HIGH STREET DRAINAGE PLAN

for

STORMWATER IMPROVEMENTS

Prepared for the:

TOWN OF PALMER LAKE

GMS, Inc.
Consulting Engineers

HIGH STREET DRAINAGE PLAN
FOR
THE TOWN OF PALMER LAKE

PROJECT NO. 2021-073.100

MAY 2022

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SECTION I
EXECUTIVE SUMMARY

The Town of Palmer Lake currently experiences unacceptable stormwater runoff conditions; particularly, along High Street which is on the western side of Town. Reports from Town staff indicate that debris and sediment plug the culverts and reroute the water causing the roads to wash out and cause localized flooding. There are no specific areas where flooding consistently occurs.

- The purpose of this report is to provide a Drainage Plan for High Street that will enable the Town to:

  - ➢ Evaluate the adequacy of existing drainage facilities and recommend improvements necessary to correct the stormwater management deficiencies along High Street.
  - ➢ Provide preliminary cost estimates for recommended improvements and prioritize the improvements that should be accomplished.

- Adoption of the High Street Drainage Plan and implementation of the recommendations will:

  - ➢ Reduce flooding in localized areas of Town during minor storm events.
  - ➢ Reduce the potential for damage to private and public property and facilities from stormwater runoff.

SECTION II
BACKGROUND AND OBJECTIVES

A. PURPOSE AND SCOPE

The Town of Palmer Lake undertook a drainage plan evaluation of High Street, as this specific area of Town is experiencing localized flooding that occurs regularly during storm events. As a result, this High Street Drainage Plan was prepared for the Town of Palmer Lake. The purpose of this study is to evaluate existing stormwater management systems along High Street and recommend drainage system improvements for this specific area. This report is intended to serve as a guide for addressing existing drainage problems along High Street.

B. GEOGRAPHIC CONDITIONS

1. Location

The Town of Palmer Lake is located in the northwest of El Paso County bordering Douglas County. El Paso County is located along the Front Range of Colorado. The City of Colorado Springs lies approximately 18 miles southeast on Interstate 25. The Town of Monument is located approximately 3 miles to the east-southeast along Highway 105 and Interstate 25. Figure 1 shows the general location of the Town of Palmer Lake and its relationship to the surrounding communities.

Colorado State Highway 105 bisects the Town of Palmer Lake and is the primary transportation corridor within the Town. The Union Pacific Railroad also bisects the Town of Palmer Lake, running parallel to Highway 105. Interstate 25 is the major transportation network in the County.

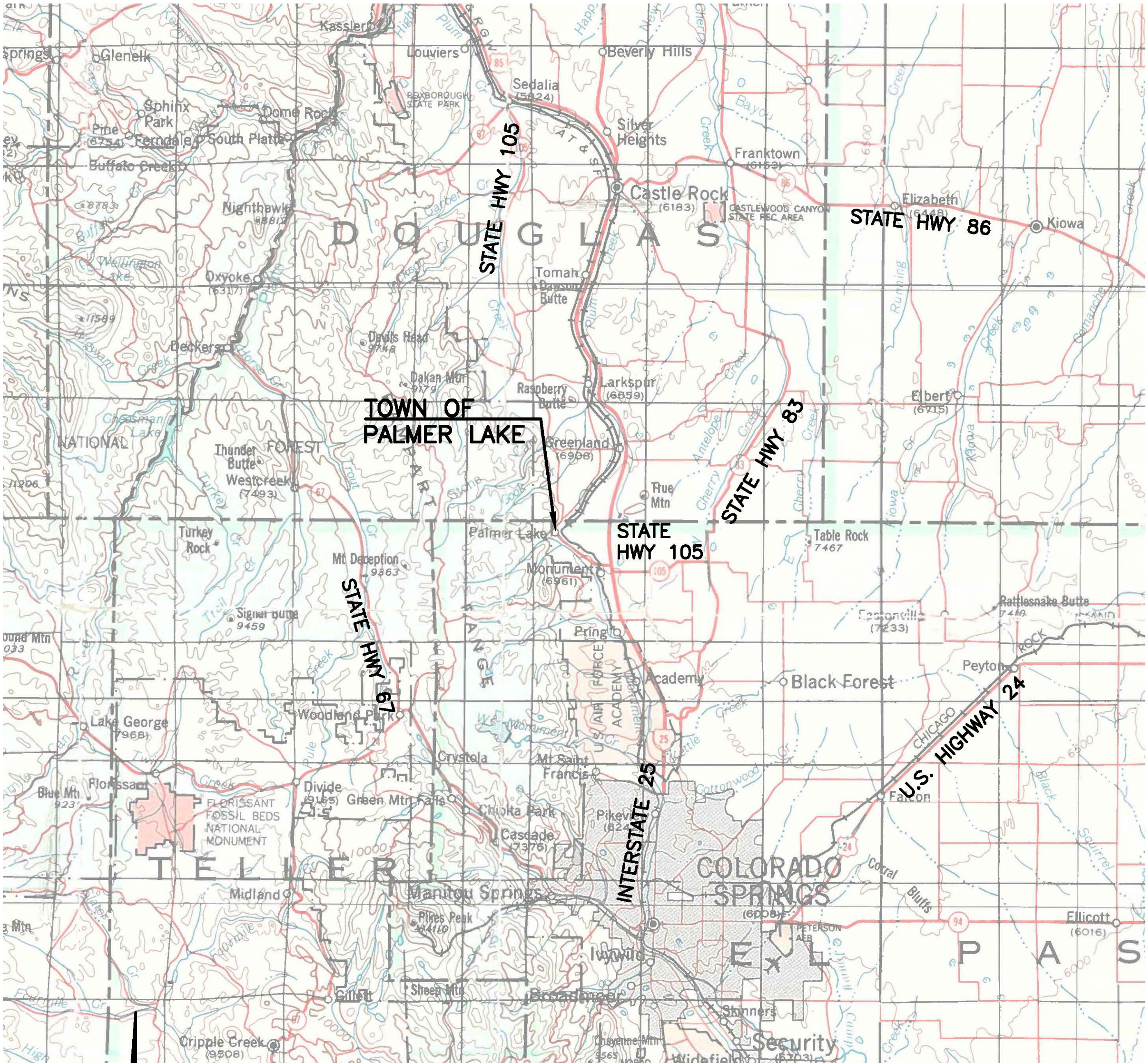

FIGURE 1.DWG

SCALE: 1" = 8miles
(approximate)

SOURCE: USGS MAP OF COLORADO

FIGURE 1
VICINITY MAP
TOWN OF PALMER LAKE

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Figure 2 shows the street configurations of the community, general building locations, general topography, the railroad tracks, the approximate location of the Town limits, the county roadway system, U.S. Highway 105, and Interstate 25's relationship to the community. Access off Interstate 25 is provided to the Town of Palmer Lake by State Highway 105.

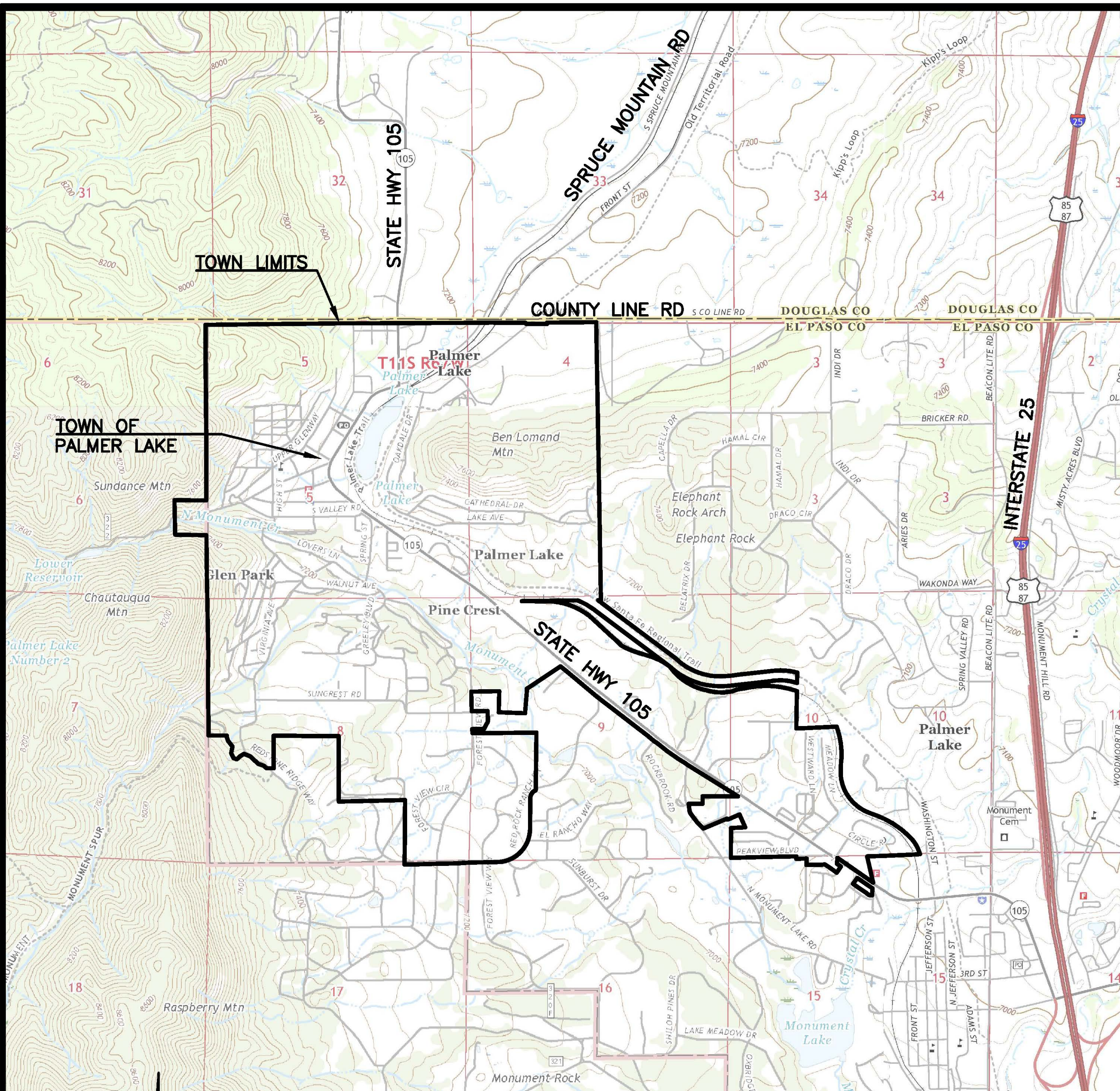
2. Topography

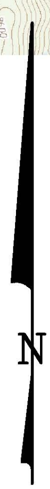
El Paso County is situated between the southern end of the Front Range and the Great Plains. For the most part, the topography of the Town is representative of the Colorado Rocky Mountain foothills. The topography of the Palmer Lake area is shown on Figure 2. Elevations range from a high slightly in excess of 7,800 feet above mean sea level (msl) in the Northwestern portion of the Town, in the mountains, to a low of approximately 7,000 feet msl at the southeastern portion of the Town. The Town of Palmer Lake is located virtually at the topographic divide of the Arkansas River and South Platte River basins. In general, the majority of the drainage exits the Town in a southerly direction towards Monument Creek, which eventually confluences with the Arkansas River.

3. Climate

Data pertaining to climate has been obtained from the National Weather Service and National Oceanic and Atmospheric Administration in conjunction with data available through the Colorado Climate Center. Also referenced is the Climatic Atlas of the United States prepared by the U.S. Department of Commerce. Rainfall, generally between April 1 and October 31, is of the most interest in this Drainage Plan. Frequency analyses and total individual storm precipitation depth have been used to develop hydrologic criteria.

Generally speaking, the area along the Palmer Divide, which is a topographic regional high ridge, receives higher levels of precipitation than other places along the Front Range and El Paso County. Although precipitation conditions within the Town of Palmer Lake are above average for the Front Range of Colorado, they are not extreme to where extraordinary attention must be given to control inflow or infiltration. The Colorado Front Range snowfall





SCALE: 1" = 3,000'

SOURCE: PALMER LAKE AND LARKSPUR USGS QUAD MAPS

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FIGURE 2.DWG

FIGURE 2
LOCATION MAP
TOWN OF PALMER LAKE

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APRIL 2022

typically contains a relatively low amount of water. The majority of the precipitation falls in the form of spring and summer thunderstorms. Temperature conditions in the Town of Palmer Lake are typical of Rocky Mountain foothill conditions.

Based on the Climatic Atlas of the United States, the average annual precipitation in the area is approximately 20 inches. The Colorado Climate Center has a station in Palmer Lake; however, the collected data is sporadic over the last 30 years. There are several weather stations in the Monument area which have comparable weather patterns as Palmer Lake. One station (Monument 3S) is located approximately 3 miles south of the eastern Town boundary. This weather station has data from 2009 to 2021. Based on the information collected by this weather station, the average annual precipitation in the area is approximately 14.93 inches. Most of the precipitation comes in late spring and summer as local thundershowers, some with significant intensity.

The last day of anticipated 32°F temperature in the spring occurs in early to mid-May. The first day of 32°F temperature in the fall occurs around October. Average temperatures from November through March are normally at or near freezing. Average daily maximum temperatures from November through March do not exceed 50°F, while minimum temperatures are between 13 and 22 degrees F.

C. INSTITUTIONAL, POLITICAL AND MANAGERIAL CONDITIONS

The Town of Palmer Lake is a statutory town generally governed by the provisions of the Colorado Revised Statues. The Town was incorporated in 1889. The Town, as an incorporated statutory entity, provides the general public potable water service, a community building, public parks, street maintenance, police department, fire department, and administrative staff. Emergency medical services are provided by county-wide agencies. For the purposes of this study, the drainage services provided by the Town have been examined, in detail, for a localized part of Town.

Historically, stormwater drainage has been handled by the Town to the extent that curb and gutter, roadside ditch sections, and culverts have been placed at appropriate locations to handle the immediate needs of the community. Because of limited Town staff and resources, the Town's current stormwater management plan consists of addressing stormwater and stormwater runoff on an as-needed/crisis basis in an attempt to limit or mitigate the effects of local flooding throughout the community. Palmer Lake is regulated by the Colorado Department of Health and Environment. The Water Quality Control Division regulates stormwater discharges from cities and towns through a Municipal Storm Sewer System (MS4) Permit. The Town has no other requirements or guidelines for implementation beyond that required by the MS4 permit when addressing existing drainage issues or reviewing new areas of development.

D. STORMWATER MANAGEMENT

Throughout this High Street Drainage Plan, reference is made to terminology such as 10-year or 100-year storm event. For purposes of understanding and definition, Table 1 provides a representation of the statistical meaning of these terms. In general, the use of the "…100-year…" terminology indicates that statistically, with a very large set of data, a given storm event defined by that data by precipitation depth and duration would occur only once every 100 years. In practical application, there is a very limited set of data in order to evaluate this storm frequency.

The terminology related to the storm return periods defined above and in Table 1 is better thought of in terms of the probability of occurrence in any given year, that is, the 100-year storm event can occur in any given year. However, statistically, it only has a one percent chance of doing so, whereas a 5-year storm event has a 20% chance of occurrence in any given year.

TABLE 1
TOWN OF PALMER LAKE
STORM RETURN FREQUENCY & PROBABILITY OF OCCURRENCE

Storm Return Frequency	Probability of Occurrence in any Year
2 years	50%
5 years	20%
10 years	10%
100 years	1%

1. Historical Stormwater Management Conditions

The Town presently has stormwater conveyance structures along High Street to accommodate stormwater runoff. The facilities consist of curb and gutter with paved streets, culverts under driveways and intersections, and grass and concrete ditch sections within the street rights-of-way. Many of the roadways have gravel surfaces and concrete channels adjacent to the road. These facilities were not specifically designed to handle a storm event of any given defined magnitude. Typically, stormwater management improvements made within street rights-of-way and on Town-owned property have been constructed to handle immediate stormwater runoff needs. These improvements and modifications typically consist of digging a deeper ditch section, constructing concrete ditch sections, placement of curb and gutter, or the installation of a culvert or installing a larger culvert. The modifications made are generally site specific, and long-range stormwater objectives have not been reviewed to determine if additional modifications, upsizing, or reconfigurations should be considered when addressing site specific drainage concerns. These improvements were completed to address acute drainage problems; however, it is understood that an engineering plan of this local area was not completed.

A topographic survey was performed at the onset of the study, which included an aerial survey including High Street and the surrounding area, including the mountain range to the west. Additionally, a field survey identified the existing drainage structures and facilities along High Street. An observation of the drainage characteristics and flow patterns along High Street was completed. Based upon the information acquired, and the analysis completed, most of the existing facilities can convey a 10-year storm event; however, there are several culverts located along the west side of High Street that cannot accommodate a 10-year storm event. It was also found that none of the existing stormwater runoff facilities within the Town limits are capable of handling the runoff from a 100-year storm event. The 100-year storm event is referenced as many communities including El Paso County require designs to accommodate a 100-year storm event. All of the existing stormwater infrastructure along High Street is capable of conveying a 2-year storm event. Reports from Town staff indicate that debris and sediment plug the culverts and reroute the water, which cause the roads to wash out and creates localized flooding. There are no specific areas where flooding consistently occurs, according to Town staff.

2. Future Stormwater Management Conditions

The improvements proposed within the High Street Drainage Plan are based upon providing a reasonable level of protection from flooding during a 10-year storm event. An underground stormwater system that can convey a 50-year storm event is also proposed as an alternate. The following areas to be examined as a part of the High Street Drainage Plan:

a. All existing culverts were reviewed to determine their current capacity. If overtopping occurs, it was determined whether stormwater runoff contained within the street right-of-way creates unacceptable conditions for pedestrians and vehicular traffic. If conditions are found unacceptable to provide a minimum of one lane of traffic, improvements will be recommended to resolve these issues.

b. Those areas that are likely to be inundated by a 10-year or 100-year storm event will be identified. Again, the storm drainage improvements that can be accomplished to eliminate local flooding will be addressed, with alternative plans for implementation.

Once drainage improvements have been installed and maintained, local flooding within High Street should be minimized and adverse impacts on residents reduced. This study is limited to High Street and contributing basins. In order for the Town to have a full understanding of existing stormwater convenance challenges and proposed measures; the entire Town should be evaluated in time.

E. METHODOLOGY FOR HIGH STREET DRAINAGE PLAN COMPONENT EVALUATION

1. Hydrologic Evaluation

The hydrologic methodology to be utilized in evaluating stormwater runoff and establishing a stormwater management plan was developed, which is discussed in the following paragraphs.

The Federal Emergency Management Agency (FEMA) data was researched to determine if Flood Insurance Rate Maps, typically referred to as FIRM maps, were available for the Palmer Lake area. After researching the most current records on the FEMA website, a FIRM map for the Town of Palmer Lake shows the portions of the Town within a 100-year floodplain. The floodplain delineation follows Monument Creek; High Street does not fall within the delineated floodplain.

The United States Department of Agriculture, Natural Resource Conservation Service (NRCS) developed numerical methods for analyzing stormwater runoff in rural areas. The rationale and methodology developed by the NRCS is extensively used throughout the United States and is widely recognized by many governmental agencies as an acceptable hydrologic evaluation tool. While this methodology was utilized to evaluate the basins, the specific NRCS software was not used. The AutoCAD Storm and Sanitary Analysis program was used to model the calculations.

Not only was it important to determine what methodology was to be used in the hydrologic evaluation, it was also necessary to identify those factors having an impact on the hydrology. Those factors considered are as follows:

a. Land Use and Density

The Town consists of residential and commercial developments. The area surrounding High Street is nearly at full build-out with the potential for a small amount of infill construction yet to be completed. Google Maps was used to determine the amount of pervious surface, i.e., lawns, sports fields, open area and parks, and the amount of impervious surface, i.e., streets, rooftops, sidewalks, and parking lots. These conditions influence the amount of stormwater that has potential to percolate into the soil, or those areas where surface runoff flows will be concentrated as a result of an impermeable surface.

b. Storm Intensity

In order to evaluate and establish the impact of stormwater for 10-year, 50-year, and 100-year storm events, total precipitation depths for various storm durations were determined for the overall area of the Town. The precipitation depth for each storm event was taken from the Precipitation Frequency Data Server (PFDS) mapping in the Colorado NOAA Atlas 14, Volume 8, prepared by the U.S. Department of Commerce, National Weather Service, Office of Hydrology. The rainfall distribution for each storm event is based on a Type II-A storm. Using this information, the recommended drainage improvements listed in the study are based on providing a reasonable level of flood protection during 10-year or 50-year storm events. Appendix A contains the Storm Intensity Data for storm events used for calculating runoff in this report.

c. Soil Conditions

The type of soil affects the retention or infiltration rate which subsequently affects the stormwater runoff. For the purposes of this report, the NRCS Web Soil Survey for Palmer Lake was utilized. The soils located within the High Street sub-basins are predominantly rock outcrops and sandy loams. The hydrological group for the soils within the Town limits is listed as either "B" or "D". Appendix B contains the Soils Data from the NRCS Web Soil Survey for use in the High Street Drainage Plan.

