Final Design Concept Report

Church Street Widening - Stadium Avenue to US 70

ADOT Contract Number: 2010-021.12
ADOT Project Number: TRACS 0000 GH THR SZ027 03D
Federal Project Number: STP-THR-0(203)T

Town of Thatcher, Arizona

Prepared for the Town of Thatcher
by Kittelson & Associates, Inc.

Final Draft

April 2014

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Project No. 12418

April 2014

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EXECUTIVE SUMMARY

ADOT Project Number: TRACS 0000 GH THR SZ027 03D
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The project is located in the Town of Thatcher, within Graham County, along Church Street. The Improvements extend between Stadium Avenue to the west and US 70 to the east. The approximate length of the project is 5,584 feet.

Southeastern Arizona Governments Organization has programmed $184,517 for right-of-way acquisition during the fiscal year 2014 for the project. The engineer's opinion of probable construction cost for the preferred project improvements is $2,503,981.

No future or concurrent projects are anticipated adjacent to, or within, the improvement section.

ADOT will provide project administration, management, and review for both design and construction phases. Kittelson & Associates, Inc. is providing design services under contract with ADOT. The Town of Thatcher will enter into an agreement with ADOT for the administration of the project construction phase. Once complete, the Town of Thatcher will take maintenance responsibilities of the updated facility.

Church Street is a flat neighborhood street with unimproved shoulders which experiences periodic flooding during rain events. The widening of Church Street, between US 70 and Stadium Avenue, is intended to improve multimodal traffic operations and to alleviate surface ponding of storm water following rain events. The improvements will include widening the pavement, providing curb and gutter for the length of the project, provide for on-street parking and accommodate non-vehicular uses. The improvements are not intended to increase the capacity of the roadway, but rather improve the mobility for all road users and increase driver compliance with the posted speed limit.

The preferred alternative incorporates several multi-modal elements for users on Church Street. The cross section will maintain two 12-foot wide travel lanes and add five-foot wide bicycle lanes and 8.5-foot wide paved shoulders on both sides of the road to accommodate on-street parking. Between Stadium Avenue and High School Avenue the shoulder and bicycle lane on the north side of Church Street will be combined to provide diagonal parking for two major local educational and religious institutions in town. The parking and bicycle elements along Church Street maintain the neighborhood character of the road. In addition to vehicular elements, the preferred alternative includes five-foot wide sidewalks, three feet behind the curb, on both side of Church Street.

Curb bulb-outs are proposed as speed mitigation measures at four locations along the project to set the driving tone along the corridor and to increase compliance with the local speed limit. Raised median islands are also used as traffic calming devices at T-intersections along Church Street.

The preferred improvement alternative is estimated to require approximately 136,258 square feet of additional right-of-way.

1. INTRODUCTION

1.1 FOREWORD

Church Street is a two-lane neighborhood facility that runs east-west in the southern part of the Town of Thatcher. It is considered an Urban Collector based on AASHTO functional classification guidelines. It has a posted speed of 25 mph. The project is approximately 1 mile in length, and extends from Stadium Avenue on the west to US 70 on the east. Eastern Arizona College and the local high school are the major traffic generators along Church Street. A location map for the project is provided in Figure 1.

1.2 NEED FOR THE PROJECT

Church Street provides access to three landmark uses for the town, the Eastern Arizona College, the Latter-Day Saints (LDS) Institute, and Thatcher High School. A SpringHill Suites is located at the western end of the corridor and multiple residential properties line the street. The roadway pavement surface has degraded beyond repair and the gravel shoulders cannot convey the stormwater after each rain event. Water ponds within the roadway and shoulders following rainfall events. Curb and sidewalks are present intermittently and the majority of the intersections do not feature Americans with Disabilities Act (ADA) compliant ramps. Figure 2 illustrates examples of the conditions described above. Due to the important connections for the community, and the frequent ponding of rain water, this roadway was nominated for federal funding through ADOT.

1.3 DESCRIPTION OF THE PROJECT

Church Street improvements are aimed at alleviating roadway surface ponding after rain events, creating a continuous sidewalk network along the corridor, adding ADA compliant ramps at intersections, and creating an inviting neighborhood street character for all users, pedestrians, bicyclists, and automobiles. Proposed project elements include widening the pavement, providing curb and gutter for the length of the corridor, and reconstructing the intersections with side streets. The limits of the project extend up and downstream from Church Street along the side streets only to the extent required to rebuild the intersections.

Corridor improvements along Church Street commence east of Stadium Avenue (Sta 50+34.71) and terminate approximately 75 feet west of US 70 (Sta 104+63.00). This latter intersection between Church Street and US 70 was reconstructed by ADOT. Figure 3 illustrates the corridor vicinity and identifies the project termini.

Southeast Arizona Governments Organization (SEAGO) Transportation Improvement Program (TIP) assigns $184,517 in fiscal year 2014 to the Church Street improvement for right-of-way acquisitions. The project design was funded in fiscal year 2012 in the amount of $516,437 through the ADOT State Transportation Improvement Program (STIP).

Figure 1 Project Location

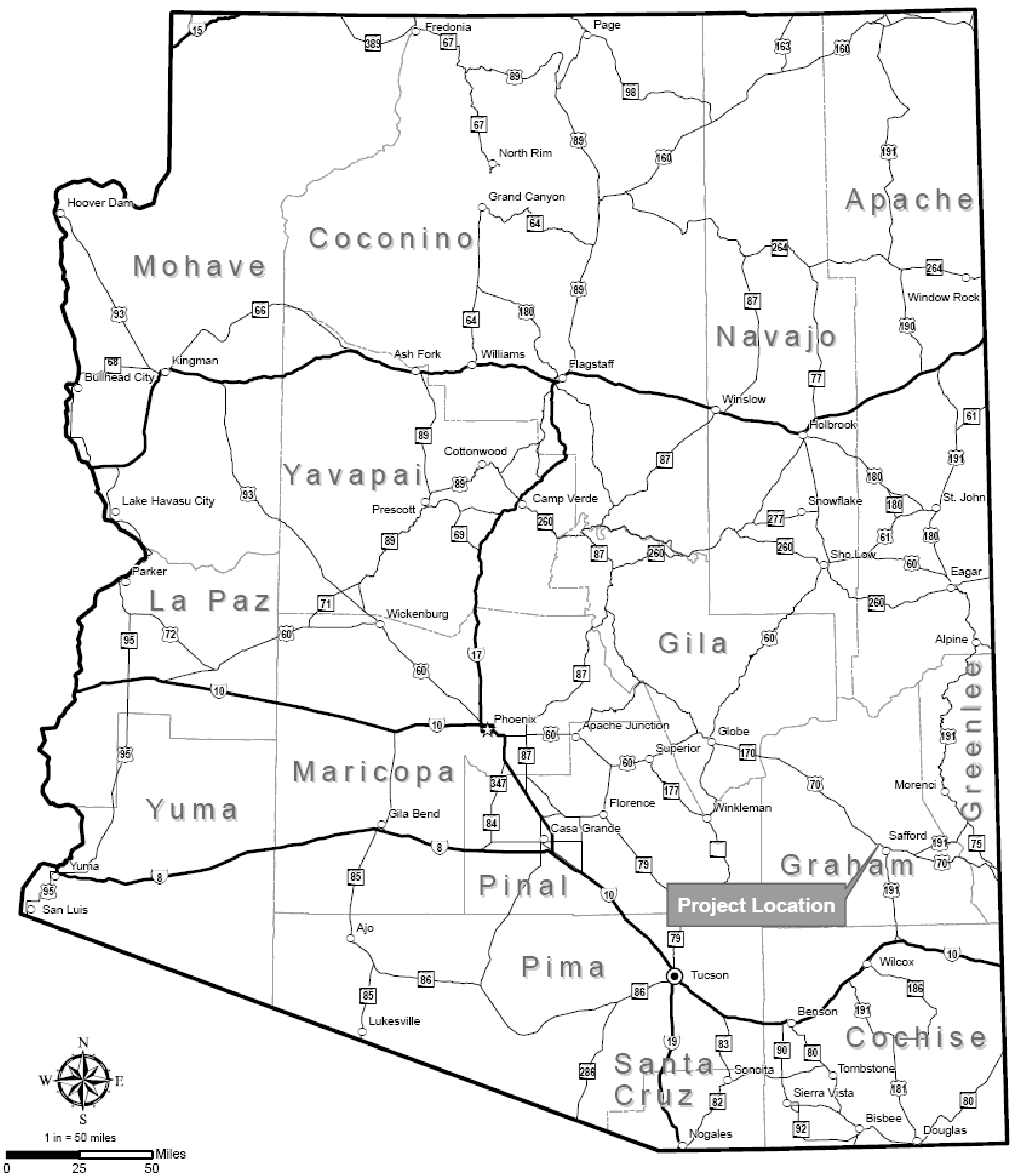
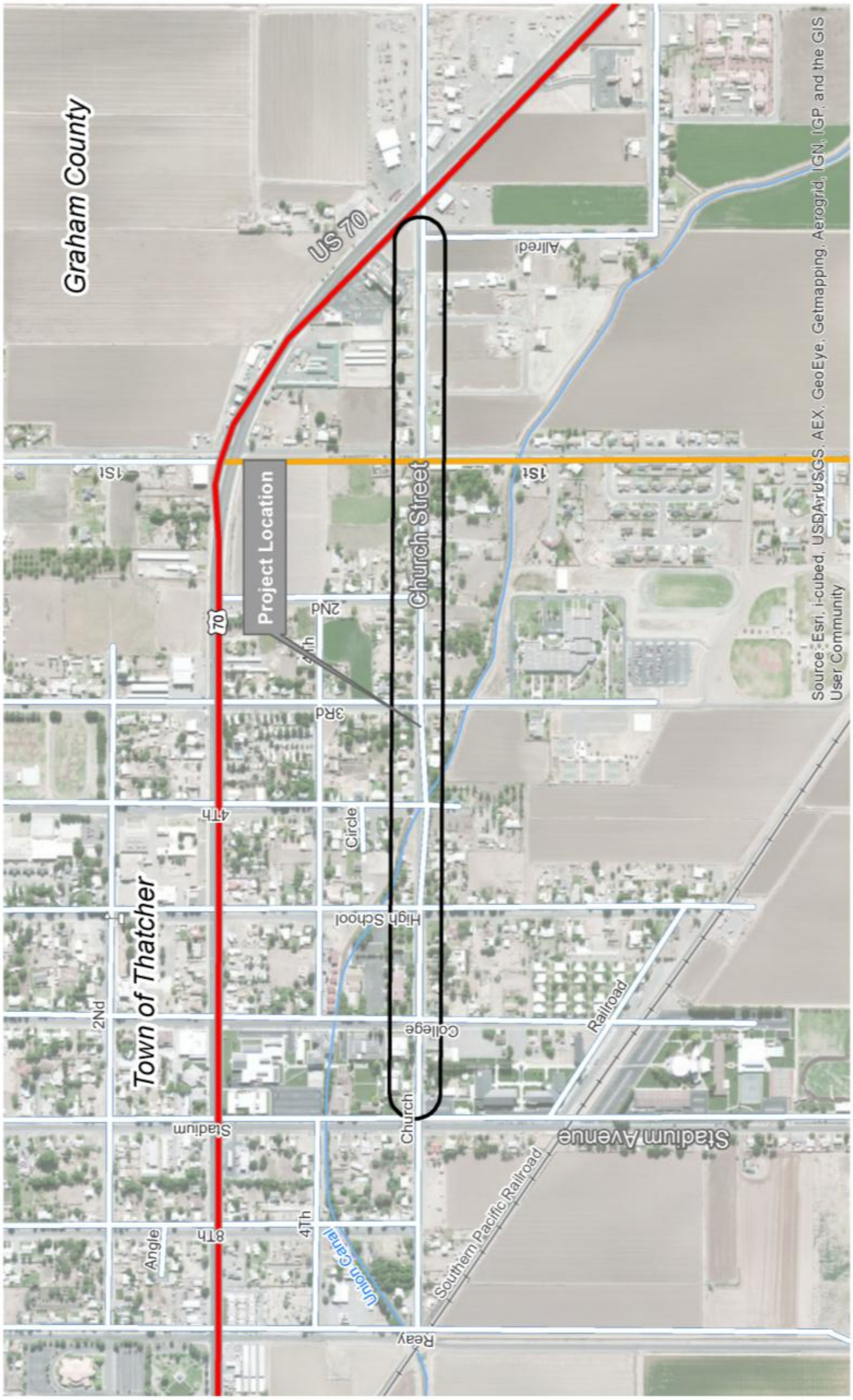


Figure 2 Examples of Existing Conditions

Figure 3   Corridor Vicinity



1.4 CHARACTERISTICS OF THE CORRIDOR

Church Street is the most southern continuous east-west street part of the originally platted Town of Thatcher grid network. This neighborhood street is paved with asphalt concrete and features two-travel lanes, one in each direction. The posted speed limit is 25 mph and all-way stop signs control the traffic at the intersections of Church Street and College Avenue and Church Street and 3rd Avenue. The pavement cross section differs along the corridor as follows:

- Between Stadium Avenue and High School Avenue it is approximately 60-foot wide
- Between High School Avenue and Diamond Springs Lane it is approximately 26-foot wide
- Between Diamond Springs Lane and US 70 it is approximately 36-foot wide.

In sections where the paved area narrows, a gravel shoulder takes its place. The shoulder is approximately 18-foot wide on the south side and 12-foot wide on the north side of the road. On-street parking is permitted on both the paved and gravel shoulder areas along the entire alignment. The existing Church Street profile is very flat, with a grade of approximately 0.2-percent. The roadway profile features sags in the vicinity of side street intersections. The general drainage pattern along the corridor is from the south to the north along the side streets and from the west to the east along Church Street.

Eight-foot wide sidewalks are built along the north side of Church Street in the vicinity of the Eastern Arizona College and LDS Institute, between Stadium Avenue and High School Avenue. Narrower, four-foot sidewalks extend between High School Avenue and 1st Avenue. Four-foot sidewalks are also present along the south side of Church Street between Stadium Avenue and 1st Avenue.

Church Street is located at the southern end of the original Town of Thatcher plat and therefore has an inconsistent right-of-way. From Stadium Avenue to west of 1st Avenue the right-of-way width is 82.5 feet, split between 49 feet to the north of the centerline and 33.5 feet to the south of the centerline. East of the 1st Avenue, the roadway has no formal right-of-way until approximately Sta 104+69.5, west of US 70. The surrounding property is privately or institutionally owned as is the case with the Eastern Arizona College.

Drainage in the project corridor has little to no definition; hence the ponding issues noted in the project need section of this report. Offsite drainage originates south of Church Street and is captured by the Union Canal. This canal bisects the project alignment west of 4th Avenue at approximate Sta 69+25. It crosses under the roadway via a reinforced concrete box culvert (RCBC) 6-foot high by 14-foot wide. This RCBC is the only structure crossing the alignment. Irrigation inlets and pipes are present at the following intersections with Church Street: Stadium Avenue, High School Avenue, and 1st Avenue. An irrigation ditch runs parallel to Church Street along the northern right-of-way line between approximate Sta 85+60 and the east side of 1st Avenue. It crosses under the north leg of the 1st Avenue and Church Street intersection via a 24-inch Reinforced Concrete Pipe (RCP). Another RCP crosses Church Street at approximate Sta 93+70 in the vicinity of the Diamond Springs Drive intersection. This pipe connects irrigation ditches south and north of Church Street.

The general topography within the study area is flat with built-out residential and institutional buildings along the Church Street alignment. Agricultural fields surround the town on all sides with the Gila River extending north-south approximately ¾ mile east of the project terminus. The soils along the corridor are "clay loam" and generally consistent with the AASHTO classification of A-4 or A-6. Pima Clay occurs along the alignment between approximate Sta 76+50 and 85+50. This type of soil is consistent with the AASHTO classification A-6. Vegetation along Church Street is consistent with urban landscaping plants since the corridor is built out.

The Thatcher General Plan indicates that the future land uses along Church Street will not differ greatly from what is currently in place. The plan does indicate that commercial land use will occur east of 1st Avenue, on the north side of Church Street, while the remainder is set as Low Density Residential, with Public/Institutional land use where the college and LDS church sits. No large developments are planned in the project corridor at this time.

1.5 AGENCY AND PUBLIC SCOPING

Given the small size of the community and the importance of the project to the Town of Thatcher, both the local administration and public have been informed of the project scope. The town council was briefed on the project scope and was involved in the improvement alternative selection process. The Town of Thatcher conducted a public open house on April 10, 2013 to present an overview of the project and alternatives for the future roadway cross section. The meeting was advertised in the Eastern Arizona Courier and property owners abutting Church Street were mailed a notification letter. Approximately 12 people attended the meeting. The study team received five written comments. In general, speed reduction and control was the most mentioned goal for the improvement. Local residents were concerned that school traffic for both the Eastern Arizona College and Thatcher High School would take advantage of the improved street to increase speeds. These concerns opened new opportunities for speed reduction corridor elements. Such elements could be intersection treatments like roundabouts or mid-block speed humps or speed tables. These are further discussed in the Design Concept Alternatives section of this report.

A project website is available to the public for general information and scoping documentation as it becomes available. The site URL is http://sites.kittelson.com/churchstreetwidening.

Arizona Game and Fish Department and the US Fish and Wildlife Service were contacted on May 9, 2013 via email. Both agencies were provided a letter describing the project and requested to provide input into the project development process. No concerns or issues were raised by the staff contacted.

2. TRAFFIC AND CRASH DATA

Church Street improvements are aimed at drainage and multi-modal access and safety. As such the traffic analysis for the corridor was limited to developing Equivalent Single Axle Load (ESAL) calculations for the design of the pavement section. No capacity analyses were performed, nor did the study collect intersection or segment traffic counts. KAI prepared a *Design Traffic and Crash Analysis Technical Memorandum*, which was approved by the Town of Thatcher on May 6, 2013. The following provides a summary of the crash and traffic analysis performed.

2.1 CRASH ANALYSIS

Crash data on Church Street for the 3-year period between 2010 and 2012 was obtained from the Town of Thatcher Police Department. The crash data is summarized in Table 1.

Table 1 Summary of Crash Data

Date	Route	Cross Street of Segment	Direction of Travel	Crash Type	Crash Severity
09/08/2010	Church St	Hwy 70	East	Rear end	Property damage only
09/23/2010	Church St	Pedestrian Crossing	West	Hit Pedestrian	Hospitalization
11/03/2010	Church St	College Ave	South	Angle – Ran Stop Sign	Property damage only
03/01/2011	College Ave	Church St	South	Hit Pedestrian	Hospitalization
09/01/2011	Church St	4th Ave	North	Angle	Property damage only
01/25/2012	Church St	Stadium Ave	East	Reversing into traffic	Property damage only
08/27/2012	Church St	Stadium Ave	West	Reversing into traffic	Property damage only

The results in Table 1 indicate that the majority of crashes occurred along the western portion of project corridor between Stadium Avenue and College Avenue. This section of Church Street is adjacent to Eastern Arizona College and the LDS Institute facility. Both institutions generate foot traffic across Church Street, hence two out of the seven crashes involved pedestrians. All other crashes were categorized as property damage only, which is consistent with the expected low travel speeds and traffic volumes along this neighborhood street. No fatalities were recorded along the project corridor between 2010 and 2012.

