Agenda Item No: 16.A

STAFF REPORT

Report To: Board of Supervisors **Meeting Date:** May 18, 2023

Staff Contact: Darren Schulz, Public Works Director

Agenda Title: For Possible Action: Discussion and possible action regarding a proposed East Carson City Area Drainage Plan ("East Carson Plan") and direction to staff concerning the exploration of funding opportunities for drainage projects in the East Carson City area. (Randall Rice, RRice@carson.org and Brianna Greenlaw, BGreenlaw@carson.org)

Staff Summary: Area drainage studies identify and quantify flood risks, collect information from residents through public outreach and propose improvements that will reduce flood damage and losses. The East Carson Plan offers three potential projects to mitigate flooding identified in the eastern portion of the City in the Pinion Hills watershed.

Agenda Action: Formal Action / Motion **Time Requested:** 10 minutes

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Proposed Motion

I move to accept the East Carson City Area Drainage Plan and direct staff to explore funding opportunities for the identified drainage projects.

Board's Strategic Goal

Safety

Previous Action

September 16, 2021 – (Item 19A): The Board of Supervisors ("Board") approved Resolution No. 2021-R-25, adopting the 2021 Hazard Mitigation Plan.

December 6, 2018 – (Item 17A): The Board approved Resolution No. 2018-R-37, adopting the 2018 Carson River Watershed Regional Floodplain Management Plan ("Regional Floodplain Management Plan").

Background/Issues & Analysis

The Hazard Mitigation Plan, adopted by the Board in 2021, contains goals to promote increased and ongoing Carson City involvement in hazard mitigation planning and projects, including reducing damage and loss due to flooding in the City. The Regional Floodplain Management Plan, adopted by the Board in 2018, guides floodplain management activities as part of an integrated watershed management plan for the Carson River Watershed. In partnership with the Carson Water Subconservancy District ("CWSD"), a Cooperative Technical Partner ("CTP") with the Federal Emergency Management Agency ("FEMA"), staff has continued to evaluate areas in Carson City for possible flood mitigation projects through area drainage plan studies identified in the Regional Floodplain Management Plan. CWSD received a CTP grant from FEMA to fund the East Carson Plan, with the Carson City Department of Public Works serving as the technical lead.

The study area for the East Carson Plan is approximately 6.1 square miles in the eastern portion of Carson City bounded by Pinion Hills to the east and the Carson River to the west. The study limit to the north is the Carson River floodplain upstream of the North Deer Run Road crossing and to the south is the southerly point of Sierra Vista Lane. The goals of the East Carson Plan included collecting data on existing drainage infrastructure, identifying and quantifying the flood risk in the study area, collecting information from residents through public outreach and preparing a flood hazard mitigation strategy by developing cost-effective project alternatives and establishing public support for future flood mitigation projects.

The East Carson Plan identifies four projects in the study area to mitigate flooding experienced during past events. Of the four projects identified, three were developed to a conceptual level so they can be utilized in planning and evaluating feasibility of capital improvement projects and opportunities for grant funding. The projects consist of channel, culvert and storm drain improvements along Pinion Hills Drive in the vicinity of Laurel Road, Juniper Road and south of Elymus Road.

Applicable Statute, Code, Policy, Rule or Regulation
Carson City Charter § 6.010; NRS 271.265

Financial Information
Is there a fiscal impact? No

If yes, account name/number: N/A

Is it currently budgeted? No

Explanation of Fiscal Impact: N/A

Alternatives
Do not accept the East Carson City Area Drainage Plan and/or provide alternative direction to staff.

Attachments:
EastCarson_ADMP_Final_combined.pdf

East Carson City Presentation Draft Final 5.10.2023.pdf

Board Action Taken:
Motion: ________________ 1) ________________ Aye/Nay
2) ________________ ________
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____

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(Vote Recorded By)

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EAST CARSON CITY AREA DRAINAGE MASTER PLAN

Prepared for: Carson Water Subconservancy District & Carson City Public Works

Carson Water Subconservancy District

Carson City Stormwater Management Program

FEMA

May 2023 FINAL

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CONTENTS

FIGURES

TABLES

APPENDICES

LIST OF ACRONYMS

1D	one-dimensional
2D	two-dimensional
ac-ft	acre-feet
ADMP	Area Drainage Master Plan
as-builts	construction plans/record drawings
BFE	base flood elevation
BLM	Bureau of Land Management
cfs	cubic feet per second
CMP	corrugated metal pipe
CWSD	Carson Water Subconservancy District
DBL	double
DEM	digital elevation model
DTM	digital terrain model
FEMA	Federal Emergency Management Agency
FIS	flood insurance study
ft	foot
fps	feet per second
GIS	geographic information system
HERCP	HE reinforced concrete pipe
HGL	hydraulic grade line
LiDAR	Light Detection and Ranging
msl	mean sea level
N/A	not applicable
NAD83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NEH	National Engineering Handbook
NFIP	National Flood Insurance Program
NGVD 29	National Geodetic Vertical Datum of 1929
NDOT	Nevada Department of Transportation
NOAA	National Oceanic and Atmospheric administration
NRCS	Natural Resources Conservation Service
QA/QC	quality assurance/quality control
RCP	reinforced concrete pipe
SR	State Route
SWE-ELM	Shallow Water Equations-Eulerian-Lagrangian Method
Tc	time of concentration
TRM	turf reinforcement mat
USBR	US Bureau of Reclamation
USEPA	US Environmental Protection Agency
USGS	US Geological Survey

EXECUTIVE SUMMARY

The East Carson City Area Drainage Master Plan (East Carson ADMP) identifies and quantifies the flood hazards within the Pinion Hills area. The study area is approximately 6.1 square miles and is in the eastern portion of Carson City, Nevada. The area is bounded by the Pinion Hills to the east and the Carson River to the west. The northern study limit is the Carson River floodplain just upstream of the North Deer Run Road crossing. To the south, the study terminates at the most southerly point of Sierra Vista Lane. The neighborhood of Pinion Hills is located at the foothills and mostly consists of 1-acre single-family parcels that were built into the existing hillside. Carson Water Subconservancy District (CWSD) requested funding from Federal Emergency Management Agency (FEMA)to prepare a hydrologic and hydraulic model predicting the existing drainage patterns and propose solutions to mitigate property damage due to flooding for Carson City.
Michael Baker International was contracted by CWSD to help establish a flood mitigation strategy for Carson City. The goals of the project were to:

- Collect data on existing drainage information through topographic survey and public sources;
- Identify and quantify the flood risk within the study area through engineering software models;
- Collect information from residents through public outreach; and
- Prepare a flood hazard mitigation strategy by developing cost-effective project alternatives and establishing public support for future flood mitigation projects.

The existing conditions were determined through a hydrologic and hydraulic study of the area. Using HEC-RAS 6.3, the peak flows and maximum flood depths were calculated for the 10-, 25-, and 100-year, 24-hour storm events. The hydrologic methods utilized topography, soil, and land cover from publicly available sources. Infiltration was modeled using the Green-Ampt method. The HEC-RAS simulation performed a rain-on-grid simulation to model rainfall runoff through the study area. Hydraulic calculations were prepared using a 2D grid cell mesh and culvert data obtained from Carson City as-builts and site visits. Model results were validated using U.S. Geological Survey Regression equations and anecdotal accounts from the residents.

Public outreach was integral to obtaining drainage information from residents as well as their feedback on preferred alternatives. Residents in the proposed areas of interest who were directly affected expressed support for the drainage mitigation solutions for the following identified flood hazard areas:

- Laurel Road downstream of Pinion Hills Drive
- Intersection of Juniper Road and Pinion Hills Drive
- Crossing at Pinion Hills Drive south of Elymus Road

Preliminary cost estimates and 10% conceptual design plans were prepared for the selected alternatives for Carson City to utilize in planning and evaluating feasibility of Capital Improvement Projects and/or prepare competitive grant applications.

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1 INTRODUCTION

Michael Baker International was contracted by Carson Water Subconservancy District (CWSD) to prepare a drainage master plan for the Pinion Hills area in east Carson City, Nevada. The affected neighborhood is the Pinion Hills residential development, which consists of a grid of 1-acre parcels with single-family homes on most parcels. The area was built over the existing drainage paths (washes) flowing out of the Pinion Hills from the east. As a result, residents have complained of flooding issues in the past. Carson City submitted a request for FEMA funding through CWSD for an evaluation of the existing drainage, identification and prioritization of the most hazardous areas, and recommended solutions to mitigate the issues. This report presents the development of the flood model, evaluation of alternatives, and the selected improvements for conceptual design.

1.1 PROJECT PURPOSE

The purpose of the East Carson City Area Drainage Master Plan (ADMP) is to identify and quantify the flood hazard risk within the Pinion Hills area in Carson City, Nevada, and develop alternative drainage mitigation projects to reduce the number of properties and structures in this area that are subject to shallow flooding. The study area, located in Carson City, Nevada, is approximately 3,856 acres (6 mi^2) and is bounded to the north and west by the Carson River at about 4,600 feet mean sea level (msl), and to the east by the Pinion Hills rising to an elevation of about 5,900 feet msl. The study area is affected by shallow, storm-induced runoff from the Pinion Hills. This intermittent runoff flows through the low-density urbanized area, where it travels across private property, along streets or in miscellaneous culverts that traverse the area, ultimately discharging onto the Carson River floodplain.

To achieve these goals, MBI was tasked to:

1. Collect data, including topographic survey and existing drainage information;
2. Identify and quantify the flood risk within the study area using a two-dimensional (2D) HEC-RAS model;
3. Conduct public outreach to solicit historical flooding information from the watershed's residents and engage stakeholders on proposed solutions to shallow flooding hazards; and
4. Establish guidance for future development and establish a flood hazard mitigation strategy that protects public safety and considers the unique natural and physical characteristics of the watershed.

1.2 PROJECT LOCATION

The East Carson ADMP study area, Pinion Hills, is located within Carson City, Nevada, Township 15 North and Range 20 East of the Mount Diablo Meridian and Base Line. The contributing watershed is bounded to the north and west by the Carson River and to the east by McTarnahan Hill. Prominent features in the study area include the U.S. Geological Survey (USGS) streamflow gauge Mexican Dam (10311002) located just southeast of Prison Hill. It is approximately 6.0 miles east of Carson City and 35 miles south of Reno. The project area consists of the various single-family zones, agricultural zones, BLM, conservation reserve zones, and public community spaces. See Figure 1-1 and Figure 1-2 for an overview of the study area.

Figure 1-1: Study Area Location Map

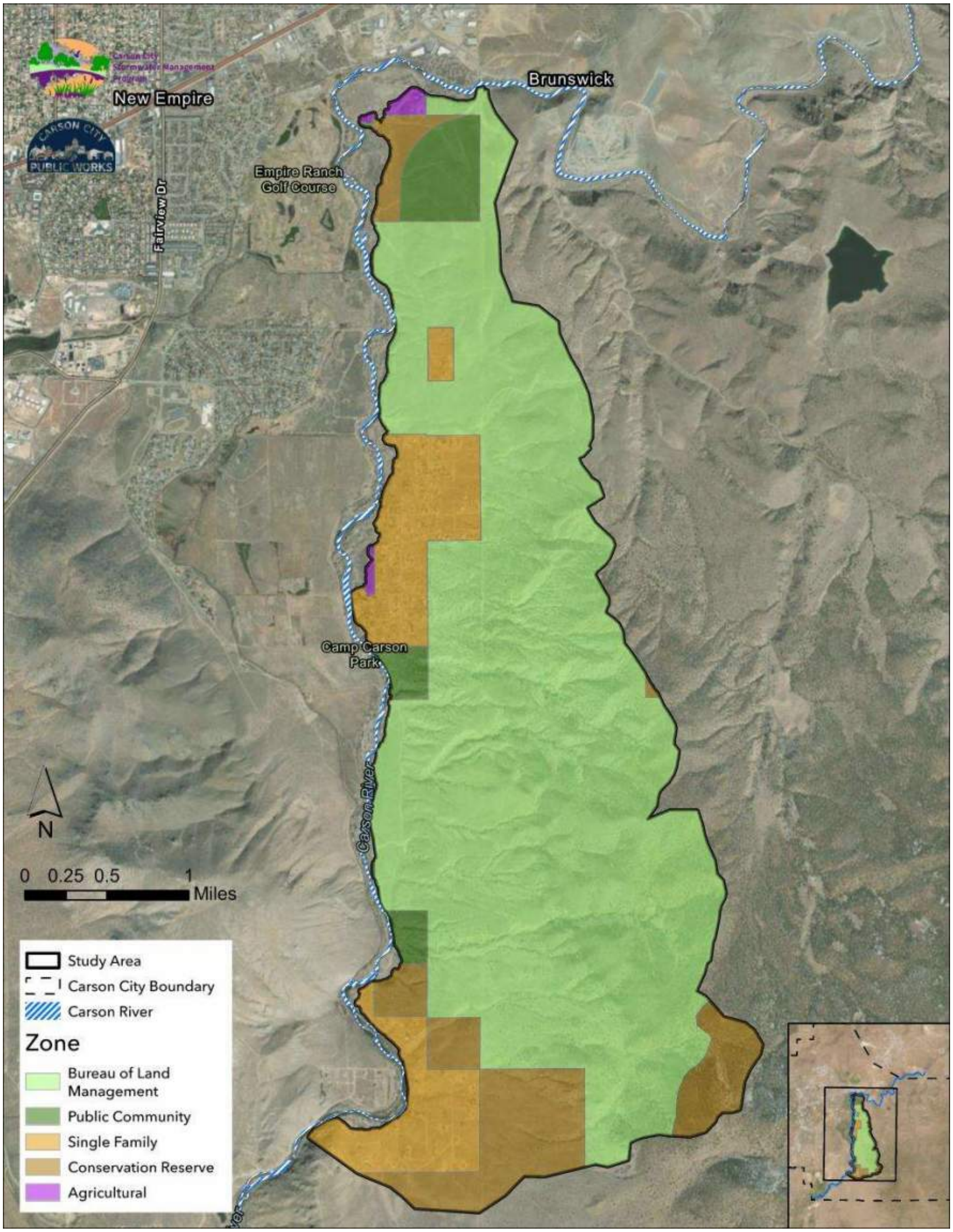
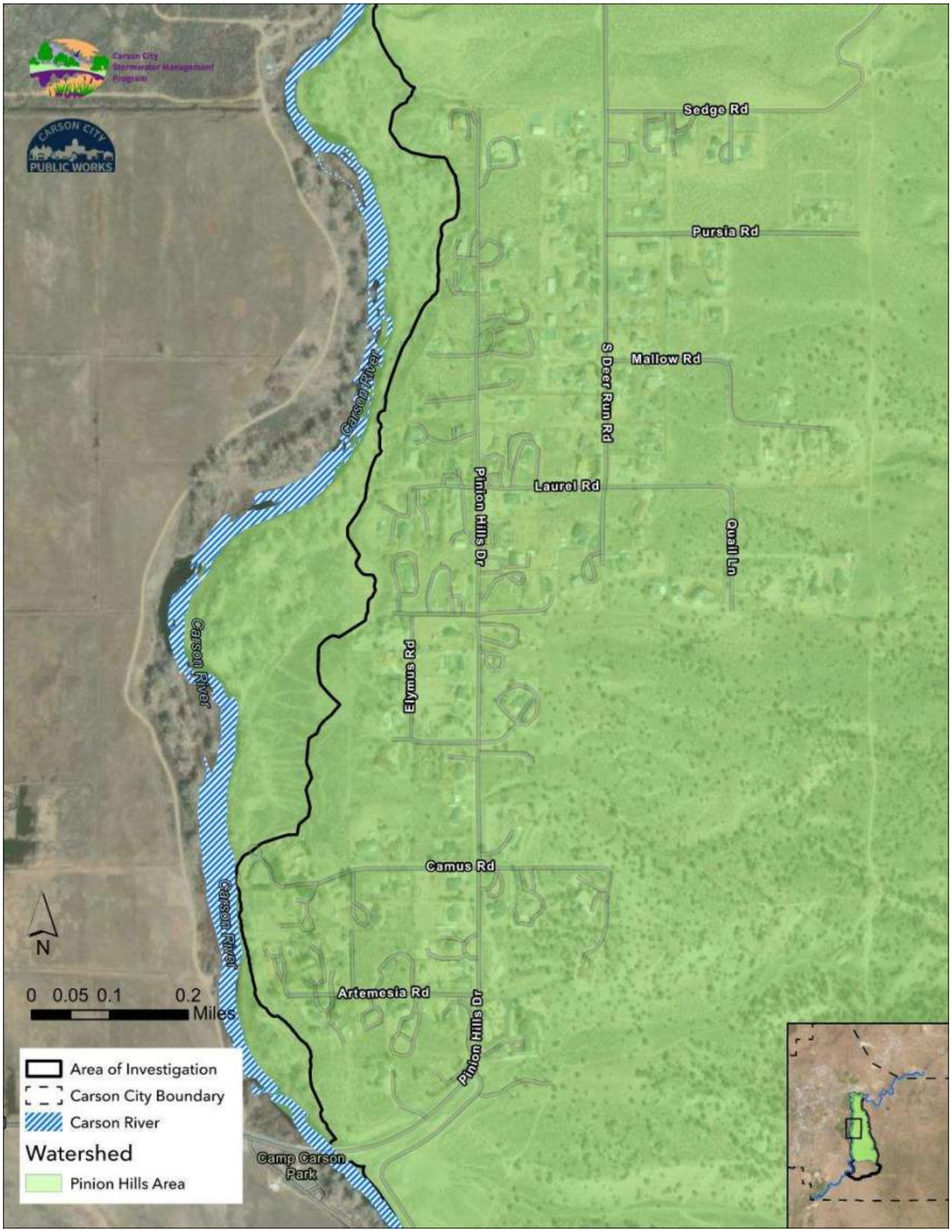


Figure 1-2: Study Area Vicinity Map



1.3 Authority for Study

This project was funded by a FEMA Cooperating Technical Partner (CTP) grant to CWSD who provided the grant and project administration oversight. Carson City serves as the floodplain administration agency for the watershed and determines and authorizes necessary floodplain studies pursuant to the National Flood Insurance Program (NFIP). The hydrologic and the hydraulic analyses for this study were performed by Michael Baker International, Inc. The technical project managers for Carson City were Robb Fellows, PE, and Brianna Greenlaw, PE.

1.4 Data Research and Previous Studies

The data acquisition and research process included coordination with CWSD and Carson City, as well as field review of the watershed and existing facilities. The goal of the research was to identify available data provided in previous drainage-related studies, drainage facility as-built plans, precipitation records and data, news articles, historical storm photos and any other documentation regarding previous flooding events. Information and documents collected during the research are summarized in Table 1-1.

Table 1-1: Data Research and Previous Studies

Title	Author	Date	Study Area
West Carson City Drainage Plan	Kimley-Horn and Associates, Inc.	July 2021	West Carson City
Modernize Hydrologic Prediction Processes by Creating Custom Statewide SSURGO Green and Ampt Parameter Database	Nevada DOT	December 2020	Nevada
North Carson City Drainage Plan	Kimley-Horn and Associates, Inc.	June 2020	Northern Carson City
Hydrology & Hydraulic Report Voltaire and Saliman Restudy & Floodplain Remapping	Cardno, Inc.	March 2019	Voltaire Canyon Creek and Saliman Road Tributary
Eagle Valley A & B Drainage Study	Michael Baker Intl.	January 2016	Eagle Valley
Goni Creek Restudy and Remapping Flood Plain Technical Data Notebook	Michael Baker Intl.	-	Goni Creek
As-Builts	**Plans Prepared**	**Date**	
USDOT Federal Highway Administration – Plans for Proposed NV Flap 100(1) Sierra Vista Lane, Carson City Nevada	Muller Engineering Company	September 2017	Carson City

During a field visit conducted in November 2022, staff identified culverts throughout the area that are not in the as-builts or Carson City stormwater infrastructure database. Approximate pipe sizes and locations were input into the baseline model to evaluate baseline conditions more accurately. Data was provided to Carson City via an updated geodatabase.

1.5 FEMA FLOODPLAIN MAPPING

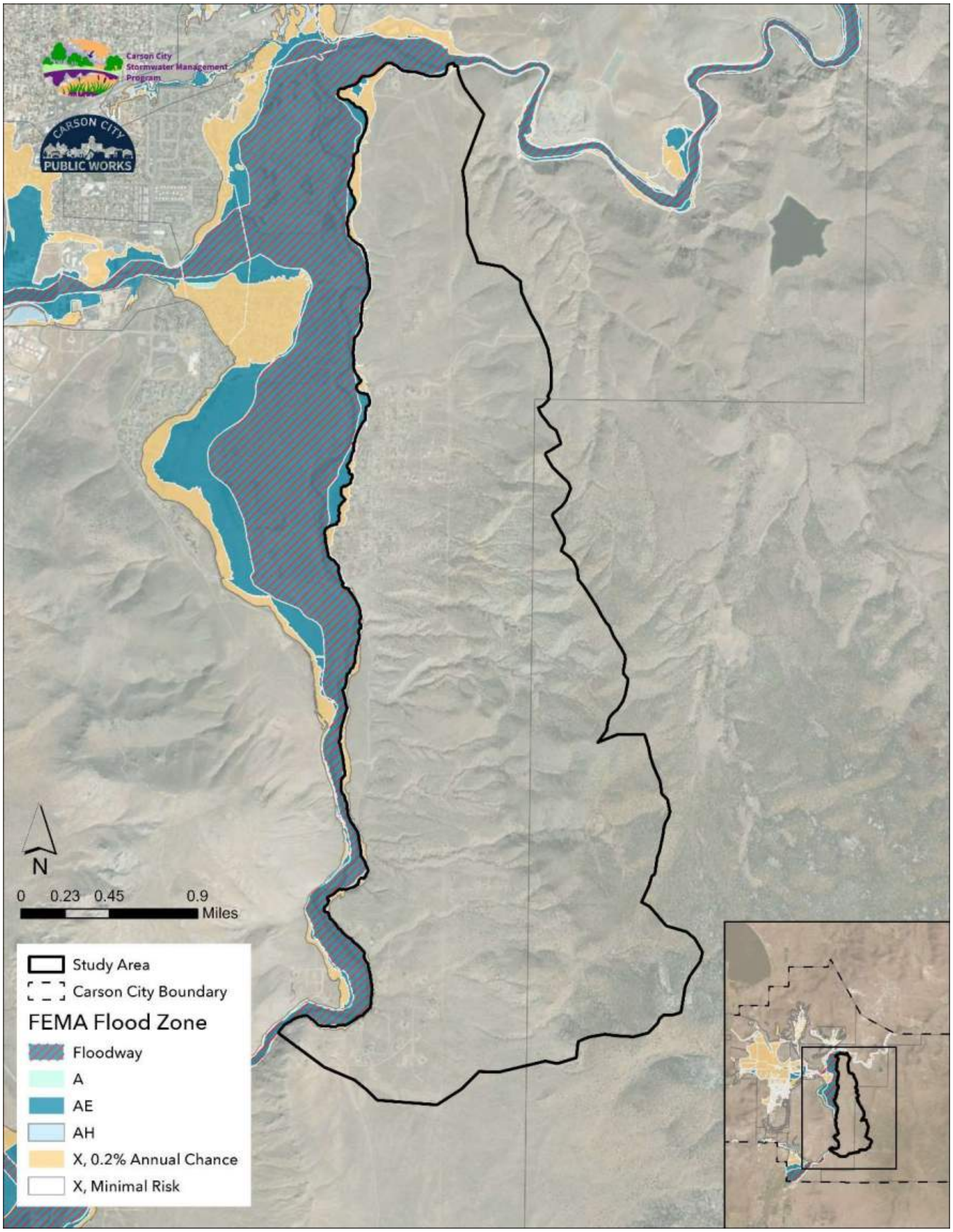
Carson City is a participant in the Federal Emergency Management Agency's (FEMA) NFIP. Communities participating in the NFIP must adopt and enforce minimum floodplain management standards, including identification of flood hazards and flooding risks.

