	E	D	C	F	C		E	D	E	E	E	
Approach Delay (s)		46.4			38.1			58.0			70.9	
Approach LOS		D			D			E			E	

Intersection Summary			
HCM 2000 Control Delay	45.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	21.3
Intersection Capacity Utilization	81.1%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Intersection: 3: Walnut & Klein

Movement	EB	EB	EB	NB	NB	NB	SB	SB	SB
Directions Served	L	LR	R	L	T	T	T	T	R
Maximum Queue (ft)	265	327	175	138	137	98	163	291	125
Average Queue (ft)	134	171	77	71	75	41	90	119	81
95th Queue (ft)	210	280	190	118	128	89	149	211	148
Link Distance (ft)	312	312			340	340	1094	1094	
Upstream Blk Time (%)		1							
Queuing Penalty (veh)		0							
Storage Bay Dist (ft)			150	150					100
Storage Blk Time (%)		10	1	0	0			10	0
Queuing Penalty (veh)		18	2	0	0			22	1

Intersection: 5: Klein & Roadrunner/Stoeger

Movement	EB	WB	NB	SB
Directions Served	LTR	LTR	L	L
Maximum Queue (ft)	55	55	28	52
Average Queue (ft)	22	16	8	20
95th Queue (ft)	50	45	28	48
Link Distance (ft)	515	438		
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)			150	150
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Klein & Dove Crossing

Movement	EB	EB	NB	SB
Directions Served	L	R	L	TR
Maximum Queue (ft)	117	69	31	22
Average Queue (ft)	51	35	12	1
95th Queue (ft)	102	58	36	7
Link Distance (ft)	596	596		1216
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)			150	
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 10: Klein & FM 725

Movement	EB	EB	EB	EB	EB	WB	WB	WB	WB	WB	NB	NB
Directions Served	L	T	T	T	R	L	L	T	T	TR	L	L
Maximum Queue (ft)	174	386	410	386	275	262	275	391	391	367	225	259
Average Queue (ft)	66	383	368	288	198	199	248	268	246	175	122	137
95th Queue (ft)	146	401	431	443	325	276	304	423	390	314	191	201
Link Distance (ft)		371	371	371				352	352	352		1216
Upstream Blk Time (%)		25	10	5				3	2	0		
Queuing Penalty (veh)		0	0	0				0	0	0		
Storage Bay Dist (ft)	150				250	250	250				250	
Storage Blk Time (%)	0	38		5	3	0	9	4				1
Queuing Penalty (veh)	0	16		29	20	1	55	19				1