2.2 TRAFFIC ANALYSIS

Design traffic data was developed for year 2040 for use in calculating an Equivalent Single Axle Load for the pavement design. This project is not intended to increase capacity along Church Street; therefore only one average daily traffic (ADT) volume estimate was developed. Both the no-build and improvement alternative are estimated to accommodate the same amount of traffic.

The 2040 AADT volume was estimated using available count data from 2009 along Church Street just west of College Avenue and the estimated yearly population growth based on the Town of Thatcher General Plan. The 2009 Church Street ADT was recorded at 1,905 and the yearly population growth is estimated at 4%; therefore the 2040 design traffic along Church Street is estimated at approximately 4,270 vehicles.

Heavy vehicle traffic by-passes the Church Street corridor along US 70. The largest vehicles expected along Church Street are buses and emergency vehicles. An estimated 32 school buses use Church Street while school is in session to access the local high school. Based on the assumed existing traffic volume, that equates to a heavy vehicle percentage of 1.7%. The design heavy vehicle percentage was rounded up to two (2) percent.

3. DESIGN CONCEPT ALTERNATIVES

3.1 INTRODUCTION

Three future roadway cross sections were evaluated and presented to the public:

- Cross Section 1: This alternative includes two travel lanes, two bicycle lanes, paved shoulders, and rebuilt sidewalks. This cross section accommodates all uses along the corridor. Both the public and town officials preferred this alternative.
- Cross Section 2: This alternative includes a two-way left-turn lane, two travel lanes, two bicycle lanes, and rebuilt sidewalks. The emphasis of this alternative is access and turning movements at intersections.
- Cross Section 3: This alternative includes two travel lanes, paved shoulders, and wide multi-use paths on both sides of the road. The emphasis of this alternative is pedestrian and bicyclist activity.

Three intersection treatments were evaluated for their effectiveness at reducing vehicular travel speeds and enhancing the built environment along the corridor:

- Four-way curb bulb-outs
- Mini-roundabouts with traversable intersection island
- Urban roundabouts with raised intersection island

3.2 DESIGN CONCEPT ALTERNATIVES CONSIDERED AND DISCONTINUED

The No-build alternative was not considered in the evaluation because it would not resolve the drainage and pedestrian accessibility issues noted in the project need. Rehabilitating the existing pavement surface still allows for ponding in the roadway shoulder because the roadway profile and undefined drainage patterns are not addressed.

A minimized future cross section with only two travel lanes, bicycle lanes, and upgraded sidewalks was considered for the section of Church Street east of 1st Avenue; however, it was discontinued due to the lack of flexibility in adding roadway elements in the future. It also lacks consistency along the corridor, which may disadvantage the residents in this section of the corridor.

Cross sections without bicycle elements were removed from consideration because the town and local residents are supportive of these elements being included in all cross sections.

Traffic signal control was not evaluated at any intersections along the study corridor due to the low traffic volumes projected for the design year.

3.3 DESIGN CONCEPT ALTERNATIVES STUDIED IN DETAIL

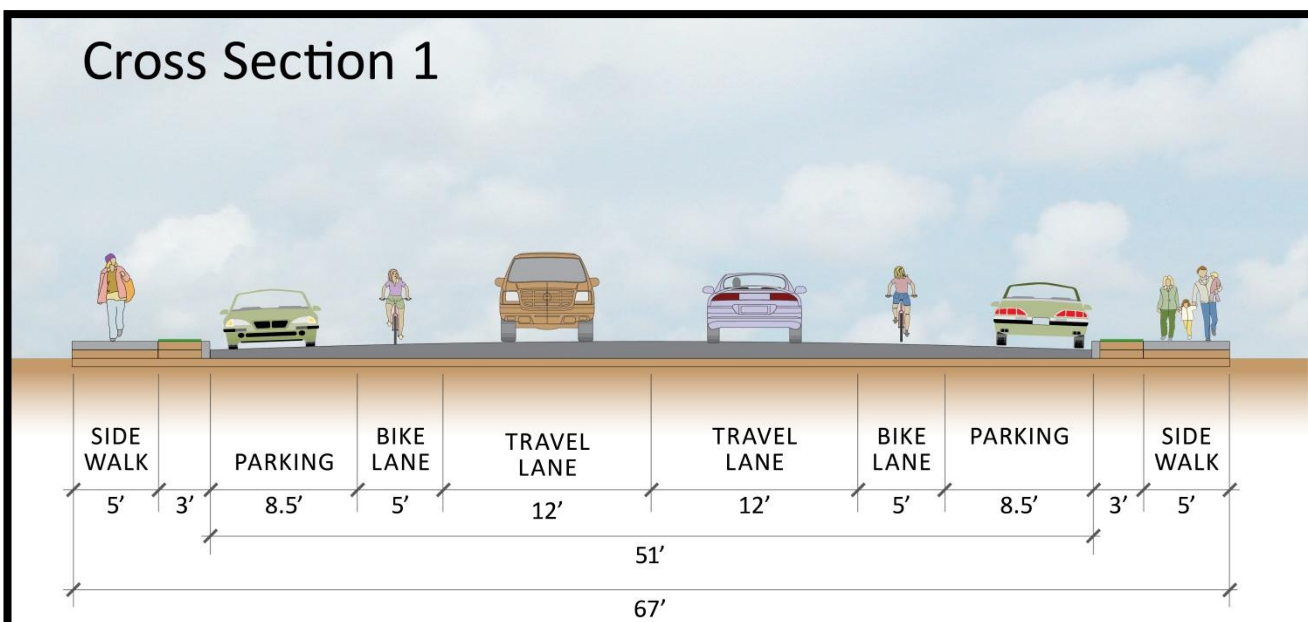
Evaluating the design alternatives followed a two-step process. First, the engineering team provided the town staff and the public alternatives for future street cross sections. Input collected during the public open house helped in the selection of a cross section and established additional criteria for the corridor design. The public focused on speed control and safety for the pedestrians. These needs led the team to evaluate different intersection treatments that can best meet the criteria. This second tier of analysis implements the preferred cross section from the first phase of evaluation. The following sections describe the alternatives and evaluation process in further detail.

3.3.1 CROSS SECTION 1

Cross Section 1 incorporates several multi-modal elements for multiple users on Church Street. The cross section will maintain two 12-foot wide travel lanes and add 8.5-foot wide paved shoulders on both sides of the road to accommodate on-street parking. These two elements maintain the neighborhood character and use of the road while improving the pavement section for the two existing travel lanes. In addition to vehicular elements, Cross Section 1 includes a five-foot bicycle lane and five-foot sidewalks three feet behind curb on both side of Church Street. These elements create the space necessary to facilitate the movement of pedestrians and bicyclists.

The overall cross section width would be 67 feet with a 51-foot wide paved area. Cross Section 1 is illustrated in Figure 4.

Figure 4 Cross Section 1 Illustration

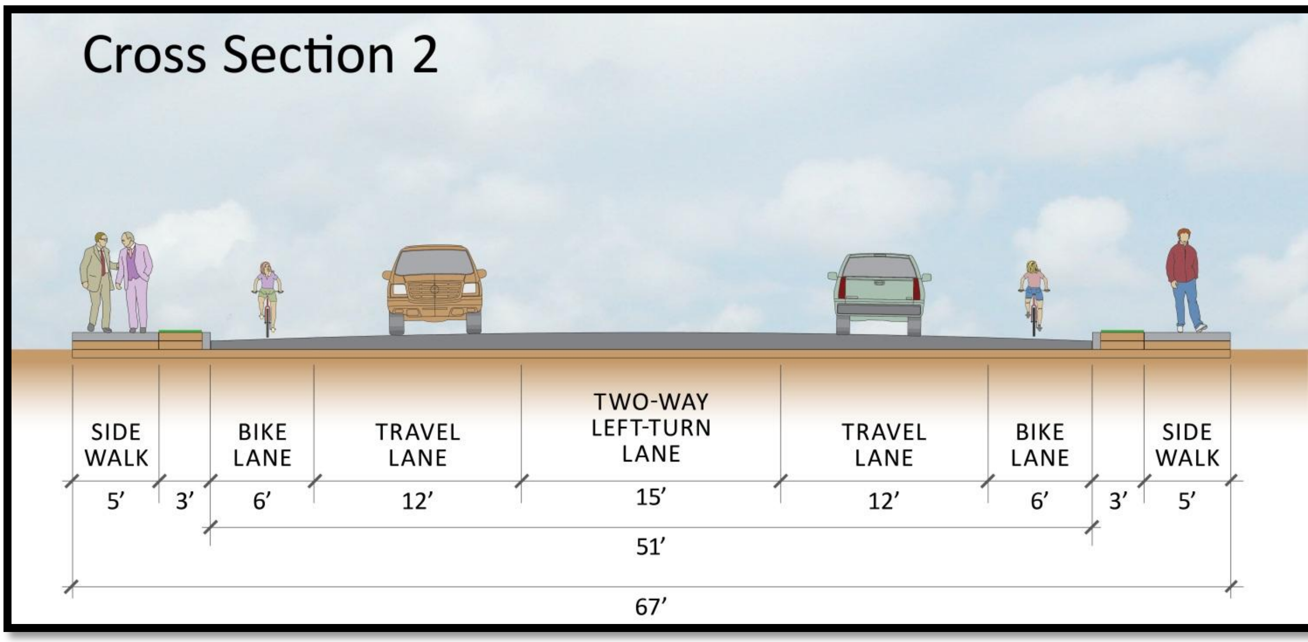


3.3.2 CROSS SECTION 2

Cross Section 2 provides a center two-way left-turn lane to facilitate access to and from the side streets and residential driveways. This center lane would be 15-foot wide. Two 12-foot wide general travel lanes and a six-foot wide bicycle lane in each direction would be provided. The bicycle lanes are wider in this alternative cross section compared to Cross Section 1 because they are located between the active travel lane and the curb, limiting the buffer room for the cyclists. The sidewalks in Cross Section 2 would be the same as in Cross Section 1, five-foot wide with a three-foot buffer.

The overall cross section width would be 67 feet with a 51-foot wide paved area. Cross Section 2 is illustrated in Figure 5.

Figure 5 Cross Section 2 Illustration

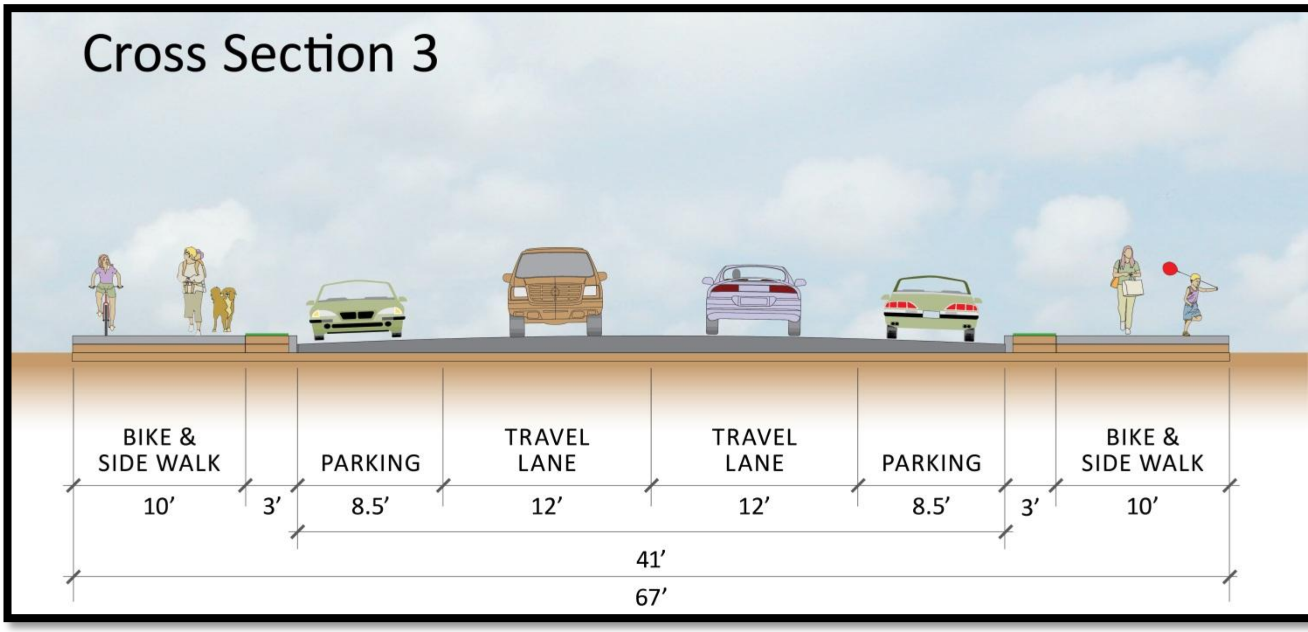


3.3.3 CROSS SECTION 3

Cross Section 3 separates the vehicular and non-vehicular users by providing a wide 10-foot multi-use path on either side of the road. This area is separated from the roadway by a three-foot buffer and would accommodate both pedestrians and cyclists. The roadway cross section comprises two 12-foot travel lanes and 8.5-foot wide paved shoulders for parking on either side of the road.

The overall cross section width would be 67 feet with a 41-foot wide paved area. Cross Section 3 is illustrated in Figure 6.

Figure 6 Cross Section 3 Illustration



3.4 INTERSECTIONS ALTERNATIVES

The general consensus among the public open house attendees was that vehicular travel speeds should be kept low after the street improvement, consistent with the posted speed limit, which is 25 mph. As a result, the design team suggested three different intersection treatments that may reduce driving speeds.

The first alternative narrows the paved section at four-way intersections with curb bulb-outs. This treatment gives drivers the physical cues to slow down as they approach the intersection but does not impede the flow of traffic. Once drivers get used to the treatment it may become less effective. Curb bulb-outs also reduce the pedestrian crossing length at these intersections.

The second intersection treatment would be a mini-roundabout with traversable center and approach splitter islands. This alternative builds upon the curb bulb-outs by providing additional physical elements in the center of the roadway both in the center and along the intersection approaches. The mini-roundabout can increase compliance for passenger vehicles and reduce the driving speed; however, it may not be as effective with light or large pickup trucks.

The third option is an urban roundabout with raised intersection center and approach splitter islands. These islands would feature rolling curbs and would be filled with concrete, similar to large traffic separators. The urban roundabout option provides a physically channelized path through the intersection that slows down driving speeds due to the turning maneuvers required to navigate the intersection. The raised curbs create an environment where a vehicle would not exceed 25 mph while navigating the intersection safely. This type of intersection provides the most consistent speed compliance from drivers.

3.5 EVALUATION OF ALTERNATIVES

3.5.1 CROSS SECTIONS EVALUATION

All cross section alternatives considered and presented to the public have the same overall constructed footprint, 67 feet wide. In general, the project corridor has a built cross section from the back of the south sidewalk to the back of the north sidewalk of approximately 65 feet. Since the corridor is built out to approximately the same extent as the proposed cross sections, all three alternatives have minimal to no additional impact on the following evaluation criteria:

- present and future land use
- environmental
- cultural resources
- archeological
- floodplains
- structures

The three cross section alternatives have the same impact on the following evaluation criteria:

- right-of-way
- utilities
- drainage
- earthwork
- constructability
- traffic control

The following evaluation criteria emerged as key decision points for the Town of Thatcher community based on the public open house discussions and comments:

- capacity and level of service
- safety
- socio-economic considerations
- construction cost

Each criterion is described here in further detail, explaining what objectives the alternative cross sections should meet in order to be evaluated. Intersection options are evaluated later in this report section after the selection of a typical section for Church Street.

Capacity and level of service: Vehicle capacity along the corridor is not currently an issue, nor is it expected to become an issue due to the low projected traffic volumes; however, with increased pavement width the driving speed along the corridor may increase. The open house participants were concerned about the possibility of drivers exceeding the 25-mph posted speed limit after the completion of the project; therefore, this evaluation criterion focuses on the ability of a cross section to maintain the existing capacity without enabling drivers to increase speeds. Cross Section 3 ranked highest in this criterion because it has the narrowest roadway pavement width; therefore, providing a more constrained driving environment that may discourage drivers from speeding. Cross Section 2 ranked the lowest in this criterion because it has a wider roadway pavement width with fewer potential obstructions, such as on-street parked cars.

Safety: Safety was assessed along Church Street from the most vulnerable user's perspective. Since the facility is a neighborhood street with casual bicycle riders and frequent pedestrians, the safety evaluation along the corridor is a measure of how well each cross section accommodates these two user groups. Another measure of safety effectiveness is the interactions between all street users. Bicycle lanes are considered an effective way to improve the environment for cyclists. Sidewalks are a part of each alternative for pedestrians; however, Cross Section 3 includes a shared-use path. This facility was considered less desirable for the pedestrian users because it forces them to use the same space with faster moving bicycles. Cross section 1 ranked the best in this criterion because it separates the cyclists from pedestrians, and because cars may be driving slower next to the adjacent bicycle lanes and parked cars. Cross section 2 ranked the lowest in this criterion because vehicles are likely to drive faster next to the bicycle lanes due to the additional pavement width available to them.

Socio-economic considerations: Eastern Arizona College is a landmark for the Town of Thatcher. Church Street bisects the campus and connects the college to the community. Cross sections that foster the movement of people to and from the college and enhance the corridor visually were preferred. Maintaining on street parking is also a key measure for socio-economic consideration. Cross section 1 ranked the best in this criterion because it includes both parking facilities for patrons of the local college and business but also includes separate spaces for cyclists and pedestrians. Cross section 2 ranked the lowest due to the lack of parking facilities.

Construction costs: A preliminary cost comparison was performed between the three sections. The additional concrete required to construct wider shared-use paths is higher than the same area paved with asphalt; Cross Section 3 would be more expensive to build than the other two alternatives. Cross Sections 1 and 2 would have approximately the same construction costs because they have the same roadway pavement width and sidewalk elements. Section 5.3 of this report includes preliminary costs for Cross Section 1 and 3.

Each cross section alternative was ranked relative to each other. The alternative that meets the criteria the best was given 3 points, while the alternative with the worst relative performance was given 1 point. Table 2 summarizes the scores and overall ranking of the three cross section alternatives.

Table 2 Cross Sections Evaluation Matrix

Evaluation Criteria	Capacity/LOS	Safety	Socio-economics	Construction Cost	Total Points
Cross Section 1	2	3	3	3	11
Cross Section 2	1	1	1	3	6
Cross Section 3	3	2	2	1	8

Cross Section 1 scored the highest in the evaluation matrix. It was also the preferred alternative at the public open house. Attendees preferred Cross Section 1 because it balances all modes of transportation while maintaining the neighborhood character and use of the roadway.

3.5.2 INTERSECTIONS EVALUATION

Intersection treatments were evaluated based on the same key criteria used for the cross sections evaluation: capacity and level of service, safety, socio-economic considerations, and construction cost. The intersection treatment alternatives were previously described in Section 3.4 and include:

- Curb Bulb-outs with stop-control
- Mini-roundabout
- Urban roundabout

The following section describes the evaluation criteria for the three preferred intersection treatments.