2. Numerical Hydrologic Model

As noted in our hydrologic evaluation section, the NRCS methodology will be used in this report. This methodology was selected, in part, because of its recognition as an acceptable methodology by many regulatory agencies. This method was used in evaluating the drainage basins and sub-basins within the study area. The AutoCAD Storm and Sanitary Analysis program was used to analyze the existing stormwater facilities. The evaluations are based on ariel photography acquired from Google Earth and survey data obtained through standard surveying methods and aerial surveying.

3. Infrastructure Evaluation

In order to recommend drainage improvements to minimize stormwater runoff impacts, it was necessary to evaluate the existing drainage infrastructure. The existing drainage facilities, including, culverts, ditches, curb and gutter, and street sections, were inventoried during a field survey. The existing structure information has been used to assess the suitability of the facilities for adequate stormwater runoff control. All culverts are identified on Figure 3, enclosed in the back of this study.

F. DRAINAGE PLAN OBJECTIVES

In this study, numerous objectives have been discussed that can and should be achieved in the preparation and implementation of the High Street Drainage Plan. In general, those objectives are:

1. Evaluate the adequacy of existing drainage facilities.
2. Recommend improvements necessary to address the drainage facility deficiencies.
3. Provide preliminary cost estimates for recommended improvements and prioritize the improvements that should be accomplished.

SECTION III
EXISTING STORMWATER CONDITIONS

A. HYDROLOGIC EVALUATION

1. Tributary Area Definition

a. High Street Tributary Areas Draining Offsite

The following is a brief description of the basins that drain toward off-site (OS) points. By definition within this report, offsite basins are basins which do not contribute flow to High Street. All but one of the sub-basins east of High Street drain to off-site points and do not affect the stormwater facilities along High Street.

Sub-basins 1E, 6E, and 7E all drain southeast away from High Street. These sub-basins do not affect the stormwater system along High Street. However, the Town staff reports silt and debris build-up at the intersection of Dixie Street and Upper Glenway Road. There are no culverts at the design point of these sub-basins to direct the stormwater to another basin. Curb and gutter was constructed along Upper Glenway Road and Glenway Street.

Most of the sub-basins around High Street drain in a southern direction into North Monument Creek. Monument Creek is a hydrologic feature that bisects the Town and drains in a southeast direction. This channel is tributary to Fountain Creek and ultimately the Arkansas River. The creek crosses under Walnut Avenue south of Old Carriage Road and continues southeast. An analysis of the creek was not completed since it is outside the area of High Street, which is the scope this project is limited to.

b. Drainage basins in Town limits

High Street runs north and south through the western edge of the Town separating this part of town into east basins and west basins. High Street has been separated even further into individual sub-basins which are identified on Figure 3, which is contained at the back of this report.

1) EAST DRAINAGE BASINS: The eastern sub-basins contain all of the sub-basins east of High Street. Most of these basins drain southeast away from High Street. One eastern sub-basin drains southwest to a culvert that crosses under High Street. The east sub-basins are shown on Figure 3 and are identified as follows:

   - Sub-Basin 1E: This basin is located north of Brook Street, west of Viola Street, and extends northwest into the mountains approximately 1.5 miles. This sub-basin contains 16.1 acres and drains southeast over Viola Street. This basin is largely undeveloped contains steep terrain. There is no culvert or cross pan within this basin.

   - Sub-Basin 2E: This basin is located south of Brook Street, north of the alley between Milton Street and Glenarm Street, and east of High Street. The northwest boundary of this sub-basin extends from the southeast corner of the intersection of Brook Street and High Street to the northwest corner of the intersection of Dixie Street and Milton Street. The basin continues south to the alley between Milton Street and Glenarm Street. This sub-basin contains 2 acres and drains south-southeast to a culvert under the alley between Milton Street and Glenarm Street. This basin is completely infilled. This basin does not contribute flow to High Street. Dixie Street was not included in the drainage system inventory survey; therefore, the size of this culvert is unknown. This culvert is identified as C-15 on Figure 3.

   - Sub-Basin 3E: This basin is located south of Brook Street, north of Milton Street, and west of Dixie Street. The western boundary of this sub-basin extends from the southeast corner of the intersection of Brook Street and High Street to the northwest corner of the intersection of Dixie Street and Milton Street. This sub-basin contains 1.2 acres and drains southeast to the culvert under Milton Street. This basin is completely infilled. Dixie Street was not included in the drainage system inventory survey; therefore, the size of this culvert is unknown. This culvert is identified as C-14 on Figure 3. This basin does not contribute flow to High Street.

- Sub-Basin 4E: This basin is located south of the alley between Glenarm Street and Milton Street, north of Glenarm Street, east of High Street, and west of Dixie Street. This sub-basin contains 1 acre and drains southeast to the culvert under Glenarm Street. This basin is completely infilled. This basin does not contribute flow to High Street. Dixie Street was not included in the drainage system inventory survey; therefore, the size of this culvert is unknown. This culvert is identified as C-16 on Figure 3.

- Sub-Basin 5E: This basin is located south of Glenarm Street, north of Upper Glenway Road, east of High Street, and extends east approximately 270 feet along Upper Glenway Road. This sub-basin contains 3.4 acres and drains south to the curb and gutter on the south side of Upper Glenway Road. The stormwater then discharges to an inlet and into a culvert under High Street, located at the southwest corner of the sub-basin. This 24-inch culvert is designated as C-10 on Figure 3.

- Sub-Basin 6-E: This basin is located south of Glenarm Street, north of Upper Glenway Road, west of Dixie Street and extends west approximately 168 feet from the intersection of Dixie Street and Upper Glenway Road. This sub-basin contains 2.2 acres and drains southeast across Upper Glenway Road to a curb and gutter on the south side of the road. The stormwater then drains east along the curb and gutter, away from High Street.

- Sub-Basin 7E: This basin is located south of Upper Glenway Road, north of Glenway Street, east of High Street, and extends east approximately 500 feet to an unnamed alley. This sub-basin contains 3.7 acres and drains southeast to curb and gutter along Glenway Street and then east along Glenway, away from High Street.

2) WEST DRAINAGE BASINS: The west sub-basins contain the majority of the drainage area that affects High Street. For the most part these basins drain east along High Street and eventually discharge into North Monument Creek. There are

limited places where stormwater crosses High Street and drains east. The west sub-basins are shown on Figure 3 and are identified as follows.

- Sub-Basin 1W: This basin is located north of Milton Street, west of Highland Road, and east of the drainage creek coming off the hillside. This sub-basin extends north of Brook Street to the northern mountain ridge. This sub-basin contains 5.7 acres and drains southeast to a culvert under Highland Road. This basin is largely undeveloped with most of the contributing area located on the hillside. This 18-inch corrugated HDPE culvert is designated as C-1 on Figure 3.

- Sub-Basin 2W: This basin is located north of Milton Street, east of Highland Road, and west of High Street. This sub-basin extends north of Brook Street to the northern mountain ridge. This basin is partially developed; however, a significant portion of the basin contains the hillside and is undeveloped. This sub-basin contains 6.1 acres and drains southeast to a culvert under Milton Street. This 18-inch corrugated metal culvert is designated as C-3 on Figure 3.

- Sub-Basin 3W: This basin is the largest sub-basin that was identified and included in drainage calculations for High Street. The defined valley between the east-west mountain ridges means this sub-basin cannot be divided any further. This sub-basin is located west of Highland Road and extends west, bounded by the southern, western, and northern mountain ridge around the defined valley. This sub-basin contains 72.5 acres and drains east over Highland Road. The flow is not directed to a culvert or a cross pan.

- Sub-Basin 4W: This basin is located south of Milton Street, north of Glenarm Street, and east of Highland Road. This sub-basin's eastern border extends diagonally from the intersection of Highland Road and Milton Street to the intersection of High Street and Glenarm Street. This sub-basin contains 1 acre and drains southeast to a culvert under Glenarm Street. This 18-inch corrugated HDPE culvert under Glenarm Street designated as C-2 on Figure 3.

- Sub-Basin 5W: This basin is located south of Milton Street, north of Glenarm Street, and west of High Street. This sub-basin's western border extends diagonally from the intersection of Highland Road and Milton Street to the intersection of High Street and Glenarm Street. This sub-basin contains 1.3 acres and drains southeast to a culvert under Glenarm Street. This 18-inch corrugated metal culvert under Glenarm Street designated as C-5 on Figure 3.

- Sub-Basin 6W: This basin is located south of Glenarm Street, north of Park Street, west of High Street, and east of Highland Road. The northwest corner of this basin extends northwest approximately 400 feet into the hillside. This sub-basin contains 2.3 acres and drains to the southeast to a culvert under Park Street at High Street. This 18-inch corrugated metal culvert is designated as C-8 on Figure 3.

- Sub-Basin 7W: This basin is located west of Highland Road and extends west into the hillside approximately 845 feet. This basin remains north of Thompson Place and extends north approximately 365 feet along Highland Road. This sub-basin contains 4.1 acres and drains southeast across Highland Road and then east along Thompson Place. The flow is not directed to a culvert or cross pan. The flow is directed overland over Thompson Place to High Street.

- Sub-Basin 8W: This basin is located north of Thompson Place, west of Abbey Street, east of Highland Road, extends north to Park Street and then west approximately 920 west into the hillside. This sub-basin contains 9 acres and drains southeast over Abbey Street and then east along Thompson Place towards High Street. The flow is not directed to a culvert or a cross pan.

- Sub-Basin 9W: This basin is located north of Thompson Place, east of Abbey Street, west of High Street, and predominantly south of Park Street. The northwest corner of this sub-basin extends northwest approximately 695 feet into the hillside. This sub-basin contains 3.6 acres and drains southeast to a culvert under Thompson Place at the intersection of High Street. This 26-inch corrugated metal culvert is designated as C-9 on Figure 3.

- Sub-Basin 10W: This basin is located south of Thompson Place, west of High Street, and extends approximately 520 feet west of Highland Road. This basin extends approximately 280 feet south of Thompson Place. This sub-basin contains 5.7 acres and drains east to a culvert under Glenway Street at High Street. This 18-inch corrugated metal culvert is designated as C- 11 on Figure 3.

- Sub-Basin 11W: This basin is located predominantly north of Lower Glenway Street and extends north approximately 345 feet. This basin is also located west of High Street, and extends approximately 110 feet west of Highland Road. This sub-basin contains 5.7 acres and drains east to a culvert under High Street which crosses the intersection of Lower Glenway Street and High Street to the southeast. This 18-inch corrugated metal culvert is designated as C-12 on Figure 3.

- Sub-Basin 12W: This basin is located predominantly south of Lower Glenway Street, north of Glenside Road, west of High Street, and extends west approximately 115 feet west of Hillside Road. This sub-basin contains 3.2 acres and drains southeast to a 30-inch corrugated metal culvert identified as C-13 under South Valley Road at High Street on Figure 3.

2. Design Precipitation Events

Stormwater runoff events reviewed in this study are for the 10-year, 50-year, and 100-year, 6-hour storm events. Evaluations of existing improvements are based on the 10-year and 100-year storm events.

B. STORMWATER RUNOFF EVALUATION

A weighted curve number was established for each sub-basin. This component of the hydrologic model has been developed using the native soil conditions, land uses, and land surface conditions directly related to the amount of precipitation that appears as runoff.

The following is an evaluation of each hydrologic design point. Attached as Appendix C are the runoff calculations for each of the design points lying within the East and West drainage basins. All design points are shown on Figure 3.

1. Design Point Evaluation

    a. Design Point DP 1

    This design point is located at the northwest corner of the intersection of High Street and Milton Street. The contributing basin is 2W. There is one 18-inch CMP culvert, C-3, that crosses south under Milton Street at this intersection. The existing culvert can convey 31.6 cfs at capacity assuming no backwater conditions. The calculated stormwater runoff for the 100-year storm event is approximately 5.8 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 4.2 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 1.6 cfs. Based on the surface profile and field measurements, the culvert can convey the calculated stormwater runoff from both a 10-year and 100-year storm event.

    b. Design Point DP 2

    This design point is located at the northwest corner of the intersection of High Street and Glenarm Street. The contributing basin are 2W and 5W. There is one 18-inch CMP culvert, C-5, that crosses south under Glenarm Street at this intersection. The existing culvert can convey 26.8 cfs at capacity assuming no backwater conditions. The calculated stormwater runoff for the 100-year storm event is approximately 7.3 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 5.3 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 2.0 cfs. Based on the surface profile and field measurements, the culvert can convey the calculated stormwater runoff from both a 10-year and 100-year storm event.

    c. Design Point DP 3

    This design point is located on the west side of Highland Road, approximately 75 feet south of the intersection of Highland Road and Milton Street. The contributing basin is 1W. There is one 18-inch HDPE culvert, C-1, that crosses southeast under Highland Road at this design point location. The existing culvert can convey 16.7 cfs at capacity assuming no backwater conditions. The calculated stormwater runoff for the 100-year storm event is approximately 5.4 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 3.9 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 1.6 cfs. Based on the surface profile and field measurements, the culvert can convey the calculated stormwater runoff from both a 10-year and 100-year storm event.

d. Design Point DP 4

This design point is located on the west side of Highland Road, approximately 120 feet south of the intersection of Highland Road and Milton Street. The contributing basin is 3W. The calculated stormwater runoff for the 100-year storm event is approximately 82.3 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 58.9 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 21.0 cfs. Based on the surface profile and the lack of stormwater conveyance, stormwater sheet flows southeast over Highland Road.

e. Design Point DP 5

This design point is located on the north side of Glenarm Street, approximately 55 feet west of the intersection of High Street and Glenarm Street. There is one 18-inch HDPE culvert, C-2, that crosses southeast under Glenarm Street. The contributing basins are 1W, 3W and 4W. The calculated stormwater runoff for the 100-year storm event is approximately 89.0 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 63.8 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 23.0 cfs. Based on the surface profile and field measurements, the stormwater runoff overtops this pipe and flows overland to the south over Howell Street. This existing culvert can convey 27.2 cfs at capacity assuming no backwater conditions.

f. Design Point DP 6

This design point is located at the northwest corner of the intersection of High Street and Park Street. The contributing basins are 1W, 2W, 3W, 4W, 5W and 6W. There is one 18-inch CMP culvert, C-8, that crosses south under Park Street. The calculated stormwater runoff for the 100-year storm event is approximately 97.9 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 70.2 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 25.0 cfs. Based on the surface profile and field measurements, the stormwater runoff overtops this pipe and flows overland to the south over Park Street. The existing culvert can convey 30.1 cfs at capacity assuming no backwater conditions.

g. Design Point DP 7

This design point is located at the northeast corner of the intersection of Thompson Place and Highland Road. The contributing basin is 7W. The calculated stormwater runoff for the 100-year storm event is approximately 4.2 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 3.1 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 1.2 cfs. Based on the surface profile, the stormwater runoff flows east along Thompson Place in a grass channel along the north side of the road.

h. Design Point DP 8

This design point is located at the northeast corner of the intersection of Abbey Street and Thompson Place. The contributing basins are 7W and 8W. The calculated stormwater runoff for the 100-year storm event is approximately 11.3 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 8.1 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 2.9 cfs. Based on the surface profile, the stormwater runoff flows east along Thompson Place along the north side of the road, in a grass channel. There are 3 driveway culverts of unknown size.

i. Design Point DP 9

This design point is located at the northwest corner of the intersection of Thompson Place and High Street. The contributing basins are 1W, 2W, 3W, 4W, 5W, 6W, 7W, 8W and 9W. There is one 26-inch CMP culvert, C-9, that crosses south under Thompson Place at this intersection. The calculated stormwater runoff for the 100-year storm event is approximately 112.5 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 80.7 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 28.8 cfs. Based on the surface profile and field measurements, the stormwater runoff overtops this pipe and flows overland to the south over Thompson Place. The culvert can convey 64.0 cfs at capacity assuming no backwater conditions.

j. Design Point DP 10

This design point is located at the southeast corner of the intersection of High Street and Upper Glenway Street. The only contributing basin is 5E. There is one 24-inch HDPE culvert, C-11, that crosses southwest under High Street at this intersection. The culvert can convey 20.8 cfs at capacity assuming no backwater conditions. The calculated stormwater runoff for the 100-year storm event is approximately 3.6 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 2.7 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 1.1 cfs. Based on the surface profile and field measurements, the culvert can convey the calculated stormwater runoff from both a 10-year and 100-year storm event.

k. Design Point DP 11

This design point is located at the northwest corner of the intersection of High Street and Glenway Street. The contributing basins are 1W through 10W and 5E. There is one 18-inch CMP culvert, C-11, that crosses south under Glenway Street at this intersection. The calculated stormwater runoff for the 100-year storm event is approximately 119.9 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 86.1 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 30.8 cfs. Based on the surface profile and field measurements, the stormwater runoff overtops this pipe and flows overland to the south over Glenway Street. The culvert can convey 18.4 cfs assuming no backwater conditions.

l. Design Point DP 12

This design point is located at the northwest corner of the intersection of Lower Glenway Street and High Street. The contributing basins are 1W through 11W and 5E. There is one 18-inch CMP culvert, C-12, that crosses southeast under High Street at this intersection. The calculated stormwater runoff for the 100-year storm event is approximately 123.9 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 89.0 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 31.8 cfs. Based on the surface profile and field measurements, the stormwater runoff overtops this pipe and flows overland, through the intersection of Lower Glenway Street and High Street. The flow then continues down High Street. The capacity of this culvert is 9.2 cfs assuming no backwater conditions.

m. Design Point DP 13

This design point is located at the northeast corner of the intersection of South Valley Road and High Street. The contributing basins are 1W through 12W and 5E. There is one 30-inch CMP culvert, C-13, that crosses south under South Valley Road. The calculated stormwater runoff for the 100-year storm event is approximately 126.3 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 90.7 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 32.5 cfs. Based on the surface profile and field measurements, the stormwater runoff overtops this culvert and flows overland to the south over South Valley Road. The capacity of this culvert is 64.8 cfs assuming no backwater conditions.

n. Off Site OS 1

This design point is located at the northwest corner of the intersection of Viola Street and Brook Street. The contributing basin is 1E. The calculated stormwater runoff for the 100-year storm event is approximately 9.8 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 7.0 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 2.6 cfs. Based on the surface profile, stormwater sheet flows over Viola Street and continues southeast both overland and down Viola Street. Flow is directed away from High Street; therefore, it was not analyzed further.

o. Off Site OS 2

This design point is located at the northwest corner of the intersection of Milton Street and Dixie Street. The contributing basin is 3E. There is one culvert, C-14, that crosses south under Milton Street. The calculated stormwater runoff for the 100-year storm event is approximately 1.2 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 0.8 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 0.3 cfs. The culvert size and type are unknown; this culvert is outside of the surveyed inventory area. Flow is directed away from High Street; therefore, it was not analyzed further.

p. Off Site OS 3

This design point is located at the northwest corner of the intersection of Dixie Street and the alley between Milton Street and Glenarm Street. The contributing basins are 2E and 3E. There is one culvert, C-15, that crosses south under that alley. The calculated stormwater runoff for the 100-year storm event is approximately 3.9 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 2.7 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 1.0 cfs. The culvert size and type are unknown; this culvert is outside of the surveyed inventory area. Flow is directed away from High Street; therefore, it was not analyzed further.

q. Off Site OS 4

This design point is located at the northwest corner of the intersection of Dixie Street and Glenarm Street. The contributing basins are 2E, 3E and 4E. There is one culvert, C-16, that crosses south under Glenarm Street. The calculated stormwater runoff for the 100-year storm event is approximately 5.5 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 3.9 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 1.5 cfs. The culvert size and type are unknown; this culvert is outside of the surveyed inventory area. Flow is directed away from High Street; therefore, it was not analyzed further.

r. Off Site OS 5

This design point is located at the intersection of Upper Glenway Road and Dixie Street. The contributing basins are 2E, 3E, 4E and 6E. The calculated stormwater runoff for the 100-year storm event is approximately 8.6 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 6.1 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 2.3 cfs. Based on the surface profile, stormwater sheet flows over Upper Glenway Road into curb and gutter along the south end of the road. Flow is directed away from High Street; therefore, it was not analyzed further.

s. Off Site OS 6

This design point is located at the northwest corner of the intersection of Glenway Street and the alley between High Street and Pie Corner. The contributing basin is 7E. The calculated stormwater runoff for the 100-year storm event is approximately 9.8 cfs. The calculated stormwater runoff for the 50-year storm event is approximately 8.1 cfs. The calculated stormwater runoff for the 10-year storm event is approximately 4.8 cfs. Based on the surface profile, stormwater sheet flows southeast over Glenway Street into curb and gutter along Glenway Street. Flow is directed away from High Street; therefore, it was not analyzed further.