The Pinion Hills watershed has not been mapped as a floodplain. The goal herein is to identify flood hazards for the purpose of improving drainage infrastructure and reduce the flood risk for the residents. Adjacent and downstream from the study area, the effective FEMA floodplain is along the Carson River and includes Zone A and Zone AE. The project area is within the effective flood insurance rate map panels 3200010112F and 3200010114F. The effective maps are dated 06/20/2019. The FEMA flood zones are shown on Figure 1-3. Flood zone descriptions are as follows:

Table 1-2: Flood Zone Areas

Flood Zone	Definition	Flooding Type	Recurrence Interval
A	No base flood elevation provided	Riverine	1% annual chance
AE	Base flood elevation (BFE) provided	Riverine	1% annual chance

Figure 1-3: Effective FEMA Floodplains



2 HYDROLOGIC AND HYDRAULIC MODELING

2.1 METHODOLOGY

The hydrologic and hydraulic modeling for this study was completed using HEC-RAS 6.3 developed by the US Army Corps of Engineers. HEC-RAS 6.3 was selected for this study as it is one of FEMA's approved 2D modeling tools and can be used to estimate spatial and time varying precipitation and infiltration to 2D flow areas and storage areas. HEC-RAS includes the option to model infiltration using Green-Ampt infiltration equations and can solve depth -averaged equations of motion using a grid-based system. This study utilized a rain-on-grid scenario to account for runoff generated in the model domain. Culverts in the study area were modeled using HEC-RAS storage area/2D hydraulic connections. As-built drainage design plans for Sierra Vista Lane dated August 29, 2017 were provided by Carson City and were used to incorporate the location, size, and type of culvert crossings in the study area. Google Earth aerial imagery and site visits were also used to verify culvert locations and add crossings to locations identified in the field.

2.2 TERRAIN

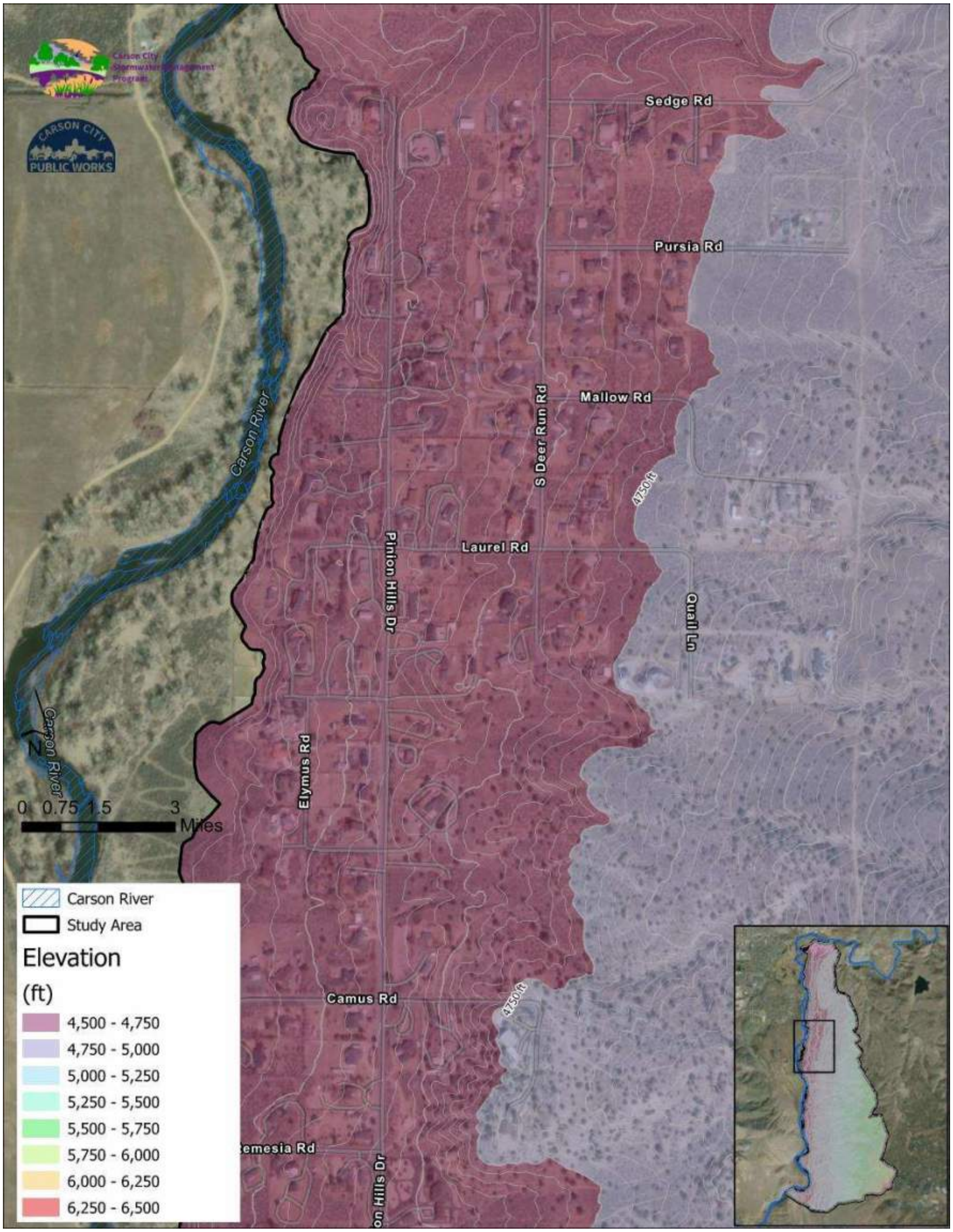
The terrain data used for this study is the U.S. Geological Survey National Topographic Map (USGS 2020). The dataset was used as the primary source of ground elevations obtained in 1,000 meter by 1,000 meter tiles. The spatial reference used for tiles of the 1-meter digital elevation model (DEM) within the conterminous United States is Universal Transverse Mercator in units of meters, and in conformance with the North American Datum of 1983 (NAD83). All bare-earth elevation values were in meters and are referenced to the North American Vertical Datum of 1988 (NAVD88). The DEM dataset was a 1 -meter pixel size GeoTiff format.

The bare-earth terrain dataset was then converted to match the project coordinate system:

- Horizontal Datum: North American Datum (NAD) 1983 State Plane Nevada West FIPS 2703
- Vertical Datum: North American Vertical Datum of 1988 (NAVD88)
- Units: Feet

A topographic contour map of the region is provided in Figure 2-1.

Figure 2-1: Topographic Contour Map



2.3 2D MESH DEVELOPMENT

A 2D flow area polygon was created to represent the watershed boundary of the study area. The flow area defines the boundary for which 2D computations will occur. The computational mesh represents the terrain that models water movement through the study area. The determination of the mesh grid cell size requires a trade-off to ensure a reasonable model run time without compromising accuracy. Small grid cell sizes increase accuracy but require longer computation times, while larger grid sizes compromise accuracy but decrease computation time. Multiple grid sizes were tested to ensure the cells in the model most adequately represented the terrain being studied. A mesh grid was created using 25 ft. by 25 ft. grid cell sizes to achieve this balance.

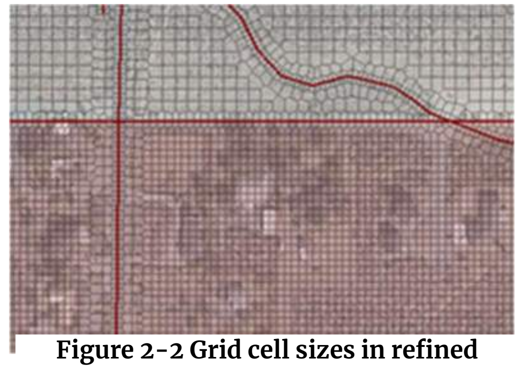


Figure 2-2 Grid cell sizes in refined regions

Mesh refinement regions and breaklines were added in the developed portions of the study area to give a more detailed result. Breaklines were added along features that were deemed significant to flow direction and accumulation, such as crests of roads and thalwegs of canyons, to force the mesh to align the computational cell faces along these features. Cell sizes were reduced to 15 ft. by 15 ft. refinement regions around developed areas, and cell sizes along breaklines were reduced to 10 ft. by 10 ft. Figure 2-2 shows the study area mesh with the varying cell sizes for the refined regions.

An outflow boundary condition was placed along the downstream boundary of the study area along the Carson River floodplain limit. Flow leaving the study area was modeled using normal depth calculations with an assigned friction slope of 0.01 ft./ft. to match the natural terrain.

2.4 PRECIPITATION DEVELOPMENT

Rainfall data depths were obtained from the National Oceanic and Atmospheric Administration Atlas 14 (NOAA 14) Precipitation-Frequency estimates. Three design storms were simulated for this study:

- 10-year, 24-hour
- 25-year, 24-hour
- 100-year, 24-hour

The rainfall distribution was derived from the 24-hour SCS Type II Rainfall distribution. This storm pattern resembles events anticipated in most of the inland U.S. and this study area. The 24-hour durations were chosen to best represent peak flow estimates anticipated in the study area. NOAA 14 precipitation depth estimates were converted into 5-minute incremental depths using the SCS Standard Rainfall Distributions tool provided by the Natural Resources Conservation Service (NRCS). Hydrologic transformation was determined using the HEC-RAS 2D rain-on-grid model. This method was chosen as it simulates the runoff response of the study area to a given rainfall depth evenly distributed across the study region, as opposed to unit hydrograph transformations, which rely on simplified assumptions of inflow hydrographs to specified locations. Table 2-1 shows the applied rainfall depths used to model the selected storm frequencies.

Table 2-1: Precipitation Depths

Precipitation Depths	
Storm Event	**Depth (in)**
10Yr, 24Hr	2.18
25Yr, 24Hr	2.62
100Yr, 24Hr	3.31

2.5 INFILTRATION DEVELOPMENT

2.5.1 Green and Ampt Infiltration Method

This study utilized Green and Ampt (1911) (Green-Ampt) methodology to calculate infiltration using parameters established by the Nevada Department of Transportation (NDOT) in a report titled *Modernize Hydrologic Prediction Processes by Creating Custom Statewide SSURGO Green and Ampt Parameter Database* (December 2020) that developed statewide Green-Ampt parameters. The NDOT parameters were determined by examining the top three inches of the soil horizon and built on Saxton and Rawls (2006) research that provided empirically estimated values for soils based on NRCS soil survey databases— specifically percentages of sand, clay, gravel, organic content, and salinity.

This study refined the infiltration layer further as HEC-RAS 2D only employs Green-Ampt with the Redistribution (GAR) method, which requires the same infiltration parameters as the Green-Ampt method but with the addition of two parameters: pore-size distribution and the residual water content. These additional parameters are to simulate the recovery of the soil moisture profile between rain events (US Army Corps of Engineers 2022).

2.5.2 Soil Data

Soil types were obtained from the NRCS Soil Survey Geographic database (NRCS 2022). Soils for the study area are summarized in Table 2-2. The soil names were cross-referenced with NDOT (2020) to determine a texture classification, which was later used to assign residual soil water content and pore size distribution index parameters. Figure 2-3 shows the distribution of soil types throughout the study area.

Table 2-2: Soil Types in East Carson Study Area

Soil Name	Texture Group	Percentage of Study Area (%)
Carwalker fine sand	Fine sand	1.85
Deven-Rock outcrop complex, 4 to 15 percent slopes	Very cobbly loam	3.46
Greenbrae gravelly sandy loam, 4 to 8 percent slopes	Gravelly sandy loam	3.82
Haybourne sandy loam, 4 to 8 percent slopes	Sandy loam	1.44
Hocar-Rock outcrop complex, 15 to 50 percent slopes	Gravelly loam	11.15
Hocar-Rock outcrop complex, 15 to 30 percent slopes, eroded	Very gravelly loam	30.70
Incy fine sand, 4 to 30 percent slopes	Fine sand	14.64
Jubilee coarse sandy loam, 0 to 2 percent slopes	Coarse sandy loam	2.22
Prey fine sandy loam, gravelly substratum, 4 to 8 percent slopes	Fine sandy loam	8.25
Prey gravelly fine sandy loam, gravelly substratum, 8 to 15 percent slopes	Gravelly fine sandy loam	12.78
Surpass coarse sandy loam, 2 to 4 percent slopes MLRA 26	Coarse sandy loam	1.12
Tarloc-Glenbrook association	Gravelly coarse sandy loam	0.62
Ursine variant very gravelly fine sandy loam, 8 to 15 percent slopes	Very gravelly fine sandy loam	7.18
Riverwash-Water complex	Very gravelly coarse sand	0.47
Ister-Reywat-Koontz association	Very cobbly sandy loam	0.07
Glenbrook-Rock outcrop complex, 8 to 30 percent slopes	Gravelly loamy coarse sand	0.22

2.5.3 Land Use

Land cover/land use was obtained from the National Land Cover Database (NLCD) and used for developing the initial moisture condition, grid roughness (Manning's n-values), and percent imperviousness assumptions. The coverage was verified with Google Earth imagery and adjusted in the developed areas wherever the imagery conflicted with the dataset value.

Buildings were added to the land use dataset based on the aerial imagery to represent flow obstruction areas. Table 2-3 shows the land use types and the corresponding percentage of cover represented in the study area. Figure 2-4 depicts the land uses spatially.

Figure 2-3 Soils

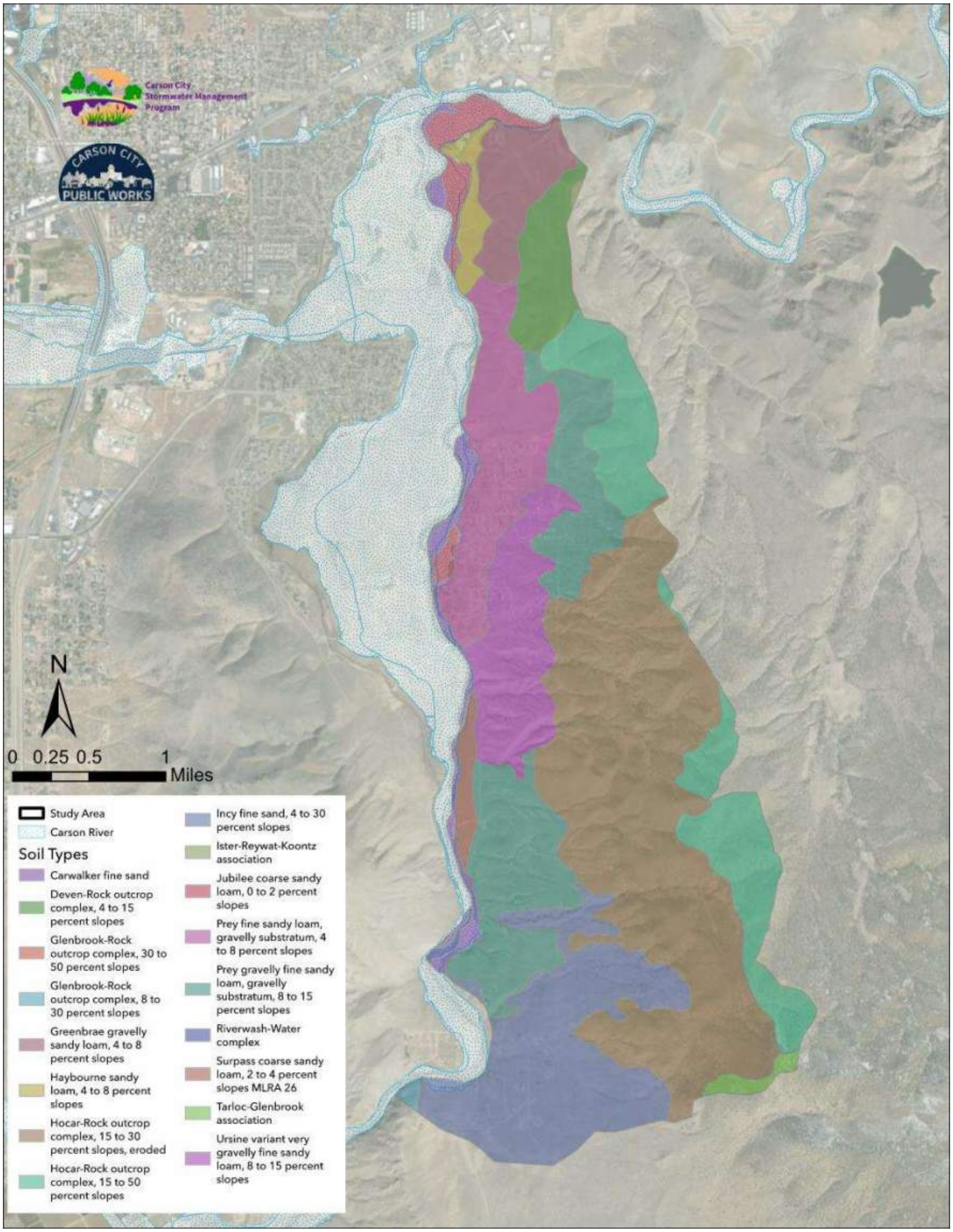


Table 2-3: Land Use

Land Use	Acres	Percentage of Study Area (%)
Buildings	16.8	0.38
Shrub-Scrub	3857.9	87.5
Developed, High Intensity	3.9	0.09
Developed, Medium Intensity	74.8	1.70
Developed, Low Intensity	213.1	4.84
Open Water	41.0	0.93
Emergent Herbaceous Wetlands	1.7	0.04
Developed, Open Space	27.5	0.63
Woody Wetlands	67.5	1.53
Herbaceous	3.9	0.09
Evergreen Forest	97.0	2.20
Total	4405	100

2.5.4 Infiltration Parameters

In determining infiltration rates, Green-Ampt assumes a soil layer with constant hydraulic conductivity, initial water content, and hydraulic head at the wetting front. It assumes that a sharp wetting front exists in the soil column, separating soil with some initial moisture content below the saturated soil above. After an initial soil moisture deficit is satisfied, infiltration occurs at a decaying rate until a saturated hydraulic conductivity rate is reached. Parameters used in the GAR model are as follows:

- Wetting Front Suction (inches)
    - Describes the attraction of water within the void spaces of the soil column
- Saturated Hydraulic Conductivity (inches per hour)
    - Describes the rate at which surface water will enter the soil column at saturation
- Initial Water Content (volumetric ratio)
    - Describes the soil moisture content of the soil. It can be modeled as either:
        - Dry - wilting point
        - Wet - field capacity
- Saturated Soil Water Content (volumetric ratio)
    - Describes a soil's moisture content at saturation
- Residual Soil Water Content (volumetric ratio)
    - Remaining water at high tension
- Pore Size Distribution Index (dimensionless)
    - Relates pore size distribution to soil water retention

NDOT (2020) also recommends that the land use type be considered when assigning an initial soil water content. All land use types were assumed dry (wilting point) for the initial water content. Table 2-4 shows a summary of the Green-Ampt soil infiltration parameters associated with the different soil names. See Appendix A for the comprehensive parameters of soil name and assigned Land Use Initial Moisture Condition used in the model.