Capacity and level of service: Traffic volumes along the Church Street are projected to be low in the design year; hence capacity at the intersections is not expected to be an issue. Level of service at intersections is a measure of time delay incurred by drivers waiting to go through the intersection. NCHRP Report 672 notes in section 3.6 COMPARING PERFORMANCE OF ALTERNATIVE INTERSECTION TYPES that "A roundabout will always provide a higher capacity and lower delays than all-way stop-control (AWSC) operating with the same traffic volumes." Traffic operations research models also indicate that mini-roundabouts have a slightly lower capacity than urban single-lane roundabouts. Based on these two planning level comparisons, the urban roundabout ranked the best in this criterion. The curb bulb-outs with AWSC ranked the lowest.

Safety: Pedestrian safety was paramount in the evaluation of intersection treatments due to the location of two educational facilities along Church Street. The roundabout treatments require narrower entry lanes to the intersections in order to accommodate raised median islands. Cyclists approaching the roundabouts can use slightly wider sidewalks around the roundabouts or they can ride in the vehicle travel lanes. Mixing the cyclists and pedestrians on the roundabout approaches may increase the potential for conflict between these different users. Pedestrians crossing the roundabout approaches have an additional refuge in the middle of the roadway provided by the median islands as compared to the typical crosswalks featured by the curb bulb-out intersections. All three intersection treatments add enhancements and potential challenges for pedestrians relative to each other; therefore, all three alternatives were ranked equally in this criterion.

Socio-economic considerations: Church Street is a built urban environment with businesses and residences abutting the roadway. The socio-economic impact of intersection treatments was measured in terms of impacts to adjacent properties, new right-of-way required to build the intersection and the availability of on-street parking near the intersection. The two roundabout options would require approximately 8,750 square feet of new right-of-way. In addition, the urban roundabout would displace approximately 22 on-street parking spaces adjacent to the Stadium Avenue, 3rd Avenue, and 1st Avenue intersections. The mini-roundabout alternative would displace approximately six on-street parking spaces adjacent to the same intersections. For these reasons, the curb bulb-out alternative ranked best in this criterion, followed by the mini-roundabout. The urban roundabout would have the greatest impacts; therefore, ranking the lowest.

Construction costs: A preliminary cost comparison was performed between the intersection treatment alternatives. The urban roundabout was estimated to cost approximately $100,000 more per intersection than building curb bulb-outs. This cost difference was primarily due to the additional raised median deflection islands on all four intersection approaches and work required to install a center raised island. The mini-roundabout cost would be slightly lower than the urban roundabout because the center island is not raise and the approach median islands are shorter, but it would still be more expensive than the curb bulb-outs. As a result, the curb bulb-out intersection treatment ranked the best in this evaluation criterion.

Each intersection treatment alternative was ranked relative to each other. The alternative that meets the criteria the best was given 3 points, while the alternative with the worst relative performance was given 1 point. Table 3 summarizes the scores and overall ranking of the three intersection alternatives.

Table 3 Intersection Treatments Evaluation Matrix

Evaluation Criteria	Capacity/LOS	Safety	Socio-economics	Construction Cost	Total Points
Curb Bulb-outs	1	2	3	3	9
Mini Roundabout	2	2	2	2	8
Urban Roundabout	3	2	1	1	7

The use of curb bulb-outs at intersections scored the highest in the evaluation matrix.

3.6 RECOMMENDATIONS

Cross Section 1 with curb bulb-outs treatments at College Avenue, High School Avenue, 3rd Avenue, and 1st Avenue intersections were selected as the preferred improvements for the following reasons:

- Cross Section 1 scored the highest in the evaluation matrix, meets the corridor enhancement needs, and is preferred by the public.
- Curb bulb-outs along the corridor may improve driver adherence to the posted speed limit with little or no impact on the surrounding properties.

4. MAJOR DESIGN FEATURES (PREFERRED ALTERNATIVE)

4.1 INTRODUCTION

The project will be implemented in accordance with Maricopa Association of Governments (MAG) and ADOT standards, to the extent practical for an urban neighborhood street. Additional guidance manuals utilized in the project development process include:

- A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, 2011
- Roadside Design Guide (RDG), AASHTO, 2011
- Manual on Uniform Traffic Control Devices (MUTCD), Federal Highway Administration (FHWA), 2009 Edition
- Arizona Supplement to the 2009 Manual On Uniform Traffic Control Devices (January 2012)
- ADOT Roadway Design Guidelines (ARDG), ADOT, 2012
- Maricopa County Roadway Design Manual (MCRDM), Maricopa County Department of Transportation, 2011

4.2 DESIGN CONTROLS

Church Street is an urban undivided neighborhood street with a posted speed limit of 25 mph. As such, the design speed for the facility is 30 mph. The project design year is 2040. The preferred right-of-way width is 82.5 feet. Table 4 lists the roadway geometric design controls and sources for these standards.

Table 4 Design Controls

Geometric Element	Controlling Standard	Source
Lane Widths		
Through Lanes	12’	MCRDM Table 5.1
Parking Lane	8’	MCRDM Table 5.1
Bicycle Lane	5’ (without gutter)	MCRDM Table 5.1
Sidewalk Width	5’	MCRDM Section 5.36
Max. Superelevation	0.02 ft/ft	Green Book Table 3-15
Max. Relative Slope	1:152	Green Book Table 3-15
Max. Gradient	7% (Level Terrain)	MCRDM Table 5.5
Min. Gradient	0.25% (0.15% in special cases)	MCRDM Section 5.11
Vertical Grade Break	2.0% max. (roadway) 4.0% (sidestreet)	MCRDM Section 5.11
Vertical Curve Length	Min. 3 x Design Speed	ARDG Section 204.4
Clear Zone Width	1.5’ (from the face of curb)	RDG Chapter 10
Side Slopes	3:1 (cut & fill) or retaining wall	RDG

4.3 HORIZONTAL AND VERTICAL ALIGNMENT

The project begins at station 50+34.71 east of Stadium Avenue and ends at station 104+63.00 west of US 70. The construction centerline alignment for Church Street parallels the 1, 2, 11, and 12 section lines approximately 16 feet south. The start bearing for the alignment is S 89°38’49" E, which shifts to S 89°55’57" E east of Stadium Avenue. The same bearing is maintained until the alignment reaches Allred Lane and a 45°40’45" curve is introduced. The tangents’ point of intersection (PI) is located at station 103+99.63. The alignment terminates along a tangent bearing N 44°23’18" E and perpendicular to the US 70 right-of-way centerline.

The project corridor is flat with a total change of elevation of approximately 12 feet over the mile long project. Consequently, the proposed Church Street profile features shallow grades. Sags were located at side street intersections to allow for the stormwater to drain away from Church Street north, along the existing natural flow paths along the corridor. Small crests were located mid-block to facilitate the water flow down to the intersections.

4.4 ACCESS

Church Street is a neighborhood street with existing residential and business driveways accessing the road along the entire alignment. Unrestricted access will be maintained along the alignment.

4.5 RIGHT-OF-WAY

Church Street was once the southern edge of Thatcher. As such, the Town did not assign the typical 99 feet of right-of-way to this corridor during the original platting of the community. The existing right-of-way width is 82.5 feet between Stadium Avenue and 1st Avenue. The existing Church Street elements are built close to the southern right-of-way line between these two intersections. Property owners will not see a considerable shift in the existing back of sidewalk; however, some additional right-of-way is required in areas where the existing sidewalk extends within private property.

An additional five feet of right-of-way will be required on the south side of Church Street between Stadium Avenue and College Avenue and eight additional feet will be required between College Avenue and High School Avenue. The proposed southern sidewalk will be built within or along the existing southern right-of-way line between High School Avenue and 1st Avenue; however, a 7.5-foot wide temporary construction easement will be required. Small right-of-way outcrops that extend south along the southern intersection legs of College Avenue and 1st Avenue are required. These are small areas that will accommodate the new pedestrian ramps on the southwest corners at the intersections of Church Street and College Avenue, and Church Street and 1st Avenue.

The Town will also acquire right-of-way east of 1st Avenue to US 70 to formally take ownership of areas where the roadway is built today. The right-of-way cross section east of 1st Avenue will be 68.5-foot wide. A 12-foot wide temporary construction easement will be required on the south side of Church Street between 1st Avenue and Allred Lane. A 14.5-foot wide temporary construction easement will be required on the north side of Church Street between 1st Avenue and the east leg of Diamond Springs

Drive. A total of 48 parcels will be impacted along the corridor with a total area of 71,173 square feet or 1.64 acres needed for right-of-way and 52,549 square feet or 1.21 acres needed for temporary construction easements. All right-of-way acquisitions are anticipated to result in partial takes only. No business or residential relocations are anticipated.

4.6 DRAINAGE

A drainage report was prepared for the preferred alternative and details the existing and proposed drainage conditions. Per coordination with the Town of Thatcher, stormwater drainage can be allowed to flow along Church Street to the side streets, where it will be conveyed north to a point of discharge. No new storm drains are proposed as part of the roadway design. The anticipated 10-year flows can be conveyed within the roadway right-of-way at a depth of less than 12 inches (as required per Section 29-32-6 of the Town of Thatcher subdivision regulations). Existing inlets at intersections will be reconstructed to accept flows as occurs under existing conditions. Some design elements may require coordination with irrigation districts/companies which own facilities in the area that connect and/or conflict with existing drainage facilities.

Stormwater is expected to flow above the top of curb into adjacent properties, as it does today. However, the new curbed roadway section has increased carrying capacity; therefore it limits the future stormwater flows outside the roadway. Table 5 summarizes the existing and proposed roadway stormwater carrying capacity by street block along the study corridor. Appendix 1 includes the Drainage Report with additional details.

Table 5 Comparison of Roadway Stormwater Flow Capacities

Location	Curb-Full Street Flow Capacity (cfs)	
	Existing	Design
Stadium Ave to College Ave	6.68	25.12
College Ave to High School Ave	17.20	55.07
High School Ave to 4th Ave	2.29	18.31
4th Ave to 3rd Ave	20.85	29.81
3rd Ave to 2nd Ave	13.92	36.85
2nd Ave to 1st Ave	4.89	38.94
1st Ave to Diamond Springs-West	0.24	30.37

4.7 SECTION 401 AND 404 OF THE CLEAN WATER ACT

The project will not involve disturbance to jurisdictional waters of the United States as regulated by the US Army Corps of Engineers under the Clean Water Act; therefore, a Section 404 permit will not be required. Because more than 1 acre of land will be disturbed, an Arizona Pollutant Discharge Elimination System (AZPDES) permit will be required. As part of the AZPDES permit, a Storm Water

Pollution Prevention Plan will be prepared and implemented, which will minimize the transport of sediment by requiring the contractor to use stormwater and erosion control best management practices.

4.8 FLOODPLAIN CONSIDERATIONS

The study corridor is not located in a FEMA designated 100-year floodplain.

4.9 EARTHWORK

Given the flat terrain and age of the existing roadway bed, the Church Street reconstruction will require less embankment material than will be generated during the roadway excavation. Roadway excavation will remove just enough existing material for the future aggregate base and asphalt concrete structural sections. The total roadway waste material to be hauled away will be approximately is 3,911 cubic yards.

Preliminary geotechnical reviews of online NRCS maps indicate the potential presence of Pima Clay units between approximate Sta 76+50 and Sta 85+50. The design team is assuming over excavation of the entire road width between these two stations at a depth of three feet below the finish grade. This section of the roadway will be scrutinized during the field investigations to better define the need and limits of over excavation.

A private borrow pit is located in the vicinity of the project corridor approximately 5 miles away from the site, along Airport Road in Safford. This location has previously completed the ADOT Environmental Analysis Process in June 2013 and was assigned the following tracking number: CM0016.

4.10 CONSTRUCTION PHASING AND TRAFFIC CONTROL

Traffic control will be specified by a traffic control plan or procedures and guidelines in the ADOT Traffic Control Manual for Highway Construction and Maintenance. Access to adjacent properties will be maintained during construction. Intersection curb extensions are elements of the proposed design that required special construction phasing consideration. The proposed improvements construction is anticipated to proceed in four major phases. They are described below:

- Phase 1
    - Place the advance warning signs
    - Clear obstructions in the south shoulder of Church Street and relocate utilities
    - Grade and compact the south shoulder for traffic use
- Phase 2
    - Open the south shoulder and shift the eastbound traffic onto it.
    - Shift the westbound traffic onto the existing eastbound Church Street
    - Construct the north half of Church Street. Do not install intersection bulb-outs at this phase.

- Phase 3
  - Open the reconstructed north half of Church Street and shift both sides of traffic onto it.
  - Construct the south half of Church Street, including the intersection curb extensions.
- Phase 4
  - Open the reconstructed Church Street travel lanes. Shift both sides of traffic onto them.
  - Finalize the intersection construction, including the north side bulb-outs.
  - Place final pavement makings and remove advance warning signs.

Detours are not anticipated as part of the preliminary traffic control plan. However, the adjacent street network is laid out in a grid format and allows the flexibility to temporarily close intersections along Church Street with minimal detours, less than half mile.

4.11 TRAFFIC DESIGN

Intersection treatments that promote slower vehicular travel speeds are incorporated along the entire corridor. Curb bulb-outs are proposed at the intersections of Church Street and College Avenue, High School Avenue, 3rd Avenue, and 1st Avenue. The Church Street cross section is narrowed to 34 feet at these intersections to reduce the pedestrian crossing distances and provide additional visual cues to drives that they are approaching an intersection. All four intersections will be four-way stop-controlled to help maintain the local speed limit of 25-mph.

Median islands, three-foot wide by 17-foot long, are proposed along Church Street at the T-intersections of 4th Avenue, 2nd Avenue, and Diamond Springs Lane. These elements will be signed as obstructions, consistent with traffic separators signing.

Final pavement markings and signs shall conform to the Arizona Supplement to the Manual on Uniform Traffic Control Devices, 2009 Edition.

4.12 UTILITIES, RAILROAD AND IRRIGATION SYSTEMS

Several utilities have been identified within the project limits. These include:

- ADOT – electric (roadway lighting along US 70)
- Centurylink – communication cable (overhead) and fiber optic (underground)
- City of Safford –water
- Copper Valley Telephone Co-op – communication cable and fiber optic
- Graham County Electric Co-op – gas
- Town of Thatcher – electric (overhead)

Overhead power and cable facilities from the Town of Thatcher and Centurylink, respectively require relocation. In pavement water valves and manholes will be adjusted to the final grade of the improved road.

4.13 STRUCTURES

No new structures are proposed as part of the preferred improvement alternative. Existing stormwater inlet and catch basins will be reconstructed to match the future roadway surface elevations and/or curb profiles.

4.14 PRELIMINARY PAVEMENT DESIGN

Preliminary pavement recommendations were prepared for the preferred alternative. The structural coefficients for asphaltic concrete (AC) and base materials used for design were given in Table 202.02-6 of the Preliminary Engineering and Design (PE&D) Manual. Accordingly, the structural coefficients used for AC and aggregate base materials were 0.44 and 0.14, respectively. A drainage coefficient of 0.93 was assigned based on Table 202.02-7 of the ADOT Materials Design Manual for poor drainage conditions and with a seasonal variation factor (SVF) for the Safford area of 1.6 based on Figure 202.02-1 and Table 202.02-4 of the ADOT Materials Design Manual.

The required pavement structural number was calculated as 2.25 based on the design parameters described above. This exceeded minimum required structural number of 2.0 based on page 202.04-1 of the PE&D Manual, so a structural number of 2.25 was used for design of the pavement structural sections. A preliminary pavement structure of 4 inches of AC on top of 9 inches of aggregate base (AB) was chosen. This section yields a structural number of 2.65, which is higher than then calculated required number. Appendix 2 includes the preliminary Geotechnical and Pavement Recommendations Technical Memorandum.

4.15 HABITAT CONNECTIVITY

The project area is urbanized, with vegetation consisting of landscaped trees and shrubs; native vegetation is mostly lacking. Agricultural fields are present near the eastern end of the project area, both north and south of the project limits. There are no natural drainages in the project area, though a cement-bottom canal crosses the project limits at 4^{th} Avenue. Adjacent lands to the north and south are urban areas with residential development and agricultural fields. Due to the urbanized and agricultural surroundings of the corridor no habitat connectivity features are included in this project.

4.16 MULTIMODAL CONSIDERATIONS

Church Street is being used by pedestrians, bicyclists, and motor vehicles. The proposed cross section and intersection treatments are designed to accommodate all three user groups in the designated roadway envelope. Sidewalks and shorter intersection cross walks are being provided for pedestrians. Bicycle lanes are provided for bicyclists and two travel lanes are maintained for the driving traffic.

4.17 DESIGN EXCEPTIONS

All roadway design elements meet or exceed the design criteria outlined in Table 4.

4.18 INTERGOVERNMENTAL AGREEMENTS

As the project is utilizing federal funds, ADOT will provide project administration, management, and review, for both design and construction phases. Kittelson & Associates, Inc. is providing design services under contract with ADOT.

The Town of Thatcher will enter into an agreement with ADOT for the administration of the project construction phase. Once complete, the Town of Thatcher will take maintenance responsibilities of the updated facility.

5. ITEMIZED COST ESTIMATE

5.1 COST ESTIMATE OF THE PREFERRED ALTERNATIVE

The engineer's opinion of probable construction costs for the Church Street improvements is $2,503,981. The related right-of-way estimated costs for the improvements are $532,282 for a total estimated project cost of $3,036,263 for the preferred alternative. The preliminary construction cost estimate was performed using measured quantities from the 30% preliminary design concept and historic bid unit prices from ADOT Safford District projects completed in the past 12 months. Quantities, item numbers and unit prices used are summarized in Table 6.