SECTION IV
INFRASTRUCTURE EVALUATION AND NEEDS

A. EXISTING INFRASTRUCTURE EVALUATION

1. Street Drainage Evaluation

The street drainage within the evaluated area along High Street appears to be capable of conveying a 2-year storm event. Major flooding of streets will occur during a 100-year storm event. Many of the local streets that contribute flow to High Street are gravel surfaced with paralleling concrete or grass lined ditches. Flows within the ditch sections are interrupted by driveway culverts which have limited capacity.

The concrete ditch sections north of Glenarm Street have varying capacities between 40 cfs and 68 cfs and can convey a 25-year storm event. All of the driveway culverts north of Glenarm Street are 18 inches in diameter and have varying capacities between 18 cfs and 35 cfs. The concrete ditch between Glenarm Street and Park Street has a capacity of approximately 72 cfs and can convey a 50-year storm event. There is one 18-inch driveway culvert between Glenarm Street and Park Street that has a capacity of 28 cfs. The concrete ditch sections between Park Street and Thompson Place have varying capacities between 47 cfs and 110 cfs and can convey a 25-year storm event. The driveway culverts between Park Street and Thompson Place are 18-inch driveway culverts with one 16-inch driveway culvert. These culverts have varying capacities between 20 cfs and 30 cfs. The concrete ditch sections south of Thompson Place have varying capacities between 33 cfs and 56 cfs and can convey a 10-year storm event. There are two 18-inch driveway culverts and one 12-inch driveway culvert located south of Thompson Place and they have varying capacities between 0 cfs and 25 cfs.

A limited number of streets have curb and gutter along the road which contribute flow to High Street. The only street that has contributing curb and gutter is Upper Glenway. Those areas where the most significant flooding will occur outside the street right-of-way limits are addressed in the following INFRASTRUCTURE NEEDS section.

B. INFRASTRUCTURE NEEDS - 10 YEAR STORM

With the current build-out conditions of the Town, runoff conditions may be impacted in the future with further improvements such as new homes or additional paved roads. There will be more impact with more impervious area, but it is impossible to predict the amount of future impervious area so it is not accounted for in this Drainage Report. Additionally, this report is limited to a review of drainage facilities along High Street.

As stated above, the existing stormwater infrastructure can convey a 2-year storm. A larger storm will cause culverts to reach capacity, starting with the southern end of High Street. There is one driveway culvert with backflow conditions in a 2-year event located along the east side of High Street, south of Lower Glenway Street. This culvert can only convey a 1-year storm event before it reaches capacity due to its backwards slope. Given the sizes of the existing concrete ditches and the amount of cover over the existing culverts, the following infrastructure needs are based on the system conveying a 10-year storm event. The following is an evaluation of those areas where infrastructure improvements are recommended.

1. Drainage Sub-Basin 3W

Sub-basin 3W sheet flows over Highland Road and is the largest sub-basin identified that affects High Street. The culverts are blocked with debris with each minor storm causing flow to be directed overland. This causes the roads to wash out and causes flooding. Since this sub-basin contributes the most stormwater to the system, it is recommended that riprap or other feature to slow the stormwater be installed in the existing ditch behind the homes west of Highland Road. This will slow the stormwater flowing through the ditch, thus causing debris and silt to be caught before entry into any stormwater conveyance structure.

2. Drainage Sub-Basin 9W

Sub-basin 9W drains south under Thompson Place through a 26-inch culvert, C-9. This sub-basin has a series of concrete ditches and culverts along the west edge of High Street. The stormwater flow calculations and the culvert analysis in Appendix C were used to determine that there are two culverts in this sub-basin that are undersized. The proposed improvements are reflected on Figure 4 at the back of this report. Culverts identified with a D are driveway culverts. One culvert is a driveway culvert, D-9, and the other is a short culvert located under a front walk, D-13. In order to convey stormwater for a 10-year storm event, the recommendation is made that the following improvements be undertaken to address the deficient drainage conditions in this area.

- Remove the existing 16-inch CMP culvert, D-9, and replace with a reinforced concrete pipe (RCP) 18-inch horizontal elliptical RCP culvert in the same location.
- Install a headwall on upstream side of D-9 and expand the existing concrete ditch section to accommodate the new pipe's width.
- Remove the existing 16-inch CMP culvert, D-13, and replace with two 15-inch RCP culverts in the same location.
- Install a headwall and expand the existing concrete ditch section to accommodate the second culvert on the upstream side of D-13.

Both existing 16-inch culverts have limited cover, so it is not possible to upsize these culverts. Therefore, an elliptical culvert can be used to upsize to the necessary capacity without decreasing the amount of cover over the culvert. A second culvert is necessary to increase the capacity for the front walk culvert. These improvements will allow the culverts to convey stormwater from a 10-year storm event.

3. Drainage Sub-Basin 10W

Sub-basin 10W drains south under Glenway Street through an 18-inch culvert, C-11. This sub-basin has a series of concrete ditches and culverts along the west edge of High Street. The stormwater flow calculations and the culvert analysis in Appendix C were used to determine that there are two culverts in this sub-basin that are undersized to accommodate a 10-year event. One culvert is a driveway culvert, D-14, and the other is the culvert under Glenway Street, C-11. In order to convey stormwater for a 10-year storm event, the recommendation is made that the following improvements be undertaken to address the deficient drainage conditions in this area.

- Remove the existing 18-inch CMP culvert, D-14, and replace with two 15-inch RCP culverts in the same location.

- Install a headwall on the upstream side of 4D-1A and expand the existing concrete ditch section to accommodate the second culvert.
- Remove the existing 18-inch CMP culvert, C-11 and replace with two 18-inch RCP culverts in the same location.
- Install a headwall on the upstream side of C-11 and expand the existing concrete ditch section to accommodate the second culvert.

Both existing 18-inch culverts have limited cover, so it is not possible to upsize these culverts. Therefore, a second culvert is necessary to increase the stormwater capacity. These improvements will allow the culverts to convey stormwater from a 10-year storm event.

4. Drainage Sub-Basin 11W

Sub-basin 11W drains south under Lower Glenway Street through an 18-inch culvert, C-12. This sub-basin has a series of concrete ditches and culverts along the west edge of High Street. The stormwater flow calculations and the culvert analysis in Appendix C were used to determine that there is one culvert in this sub-basin that is undersized, C-12. In order to convey stormwater for a 10-year storm event, the recommendation is made that the following improvements be undertaken to address the deficient drainage conditions in this area.

- Remove the existing 18-inch CMP culvert, C-12 and replace with two 18-inch RCP culverts in the same location.
- Install a headwall and expand the existing concrete ditch section to accommodate the second culvert on the upstream side of C-12.

The existing 18-inch culvert has a limited cover, so it is not possible to upsize this culvert. Therefore, a second culvert is necessary to increase the stormwater capacity. These improvements will allow the culvert to convey stormwater from a 10-year storm event. Additionally, the culvert will be regraded along with the improvements to sub-basin 12W to provide the culvert with more slope.

5. Drainage Sub-Basin 12W

Sub-basin 12W drains south under Glenside Road through a 30-inch culvert, C-13. The northern inlet of this culvert has been partially crushed. There is also a driveway culvert, D-15, that has reverse slope. The stormwater calculations and the culvert analysis in Appendix C were used to determine that this driveway culvert is also undersized. In order to convey stormwater for a 10-year storm event and fix the reverse slope, the recommendation is made that the following improvements be undertaken to address the deficient drainage conditions in this area.

- Remove the existing 12-inch CMP culvert, D-15, and replace with two 12-inch RCP culverts in the same location.
- Install a headwall and expand the existing concrete ditch section to accommodate the second culvert for D-15.
- Remove the existing 30-inch CMP culvert, C-13 and replace with a new 30-inch RCP culvert in the same location.
- Install a headwall and expand the existing concrete ditch section to accommodate the second culvert for culvert C-13.

Like the culverts above, there is not enough cover over the driveway culvert, D-15, to be able to increase the diameter. Therefore, a second culvert is necessary to increase the stormwater capacity. These improvements will allow culvert D-15 to convey stormwater from a 10-year storm event. Culvert C-13 does not need to be upsized because it can convey stormwater from a 10-year storm event, but the end of the culvert is crushed so it is recommended this culvert get replaced. Additionally, the ditch along the east side of High Street was evaluated and it was determined that the ditch and the culverts can be regraded to a 2% slope from culvert C-13 through culvert C-12. This will fix the backwards slope in the driveway culvert D-15 and create a consistent slope throughout, which will allow for better stormwater conveyance.

C. INFRASTRUCTURE NEEDS - 100 YEAR STORM

As stated above, the existing stormwater infrastructure along High Street can convey a 2-year storm. The improvements recommended in the subsection above will increase the current system's capacity such that it can convey a 10-year storm event. Given the sizes of the existing concrete ditches and the amount of cover over the existing culverts, the existing system cannot be improved beyond conveying a 10-year storm event. As an alternative, the Town can convey up to a 100-year storm event with the installation of a new stormwater management system. The following is an alternate recommendation for infrastructure improvements.

1. Drainage Sub-Basin 3W

   Sub-basin 3W sheet flows over Highland Road and is the largest sub-basin identified that affects High Street. The culverts are blocked with debris with each minor storm causing flow to be directed overland. This causes the roads to wash out and causes flooding. Since this sub-basin contributes the most stormwater to the system, it is recommended that riprap or other feature to slow the stormwater be installed in the existing ditch behind the homes west of Highland Road. This will slow the stormwater flowing through the ditch, thus causing debris and silt to be caught before entry into any stormwater conveyance structure.

2. New Stormwater Drainage System

   The existing stormwater system along High Street contains a series of concrete ditches and culverts. The current system is limited to carrying only 10-year storm event. A new underground stormwater system would protect the Town from larger storm systems up to a 100-year storm event. It is recommended a 24-inch RCP pipe be installed starting near Design Point 4 extending to the intersection of High Street and Park Street. Then a 30- inch RCP carrier pipe will be installed from Park Street to the existing riprap on Old Carriage Road. Several inlets will be placed along High Street to collect water in the system. Based on the position of the sanitary sewer and water lines, the new stormwater system will be located on the east side of High Street. The exact position of the new stormwater system will be determined during the design.

SECTION V

DRAINAGE PLAN RECOMMENDATIONS AND PRIORITIES

A. INSTITUTIONAL ARRANGEMENTS

1. Stormwater Management Responsibility and Authority

It is recommended that the Town of Palmer Lake retain and enhance its active role in stormwater management in and adjacent to the corporate limits of the Town. There does not appear to be any benefit in considering the creation of another entity or a new "department" to deal with stormwater management, improvements, and maintenance. The Board of Trustees and existing staff should have the expertise and authority to comprehensively deal with stormwater management and develop those resources needed for proactive planning and implementation of enhanced stormwater control which affects the Town.

However, the establishment of a stormwater enterprise should be strongly considered. Enterprise funds allow for the generation of revenues to provide critical stormwater infrastructure improvements. If external funding is desired in the form of either Department of Local Affairs grants or loans through the State Revolving Fund, a stormwater enterprise may be required. Loan funding requires a stable revenue for the duration of the loan; thus, a stormwater enterprise ensures this. Other enterprise funds provide for service like water and sewer service. Enterprise funds for stormwater should be viewed in a similar manner giving the Town the financial ability to maintain and upgrade this important infrastructure.

The Town currently inspects and cleans culverts of sediment and debris after each storm event. It is recommended that the Town continue to inspect the stormwater structures regularly.

B. PROJECT PRIORITIES

As discussed in Section IV, several infrastructure inadequacies were identified and two alternate infrastructure improvements were recommended. Those improvements were recommended based upon the following guidelines:

- Public safety
- Protection of private property
- Protection of public property
- Reduction of nuisance flooding

Two alternatives were proposed for the Town to consider. The first alternative continues the above ground conveyance of stormwater. This type of system is limited in capacity and can only convey a 10-year storm event, but is less expensive. The second alternative is an underground conveyance system which is able to convey a 100-year storm event. The underground system will provide High Street with more protection against larger storm events, but is significantly more expensive. A 50-year storm event was analyzed; however, the cost was comparable to a system to facilitate a 100-year storm. Therefore, only the system to convey a 100-year storm event is presented.

These two Alternatives were presented to the Town of Palmer Lake at a workshop. After the workshop, the Town desired another alternative to be evaluated, which consists of installing part of the new subsurface stormwater system presented in Alternative II. These proposed improvements are presented as Alternative III below.

1. Alternative I Improvements

   The Alternative I improvements maintain the above ground conveyance of stormwater through open ditches and a limited number of culverts. There are no specific areas where wide-spread flooding consistently occurs; however, the localized flooding is caused partially by debris blocking culverts. An in-depth evaluation of the existing stormwater facilities indicates several culverts are undersized and inadequate to convey the flows experienced during a 10-year storm event.

   Our recommendation is to remove seven corrugated metal pipe (CMP) culverts and replace each of them with two reinforced concrete pipe (RCP) culverts to convey more flow. In addition, riprap or other improvement to slow the stormwater should be placed along a portion of the existing drainage Sub-Basin 3W. The riprap will help to prevent excess silt and debris from entering into the existing stormwater system. These improvements will allow the infrastructure to convey flows experienced during a 10-year storm event. These improvements are shown on Figure 4.

The following is a preliminary cost estimate for the proposed work for Alternative I.

TABLE 2

TOWN OF PALMER LAKE

PRELIMINARY COST ESTIMATE - ALTERNATIVE I IMPROVEMENTS

Item No.	Description	Quantity		Unit Price	Total Price
Existing System Improvements					
1.	18-inch Horizontal Elliptical Reinforced Concrete Pipe (Culvert D-10) (1 culverts)	25	LF	$340	$8,495
2.	15-inch Reinforced Concrete Pipe (Culvert D-14) (2 culverts)	50	LF	$310	$15,500
3.	18-inch Reinforced Concrete Pipe (Culvert C-11) (2 culverts)	80	LF	$340	$27,200
4.	18-inch Reinforced Concrete Pipe (Culvert C-12) (2 culverts)	130	LF	$340	$44,200
5.	12-inch Reinforced Concrete Pipe (Culvert D-15) (2 culverts)	40	LF	$310	$12,400
6.	30-inch Reinforced Concrete Pipe (Culvert C-13) (1 culvert)	100	LF	$420	$42,000
7.	Concrete Headwall at Culvert Inlet (6 Headwalls)	5	CY	$1,500	$7,500
8.	Clearing, grubbing, and regrading	1	LS	$21,000	$21,000
9.	Modification to Sub-Basin 3W Ditch	1	LS	$20,000	$20,000
10.	Flow fill	55	CY	$300	$16,500
11.	Gravel Road remove/replace	45	SY	$12	$540
12.	4-inch asphalt pavement remove/replace	55	SY	$160	$8,800
13.	Concrete remove/replace	15	CY	$225	$3,375
14.	Reseeding and mulching	0.2	AC	$4,000	$800
15.	Traffic Control	1	LS	$10,000	$10,000
Subtotal					$238,310
15% Construction Contingency					$35,730
Engineering Design/Contract Administration					$27,960
Construction Observation based on 30 calendar days					$30,000
Other Engineering [1)]					$58,500
Administration Expenses [2)]					$9,500
Total Preliminary Construction Cost Estimate					$400,000

1) Other engineering includes funding administration, geotechnical services, permits, project needs assessment, environmental assessment, and reproduction. These costs would be adjusted if no SRF loan is obtained.

2) Administration expenses are for advertising, legal counsel and bond counsel.

2. Alternative II Improvements

The Alternative II Improvements are for the installation of a new underground stormwater system. These improvements will run the length of High Street from Glenarm Street down to Old Carriage Road. The Alternative II Improvements also include the placement of riprap along the existing drainage ditch in Sub-Basin 3W.

The improvements require the installation of 30-inch and 36-inch RCP and several grated inlets placed along High Street. The final position of the new system will be determined during the design based on the location of existing water and sanitary sewer systems.

The installation of these improvements will greatly improve the amount of stormwater that can be conveyed through the system. These improvements will allow the infrastructure to convey flows experienced during a 100-year storm event. These improvements are shown on Figure 5 contained at the back of this report.

The following table is the cost estimate for Alternative II Improvements.

TABLE 3

TOWN OF PALMER LAKE

PRELIMINARY COST ESTIMATE - ALTERNATIVE II IMPROVEMENTS

Item No.	Description	Quantity		Unit Price	Total Price
New Stormwater System Improvements					
1.	30-inch Reinforced Concrete Pipe	1,135	LF	$420	$476,700
2.	36-inch Reinforced Concrete Pipe	1,340	LF	$480	$643,200
3.	15-inch Reinforced Concrete Pipe	130	LF	$310	$40,300
4.	18-inch Reinforced Concrete Pipe	30	LF	$340	$10,200
5.	Grated Inlet	8	EA	$6,500	$52,000
6.	New 5' I.D. Stormwater Manhole	12	EA	$6,000	$72,000
7.	Flared End Section	1	EA	$1,800	$1,800
8.	Modification to Sub-Basin 3W Ditch	1	LS	$20,000	$20,000
9.	Gravel Road remove/replace	975	SY	$12	$11,700
10.	4-inch asphalt pavement remove/replace	1,275	SY	$160	$204,000
11.	Reseeding and mulching	0.1	AC	$4,000	$400
12.	Traffic Control	1	LS	$10,000	$10,000
Subtotal					$1,542,300
15% Construction Contingency					$231,56
Engineering Design/Contract Administration					$140,140
Construction Observation based on 90 calendar days					$90,000
Other Engineering 1)					$60,000
Administration Expenses 2)					$12,500
Total Preliminary Construction Cost Estimate					$2,076,000

1) Other engineering cost includes funding administration, geotechnical services, permits, project needs assessment, environmental assessment, and reproduction. These costs would be adjusted if no SRF loan is obtained.
2) Administration expenses is for advertising, legal counsel and bond counsel.

3. Alternative III Improvements

The Alternative III improvements are a partial installation of the Alternative II Improvements. These improvements will consist of installing part of the new underground stormwater system proposed in Alternative II. These improvements will start at the south end of High Street on Old Carriage Road and continue north along High Street to Lower Glenway Street.

The improvements include the installation of 36-inch RCP and two grated inlets. Additionally, a new 36-inch RCP culvert will be installed under South Valley Crescent from the bottom of the existing riprap and discharge into North Monument Creek. Improvements will also be made to the existing ditch in sub-basin 3W. The final position of the new system will be determined during the design based on the location of existing water and sanitary sewer systems.

This alternative enables the Town to implement a smaller scale project, while also giving the Town the ability to expand the underground stormwater infrastructure in the future. These improvements are shown on Figure 6 in the back of this report.

The following table is the cost estimate for Alternative III Improvements.

TABLE 4

TOWN OF PALMER LAKE

PRELIMINARY COST ESTIMATE - ALTERNATIVE III IMPROVEMENTS

Item No.	Description	Quantity		Unit Price	Total Price
New Stormwater System Improvements					
1.	36-inch Reinforced Concrete Pipe (Culvert C-14) (1 culvert)	30	LF	$480	$14,400
2.	36-inch Reinforced Concrete Pipe	645	LF	$480	$309,600
3.	15-inch Reinforced Concrete Pipe	55	LF	$310	$17,050
4.	Grated Inlet	2	EA	$6,500	$13,000
5.	New 5' I.D. Stormwater Manhole	7	EA	$6,000	$42,000
6.	Flared End Section	1	EA	$1,800	$1,800
7.	Concrete Wingwall at Culvert Inlet	5	CY	$1,500	$7,500
8.	Modification to the Existing Riprap North of S Valley Crescent	1	LS	$20,000	$20,000
9.	Modification to Sub Basin 3W Ditch	1	LS	$20,000	$20,000
10.	4-inch asphalt pavement remove/replace	640	SY	$160	$102,400
11.	Concrete remove/replace	6	CY	$225	$1,350
12.	Reseeding and mulching	0.1	AC	$4,000	$400
13.	Traffic Control	1	LS	$10,000	$10,000
Subtotal					$559,500
15% Construction Contingency					$84,400
Engineering Design/Contract Administration					$55,600
Construction Observation based on 90 calendar days					$90,000
Other Engineering 1)					$83,500
Administration Expenses 2)					$12,000
Total Preliminary Construction Cost Estimate					$885,000

1) Other engineering cost includes funding administration, geotechnical services, permits, project needs assessment, environmental assessment, and reproduction. These costs would be adjusted if no SRF loan is obtained.
2) Administration expenses is for advertising, legal counsel and bond counsel.