Intersection: 10: Klein & FM 725

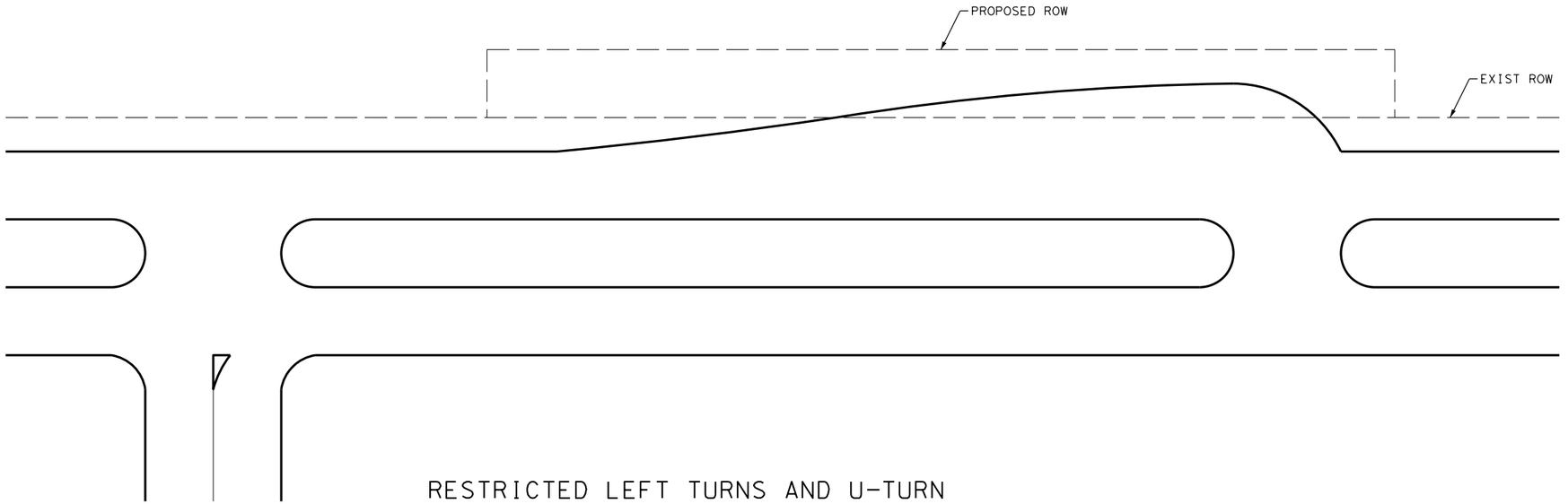
Movement	NB	NB	SB	SB
Directions Served	TR	R	L	TR
Maximum Queue (ft)	139	166	50	53
Average Queue (ft)	87	91	15	17
95th Queue (ft)	137	158	40	43
Link Distance (ft)	1216			375
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)		150	120	
Storage Blk Time (%)	0	1		
Queuing Penalty (veh)	0	2		

Network Summary

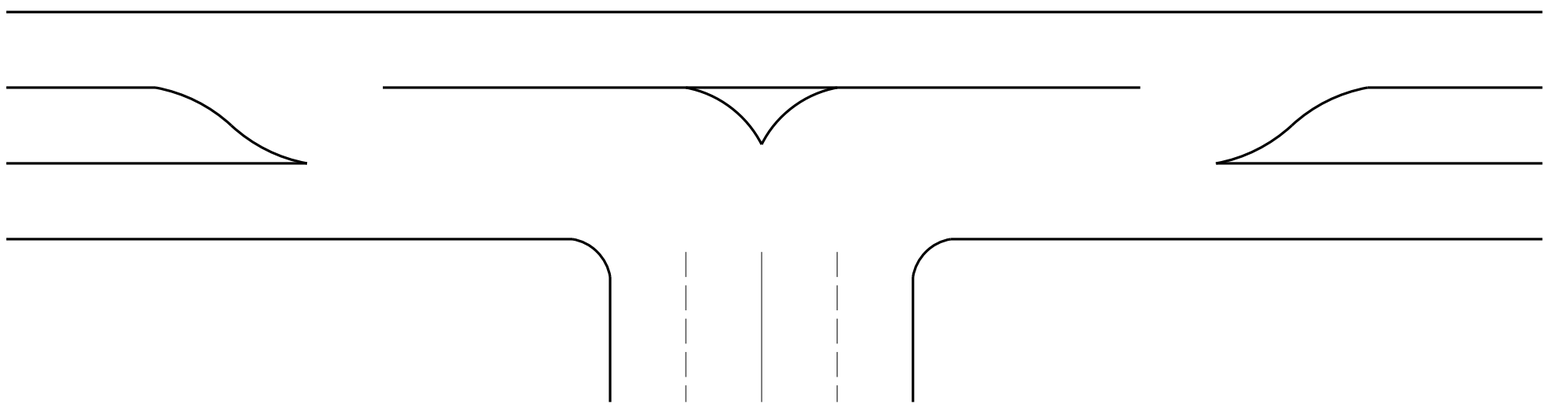
Network wide Queuing Penalty: 188

APPENDIX C7

Plotted on: 7/31/2018



RESTRICTED LEFT TURNS AND U-TURN



FLYING-T INTERSECTION

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Texas Department of Transportation
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ALTERNATIVE TRAFFIC OPERATIONS EXAMPLES

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