Table 6 Opinion of Probable Construction Cost

ITEM No.	ITEM DESCRIPTION	UNIT	UNIT PRICE	QUANT.	AMOUNT
2010001	Clearing and Grubbing	L.S.	$ 10,000.00	1	$ 10,000
2020020	REMOVAL OF CONCRETE CURB	L.F.	$ 3.75	2,856	$ 10,711
2020025	REMOVAL OF CONCRETE SIDEWALKS, DRIVEWAYS AND SLABS	SQ.YD.	$ 2.00	2,369	$ 4,738
2020029	REMOVAL OF ASPHALTIC CONCRETE PAVEMENT	SQ.YD.	$ 5.00	17,085	$ 85,427
2020083	REMOVE BITUMINOUS PAVEMENT (MILLING) (2")	SQ.YD.	$ 2.75	5,074	$ 13,952
2020201	SAW CUTTING	L.FT.	$ 1.75	1,253	$ 2,193
2030301	ROADWAY EXCAVATION	CU.YD.	$ 7.00	7,618	$ 53,326
3030022	AGGREGATE BASE, CLASS 2	CU.YD.	$ 65.00	5,778	$ 375,570
4040111	BITUMINOUS TACK COAT	TON	$ 550.00	11	$ 6,050
4060006	ASPHALTIC CONCRETE (3/4" MIX)	TON	$ 37.00	6,496	$ 240,352
4060026	MINERAL ADMIXTURE (FOR 3/4" MIX)	TON	$ 90.00	65	$ 5,850
5050202	RESET FRAME AND COVER FOR MANHOLE (	EACH	$ 720.00	15	$ 10,800
6070054	SIGN POST (PERFORATED) (2 S)	L.FT.	$ 8.00	372	$ 2,976
6070060	FOUNDATION FOR SIGN POST (CONCRETE)	EACH	$ 170.00	31	$ 5,270
6080005	WARNING, MARKER, OR REGULATORY SIGN PANEL	SQ.FT.	$ 21.00	157	$ 3,297
7040001	PAVEMENT MARKING	L.S.	$ 30,000.00	1	$ 30,000
8100001	AZPDES/NPDES (Original)	L.S.	$ 20,000.00	1	$ 20,000
8100100	AZPDES/NPDES (Modified)	FA	$ 10,000.00	1	$ 10,000
9080001	CONCRETE CURB (MAG TYPE A)	L.FT.	$ 37.00	4,972	$ 183,964
9080031	CONCRETE CURB (MAG TYPE G)	L.FT.	$ 32.00	243	$ 7,776
9080201	CONCRETE SIDEWALK (C-05.20)	SQ.FT.	$ 5.00	32,895	$ 164,475
9080296	CONCRETE SIDEWALK RAMP (	EACH	$ 2,000.00	50	$ 100,000

ITEM No.	ITEM DESCRIPTION	UNIT	UNIT PRICE	QUANT.	AMOUNT
9080301	CONCRETE DRIVEWAY (C-05.20)	SQ.FT.	$ 5.50	7,320	$ 40,260
9090034	RESET VALVE BOX	EACH	$ 515.00	26	$ 13,390
9090531	RESET SURVEY MONUMENT	EA	$ 345.00	11	$ 3,795
9170031	INLET (C-4.20) (SINGLE)	EACH	$ 2,200.00	13	$ 28,600
9210100	CONCRETE UNIT PAVERS	SQ.YD.	$ 110.00	28	$ 3,080
9230001	PROVIDE ON-THE-JOB TRAINING	HOUR	$ 0.80	2,000	$ 1,600
9240170	Contractor Quality Control	L.S.	$ 15,000.00	1	$ 15,000
9250001	Construction Survey and Layout	L.S.	$ 72,000.00	1	$ 72,000
	CONSTRUCTION SUBTOTAL				$ 1,524,452
	CONTINGENCIES			15.0%	$ 228,668
	INTERMEDIATE SUBTOTAL 1				$ 1,753,120
	MAINTENANCE AND PROTECTION OF TRAFFIC			15.0%	$ 262,968
	INTERMEDIATE SUBTOTAL 2				$ 2,016,088
	MOBILIZATION			8.0%	$ 161,287
	CONSTRUCTION COST SUBTOTAL				$ 2,177,375
	CONSTRUCTION ENGINEERING/ADMIN			15.0%	$ 326,606
	PROJECT CONSTRUCTION COST				**$ 2,503,981**

The total project right-of-way area need and associated purchase costs are summarized in Table 7. The Town of Thatcher estimates the average property purchase cost to be approximately $0.55 per square foot. Temporary construction easements were estimated at $0.25 per square foot. A $10,000 transaction fee is included in the estimate for professional services associated with each acquisition. These transaction fees will vary based on the complexity of the acquisition process and the level of stakeholder involvement.

Table 7 Right-of-Way Probable Cost

	Cost/Sq Ft.	Area (Sq Ft)	Amount
ESTIMATED RIGHT-OF-WAY AREA NEEDED FOR THE PROJECT	$ 0.55	71,173.0	$ 39,145
ESTIMATED AREA NEEDED FOR TEMPORARY CONSTRUCTION EASEMENTS	$ 0.25	52,549.0	$ 13,137
	Cost/Parcel	Parcels	Amount
ESTIMATED LEGAL FEES PER PARCEL ACQUISION TRANSACTION	$10,000	48	$480,000
RIGHT-OF-WAY ACQUISION TOTAL			**$532,282**

5.2 ESTIMATE OF FUTURE MAINTENANCE COSTS

The Town of Thatcher will maintain the improved roadway facility. Milling and resurfacing the roadway was used as a basis of estimating maintenance costs for Church Street. Performing this pavement rehabilitation work is estimated to cost approximately $300,000 in 2014 US Dollars.

5.3 DETAILED COST ESTIMATES OF OTHER ALTERNATIVES CONSIDERED

Alternative Cross Section 2 features the same roadway construction elements as the preferred alternative Cross Section 1. Both sections have a paved roadway width of 51 feet and two 5-foot wide sidewalks; therefore the construction cost does not differ between these two sections.

Alternative Cross Section 3 has a 10-foot narrower roadway paved area width but features two 10-foot wide multi-use paths compared to Cross Sections 1 and 2. The construction quantities for alternative Cross Section 3 were adjusted accordingly and are presented in Table 8.

Table 8 Opinion of Probable Construction Cost for Alternative Cross Section 3

ITEM No.	ITEM DESCRIPTION	UNIT	UNIT PRICE	QUANT.	AMOUNT
2010001	Clearing and Grubbing	L.S.	$ 10,000.00	1	$ 10,000
2020020	REMOVAL OF CONCRETE CURB	L.F.	$ 3.75	2,856	$ 10,711
2020025	REMOVAL OF CONCRETE SIDEWALKS, DRIVEWAYS AND SLABS	SQ.YD.	$ 2.00	2,369	$ 4,738
2020029	REMOVAL OF ASPHALTIC CONCRETE PAVEMENT	SQ.YD.	$ 5.00	17,085	$ 85,427
2020083	REMOVE BITUMINOUS PAVEMENT (MILLING) (2")	SQ.YD.	$ 2.75	5,074	$ 13,952
2020201	SAW CUTTING	L.FT.	$ 1.75	1,253	$ 2,193
2030301	ROADWAY EXCAVATION	CU.YD.	$ 7.00	6,246	$ 43,722
3030022	AGGREGATE BASE, CLASS 2	CU.YD.	$ 65.00	4,596	$ 298,740
4040111	BITUMINOUS TACK COAT	TON	$ 550.00	9	$ 4,950
4060006	ASPHALTIC CONCRETE (3/4" MIX)	TON	$ 37.00	5,340	$ 197,580
4060026	MINERAL ADMIXTURE (FOR 3/4" MIX)	TON	$ 90.00	54	$ 4,860
5050202	RESET FRAME AND COVER FOR MANHOLE (	EACH	$ 720.00	15	$ 10,800
6070054	SIGN POST (PERFORATED) (2 S)	L.FT.	$ 8.00	372	$ 2,976
6070060	FOUNDATION FOR SIGN POST (CONCRETE)	EACH	$ 170.00	31	$ 5,270
6080005	WARNING, MARKER, OR REGULATORY SIGN PANEL	SQ.FT.	$ 21.00	157	$ 3,297
7040001	PAVEMENT MARKING	L.S.	$ 30,000.00	1	$ 30,000
8100001	AZPDES/NPDES (Original)	L.S.	$ 20,000.00	1	$ 20,000
8100100	AZPDES/NPDES (Modified)	FA	$ 10,000.00	1	$ 10,000
9080001	CONCRETE CURB (MAG TYPE A)	L.FT.	$ 37.00	4,972	$ 183,964

ITEM No.	ITEM DESCRIPTION	UNIT	UNIT PRICE	QUANT.	AMOUNT
9080031	CONCRETE CURB (MAG TYPE G)	L.FT.	$ 32.00	243	$ 7,776
9080201	CONCRETE SIDEWALK (C-05.20)	SQ.FT.	$ 5.00	65,789	$ 328,945
9080296	CONCRETE SIDEWALK RAMP (	EACH	$ 2,000.00	50	$ 100,000
9080301	CONCRETE DRIVEWAY (C-05.20)	SQ.FT.	$ 5.50	10,980	$ 60,390
9090034	RESET VALVE BOX	EACH	$ 515.00	26	$ 13,390
9090531	RESET SURVEY MONUMENT	EA	$ 345.00	11	$ 3,795
9170031	INLET (C-4.20) (SINGLE)	EACH	$ 2,200.00	13	$ 28,600
9210100	CONCRETE UNIT PAVERS	SQ.YD.	$ 110.00	28	$ 3,080
9230001	PROVIDE ON-THE-JOB TRAINING	HOUR	$ 0.80	2,000	$ 1,600
9240170	Contractor Quality Control	L.S.	$ 15,000.00	1	$ 15,000
9250001	Construction Survey and Layout	L.S.	$ 75,000.00	1	$ 75,000
	CONSTRUCTION SUBTOTAL				$ 1,580,756
	CONTINGENCIES			15.0%	$ 237,113
	INTERMEDIATE SUBTOTAL 1				$ 1,817,869
	MAINTENANCE AND PROTECTION OF TRAFFIC			15.0%	$ 272,680
	INTERMEDIATE SUBTOTAL 2				$ 2,090,550
	MOBILIZATION			8.0%	$ 167,244
	CONSTRUCTION COST SUBTOTAL				$ 2,257,794
	CONSTRUCTION ENGINEERING/ADMIN			15.0%	$ 338,669
	PROJECT CONSTRUCTION COST				**$ 2,596,463**

The total project construction cost for alternative Cross Section 3 is estimated to be approximately $100,000 higher than the estimate for Cross Section 1. The main element that contributes to the higher construction cost is the wider concrete sidewalks, which are more expensive to build than the asphalt roadway pavement.

6. AASHTO CONTROLLING DESIGN CRITERIA AND EXCEPTIONS

The following AASHTO design criteria documents were consulted:

- A Policy on Geometric Design of Highways and Streets, Sixth Edition, 2011
- Roadside Design Guide, Fourth Edition, 2011

An AASHTO Controlling Design Criteria Report was not prepared for this project.

6.1 AASHTO NON-CONFORMING GEOMETRIC DESIGN ELEMENTS

The geometry along Church Street conforms to the 13 AASHTO design criteria. The majority of the roadway alignment will be reconstructed to provide sufficient grades to drain the pavement stormwater along the curb lines and toward the side streets.

6.2 AASHTO DESIGN EXCEPTIONS

Church Street is not part of the National Highway System (NHS). No design exceptions are required.

6.3 ADOT RDG NON-CONFORMING GEOMETRIC DESIGN ELEMENTS

The proposed roadway profile will continue to be fairly flat with grades ranging between 1.2200 % and 0.2114% due to topography of the terrain. The minimum grade used along the proposed roadway profile meets the special case criteria in the Maricopa County Roadway Design Manual, which was used to set this design parameter. The above mentioned document was used as the defining criteria because Church Street is a residential local collector and does not fit the roadway categories usually coved by the ADOT Roadway Design Guidelines.

6.4 ADOT DESIGN EXCEPTIONS

No ADOT design exceptions are required.

7. SOCIAL, ECONOMIC AND ENVIRONMENTAL CONCERNS

A Project Data Sheet was prepared and approved by the ADOT Environmental Planning Group prior to the completion of the Initial DCR. The following sections describe the type of environmental documents that will be completed as part of this project.

7.1 ENVIRONMENTAL DOCUMENTATION

A Categorical Exclusion Group 2 document is being prepared for this project. The following supporting documents will also be completed and submitted to the ADOT's Environmental Planning Group for approval:

- Biological Review (Completed and approved)
- Preliminary-Initial Site Assessment (To be completed)
- Cultural Resource Report (Under ADOT review)

ADOT's EPG determined that noise and air quality analyses will not be required for this project since the project does not add new traffic lanes to the roadway cross section. The air impacts will be addressed qualitatively in the Categorical Exclusion.

Coordination with other environmental agency stakeholder took during the environmental review process. A letter describing the project was sent via email to the following agencies on May 9, 2013, to inform them of the project:

- Arizona Game and Fish Department Laura Canaca, Supervisor, Project Evaluation Program
- US Fish and Wildlife Service
    - Steve Spangle, Field Supervisor, Arizona Ecological Services Field Office
    - Jean Calhoun, Assistant Field Supervisor, Arizona Ecological Services Field Office

7.2 MITIGATION MEASURES

The approved Biological Review found that the project will have no effect on threatened and endangered listed species and identifies the following construction stage mitigation measures. Additional information about these measures can be found in the Biological Report appendices.

Burrowing Owl

- ADOT Safford District
    - If any burrowing owls or active burrows are identified during construction, no construction activities will take place within 100 feet of any active burrow until the owls have been relocated.
    - If burrowing owls or active burrows are identified during a pre-construction survey or construction, the Engineer will contact the Arizona Department of Transportation Environmental Planning Group Biologist (602.712.8695 or 602.712.7767) to arrange

for a qualified biologist to evaluate the situation. The Engineer and qualified biologist will determine whether the owls can be avoided during construction or if a biologist holding a permit from the US Fish and Wildlife Service is needed to relocate burrowing owls from the project area.

- Contractor
  - The contractor shall not begin work prior to receiving the attached Western Burrowing Owl information flyer or presentation of the environmental awareness program to all personnel who will be on-site, including but not limited to, contractors, contractor's employees, supervisors, inspectors, and subcontractors working at the Church Street Widening Project in Thatcher, Arizona.
  - If any burrowing owls or active burrows are identified during construction, no construction activities will take place within 100 feet of any active burrow until the owls have been relocated.

Noxious and Invasive Species

- ADOT Design
  - All disturbed soils or edge-of-pavement buildup that will not be landscaped or otherwise permanently stabilized by construction will be seeded using species native to the project vicinity as specified in the contract documents.
- Town of Thatcher
  - All disturbed soils or edge-of-pavement buildup that will not be landscaped or otherwise permanently stabilized by construction will be seeded using species native to the project vicinity as specified in the contract documents.
  - To prevent the introduction of invasive species seeds, the contractor shall inspect all earthmoving and hauling equipment at the equipment storage facility and the equipment shall be washed prior to entering the construction site.
  - To prevent invasive species seeds from leaving the site, the contractor shall inspect all construction equipment and remove all attached plant/vegetation and soil/mud debris prior to leaving the construction site.
  - All disturbed soils and edge-of-pavement buildup shall be seeded using species native to the project vicinity as specified in the contract documents.
- Contractor Responsibilities
  - To prevent the introduction of invasive species seeds, the contractor shall inspect all earthmoving and hauling equipment at the equipment storage facility and the equipment shall be washed prior to entering the construction site.
  - To prevent invasive species seeds from leaving the site, the contractor shall inspect all construction equipment and remove all attached plant/vegetation and soil/mud debris prior to leaving the construction site.
  - All disturbed soils and edge-of-pavement buildup shall be seeded using species native to the project vicinity as specified in the contract documents.

Appendix 1
Drainage Report

DRAINAGE REPORT
FOR
CHURCH STREET WIDENING
US 70 TO STADIUM AVENUE
THATCHER, AZ

October 2013

Prepared for;
Kittelson & Associates, Inc.
Transportation Engineering / Planning
33 North Stone Avenue, Suite 800
Tucson, Arizona 85701

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO.
22922
JOHN M.
WALLACE
DATE SIGNED 10-14-13
ARIZONA U.S.A.

EXPIRES 12-31-2013

Prepared by:

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

40 E. Helen Street **520-623-3112 (voice)**
Tucson, Arizona 85705 **520-623-3130 (fax)**

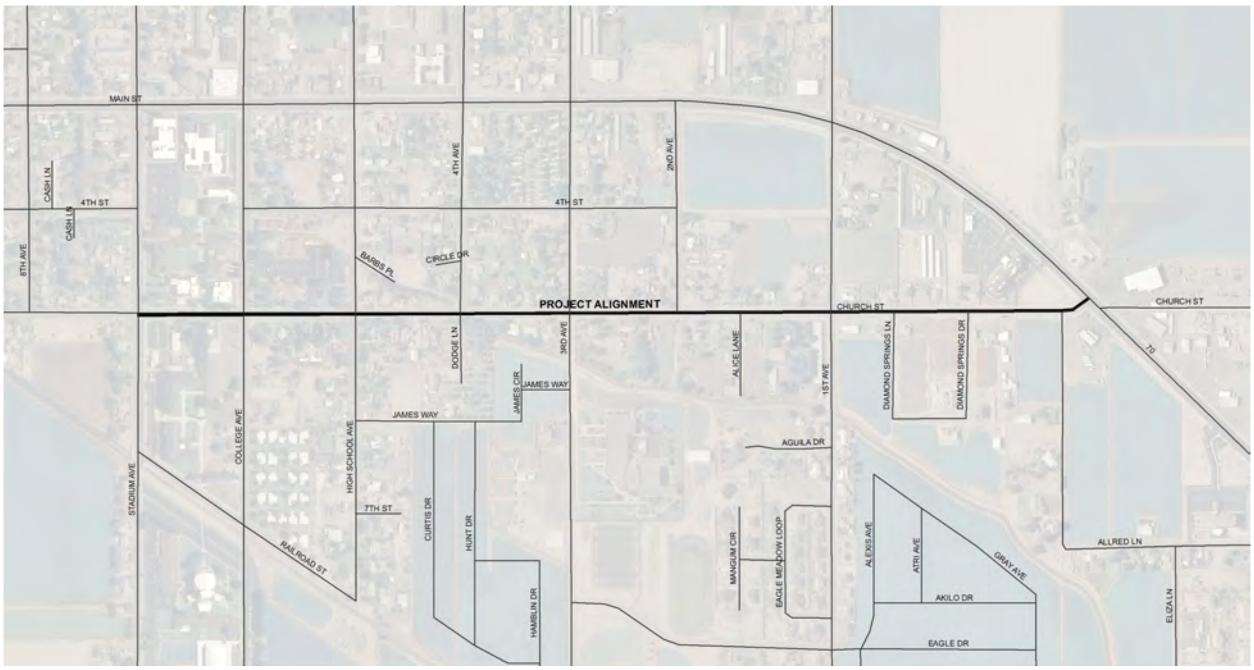
TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION AND PURPOSE

This report was prepared to document existing and proposed drainage conditions along Church Street, US 70 to Stadium Avenue, Thatcher, Arizona. The project location is shown below.

FIGURE 1 – PROJECT LOCATION MAP



EXISTING CONDITIONS

The project alignment is impacted by offsite drainage originating to the south and generally collecting in dispersed fashion along the project alignment. There is little to no drainage definition along the project alignment with the exception of drainage inlets to local storm drains at some intersections. The project alignment is bisected by the Union Canal at the 4th Avenue intersection. The Union Canal forms the upstream limit of contributing drainage east of this point. West of this point, the canal is the receiving water for all drainage crossing Church St.

Hydrologic calculations for the Church Street project were prepared using the rational method as outlined in the Arizona Department of Transportation (ADOT) Hydrology Manual (1993). Rainfall data were determined from NOAA Atlas 14 as presented on the NOAA Precipitation Data Server. Watersheds and associated drainage areas were determined from topography provided by the Town of Thatcher. In determining the appropriate watersheds, an agricultural area south of the railroad tracks and immediately east of the Easter Arizona College campus was treated as ineffective due to the high degree of runoff storage available in the fields and detention areas, and the associated lag in runoff from the area relative to the downstream drainage areas. Runoff coefficients were selected from the ADOT Hydrology Manual based on land use as determined for each watershed from review of Figure 3 of the Town of Thatcher General Plan Update. Figure 2 shows the watersheds (DA) determined as impacting the project alignment.

The table below summarizes the results of the hydrologic calculations performed for each of the watersheds (DA) shown on Figure 2.