Figure 2-4 Land Use

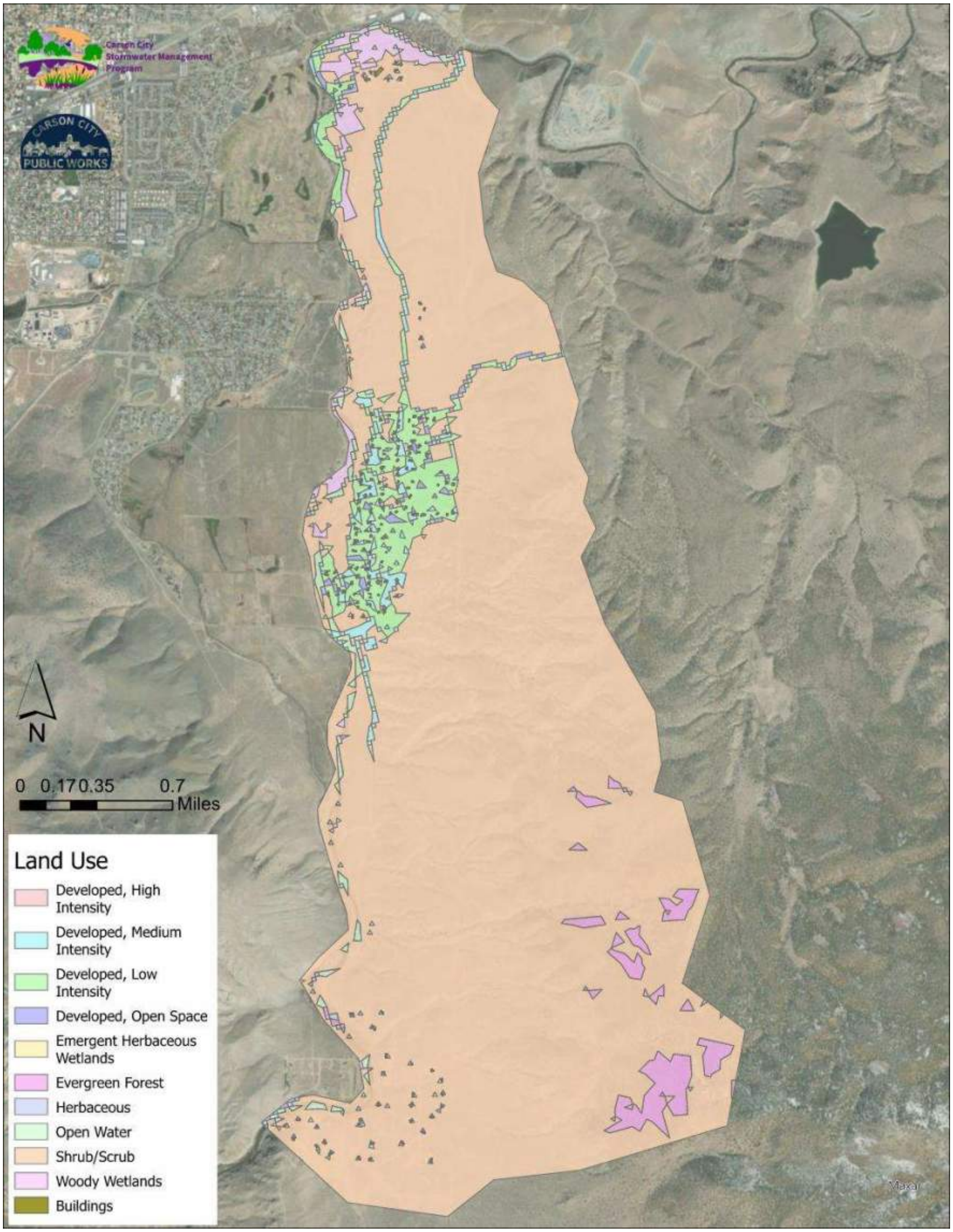


Table 2-4: Green-Ampt Soil Infiltration Parameters

Soil Name	Wetting Front Suction (in)	Saturated Hydraulic Conductivity (in/hr)	Initial Soil Water Content (Dry)	Initial Soil Water Content (Wet)	Saturated Soil Water Content	Residual Soil Water Content	Pore Size Distribution Index
Carwalker fine sand	0.01	1.84	0.024	0.063	0.441	0.02	0.694
Deven-Rock outcrop complex, 4 to 15 percent slopes	17	0.02	0.253	0.385	0.461	0.027	0.117
Glenbrook-Rock outcrop complex, 30 to 50 percent slopes	0.75	0.63	0.081	0.16	0.432	0.035	0.055
Glenbrook-Rock outcrop complex, 8 to 30 percent slopes	1.39	0.56	0.085	0.164	0.43	0.035	0.055
Greenbrae gravelly sandy loam, 4 to 8 percent slopes	4.05	0.48	0.094	0.18	0.415	0.041	0.378
Haybourne sandy loam, 4 to 8 percent slopes	3.34	0.72	0.072	0.161	0.423	0.041	0.378
Hocar-Rock outcrop complex, 15 to 30 percent slopes, eroded	0.091	0.225	0.091	0.1	0.427	0.027	0.117
Hocar-Rock outcrop complex, 15 to 50 percent slopes	11.04	0.16	0.136	0.269	0.438	0.027	0.117
Incy fine sand, 4 to 30 percent slopes	0.01	2	0.014	0.048	0.439	0.02	0.694
Ister-Reywat-Koontz association	5.47	0.43	0.096	0.204	0.43	0.041	0.378
Jubilee coarse sandy loam, 0 to 2 percent slopes	1.21	1.02	0.09	0.191	0.476	0.041	0.378
Prey fine sandy loam, gravelly substratum, 4 to 8 percent slopes	3.6	0.85	0.055	0.148	0.419	0.041	0.378
Prey gravelly fine sandy loam, gravelly substratum, 8 to 15 percent slopes	3.6	0.79	0.055	0.148	0.419	0.041	0.378
Riverwash-Water complex	0.06	0.57	0.086	0.153	0.455	0.02	0.694
Surpass coarse sandy loam, 2 to 4 percent slopes MLRA 26	1.5	0.99	0.066	0.154	0.439	0.041	0.378

Soil Name	Wetting Front Suction (in)	Saturated Hydraulic Conductivity (in/hr)	Initial Soil Water Content (Dry)	Initial Soil Water Content (Wet)	Saturated Soil Water Content	Residual Soil Water Content	Pore Size Distribution Index
Tarloc-Glenbrook association	1.72	1.08	0.045	0.125	0.421	0.041	0.378

2.6 Grid Element Roughness (Manning's Roughness Coefficients)

The different land uses within the model are represented by a distinct Manning's roughness coefficient, or n-value, since changes in land use affects rates of evapotranspiration, interception, and infiltration which impacts the excess precipitation volumes. The percent impervious and n-values on building sites were intentionally set very high to discourage flow from accumulating on a building pad and potentially skewing results. Table 2-5 shows the Manning's n-values and percent impervious numbers used for each land use/land cover type for this analysis per HEC-RAS 2D Modeling User's Manual. Each grid is assigned an average n-value based on the underlying surface conditions developed from the Land Use layer.

Table 2-5: Land Use - Manning's "n" and % Impervious

Land Use	Manning's, N	% Impervious
No Data	0.035	100
Buildings	1.00	100
Evergreen Forest	0.12	0
Shrub-scrub	0.12	0
Developed Open space	0.09	0
Developed low intensity	0.1	35
Developed medium intensity	0.1	65
Open water	0.035	100
Developed high intensity	0.15	90
Woody wetlands	0.07	50
Grassland-herbaceous	0.07	0

2.7 Hydraulic Structures

Information about existing hydraulic structures was determined from as-builts provided by the Carson City as well as during Michael Baker's site visits to the area. A hydraulic structure database was compiled and imported to the geometry as storage area/2D connections. Hydraulic structures inside of a 2D flow area were modeled by defining the station elevation data for the structure that is the same or higher than natural ground using the weir/embankment editors. The culvert editor requires users to input culvert lengths, entrance and exit loss coefficients and manning's n, and the upstream and downstream invert elevations. Flows overtopping the structures were modeled using the weir equation. A weir flow coefficient of 3.0 was used as recommended for flow over elevated roadways. Table 2-6 summarizes the culvert information included in the model and Figure 2-5 shows the culverts modeled as part of this study, most of which are along Sierra Vista Lane.

Table 2-6 Culvert Data Table

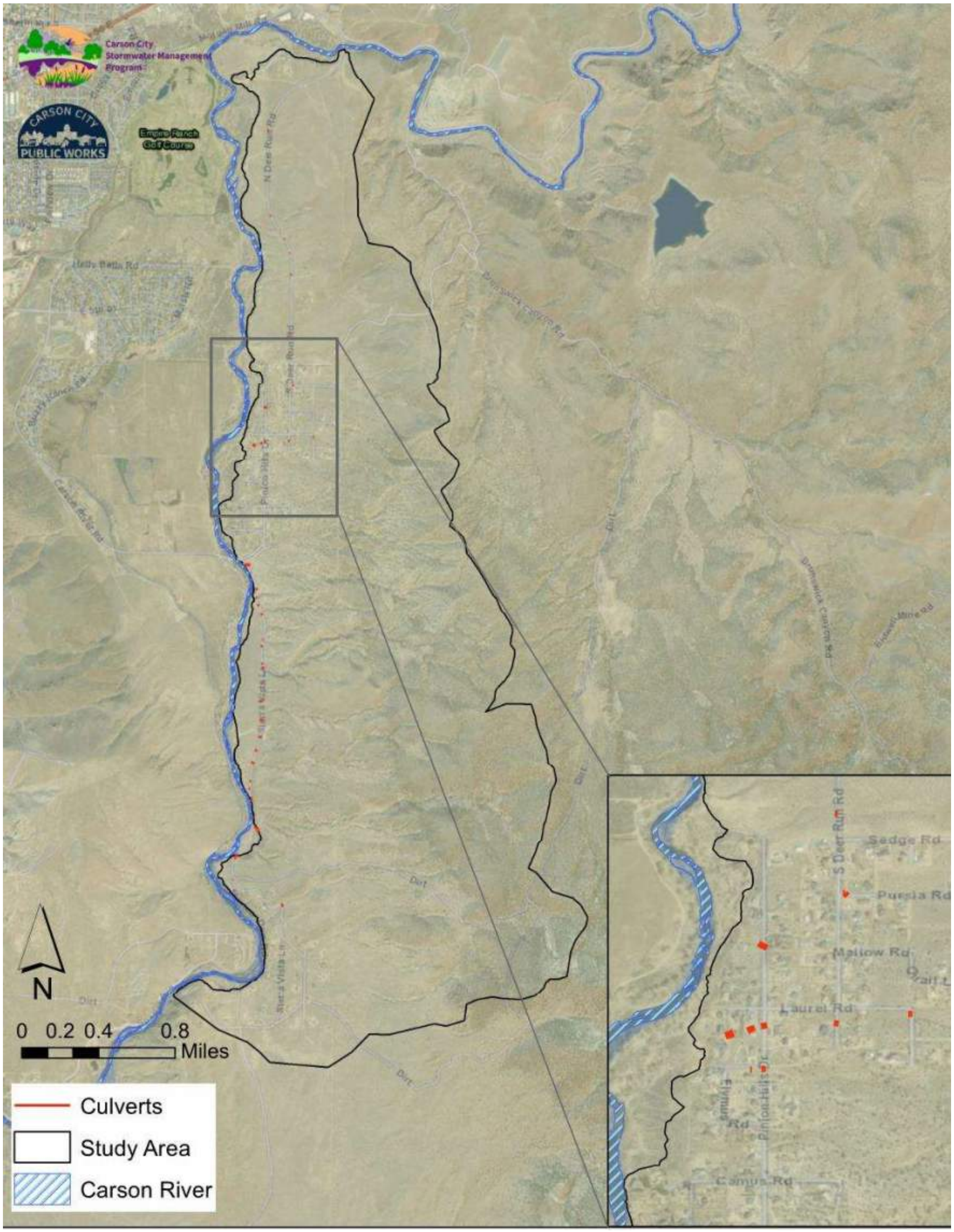
Label	Type	Shape	Length (ft)	Number of Barrels	Diameter (in)
DR 1	RCP	Circular	60	1	24
DR 2	RCP	Circular	40	1	24
DR 3	RCP	Circular	40	1	24
DR 4	RCP	Circular	25	1	18
DR 5	RCP	Circular	24	1	24
DR 6	RCP	Circular	31	1	18
DR 7	RCP	Circular	26	1	24
DR 8	RCP	Circular	22	1	24
DR 9	RCP	Circular	42	1	15
Laurel_24s	RCP	Circular	65	2	24
Laurel_36	RCP	Circular	60	1	36
Sierra Ln	RCP	Circular	150	1	36
SierraLn1	CMP	Circular	155	1	18
SL 1	CMP	Circular	61	1	18
SL 1.1	CMP	Circular	26	1	18
SL2.1	RCP	Circular	43	1	30
SL 3	RCP	Ellipse	67	1	30, 18
SL 3.1	CMP	Circular	33	1	18
SL 4.1	CMP	Circular	60	1	18
SL5.1	CMP	Circular	43	1	18
SL 5	RCP	Circular	40	1	48
SL6	HERCP	Ellipse	92	1	30, 18
SL7	RCP	Ellipse	90	1	30, 19
SL8	RCP	Ellipse	79	1	30, 18
SL9	CMP	Circular	71	1	18
SL10	CMP	Circular	106	1	18
SL11	RCP	Circular	51	1	48
SL 13	RCP	Circular	45	1	24
SL 14	RCP	Circular	33	1	24
SL 18	CMP	Circular	43	1	18
SL 19	CMP	Circular	68	1	24
SL 19.1	HERCP	Ellipse	117	1	60, 38

To compute friction losses in the culvert barrel, Manning's roughness coefficients were entered for each culvert type. The values for the various pipes modeled are summarized in Table 2-7. The Manning’s n-value represents closed conduits flowing partly full.

Table 2-7: Loss Coefficients for Culverts and Manning’s Roughness Coefficient

Pipe Material	Manning’s n	Entrance Loss Coefficient	Exit Loss Coefficient
Reinforced Concrete Pipe (RCP)	0.013	0.7	0.7
Corrugated Metal Pipe (CMP)	0.021	0.9	0.9
Polyvinyl Chloride (PVC)	0.010	0.7	0.7
Horizontal Elliptical Reinforced Concrete Pipe (HERCP)	0.013	0.7	0.7

Figure 2-5: Existing Culverts



2.8 MODEL CONTROL PARAMETERS

The model simulated the unsteady flow regime and Shallow Water Equations (SWE) Eulerian-Lagrangian Method (ELM). SWE-ELM was selected as the model is attempting to predict detailed velocities and water surface elevations, which are often influenced by hydraulic structures. The model uses a variable time step based on the Courant number which monitors the residence time within a cell. The variable time step ultimately improves the stability of the model when using SWE-ELM equations.

The existing conditions model used the following parameters for the 10-, 25-, and 100-year runs:

- Computation Interval: 15 second
- Equation Set: SWE-ELM
- Maximum Courant: 1
- Minimum Courant: 0.2
- Courant Methodology: Velocity/Length

3 MODELING RESULTS

3.1 QUERYING MODEL RESULTS

To query model results, the "profile tool" in HEC-RAS Mapper was used to determine peak flows and volume accumulated at key locations. Key locations were identified where large flow concentrations were shown in the model grid results. These areas were flagged for a ground-truthing site visit to validate the model results. These were discussed with Carson City and CWSD to identify sites for potential mitigation analysis. Table 3-1 illustrates the peak flows and volumes for each designated drainage area's existing conditions for the 10-year, 25-year, and 100-year HEC-RAS model results.

Table 3-1: Peak Flow and Volume Results

Basin ID	10-yr, 24-hour		25-yr, 24-hour		100-yr, 24-hour	
	Peak Flow (cfs)	Volume (ac-ft)	Peak Flow (cfs)	Volume (ac-ft)	Peak Flow (cfs)	Volume (ac-ft)
1	45.1	4.4	66.9	6.7	101.5	10.2
2	37.6	5.8	50.3	8.5	62.0	18.5
3	6.5	1.9	8.3	2.4	18.7	3.6
4	17.2	2.9	30.1	4.2	56.8	6.9
5	22.4	3.0	31.3	4	82.5	8.5
6	34.4	3.9	45.5	5.1	81.4	8.5
7	23.1	2.9	56.5	5.7	117.7	10.9
8	41.6	4.7	102.8	9.8	212.0	18.8
9	37.0	5.0	92.4	9.7	268.0	24.4
10	42.3	3.8	68.2	5.9	101.2	8.7
11	38.0	5.0	134.1	13.1	292.9	26.3
12	4.1	0.5	37.4	3.7	104.4	9.4
13	9.6	1.3	48.2	5.7	203.8	18.8
14	31.4	3.9	39.1	4.6	188.2	20.8
15	33.0	4.7	49.0	6.2	74.0	13.6
16	6.6	1.7	12.9	2.6	38.3	7.8

cfs = cubic feet per second
ac-ft = acre-feet

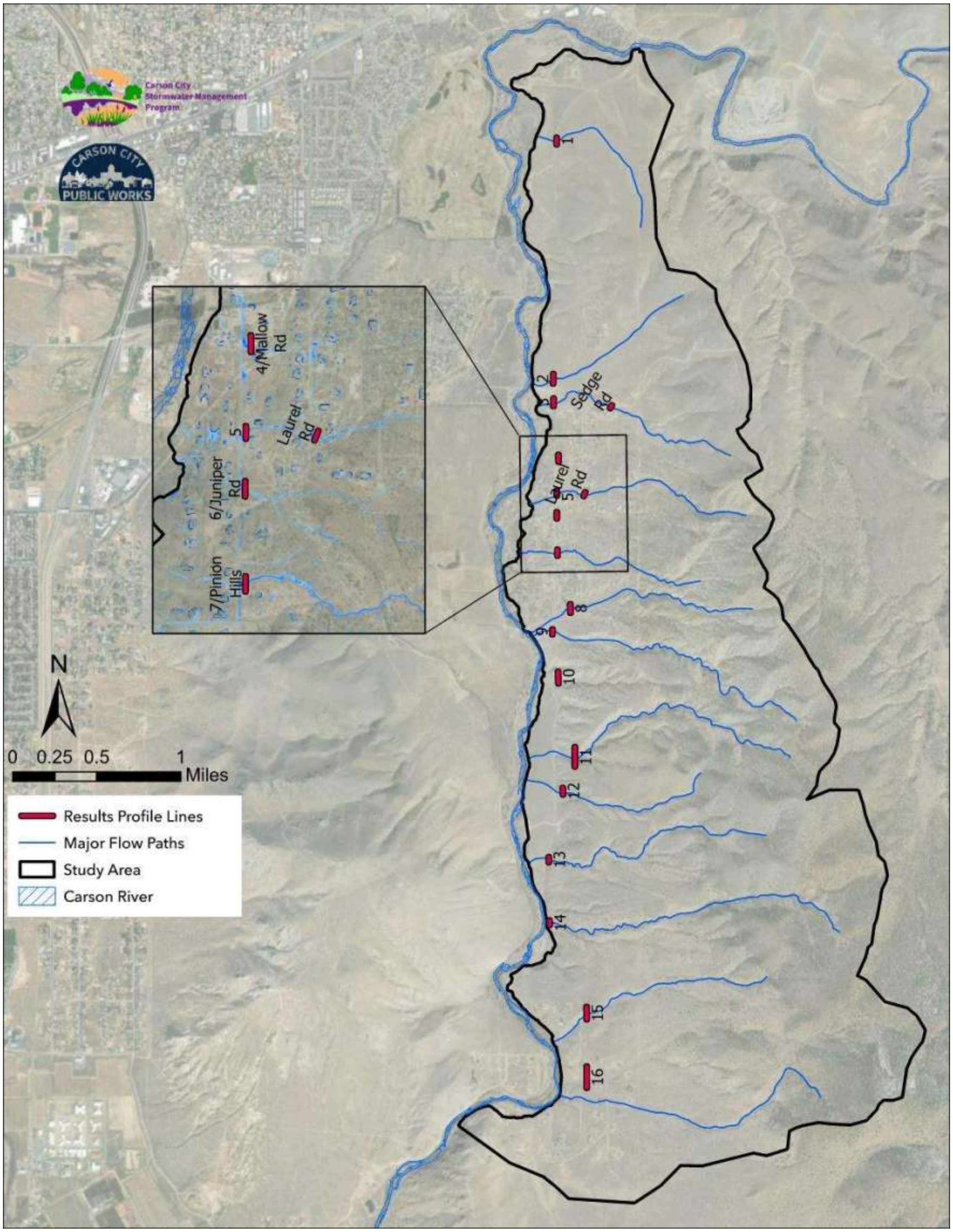
Table 3-2 summarizes the total runoff volume per storm event for each major street identified as an area of interest for potential improvements. Locations of the profiles are shown on Figure 3-1.

Table 3-2: Peak Flow and Volume Results at Areas of Interest

Street ID	10-yr, 24-hour		25-yr, 24-hour		100-yr, 24-hour	
	Peak Flow (cfs)	Volume (ac-ft)	Peak Flow (cfs)	Volume (ac-ft)	Peak Flow (cfs)	Volume (ac-ft)
Sedge Road	33.7	3.4	67.7	6.4	125.8	11.3
Mallow	17.1	2.8	30.1	4.2	56.8	6.9
Laurel	24.8	3.0	31.3	3.8	98.9	9.6
Juniper	34.4	3.9	45.5	5.1	81.4	8.5
Pinion Hills	23.1	2.8	56.5	5.7	117.7	10.9

cfs = cubic feet per second
ac-ft = acre-feet

Figure 3-1: Locations of Profile Lines for Results



3.2 Depth and Velocity Results

Figures 3-2 through 3-7 depict the existing conditions flow depth and velocity results for the study area.