TABLE 4

TOWN OF PALMER LAKE

SUMMARY OF PROJECT COSTS

Project	Cost
Alternative I Improvements	$400,000
Alternative II Improvements	$2,076,000
Alternative III Improvements	$885,000

The Town would select one of the Alternatives above based on, among other considerations, preference of how the Town wants to convey stormwater through the community. Whether that be through above ground or subsurface infrastructure. Currently, the Town does not have subsurface stormwater conveyance.

The Town wanted to integrate a subsurface stormwater system with a smaller scope, but to lower the project cost. Therefore, an Alternative III was developed after the presentation to the Board. If implemented, the remaining subsurface infrastructure proposed in Alternative II would be completed at a later date.

C. FUNDING ALTERNATIVES

Because the Town of Palmer Lake does not have a stormwater enterprise or funds specifically allocated and set aside for stormwater management and improvements, it will be necessary to accomplish this work utilizing revenues transferred from, or generated within, the general fund and/or seek funding from outside sources.

There are a couple of available funding sources for stormwater improvements. First, funds may be available through the Water Quality Improvement Fund (WQIF), which is funded through the Colorado Department of Public Health and Environment (CDPHE). These funds were utilized for the production of this report. The amount of funds available through this grant varies from year to year and was not made available for construction for this current fiscal year. This grant is very competitive. There are five scoring criteria for this grant which include financial/affordability (size of community and median household income of the community), water quality benefit, permit compliance, readiness to proceed, and cost matching. This grant does not have any matching requirements and is typically offered once a year.

Second, the Town may desire to pursue funds available from the Energy and Mineral Impact Assistance (EIAF) program administered by the Department of Local Affairs (DOLA). The submittal of applications for these funds is undertaken on a cycle basis. The next cycle of applications are due in September 2022 with the following application due in March 2023. The EIAF program has less funding available due to its revenues being generated from oil/mineral/gas severance taxes and these taxes being decreased over the years. The probability of receiving these funds is unknown as DOLA will likely require a stormwater enterprise to be established prior to considering an EIAF application. The Town should explore this option for funding; however, this is not included in the funding scenario since the funding of this project seems improbable at this juncture.

Another federal program is the American Rescue Plan Act (ARPA), also known as the COVID-19 Stimulus Package, which was signed into law on March 11, 2021. ARPA is providing funding to state and local governments. The purpose of ARPA is to provide resources to help governments respond to the pandemic and its economic effects and replace revenue lost during the pandemic. The ARPA funds can be utilized for helping with the economic impacts of the pandemic to businesses, provide premium pay to eligible workers, provide government services that have been impacted by lower revenue, and lastly to make necessary investments in water, sewer, or broadband infrastructure. Most small communities were not greatly impacted by the pandemic as it relates to the first three eligible categories. Therefore, the only remaining eligible expense is for investment in water, sewer, or broadband infrastructure. The ARPA allocation was split into two payments and requires the monies to be spent by the end of 2026. The Town of Palmer Lake was allocated approximately $752,289. Additionally, El Paso County received applications for qualified projects on April 22, 2022 to appropriate some of their ARPA funds. The Town submitted an application for this project. This is not listed as a funding source as the probability of this funding being awarded is unknown.

The most viable loan and grant funding source is the use of the CWR&PDA's WPCRF program. The program typically provides primarily loan funds; however, for those communities falling in the Disadvantaged Community (DAC) category, a portion of the funding is available in the form of loan forgiveness (grant) funds. This portion is dedicated to frontend non-construction engineering and planning related expenses with a cap of $300,000. The State has allocated a portion of its funding to function as loan forgiveness to offset loan proceeds.

In order for a community to be designated as a Disadvantaged Community (DAC), the community must meet at least two of the three scenarios. The first item pertains to the communities' median household income; the second factor reviews the communities' median home value (MHV); and the third item examines the County's unemployment numbers or job loss numbers within the community itself. As long as the community meets two of these three factors, the community will be characterized as a DAC. Once a community has been designated as a DAC, a portion of the funding will be available in the form of a Design and Engineering Grant. The total amount for this is up to $300,000. The specific amount is ultimately determined by the CDPHE after the Project Needs Assessment has been submitted and reviewed.

Two eligibility categories have been established for the DAC program. Category One is for communities with a population of less than 10,000 with a median household income between 80% and 61% of the Colorado statewide median household income (includes metropolitan areas). The most recent data shows the state median household income level at $72,331. Thus, Category One represents income levels between $43,399 and $57,865. Eligible entities in this category can now obtain 30-year loans for sewer projects of up to $3,000,000 with an interest rate of 1.5%. Category Two is for similar size communities with a median household income of less than $43,399 and offers a 0.5% loan rate. The Town of Palmer Lake has a median household income of $77,216; therefore, the community does not qualify for DAC based on this parameter. However, final eligibility will be completed during the loan application process. If the Town does not qualify as a DAC, the current direct loan interest rate is 2.25% with a 30-year loan term.

The CWR&PDA would require a reliable funding pledge in order to receive a loan for this project. The CWR&PDA may require a stormwater enterprise to be established before executing the loan. Further conversations between the Town and CWR&PDA would be required to determine if there is another eligible pledge for the loan repayment.

The State Revolving Fund has unique administrative related costs including bond counsel, legal counsel and preparation of a Project Needs Assessment (PNA), which is a combination of this PER and a Technical, Managerial and Financial Capacity Assessment (TMF) report. These costs have been included within the project cost estimate.

There are various steps required in the application process for the WPCRF program. An applicant is required to submit a Prequalification Form to the Water Quality Control Division. A preapplication meeting is conducted with the Owner, the Owner's consultant and the State Revolving Fund Agency personnel who review the prequalification form. If the prequalification form is deemed by the Revolving Fund agency representatives to be adequate, then a PNA is required.

The PNA requires technical related information that must be completed by a professional engineer. This portion of the application process also includes environmental related information together with a Technical, Managerial and Financial Capacity Assessment. Upon the submission of this information, the WQCD and CWR&PDA may provide funds to cover design and engineering related costs that would occur prior to construction in the form of loan forgiveness funds (grant) if the applicant is a DAC. A public hearing is required. Any outstanding issues from an environmental standpoint must also be resolved. Final plans and specifications may be submitted in advance of, or at the time of, the loan application.

The third step is the actual loan application. Upon loan approval, the closing will not occur until such time as the plans and specifications are fully approved by the Division. The applicant's consultant may provide a self-certification of the plans and specifications or request a streamlined design review, if applicable. With the approval of the plans and specifications fully in place, the loan may be executed and the project may proceed into bidding.

This multistep process lengthens the overall application process, but provides for the ability of the Water Quality Control Division and the Colorado Water Resources and Power Development Authority to have their funds quickly utilized during the construction phase of the project in accordance with EPA's criteria.

The Infrastructure Investment and Jobs Act (IIJA) was signed into law on November 15, 2021. The IIJA allocation to Colorado for drinking water and clean water (wastewater and stormwater) will be through the State Revolving Fund (SRF). Thus, there will be supplemental money through the SRF. The EPA has placed an emphasis on small, underserved, and disadvantaged communities in the IIJA. The final ruling and funding allocation to the State of Colorado are still underway; however, preliminarily the SRF anticipates receiving at least $14 million a year for clean water projects for the next five years. Of these potential funds, half of these funds need to be allocated in grant funding. The final determination of how communities can access these funds is still underway. The consultant will continue to monitor this and advocate for the Town. The CWR&PDA may create another Category that may qualify communities like Palmer Lake for grant funding. Since the final determination is unknown, there are no grant funds shown in the funding scenario.

TABLE 5
TOWN OF PALMER LAKE
FUNDING SCENARIO

	Alternative I	Alternative II	Alternative III
Total Project Cost	$400,000	$2,076,000	$885,000
WPCRF Loan	$400,000	$2,076,000	$885,000
Local Funds	-	-	
Annual Debt Payment [1)]	$18,480	$95,909	$40,886
10% Reserve Requirement	$1,848	$9,590	$4,089
Annual Debt and Reserve	$20,328	$105,500	$44,975

1) This is based on a 2.25% interest rate and a 30-year loan agreement

Upon approval of this report, it is recommended the Town pursue grant funding to minimize the burden on the community. Conversations should be initiated with funding agencies; however, some agencies may require a stormwater enterprise be established to receive funding. The degree to which the Town at this point pursues funding will be a function of other community wide infrastructure needs and the prioritization of them.

D. OTHER FINANCIAL CONSIDERATIONS

We recommend the Town consider establishing a stormwater enterprise or stormwater account within the Town's annual budget. Revenue for the stormwater enterprise would be generated by implementing a stormwater user fee on a monthly basis to each unit user with the Town similar to a minimum user fee for water service. Revenue generated from this monthly fee would be placed in the stormwater enterprise for maintenance and capital improvements required within the Town. The rate schedule for the user fee could be adjusted to allow for a larger user fee for larger parcels with greater surface runoff that impact the Town's drainage facilities. The City of Colorado Springs established a stormwater enterprise in recent years and its fee is added on the monthly water bill.

The initial step in this process would be to establish the stormwater enterprise. To initiate the program, a flat monthly user fee could be charged for stormwater service to each of the unit users based upon the alternative recommended for implementation as outlined earlier in this section. The Town of Palmer Lake could consider a similar mechanism as Colorado Springs. Since a loan is required to complete the selected project, revenue collected through the enterprise would be used to repay the loan and capitalize other stormwater projects.

SECTION VI

PLAN OF ACTION

A plan of action and schedule has been developed for the Stormwater Improvements recommended herein. The following table has been developed based upon the normal progression of a project of this nature. The table is based on utilizing the State Revolving Fund.

TABLE 6

TOWN OF PALMER LAKE

PLAN OF ACTION AND IMPLEMENTATION SCHEDULE

Scheduled Event	Date
Drainage Plan Workshop with the Town	April 2022
Submit Final Report to the Town	May 2022
Initiate SRF Process	June 2022
Authorize Design	June 2022
Submit Loan Application	January 2023
Advertise Project for Bid	May 2023
Bid Opening	June 2023
Project Award	July 2023
Initiate Construction	August 2023
Completion of Construction	November 2023

The above schedule realistically represents the required timeline for implementation of the recommended improvements. The primary activity focuses on securing the necessary funds; if funding is not secured with the first application, then this timeframe will be extended until enough funding is secured.

This plan of action and schedule is a dynamic activity that will require modifications and refinements as the project evolves. A delay in one activity will result in subsequent delays in following activities. Securing adequate funding in a timely manner will be crucial not only to maintaining the schedule, but ultimately in implementing the needed improvements.

APPENDIX A – STORM INTENSITY DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: Palmer Lake, Colorado, USA*
Latitude: 39.1202°, Longitude: -104.9163°
Elevation: 7260.53 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.256 (0.209-0.310)	0.332 (0.271-0.402)	0.458 (0.373-0.556)	0.564 (0.457-0.688)	0.713 (0.557-0.894)	0.830 (0.633-1.05)	0.949 (0.699-1.22)	1.07 (0.755-1.41)	1.24 (0.837-1.66)	1.36 (0.899-1.85)
10-min	0.374 (0.306-0.454)	0.485 (0.397-0.589)	0.670 (0.546-0.815)	0.826 (0.669-1.01)	1.05 (0.816-1.31)	1.22 (0.927-1.54)	1.39 (1.02-1.79)	1.57 (1.11-2.06)	1.81 (1.23-2.43)	2.00 (1.32-2.70)
15-min	0.456 (0.374-0.553)	0.592 (0.484-0.718)	0.817 (0.666-0.994)	1.01 (0.816-1.23)	1.27 (0.995-1.60)	1.48 (1.13-1.88)	1.70 (1.25-2.18)	1.91 (1.35-2.51)	2.21 (1.50-2.96)	2.44 (1.61-3.30)
30-min	0.566 (0.463-0.686)	0.738 (0.603-0.895)	1.02 (0.832-1.24)	1.26 (1.02-1.54)	1.59 (1.25-2.00)	1.86 (1.41-2.35)	2.12 (1.56-2.73)	2.39 (1.69-3.14)	2.76 (1.87-3.69)	3.03 (2.00-4.11)
60-min	0.706 (0.578-0.856)	0.878 (0.718-1.07)	1.18 (0.960-1.43)	1.44 (1.17-1.76)	1.83 (1.44-2.32)	2.15 (1.65-2.74)	2.49 (1.84-3.23)	2.85 (2.02-3.77)	3.35 (2.28-4.52)	3.76 (2.48-5.09)
2-hr	0.845 (0.697-1.02)	1.02 (0.839-1.23)	1.33 (1.10-1.61)	1.63 (1.33-1.97)	2.07 (1.65-2.62)	2.45 (1.90-3.12)	2.86 (2.14-3.70)	3.31 (2.37-4.36)	3.95 (2.71-5.31)	4.48 (2.97-6.02)
3-hr	0.964 (0.798-1.15)	1.12 (0.929-1.34)	1.43 (1.18-1.72)	1.74 (1.42-2.09)	2.22 (1.79-2.81)	2.64 (2.06-3.36)	3.12 (2.34-4.03)	3.64 (2.62-4.80)	4.41 (3.04-5.92)	5.05 (3.36-6.77)
6-hr	1.20 (1.00-1.42)	1.38 (1.15-1.64)	1.74 (1.45-2.07)	2.10 (1.73-2.50)	2.68 (2.18-3.38)	3.20 (2.52-4.04)	3.78 (2.86-4.85)	4.42 (3.21-5.79)	5.37 (3.74-7.17)	6.16 (4.13-8.21)
12-hr	1.48 (1.25-1.74)	1.76 (1.48-2.07)	2.27 (1.90-2.67)	2.74 (2.28-3.24)	3.47 (2.82-4.29)	4.09 (3.22-5.08)	4.76 (3.62-6.02)	5.49 (4.00-7.10)	6.54 (4.57-8.63)	7.40 (5.00-9.79)
24-hr	1.82 (1.54-2.12)	2.18 (1.84-2.53)	2.81 (2.36-3.27)	3.37 (2.82-3.94)	4.21 (3.43-5.13)	4.91 (3.89-6.02)	5.66 (4.32-7.07)	6.46 (4.72-8.25)	7.59 (5.32-9.91)	8.49 (5.78-11.2)
2-day	2.19 (1.86-2.52)	2.55 (2.17-2.94)	3.20 (2.71-3.69)	3.79 (3.19-4.39)	4.68 (3.84-5.64)	5.42 (4.33-6.60)	6.22 (4.78-7.72)	7.08 (5.21-8.98)	8.30 (5.86-10.8)	9.28 (6.36-12.1)
3-day	2.37 (2.03-2.71)	2.77 (2.36-3.17)	3.47 (2.95-3.98)	4.11 (3.47-4.72)	5.04 (4.15-6.04)	5.82 (4.66-7.03)	6.65 (5.13-8.20)	7.54 (5.57-9.51)	8.78 (6.23-11.3)	9.79 (6.73-12.7)
4-day	2.51 (2.15-2.86)	2.94 (2.52-3.35)	3.69 (3.14-4.21)	4.35 (3.69-4.98)	5.33 (4.39-6.35)	6.13 (4.92-7.38)	6.98 (5.40-8.58)	7.90 (5.85-9.92)	9.17 (6.52-11.8)	10.2 (7.03-13.2)
7-day	2.91 (2.50-3.28)	3.35 (2.89-3.79)	4.14 (3.55-4.69)	4.84 (4.13-5.51)	5.89 (4.88-6.96)	6.75 (5.45-8.06)	7.67 (5.97-9.35)	8.65 (6.45-10.8)	10.0 (7.18-12.8)	11.1 (7.73-14.4)
10-day	3.27 (2.83-3.68)	3.74 (3.23-4.21)	4.57 (3.94-5.15)	5.32 (4.55-6.02)	6.42 (5.34-7.56)	7.34 (5.94-8.72)	8.31 (6.49-10.1)	9.35 (6.99-11.6)	10.8 (7.77-13.8)	12.0 (8.35-15.4)
20-day	4.31 (3.75-4.79)	4.93 (4.29-5.49)	5.99 (5.19-6.68)	6.91 (5.95-7.74)	8.23 (6.87-9.54)	9.30 (7.57-10.9)	10.4 (8.17-12.5)	11.6 (8.70-14.2)	13.2 (9.51-16.6)	14.4 (10.1-18.4)
30-day	5.15 (4.51-5.70)	5.91 (5.16-6.54)	7.17 (6.24-7.96)	8.23 (7.12-9.17)	9.72 (8.13-11.2)	10.9 (8.88-12.7)	12.1 (9.51-14.4)	13.3 (10.0-16.2)	14.9 (10.8-18.7)	16.2 (11.4-20.6)
45-day	6.20 (5.45-6.82)	7.11 (6.24-7.83)	8.59 (7.52-9.48)	9.81 (8.53-10.9)	11.5 (9.60-13.0)	12.7 (10.4-14.7)	14.0 (11.0-16.5)	15.2 (11.5-18.4)	16.9 (12.2-21.0)	18.1 (12.8-22.9)
60-day	7.07 (6.23-7.74)	8.10 (7.13-8.88)	9.75 (8.55-10.7)	11.1 (9.65-12.2)	12.8 (10.8-14.5)	14.2 (11.6-16.2)	15.4 (12.2-18.1)	16.7 (12.6-20.1)	18.3 (13.3-22.6)	19.4 (13.8-24.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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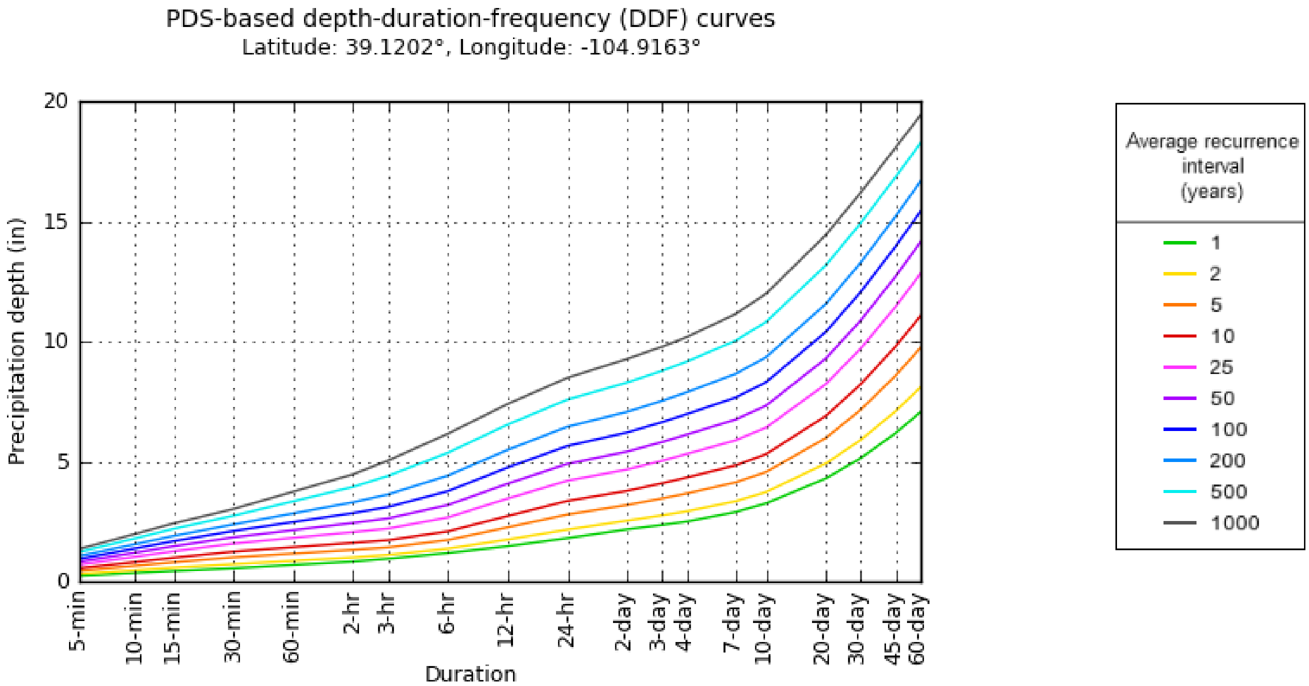
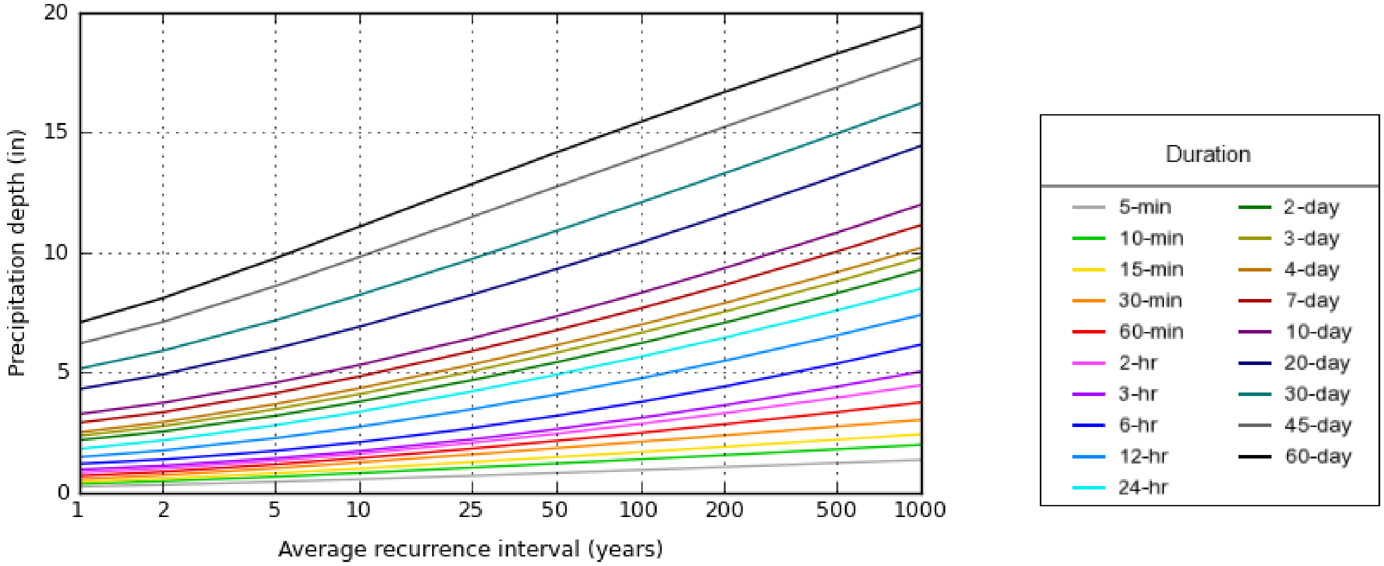
PF graphical