DA	Area (ac)	Q10 (cfs)	Q100 (cfs)
1	45.6	43	95
2	12.2	27	51
3	21.4	52	98
4	12.7	28	53
5	22.8	28	62
6	1.9	4	8
7	15.4	34	64
8	5.2	11	22
9	25.5	55	107
10	7.8	25	44

Flows from the above sources generally occur as sheet flow along the project alignment with no defined point of concentration or crossing. These flows tend to drain toward the various intersections along the project alignment. From the intersections, flows are conveyed north within the intersecting streets or within associated storm drains (where they exist). The following existing drainage infrastructure were observed in the field (listed by intersection with the project alignment);

Location	Existing Drainage Infrastructure Noted
Stadium Avenue	Storm drain running north with inlets north and south on Church St.
College Avenue	Curb & grate inlets observed on south side of intersection. According to City staff these inlets are connected to an underground pipe that drains to the Union Canal.
High School Avenue	Curb inlet on SW corner, raised grates on SW, SE and NW corners, storm drain running north to Union Canal.
4th Avenue	Curb inlet on south side connected to Union Canal underpass via pipe. Also spillway from Church St. into canal on north side.
3rd Avenue	Inlets on SW and SE corners connected by pipe to a junction box (with hinged lid) on the NE corner. Junction box has pipe draining north along east side of 3rd Avenue but outlet point was not visible.
2nd Avenue	No drainage infrastructure. This intersection appears to be a low point where drainage collects on the surface and runs north along 2nd Avenue.
Between 1st & 2nd Ave	Approximately halfway between 1st and 2nd Avenues is a grate inlet on the south side of Church Street that drains to a grate on the north side, which in turn drains to a collection of ditches and pipes to the north of the road which drain off into an agricultural field to the north.
1st Avenue	Curb inlets on SW and NW corners draining to junction structure at NW corner. Also, crushed inlet on SE corner collecting from pipe to the south. Crushed inlet appears to drain north then west to NW corner.
Diamond Springs Lane	Grate inlet on south side of Church Street with pipe leading to junction structure on north side of road with irrigation ditch leading north away from Church St.
Allred Lane	Combination curb & grate inlet on SW corner, grate inlet on SE corner. Both appear to drain to curb inlet on north side of Church St. which in turn appears to drain to a grate inlet box behind the sidewalk with a vertical gate fitting.

The inlets listed above are shown on Figure 3 of this report. Inlet capacities for the structures listed above and shown on Figure 3 are included in the Appendix of this report.

DESIGN CONDITIONS

Per coordination with the Town of Thatcher, stormwater drainage can be allowed to flow along Church Street to the side streets, where it will be conveyed north to a point of discharge. To this end, no new storm drains are proposed as part of the roadway design. Review of the proposed street section indicates that the anticipated 10-year flows can be conveyed within the roadway right-of-way at a depth of less than 12 inches (as required per Section 29-32-6 of the Town of Thatcher subdivision regulations) *assuming containment within the overall street section (back of sidewalk to back of sidewalk)*. However, it should be noted that under both existing and proposed conditions the street capacity is very limited due to lack of slope and flow is generally not contained within the curbed street section. Flows in excess of the street section spill north out of the roadway into adjoining private properties. This condition exists because the prevailing direction of flow is south to north rather than east or west along the road. Spillover occurs under both existing and design conditions, although it is lessened under design conditions. The table below provides curb-full street capacity at various locations under existing and proposed design conditions. As shown in the table below, all design capacities are greater than the 10-year discharge at a depth of less than 12 inches, therefore the Town Code requirements of Section 29-32-6 (referenced above) are met.

Location	Curb-Full Street Flow Capacity (cfs)		Q10 (cfs)
	Existing	Design [1]	
Stadium Ave to College Ave	6.68	25.12 [2]	27
College Ave to High School Ave	17.20	55.07	52
High School Ave to 4th Ave	2.29	18.31 [3]	28
4th Ave to 3rd Ave	20.85	29.81	4
3rd Ave to 2nd Ave	13.92	36.85	34
2nd Ave to 1st Ave	4.89	38.94	34
1st Ave to Diamond Springs-West	0.24	30.37	11

Notes; 1. Design capacities shown are for curb-full capacity (0.5 foot depth)
2. Depth at Q10 is 0.51 feet
3. Depth at Q10 is 0.57 feet

As part of the design, existing inlets at the intersections will be reconstructed to accept flows as occurs under existing conditions. Some design elements may require coordination with irrigation districts/companies which own facilities in the area that connect and/or conflict with existing drainage facilities.

Figure 2 - Project Watershed Map

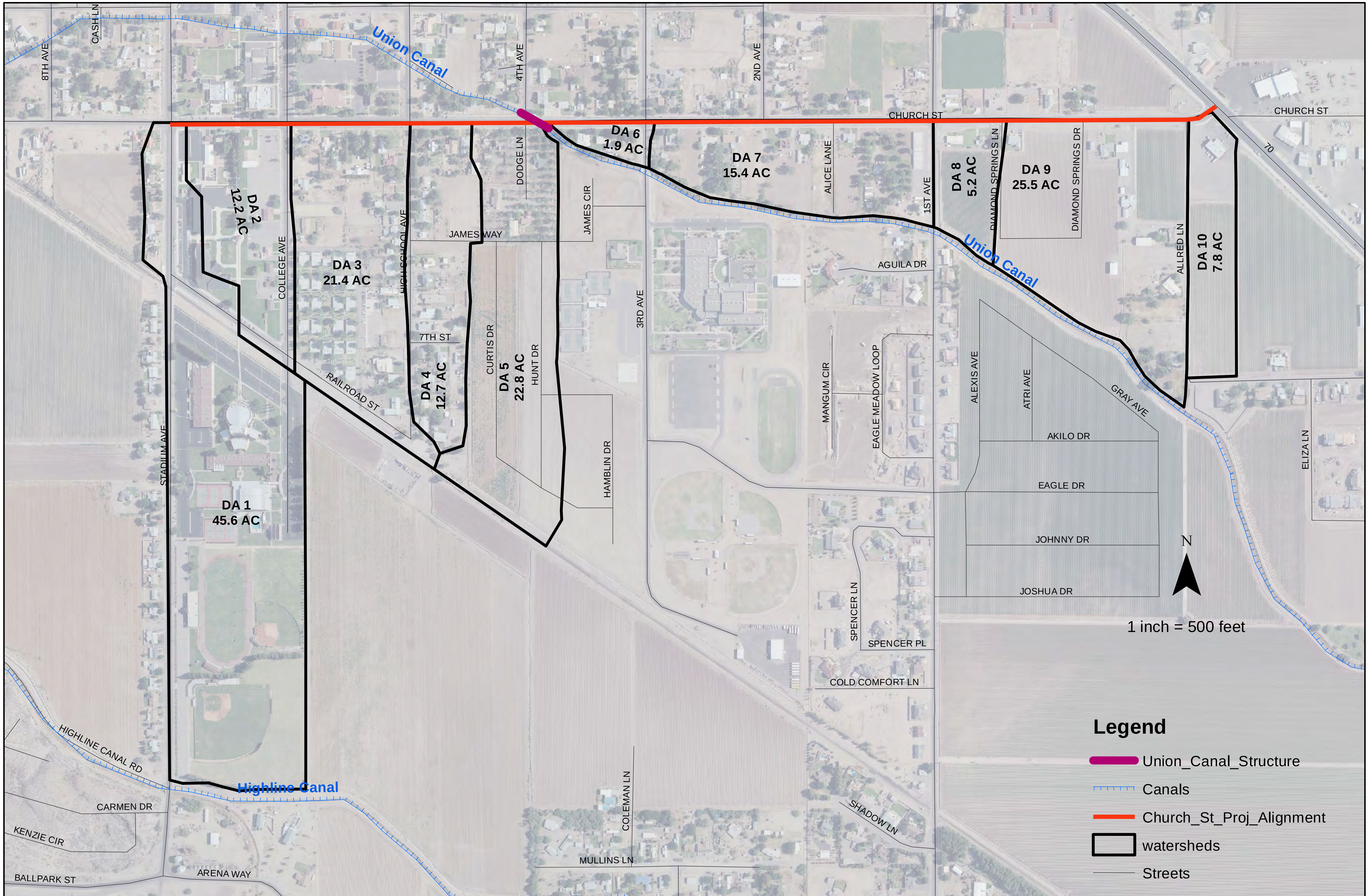
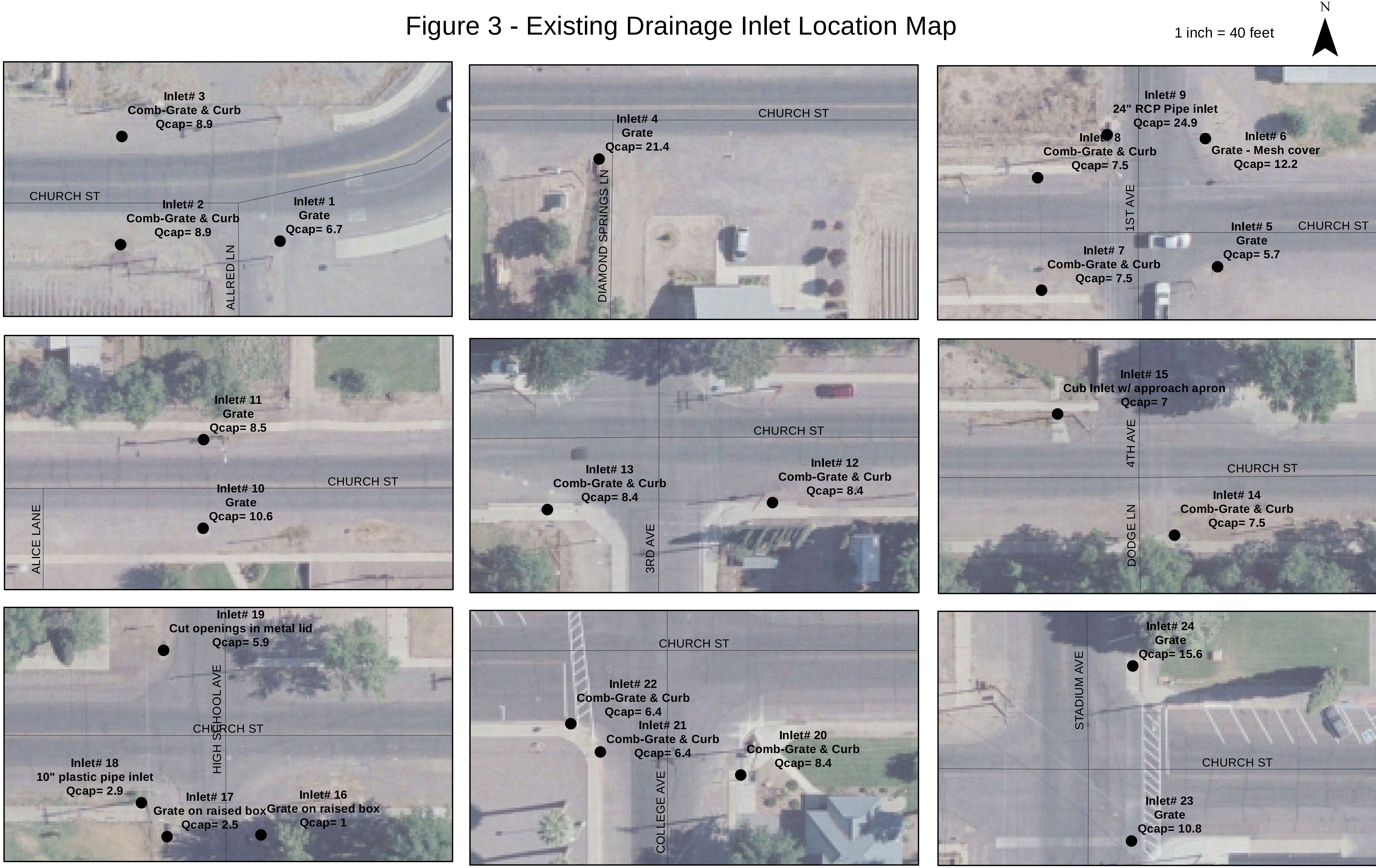


Figure 3 - Existing Drainage Inlet Location Map

1 inch = 40 feet



Appendix

- **Hydrologic Data Sheets (10 pages)**
- **Inlet Capacity Calculation Summary (1 page)**
- **Existing Street Section Hydraulic Ratings (15 pages)**
- **Design Street Section Hydraulic Ratings (8 pages)**

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 1 Landuse: Mod. Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	45.6	45.6	45.6	45.6	45.6	45.6	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.44	0.52	0.56	0.62	0.66	0.68	
L	mile	0.69	0.69	0.69	0.69	0.69	0.69	
d1	feet	3650	3650	3650	3650	3650	3650	
H1	feet	24.0	24.0	24.0	24.0	24.0	24.0	
j1	feet	45013	45013	45013	45013	45013	45013	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	45013	45013	45013	45013	45013	45013	
S	feet/mile	35	35	35	35	35	35	
Kb	dimless	0.100	0.100	0.100	0.100	0.100	0.100	
Tc (assum)	hours	0.98	0.85	0.78	0.70	0.66	0.62	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	0.92	1.35	1.69	2.22	2.61	3.06	
Tc (calc)	hours	0.98	0.85	0.78	0.70	0.66	0.62	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**19**	**32**	**43**	**63**	**79**	**95**	
q = Q/A =	cfs/ac	0.41	0.70	0.95	1.38	1.72	2.08	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 2 Landuse: Mod. Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	12.2	12.2	12.2	12.2	12.2	12.2	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.44	0.52	0.56	0.62	0.66	0.68	
L	mile	0.24	0.24	0.24	0.24	0.24	0.24	
d1	feet	1256	1256	1256	1256	1256	1256	
H1	feet	11.0	11.0	11.0	11.0	11.0	11.0	
j1	feet	13421	13421	13421	13421	13421	13421	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	13421	13421	13421	13421	13421	13421	
S	feet/mile	46	46	46	46	46	46	
Kb	dimless	0.025	0.025	0.025	0.025	0.025	0.025	
Tc (assum)	hours	0.17	0.16	0.14	0.13	0.12	0.12	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	2.58	3.45	4.25	5.29	6.12	6.86	
Tc (calc)	hours	0.17	0.16	0.14	0.13	0.12	0.12	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**14**	**22**	**27**	**37**	**44**	**51**	
q = Q/A =	cfs/ac	1.14	1.77	2.24	3.01	3.62	4.18	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 3 Landuse: Mod. - Hvy Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	21.4	21.4	21.4	21.4	21.4	21.4	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.54	0.605	0.645	0.695	0.725	0.745	
L	mile	0.37	0.37	0.37	0.37	0.37	0.37	
d1	feet	1931	1931	1931	1931	1931	1931	
H1	feet	16.0	16.0	16.0	16.0	16.0	16.0	
j1	feet	21214	21214	21214	21214	21214	21214	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	21214	21214	21214	21214	21214	21214	
S	feet/mile	44	44	44	44	44	44	
Kb	dimless	0.025	0.025	0.025	0.025	0.025	0.025	
Tc (assum)	hours	0.23	0.20	0.19	0.17	0.16	0.16	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	2.28	3.16	3.80	4.82	5.57	6.24	
Tc (calc)	hours	0.23	0.20	0.19	0.17	0.16	0.16	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**26**	**41**	**52**	**72**	**85**	**98**	
q = Q/A =	cfs/ac	1.23	1.91	2.45	3.35	3.98	4.58	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 4 Landuse: Mod. Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	12.7	12.7	12.7	12.7	12.7	12.7	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.44	0.52	0.56	0.62	0.66	0.68	
L	mile	0.32	0.32	0.32	0.32	0.32	0.32	
d1	feet	1712	1712	1712	1712	1712	1712	
H1	feet	16.0	16.0	16.0	16.0	16.0	16.0	
j1	feet	17709	17709	17709	17709	17709	17709	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	17709	17709	17709	17709	17709	17709	
S	feet/mile	49	49	49	49	49	49	
Kb	dimless	0.025	0.025	0.025	0.025	0.025	0.025	
Tc (assum)	hours	0.21	0.18	0.17	0.16	0.15	0.14	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	2.37	3.30	3.97	4.93	5.70	6.53	
Tc (calc)	hours	0.21	0.18	0.17	0.16	0.15	0.14	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**13**	**22**	**28**	**38**	**46**	**53**	
q = Q/A =	cfs/ac	1.04	1.72	2.22	3.01	3.62	4.18	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 5 Landuse: Suburban

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	22.8	22.8	22.8	22.8	22.8	22.8	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.36	0.44	0.48	0.54	0.57	0.61	
L	mile	0.38	0.38	0.38	0.38	0.38	0.38	
d1	feet	2003	2003	2003	2003	2003	2003	
H1	feet	15.0	15.0	15.0	15.0	15.0	15.0	
j1	feet	23146	23146	23146	23146	23146	23146	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	23146	23146	23146	23146	23146	23146	
S	feet/mile	40	40	40	40	40	40	
Kb	dimless	0.080	0.080	0.080	0.080	0.080	0.080	
Tc (assum)	hours	0.52	0.46	0.42	0.38	0.36	0.34	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	1.45	2.06	2.56	3.29	3.83	4.43	
Tc (calc)	hours	0.52	0.46	0.42	0.38	0.36	0.34	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**12**	**21**	**28**	**41**	**50**	**62**	
q = Q/A =	cfs/ac	0.52	0.90	1.23	1.78	2.19	2.70	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 6 Landuse: Mod. Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	1.9	1.9	1.9	1.9	1.9	1.9	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.44	0.52	0.56	0.62	0.66	0.68	
L	mile	0.05	0.05	0.05	0.05	0.05	0.05	
d1	feet	260	260	260	260	260	260	
H1	feet	3.0	3.0	3.0	3.0	3.0	3.0	
j1	feet	2420	2420	2420	2420	2420	2420	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	2420	2420	2420	2420	2420	2420	
S	feet/mile	61	61	61	61	61	61	
Kb	dimless	0.040	0.040	0.040	0.040	0.040	0.040	
Tc (assum)	hours	0.09	0.08	0.07	0.07	0.06	0.06	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	3.14	4.21	5.10	6.19	7.20	8.06	
Tc (calc)	hours	0.09	0.08	0.07	0.07	0.06	0.06	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**2**	**3**	**4**	**6**	**7**	**8**	
q = Q/A =	cfs/ac	1.14	1.77	2.24	3.01	3.62	4.18	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 7 Landuse: Mod. Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	15.4	15.4	15.4	15.4	15.4	15.4	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.44	0.52	0.56	0.62	0.66	0.68	
L	mile	0.09	0.09	0.09	0.09	0.09	0.09	
d1	feet	484	484	484	484	484	484	
H1	feet	4.0	4.0	4.0	4.0	4.0	4.0	
j1	feet	5324	5324	5324	5324	5324	5324	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	5324	5324	5324	5324	5324	5324	
S	feet/mile	44	44	44	44	44	44	
Kb	dimless	0.040	0.040	0.040	0.040	0.040	0.040	
Tc (assum)	hours	0.14	0.12	0.11	0.10	0.10	0.09	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	2.76	3.79	4.58	5.70	6.44	7.41	
Tc (calc)	hours	0.14	0.12	0.11	0.10	0.10	0.09	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**18**	**27**	**34**	**46**	**56**	**64**	
q = Q/A =	cfs/ac	1.14	1.77	2.24	3.01	3.62	4.18	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 8 Landuse: Mod. Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	5.2	5.2	5.2	5.2	5.2	5.2	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.44	0.52	0.56	0.62	0.66	0.68	
L	mile	0.14	0.14	0.14	0.14	0.14	0.14	
d1	feet	716	716	716	716	716	716	
H1	feet	2.0	2.0	2.0	2.0	2.0	2.0	
j1	feet	13547	13547	13547	13547	13547	13547	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	13547	13547	13547	13547	13547	13547	
S	feet/mile	15	15	15	15	15	15	
Kb	dimless	0.040	0.040	0.040	0.040	0.040	0.040	
Tc (assum)	hours	0.25	0.22	0.21	0.19	0.18	0.17	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	2.19	3.04	3.65	4.62	5.33	6.10	
Tc (calc)	hours	0.25	0.22	0.21	0.19	0.18	0.17	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**5**	**8**	**11**	**15**	**18**	**22**	
q = Q/A =	cfs/ac	0.96	1.58	2.04	2.86	3.52	4.15	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 9 Landuse: Mod. Urb.