Figure 3-2: Existing Conditions 10-year, 24-hour Flow Depths

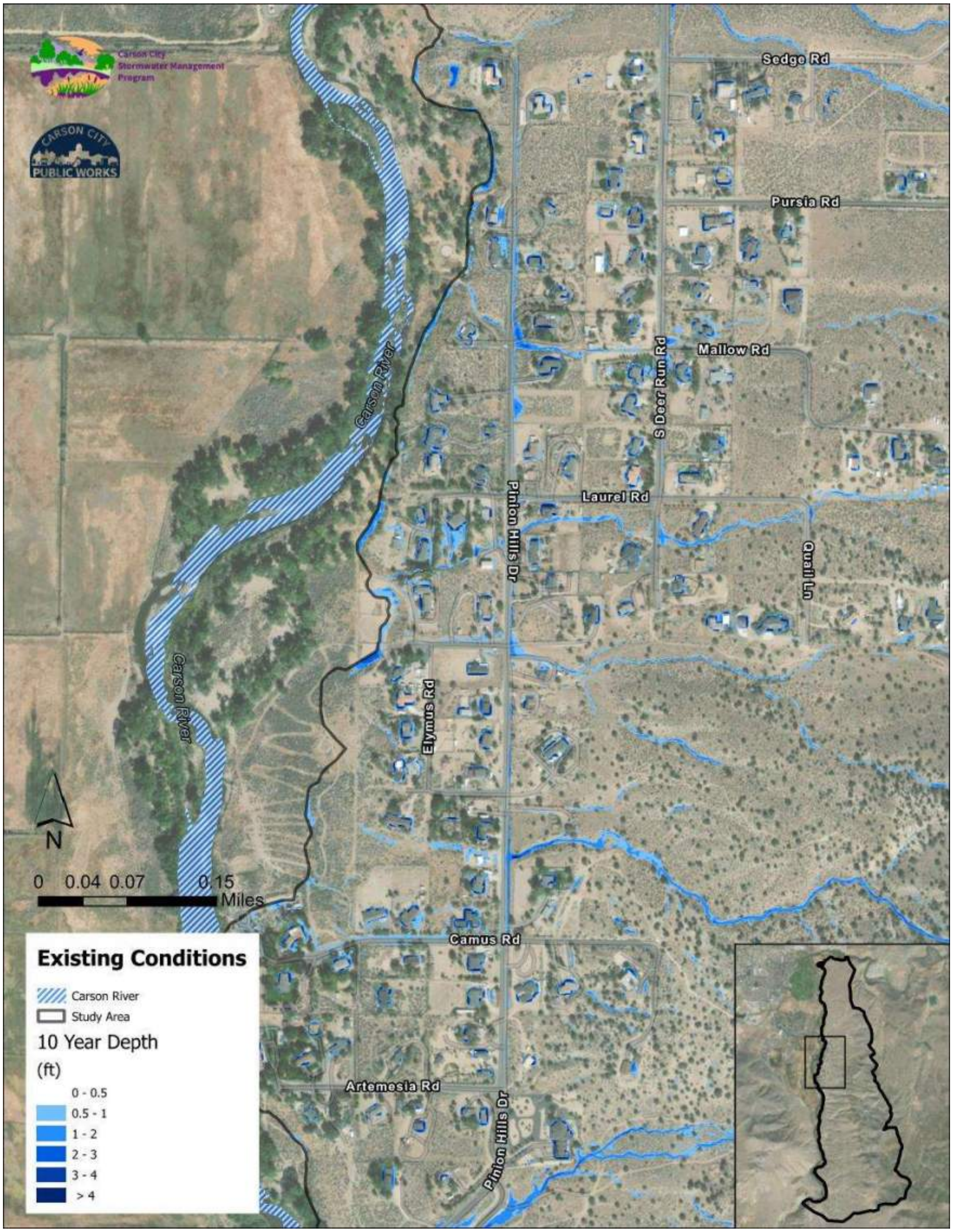


Figure 3-3: Existing Conditions 10-year Velocities

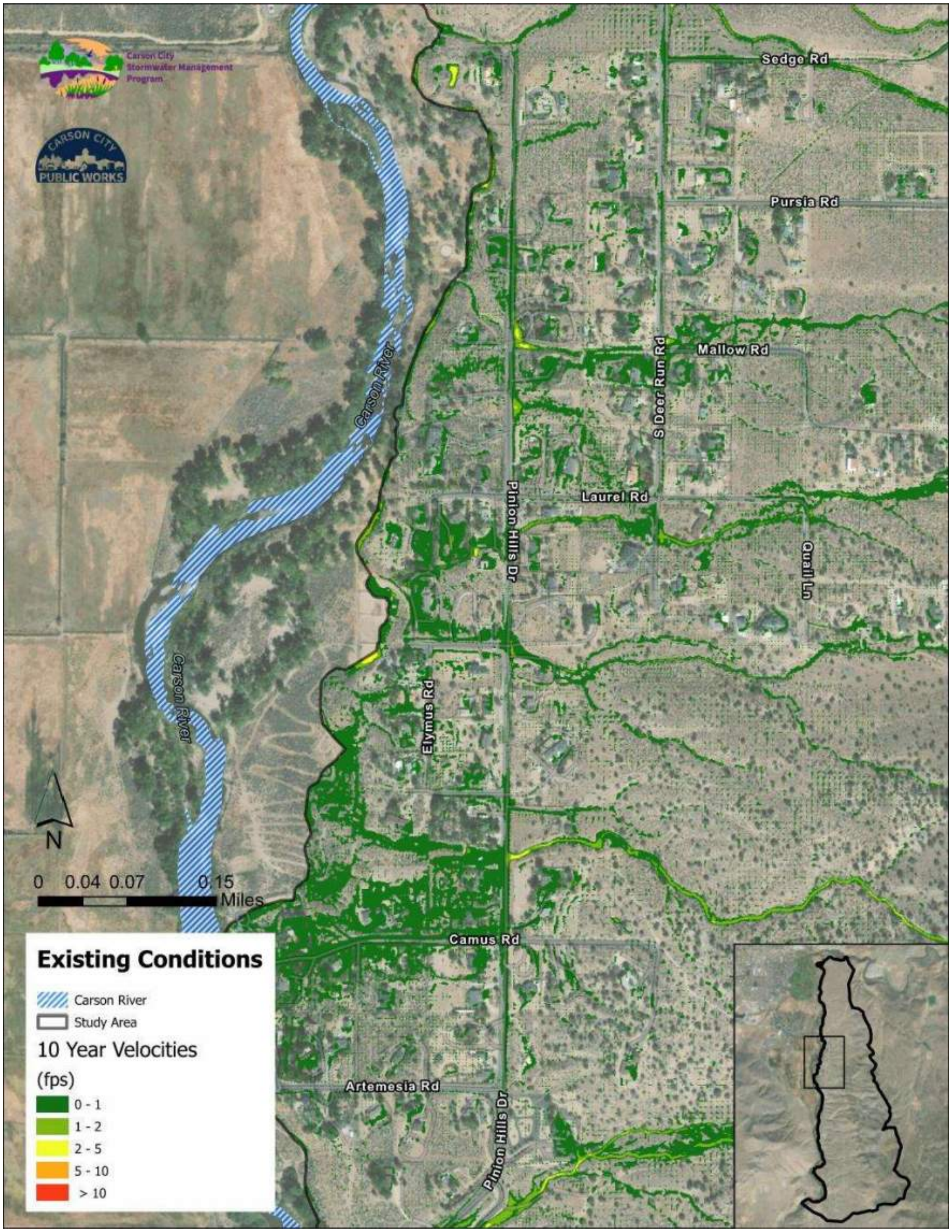


Figure 3-4: Existing Conditions 25-year, 24-hour Flow Depths

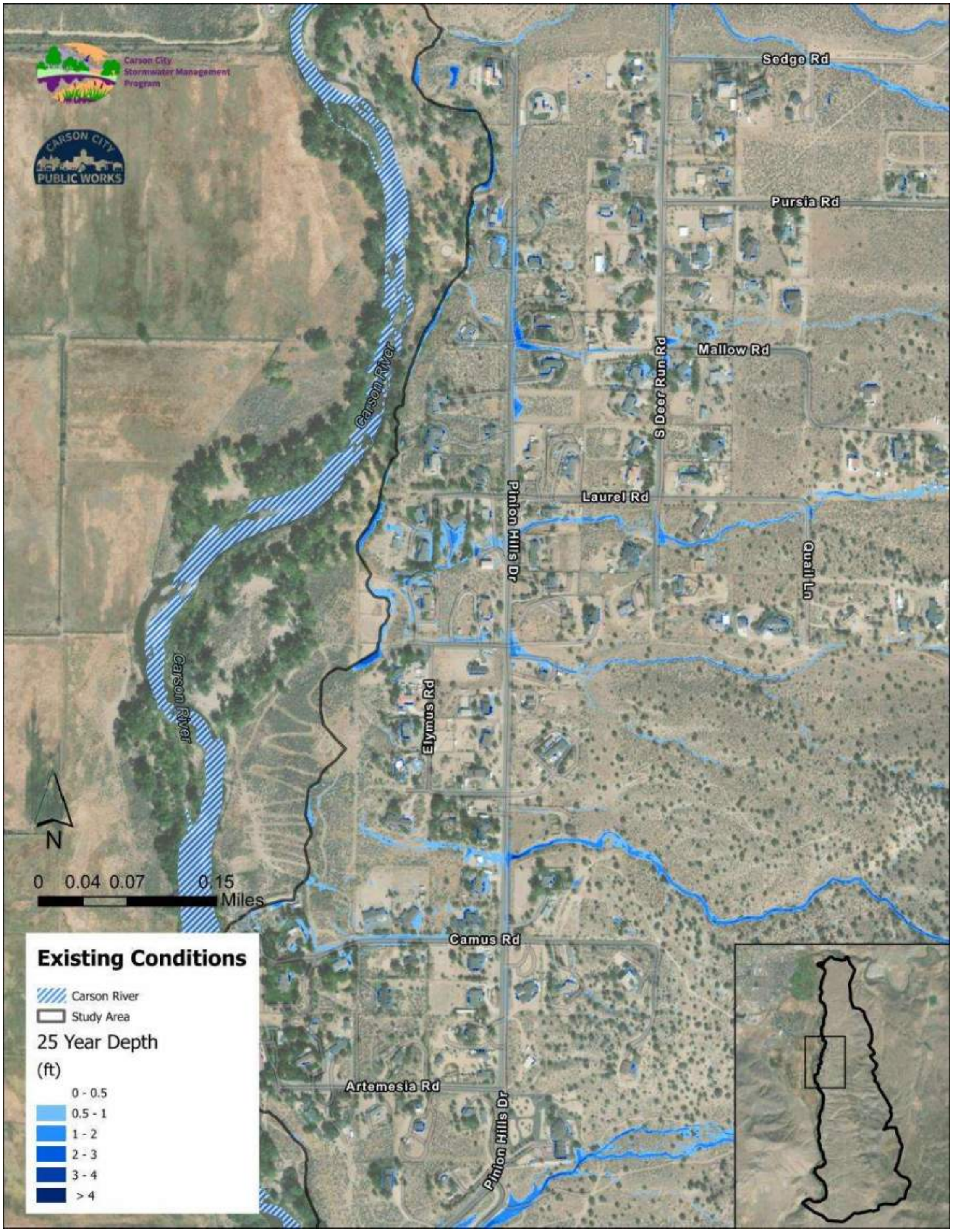


Figure 3-5: Existing Conditions 25-year Velocities

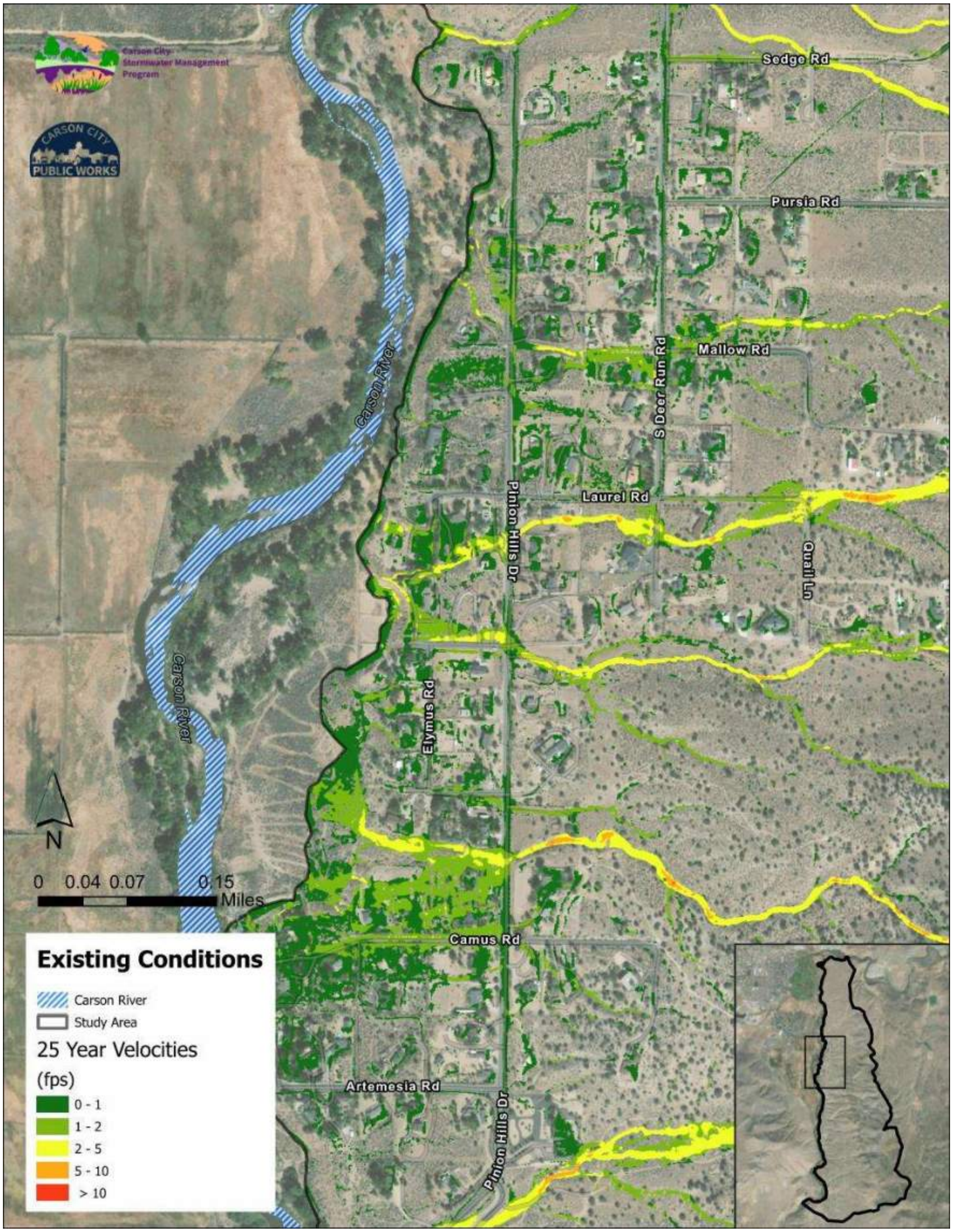
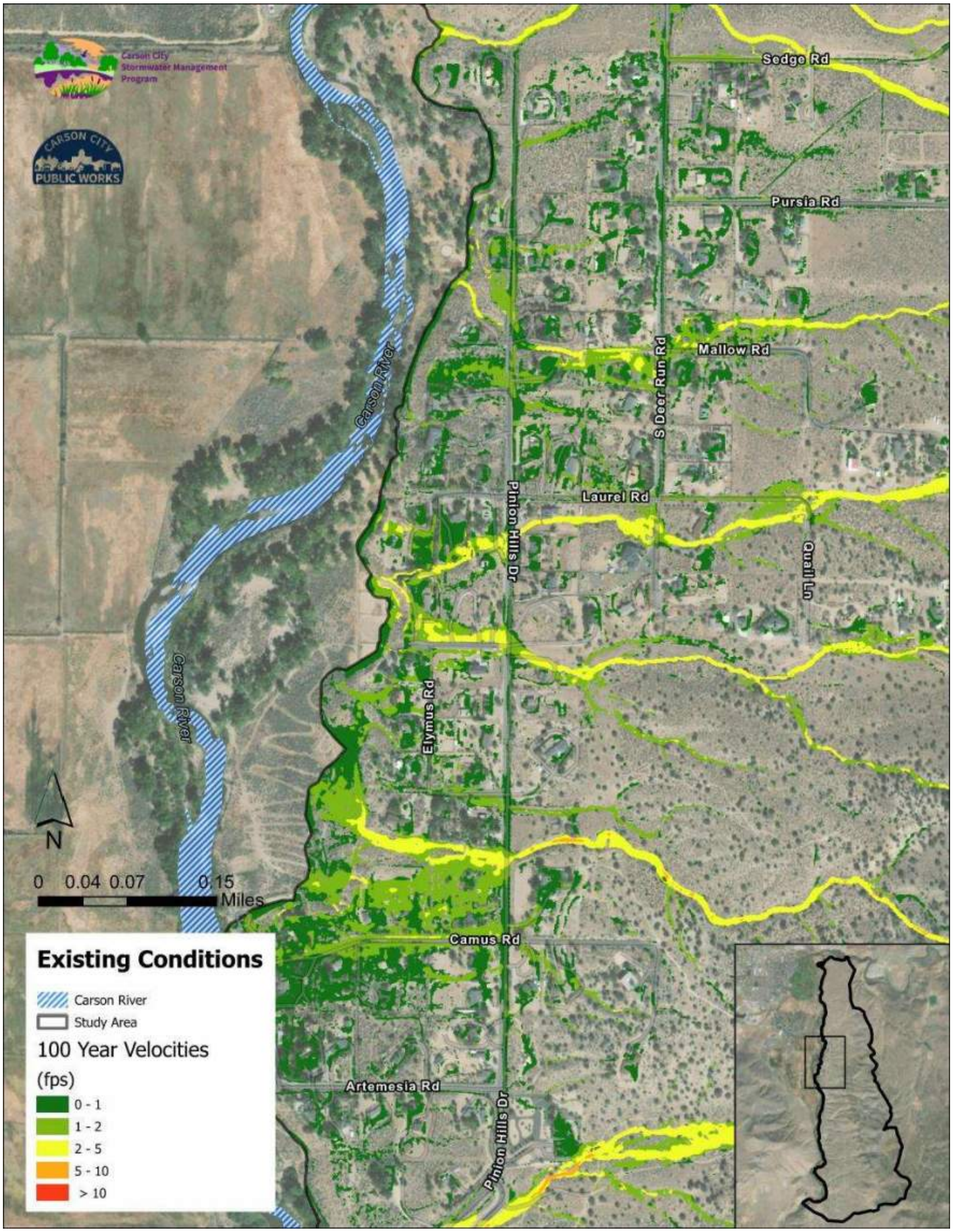


Figure 3-6: Existing Conditions 100-year, 24-hour Flow Depths

Figure 3-7: Existing Conditions 100-year Velocities



3.3 MODEL VALIDATION

The study area lacks sufficient gage data to perform a robust hydrologic calibration; therefore, the parameter development relied on previously completed studies in the Carson River watershed to compare results and adjust the approach as needed. Initially, model results yielded lower than expected runoff volumes. Rather than using HEC-RAS default parameters based on soil texture, the specific parameters developed for the NDOT study based on soil type were incorporated into the infiltration calculations. Further refining was done for the initial moisture content assumptions and land use layer to arrive at more reasonable runoff volumes. Areas with high percentages of shrub-scrub and sandy loam soils were expected to have higher infiltration and lower runoff. Table 3-3 shows the total rainfall volume, runoff volume, and the percentage lost to infiltration for the final existing conditions model run.

Table 3-3: Runoff Volumes Comparison in East Carson Watershed

Storm Event	Total Precipitation Volume (ac-ft)	Excess Precipitation Volume (ac-ft)	Percentage of Runoff (%)
10-year	711	118	17%
25-year	860	183.1	21%
100-year	1203	283.5	24%

ac-ft = acre-feet

The closest USGS gage downstream of the study area is at the North Deer Run Road crossing with the Carson River (USGS 10311000). While data is available for discharge and gage height, the contributing watershed is much greater than the individual washes flowing over the study area and is upstream of their confluence with the Carson River. Validation was completed using USGS Regression Equations for the Eastern Sierras Region 5 (USGS 1997). Since there was not any official FEMA hydrology in this area finding a representative site for calibration was not feasible. Brunswick Canyon was examined but its soil types and population densities were too different to be used as a representative watershed.

Sixteen (16) separate subbasins were delineated for the main washes that traverse the study area. Figure 3-8 shows the subbasin delineations. A regression peak flow was calculated using the required exponents for average elevation, latitude, and acreage per subbasin and for the three studied events. The average standard error of prediction is between 84 percent and 95 percent for the regression equations.

Figure 3-8: USGS Regression Basins

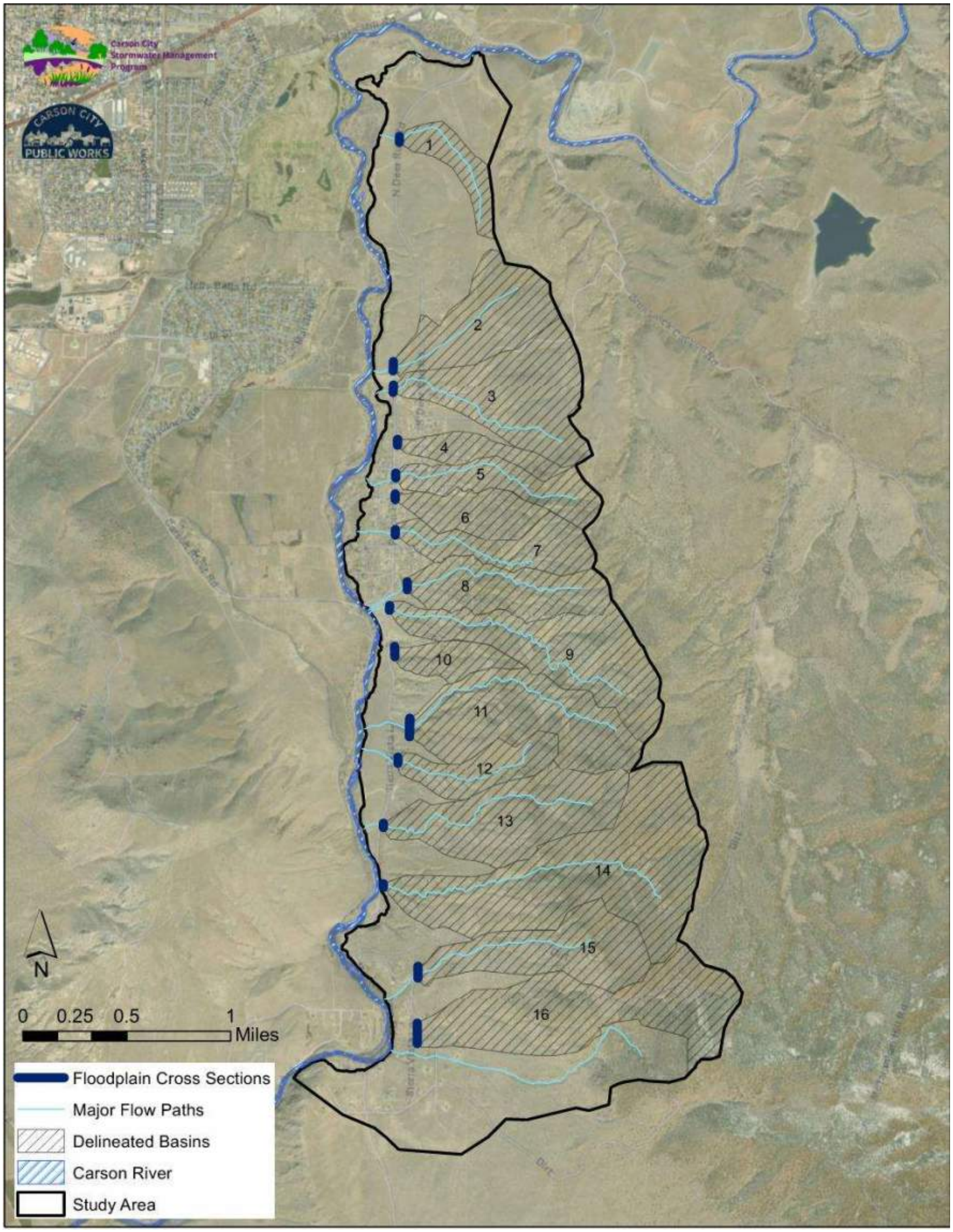


Table 3-4 lists the calculated peak flows from the existing conditions model compared to the USGS Regression calculated values. In general, the model predicted higher peak flow rates than the USGS regression equations. However, the developed regions (drainage areas 4 through 7) tended to track closer to the USGS estimates. The subbasins in the study area are very steep and narrow resulting in a relatively shorter lag time, which would result in higher peak flows than a regression model would predict. Without specific calibration data it can be challenging to fit parameters, so the modeling effort focused on a representative but conservative approach.

A site visit was conducted in November 2022 to verify model results on the ground. Additional culverts were identified on private property and were added to the model. The residents informed the Michael Baker team that the 36-inch culvert crossing at Laurel Road and Pinion Hills Drive overtops frequently (drainage area 5). Simple capacity calculations for that culvert indicate overtopping at approximately 60 cfs, which is higher than the USGS regression predicted for a 10-year event. A video was also shared with the Michael Baker team showing flooding in this location that further indicates USGS may be underpredicting the more frequent events.

Table 3-4: Peak Flow Comparison to USGS Regression

Drainage Area	Area (sq mi)	USGS 100-yr	Existing 100-yr	USGS 25-yr	Existing 25-yr	USGS 10-yr	Existing 10-yr
1	0.09	56.2	101.5	16.7	66.9	6.0	45.1
2	0.24	121.1	62.0	37.5	50.3	13.6	37.6
3	0.33	148.6	18.7	47.4	8.3	17.7	6.5
4	0.08	51.6	56.8	15.5	30.1	5.6	17.2
5	0.15	79.0	82.5	24.9	31.3	9.3	22.4
6	0.12	69.8	81.4	21.4	45.5	7.8	34.4
7	0.16	79.0	117.7	25.3	56.5	9.6	23.1
8	0.21	98.0	212.0	31.7	102.8	12.1	41.6
9	0.35	133.6	268.0	46.1	92.4	18.6	37.0
10	0.08	48.7	101.2	14.7	68.2	5.3	42.3
11	0.35	138.6	292.9	47.0	134.1	18.7	38.0
12	0.13	68.4	104.4	21.9	37.4	8.3	4.1
13	0.33	131.9	203.8	44.6	48.2	17.7	9.6
14	0.64	203.7	188.2	73.3	39.1	30.6	31.4
15	0.26	102.7	74.0	35.4	49.0	14.3	33.0
16	0.46	150.6	38.3	54.9	12.9	23.3	6.6

A HEC-HMS model was developed to check the HEC-RAS hydrology results. The soil, land cover, and drainage area attributes were included in the HEC-HMS model and run with default settings for routing and the Green-Ampt infiltration parameters. The results matched the HEC-RAS volumes to a 1% difference in the 10-year, 2% difference in the 25-year, and 16% difference for the 100-year return period. HEC-HMS results are included in Appendix A.

4 FLOOD HAZARD CLASSIFICATION

4.1 PURPOSE

Flood hazards were defined based on existing flow depths and velocities from the HEC-RAS results and presented to Carson City's Stormwater Program Manager and residents for validation. The model results showed that the hilly terrain to the east of the Pinion Hills neighborhood had developed multiple washes that flow through private property and/or onto roads. The City's Stormwater Program Manager wanted to identify areas where mitigation solutions could be proposed to the residents to reduce the risk of property damage and maintain safe access to roads. Flood hazards were identified based on the existing flow depths and velocities from the model output and denoted as "areas of interest" (AOIs) as shown in Figure 4-1. Conceptual alternatives were developed for the AOIs but ultimately three of the four AOIs were recommended for further design development.