NOAA Atlas 14, Volume 8, Version 2 Created (GMT): Mon Mar 14 19:48:17 2022

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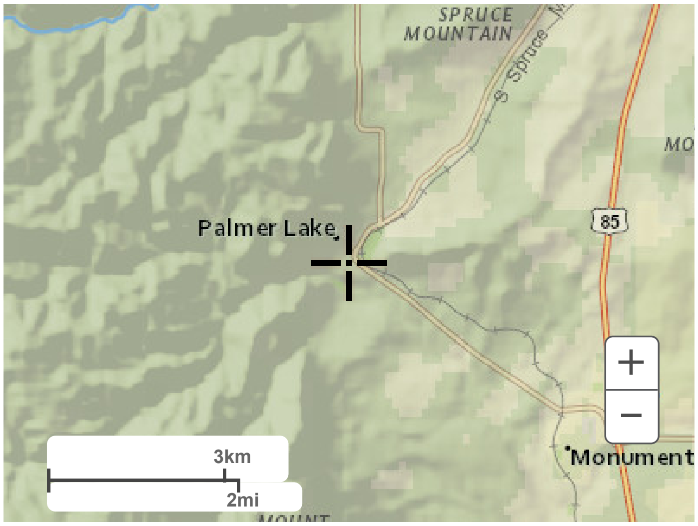
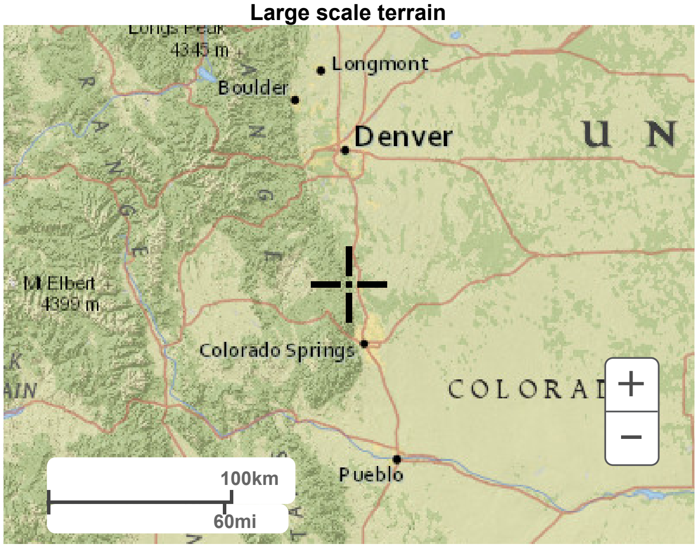
Maps & aerials

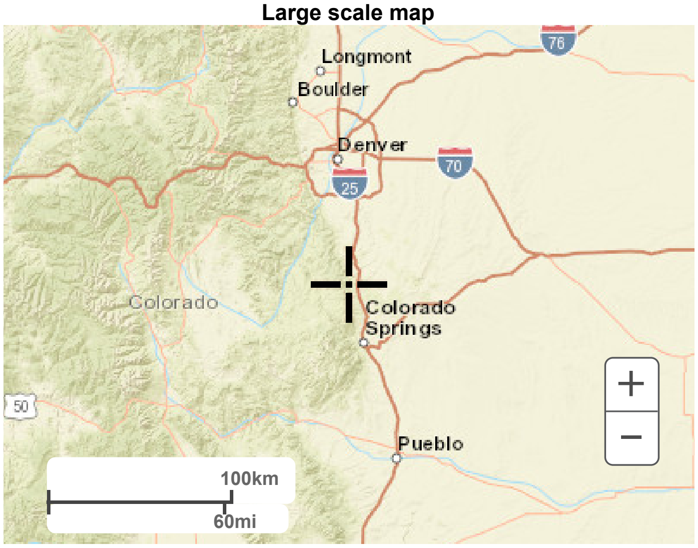
Small scale terrain



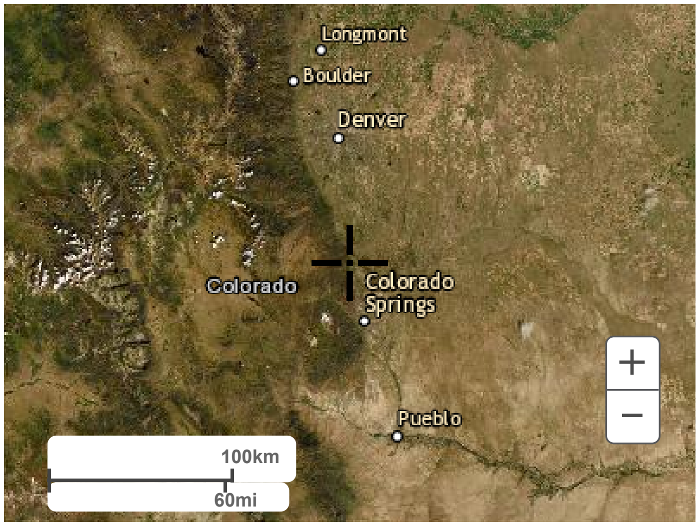
Large scale terrain



Large scale map



Large scale aerial



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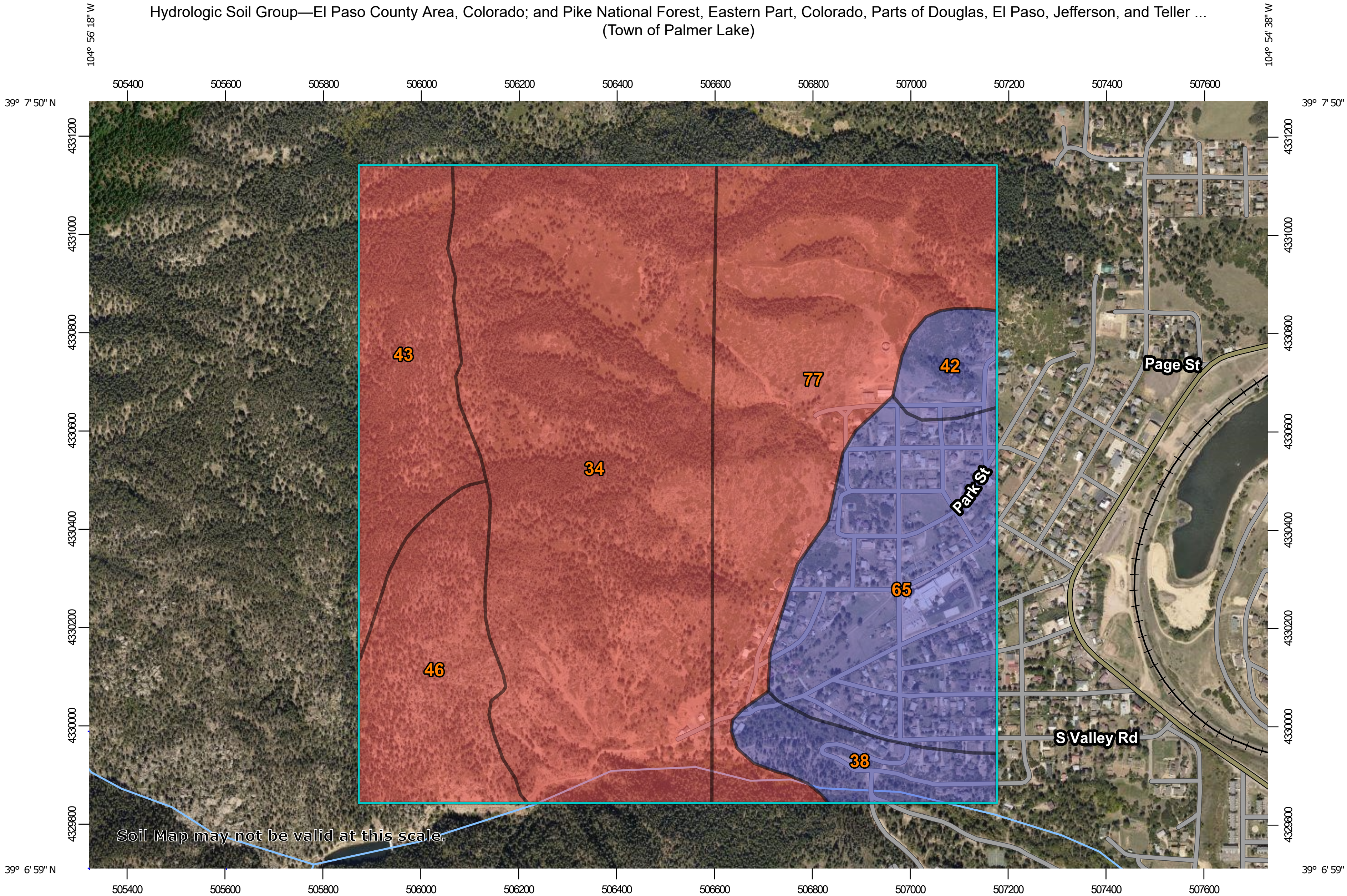
US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX B – SOILS DATA

Hydrologic Soil Group—El Paso County Area, Colorado; and Pike National Forest, Eastern Part, Colorado, Parts of Douglas, El Paso, Jefferson, and Teller ...
(Town of Palmer Lake)



Map Scale: 1:11,000 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 150, 300, 600, 900

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 19, Aug 31, 2021

Soil Survey Area: Pike National Forest, Eastern Part, Colorado, Parts of Douglas, El Paso, Jefferson, and Teller Counties
Survey Area Data: Version 8, Aug 31, 2021

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 19, 2018—Sep 23, 2018

MAP LEGEND

MAP INFORMATION

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
38	Jarre-Tecolote complex, 8 to 65 percent slopes	B	16.9	4.0%
42	Kettle-Rock outcrop complex	B	10.0	2.4%
65	Perrypark gravelly sandy loam, 3 to 9 percent slopes	B	64.0	15.2%
77	Rock outcrop-Coldcreek-Tolman complex, 9 to 90 percent slopes	D	95.8	22.8%
Subtotals for Soil Survey Area			**186.7**	**44.5%**
Totals for Area of Interest			**420.0**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
34	Rock outcrop-Security-Cathedral complex, 15 to 65 percent slopes	D	155.3	37.0%
43	Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes	D	40.2	9.6%
46	Sphinx-Rock outcrop complex, 15 to 80 percent slopes	D	37.8	9.0%
Subtotals for Soil Survey Area			**233.3**	**55.5%**
Totals for Area of Interest			**420.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX C – EXISTING DRAINAGE BASIN CALCULATIONS

Town of Palmer Lake
High Street Drainage Plan
Drainage Calculations - Existing Conditions

Site Location: 149.7 acres in Section 6 and Section 5, Township 11 South, Range 67 West of the 6th P.M.

Drainage Basin Delineation: See Attached Map

Basin	Total acres
Basin 1W	5.7 ac
Basin 2W	6.1 ac
Basin 3W	72.5 ac
Basin 4W	1.0 ac
Basin 5W	1.3 ac
Basin 6W	2.3 ac
Basin 7W	4.1 ac
Basin 8W	9.0 ac
Basin 9W	3.6 ac
Basin 10W	5.7 ac
Basin 11W	5.7 ac
Basin 12W	3.2 ac
Basin 1E	16.1 ac
Basin 2E	2.0 ac
Basin 3E	1.2 ac
Basin 4E	1.0 ac
Basin 5E	3.4 ac
Basin 6E	2.2 ac
Basin 7E	3.7 ac

Design Points

Point	Acres	Contributing Basins
Design Pt 1	6.1 ac	2W
Design Pt 2	7.5 ac	2W & 5W
Design Pt 3	5.7 ac	1W
Design Pt 4	72.5 ac	3W
Design Pt 5	79.2 ac	1W, 3W, & 4W
Design Pt 6	89.0 ac	1W, 2W, 3W, 4W, 5W, & 6W
Design Pt 7	4.1 ac	7W
Design Pt 8	13.0 ac	7W, 8W
Design Pt 9	105.5 ac	1W, 2W, 3W, 4W, 5W, 6W, 7W, 8W, & 9W
Design Pt 10	3.4 ac	5E
Design Pt 11	114.7 ac	1W, 2W, 3W, 4W, 5W, 6W, 7W, 8W, 9W, 10W, & 5E
Design Pt 12	120.3 ac	1W, 2W, 3W, 4W, 5W, 6W, 7W, 8W, 9W, 10W, 11W, & 5E
Design Pt 13	123.5 ac	1W, 2W, 3W, 4W, 5W, 6W, 7W, 8W, 9W, 10W, 11W, 12W, & 5E
Off Site Pt 1	16.1 ac	1E
Off Site Pt 2	1.2 ac	3E
Off Site Pt 3	3.2 ac	2E & 3E
Off Site Pt 4	4.2 ac	2E, 3E, & 4E
Off Site Pt 5	6.5 ac	2E, 3E, 4E, & 6E
Off Site Pt 6	3.7 ac	7E

Design Storms

Condition		Source
10yr, 6hr	0.351	NOAA Atlas 14 Point Precipitation Frequency Estimate
100yr, 6hr	0.631	NOAA Atlas 14 Point Precipitation Frequency Estimate

Soil Map Unit Symbol Map and Name

Soil		Hydrologic Soil Group
34 -	Rock outcrop-Security-Cathedral complex, 15 to 65 percent slopes	D
38 -	Jarre-Tecolote complex, 8 to 65 percent slopes	B
42 -	Kettle-Rock outcrop complex	B
43 -	Sphinx gravelly coarse sandy loam, 40 to 70 percent slopes	D
46 -	Sphinx -Rock outcrop complex, 15 to 80 percent slopes	D
65 -	Perrypark gravelly sandy loam, 3 to 9 percent slopes	B
77 -	Rock outcrop-Coldcreek-Tolman complex, 9 to 90 percent slopes	D

Runoff Coefficients

Existing Conditions					Runoff Coefficient	
Basin	Description		Acres	CN	10 yr	100 yr
Basin 1W						
	Forested, Slope > 6%, Soil D		4.3	77	0.32	0.38
	Gravel Road, Soil D		0.4	91	0.5	0.69
	Residential District, 1/8 Acre, Soil D		0.2	92	0.57	0.73
	Residential District, 1/4 Acre, Soil D		0.5	87	0.53	0.71
	Residential District, 1/3 Acre, Soil D		0.3	79	0.42	0.64
		Total	5.7	79.5 WCN	0.36	0.46
Basin 2W						
	Forested, Slope > 6%, Soil D		3.1	77	0.32	0.38
	Gravel Road, Soil B		0.2	85	0.45	0.65
	Gravel Road, Soil D		0.4	91	0.5	0.69
	Open Space, Lawn, Soil D		0.4	84	0.22	0.52
	Paved Parking Lots/driveways, Soil B		0.2	98	0.85	0.9
	Residential District, 1/8 Acre, Soil D		0.2	92	0.57	0.73
	Residential District, 1/2 Acre, Soil B		0.6	70	0.37	0.6
	Residential District, 1/2 Acre, Soil D		0.1	85	0.42	0.64
	Residential District, 1 Acre, Soil B		0.4	68	0.29	0.55
	Residential District, 1 Acre, Soil D		0.4	84	0.35	0.6
		Total	6.1	79.2 WCN	0.4	0.5
Basin 3W						
	Open Space, Lawn, Soil B		0.2	69	0.14	0.46
	Residential District, 1/2 Acre, Soil D		0.5	85	0.42	0.64
	Forested, Slope > 6%, Soil D		71.9	77	0.32	0.38
		Total	72.5	77.0 WCN	0.32	0.38
Basin 4W						
	Gravel Road, Soil B		0.2	85	0.45	0.65
	Paved Parking Lots/driveways, Soil B		0.1	98	0.85	0.9
	Residential District, 1/4 Acre, Soil B		0.2	75	0.49	0.67
	Residential District, 1/3 Acre, Soil B		0.4	72	0.53	0.7
	Open Space, Undeveloped, 1/4 Acre, Soil B		0.1	69	0.14	0.46
		Total	1.0	76.3 WCN	0.47	0.66
Basin 5W						
	Gravel Road, Soil B		0.3	85	0.45	0.65
	Paved Parking Lots/driveways, Soil B		0.1	98	0.85	0.9
	Residential District, 1/4 Acre, Soil B		0.3	75	0.49	0.67
	Residential District, 1/3 Acre, Soil B		0.6	72	0.53	0.7
		Total	1.3	77.5 WCN	0.52	0.70
Basin 6W						
	Gravel Road, Soil B		0.4	85	0.45	0.65
	Paved Parking Lots/driveways, Soil B		0.1	98	0.85	0.9
	Open Space, Lawn, Soil B		0.4	69	0.14	0.46
	Residential District, 1/8 Acre, Soil B		0.1	85	0.53	0.7
	Residential District, 1/3 Acre, Soil B		0.2	72	0.37	0.6
	Residential District, 1 Acre, Soil B		1.1	68	0.29	0.55
		Total	2.3	73.3 WCN	0.33	0.57
Basin 7W						
	Forested, Slope > 6%, Soil D		3.3	77	0.32	0.38
	Residential District, 1/3 Acre, Soil D		0.4	86	0.42	0.64
	Residential District, 1/4 Acre, Soil D		0.2	87	0.53	0.71
	Gravel Road, Soil D		0.2	91	0.5	0.69
		Total	4.1	79.1 WCN	0.35	0.44
Basin 8W						
	Forested, Slope > 6%, Soil D		5.4	77	0.32	0.38
	Gravel Road, Soil B		0.6	85	0.45	0.65
	Paved Parking Lots/driveways, Soil B		0.1	98	0.85	0.9
	Residential Distrct, 1/8 Acre, Soil B		0.2	85	0.53	0.7
	Residential Distrct, 1/4 Acre, Soil B		0.4	75	0.49	0.67
	Residential Distrct, 1/3 Acre, Soil B		0.3	72	0.37	0.6
	Residential Distrct, 1 Acre, Soil B		2.0	68	0.29	0.55
		Total	9.0	75.7 WCN	0.34	0.47
Basin 9W						
	Forested, Slope > 6%, Soil D		0.4	77	0.32	0.38
	Gravel Road, Soil B		0.8	85	0.45	0.65
	Paved Road, Open Ditches, Soil B		0.3	89	0.94	0.94
	Paved Parking Lots/driveways, Soil B		0.2	98	0.85	0.9
	Residential Distrct, 1/4 Acre, Soil B		1.7	75	0.49	0.67
	Residential District, 1 Acre, Soil B		0.2	68	0.29	0.55
		Total	3.6	79.4 WCN	0.50	0.66