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	25.5	25.5	25.5	25.5	25.5	25.5	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.44	0.52	0.56	0.62	0.66	0.68	
L	mile	0.27	0.27	0.27	0.27	0.27	0.27	
d1	feet	1438	1438	1438	1438	1438	1438	
H1	feet	8.0	8.0	8.0	8.0	8.0	8.0	
j1	feet	19279	19279	19279	19279	19279	19279	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	19279	19279	19279	19279	19279	19279	
S	feet/mile	29	29	29	29	29	29	
Kb	dimless	0.025	0.025	0.025	0.025	0.025	0.025	
Tc (assum)	hours	0.22	0.20	0.18	0.17	0.16	0.15	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	2.32	3.16	3.88	4.82	5.57	6.38	
Tc (calc)	hours	0.22	0.20	0.18	0.17	0.16	0.15	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**26**	**42**	**55**	**76**	**92**	**107**	
q = Q/A =	cfs/ac	1.02	1.65	2.18	2.99	3.62	4.18	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL ADOT 1993 Rational Method Solution

All variables and solutions are as defined in the ADOT Hydrology Manual (1993)

Watershed/CP: 10 Landuse: Commercial

Parameter	Units	Value/Results						
Event	**Years**	**2**	**5**	**10**	**25**	**50**	**100**	
A	acres	7.8	7.8	7.8	7.8	7.8	7.8	
P1	inches	0.91	1.19	1.40	1.70	1.92	2.15	
C	dimless	0.77	0.82	0.84	0.88	0.90	0.92	
L	mile	0.28	0.28	0.28	0.28	0.28	0.28	
d1	feet	1457	1457	1457	1457	1457	1457	
H1	feet	8.0	8.0	8.0	8.0	8.0	8.0	
j1	feet	19663	19663	19663	19663	19663	19663	
d2	feet		0	0	0	0	0	
H2	feet		0.0	0.0	0.0	0.0	0.0	
j2	feet	0	0	0	0	0	0	
d3	feet		0	0	0	0	0	
H3	feet		0.0	0.0	0.0	0.0	0.0	
j3	feet	0	0	0	0	0	0	
J	feet	19663	19663	19663	19663	19663	19663	
S	feet/mile	29	29	29	29	29	29	
Kb	dimless	0.025	0.025	0.025	0.025	0.025	0.025	
Tc (assum)	hours	0.22	0.20	0.18	0.17	0.16	0.15	
S-DRRZ	dimless	8	8	8	8	8	8	
I (calc)	in/hr	2.32	3.16	3.88	4.82	5.57	6.38	
Tc (calc)	hours	0.22	0.20	0.18	0.17	0.16	0.15	
I (max)	in/hr	2.60	3.40	4.00	4.86	5.49	6.14	see note below
Q = CIA =	**cfs**	**14**	**20**	**25**	**33**	**39**	**44**	
q = Q/A =	cfs/ac	1.79	2.60	3.26	4.24	4.94	5.65	

= required input parameter for spreadsheet

I max is the maximum intensity possible based on a minimum value of Tc = 10 min.
discharge, Q, is based on the lesser of the calculated or maximum intensity

PROJ: Kittleson/Church Street - Thatcher
DETAIL: Inlet Capacity Calculations (see Figure 3 of Drainage report for inlet locations)

			Curb inlet			Grate Inlet					Curb Inlet	Grate	Total	Notes
Inlet #	Type	Cond.	Length	Height	Curb Ht.	Perimeter	Tot. Area	% Open	Open Area	AHW	Capacity	Capacity	Capacity	
1	1	1				6.33	2.48	50%	1.24	0.50	0.0	6.7	6.7	
2	3	1	3.42	0.33	0.50	5.75	3.99	50%	1.99	0.50	2.8	6.1	8.9	
3	3	1	3.42	0.25	0.50	5.75	3.99	50%	1.99	0.50	2.8	6.1	8.9	
4	1	1				20.17	23.53	50%	11.76	0.50	0.0	21.4	21.4	
5	1	1				5.33	1.77	50%	0.89	0.50	0.0	5.7	5.7	
6	1	1				11.50	8.18	50%	4.09	0.50	0.0	12.2	12.2	
7	3	1	2.75	0.38	0.50	4.92	3.01	50%	1.51	0.50	2.2	5.2	7.5	
8	3	1	2.75	0.38	0.50	4.92	3.01	50%	1.51	0.50	2.2	5.2	7.5	
9	4								0.00	3.33	0.0		24.9	24" RCP, rated as culvert
10	1	1				10.00	6.25	50%	3.13	0.50	0.0	10.6	10.6	
11	1	1				8.00	4.00	50%	2.00	0.50	0.0	8.5	8.5	
12	3	1	3.33	0.29	0.50	5.33	3.33	60%	2.00	0.50	2.7	5.7	8.4	
13	3	1	3.33	0.29	0.50	5.33	3.33	60%	2.00	0.50	2.7	5.7	8.4	
14	3	1	2.75	0.38	0.50	4.92	3.01	50%	1.51	0.50	2.2	5.2	7.5	
15	2	1	4.00	0.46	0.83				0.00	0.83	7.0		7.0	
16	1	1				14.33	11.84	80%	9.47	0.08	0.0	1.0	1.0	
17	1	1				35.00	26.81	80%	21.45	0.08	0.0	2.5	2.5	
18	4								0.00	1.67	0.0		2.9	10" dia pipe in sump @ curb, rated as culvert
19	4						1.56	100%	1.56	0.50	0.0		5.9	Series of holes in a metal plate, rated as orifice flow
20	3	1	3.33	0.29	0.50	5.33	3.33	60%	2.00	0.50	2.7	5.7	8.4	
21	3	1	1.83	0.38	0.50	4.58	2.56	60%	1.53	0.50	1.5	4.9	6.4	
22	3	1	1.92	0.29	0.50	4.58	2.56	60%	1.53	0.50	1.6	4.9	6.4	
23	1	1				10.17	6.25	60%	3.75	0.50	0.0	10.8	10.8	
24	1	1				14.67	13.19	60%	7.92	0.50	0.0	15.6	15.6	

Type: 1 = Grate, 2 = Curb Inlet, 3 = Combo (Grate & Curb inlet), 4 = Other
Cond: 1 = Sag, 2 = Ongrade

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway - Summary**
Sections taken from existing project DTM

	Flow Capacity (cfs)		
Location	**WB**	**EB**	**TOTAL**
Stadium to Colllege	3.24	3.45	6.68
College to High School	11.86	5.35	17.20
High School to 4th	0.77	1.52	2.29
4th to 3rd	12.28	8.57	20.85
3rd to 2nd	10.70	3.23	13.92
2nd to 1st	1.51	3.38	4.89
East of 1st	0.00	0.24	0.24
Average	**5.76**	**3.68**	**9.44**

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
Between Staduim and College Ave. WESTBOUND

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2923.30
SLOPE = 0.0015

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2922.94								
2	0.87	2923.08	0.018	0.25	0.88	0.29	1.40	0.36	0.9	0.4
3	4.67	2923.17	0.018	0.67	3.80	0.17	1.01	0.22	3.8	0.7
4	9.92	2923.30	0.018	0.34	5.25	0.06	0.52	0.13	5.3	0.2
5	10.38	2923.06	0.018	0.06	0.52	0.11	0.72	0.24	0.5	0.0
6	10.42	2922.85	0.018	0.01	0.21	0.06	0.52	0.45	0.0	0.0
7	10.64	2922.87	0.018	0.10	0.22	0.44	1.85	0.45	0.2	0.2
8	11.19	2922.93	0.018	0.22	0.55	0.40	1.74	0.43	0.5	0.4
9	25.92	2923.33	0.018	2.52	13.63	0.18	1.04	0.37	13.6	2.6
10	28.74	2923.41	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
11	31.15	2923.44	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
12	43.45	2923.59	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
13	46.12	2923.57	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
14	54.98	2923.50	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
15	60.49	2923.46	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
16	70.13	2923.32	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
17	71.67	2923.29	0.018	0.00	0.51	0.00	0.09	0.01	0.5	0.0
18	71.80	2923.41	0.018	0.00	0.01	0.00	0.08	0.01	0.0	0.0
19	72.05	2923.66	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
20	77.32	2923.77	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
21	78.22	2923.78	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	79.68	2923.77	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
23	80.93	2923.76	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
24	82.71	2923.76	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**4.17**	**25.60**	**1.73**	**1.06**		**25.34**	**4.44**
	SEGMENT OF INTEREST =									**3.24**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
Between Staduim and College Ave. EASTBOUND

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n}\ A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2923.59
SLOPE = 0.0015

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2922.94								
2	0.87	2923.08	0.018	0.50	0.88	0.57	2.22	0.65	0.9	1.1
3	4.67	2923.17	0.018	1.77	3.80	0.46	1.93	0.51	3.8	3.4
4	9.92	2923.30	0.018	1.86	5.25	0.35	1.61	0.42	5.3	3.0
5	10.38	2923.06	0.018	0.19	0.52	0.36	1.64	0.53	0.5	0.3
6	10.42	2922.85	0.018	0.03	0.21	0.12	0.78	0.74	0.0	0.0
7	10.64	2922.87	0.018	0.16	0.22	0.73	2.60	0.74	0.2	0.4
8	11.19	2922.93	0.018	0.38	0.55	0.69	2.50	0.72	0.5	0.9
9	25.92	2923.33	0.018	6.78	14.74	0.46	1.91	0.66	14.7	13.0
10	28.74	2923.41	0.018	0.62	2.82	0.22	1.17	0.26	2.8	0.7
11	31.15	2923.44	0.018	0.40	2.41	0.16	0.97	0.18	2.4	0.4
12	43.45	2923.59	0.018	0.92	12.30	0.07	0.57	0.15	12.3	0.5
13	46.12	2923.57	0.018	0.03	2.67	0.01	0.15	0.02	2.7	0.0
14	54.98	2923.50	0.018	0.49	8.86	0.05	0.46	0.09	8.9	0.2
15	60.49	2923.46	0.018	0.61	5.51	0.11	0.74	0.13	5.5	0.4
16	70.13	2923.32	0.018	1.93	9.64	0.20	1.10	0.27	9.6	2.1
17	71.67	2923.29	0.018	0.44	1.54	0.28	1.39	0.30	1.5	0.6
18	71.80	2923.41	0.018	0.03	0.18	0.18	1.01	0.30	0.1	0.0
19	72.05	2923.66	0.018	0.02	0.25	0.06	0.51	0.18	0.2	0.0
20	77.32	2923.77	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
21	78.22	2923.78	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	79.68	2923.77	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
23	80.93	2923.76	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
24	82.71	2923.76	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**17.14**	**72.36**	**5.11**	**1.59**		**71.98**	**27.28**
	SEGMENT OF INTEREST =									**3.45**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
College Ave. & High School Ave. **WESTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2922.10
SLOPE = 0.0029

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2922.20								
2	0.65	2922.14	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
3	5.01	2922.12	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
4	9.37	2922.10	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
5	9.77	2921.80	0.018	0.06	0.50	0.12	1.09	0.30	0.4	0.1
6	10.04	2921.60	0.018	0.11	0.34	0.32	2.10	0.50	0.3	0.2
7	12.70	2921.66	0.018	1.25	2.66	0.47	2.71	0.50	2.7	3.4
8	18.36	2921.76	0.018	2.21	5.66	0.39	2.39	0.44	5.7	5.3
9	31.90	2922.13	0.018	2.12	12.45	0.17	1.37	0.34	12.4	2.9
10	41.22	2922.38	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
11	52.51	2922.26	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
12	55.36	2922.24	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
13	58.07	2922.14	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
14	67.72	2921.78	0.018	1.37	8.58	0.16	1.32	0.32	8.6	1.8
15	70.72	2921.58	0.018	1.26	3.01	0.42	2.51	0.52	3.0	3.2
16	72.61	2921.45	0.018	1.11	1.89	0.58	3.13	0.65	1.9	3.5
17	72.69	2921.79	0.018	0.04	0.35	0.11	1.03	0.65	0.1	0.0
18	72.71	2921.90	0.018	0.01	0.11	0.05	0.57	0.31	0.0	0.0
19	74.67	2921.96	0.018	0.33	1.96	0.17	1.37	0.20	2.0	0.5
20	79.53	2922.09	0.018	0.36	4.86	0.07	0.80	0.14	4.9	0.3
21	80.19	2922.12	0.018	0.00	0.22	0.00	0.13	0.01	0.2	0.0
22	82.75	2922.20	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**10.22**	**42.59**	**3.04**	**2.06**		**42.04**	**21.07**
	SEGMENT OF INTEREST =									**11.86**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
College Ave. & High School Ave. **EASTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2922.00
SLOPE = 0.0029

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2922.20								
2	0.65	2922.14	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
3	5.01	2922.12	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
4	9.37	2922.10	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
5	9.77	2921.80	0.018	0.03	0.33	0.08	0.83	0.20	0.3	0.0
6	10.04	2921.60	0.018	0.08	0.34	0.24	1.73	0.40	0.3	0.1
7	12.70	2921.66	0.018	0.98	2.66	0.37	2.31	0.40	2.7	2.3
8	18.36	2921.76	0.018	1.64	5.66	0.29	1.96	0.34	5.7	3.2
9	31.90	2922.13	0.018	1.05	8.79	0.12	1.09	0.24	8.8	1.1
10	41.22	2922.38	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
11	52.51	2922.26	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
12	55.36	2922.24	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
13	58.07	2922.14	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
14	67.72	2921.78	0.018	0.65	5.90	0.11	1.03	0.22	5.9	0.7
15	70.72	2921.58	0.018	0.96	3.01	0.32	2.09	0.42	3.0	2.0
16	72.61	2921.45	0.018	0.92	1.89	0.48	2.76	0.55	1.9	2.5
17	72.69	2921.79	0.018	0.03	0.35	0.09	0.88	0.55	0.1	0.0
18	72.71	2921.90	0.018	0.00	0.11	0.03	0.41	0.21	0.0	0.0
19	74.67	2921.96	0.018	0.14	1.96	0.07	0.76	0.10	2.0	0.1
20	79.53	2922.09	0.018	0.03	1.50	0.02	0.33	0.04	1.5	0.0
21	80.19	2922.12	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	82.75	2922.20	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**6.51**	**32.50**	**2.22**	**1.86**		**31.98**	**12.15**
	SEGMENT OF INTEREST =									**5.35**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
High School Ave to 4th Avenue **WESTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2920.81
SLOPE = 0.0017

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2920.71								
2	1.79	2920.70	0.018	0.19	1.79	0.10	0.76	0.11	1.8	0.1
3	2.56	2920.72	0.018	0.08	0.77	0.10	0.74	0.11	0.8	0.1
4	2.76	2920.73	0.018	0.02	0.20	0.08	0.66	0.09	0.2	0.0
5	3.15	2920.77	0.018	0.02	0.39	0.06	0.52	0.08	0.4	0.0
6	3.73	2920.82	0.018	0.01	0.47	0.02	0.25	0.04	0.5	0.0
7	7.40	2920.81	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
8	8.89	2920.69	0.018	0.09	1.49	0.06	0.52	0.12	1.5	0.0
9	10.13	2920.60	0.018	0.20	1.24	0.16	1.03	0.21	1.2	0.2
10	14.47	2920.76	0.018	0.56	4.34	0.13	0.88	0.21	4.3	0.5
11	15.46	2920.79	0.018	0.03	0.99	0.03	0.37	0.05	1.0	0.0
12	15.82	2920.81	0.018	0.00	0.36	0.01	0.16	0.02	0.4	0.0
13	23.62	2920.97	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
14	35.66	2921.37	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
15	37.23	2921.42	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
16	37.55	2921.41	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
17	48.48	2921.19	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
18	49.62	2921.25	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
19	52.86	2921.44	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
20	69.97	2921.70	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
21	76.25	2921.43	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	76.38	2921.40	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
TOTAL SECTION VALUES =				**1.21**	**12.05**	**0.77**	**0.82**		**12.03**	**0.99**
SEGMENT OF INTEREST =										**0.77**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
High School Ave to 4th Avenue **EASTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2921.42
SLOPE = 0.0017

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2920.71								
2	1.79	2920.70	0.018	1.28	1.79	0.71	2.74	0.72	1.8	3.5
3	2.56	2920.72	0.018	0.55	0.77	0.71	2.73	0.72	0.8	1.5
4	2.76	2920.73	0.018	0.14	0.20	0.69	2.69	0.70	0.2	0.4
5	3.15	2920.77	0.018	0.26	0.39	0.67	2.62	0.69	0.4	0.7
6	3.73	2920.82	0.018	0.36	0.58	0.62	2.50	0.65	0.6	0.9
7	7.40	2920.81	0.018	2.22	3.67	0.60	2.45	0.61	3.7	5.4
8	8.89	2920.69	0.018	1.00	1.49	0.67	2.62	0.73	1.5	2.6
9	10.13	2920.60	0.018	0.96	1.24	0.77	2.89	0.82	1.2	2.8
10	14.47	2920.76	0.018	3.21	4.34	0.74	2.80	0.82	4.3	9.0
11	15.46	2920.79	0.018	0.64	0.99	0.64	2.56	0.66	1.0	1.6
12	15.82	2920.81	0.018	0.22	0.36	0.62	2.49	0.63	0.4	0.6
13	23.62	2920.97	0.018	4.13	7.80	0.53	2.24	0.61	7.8	9.3
14	35.66	2921.37	0.018	3.01	12.05	0.25	1.36	0.45	12.0	4.1
15	37.23	2921.42	0.018	0.04	1.57	0.02	0.29	0.05	1.6	0.0
16	37.55	2921.41	0.018	0.00	0.32	0.00	0.10	0.01	0.3	0.0
17	48.48	2921.19	0.018	1.31	10.93	0.12	0.83	0.23	10.9	1.1
18	49.62	2921.25	0.018	0.23	1.14	0.20	1.17	0.23	1.1	0.3
19	52.86	2921.44	0.018	0.25	2.90	0.08	0.66	0.17	2.9	0.2
20	69.97	2921.70	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
21	76.25	2921.43	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	76.38	2921.40	0.018	0.00	0.09	0.01	0.16	0.02	0.1	0.0
	TOTAL SECTION VALUES =			**19.81**	**52.64**	**8.68**	**2.22**		**52.61**	**43.90**
	SEGMENT OF INTEREST =									**1.52**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
4th Avenue to 3rd Avenue **WESTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2919.82
SLOPE = 0.0049