4.2 AREAS OF INTEREST

A site visit was conducted in November 2022 to verify the model results on the ground and discuss potential solutions with the residents and the City's Stormwater Program Manager. Four AOIs were identified based on model results and discussed with Carson City and CWSD on noted problem areas during past storms. These designated areas were 1) Sedge Road, 2) Laurel Road, 3) Juniper Road, and 4) Pinion Hills Drive. The selected sites were then studied in greater detail to prepare conceptual alternatives to reduce flooding risk. One alternative (Alternative A) was presented for Sedge Road, and two alternatives (Alternatives A and B) were presented for the rest of the AOIs. The 10-year storm event was targeted for design solutions; however, other events were evaluated if the potential to provide greater protection was feasible. Figure 4-2 through Figure 4-5 describe the design solutions in more detail.

4.2.1 Sedge Road

Runoff from the hills to the east flows onto Sedge Road, creating road access and travel issues affecting approximately four properties. There is no existing infrastructure on Sedge Road and the absence of a culvert and curb and gutter causes flow to travel down the street toward S. Deer Run Road. During a site visit, the Carson City's Stormwater Program Manager noted that flow from the hillside causes flooding to Pursia Road as reported by residents. Additionally, there is a Bureau of Land Management (BLM) trail access point at the end of Sedge Road that leads uphill to another wash crossing. There is currently no drainage infrastructure at this crossing, so runoff either backs up onto the easement access or overtops the trail.

One of the improvements proposed to Sedge Road (Alternative A) was to construct culverts and diversion channels to route flows away from property or access roads. The existing drainage pattern under Sedge Road would be facilitated by two 36-inch culverts underneath the road. Minor grading would be performed to shorten the length of the required culverts. Runoff flowing onto Pursia Road would be diverted with a channel constructed between property lines and the BLM easement trail. The channel would end where it joins with the existing wash. At the trail access, a 30-inch culvert was proposed to connect the wash downstream without overtopping the trail. These proposed improvements were sized to contain the 25-year event.

This alternative may require additional coordination both with BLM for access to the easement and with the affected property owners. Additional alternatives (e.g., divert flows north from Sedge Road on BLM parcels) were evaluated but ultimately determined infeasible due to topography. Figure 4-2 shows a schematic of the proposed Sedge Road improvement.

4.2.2 Laurel Road

The existing wash near Laurel Road affects residents from Quail Lane to its outfall at the Carson River. The wash flows directly through private property and is at high risk for damaging structures. There is a large headcut at the end of Laurel Road where flows enter a steep drop before reaching the floodplain of the Carson River. The residents have constructed several culverts through their properties to direct the flow away from their homes but are encouraged to know that this study provides Carson City a more comprehensive solution.

Laurel Road Headcut at Downstream Discharge

Originally the proposed alternative (Alternative A) was to construct a channel in the right-of-way to divert flows from private property. A site visit concluded that diversion channels would be infeasible as there is limited room for grading in the right-of-way. The residents that responded to the outreach were not opposed to improvements on private property, and suggested enhancement of an existing natural swale to a more defined ditch through 5607 Laurel Road to facilitate the existing drainage path toward the Carson River. The City Streets Supervisor that responds to storm event noted that the drainages in this area are prone to clogging with sand and large rocks that would require access to maintain. This information led to proposing another alternative (Alternative B) that includes piping flows from the South Deer Run Road crossing via storm drain in the Laurel Road right-of-way to discharge at the end of the street. Channel stabilization features at the downstream discharge point such as gabion or rock drop structure would be required to repair and stabilize the headcut (shown in photo above) that could reach the property line at 5555 Laurel Road at the discharge point. The improvements for this alternative were sized for the 25-year event and would benefit four structures. Figure 4-3 shows a schematic of the proposed Laurel Road improvements.

4.2.3 Juniper Road

Runoff from the hills to the east flows through private property risking property damage along Juniper Road. When the flows reach the intersection of Juniper Road and Pinion Hills Drive from the east, ponding occurs at 1901 Pinion Hills Drive. A canyon with steep slopes on both sides is upstream of that point and confines the flows onto the property. Downstream, flow overtops the existing culvert at Pinion Hills Drive and flows through the properties on the north side of Juniper Road before reaching an existing horse corral that connects to the Carson River floodplain.

One proposed improvement (Alternative A) was to construct a culvert to direct flow northwest across Juniper Road into a diversion channel in the right-of-way. The flow ponding at 1901 Pinion Hills Drive would be conveyed across Pinion Hills with a culvert to the right-of-way along the north side of Juniper Road. A series of culverts would be installed beneath the private driveways and a channel excavated to direct flow to the western end of Juniper Road before discharging to the Carson River floodplain. Alternatively, to avoid exposing more soil to erosion using ditches, flows would be piped across Pinion Hills Drive to the north side of Juniper Road and discharge in the right-of-way at the end of the street (Alternative B). Approximately five structures would benefit from the improvements. The proposed alternatives were sized for the 10-year event and are shown in Figure 4-4.

4.2.4 Pinion Hills Drive

Runoff from the hills to the east overtops Pinion Hills Drive as flow meets Pinion Hills Drive and ponds at an existing drainage ditch since there is no existing culvert for the runoff to pass through. The first alternative (Alternative A) would construct culverts to route flow under Pinion Hills Drive, and outlet downstream at 5569 Elymus Road to a natural drainage path before reaching the Carson River but is on private property. Although the owner at 5569 Elymus did not appear to be opposed to this alternative since the existing drainage currently flows through the property, there are two additional parcels downstream that could potentially see increases in flows from the proposed culverts and the owners were not available for comment.

The other proposed alternative (Alternative B) was to facilitate flows across Pinion Hills Drive using culverts and diversion channels to direct flow in the right-of-way north towards Elymus Drive before discharging at the end of the street. A site visit confirmed ample space for a drainage in the right-of-way and the higher flow rates seen at this location would require the additional capacity a diversion channel can afford. Approximately five structures would benefit from the improvements by reducing flooding downstream. The proposed alternatives were sized for the 25-year event and are shown in Figure 4-5.

Figure 4-1: Areas of Interest (AOIs)

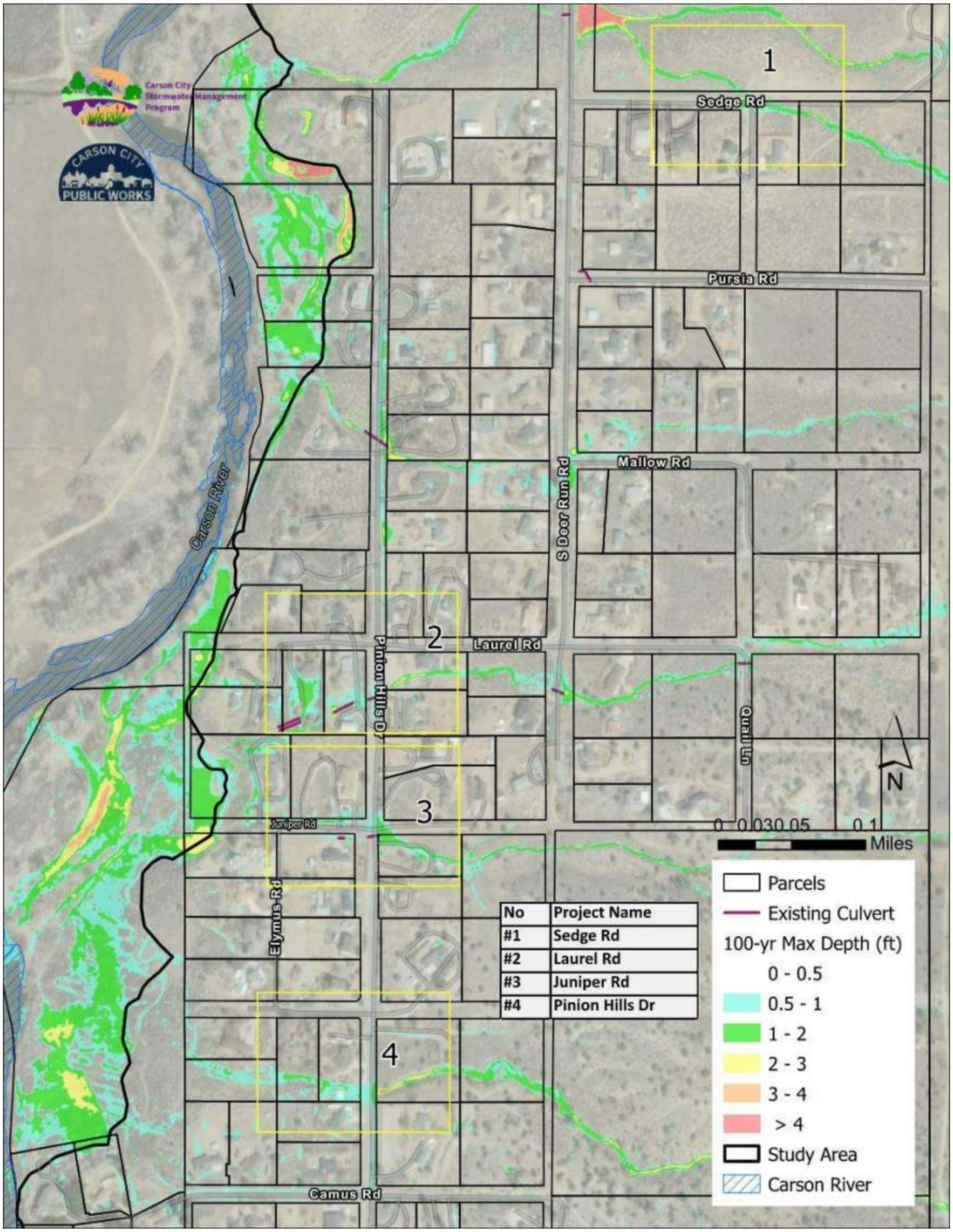


Figure 4-2: Sedge Road Potential Improvements

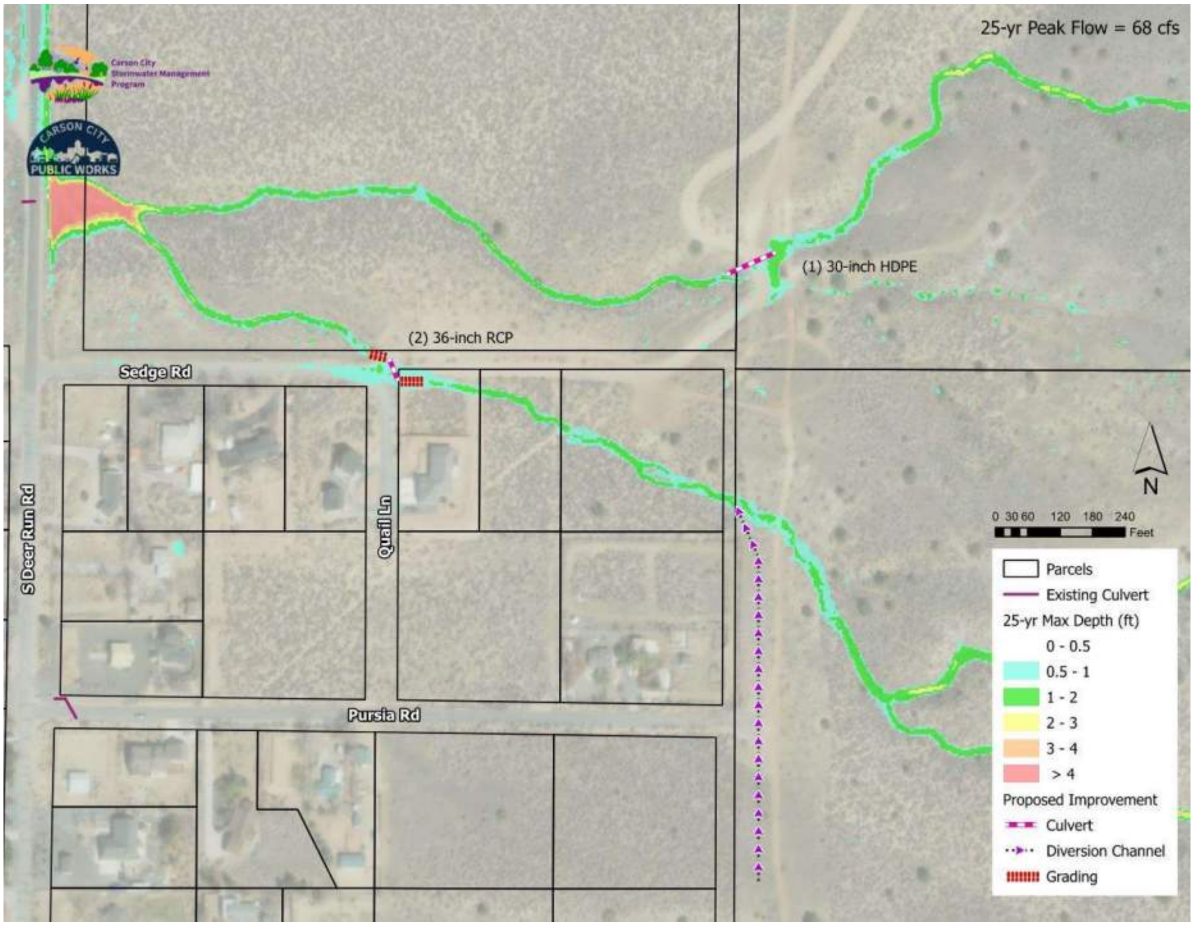


Figure 4-3: Laurel Road Potential Improvements

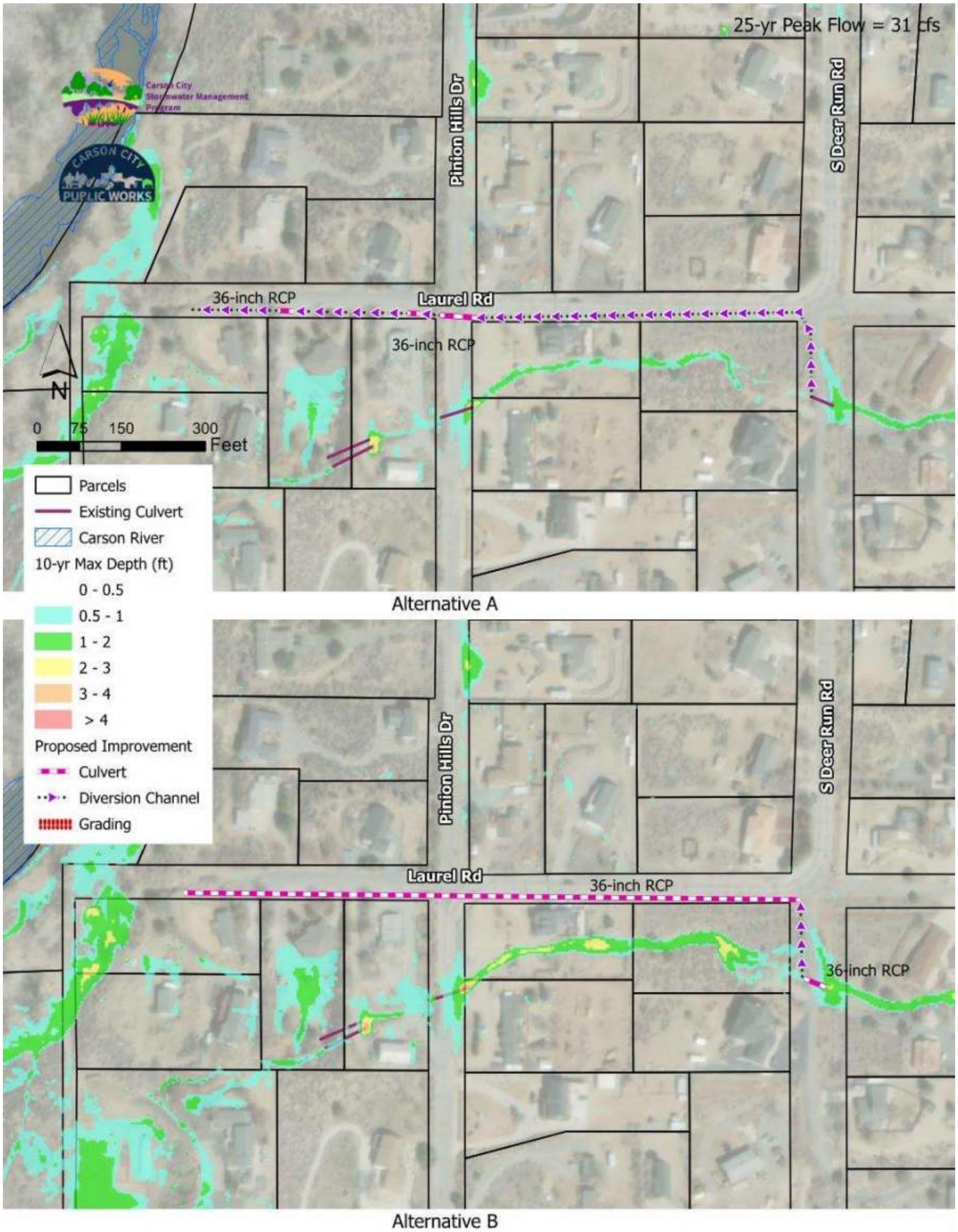


Figure 4-4: Juniper Road Potential Improvements

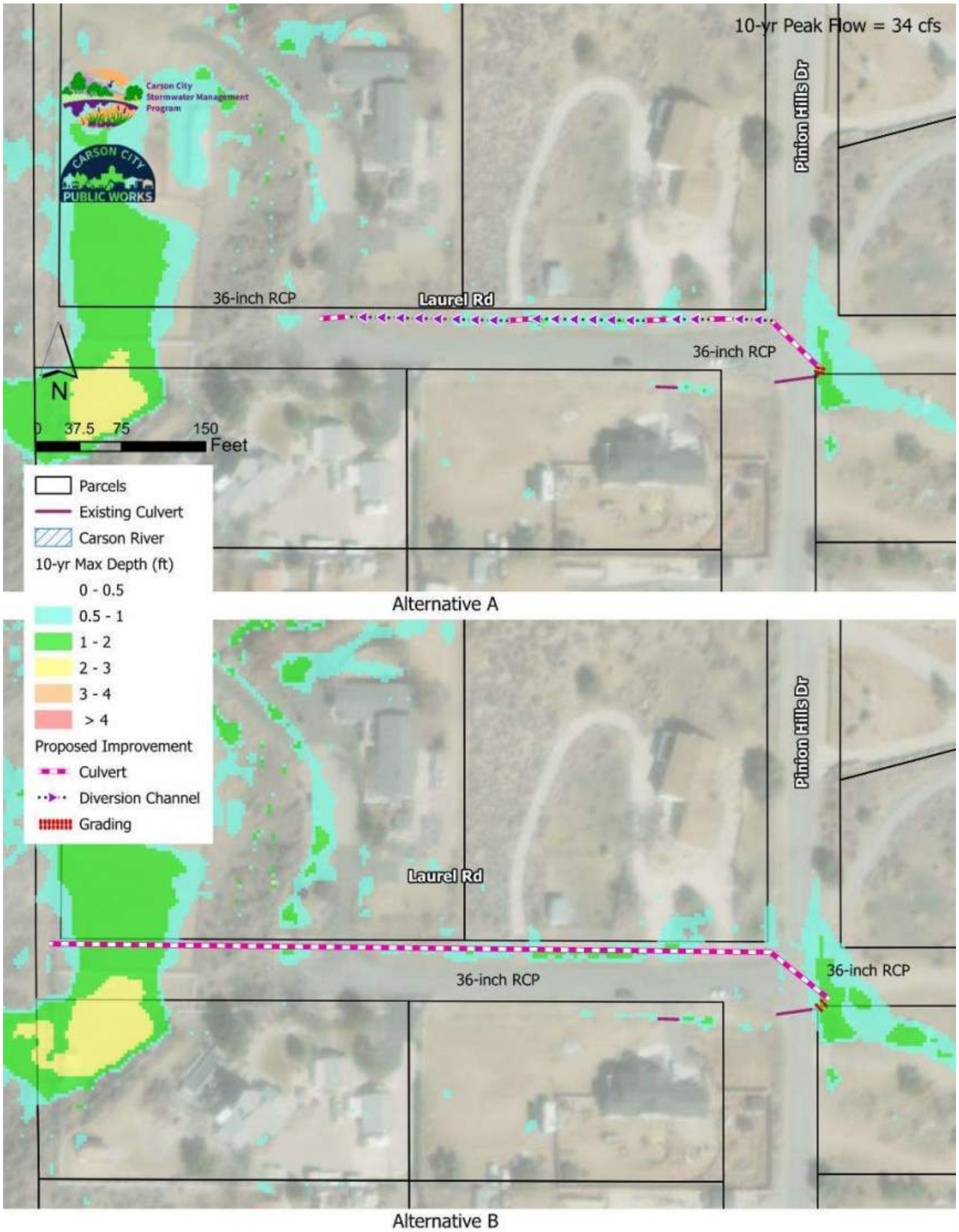
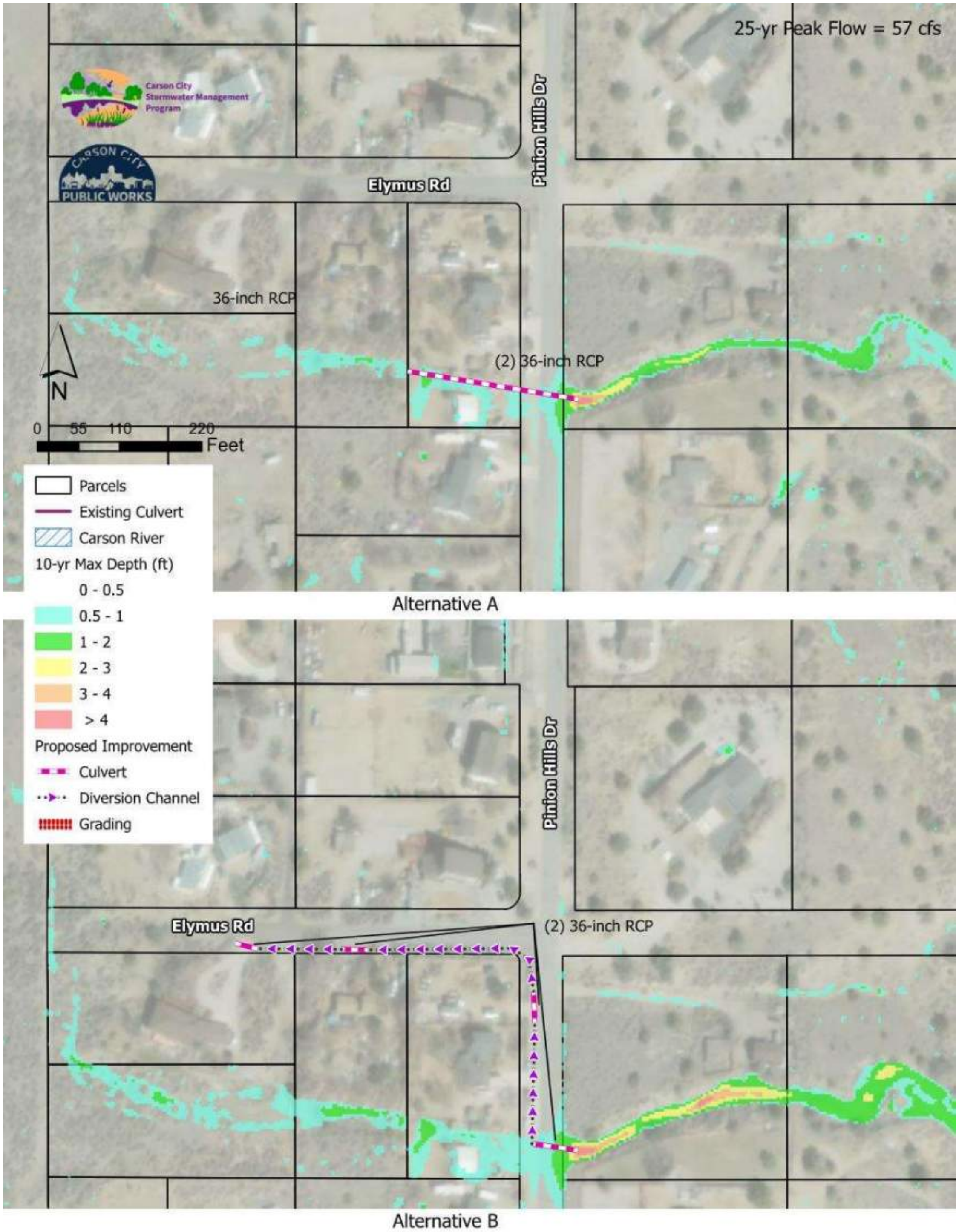


Figure 4-5: Pinion Hills Drive Potential Improvements



4.3 Resident Outreach

Public input and support were critical to alternative selection in this study. The project area consists of approximately 125 residents, and outreach events were held to acquire feedback and input. Initially, events were held at a public meeting location, but little turnout resulted in a transition to more focused outreach and door-to-door conversations with those directly affected by the proposed improvements.