Basin	Description		Acres	CN		10 yr	100 yr
Basin 10W							
	Forested, Slope > 6%, Soil D		0.4	77		0.32	0.38
	Gravel Road, Soil D		0.1	85		0.5	0.69
	Residential District, 1/3 Acre, Soil D		0.2	86		0.42	0.64
	Residential District, 1 Acre, Soil D		0.3	84		0.35	0.6
	Open Space, Lawn, Soil B		2.0	69		0.14	0.46
	Gravel Road, Soil B		0.9	85		0.45	0.65
	Paved Road, Open Ditches, Soil B		0.2	89		0.94	0.94
	Paved Parking Lots/driveways, Soil B		0.1	98		0.85	0.9
	Residential District, 1/8 Acre, Soil B		0.2	85		0.53	0.7
	Residential District, 1/4 Acre, Soil B		0.5	75		0.49	0.67
	Residential District, 1/2 Acre, Soil B		0.5	70		0.33	0.58
	Residential District, 1 Acre, Soil B		0.4	68		0.29	0.55
		Total	5.7	76.0	WCN	0.34	0.57
Basin 11W							
	Gravel Road, Soil B		0.4	85		0.45	0.65
	Paved Road, Open Ditches, Soil B		1.1	89		0.94	0.94
	Paved Parking Lots/driveways, Soil B		0.1	98		0.85	0.9
	Open Space, Lawn, Soil B		2.1	69		0.14	0.46
	Residential Distrct, 1/8 Acre, Soil B		0.6	85		0.53	0.7
	Residential Distrct, 1/4 Acre, Soil B		0.2	75		0.49	0.67
	Residential Distrct, 1/3 Acre, Soil B		0.9	72		0.37	0.6
	Residential Distrct, 1 Acre, Soil B		0.4	68		0.29	0.55
		Total	5.7	76.7	WCN	0.43	0.63
Basin 12W							
	Gravel Road, Soil B		0.2	85		0.45	0.65
	Paved Road, Open Ditches, Soil B		0.6	89		0.94	0.94
	Paved Parking Lots/driveways, Soil B		0.1	98		0.85	0.9
	Open Space, Lawn, Soil B		0.4	69		0.14	0.46
	Residential District, 1/8 Acre, Soil B		0.4	85		0.53	0.7
	Residential District, 1/4 Acre, Soil B		0.8	75		0.49	0.67
	Residential Distrct, 1/3 Acre, Soil B		0.2	72		0.37	0.6
	Residential District, 1/2 Acre, Soil B		0.4	70		0.33	0.58
		Total	3.2	78.7	WCN	0.52	0.69
Basin 1E							
	Forested, Slope > 6%, Soil D		13.3	77		0.32	0.38
	Residential District, 1 Acre, Soil B		1.5	68		0.29	0.55
	Residential District, 1 Acre, Soil D		0.5	84		0.35	0.6
	Residential District, 1/2 Acre, Soil D		0.3	85		0.39	0.62
	Residential District, 1/3 Acre, Soil B		0.1	72		0.37	0.6
	Gravel Road, Soil B		0.3	85		0.45	0.65
	Gravel Road, Soil D		0.2	91		0.5	0.69
		Total	16.1	76.8	WCN	0.32	0.42
Basin 2E							
	Gravel Road, Soil B		0.4	85		0.45	0.65
	Open Space, Lawn, Soil B		0.4	69		0.14	0.46
	Paved Parking Lots/driveways, Soil B		0.1	98		0.85	0.9
	Residential District, 1/4 Acre, Soil B		1.1	75		0.49	0.67
	Residential District, 1/3 Acre, Soil B		0.1	72		0.37	0.6
		Total	2.0	76.4	WCN	0.42	0.63
Basin 3E							
	Open Space, Lawn, Soil B		0.1	69		0.14	0.46
	Paved Parking Lots/driveways, Soil B		0.1	98		0.85	0.9
	Residential District, 1/3 Acre, Soil B		0.6	72		0.37	0.6
	Residential District, 1/8 Acre, Soil B		0.1	85		0.57	0.73
	Residential District, 1/4 Acre, Soil B		0.1	75		0.49	0.67
	Gravel Road, Soil B		0.2	85		0.45	0.65
		Total	1.2	77.0	WCN	0.42	0.63
Basin 4E							
	Gravel Road, Soil B		0.4	85		0.45	0.65
	Residential District, 1/4 Acre, Soil B		0.6	75		0.49	0.67
			1.0	78.9	WCN	0.47	0.66
Basin 5E							
	Gravel Road, Soil B		0.8	85		0.45	0.65
	Paved Road, Curb and Gutter, Soil B		0.5	98		0.94	0.94
	Paved Parking Lots/driveways, Soil B		0.1	98		0.85	0.9
	Residential District, 1/8 Acre, Soil B		0.4	85		0.53	0.7
	Residential District, 1/4 Acre, Soil B		0.2	75		0.49	0.67
	Residential District, 1/2 Acre, Soil B		0.1	70		0.37	0.6
	Residential District, 1/3 Acre, Soil B		0.7	72		0.39	0.62
	Residential District, 1 Acre, Soil B		0.5	68		0.29	0.55
		Total	3.4	81.1	WCN	0.51	0.69

Basin	Description	Acres	CN		10 yr	100 yr
Basin 6E						
	Gravel Road, Soil B	0.6	85		0.45	0.65
	Paved Road, Open Ditches, Soil B	0.2	98		0.94	0.94
	Residential District, 1/4 Acre, Soil B	0.3	75		0.49	0.67
	Residential District, 1/2 Acre, Soil B	0.4	70		0.37	0.6
	Open Space Land, Lawn, Fair Condition, Soil B	0.8	69		0.14	0.46
	Total	2.2	76.8	WCN	0.38	0.61
Basin 7E						
	Gravel Road, Soil B	0.1	85		0.45	0.65
	Paved Road, Curb and Gutter, Soil B	0.5	98		0.94	0.94
	Paved Parking Lots/driveways, Soil B	0.7	98		0.85	0.9
	Commercial, School, Soil B	2.5	92		0.57	0.72
	Total	3.7	93.8	WCN	0.67	0.78

Design Point	Acres	CN	Weighted Runoff Coefficient 10 yr	100 yr
Design Pt 1	6.1	79.2	0.36	0.50
Design Pt 2	7.5	78.2	0.39	0.53
Design Pt 3	5.7	79.5	0.36	0.46
Design Pt 4	72.5	77.0	0.32	0.38
Design Pt 5	79.2	77.1	0.33	0.39
Design Pt 6	89.0	77.2	0.33	0.41
Design Pt 7	4.1	79.1	0.35	0.44
Design Pt 8	13.0	77.2	0.35	0.46
Design Pt 9	105.5	77.3	0.34	0.42
Design Pt 10	3.4	81.1	0.51	0.69
Design Pt 11	114.7	77.3	0.34	0.44
Design Pt 12	120.3	77.4	0.35	0.45
Design Pt 13	123.5	77.5	0.35	0.45
Off Site Pt 1	16.1	76.8	0.32	0.42
Off Site Pt 2	1.2	77.0	0.42	0.63
Off Site Pt 3	3.2	75.8	0.42	0.62
Off Site Pt 4	4.2	76.8	0.43	0.64
Off Site Pt 5	6.5	76.8	0.41	0.63
Off Site Pt 6	3.7	93.8	0.67	0.78

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Town of Palmer Lake
High Street Drainage Plan
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Time of Concentration

Sheet Flow: $T_c = \frac{0.007*(n*L_f)^{0.8}}{P^{0.5}*S_f^{0.4}}$

Shallow Concentrated Flow: $T_c = \frac{L_f}{V*3600}$

Channel Flow: $T_c = \frac{L_f}{V*3600}$

V = Velocity (ft/sec) $V = \frac{1.49*R^{\frac{2}{3}}*S_f^{0.5}}{n}$

R = Hydraulic Radius (ft) $R = \frac{A_q}{W_p}$

Basin	Sheet Flow					Shallow Concentrated Flow					Channel Flow							Time of Concentration
	Length (ft), L	Slope (ft/ft), S_o	Manning's Roughness, n	2 yr, 24 hr Rainfall (in), P	Flow Time (min), T_c	Length (ft), L	Slope (ft/ft), S_o	Surface Type	Velocity (ft/sec), V	Flow Time (min), T_c	Length (ft), L	Slope (ft/ft), S_o	Manning's Roughness, n	Cross Section Area (ft^2), A_q	Wetted Perimeter (ft), W_p	Velocity (ft/sec), V	Flow Time (min), T_c	(min), T_c
Basin 1W	1041	0.4400	0.4	2.10	50.16	137	0.0657	Unpaved	4.14	0.55	100	0.1100	0.015	7.67	6.50	36.79	0.05	50.76
Basin 2W	932	0.4206	0.4	2.1	46.75	134	0.1045	Unpaved	5.22	0.43	240	0.1750	0.015	5.30	6.67	35.65	0.11	47.29
Basin 3W	278	0.4388	0.4	2.1	17.46	2823	0.2635	Unpaved	8.28	5.68								23.15
Basin 4W	120	0.1167	0.3	2.1	12.03						472	0.1186	0.015	6.00	6.90	31.17	0.25	12.28
Basin 5W	279	0.1341	0.3	2.1	22.35	118	0.1398	Unpaved	6.03	0.33	145	0.0586	0.015	6.67	7.13	23.00	0.11	22.78
Basin 6W	767	0.2920	0.4	2.1	46.29						130	0.0846	0.015	6.67	7.13	27.64	0.08	46.37
Basin 7W	840	0.5786	0.4	2.1	37.87	255	0.1176	Unpaved	5.53	0.77								38.64
Basin 8W	1003	0.5165	0.4	2.1	45.67						542	0.1033	0.030	4.00	6.50	11.55	0.78	46.45
Basin 9W	930	0.2602	0.35	2.1	50.82						300	0.1033	0.015	6.67	7.13	30.54	0.16	50.99
Basin 10W	1292	0.0417	0.15	2.1	65.21						180	0.0417	0.015	6.60	7.13	19.27	0.16	65.37
Basin 11W	1032	0.1395	0.3	2.1	62.65						140	0.0357	0.015	6.67	7.13	17.95	0.13	62.78
Basin 12W	1045	0.1043	0.3	2.1	71.09						113	0.0265	0.030	8.00	10.00	6.97	0.27	71.36
Basin 1E	364	0.4176	0.4	2.1	22.10	15625	0.0317	Bare & Un	1.78	146.30								
						240	0.1125	Unpaved	5.41	0.74	258	0.1395	0.015	5.30	6.67	31.83	0.14	84.64
Baisn 2E	120	0.1583	0.3	2.1	10.65	650	0.1254	7		4.37	650	0.1254	0.030	6.00	6.90	16.02	0.68	11.33
Basin 3E	568	0.1479	0.3	2.1	37.96						145	0.1379	0.030	5.33	6.67	15.88	0.15	38.11

Basin	Sheet Flow					Shallow Concentrated Flow					Channel Flow							Time of Concentration
	Length (ft), L	Slope (ft/ft), S_o	Manning's Roughness, n	2 yr, 24 hr Rainfall (in), P	Flow Time (min), T_c	Length (ft), L	Slope (ft/ft), S_o	Surface Type	Velocity (ft/sec), V	Flow Time (min), T_c	Length (ft), L	Slope (ft/ft), S_o	Manning's Roughness, n	Cross Section Area (ft^2), A_q	Wetted Perimeter (ft), W_p	Velocity (ft/sec), V	Flow Time (min), T_c	(min), t_c
Basin 4E	30	0.1000	0.3	2.1	4.22						161	0.1056	0.030	6.00	6.87	14.75	0.18	4.40
Basin 5E	601	0.1181	0.3	2.1	43.45						420	0.0024	0.015	6.67	7.13	4.65	1.50	44.96
Basin 6E	25	0.1200	0.3	2.1	3.39						702	0.0954	0.015	7.33	7.44	30.38	0.39	3.78
Basin 7E	15	0.0667	0.3	2.1	2.85						795	0.0377	0.015	6.67	7.13	18.45	0.72	3.57

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High Street Drainage Plan
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Sub-Basin Runoff Summary

Basin	Design Storm	Area (ac)	Weighted Curve Number	Time of Concentration (min)	Peak Runoff (cfs)
Basin 1W					
	10 Year, 6 Hour Storm	5.7	79.51	50.76	1.60
	50 Year, 6 Hour Storm	5.7	79.51	50.76	3.9
	100 Year, 6 Hour Storm	5.7	79.51	50.76	5.4
Basin 2W					
	10 Year, 6 Hour Storm	6.1	79.18	47.29	1.6
	50 Year, 6 Hour Storm	6.1	79.18	47.29	4.2
	100 Year, 6 Hour Storm	6.1	79.18	47.29	5.8
Basin 3W					
	10 Year, 6 Hour Storm	72.5	77.03	23.15	21.0
	50 Year, 6 Hour Storm	72.5	77.03	23.15	58.9
	100 Year, 6 Hour Storm	72.5	77.03	23.15	82.3
Basin 4W					
	10 Year, 6 Hour Storm	1.0	76.31	12.28	0.4
	50 Year, 6 Hour Storm	1.0	76.31	12.28	1.0
	100 Year, 6 Hour Storm	1.0	76.31	12.28	1.3
Basin 5W					
	10 Year, 6 Hour Storm	1.3	77.53	22.78	0.4
	50 Year, 6 Hour Storm	1.3	77.53	22.78	1.1
	100 Year, 6 Hour Storm	1.3	77.53	22.78	1.5
Basin 6W					
	10 Year, 6 Hour Storm	2.3	73.32	46.37	0.3
	50 Year, 6 Hour Storm	2.3	73.32	46.37	1.1
	100 Year, 6 Hour Storm	2.3	73.32	46.37	1.6
Basin 7W					
	10 Year, 6 Hour Storm	4.1	79.07	38.64	1.2
	50 Year, 6 Hour Storm	4.1	79.07	38.64	3.1
	100 Year, 6 Hour Storm	4.1	79.07	38.64	4.2
Basin 8W					
	10 Year, 6 Hour Storm	9.0	75.67	46.45	1.7
	50 Year, 6 Hour Storm	9.0	75.67	46.45	5.0
	100 Year, 6 Hour Storm	9.0	75.67	46.45	7.1
Basin 9W					
	10 Year, 6 Hour Storm	3.6	79.36	50.99	0.9
	50 Year, 6 Hour Storm	3.6	79.36	50.99	2.4
	100 Year, 6 Hour Storm	3.6	79.36	50.99	3.3
Basin 10W					
	10 Year, 6 Hour Storm	5.7	75.97	65.37	0.9
	50 Year, 6 Hour Storm	5.7	75.97	65.37	2.7
	100 Year, 6 Hour Storm	5.7	75.97	65.37	3.8

Basin	Design Storm	Area (ac)	Weighted Curve Number	Time of Concentration (min)	Peak Runoff (cfs)
Basin 11W					
	10 Year, 6 Hour Storm	5.7	76.66	62.78	1.0
	50 Year, 6 Hour Storm	5.7	76.66	62.78	2.9
	100 Year, 6 Hour Storm	5.7	76.66	62.78	4.0
Basin 12W					
	10 Year, 6 Hour Storm	3.2	78.72	71.36	0.7
	50 Year, 6 Hour Storm	3.2	78.72	71.36	1.7
	100 Year, 6 Hour Storm	3.2	78.72	71.36	2.4
Basin 1E					
	10 Year, 6 Hour Storm	16.1	76.76	84.64	2.6
	50 Year, 6 Hour Storm	16.1	76.76	84.64	7.0
	100 Year, 6 Hour Storm	16.1	76.76	84.64	9.8
Baisn 2E					
	10 Year, 6 Hour Storm	2.0	76.40	11.33	0.7
	50 Year, 6 Hour Storm	2.0	76.40	11.33	1.9
	100 Year, 6 Hour Storm	2.0	76.40	11.33	2.7
Basin 3E					
	10 Year, 6 Hour Storm	1.2	76.99	38.11	0.3
	50 Year, 6 Hour Storm	1.2	76.99	38.11	0.8
	100 Year, 6 Hour Storm	1.2	76.99	38.11	1.2
Basin 4E					
	10 Year, 6 Hour Storm	1.0	78.91	4.40	0.5
	50 Year, 6 Hour Storm	1.0	78.91	4.40	1.2
	100 Year, 6 Hour Storm	1.0	78.91	4.40	1.6
Basin 5E					
	10 Year, 6 Hour Storm	3.4	81.09	44.96	1.1
	50 Year, 6 Hour Storm	3.4	81.09	44.96	2.7
	100 Year, 6 Hour Storm	3.4	81.09	44.96	3.6
Basin 6E					
	10 Year, 6 Hour Storm	2.2	76.80	3.78	0.8
	50 Year, 6 Hour Storm	2.2	76.80	3.78	2.2
	100 Year, 6 Hour Storm	2.2	76.80	3.78	3.1
Basin 7E					
	10 Year, 6 Hour Storm	3.7	93.75	3.57	4.8
	50 Year, 6 Hour Storm	3.7	93.75	3.57	8.1
	100 Year, 6 Hour Storm	3.7	93.75	3.57	9.8

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Design Point Runoff Summary

Design Point	Contributing Basins	Design Storm	Area (ac)	Weighted Curve Number	Peak Runoff (cfs)
Design Point 1					
		10 Year, 6 Hour Storm	6.1	79.18	1.6
		50 Year, 6 Hour Storm	6.1	79.18	4.2
	2W	100 Year, 6 Hour Storm	6.1	79.18	5.8
Design Point 2					
		10 Year, 6 Hour Storm	7.5	78.24	2.0
		50 Year, 6 Hour Storm	7.5	78.24	5.3
	2W & 5W	100 Year, 6 Hour Storm	7.5	78.24	7.3
Design Point 3					
		10 Year, 6 Hour Storm	5.7	79.51	1.6
		50 Year, 6 Hour Storm	5.7	79.51	3.9
	1W	100 Year, 6 Hour Storm	5.7	79.51	5.4
Design Point 4					
		10 Year, 6 Hour Storm	72.5	77.03	21.0
		50 Year, 6 Hour Storm	72.5	77.03	58.9
	3W	100 Year, 6 Hour Storm	72.5	77.03	82.3
Design Point 5					
		10 Year, 6 Hour Storm	79.2	77.15	23.0
		50 Year, 6 Hour Storm	79.2	77.15	63.8
	1W, 3W, & 4W	100 Year, 6 Hour Storm	79.2	77.15	89.0
Design Point 6					
		10 Year, 6 Hour Storm	89.0	77.18	25.0
	1W, 2W, 3W, 4W,	50 Year, 6 Hour Storm	89.0	77.18	70.2
	5W, & 6W	100 Year, 6 Hour Storm	89.0	77.18	97.9
Design Point 7					
		10 Year, 6 Hour Storm	4.1	79.07	1.2
		50 Year, 6 Hour Storm	4.1	79.07	3.1
	7W	100 Year, 6 Hour Storm	4.1	79.07	4.2
Design Point 8					
		10 Year, 6 Hour Storm	13.0	77.15	2.9
		50 Year, 6 Hour Storm	13.0	77.15	8.1
	7W, 8W	100 Year, 6 Hour Storm	13.0	77.15	11.3
Design Point 9					
	1W, 2W, 3W, 4W,	10 Year, 6 Hour Storm	105.5	77.30	28.8
	5W, 6W, 7W, 8W, &	50 Year, 6 Hour Storm	105.5	77.30	80.7
	9W	100 Year, 6 Hour Storm	105.5	77.30	112.5
Design Point 10					
		10 Year, 6 Hour Storm	3.4	81.09	1.1
		50 Year, 6 Hour Storm	3.4	81.09	2.7
	5E	100 Year, 6 Hour Storm	3.4	81.09	3.6