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2919.00								
2	4.67	2919.22	0.018	3.32	4.68	0.71	4.59	0.82	4.7	15.2
3	7.30	2919.41	0.018	1.33	2.64	0.50	3.65	0.60	2.6	4.8
4	7.93	2919.59	0.018	0.20	0.66	0.31	2.63	0.41	0.6	0.5
5	8.72	2919.82	0.018	0.09	0.82	0.11	1.33	0.23	0.8	0.1
6	10.05	2919.76	0.018	0.04	1.33	0.03	0.56	0.06	1.3	0.0
7	12.48	2919.64	0.018	0.29	2.43	0.12	1.40	0.18	2.4	0.4
8	13.69	2919.60	0.018	0.24	1.21	0.20	1.97	0.22	1.2	0.5
9	19.02	2919.37	0.018	1.79	5.33	0.33	2.78	0.45	5.3	5.0
10	21.90	2919.48	0.018	1.14	2.88	0.39	3.10	0.45	2.9	3.5
11	25.82	2919.66	0.018	0.98	3.92	0.25	2.29	0.34	3.9	2.2
12	33.36	2919.86	0.018	0.48	6.03	0.08	1.07	0.16	6.0	0.5
13	39.54	2920.04	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
14	50.96	2919.76	0.018	0.07	2.45	0.03	0.56	0.06	2.4	0.0
15	52.23	2919.73	0.018	0.10	1.27	0.07	1.03	0.09	1.3	0.1
16	54.66	2919.79	0.018	0.15	2.43	0.06	0.88	0.09	2.4	0.1
17	61.22	2919.95	0.018	0.02	1.23	0.01	0.35	0.03	1.2	0.0
18	69.39	2919.86	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
19	70.50	2919.85	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
20	70.95	2919.92	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
21	71.33	2919.97	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	72.04	2919.98	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
23	76.29	2920.03	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
24	78.77	2920.02	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
25	79.14	2920.02	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**10.23**	**39.32**	**3.22**	**3.24**		**39.23**	**33.13**
	SEGMENT OF INTEREST =									**12.28**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: Kittelson/Church Street - Thatcher
DETAIL: Manning's Rating for Irregular Section

Section: Existing Roadway
4th Avenue to 3rd Avenue **EASTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2920.03
SLOPE = 0.0049

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2919.00								
2	4.67	2919.22	0.018	4.30	4.68	0.92	5.45	1.03	4.7	23.4
3	7.30	2919.41	0.018	1.88	2.64	0.71	4.60	0.81	2.6	8.7
4	7.93	2919.59	0.018	0.33	0.66	0.51	3.68	0.62	0.6	1.2
5	8.72	2919.82	0.018	0.26	0.82	0.31	2.65	0.44	0.8	0.7
6	10.05	2919.76	0.018	0.32	1.33	0.24	2.23	0.27	1.3	0.7
7	12.48	2919.64	0.018	0.80	2.43	0.33	2.75	0.39	2.4	2.2
8	13.69	2919.60	0.018	0.50	1.21	0.41	3.18	0.43	1.2	1.6
9	19.02	2919.37	0.018	2.90	5.33	0.54	3.84	0.66	5.3	11.2
10	21.90	2919.48	0.018	1.74	2.88	0.60	4.12	0.66	2.9	7.2
11	25.82	2919.66	0.018	1.80	3.92	0.46	3.43	0.55	3.9	6.2
12	33.36	2919.86	0.018	2.04	7.54	0.27	2.41	0.37	7.5	4.9
13	39.54	2920.04	0.018	0.50	5.84	0.08	1.11	0.17	5.8	0.6
14	50.96	2919.76	0.018	1.49	11.02	0.13	1.52	0.27	11.0	2.3
15	52.23	2919.73	0.018	0.36	1.27	0.28	2.50	0.30	1.3	0.9
16	54.66	2919.79	0.018	0.66	2.43	0.27	2.41	0.30	2.4	1.6
17	61.22	2919.95	0.018	1.05	6.56	0.16	1.70	0.24	6.6	1.8
18	69.39	2919.86	0.018	1.02	8.17	0.12	1.44	0.17	8.2	1.5
19	70.50	2919.85	0.018	0.19	1.11	0.17	1.80	0.18	1.1	0.4
20	70.95	2919.92	0.018	0.07	0.46	0.14	1.58	0.18	0.5	0.1
21	71.33	2919.97	0.018	0.03	0.38	0.08	1.11	0.11	0.4	0.0
22	72.04	2919.98	0.018	0.04	0.71	0.05	0.83	0.06	0.7	0.0
23	76.29	2920.03	0.018	0.11	4.25	0.02	0.49	0.05	4.3	0.1
24	78.77	2920.02	0.018	0.01	2.48	0.00	0.17	0.01	2.5	0.0
25	79.14	2920.02	0.018	0.00	0.37	0.01	0.27	0.01	0.4	0.0
	TOTAL SECTION VALUES =			**22.40**	**78.50**	**6.87**	**3.44**		**78.39**	**77.04**
	SEGMENT OF INTEREST =									**8.57**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
3rd Avenue to 2nd Avenue **WESTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n}\ A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2917.73
SLOPE = 0.0058

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2916.85								
2	2.94	2917.12	0.018	2.19	2.95	0.74	5.14	0.88	2.9	11.3
3	4.14	2917.26	0.018	0.65	1.21	0.54	4.14	0.61	1.2	2.7
4	8.77	2917.66	0.018	1.25	4.65	0.27	2.61	0.47	4.6	3.3
5	9.53	2917.73	0.018	0.03	0.76	0.03	0.67	0.07	0.8	0.0
6	11.02	2917.71	0.018	0.01	1.49	0.01	0.29	0.02	1.5	0.0
7	13.20	2917.70	0.018	0.05	2.18	0.02	0.54	0.03	2.2	0.0
8	15.00	2917.68	0.018	0.07	1.80	0.04	0.73	0.05	1.8	0.1
9	17.70	2917.58	0.018	0.27	2.70	0.10	1.35	0.15	2.7	0.4
10	20.42	2917.46	0.018	0.57	2.72	0.21	2.21	0.27	2.7	1.3
11	21.99	2917.42	0.018	0.46	1.57	0.29	2.75	0.31	1.6	1.2
12	23.08	2917.40	0.018	0.35	1.09	0.32	2.93	0.33	1.1	1.0
13	24.56	2917.38	0.018	0.50	1.48	0.34	3.05	0.35	1.5	1.5
14	26.19	2917.36	0.018	0.59	1.63	0.36	3.17	0.37	1.6	1.9
15	30.57	2917.57	0.018	1.16	4.39	0.26	2.58	0.37	4.4	3.0
16	40.41	2918.04	0.018	0.27	3.35	0.08	1.16	0.16	3.3	0.3
17	46.05	2918.03	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
18	57.44	2917.97	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
19	61.96	2917.99	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
20	67.20	2917.90	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
21	71.11	2917.80	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	71.51	2917.85	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
23	71.77	2917.88	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
24	74.97	2918.18	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
25	75.39	2918.22	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
26	75.59	2918.18	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
27	77.35	2917.89	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
28	78.85	2918.03	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
29	80.14	2918.17	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
30	81.76	2918.01	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
31	82.16	2917.97	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
32	85.03	2917.91	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
33	89.37	2917.81	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**8.42**	**33.98**	**3.62**	**3.31**		**33.92**	**27.91**
	SEGMENT OF INTEREST =									**10.70**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
3rd Avenue to 2nd Avenue **EASTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2918.04
SLOPE = 0.0058

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2916.85								
2	2.94	2917.12	0.018	3.10	2.95	1.05	6.48	1.19	2.9	20.1
3	4.14	2917.26	0.018	1.02	1.21	0.84	5.60	0.92	1.2	5.7
4	8.77	2917.66	0.018	2.69	4.65	0.58	4.35	0.78	4.6	11.7
5	9.53	2917.73	0.018	0.26	0.76	0.34	3.07	0.38	0.8	0.8
6	11.02	2917.71	0.018	0.48	1.49	0.32	2.93	0.33	1.5	1.4
7	13.20	2917.70	0.018	0.73	2.18	0.33	3.02	0.34	2.2	2.2
8	15.00	2917.68	0.018	0.63	1.80	0.35	3.11	0.36	1.8	2.0
9	17.70	2917.58	0.018	1.11	2.70	0.41	3.46	0.46	2.7	3.8
10	20.42	2917.46	0.018	1.41	2.72	0.52	4.05	0.58	2.7	5.7
11	21.99	2917.42	0.018	0.94	1.57	0.60	4.46	0.62	1.6	4.2
12	23.08	2917.40	0.018	0.69	1.09	0.63	4.61	0.64	1.1	3.2
13	24.56	2917.38	0.018	0.96	1.48	0.65	4.70	0.66	1.5	4.5
14	26.19	2917.36	0.018	1.09	1.63	0.67	4.80	0.68	1.6	5.2
15	30.57	2917.57	0.018	2.52	4.39	0.57	4.33	0.68	4.4	10.9
16	40.41	2918.04	0.018	2.31	9.85	0.23	2.38	0.47	9.8	5.5
17	46.05	2918.03	0.018	0.03	5.64	0.00	0.18	0.01	5.6	0.0
18	57.44	2917.97	0.018	0.46	11.39	0.04	0.73	0.07	11.4	0.3
19	61.96	2917.99	0.018	0.27	4.52	0.06	0.96	0.07	4.5	0.3
20	67.20	2917.90	0.018	0.50	5.24	0.09	1.30	0.14	5.2	0.6
21	71.11	2917.80	0.018	0.74	3.91	0.19	2.07	0.24	3.9	1.5
22	71.51	2917.85	0.018	0.09	0.40	0.21	2.24	0.24	0.4	0.2
23	71.77	2917.88	0.018	0.05	0.26	0.17	1.95	0.19	0.3	0.1
24	74.97	2918.18	0.018	0.14	1.71	0.08	1.16	0.16	1.7	0.2
25	75.39	2918.22	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
26	75.59	2918.18	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
27	77.35	2917.89	0.018	0.07	0.92	0.07	1.10	0.15	0.9	0.1
28	78.85	2918.03	0.018	0.12	1.51	0.08	1.16	0.15	1.5	0.1
29	80.14	2918.17	0.018	0.00	0.09	0.00	0.18	0.01	0.1	0.0
30	81.76	2918.01	0.018	0.00	0.31	0.01	0.38	0.03	0.3	0.0
31	82.16	2917.97	0.018	0.02	0.40	0.05	0.85	0.07	0.4	0.0
32	85.03	2917.91	0.018	0.29	2.87	0.10	1.35	0.13	2.9	0.4
33	89.37	2917.81	0.018	0.78	4.34	0.18	2.00	0.23	4.3	1.6
	TOTAL SECTION VALUES =			**23.49**	**84.00**	**9.47**	**3.93**		**83.89**	**92.36**
	SEGMENT OF INTEREST =									**3.23**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
2nd Avenue to 1st Avenue **WESTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2916.30
SLOPE = 0.0012

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2915.97								
2	2.51	2916.03	0.018	0.75	2.51	0.30	1.28	0.33	2.5	1.0
3	6.99	2916.15	0.018	0.94	4.48	0.21	1.01	0.27	4.5	0.9
4	7.46	2916.23	0.018	0.05	0.48	0.11	0.65	0.15	0.5	0.0
5	7.89	2916.30	0.018	0.02	0.44	0.03	0.30	0.07	0.4	0.0
6	12.84	2916.20	0.018	0.25	4.95	0.05	0.39	0.10	5.0	0.1
7	14.01	2916.11	0.018	0.17	1.17	0.14	0.79	0.19	1.2	0.1
8	14.57	2916.12	0.018	0.10	0.56	0.18	0.93	0.19	0.6	0.1
9	19.39	2916.13	0.018	0.84	4.82	0.17	0.89	0.18	4.8	0.8
10	22.26	2916.19	0.018	0.40	2.87	0.14	0.77	0.17	2.9	0.3
11	24.87	2916.25	0.018	0.21	2.61	0.08	0.53	0.11	2.6	0.1
12	25.97	2916.28	0.018	0.04	1.10	0.03	0.31	0.05	1.1	0.0
13	36.66	2916.55	0.018	0.01	0.79	0.01	0.13	0.02	0.8	0.0
14	47.08	2916.38	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
15	48.52	2916.35	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
16	49.94	2916.36	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
17	59.68	2916.39	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
18	67.89	2916.44	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
19	68.28	2916.46	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
20	68.48	2916.61	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
21	68.65	2916.74	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	71.93	2916.86	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
23	72.68	2916.89	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
24	75.01	2916.91	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
25	77.27	2916.84	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
26	81.10	2916.86	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**3.78**	**26.78**	**1.47**	**0.92**		**26.76**	**3.46**
	SEGMENT OF INTEREST =									**1.51**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
2nd Avenue to 1st Avenue **EASTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2916.55
SLOPE = 0.0012

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2915.97								
2	2.51	2916.03	0.018	1.38	2.51	0.55	1.92	0.58	2.5	2.6
3	6.99	2916.15	0.018	2.06	4.48	0.46	1.70	0.52	4.5	3.5
4	7.46	2916.23	0.018	0.17	0.48	0.35	1.43	0.40	0.5	0.2
5	7.89	2916.30	0.018	0.12	0.44	0.28	1.23	0.32	0.4	0.2
6	12.84	2916.20	0.018	1.49	4.95	0.30	1.28	0.35	5.0	1.9
7	14.01	2916.11	0.018	0.46	1.17	0.39	1.53	0.44	1.2	0.7
8	14.57	2916.12	0.018	0.24	0.56	0.43	1.64	0.44	0.6	0.4
9	19.39	2916.13	0.018	2.05	4.82	0.42	1.61	0.43	4.8	3.3
10	22.26	2916.19	0.018	1.12	2.87	0.39	1.52	0.42	2.9	1.7
11	24.87	2916.25	0.018	0.86	2.61	0.33	1.36	0.36	2.6	1.2
12	25.97	2916.28	0.018	0.31	1.10	0.28	1.24	0.30	1.1	0.4
13	36.66	2916.55	0.018	1.44	10.69	0.13	0.75	0.27	10.7	1.1
14	47.08	2916.38	0.018	0.89	10.42	0.08	0.55	0.17	10.4	0.5
15	48.52	2916.35	0.018	0.27	1.44	0.18	0.93	0.20	1.4	0.2
16	49.94	2916.36	0.018	0.28	1.42	0.19	0.96	0.20	1.4	0.3
17	59.68	2916.39	0.018	1.70	9.74	0.17	0.89	0.19	9.7	1.5
18	67.89	2916.44	0.018	1.11	8.21	0.13	0.75	0.16	8.2	0.8
19	68.28	2916.46	0.018	0.04	0.39	0.10	0.61	0.11	0.4	0.0
20	68.48	2916.61	0.018	0.01	0.15	0.04	0.31	0.09	0.1	0.0
21	68.65	2916.74	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
22	71.93	2916.86	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
23	72.68	2916.89	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
24	75.01	2916.91	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
25	77.27	2916.84	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
26	81.10	2916.86	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**16.00**	**68.46**	**5.25**	**1.29**		**68.40**	**20.59**
	SEGMENT OF INTEREST =									**3.38**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
East of 1st Avenue **WESTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2916.24
SLOPE = 0.0020

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2916.24								
2	0.64	2916.25	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
3	8.21	2916.37	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
4	9.80	2916.39	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
5	17.00	2916.84	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
6	17.31	2916.86	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
7	18.01	2916.89	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
8	30.86	2917.45	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
9	42.00	2917.39	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
10	43.99	2917.38	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
11	48.74	2917.34	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
12	48.97	2917.35	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
13	49.40	2917.34	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
14	56.77	2917.24	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
15	58.87	2917.33	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**0.00**	**0.00**	**0.00**	**#DIV/0!**		**0.00**	**0.00**
	SEGMENT OF INTEREST =									**0.00**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
East of 1st Avenue **EASTBOUND**

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 2917.33
SLOPE = 0.0035

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	2916.24								
2	0.64	2916.25	0.018	0.69	0.64	1.08	5.15	1.09	0.6	3.6
3	8.21	2916.37	0.018	7.72	7.57	1.02	4.95	1.08	7.6	38.2
4	9.80	2916.39	0.018	1.51	1.59	0.95	4.72	0.96	1.6	7.1
5	17.00	2916.84	0.018	5.15	7.21	0.71	3.90	0.94	7.2	20.1
6	17.31	2916.86	0.018	0.15	0.31	0.48	2.99	0.49	0.3	0.4
7	18.01	2916.89	0.018	0.32	0.70	0.45	2.89	0.47	0.7	0.9
8	30.86	2917.45	0.018	2.22	10.11	0.22	1.78	0.44	10.1	3.9
9	42.00	2917.39	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
10	43.99	2917.38	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
11	48.74	2917.34	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
12	48.97	2917.35	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
13	49.40	2917.34	0.018	0.00	0.00	0.00	0.00	0.00	0.0	0.0
14	56.77	2917.24	0.018	0.30	6.63	0.04	0.62	0.09	6.6	0.2
15	58.87	2917.33	0.018	0.09	2.10	0.04	0.62	0.09	2.1	0.1
	TOTAL SECTION VALUES =			**18.16**	**36.87**	**5.01**	**4.10**		**36.84**	**74.52**
	SEGMENT OF INTEREST =									**0.24**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Proposed Roadway - Summary**
Sections taken from 30% plan set

Location	Curb-Full Street Flow Capacity (cfs)
	Design
Stadium Ave to College Ave	25.12
College Ave to High School Ave	55.07
High School Ave to 4th Ave	18.31
4th Ave to 3rd Ave	29.81
3rd Ave to 2nd Ave	36.85
2nd Ave to 1st Ave	38.94
1st Ave to Diamond Springs-West	30.37

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Proposed Roadway**
Between Staduim and College Ave.

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 0.50
SLOPE = 0.0020

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	0.50								
2	0.00	0.00	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
3	44.20	0.44	0.018	12.33	44.20	0.28	1.58	0.50	44.2	19.4
4	69.70	0.19	0.018	4.73	25.50	0.19	1.20	0.31	25.5	5.7
5	69.70	0.69	0.018	0.00	0.31	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**17.06**	**70.52**	**0.46**	**1.47**		**69.70**	**25.12**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Proposed Roadway**
College Ave. & High School Ave.