Figure 4-6: First Public Outreach Mailer

Initial community outreach consisted of a resident outreach information meeting on June 21, 2022, at the Sheriff's office in Carson City (Figure 4-6). Residents were invited to the meeting through a postcard mailing on June 1, 2022. This meeting was held in person as well as online through Zoom. Residents were invited to discuss flooding or drainage concerns in person at the meeting, or through an interactive website that allows users to input comments or concerns, and locations of flooding (https://arcg.is/i94b90). A short presentation was made by Robb Fellows (Carson City Stormwater Department.) to introduce the project and its partners (CWSD and Michael Baker). An overview of the project was given by Michael Baker staff members, which included location, drainage problem history, and examples of solutions in other regions of Carson City with similar drainage problems. Poster boards or "story maps" were prepared to engage the residents. Residents were encouraged to input detail into the interactive map, and to reach out to Carson City's stormwater department with any other concerns. One resident attended in person, and three other people attended through the online option. Carson City staff received comments from one person attending via phone.

A second impromptu outreach was made in conjunction with the state's Flood Awareness Week outreach activities on November 16, 2022. Residents were mailed a postcard informing them of the outreach event being held in Carson City, and additionally that Carson City and Michael Baker staff would be visiting the neighborhood that day to speak to any residents and seek input (Figure 4-7). Michael Baker staff were able to interact with residents along Laurel Road. Residents willingly discussed drainage problems with staff and encouraged improving drainage.

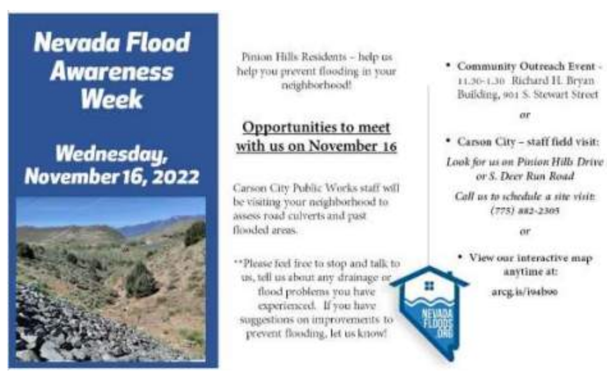


Figure 4-7. Second Public Outreach Mailer

A third outreach activity notified residents of the identified drainage issues and associated mitigation alternatives and invited residents to meet with staff to discuss the alternatives. Even more residents were engaged and provided valuable input that narrowed the project down to the final four alternatives (Figure 4-8). The invitation provided residents with a link to a brief online survey to report any drainage issues, which two residents responded to.

The final outreach activity will be a presentation to the CWSD Board of Supervisors and Carson City Board of Supervisors in May 2023. Residents will be invited to attend the presentation either virtually or in-person to see the results of the study and the selected alternatives. Full copies of mailings and survey questionnaires are included in Appendix B.

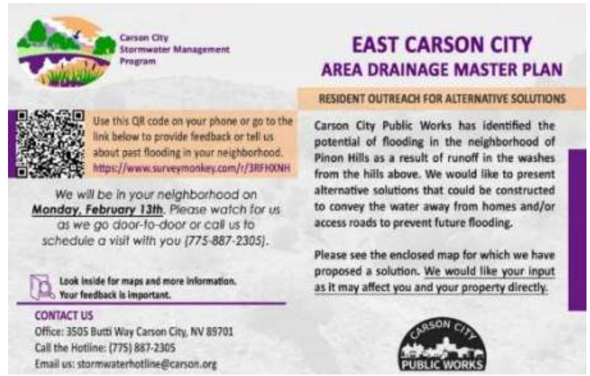


Figure 4-8. Third Public Outreach Mailer

4.4 Flood Reduction Benefits

The Carson City Stormwater Program Manager expressed interest in applying for FEMA grants to help fund these projects. Damage assessments were conducted for the AOIs and quantified in dollars mitigated to assist with future grant applications and help prioritize cost-effective solutions. FEMA's Hazus software was used to estimate potential damages to buildings and roads during the 10-, 25-, and 100-year events. The Hazus results were used to quantify the benefit value from avoided flood damages that the proposed alternatives would address. Copies of the Hazus reports for the 10-, 25-, and 100-year simulations are included in Appendix C. The flood-depth grids generated by the HEC-RAS baseline model were analyzed against a general building stock database for the state of Nevada. The default damage curves were used for all structure types. Table 4-1 presents the results of the analysis.

Table 4-1: Summary of Potential Flood Reduction Benefits

AOI ID	Level of Protection	No. of Structures Benefited in Design Storm	Potential Damages ($)*
Sedge Rd Alt. A	25	0	-
Laurel Rd Alt. A	25	4	995,500
Laurel Rd Alt. B	25	4	995,500
Juniper Rd Alt. A	10	5	1,244,300
Juniper Rd Alt. B	10	5	1,244,300
Pinion Hills Alt. A	25	5	1,244,300
Pinion Hills Alt. B	25	5	1,244,300

*Avg Building Cost = $249,896

4.5 Selection of Proposed Improvements

The proposed improvements were prioritized by the Carson City and Michael Baker staff members based on input from residents and city maintenance crews, while feasibility, and cost effectiveness helped weight decisions. Ultimately the projects were prioritized and ranked into a list based on items that the Carson City would like completed in the future, with or without grant funding. Table

4-2 ranks the projects in order of importance to the residents but also notes which could have benefits other than structure protection. Benefits to traffic and road access were evaluated as well as the potential for BLM to have better access to their facilities.

Ultimately three projects were recommended for conceptual design:

1. Pinion Hills – Alternative B
2. Laurel Road – Alternative B
3. Juniper Road – Alternative B

Table 4-2: Prioritization of Alternatives

Ranking	AOI ID	Project's Initial Cost	Max. Probable BCR	Public Support	Impacts Traffic	Impacts Other Agencies
1	Pinion Hills Alt. B	$647,000	1.9	Yes	Yes	No
2	Laurel Rd Alt. B	$924,000	1.1	Yes	No	No
3	Juniper Rd Alt. B	$589,000	2.1	Yes	No	No
4	Sedge Rd Alt. A	$205,000	0.0	Yes	No	No
5	Pinion Hills Alt. A	$292,000	4.3	Yes	No	No
6	Juniper Rd Alt. A	$219,000	5.7	Yes	Yes	No
7	Laurel Rd Alt. A	$279,000	3.6	Yes	Yes	Yes

AOI = Area of Interest; BCR = Benefit Cost Ratio

5 PROPOSED CONDITIONS RESULTS

5.1 METHODOLOGY

The proposed conditions were modeled based on the selected alternative concepts i.e., addition of culverts or channel grading, that would improve drainage in the selected AOIs. Sizing calculations were performed with Hydraflow Storm Sewers, Hydraflow Express, and Flowmaster to size the pipes and channels. Hydraflow Storm Sewers is appropriate for hydraulic analysis of both simple and complex storm drain networks. The program calculates the hydraulic grade line given a known design flow, invert elevations, deflection angles, pipe size, and material using Manning's equation for pipe flow. Hydraflow Express can be used for culvert design to compute the hydraulic grade line with any flow regime, including supercritical flow, hydraulic jumps, pressure flow, and roadway/embankment overtopping. Flowmaster is a Manning's equation calculator and can be used to size channels given a flow capacity.

Alternatives were designed to provide reduction in flood hazards for the 25-year event for Laurel Road and the 10-year event for Juniper Road. The preferred alternatives for Laurel Road and Juniper Road included long runs of storm drain at relatively steep slopes. The proposed storm drains were modeled in Storm Sewers to account for junction losses at manholes and bends in the line. To convey the full capacity of the respective design flows, 36-inch reinforced concrete pipe (RCP) were recommended at Laurel Road and Juniper Road. Reinforced concrete pipe was recommended for the ideal pipe material due to its longevity. During site visits, it was confirmed that many of the existing culverts are corrugated metal pipe (CMP) and appeared to have been crushed from vehicle traffic which reduces the available capacity. Manholes were recommended approximately every 300 feet to allow maintenance crews access to remove sediment. Downstream energy dissipation infrastructure will be required as there are steep drops and a headcut at the end of Laurel Road. A gabion drop structure or other stabilization feature is recommended to stabilize the headcut. Juniper Road will also require a drop structure at the end of the right-of-way near 5555 Juniper Road. Finally, a 36-inch RCP is recommended to convey flows under the existing corral structure to outlet at the Carson River floodplain with an energy dissipator to control outlet flow velocities.

The improvements at Pinion Hills Drive will require dual 36-inch RCPs to convey the 25-year event. The preferred alternative is to build a diversion channel to convey flow towards Elymus Road. A seven-foot-wide channel bottom was recommended for the diversion channel to allow maintenance crews access to remove sediment or rocks from the channel. Energy dissipation measures, such as gabion drop structures or rock splash pads, are also recommended at the downstream discharge point. An open channel system was recommended instead since they are cheaper to construct and easier to maintain.

The proposed improvements would eliminate almost all the flow downstream of the diversion points, leading to decreased flooded areas in the affected properties. Supporting design calculations are included in Appendix D.

6 PRELIMINARY DESIGN CONCEPTS

6.1 CONCEPT DESIGN FOR PREFERRED ALTERNATIVES

Preliminary design for the selected alternatives focused on capacity sizing of pipes and channels and controlling erosion at outfalls. The preferred concept design at Pinion Hills Dr is a dual 24-inch culverts at driveway crossings and a diversion channel system to provide capacity for the 25-year storm. The recommended pipe configuration was selected to keep the proposed diversion channel shallow for access and maintenance reasons. A turf reinforcement mat (TRM) is recommended to stabilize the open channel based on expected velocity of 5 feet per second (fps), which is low risk for erosion. TRMs are intended for open channel installation, capable of resisting flow but allowing vegetation growth beneath the material. At the outfall of the diversion/culvert system flow dissipation is recommended in the form of a rip-rap splash pad to spread the concentrated flow and mitigate possible erosion downstream.

There is an existing “basin” that is forming at 2449 Pinion Hills Drive due to flow accumulating behind Pinion Hills Drive without a culvert crossing. The basin is not recommended for improvements at this time due to being private property and outreach efforts were unable to solicit a response from the owner. However, if the owner were willing to participate, the basin could be expanded and provide a location to capture loose sediment from the hills above which is a nuisance to maintenance crews and a water pollution concern for the Carson River watershed. Further analysis of the sediment loading for this portion of the watershed is recommended if sediment capture is a goal. Removing bed material can cause scour downstream if sediment loads are not balanced.

Figure 6-1. Basin forming at 2449 Pinion Hills Drive

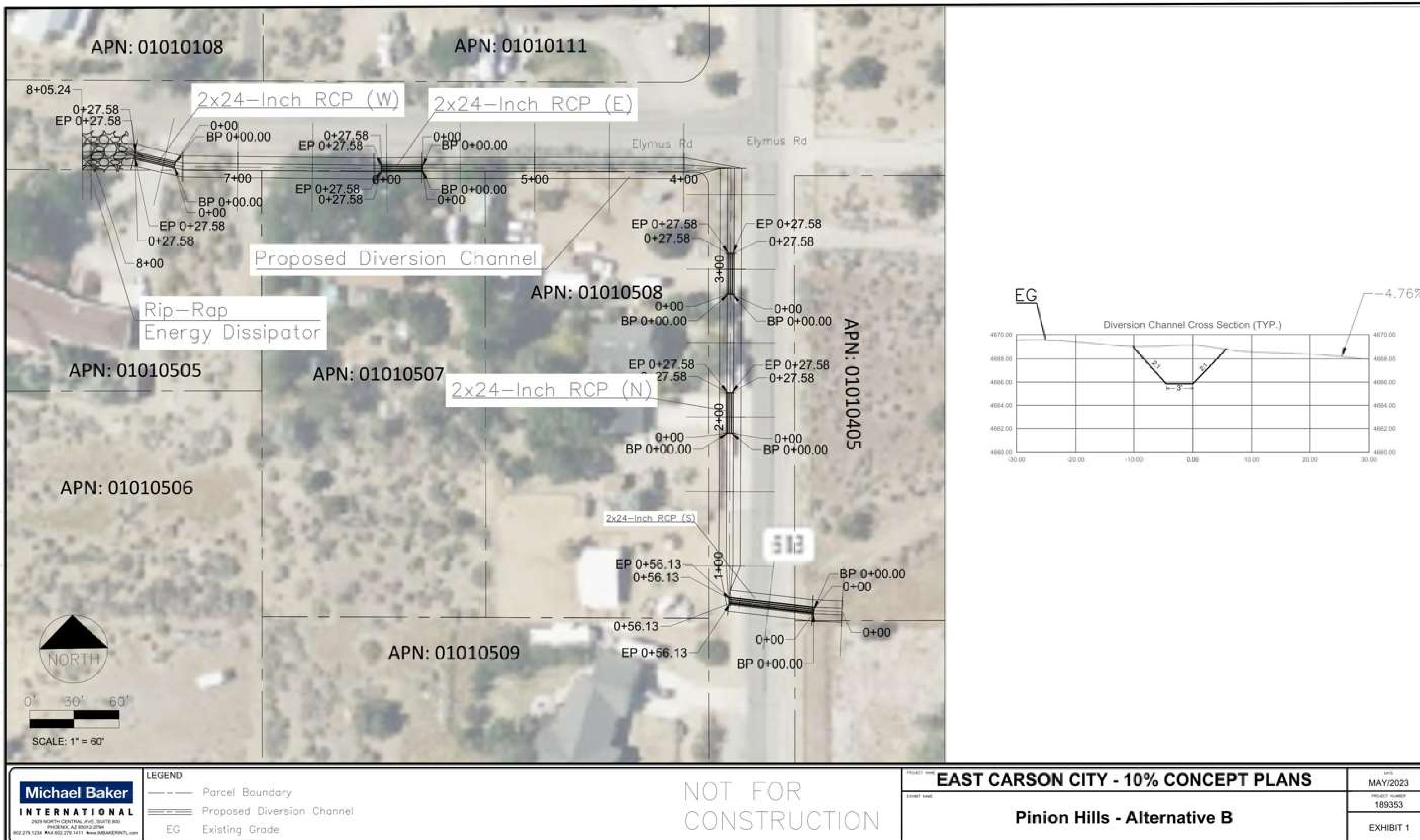
The proposed concept at Laurel Rd is a 36-inch culvert crossing South Deer Run Road which feeds into an open channel before flowing into a long run of 36-inch RCP across Laurel Road and discharging at the end of Laurel Road. A TRM is recommended at the diversion channel connecting the two pipe systems due to low erosive velocities of 4 fps. Sediment is expected to collect in the longer pipe, so cleanout manholes are recommended approximately every 300 feet (four total in this location). The exit velocity of this pipe is estimated at 7 fps which could erode the existing ground. In addition, there is a large headcut present at the discharge point which will require stabilization. Gabion drop structures are not recommended for this watershed since soil substrate is largely sand and the structure requires a rock foundation to be stable. Installing gabions in sandy substrate can lead to piping and eventual failure. Instead, a riprap stilling basin is recommended to provide grade control, energy dissipation, and ultimately reduce velocity at the discharge point to a non-erosive level. US Bureau of Reclamation Engineering Monograph No. 25 (USBR 1984) and National Engineering Handbook Technical Supplement 14G (NEH 2007) specify design guidelines for stilling basins and grade stabilization techniques.

The Juniper Road proposed concept is a 36-inch RCP that will convey flows across Pinion Hills Drive to a discharge point at the end of the western property line of 5551 Elymus Road. There is a steep drop at the end of Juniper Road, therefore a riprap stilling basin is proposed to break the pipe segments into two runs, allowing the proposed pipe to be closer to existing ground and making construction more feasible. The upstream pipe segment exit velocity is estimated at 12 fps, which will be mitigated by the riprap stilling basin to slow flows to a non-erosive velocity. The downstream pipe segment exit velocity is estimated at 7 fps, which will require an energy dissipator at the pipe outfall to spread flows into non-erosive condition.

Figure 6-2. Sediment capture basin in southern portion of the study area

Sediment is a known issue in this watershed. Flood flows carry quantities of sediment downstream and can leave deposits in flood conveyance infrastructure, eventually diminishing the capacity of the infrastructure to carry flows adequately. Sediment capture opportunities in this watershed could be implemented as sedimentation basins (see Figure below) to trap sediment before it enters the storm drain system. A detailed sediment loading analysis is recommended before any sediment basins are implemented to avoid causing scour downstream.

Figure 6-3: Proposed Concept Design Pinion Hills Alternative B (1 of 2)



6-4: Proposed Concept Design Pinion Hills Alternative B (2 of 2)

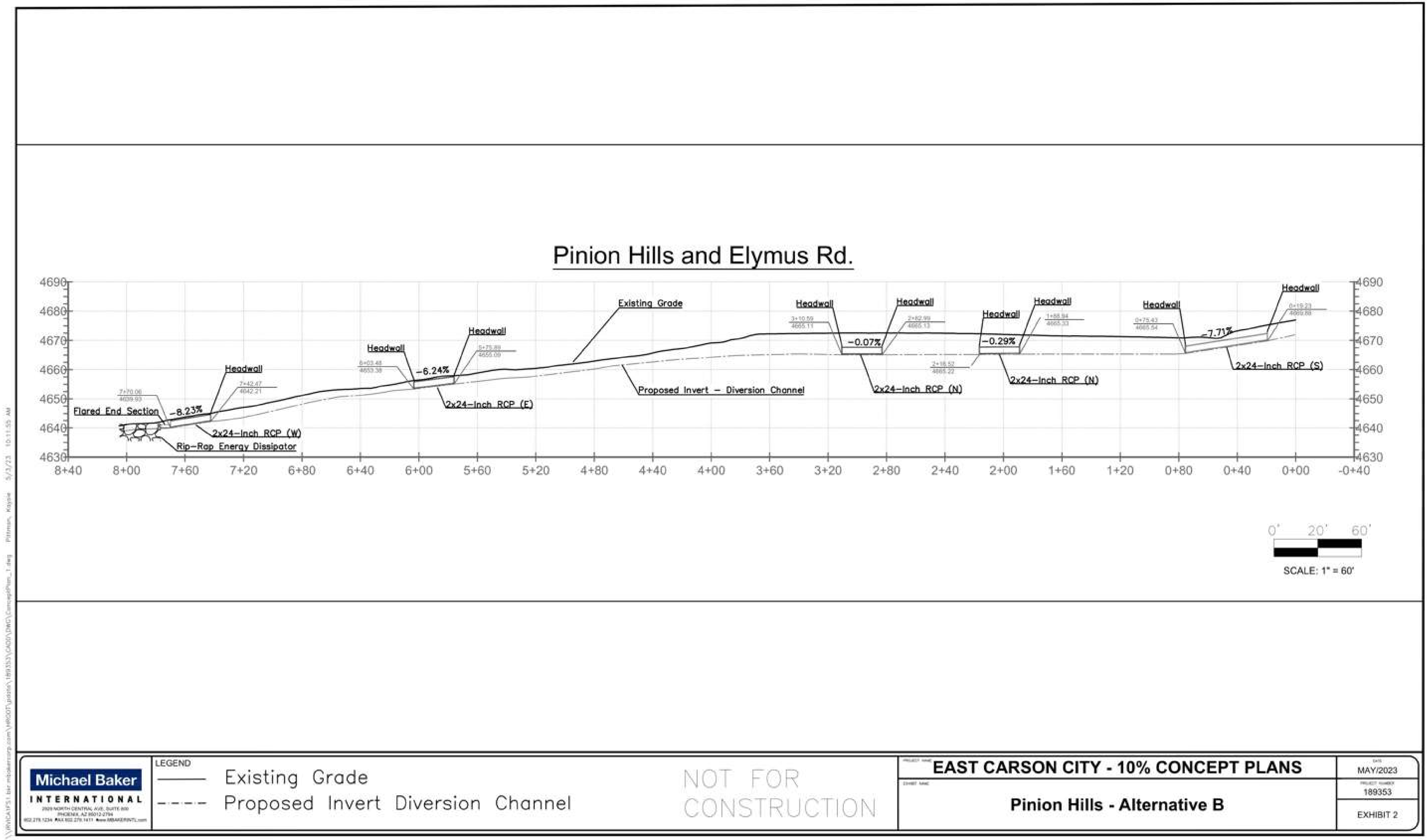


Table 6-1: Preliminary Cost Estimate Pinion Hills

East Carson ADMP					
Pinion Hills Rd					
Alternative B Estimated Cost - Diversion Channel to Elymus Rd					
May 2023					
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Price**
Design & Permitting					
1	Final Design (15% of Construction)	%		15	$54,383
2	Design Survey	LS	1	8000	$8,000
				Subtotal	$62,383
Construction Costs					
3	Mobilization & Demobilization	LS	1	30000	$30,000
4	(2) 24" RCP	LF	400	400	$160,000
5	4" AC Patching	SF	2600	9	$23,400
6	Headwalls	EA	9	5000	$45,000
7	Flared End Section	EA	1	6000	$6,000
8	Turf Reinforcement Mat	SF	6360	10	$63,600
9	Riprap Energy Dissipator	EA	1	10000	$10,000
10	Clearing & Grubbing	AC	0.1	25000	$2,500
11	Grading	CY	567.2	12	$6,807
12	Cut Offhaul	CY	453.8	12	$5,445
13	Native Vegetation and Erosion Control	AC	0.1	8000	$800
				Subtotal	$353,552
Miscellaneous Construction					
14	Traffic Control, Construction Staking, Quality Control, Construction Management	%		20	
	(20% of Design & Construction Subtotal)			***Subtotal***	$82,917
				30% Contingency	$149,250
Total Project Costs					$647,000