Design Point	Contributing Basins	Design Storm	Area (ac)	Weighted Curve Number	Peak Runoff (cfs)
Design Point 11					
	1W, 2W, 3W, 4W,	10 Year, 6 Hour Storm	114.7	77.33	30.8
	5W, 6W, 7W, 8W,	50 Year, 6 Hour Storm	114.7	77.33	86.1
	9W, 10W, & 5E	100 Year, 6 Hour Storm	114.7	77.33	119.9
Design Point 12					
	1W, 2W, 3W, 4W, 5W, 6W, 7W, 8W,	10 Year, 6 Hour Storm	120.3	77.36	31.8
	9W, 10W, 11W, &	50 Year, 6 Hour Storm	120.3	77.36	89.0
	5E	100 Year, 6 Hour Storm	120.3	77.36	123.9
Design Point 13					
	1W, 2W, 3W, 4W, 5W, 6W, 7W, 8W,	10 Year, 6 Hour Storm	123.5	77.45	32.5
	9W, 10W, 11W,	50 Year, 6 Hour Storm	123.5	77.45	90.7
	12W, & 5E	100 Year, 6 Hour Storm	123.5	77.45	126.3
Off Site Point 1					
		10 Year, 6 Hour Storm	16.1	76.76	2.6
		50 Year, 6 Hour Storm	16.1	76.76	7.0
	1E	100 Year, 6 Hour Storm	16.1	76.76	9.8
Off Site Point 2					
		10 Year, 6 Hour Storm	1.2	76.99	0.3
		50 Year, 6 Hour Storm	1.2	76.99	0.8
	3E	100 Year, 6 Hour Storm	1.2	76.99	1.2
Off Site Point 3					
		10 Year, 6 Hour Storm	3.2	75.79	1.0
		50 Year, 6 Hour Storm	3.2	75.79	2.7
	2E & 3E	100 Year, 6 Hour Storm	3.2	75.79	3.9
Off Site Point 4					
		10 Year, 6 Hour Storm	4.2	76.83	1.5
		50 Year, 6 Hour Storm	4.2	76.83	3.9
	2E, 3E, & 4E	100 Year, 6 Hour Storm	4.2	76.83	5.5
Off Site Point 5					
		10 Year, 6 Hour Storm	6.5	76.84	2.3
		50 Year, 6 Hour Storm	6.5	76.84	6.1
	2E, 3E, 4E, & 6E	100 Year, 6 Hour Storm	6.5	76.84	8.6
Off Site Point 6					
		10 Year, 6 Hour Storm	3.7	93.75	4.8
		50 Year, 6 Hour Storm	3.7	93.75	8.1
	7E	100 Year, 6 Hour Storm	3.7	93.75	9.8

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10 Year Channel Results

Channel	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Manning's Roughnes s	Design Flow Capacity (cfs)	10 Year Storm Peak Flow (cfs)	Peak Flow Velocity (ft/sec)
Channel 1	68.4	7445.87	7437.18	12.70	0.032	43.0	1.5	5.2
Channel 2	16.3	7433.89	7431.54	14.42	0.032	67.1	1.5	5.4
Channel 3	192.5	7429.67	7406.92	11.82	0.032	56.9	21.9	10.1
Channel 4	180.3	7403.08	7381.62	11.90	0.032	50.7	22.2	10.0
Channel 5	91.3	7454.62	7430.62	26.29	0.032	79.4	1.6	6.3
Channel 6	115.2	7427.62	7407.65	17.33	0.032	39.6	1.6	5.8
Channel 7	24.4	7403.63	7399.93	15.13	0.032	67.6	1.6	5.4
Channel 8	84.2	7396.76	7388.45	9.87	0.032	49.4	1.6	4.3
Channel 9	28.7	7385.49	7384.00	5.20	0.032	29.3	1.9	3.6
Channel 10	46.7	7384.00	7379.65	9.29	0.032	41.0	1.9	4.3
Channel 11	2.2	7377.33	7377.18	6.77	0.032	139.0	1.9	4.6
Channel 12	7.6	7377.18	7376.30	11.61	0.032	181.9	23.7	10.9
Channel 13	23.8	7378.56	7374.86	15.53	0.032	40.3	0.0	0.0
Channel 14	29.3	7376.07	7370.66	18.51	0.032	84.4	0.0	0.0
Channel 15	36.3	7370.66	7368.71	5.37	0.032	45.5	0.0	0.0
Channel 16	241.6	7374.15	7348.87	10.46	0.032	72.6	23.7	10.0
Channel 17	7.6	7345.85	7344.71	15.04	0.032	126.2	23.9	11.4
Channel 18	44.3	7342.74	7338.86	8.77	0.032	108.7	23.9	9.4
Channel 19	25.5	7336.74	7333.14	14.15	0.032	69.6	20.2	10.3
Channel 20	29.6	7330.85	7327.64	10.81	0.032	47.8	20.2	9.5
Channel 21	34.1	7325.89	7321.06	14.20	0.032	66.6	21.1	10.9
Channel 22	75.4	7319.03	7311.32	10.23	0.032	77.2	22.6	10.1
Channel 23	54.6	7308.02	7304.95	5.63	0.032	45.7	23.8	7.5
Channel 24	204.6	7304.95	7290.34	7.14	0.032	51.5	24.9	8.3
Channel 25	42.3	7289.40	7287.46	4.59	0.032	33.5	20.7	6.9
Channel 26	291.0	7285.53	7273.59	4.10	0.032	33.7	19.8	6.2
Channel 27	104.2	7273.12	7270.66	2.37	0.032	47.5	9.1	4.7
Channel 28	142.3	7270.68	7267.70	2.10	0.032	56.0	0.2	1.5

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50 Year Channel Results

Channel	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Manning's Roughnes s	Design Flow Capacity (cfs)	50 Year Storm Peak Flow (cfs)	Peak Flow Velocity (ft/sec)
Channel 1	68.4	7445.87	7437.18	12.70	0.032	43.0	3.9	6.8
Channel 2	46.7	7384.00	7379.65	9.29	0.032	41.0	5.0	5.8
Channel 3	2.2	7377.33	7377.18	6.77	0.032	139.0	5.0	5.9
Channel 4	7.6	7377.18	7376.30	11.61	0.032	181.9	32.1	11.8
Channel 5	23.8	7378.56	7374.86	15.53	0.032	40.3	0.0	0.0
Channel 6	29.3	7376.07	7370.66	18.51	0.032	84.4	0.0	0.0
Channel 7	36.3	7370.66	7368.71	5.37	0.032	45.5	0.0	0.0
Channel 8	241.6	7374.15	7348.87	10.46	0.032	72.6	27.2	10.4
Channel 9	7.6	7345.85	7344.71	15.04	0.032	126.2	28.3	12.0
Channel 10	44.3	7342.74	7338.86	8.77	0.032	108.7	28.3	9.9
Channel 11	25.5	7336.74	7333.14	14.15	0.032	69.6	20.2	10.3
Channel 12	16.3	7433.89	7431.54	14.42	0.032	67.1	3.9	7.1
Channel 13	29.6	7330.85	7327.64	10.81	0.032	47.8	20.2	9.5
Channel 14	34.1	7325.89	7321.06	14.20	0.032	66.6	22.6	11.1
Channel 15	75.4	7319.03	7311.32	10.23	0.032	77.2	25.8	10.4
Channel 16	54.6	7308.02	7304.95	5.63	0.032	45.7	28.8	8.0
Channel 17	204.6	7304.95	7290.34	7.14	0.032	51.5	31.5	8.9
Channel 18	42.3	7289.40	7287.46	4.59	0.032	33.5	20.7	6.9
Channel 19	291.0	7285.53	7273.59	4.10	0.032	33.7	19.8	6.2
Channel 20	104.2	7273.12	7270.66	2.37	0.032	47.5	9.1	4.7
Channel 21	142.3	7270.68	7267.70	2.10	0.032	56.0	0.2	1.5
Channel 22	192.5	7429.67	7406.92	11.82	0.032	56.9	56.9	13.2
Channel 23	180.3	7403.08	7381.62	11.90	0.032	50.7	36.1	11.5
Channel 24	91.3	7454.62	7430.62	26.29	0.032	79.4	4.2	8.4
Channel 25	115.2	7427.62	7407.65	17.33	0.032	39.6	4.2	7.7
Channel 26	24.4	7403.63	7399.93	15.13	0.032	67.6	4.2	7.2
Channel 27	84.2	7396.76	7388.45	9.87	0.032	49.4	4.2	5.7
Channel 28	28.7	7385.49	7384.00	5.20	0.032	29.3	5.0	4.8

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100 Year Channel Results

Channel	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Manning's Roughness	Design Flow Capacity (cfs)	100 Year Storm Peak Flow (cfs)	Peak Flow Velocity (ft/sec)
Channel 1	68.4	7445.87	7437.18	12.70	0.032	43.0	5.4	7.4
Channel 2	16.3	7433.89	7431.54	14.42	0.032	67.1	5.4	7.7
Channel 3	192.5	7429.67	7406.92	11.82	0.032	56.9	56.9	13.2
Channel 4	180.3	7403.08	7381.62	11.90	0.032	50.7	36.5	11.5
Channel 5	91.3	7454.62	7430.62	26.29	0.032	79.4	5.7	9.2
Channel 6	115.2	7427.62	7407.65	17.33	0.032	39.6	5.7	8.4
Channel 7	24.4	7403.63	7399.93	15.13	0.032	67.6	5.7	7.8
Channel 8	84.2	7396.76	7388.45	9.87	0.032	49.4	5.7	6.2
Channel 9	28.7	7385.49	7384.00	5.20	0.032	29.3	6.8	5.2
Channel 10	46.7	7384.00	7379.65	9.29	0.032	41.0	6.8	6.4
Channel 11	2.2	7377.33	7377.18	6.77	0.032	139.0	6.8	6.5
Channel 12	7.6	7377.18	7376.30	11.61	0.032	181.9	34.0	12.0
Channel 13	23.8	7378.56	7374.86	15.53	0.032	40.3	0.0	0.0
Channel 14	29.3	7376.07	7370.66	18.51	0.032	84.4	0.0	0.0
Channel 15	36.3	7370.66	7368.71	5.37	0.032	45.5	0.0	0.0
Channel 16	241.6	7374.15	7348.87	10.46	0.032	72.6	27.2	10.4
Channel 17	7.6	7345.85	7344.71	15.04	0.032	126.2	28.8	12.0
Channel 18	44.3	7342.74	7338.86	8.77	0.032	108.7	28.8	10.0
Channel 19	25.5	7336.74	7333.14	14.15	0.032	69.6	20.2	10.3
Channel 20	29.6	7330.85	7327.64	10.81	0.032	47.8	20.2	9.5
Channel 21	34.1	7325.89	7321.06	14.20	0.032	66.6	23.5	11.2
Channel 22	75.4	7319.03	7311.32	10.23	0.032	77.2	25.8	10.4
Channel 23	54.6	7308.02	7304.95	5.63	0.032	45.7	30.0	8.1
Channel 24	204.6	7304.95	7290.34	7.14	0.032	51.5	33.5	9.1
Channel 25	42.3	7289.40	7287.46	4.59	0.032	33.5	20.7	6.9
Channel 26	291.0	7285.53	7273.59	4.10	0.032	33.7	19.8	6.2
Channel 27	104.2	7273.12	7270.66	2.37	0.032	47.5	9.1	4.7
Channel 28	142.3	7270.68	7267.70	2.10	0.032	56.0	0.2	1.5

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10 Year Culvert Results

Culvert	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Size (in)	Manning's Roughness	Design Flow Capacity (cfs)	10 Year Storm Peak Flow (cfs)
C-1	38.4	7437.18	7433.89	8.58	18	0.024	16.7	1.6
C-2	42.0	7381.62	7377.87	8.92	18	0.015	27.2	23.0
C-3	33.3	7407.65	7403.63	12.08	18	0.015	31.6	1.6
C-4	43.9	7383.64	7378.56	11.58	18	0.015	31.0	0.0
C-5	26.9	7379.65	7377.33	8.64	18	0.015	26.8	2.0
C-6	41.7	7377.56	7376.07	3.58	18	0.015	17.2	0.0
C-7	36.9	7374.86	7370.66	11.38	18	0.015	30.7	0.0
C-8	27.8	7348.87	7345.85	10.87	18	0.015	30.0	25.0
C-9	47.5	7311.32	7308.02	6.95	26	0.015	64.0	28.8
C-10	59.9	7305.62	7304.95	1.12	24	0.015	20.7	1.1
C-11	40.7	7287.19	7285.53	4.10	18	0.015	19.8	30.8
C-12	45.9	7273.59	7273.12	1.01	18	0.015	9.1	31.8
C-13	127.4	7267.70	7263.47	3.32	30	0.015	64.7	32.5
D-1	20.7	7430.62	7427.62	14.47	18	0.015	34.6	1.6
D-2	18.4	7447.53	7445.87	9.04	18	0.024	17.1	1.6
D-3	18.4	7431.54	7429.67	10.15	18	0.024	18.1	1.6
D-4	25.7	7406.92	7403.08	14.90	18	0.015	35.1	22.6
D-5	30.1	7399.93	7396.76	10.55	18	0.015	29.6	1.6
D-6	43.8	7388.45	7385.49	6.75	18	0.015	23.7	2.0
D-7	24.0	7376.30	7374.15	8.95	18	0.015	27.2	24.7
D-8	17.6	7344.71	7342.74	11.16	18	0.015	30.4	25.0
D-9	23.0	7338.86	7336.74	9.21	16	0.015	20.2	25.0
D-10	27.9	7333.14	7330.85	8.20	18	0.015	26.1	25.0
D-11	16.4	7327.64	7325.89	10.68	18	0.015	29.8	25.0
D-12	25.3	7321.06	7319.03	8.01	18	0.015	25.8	25.9
D-13	2.5	7317.63	7317.54	3.6	16	0.015	14.02	25.9
D-14	18.2	7290.34	7289.40	5.17	18	0.015	20.7	28.8
D-15	30.1	7270.66	7270.66	0.00	12	0.015	0.2	31.8

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50 Year Culvert Results

Culvert	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Size (in)	Manning's Roughness	Design Flow Capacity (cfs)	50 Year Storm Peak Flow (cfs)
C-1	38.4	7437.18	7433.89	8.58	18	0.024	16.7	3.9
C-2	42.0	7381.62	7377.87	8.92	18	0.015	27.2	63.8
C-3	33.3	7407.65	7403.63	12.08	18	0.015	31.6	4.2
C-4	43.9	7383.64	7378.56	11.58	18	0.015	31.0	0.0
C-5	26.9	7379.65	7377.33	8.64	18	0.015	26.8	5.3
C-6	41.7	7377.56	7376.07	3.58	18	0.015	17.2	0.0
C-7	36.9	7374.86	7370.66	11.38	18	0.015	30.7	0.0
C-8	27.8	7348.87	7345.85	10.87	18	0.015	30.0	70.2
C-9	47.5	7311.32	7308.02	6.95	26	0.015	64.0	80.7
C-10	59.9	7305.62	7304.95	1.12	24	0.015	20.7	2.7
C-11	40.7	7287.19	7285.53	4.10	18	0.015	19.8	86.1
C-12	45.9	7273.59	7273.12	1.01	18	0.015	9.1	89.0
C-13	127.4	7267.70	7263.47	3.32	30	0.015	64.7	90.7
D-1	20.7	7430.62	7427.62	14.47	18	0.015	34.6	4.2
D-2	18.4	7447.53	7445.87	9.04	18	0.024	17.1	3.9
D-3	18.4	7431.54	7429.67	10.15	18	0.024	18.1	3.9
D-4	25.7	7406.92	7403.08	14.90	18	0.015	35.1	62.8
D-5	30.1	7399.93	7396.76	10.55	18	0.015	29.6	4.2
D-6	43.8	7388.45	7385.49	6.75	18	0.015	23.7	5.3
D-7	24.0	7376.30	7374.15	8.95	18	0.015	27.2	69.1
D-8	17.6	7344.71	7342.74	11.16	18	0.015	30.4	70.2
D-9	23.0	7338.86	7336.74	9.21	16	0.015	20.2	70.2
D-10	27.9	7333.14	7330.85	8.20	18	0.015	26.1	70.2
D-11	16.4	7327.64	7325.89	10.68	18	0.015	29.8	70.2
D-12	25.3	7321.06	7319.03	8.01	18	0.015	25.8	72.6
D-13	2.5	7317.63	7317.54	3.6	16	0.015	14.02	72.6
D-14	18.2	7290.34	7289.40	5.17	18	0.015	20.7	80.7
D-15	30.1	7270.66	7270.66	0.00	12	0.015	0.2	89.0

GMS, Inc.

Town of Palmer Lake
High Street Drainage Plan
El Paso County, Colorado

100 Year Culvert Results

Culvert	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Size (in)	Manning's Roughness	Design Flow Capacity (cfs)	100 Year Storm Peak Flow (cfs)
C-1	38.4	7437.18	7433.89	8.58	18	0.024	16.7	5.4
C-2	42.0	7381.62	7377.87	8.92	18	0.015	27.2	89.0
C-3	33.3	7407.65	7403.63	12.08	18	0.015	31.6	5.8
C-4	43.9	7383.64	7378.56	11.58	18	0.015	31.0	0.0
C-5	26.9	7379.65	7377.33	8.64	18	0.015	26.8	7.3
C-6	41.7	7377.56	7376.07	3.58	18	0.015	17.2	0.0
C-7	36.9	7374.86	7370.66	11.38	18	0.015	30.7	0.0
C-8	27.8	7348.87	7345.85	10.87	18	0.015	30.0	97.9
C-9	47.5	7311.32	7308.02	6.95	26	0.015	64.0	112.5
C-10	59.9	7305.62	7304.95	1.12	24	0.015	20.7	3.6
C-11	40.7	7287.19	7285.53	4.10	18	0.015	19.8	119.9
C-12	45.9	7273.59	7273.12	1.01	18	0.015	9.1	123.9
C-13	127.4	7267.70	7263.47	3.32	30	0.015	64.7	126.3
D-1	20.7	7430.62	7427.62	14.47	18	0.015	34.6	5.8
D-2	18.4	7447.53	7445.87	9.04	18	0.024	17.1	5.4
D-3	18.4	7431.54	7429.67	10.15	18	0.024	18.1	5.4
D-4	25.7	7406.92	7403.08	14.90	18	0.015	35.1	87.7
D-5	30.1	7399.93	7396.76	10.55	18	0.015	29.6	5.8
D-6	43.8	7388.45	7385.49	6.75	18	0.015	23.7	7.3
D-7	24.0	7376.30	7374.15	8.95	18	0.015	27.2	96.3
D-8	17.6	7344.71	7342.74	11.16	18	0.015	30.4	97.9
D-9	23.0	7338.86	7336.74	9.21	16	0.015	20.2	97.9
D-10	27.9	7333.14	7330.85	8.20	18	0.015	26.1	97.9
D-11	16.4	7327.64	7325.89	10.68	18	0.015	29.8	97.9
D-12	25.3	7321.06	7319.03	8.01	18	0.015	25.8	101.2
D-13	2.5	7317.63	7317.54	3.6	16	0.015	14.02	101.2
D-14	18.2	7290.34	7289.40	5.17	18	0.015	20.7	116.1
D-15	30.1	7270.66	7270.66	0.00	12	0.015	0.2	123.9

APPENDIX D – PROPOSED DRAINAGE CALCULATIONS

Town of Palmer Lake
High Street Drainage Plan
El Paso County, Colorado

10 Year Culvert Results

Culvert	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Size (in)	Manning's Roughness	Design Flow Capacity (cfs)	10 Year Storm Peak Flow (cfs)
C-1	38.4	7437.18	7433.89	8.58	18	0.024	16.7	1.6
C-2	42.0	7381.62	7377.87	8.92	18	0.015	27.2	23.0
C-3	33.3	7407.65	7403.63	12.08	18	0.015	31.6	1.6
C-4	43.9	7383.64	7378.56	11.58	18	0.015	31.0	0.0
C-5	26.9	7379.65	7377.33	8.64	18	0.015	26.8	2.0
C-6	41.7	7377.56	7376.07	3.58	18	0.015	17.2	0.0
C-7	36.9	7374.86	7370.66	11.38	18	0.015	30.7	0.0
C-8	27.8	7348.87	7345.85	10.87	18	0.015	30.0	25.0
C-9	47.5	7311.32	7308.02	6.95	26	0.015	64.0	28.8
C-10	59.9	7305.62	7304.95	1.12	24	0.015	20.7	1.1
C-11	40.7	7287.19	7285.53	4.10	18	0.015	19.8	30.8
C-12	45.9	7273.59	7273.12	1.01	18	0.015	9.1	31.8
C-13	127.4	7267.70	7263.47	3.32	30	0.015	64.7	32.5
D-1	20.7	7430.62	7427.62	14.47	18	0.015	34.6	1.6
D-2	18.4	7447.53	7445.87	9.04	18	0.024	17.1	1.6
D-3	18.4	7431.54	7429.67	10.15	18	0.024	18.1	1.6
D-4	25.7	7406.92	7403.08	14.90	18	0.015	35.1	22.6
D-5	30.1	7399.93	7396.76	10.55	18	0.015	29.6	1.6
D-6	43.8	7388.45	7385.49	6.75	18	0.015	23.7	2.0
D-7	24.0	7376.30	7374.15	8.95	18	0.015	27.2	24.7
D-8	17.6	7344.71	7342.74	11.16	18	0.015	30.4	25.0
D-9	23.0	7338.86	7336.74	9.21	16	0.015	20.2	25.0
D-10	27.9	7333.14	7330.85	8.20	18	0.015	26.1	25.0
D-11	16.4	7327.64	7325.89	10.68	18	0.015	29.8	25.0
D-12	25.3	7321.06	7319.03	8.01	18	0.015	25.8	25.9
D-13	2.5	7317.63	7317.54	3.6	16	0.015	14.02	25.9
D-14	18.2	7290.34	7289.40	5.17	18	0.015	20.7	28.8
D-15	30.1	7270.66	7270.66	0.00	12	0.015	0.2	31.8