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 0.50
SLOPE = 0.0046

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	0.50								
2	0.00	0.00	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
3	25.50	0.26	0.018	9.50	25.50	0.37	2.90	0.50	25.5	27.5
4	51.00	0.00	0.018	9.50	25.50	0.37	2.90	0.50	25.5	27.5
5	51.00	0.50	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**19.00**	**52.00**	**0.74**	**2.90**		**51.00**	**55.07**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Proposed Roadway**
High School Ave to 4th Avenue

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 0.50
SLOPE = 0.0020

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	0.50								
2	0.00	0.00	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
3	25.50	0.51	0.018	6.25	25.00	0.25	1.46	0.50	25.0	9.2
4	51.00	0.00	0.018	6.25	25.00	0.25	1.46	0.50	25.0	9.2
5	51.00	0.50	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**12.50**	**51.01**	**0.50**	**1.46**		**50.00**	**18.31**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Proposed Roadway**
4th Avenue to 3rd Avenue

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n}\ A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 0.50
SLOPE = 0.0053

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	0.50								
2	0.00	0.00	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
3	25.50	0.51	0.018	6.25	25.00	0.25	2.38	0.50	25.0	14.9
4	51.00	0.00	0.018	6.25	25.00	0.25	2.38	0.50	25.0	14.9
5	51.00	0.50	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**12.50**	**51.01**	**0.50**	**2.38**		**50.00**	**29.81**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Proposed Roadway**
3rd Avenue to 2nd Avenue

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL=	0.50
SLOPE =	0.0081

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	0.50								
2	0.00	0.00	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
3	25.50	0.51	0.018	6.25	25.00	0.25	2.95	0.50	25.0	18.4
4	51.00	0.00	0.018	6.25	25.00	0.25	2.95	0.50	25.0	18.4
5	51.00	0.50	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**12.50**	**51.01**	**0.50**	**2.95**		**50.00**	**36.85**

Legend:

"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
2nd Avenue to 1st Avenue

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 0.50
SLOPE = 0.0023

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	0.50								
2	0.00	0.00	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
3	25.50	0.26	0.018	9.50	25.50	0.37	2.05	0.50	25.5	19.5
4	51.00	0.00	0.018	9.50	25.50	0.37	2.05	0.50	25.5	19.5
5	51.00	0.50	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**19.00**	**52.00**	**0.74**	**2.05**		**51.00**	**38.94**

Legend:
- "n" = Manning's roughness coefficient
- A = flow area
- WP = wetted perimeter
- Rh = hydraulic radius
- V = flow velocity
- D = flow depth
- T = topwidth
- Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

PROJ: **Kittelson/Church Street - Thatcher**
DETAIL: **Manning's Rating for Irregular Section**

Section: **Existing Roadway**
1st Ave to Diamond Springs

Solution is for Manning's Equation for each section segment as follows:

$$Q = VA = \frac{1.49\ Rh^{2/3}\ S^{1/2}}{n} A$$

Calculation of discharge is for an assumed water surface elevation (WSEL) and given slope (SLOPE):

ASSUMED WSEL= 0.50
SLOPE = 0.0055

POINT #	STATION (FT)	ELEV (FT)	"n" value	A (sq. ft)	WP (feet)	Rh (feet)	V (ft/sec)	D (feet)	T (feet)	Q (cfs)
1	0.00	0.50								
2	0.00	0.00	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
3	25.50	0.51	0.018	6.25	25.00	0.25	2.43	0.50	25.0	15.2
4	51.00	0.00	0.018	6.25	25.00	0.25	2.43	0.50	25.0	15.2
5	51.00	0.50	0.018	0.00	0.50	0.00	0.00	0.00	0.0	0.0
	TOTAL SECTION VALUES =			**12.50**	**51.01**	**0.50**	**2.43**		**50.00**	**30.37**

Legend:
"n" = Manning's roughness coefficient
A = flow area
WP = wetted perimeter
Rh = hydraulic radius
V = flow velocity
D = flow depth
T = topwidth
Q = discharge

NOTES: Segment Q shown is for segment between indicated point and previous point
"Total" Section value for V (velocity) is average for entire section

Appendix 2
Preliminary Geotechnical and Pavement Technical Memorandum

DRAFT

TECHNICAL MEMORANDUM

Date:	July 22, 2013	**Project No.:**	123-92516
To:	Radu Nan, PE	**Company:**	Kittelson and Associates
From:	Randy Post, PE		
cc:	Jason Simmers, PE	**Email:**	

RE: THATCHER CHURCH ST. WIDENING – PRELIMINARY GEOTECHNICAL AND PAVEMENT RECOMMENDATIONS – TRACS NO. SZ027 03D

This technical memorandum presents preliminary geotechnical and pavement recommendations for the Church St. Widening Project from Stadium Avenue to US 70 in Thatcher, Arizona (TRACS No. SZ027 03D). The project is being designed by Kittelson and Associates (Kittelson) under the Arizona Department of Transportation (ADOT) Local Government On-Call contract. The scope of work for Golder Associates Inc. (Golder) includes providing a geotechnical field and laboratory investigation and providing geotechnical recommendations in the form of a Pavement Design Report and a Materials Pavement Design Memorandum.

The project team decided in the kick-off meeting on January 29, 2013 that we would not request a separate geotechnical environmental clearance for this project. The implication of this decision is that the results of the geotechnical investigation and the corresponding recommendations will not be available until later in the design phase after the environmental clearance has been obtained for the entire project. Golder suggested we provide preliminary recommendations based on existing geotechnical data, and the team agreed.

1.0 EXISTING GEOTECHNICAL DATA

1.1 Previous Geotechnical Reports

The Town of Thatcher provided copies of three geotechnical reports for subdivisions in the surrounding vicinity. These reports are:

- Quality Testing LLC (QTL, 2007). Geotechnical Investigation Report for Spring Canyon Estates, Thatcher, Arizona, QT Job No. 0730, July 13, 2007.
- Western Technologies Inc. (WTI, 2006). Geotechnical Evaluation, Proposed Cota Ranches, Lots 1 through 127, First Street and Porter Lane, Thatcher, AZ, August 7, 2006, Job No. 2926JC130.
- WTI (2006). Geotechnical Evaluation, Stadium Manor West, Phase 1, South of Highway 70 between Ray Lane and Stadium Drive, Thatcher, AZ, June 20, 2000, Job No. 2920JM127.

Golder reviewed laboratory test results for samples taken near the surface for all boreholes in these three reports. We included samples in our data set that had sieve analysis and Atterberg limits results so that

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correlated R-Values could be calculated using the methods in the ADOT Materials Group Preliminary Engineering and Design Manual (PE&D Manual, ADOT, 1989).

1.2 National Resource Conservation Service (NRCS) Soil Map

The NRCS of the US Department of Agriculture produces soil surveys that are primarily used for agricultural purposes. However, this information is also useful for engineering purposes as much of the soil science laboratory data is transferrable to geotechnical engineering. Soil scientists are primarily interested in the top 5 feet of soil, so this information is applicable to roadway subgrade analysis and other shallow engineering applications. The AASHTO Subsurface Investigations Manual (1988) discusses the use of NRCS data on transportation projects.

Golder created a project-specific soil survey report using the online web soil survey application (NRCS, 2013). The locations of boreholes from the reports described in Section 1.1 were compared to the mapped soil survey units. Golder compared the correlated R-Value ranges computed using NRCS data with the correlated R-Values from the laboratory tests in the geotechnical report data set. The range of correlated R-Values computed for each unit that appears on the project corridor was generally consistent between the two approaches.

2.0 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

2.1 Pavement Subgrade

Golder selected a design R-Value of 25 for preliminary pavement design based on the analysis described in Sections 1.1 and 1.2.

Several of the NRCS map units have a “Clay loam” layer at the surface that has a Unified Soil Classification System designation of CL or CL-ML and an AASHTO classification of A-4 or A-6. This layer is on the order of 10 to 12 inches thick in most cases, and the bottom of the pavement section will likely extend to the bottom of this layer, so no site-wide overexcavation will likely be required. Localized areas of overexcavation may be required based on the results of the geotechnical investigation.

The Pima Clay NRCS map unit occurs along the project alignment between approximately Station 76+50 and 85+50. It consists of CH or CL material (AASHTO A-6) but extends deeper than the surficial clay layers present in other map units. None of the boreholes from the investigations mentioned in Section 1.1 were located in this unit. The NRCS report indicates that this unit has high swell potential, and it is anticipated to have an R-Value below the selected design value. Accordingly, unsuitable subgrade is anticipated from approximately station 76+50 to station 85+50.

2.2 Overexcavation and Replacement

Golder recommends that the design team assume three feet (relative to finished grade) of overexcavation and replacement of the subgrade between Station 76+50 and 85+50 for preliminary design and cost estimating purposes. The limits of the overexcavation should extend the full width of the pavement reconstruction and include the curb and sidewalk. Golder will ensure that the field investigation adequately covers this zone to determine if the overexcavation is necessary. We will also investigate other mitigation options, including stabilization with lime or cement or possibly geogrid if the results of swell tests are favorable.

3.0 PRELIMINARY PAVEMENT RECOMMENDATIONS

Golder performed pavement design analysis using the flexible pavement design procedures in the PE&D Manual (ADOT, 1989). The pavement design is discussed in the following sections.

3.1 Traffic Data

Kittelson provided the estimated cumulative number of 18-kip equivalent single axle loadings (ESALs) in an email on July 1, 2013 (personal communication). The design year is given as 2040, the average daily traffic for 2013 is 1,905 vehicles per day, and the estimated average daily traffic for the design year is 4,270 vehicles per day. Kittelson used a vehicle distribution of 98 percent cars, and 2 percent trucks with a vehicle equivalency factor of 0.8. They computed the total number of ESALS in the design lane as 238,727.

3.2 Flexible Pavement Design Parameters

The flexible pavement design parameters used to develop the pavement sections for the project are shown in Table 1.

Table 1: Flexible Pavement Design Parameters

W_{18}	Z_R	S_0	P_O	P_T	ΔPSI
238,727	-1.282	0.35	4.1	2.6	1.5

Notes:
W_{18} = 18-kip ESALs applied to the pavement during the design life in the design lane
Z_R = standard normal random variable corresponding to level of reliability values on page 83 of the PE&D Manual
S_0 = standard error as given by ADOT
P_O = the initial design serviceability index, as determined from page 83 of the PE&D Manual
P_T = the design terminal serviceability index, as determined 83 of the PE&D Manual
ΔPSI = P_O - P_T; this is the change from the present serviceability index over the design period

In addition to these parameters, a resilient modulus of 11,239 pounds per square inch was used throughout the project. This value is derived from the assumed design R-Value of 25 presented in Section 2.1.

The structural coefficients for AC and base materials used for design were given in Table 202.02-6 of the PE&D Manual. Accordingly, the structural coefficients used for AC and aggregate base materials were

0.44 and 0.14, respectively. A drainage coefficient of 0.93 was assigned based on Table 202.02-7 of the ADOT Materials Design Manual for poor drainage conditions and with a seasonal variation factor (SVF) for the Safford area of 1.6 based on Figure 202.02-1 and Table 202.02-4 of the ADOT Materials Design Manual.

3.3 Required Structural Numbers

The required pavement structural number was calculated as 2.25 based on the design parameters described above. This exceeded minimum required structural number of 2.0 based on page 202.04-1 of the PE&D Manual, so a structural number of 2.25 was used for design of the pavement structural sections.

3.4 Pavement Section Alternatives

Table 2 presents the flexible pavement section alternatives that meet the required structural number of 2.25 for Church Street. The pavement design sheets for these sections are attached.

Table 2: Pavement Structural Section Alternatives

Pavement Section Alternative	Asphaltic Concrete Thickness (inches)	Aggregate Base Thickness (inches)	Total Section Thickness (inches)	Provided Structural Number
1	3.5	7.0	10.5	2.32
2	3.0	9.0	12.0	2.32

4.0 LIMITATIONS AND CLOSING

This report has been prepared exclusively for the use of Kittelson, ADOT and the Town of Thatcher for the specific application to the Roadway Improvement Project – Church Street between Stadium Avenue and US 70 (Project No. SZ027 01C). No third party engineer or consultant shall be entitled to rely on any of the information, conclusions, or opinions contained in this report without the prior written approval from Kittelson and Golder.

The conclusions and recommendations in this report have been prepared in a manner consistent with the level of care and skill ordinarily exercised by engineering professionals currently practicing under similar conditions, subject to the time limits and financial and physical constraints imposed on, or otherwise applicable to, Golder's analyses.

In preparing its conclusions and recommendations, Golder has relied upon information provided by the client, such as referenced reports, laboratory data, and topographical data. Golder is not responsible for errors or omissions in the information provided by Kittelson, ADOT, or the Town of Thatcher.

5.0 REFERENCES

AASHTO (1988). Manual on Subsurface Investigations, American Association of State Highway and Transportation Officials.

Arizona Department of Transportation (ADOT, 1989). Preliminary Engineering & Design Manual, 3rd Edition, March.

Nan, Radu. 2013. Personal communication (e-mail) between Radu Nan, PE (Kittelson and Associates) and Randy Post, PE (Senior Project Engineer, Golder Associates Inc.) regarding Church Street Widening Traffic Data.

NRCS (2013). Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/ accessed February 12, 2013.

Quality Testing LLC (QTL, 2007). Geotechnical Investigation Report for Spring Canyon Estates, Thatcher, Arizona, QT Job No. 0730, July 13, 2007.

Western Technologies Inc. (WTI, 2006). Geotechnical Evaluation, Proposed Cota Ranches, Lots 1 through 127, First Street and Porter Lane, Thatcher, AZ, August 7, 2006, Job No. 2926JC130.

WTI (2000). Geotechnical Evaluation, Stadium Manor West, Phase 1, South of Highway 70 between Ray Lane and Stadium Drive, Thatcher, AZ, June 20, 2000, Job No. 2920JM127.

Attachments

Thatcher: Church St. Widening - Preliminary Pavement Analysis (Prior to Geotech Investigation)
Church Street - Alternative 1

AASHTO Flexible Pavement Design Process

19-Jul-13	Made By:	R. Post	
	Chkd By:	M. Pegnam	

ESAL's (W-18) — **238,727** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) — **90.00 %**
Zr = -1.282 Table 202.02-1 (page 83)

Standard Error (So) — **0.35** ADOT Standard Number (202.02.D page 82)

Serviceability Index:
Po = **4.1** Table 202.02-2 (page 83)
Pt = **2.6**
Delta-PSI = 1.5

Resilient Modulus (Mr) — **11,239** psi with R value of: **25**

Seasonal Variation Factor — **1.6** (pages 89-92)
Quality of Base Drainage Number — **4** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.93 Table 202.02-7 (p.102)

Structural Number Required, SN_{reqd} = **2.25**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coeff.	Drainage Coeff.
ARAC =	D1=0.00	inches	a1 = 0.55	m1 = 1.00
Asphaltic Concrete =	D2=3.50	inches	a2 = 0.44	m2 = 1.00
Cement/Bituminous Base =	D3=0.00	inches	a3 = 0.28	m3 = 1.00
Cement/Lime Subgrade =	D4=0.00	inches	a4 = 0.23	m4 = 1.00
Aggregate Base =	D5=7.00	inches	a5 = 0.12	m5 = 0.93

Structural Number Provided, SN = **2.32**

PAVEMENT SECTION IS SUFFICIENT
103.23% of that required

Pavement Unit Costs

ARAC =		/Sq. Yd./in. of thickness
Asphaltic Concrete =		/Sq. Yd./in. of thickness
Cement/Bituminous Base =		/Sq. Yd./in. of thickness
Cement/Lime Subgrade =		/Sq. Yd./in. of thickness
Aggregate Base =		/Sq. Yd./in. of thickness

Pavement Section Costs
Initial ($/SY)
$0.00
Life-Cycle ($/SY)
-

DRAFT

Thatcher: Church St. Widening - Preliminary Pavement Analysis (Prior to Geotech Investigation)
Church Street - Alternative 2

AASHTO Flexible Pavement Design Process

19-Jul-13	Made By:	R. Post
	Chkd By:	M. Pegnam

ESAL's (W-18) — **238,727** Flexible 18-kip Equivalent Single Axle Loads

Level of Reliability (R) — **90.00 %**
Zr = -1.282 Table 202.02-1 (page 83)

Standard Error (So) — **0.35** ADOT Standard Number (202.02.D page 82)

Serviceability Index: **Po =** **4.1** Table 202.02-2 (page 83)
Pt = **2.6**
Delta-PSI = 1.5

Resilient Modulus (Mr) — **11,239** psi with R value of: **25**

Seasonal Variation Factor — **1.6** (pages 89-92)
Quality of Base Drainage Number — **4** <=

Excellent:	1
Good:	2
Fair:	3
Poor:	4
Very Poor:	5

Base Drainage Coefficient, m2 = 0.93 Table 202.02-7 (p.102)

Structural Number Required, SN_{reqd} = **2.25**

Layer (Surfacing - Base) Thicknesses:

Layer	Thickness		Layer Coeff.	Drainage Coeff.
ARAC =	D1=0.00	inches	a1 = 0.55	m1 = 1.00
Asphaltic Concrete =	D2=3.00	inches	a2 = 0.44	m2 = 1.00
Cement/Bituminous Base =	D3=0.00	inches	a3 = 0.28	m3 = 1.00
Cement/Lime Subgrade =	D4=0.00	inches	a4 = 0.23	m4 = 1.00
Aggregate Base =	D5=9.00	inches	a5 = 0.12	m5 = 0.93

Structural Number Provided, SN = **2.32**

PAVEMENT SECTION IS SUFFICIENT
103.37% of that required

Pavement Unit Costs

ARAC =	/Sq. Yd./in. of thickness
Asphaltic Concrete =	/Sq. Yd./in. of thickness
Cement/Bituminous Base =	/Sq. Yd./in. of thickness
Cement/Lime Subgrade =	/Sq. Yd./in. of thickness
Aggregate Base =	/Sq. Yd./in. of thickness

Pavement Section Costs
Initial
($/SY)
$0.00
Life-Cycle
($/SY)
-

DESIGN TRAFFIC DATA

Project Name:	Church St Widening	**KITTELSON & ASSOCIATES, INC.**
Street Name:	Church St	33 N. Stone Avenue, Suite 800
Project Number:	12418	Tucson, Arizona 85701
Analyst:	ABB	Phone: (520) 544-4067
Date:	07/01/2013	Fax: (520) 544-9616
Filename:	C:\Users\rnan\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\YR7HP8CJ\[12418 Pavement Design (MDA).xls	

ESAL Calculation

Based on the ADOT MPED

Current year	2013	
Design year	2040	
Design period, year	27	
Mid-year of design period	126.5	
Average daily traffic - 2013 vpd	1905	from Traffic Report
Average daily traffic - 2040 vpd	4270	from Traffic Report
Constant traffic growth rate, g	0.0303	
Traffic growth factor, GF	40.91	
Number of lanes each direction	1	
Percent of Total Traffic in the Design Lane	0.5	Assume 50% each direction x 100% in the design lane

	Vehicle Proportion	18-kip Factor	Vehicles	ESAL in Design Lane
Cars	98.00%	0.0008	27,878,016	11,151
Heavy Trucks - Light load	2.00%	0.8	568,939	227,576
LT (Light Truck)	0.00%		0	0
MT (Medium Truck)	0.00%		0	0
TS (Tractor Semi-Trailer)	0.00%		0	0
TT (Tractor Trailer)	0.00%		0	0
TST (Tractor Semi-Trailer Trailer)	0.00%		0	0
	100.00%		**Total ESAL in Design Lane**	**238,727**

Vehicle proportions: from Design Traffic Report

18-kip factors: from ADOT Preliminary Engineering and Design Manual, Appendix A

Appendix 3

Plans of the Preferred Alternative

(under separate cover)