Figure 6-5: Proposed Concept Design Laurel Road Alternative B

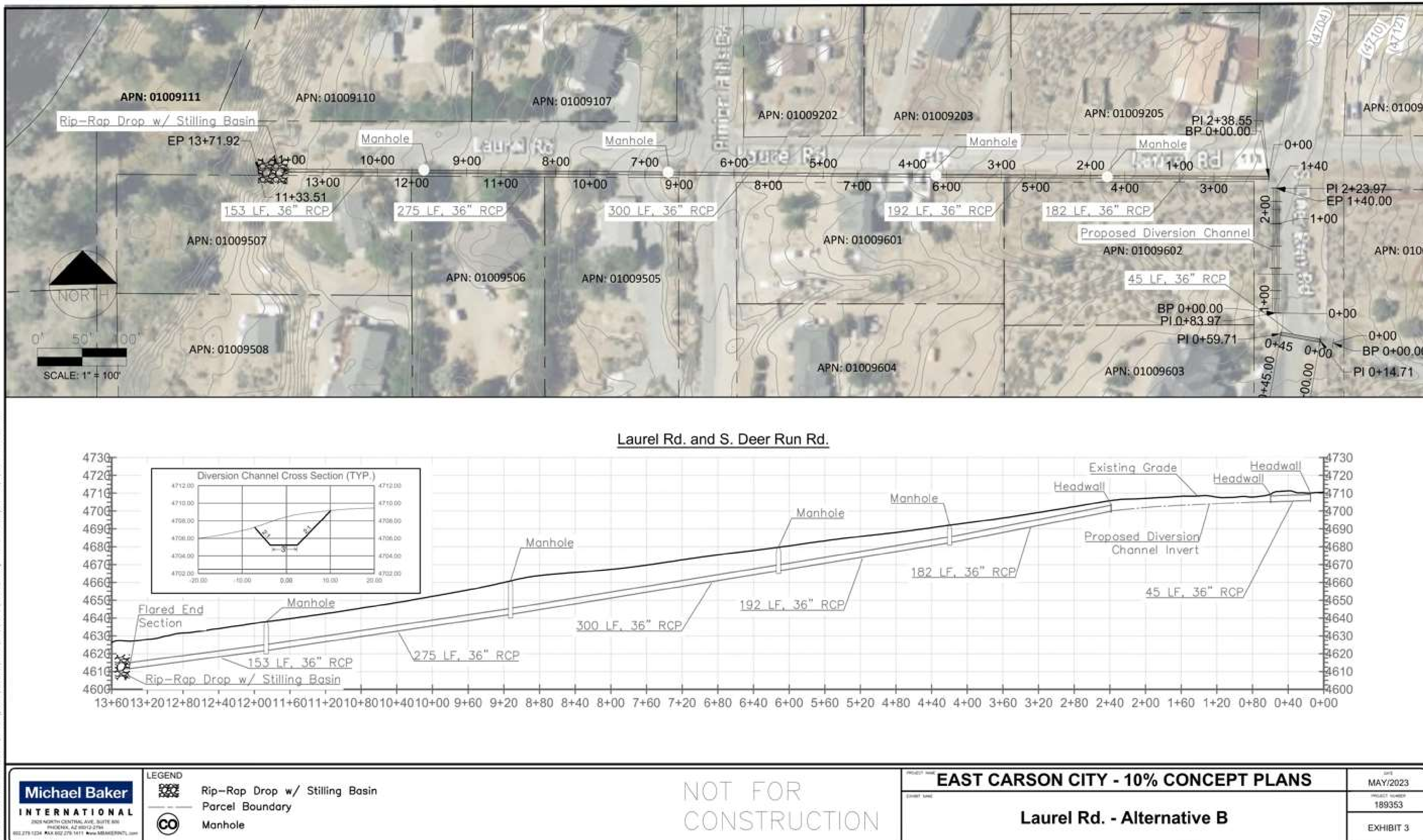


Table 6-2: Preliminary Cost Estimate Laurel Road

East Carson ADMP					
Laurel Rd					
Alternative B - Diversion Pipe to Laurel Rd					
March 2023					
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total Price**
Design & Permitting					
1	Final Design (15% of Construction)	%		15	$76,212
2	Design Survey	LS	1	8000	$8000
				Subtotal	$84,212
Construction Costs					
3	Mobilization & Demobilization	LS	1	30000	$30,000
4	Clearing & Grubbing	AC	0.1	25000	$2,500
5	Trenching/Grading	CY	478.3	12	$5,740
6	36" RCP	LF	1145	300	$353,500
7	4" AC Patching	SF	800	9	$7,200
8	Turf Reinforcement Mat	SF	2660	10	$26,600
9	Headwalls	EA	3	5000	$15,000
10	Flared End Section	EA	1	6000	$6,000
11	Manhole	EA	4	5000	$20,000
12	Offhaul	CY	478.3	12	$5,740
13	Riprap Drop w/ Stilling Basin	EA	1	45000	$45,000
14	Native Vegetation & Erosion Control	AC	0.1	8000	$800
				Subtotal	$508,080
Miscellaneous Construction					
15	Traffic Control, Construction Staking, Quality Control, Construction Management	%		20	
	(20% of Design & Construction Subtotal)			***Subtotal***	$118,458
				30% Contingency	$213,225
Total Project Costs					$924,000

Figure 6-6: Proposed Concept Design Juniper Road Alternative B

LEGEND	
	Rip-Rap Energy Dissipator
	Parcel Boundary
CO	Manhole

Michael Baker INTERNATIONAL

NOT FOR CONSTRUCTION

EAST CARSON CITY - 10% CONCEPT PLANS

Juniper Rd. - Alternative B

MAY/2023

189353

EXHIBIT 4

Table 6-3: Preliminary Cost Estimate Juniper Road

Item	Description	Unit	Quantity	Unit Price	Total Price
East Carson ADMP					
Juniper Rd					
Alternative B Estimated Cost - Diversion Pipe North Juniper					
March 2023					
Design & Permitting					
1	Final Design (15% of Construction)	%		15	$48,186
2	Design Survey	LS	1	8000	$8,000
				Subtotal	$56,186
Construction Costs					
3	Mobilization & Demobilization	LS	1	30000	$30,000
4	36" RCP	LF	630	300	$189,000
5	Cleanout	EA	2	5000	$10,000
6	Riprap Drop w/ Stilling Basin	EA	1	45000	$45,000
7	Riprap Energy Dissipator	EA	1	10000	$10,000
8	Headwalls	EA	2	5000	$10,000
9	Flared End Section	EA	2	6000	$12,000
10	4" AC Patching	SF	860	9	$7,740
11	Clearing & Grubbing	AC	0.1	25000	$2,500
12	Trenching/Grading	CY	175.0	12	$2,100
13	Cut Offhaul	CY	175.0	12	$2,100
14	Native Vegetation and Erosion Control	AC	0.1	8000	$800
				Subtotal	$321,240
Miscellaneous Construction					
15	Traffic Control, Construction Staking, Quality Control, Construction Management	%		20	
	(20% of Design & Construction Subtotal)			***Subtotal***	$75,485
				30% Contingency	$135,873
Total Project Costs					$589,000

7 CONCLUSION

This East Carson ADMP provides Carson City and residents with an understanding of the existing drainage patterns in the Pinion Hills region and presents potential solutions to reduce future flood damages. Based on the existing model results and discussion with the residents, four AOIs were identified, and three high-level conceptual design projects were developed. The proposed improvements were selected based on cost, public input, and the level of provided protection. For the three conceptual plans, the costs and benefits were evaluated to prepare a preliminary estimated benefit/cost ratio (BCR) to evaluate cost-effectiveness. A project with a BCR above 1.0 is eligible for most sources of public funding, which is the case for the three conceptual plans at this point in the project development. Though early in the planning stages, the identified projects and the developed models are flexible to allow Carson City to respond accordingly to various funding sources.

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Appendix A – Modeling Data

Table 1. 10-Year, 24-Hour SCS Type II

Minute	Cumulative Depth (in)	Incremental Depth (in)
0	0	0
5	0.002	0.002
10	0.004	0.002
15	0.005	0.001
20	0.007	0.002
25	0.009	0.002
30	0.011	0.002
35	0.013	0.002
40	0.015	0.002
45	0.017	0.002
50	0.02	0.003
55	0.022	0.002
60	0.024	0.002
65	0.026	0.002
70	0.028	0.002
75	0.031	0.003
80	0.033	0.002
85	0.035	0.002
90	0.037	0.002
95	0.039	0.002
100	0.041	0.002
105	0.044	0.003
110	0.046	0.002
115	0.048	0.002
120	0.05	0.002
125	0.052	0.002
130	0.055	0.003
135	0.057	0.002
140	0.059	0.002
145	0.061	0.002
150	0.063	0.002
155	0.066	0.003
160	0.068	0.002
165	0.07	0.002
170	0.072	0.002
175	0.074	0.002
180	0.076	0.002
185	0.079	0.003
190	0.081	0.002
195	0.083	0.002
200	0.085	0.002

205	0.087	0.002
210	0.09	0.003
215	0.092	0.002
220	0.095	0.003
225	0.097	0.002
230	0.1	0.003
235	0.102	0.002
240	0.105	0.003
245	0.108	0.003
250	0.111	0.003
255	0.114	0.003
260	0.116	0.002
265	0.119	0.003
270	0.122	0.003
275	0.125	0.003
280	0.128	0.003
285	0.131	0.003
290	0.134	0.003
295	0.137	0.003
300	0.14	0.003
305	0.143	0.003
310	0.146	0.003
315	0.149	0.003
320	0.151	0.002
325	0.154	0.003
330	0.157	0.003
335	0.16	0.003
340	0.163	0.003
345	0.166	0.003
350	0.169	0.003
355	0.172	0.003
360	0.175	0.003
365	0.178	0.003
370	0.182	0.004
375	0.186	0.004
380	0.189	0.003
385	0.193	0.004
390	0.197	0.004
395	0.2	0.003
400	0.204	0.004
405	0.207	0.003
410	0.211	0.004
415	0.215	0.004

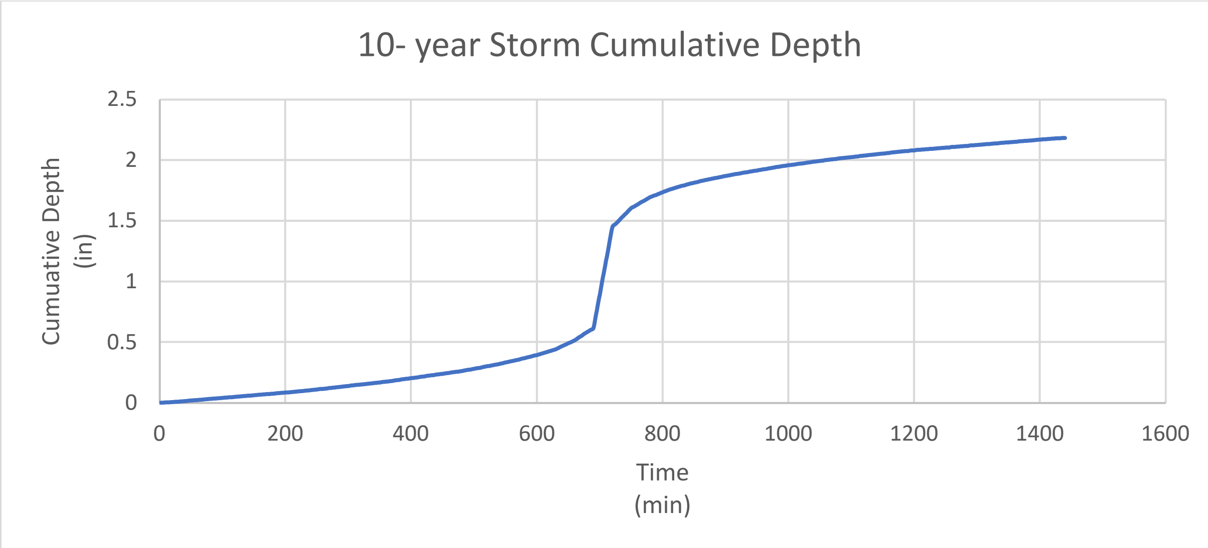
420	0.218	0.003
425	0.222	0.004
430	0.226	0.004
435	0.229	0.003
440	0.233	0.004
445	0.237	0.004
450	0.24	0.003
455	0.244	0.004
460	0.248	0.004
465	0.251	0.003
470	0.255	0.004
475	0.258	0.003
480	0.262	0.004
485	0.267	0.005
490	0.272	0.005
495	0.276	0.004
500	0.281	0.005
505	0.286	0.005
510	0.29	0.004
515	0.296	0.006
520	0.301	0.005
525	0.306	0.005
530	0.311	0.005
535	0.316	0.005
540	0.321	0.005
545	0.327	0.006
550	0.333	0.006
555	0.339	0.006
560	0.344	0.005
565	0.35	0.006
570	0.356	0.006
575	0.363	0.007
580	0.369	0.006
585	0.376	0.007
590	0.382	0.006
595	0.389	0.007
600	0.395	0.006
605	0.403	0.008
610	0.411	0.008
615	0.419	0.008
620	0.427	0.008
625	0.435	0.008
630	0.443	0.008

635	0.455	0.012
640	0.467	0.012
645	0.479	0.012
650	0.491	0.012
655	0.503	0.012
660	0.515	0.012
665	0.533	0.018
670	0.55	0.017
675	0.567	0.017
680	0.584	0.017
685	0.601	0.017
690	0.618	0.017
695	0.756	0.138
700	0.895	0.139
705	1.033	0.138
710	1.171	0.138
715	1.31	0.139
720	1.448	0.138
725	1.474	0.026
730	1.5	0.026
735	1.527	0.027
740	1.553	0.026
745	1.579	0.026
750	1.605	0.026
755	1.62	0.015
760	1.635	0.015
765	1.65	0.015
770	1.665	0.015
775	1.68	0.015
780	1.695	0.015
785	1.705	0.01
790	1.715	0.01
795	1.725	0.01
800	1.736	0.011
805	1.746	0.01
810	1.756	0.01
815	1.764	0.008
820	1.771	0.007
825	1.779	0.008
830	1.787	0.008
835	1.794	0.007
840	1.802	0.008
845	1.808	0.006

850	1.814	0.006
855	1.82	0.006
860	1.827	0.007
865	1.833	0.006
870	1.839	0.006
875	1.844	0.005
880	1.849	0.005
885	1.854	0.005
890	1.859	0.005
895	1.864	0.005
900	1.87	0.006
905	1.874	0.004
910	1.879	0.005
915	1.884	0.005
920	1.888	0.004
925	1.893	0.005
930	1.898	0.005
935	1.902	0.004
940	1.907	0.005
945	1.911	0.004
950	1.915	0.004
955	1.92	0.005
960	1.924	0.004
965	1.928	0.004
970	1.933	0.005
975	1.937	0.004
980	1.942	0.005
985	1.946	0.004
990	1.95	0.004
995	1.954	0.004
1000	1.958	0.004
1005	1.961	0.003
1010	1.965	0.004
1015	1.969	0.004
1020	1.972	0.003
1025	1.976	0.004
1030	1.979	0.003
1035	1.983	0.004
1040	1.987	0.004
1045	1.99	0.003
1050	1.994	0.004
1055	1.997	0.003
1060	2.001	0.004

1065	2.004	0.003
1070	2.007	0.003
1075	2.01	0.003
1080	2.014	0.004
1085	2.017	0.003
1090	2.019	0.002
1095	2.022	0.003
1100	2.025	0.003
1105	2.028	0.003
1110	2.031	0.003
1115	2.034	0.003
1120	2.037	0.003
1125	2.04	0.003
1130	2.043	0.003
1135	2.046	0.003
1140	2.049	0.003
1145	2.052	0.003
1150	2.054	0.002
1155	2.057	0.003
1160	2.06	0.003
1165	2.063	0.003
1170	2.066	0.003
1175	2.069	0.003
1180	2.071	0.002
1185	2.074	0.003
1190	2.076	0.002
1195	2.079	0.003
1200	2.081	0.002
1205	2.084	0.003
1210	2.086	0.002
1215	2.088	0.002
1220	2.09	0.002
1225	2.092	0.002
1230	2.094	0.002
1235	2.097	0.003
1240	2.099	0.002
1245	2.101	0.002
1250	2.103	0.002
1255	2.105	0.002
1260	2.108	0.003
1265	2.11	0.002
1270	2.112	0.002
1275	2.114	0.002

1280	2.116	0.002
1285	2.118	0.002
1290	2.121	0.003
1295	2.123	0.002
1300	2.125	0.002
1305	2.127	0.002
1310	2.129	0.002
1315	2.132	0.003
1320	2.134	0.002
1325	2.136	0.002
1330	2.138	0.002
1335	2.14	0.002
1340	2.143	0.003
1345	2.145	0.002
1350	2.147	0.002
1355	2.149	0.002
1360	2.151	0.002
1365	2.153	0.002
1370	2.156	0.003
1375	2.158	0.002
1380	2.16	0.002
1385	2.162	0.002
1390	2.164	0.002
1395	2.167	0.003
1400	2.169	0.002
1405	2.171	0.002
1410	2.173	0.002
1415	2.175	0.002
1420	2.177	0.002
1425	2.179	0.002
1430	2.18	0.001
1435	2.182	0.002
1440	2.184	0.002



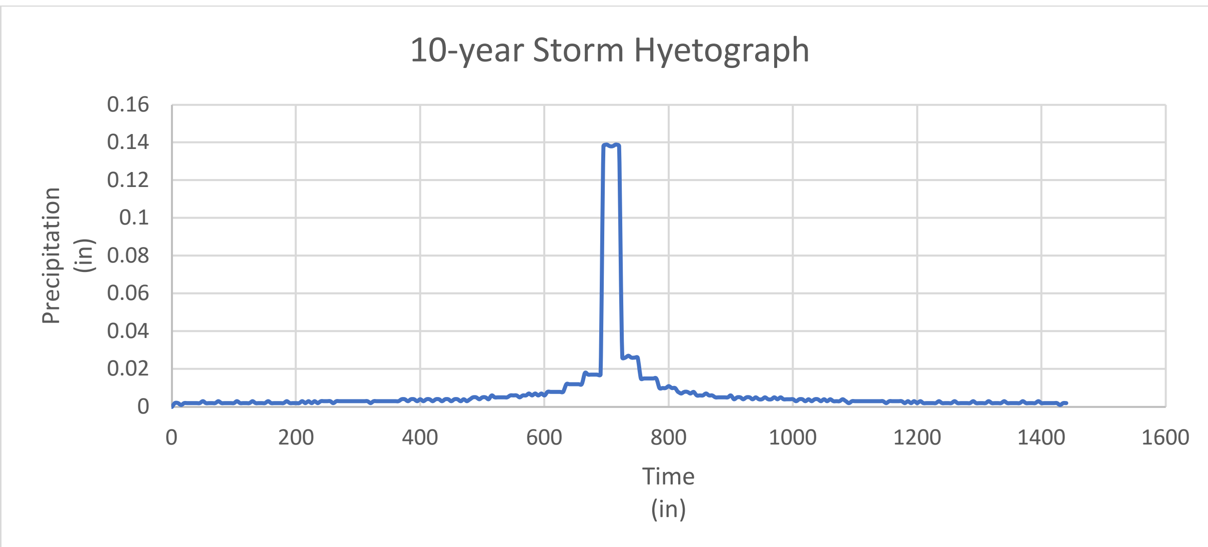


Table 2. 25-Year, 24-Hour SCS Type II

Minute	Cumulative Depth (in)	Incremental Depth (in)
0	0	0
5	0.002	0.002
10	0.004	0.002
15	0.007	0.002
20	0.009	0.002
25	0.011	0.002
30	0.013	0.002
35	0.016	0.003
40	0.018	0.003
45	0.021	0.003

50	0.024	0.003
55	0.026	0.003
60	0.029	0.003
65	0.031	0.003
70	0.034	0.003
75	0.037	0.003
80	0.039	0.003
85	0.042	0.003
90	0.044	0.003
95	0.047	0.003
100	0.05	0.003
105	0.052	0.003
110	0.055	0.003
115	0.058	0.003
120	0.06	0.003
125	0.063	0.003
130	0.065	0.003
135	0.068	0.003
140	0.071	0.003
145	0.073	0.003
150	0.076	0.003
155	0.078	0.003
160	0.081	0.003
165	0.084	0.003
170	0.086	0.003
175	0.089	0.003
180	0.092	0.003
185	0.094	0.003
190	0.097	0.003
195	0.099	0.003
200	0.102	0.003
205	0.105	0.003
210	0.107	0.003
215	0.11	0.003
220	0.113	0.003
225	0.116	0.003
230	0.119	0.003
235	0.123	0.003
240	0.126	0.003
245	0.129	0.003
250	0.133	0.003
255	0.136	0.003
260	0.14	0.003

265	0.143	0.003
270	0.146	0.003
275	0.15	0.003
280	0.153	0.003
285	0.157	0.003
290	0.16	0.003
295	0.164	0.003
300	0.167	0.003
305	0.171	0.003
310	0.174	0.003
315	0.178	0.003
320	0.181	0.003
325	0.185	0.003
330	0.188	0.003
335	0.192	0.003
340	0.195	0.003
345	0.199	0.003
350	0.202	0.003
355	0.206	0.003
360	0.209	0.003
365	0.214	0.004
370	0.218	0.004
375	0.222	0.004
380	0.227	0.004
385	0.231	0.004
390	0.235	0.004
395	0.24	0.004
400	0.244	0.004
405	0.249	0.004
410	0.253	0.004
415	0.257	0.004
420	0.262	0.004
425	0.266	0.004
430	0.27	0.004
435	0.275	0.004
440	0.279	0.004
445	0.283	0.004
450	0.288	0.004
455	0.292	0.004
460	0.296	0.004
465	0.301	0.004
470	0.305	0.004
475	0.31	0.004