Town of Palmer Lake
High Street Drainage Plan
El Paso County, Colorado

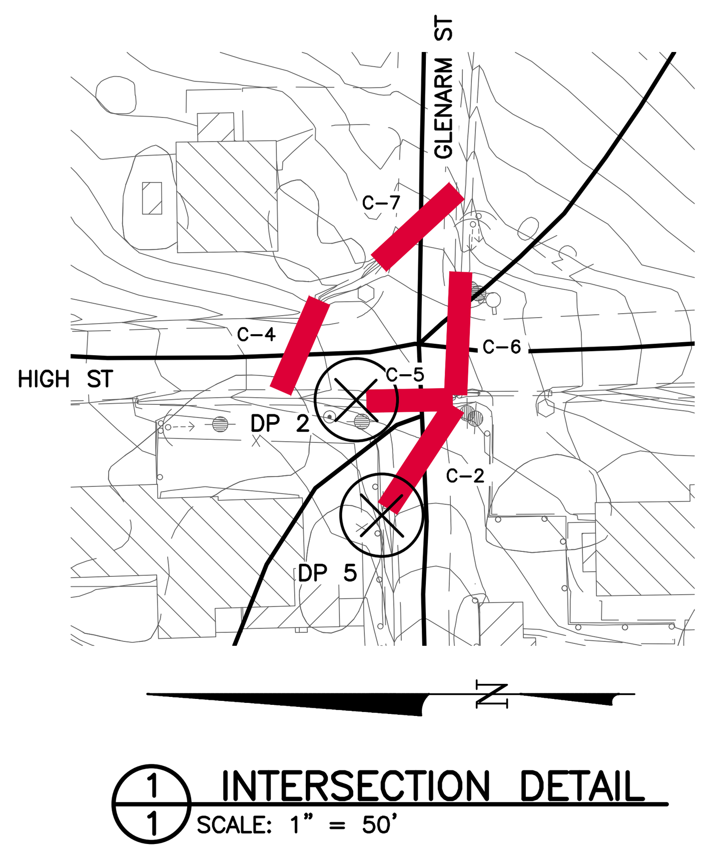
10 Year Culvert Improvements

Culvert	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Size (in)	Number of Barrels	Manning's Roughness	Design Flow Capacity (cfs)
C-1	38.4	7437.18	7433.89	8.58	18	1	0.024	16.7
C-2	42.0	7381.62	7377.87	8.92	18	1	0.015	27.2
C-3	33.3	7407.65	7403.63	12.08	18	1	0.015	31.6
C-4	43.9	7383.64	7378.56	11.58	18	1	0.015	31.0
C-5	26.9	7379.65	7377.33	8.64	18	1	0.015	26.8
C-6	41.7	7377.56	7376.07	3.58	18	1	0.015	17.2
C-7	36.9	7374.86	7370.66	11.38	18	1	0.015	30.7
C-8	27.8	7348.87	7345.85	10.87	18	1	0.015	30.0
C-9	47.5	7311.32	7308.02	6.95	26	1	0.015	64.0
C-10	59.9	7305.62	7304.95	1.12	24	1	0.015	20.7
C-11	40.7	7287.19	7285.53	4.10	15	2	0.013	28.1
C-12	45.9	7273.59	7272.49	2.39	18	2	0.013	32.5
C-13	100.8	7265.88	7263.47	2.39	30	1	0.011	74.9
D-1	20.7	7430.62	7427.62	14.47	18	1	0.015	34.6
D-2	18.4	7447.53	7445.87	9.04	18	1	0.024	17.1
D-3	18.4	7431.54	7429.67	10.15	18	1	0.024	18.1
D-4	25.7	7406.92	7403.08	14.90	18	1	0.015	35.1
D-5	30.1	7399.93	7396.76	10.55	18	1	0.015	29.6
D-6	43.8	7388.45	7385.49	6.75	18	1	0.015	23.7
D-7	24.0	7376.30	7374.15	8.95	18	1	0.015	27.2
D-8	17.6	7344.71	7342.74	11.16	18	1	0.015	30.4
D-9	23.0	7338.86	7336.74	9.21	14	1	0.013	30.2
D-10	27.9	7333.14	7330.85	8.20	18	1	0.015	26.1
D-11	16.4	7327.64	7325.89	10.68	18	1	0.015	29.8
D-12	25.3	7321.06	7319.03	8.01	18	1	0.015	25.8
D-13	2.9	7317.63	7317.54	3.34	15	2	0.013	23.6
D-14	18.2	7290.34	7289.40	5.17	15	2	0.013	29.4
D-15	30.1	7270.00	7269.28	2.39	12	2	0.013	11.0

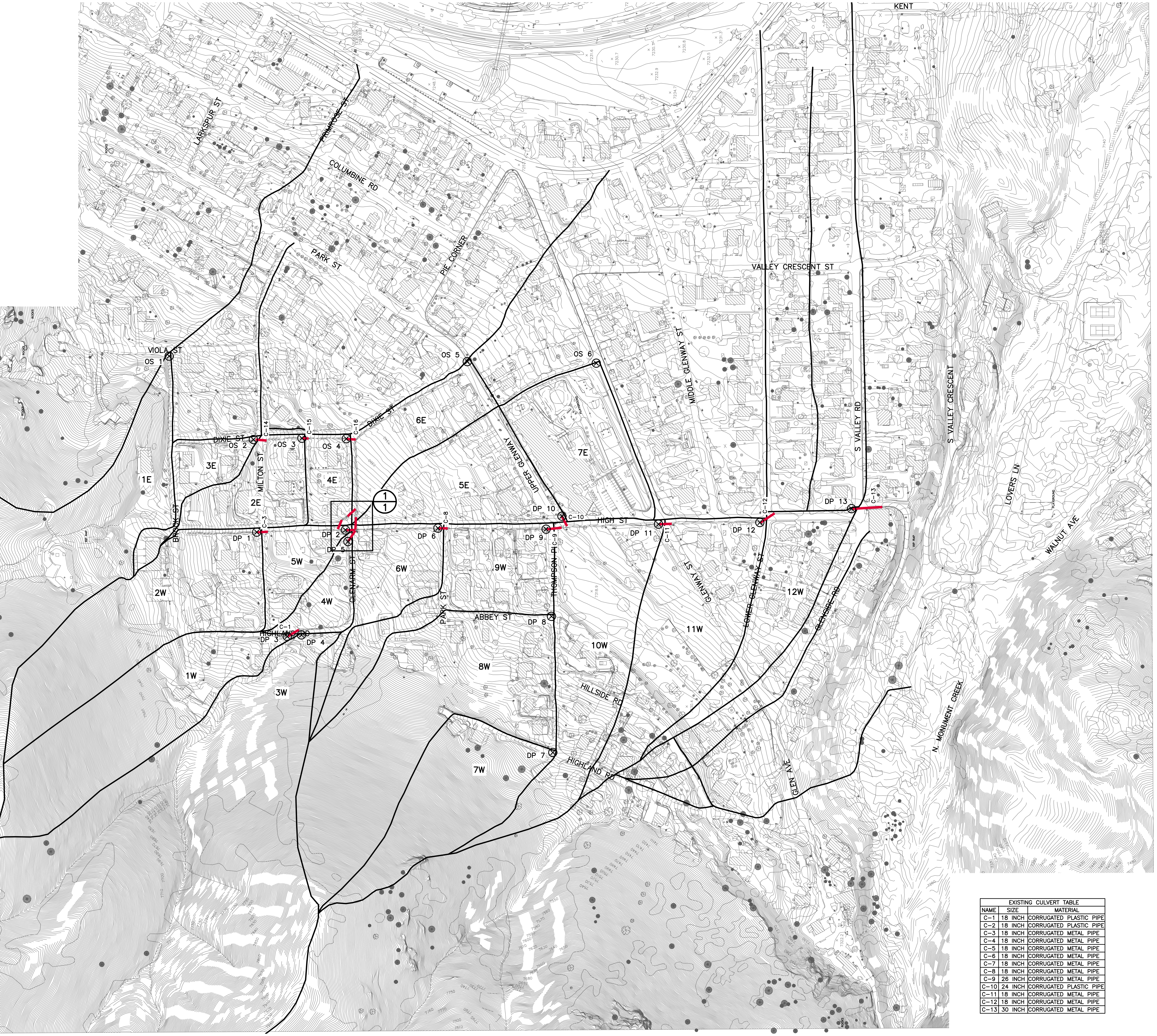
Town of Palmer Lake
High Street Drainage Plan
El Paso County, Colorado

Alternative 2 Improvements

Pipe Segment	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Size (in)	Manning's Roughness	Design Flow Capacity (cfs)	100 Year Storm Peak Flow (cfs)
Pipe-1	133	7423.72	7404.29	14.61	30	0.015	135.9	64.13
Pipe-2	50	7404.19	7398.62	11.33	30	0.015	120.7	64.13
Pipe-3	320	7398.52	7364.61	10.62	30	0.015	116.0	64.13
Pipe-4	272	7364.51	7334.21	11.16	30	0.015	119.0	92.02
Pipe-5	359	7334.11	7304.32	8.30	30	0.015	102.6	92.02
Pipe-6	367	7304.22	7283.82	5.56	36	0.015	136.6	101.39
Pipe-7	329	7283.72	7269.60	4.30	36	0.015	119.8	110.72
Pipe-8	305	7269.60	7256.20	4.40	36	0.015	121.3	110.72
Pipe-9	60	7256.10	7253.10	5.00	36	0.015	129.2	110.90
Pipe-10	74	7253.10	7249.41	5.00	36	0.015	129.2	110.90
Pipe-11	48	7249.31	7246.92	4.99	36	0.015	129.1	110.90
Pipe-12	47	7246.82	7244.47	4.99	36	0.015	129.2	110.90
Pipe-13	108	7244.37	7239.00	5.00	36	0.015	129.3	110.90
Inlet Flow-1	25	7365.86	7364.61	5.13	18	0.015	20.62	20.62
Inlet Flow-2	23	7335.58	7334.21	6.17	15	0.015	13.9	0
Inlet Flow-3	30	7305.9	7304.32	5.43	15	0.015	13.05	11.99
Inlet Flow-4	24	7284.94	7283.82	4.69	15	0.015	12.12	10.88
Inlet Flow-5	24	7270.88	7269.7	5	15	0.015	12.52	0
Inlet Flow-6	27	7257.53	7256.2	5.01	15	0.015	12.53	0.18



1/1 INTERSECTION DETAIL
SCALE: 1" = 50'



EXISTING CULVERT TABLE		
NAME	SIZE	MATERIAL
C-1	18 INCH	CORRUGATED PLASTIC PIPE
C-2	18 INCH	CORRUGATED PLASTIC PIPE
C-3	18 INCH	CORRUGATED METAL PIPE
C-4	18 INCH	CORRUGATED METAL PIPE
C-5	18 INCH	CORRUGATED METAL PIPE
C-6	18 INCH	CORRUGATED METAL PIPE
C-7	18 INCH	CORRUGATED METAL PIPE
C-8	18 INCH	CORRUGATED METAL PIPE
C-9	26 INCH	CORRUGATED METAL PIPE
C-10	24 INCH	CORRUGATED PLASTIC PIPE
C-11	18 INCH	CORRUGATED METAL PIPE
C-12	18 INCH	CORRUGATED METAL PIPE
C-13	30 INCH	CORRUGATED METAL PIPE

SCALE VERIFICATION
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET ADJUST SCALES ACCORDINGLY

REVISIONS

NO.	DATE	DESCRIPTION

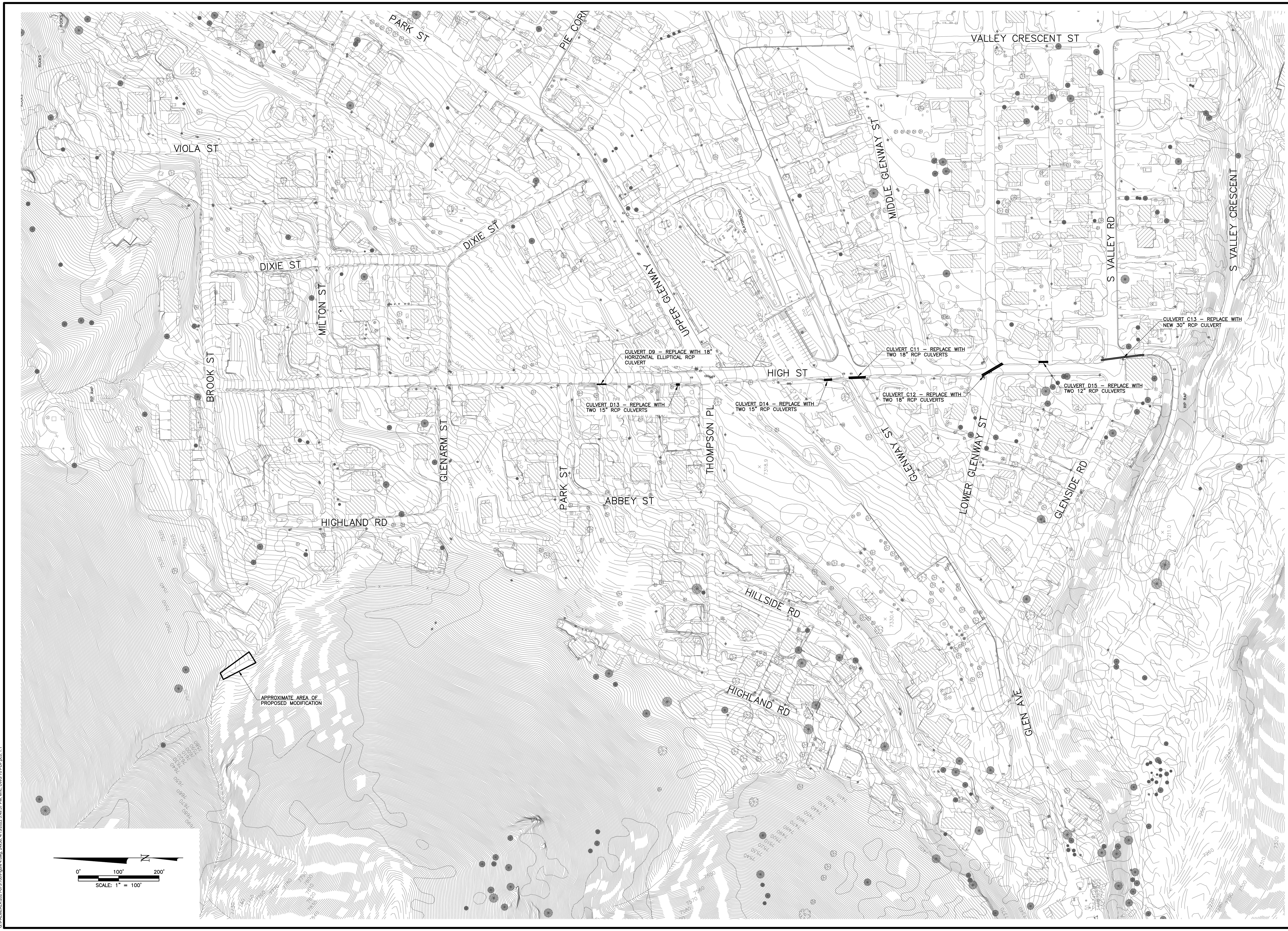
LEGEND OF UTILITY
OHE - OVERHEAD ELECTRIC
OHT - OVERHEAD TELEPHONE
UGT - UNDERGROUND TELEPHONE
GM - GAS MAIN
GS - GAS SERVICE
WM - WATER MAIN
WS - WATER SERVICE
FO - FIBER OPTIC
SD - STORM DRAIN
SS - SANITARY SEWER MAIN
IRR - IRRIGATION LINE

DRAWN	EMC
DESIGNED	
CHECKED	DMK
DATE	FEBRUARY 2022
PROJECT NO.	2021-073.100
GMS FILE NO.	

GMS INC.
CONSULTING ENGINEERS
611 N. WEBER, SUITE 300
COLORADO SPRINGS, COLORADO 80903
719-475-2935

FIGURE 3
HIGH STREET DRAINAGE PLAN
EXISTING DRAINAGE BASINS
TOWN OF PALMER LAKE

SHEET
1
OF
1



SCALE VERIFICATION
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET ADJUST SCALES ACCORDINGLY

REVISIONS

NO.	DATE	DESCRIPTION
1		

LEGEND OF UTILITY
OHE – OVERHEAD ELECTRIC
OHT – OVERHEAD TELEPHONE
UGT – UNDERGROUND TELEPHONE
GM – GAS MAIN
GS – GAS SERVICE
WM – WATER MAIN
WS – WATER SERVICE
FO – FIBER OPTIC
SD – STORM DRAIN
SS – SANITARY SEWER MAIN
IRR – IRRIGATION LINE

DRAWN	EMC
DESIGNED	EMC
CHECKED	DMK
DATE	FEBRUARY 2022
PROJECT NO.	2021–073.100
GMS FILE NO.	

GMS INC
CONSULTING ENGINEERS
611 N. WEBER, SUITE 300
COLORADO SPRINGS, COLORADO 80903
719–475–2935

FIGURE 4
HIGH STREET DRAINAGE PLAN
ALTERNATIVE 1 PROPOSED IMPROVEMENTS
TOWN OF PALMER LAKE

SHEET 1 OF 1

SCALE VERIFICATION

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IF NOT ONE INCH ON THIS SHEET ADJUST SCALES ACCORDINGLY

REVISIONS

NO.	DATE	DESCRIPTION
1		

LEGEND OF UTILITY

- OHE – OVERHEAD ELECTRIC
- OHT – OVERHEAD TELEPHONE
- UGT – UNDERGROUND TELEPHONE
- GM – GAS MAIN
- GS – GAS SERVICE
- WM – WATER MAIN
- WS – WATER SERVICE
- FO – FIBER OPTIC
- SD – STORM DRAIN
- SS – SANITARY SEWER MAIN
- IRR – IRRIGATION LINE

DRAWN	EMC
DESIGNED	EMC
CHECKED	DMK
DATE	FEBRUARY 2022
PROJECT NO.	2021-073.100
GMS FILE NO.	

GMS INC. CONSULTING ENGINEERS

611 N. WEBER, SUITE 300

COLORADO SPRINGS, COLORADO 80903

719-475-2935

FIGURE 5

HIGH STREET DRAINAGE PLAN

ALTERNATIVE 2 PROPOSED IMPROVEMENTS

TOWN OF PALMER LAKE

SHEET 1 OF 1

SCALE VERIFICATION
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET ADJUST SCALES ACCORDINGLY

REVISIONS

NO. 1	DATE	DESCRIPTION

LEGEND OF UTILITY
OHE – OVERHEAD ELECTRIC
OHT – OVERHEAD TELEPHONE
UGT – UNDERGROUND TELEPHONE
GM – GAS MAIN
GS – GAS SERVICE
WM – WATER MAIN
WS – WATER SERVICE
FO – FIBER OPTIC
SD – STORM DRAIN
SS – SANITARY SEWER MAIN
IRR – IRRIGATION LINE

DRAWN	EMC
DESIGNED	EMC
CHECKED	DMK
DATE	FEBRUARY 2022
PROJECT NO.	2021-073.100
GMS FILE NO.	

GMS INC. CONSULTING ENGINEERS
611 N. WEBER, SUITE 300
COLORADO SPRINGS, COLORADO 80903
719-475-2935

FIGURE 6
HIGH STREET DRAINAGE PLAN
ALTERNATIVE 3 PROPOSED IMPROVEMENTS
TOWN OF PALMER LAKE

SHEET 1 OF 1