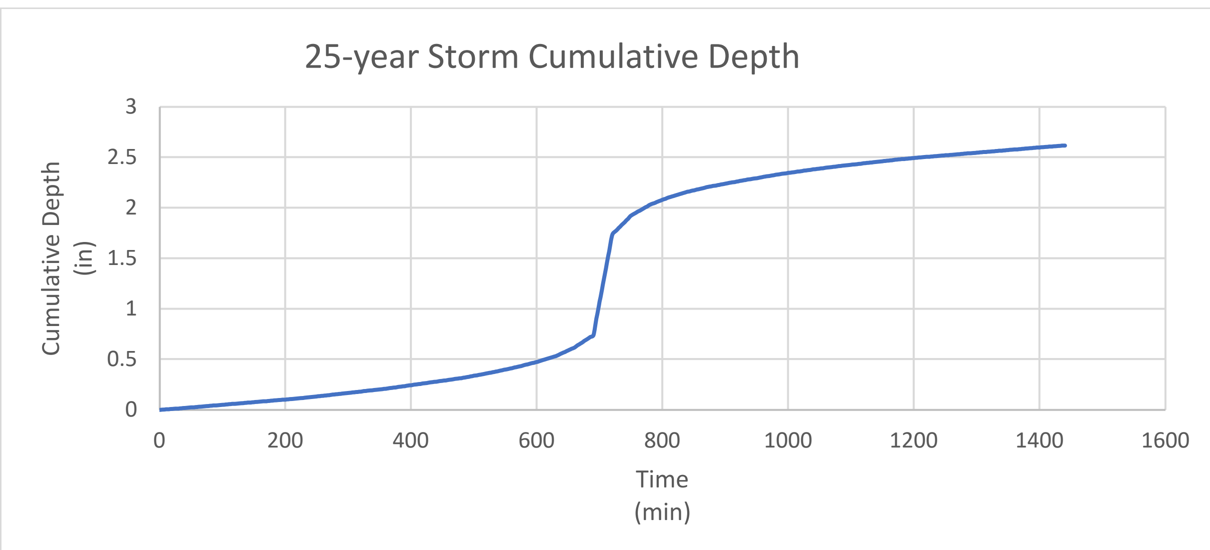
480	0.314	0.004
485	0.32	0.006
490	0.325	0.006
495	0.331	0.006
500	0.337	0.006
505	0.342	0.006
510	0.348	0.006
515	0.354	0.006
520	0.36	0.006
525	0.366	0.006
530	0.372	0.006
535	0.378	0.006
540	0.385	0.006
545	0.392	0.007
550	0.399	0.007
555	0.405	0.007
560	0.412	0.007
565	0.419	0.007
570	0.426	0.007
575	0.434	0.008
580	0.442	0.008
585	0.45	0.008
590	0.458	0.008
595	0.466	0.008
600	0.473	0.008
605	0.483	0.01
610	0.493	0.01
615	0.502	0.01
620	0.512	0.01
625	0.521	0.01
630	0.531	0.01
635	0.545	0.014
640	0.56	0.014
645	0.574	0.014
650	0.589	0.014
655	0.603	0.014
660	0.617	0.014
665	0.638	0.02
670	0.658	0.02
675	0.679	0.02
680	0.699	0.02
685	0.72	0.02
690	0.74	0.02

695	0.906	0.166
700	1.072	0.166
705	1.237	0.166
710	1.403	0.166
715	1.569	0.166
720	1.734	0.166
725	1.766	0.031
730	1.797	0.031
735	1.829	0.031
740	1.86	0.031
745	1.891	0.031
750	1.923	0.031
755	1.941	0.018
760	1.959	0.018
765	1.976	0.018
770	1.994	0.018
775	2.012	0.018
780	2.03	0.018
785	2.042	0.012
790	2.054	0.012
795	2.067	0.012
800	2.079	0.012
805	2.091	0.012
810	2.103	0.012
815	2.112	0.009
820	2.122	0.009
825	2.131	0.009
830	2.14	0.009
835	2.149	0.009
840	2.158	0.009
845	2.166	0.007
850	2.173	0.007
855	2.18	0.007
860	2.188	0.007
865	2.195	0.007
870	2.203	0.007
875	2.209	0.006
880	2.215	0.006
885	2.221	0.006
890	2.227	0.006
895	2.233	0.006
900	2.239	0.006
905	2.245	0.006

910	2.251	0.006
915	2.256	0.006
920	2.262	0.006
925	2.268	0.006
930	2.273	0.006
935	2.279	0.005
940	2.284	0.005
945	2.289	0.005
950	2.294	0.005
955	2.299	0.005
960	2.305	0.005
965	2.31	0.005
970	2.315	0.005
975	2.32	0.005
980	2.326	0.005
985	2.331	0.005
990	2.336	0.005
995	2.34	0.004
1000	2.345	0.004
1005	2.349	0.004
1010	2.354	0.004
1015	2.358	0.004
1020	2.362	0.004
1025	2.367	0.004
1030	2.371	0.004
1035	2.375	0.004
1040	2.38	0.004
1045	2.384	0.004
1050	2.388	0.004
1055	2.392	0.004
1060	2.396	0.004
1065	2.4	0.004
1070	2.404	0.004
1075	2.408	0.004
1080	2.412	0.004
1085	2.415	0.003
1090	2.419	0.003
1095	2.422	0.003
1100	2.426	0.003
1105	2.429	0.003
1110	2.433	0.003
1115	2.436	0.003
1120	2.44	0.003

1125	2.443	0.003
1130	2.447	0.003
1135	2.45	0.003
1140	2.454	0.003
1145	2.457	0.003
1150	2.461	0.003
1155	2.464	0.003
1160	2.468	0.003
1165	2.471	0.003
1170	2.475	0.003
1175	2.478	0.003
1180	2.481	0.003
1185	2.484	0.003
1190	2.487	0.003
1195	2.49	0.003
1200	2.493	0.003
1205	2.496	0.003
1210	2.498	0.003
1215	2.501	0.003
1220	2.504	0.003
1225	2.506	0.003
1230	2.509	0.003
1235	2.511	0.003
1240	2.514	0.003
1245	2.517	0.003
1250	2.519	0.003
1255	2.522	0.003
1260	2.524	0.003
1265	2.527	0.003
1270	2.53	0.003
1275	2.532	0.003
1280	2.535	0.003
1285	2.538	0.003
1290	2.54	0.003
1295	2.543	0.003
1300	2.545	0.003
1305	2.548	0.003
1310	2.551	0.003
1315	2.553	0.003
1320	2.556	0.003
1325	2.558	0.003
1330	2.561	0.003
1335	2.564	0.003

1340	2.566	0.003
1345	2.569	0.003
1350	2.572	0.003
1355	2.574	0.003
1360	2.577	0.003
1365	2.579	0.003
1370	2.582	0.003
1375	2.585	0.003
1380	2.587	0.003
1385	2.59	0.003
1390	2.592	0.003
1395	2.595	0.003
1400	2.598	0.003
1405	2.6	0.003
1410	2.603	0.003
1415	2.605	0.002
1420	2.607	0.002
1425	2.609	0.002
1430	2.612	0.002
1435	2.614	0.002
1440	2.616	0.002



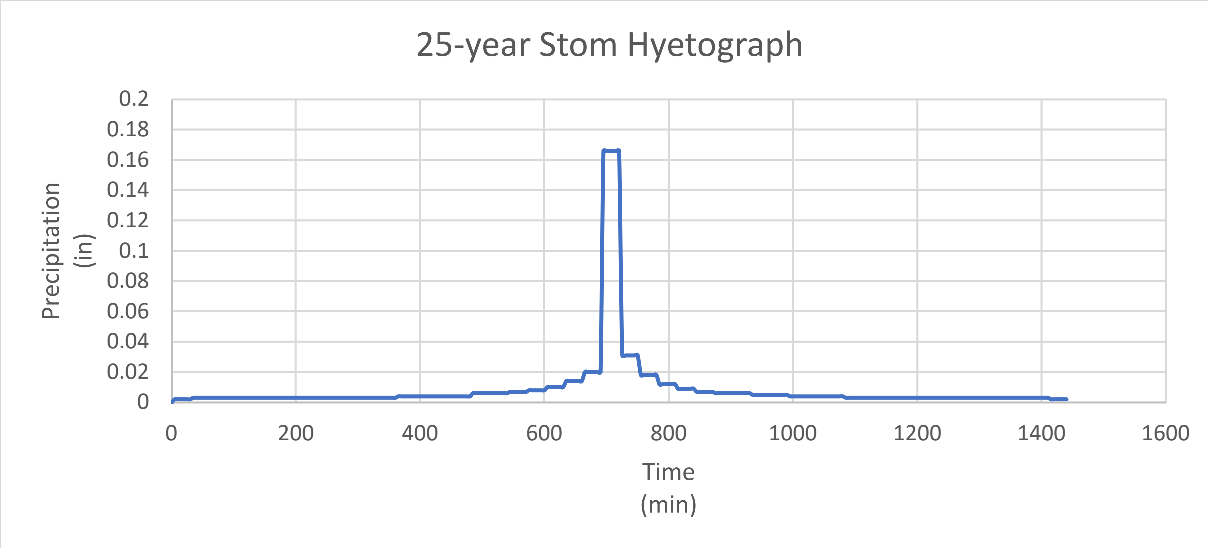


Table 3. 100-Year, 24-Hour SCS Type II

Minute	Cumulative Depth (in)	Incremental Depth (in)
0	0	0
5	0.003	0.003
10	0.006	0.003
15	0.008	0.003
20	0.011	0.003
25	0.014	0.003
30	0.017	0.003
35	0.02	0.003
40	0.023	0.003
45	0.027	0.003
50	0.03	0.003
55	0.033	0.003
60	0.036	0.003
65	0.04	0.003
70	0.043	0.003
75	0.046	0.003
80	0.05	0.003
85	0.053	0.003
90	0.056	0.003
95	0.06	0.003
100	0.063	0.003
105	0.066	0.003
110	0.07	0.003
115	0.073	0.003
120	0.076	0.003

125	0.08	0.003
130	0.083	0.003
135	0.086	0.003
140	0.089	0.003
145	0.093	0.003
150	0.096	0.003
155	0.099	0.003
160	0.103	0.003
165	0.106	0.003
170	0.109	0.003
175	0.113	0.003
180	0.116	0.003
185	0.119	0.003
190	0.123	0.003
195	0.126	0.003
200	0.129	0.003
205	0.133	0.003
210	0.136	0.003
215	0.14	0.004
220	0.144	0.004
225	0.147	0.004
230	0.151	0.004
235	0.155	0.004
240	0.159	0.004
245	0.163	0.004
250	0.168	0.004
255	0.172	0.004
260	0.177	0.004
265	0.181	0.004
270	0.186	0.004
275	0.19	0.004
280	0.194	0.004
285	0.199	0.004
290	0.203	0.004
295	0.208	0.004
300	0.212	0.004
305	0.217	0.004
310	0.221	0.004
315	0.225	0.004
320	0.23	0.004
325	0.234	0.004
330	0.239	0.004
335	0.243	0.004

340	0.247	0.004
345	0.252	0.004
350	0.256	0.004
355	0.261	0.004
360	0.265	0.004
365	0.271	0.006
370	0.276	0.006
375	0.282	0.006
380	0.287	0.006
385	0.293	0.006
390	0.298	0.006
395	0.304	0.006
400	0.309	0.006
405	0.315	0.006
410	0.32	0.006
415	0.326	0.006
420	0.331	0.006
425	0.337	0.006
430	0.342	0.006
435	0.348	0.006
440	0.353	0.006
445	0.359	0.006
450	0.365	0.006
455	0.37	0.006
460	0.376	0.006
465	0.381	0.006
470	0.387	0.006
475	0.392	0.006
480	0.398	0.006
485	0.405	0.007
490	0.412	0.007
495	0.419	0.007
500	0.426	0.007
505	0.434	0.007
510	0.441	0.007
515	0.448	0.008
520	0.456	0.008
525	0.464	0.008
530	0.472	0.008
535	0.479	0.008
540	0.487	0.008
545	0.496	0.009
550	0.505	0.009

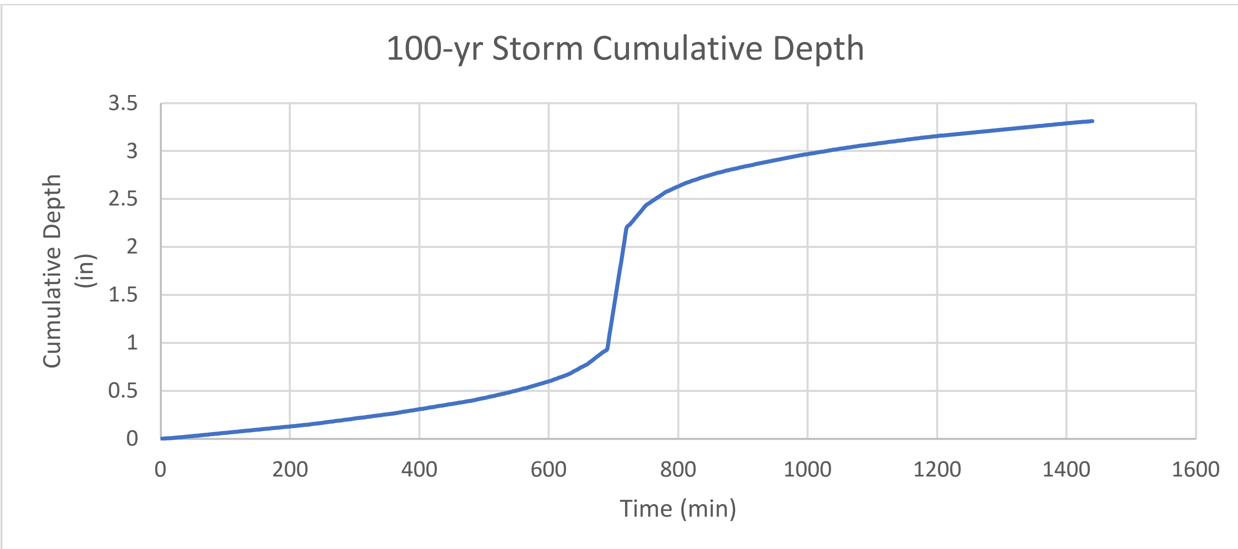
555	0.514	0.009
560	0.523	0.009
565	0.531	0.009
570	0.54	0.009
575	0.55	0.01
580	0.56	0.01
585	0.57	0.01
590	0.58	0.01
595	0.59	0.01
600	0.6	0.01
605	0.612	0.012
610	0.624	0.012
615	0.636	0.012
620	0.648	0.012
625	0.661	0.012
630	0.673	0.012
635	0.691	0.018
640	0.709	0.018
645	0.727	0.018
650	0.746	0.018
655	0.764	0.018
660	0.782	0.018
665	0.808	0.026
670	0.834	0.026
675	0.86	0.026
680	0.886	0.026
685	0.912	0.026
690	0.938	0.026
695	1.148	0.21
700	1.358	0.21
705	1.568	0.21
710	1.777	0.21
715	1.987	0.21
720	2.197	0.21
725	2.237	0.04
730	2.277	0.04
735	2.316	0.04
740	2.356	0.04
745	2.396	0.04
750	2.436	0.04
755	2.458	0.023
760	2.481	0.023
765	2.504	0.023

770	2.526	0.023
775	2.549	0.023
780	2.572	0.023
785	2.587	0.015
790	2.603	0.015
795	2.618	0.015
800	2.634	0.015
805	2.649	0.015
810	2.664	0.015
815	2.676	0.012
820	2.688	0.012
825	2.699	0.012
830	2.711	0.012
835	2.722	0.012
840	2.734	0.012
845	2.743	0.009
850	2.753	0.009
855	2.762	0.009
860	2.772	0.009
865	2.781	0.009
870	2.79	0.009
875	2.798	0.008
880	2.806	0.008
885	2.814	0.008
890	2.821	0.008
895	2.829	0.008
900	2.837	0.008
905	2.844	0.007
910	2.851	0.007
915	2.858	0.007
920	2.866	0.007
925	2.873	0.007
930	2.88	0.007
935	2.886	0.007
940	2.893	0.007
945	2.9	0.007
950	2.906	0.007
955	2.913	0.007
960	2.92	0.007
965	2.926	0.007
970	2.933	0.007
975	2.94	0.007
980	2.946	0.007

985	2.953	0.007
990	2.959	0.007
995	2.965	0.006
1000	2.97	0.006
1005	2.976	0.006
1010	2.981	0.006
1015	2.987	0.006
1020	2.993	0.006
1025	2.998	0.006
1030	3.004	0.006
1035	3.009	0.006
1040	3.015	0.006
1045	3.02	0.006
1050	3.026	0.006
1055	3.031	0.005
1060	3.036	0.005
1065	3.041	0.005
1070	3.046	0.005
1075	3.051	0.005
1080	3.056	0.005
1085	3.06	0.004
1090	3.064	0.004
1095	3.069	0.004
1100	3.073	0.004
1105	3.078	0.004
1110	3.082	0.004
1115	3.086	0.004
1120	3.091	0.004
1125	3.095	0.004
1130	3.1	0.004
1135	3.104	0.004
1140	3.109	0.004
1145	3.113	0.004
1150	3.117	0.004
1155	3.122	0.004
1160	3.126	0.004
1165	3.131	0.004
1170	3.135	0.004
1175	3.139	0.004
1180	3.143	0.004
1185	3.147	0.004
1190	3.151	0.004
1195	3.154	0.004

1200	3.158	0.004
1205	3.162	0.003
1210	3.165	0.003
1215	3.168	0.003
1220	3.171	0.003
1225	3.175	0.003
1230	3.178	0.003
1235	3.181	0.003
1240	3.185	0.003
1245	3.188	0.003
1250	3.191	0.003
1255	3.195	0.003
1260	3.198	0.003
1265	3.201	0.003
1270	3.205	0.003
1275	3.208	0.003
1280	3.211	0.003
1285	3.215	0.003
1290	3.218	0.003
1295	3.221	0.003
1300	3.225	0.003
1305	3.228	0.003
1310	3.231	0.003
1315	3.234	0.003
1320	3.238	0.003
1325	3.241	0.003
1330	3.244	0.003
1335	3.248	0.003
1340	3.251	0.003
1345	3.254	0.003
1350	3.258	0.003
1355	3.261	0.003
1360	3.264	0.003
1365	3.268	0.003
1370	3.271	0.003
1375	3.274	0.003
1380	3.278	0.003
1385	3.281	0.003
1390	3.284	0.003
1395	3.287	0.003
1400	3.291	0.003
1405	3.294	0.003
1410	3.297	0.003

1415	3.3	0.003
1420	3.303	0.003
1425	3.306	0.003
1430	3.308	0.003
1435	3.311	0.003
1440	3.314	0.003



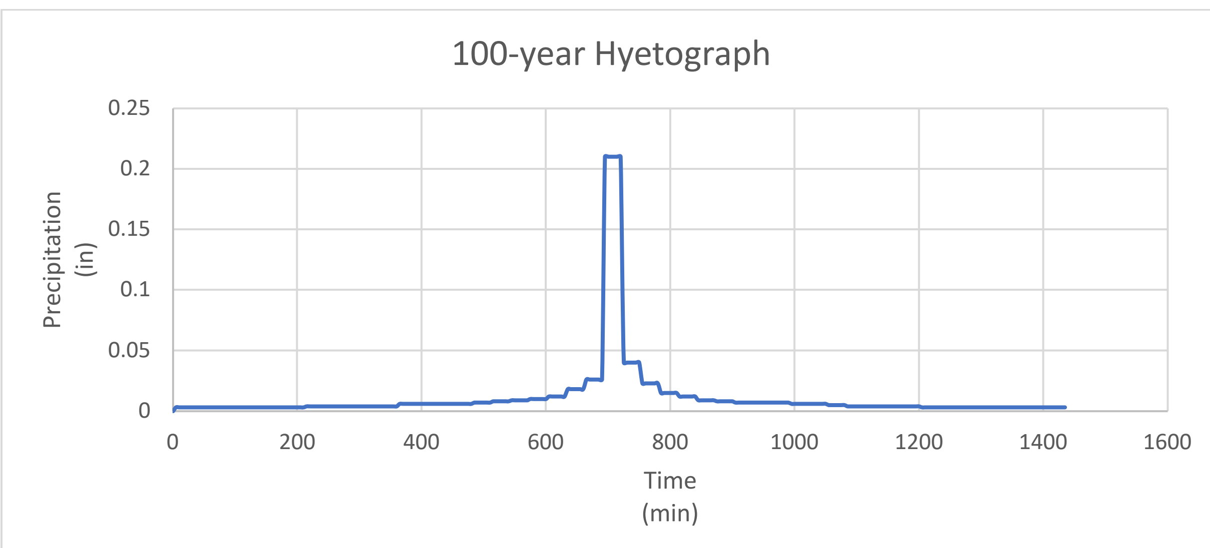


Table 4. Land Use and Soil Type Green-Ampt Redistribution Parameters

Land Use: Soil Type	Wetting Front Suction (in)	Saturated Hydraulic Conductivity (in/hr)	Initial Soil Water Content (Wilting)	Initial Soil Water Content (F.Capacity)	Saturated Soil Water Content	Residual Soil Water Content	Pore Size Dist. Index
Shrub-Scrub : NoData	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Shrub-Scrub : Ursine variant very gravelly fine sandy loam, 8 to 15 percent slopes	0.1	0.3	0.1	0.189	0.416	0.041	0.378
Shrub-Scrub : Greenbrae gravelly sandy loam, 4 to 8 percent slopes	4.05	0.48	0.094	0.18	0.415	0.041	0.378
Shrub-Scrub : Hocar-Rock outcrop complex, 15 to 50 percent slopes	11.04	0.16	0.136	0.269	0.438	0.027	0.117
Shrub-Scrub : Carwalker fine sand	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Shrub-Scrub : Hocar-Rock outcrop complex, 15 to 30 percent slopes, eroded	10.99	0.225	0.091	0.225	0.427	0.027	0.117
Shrub-Scrub : Surpass coarse sandy loam, 2 to 4 percent slopes MLRA 26	1.5	0.99	0.066	0.154	0.439	0.041	0.378
Shrub-Scrub : Jubilee coarse sandy loam, 0 to 2 percent slopes	1.21	1.02	0.09	0.191	0.476	0.041	0.378
Shrub-Scrub : Deven-Rock outcrop complex, 4 to 15 percent slopes	17	0.02	0.253	0.385	0.461	0.027	0.117
Shrub-Scrub : Prey gravelly fine sandy loam, gravelly substratum, 8 to 15 percent slopes	3.6	0.79	0.055	0.148	0.419	0.041	0.378
Shrub-Scrub : Tarloc-Glenbrook association	1.72	1.08	0.045	0.125	0.421	0.041	0.378
Shrub-Scrub : Ister-Reywat-Koontz association	5.47	0.43	0.096	0.204	0.43	0.041	0.378
Shrub-Scrub : Glenbrook-Rock outcrop complex, 30 to 50 percent slopes	0.75	0.63	0.081	0.16	0.432	0.035	0.055
Shrub-Scrub : Haybourne sandy loam, 4 to 8 percent slopes	3.34	0.72	0.072	0.161	0.423	0.041	0.378
Shrub-Scrub : Prey fine sandy loam, gravelly substratum, 4 to 8 percent slopes	3.6	0.85	0.055	0.148	0.419	0.041	0.378
Shrub-Scrub : Riverwash-Water complex	0.06	0.57	0.086	0.153	0.455	0.02	0.694
Shrub-Scrub : Glenbrook-Rock outcrop complex, 8 to 30 percent slopes	1.39	0.56	0.085	0.164	0.43	0.035	0.055
Shrub-Scrub : Incy fine sand, 4 to 30 percent slopes	0.01	2	0.014	0.048	0.439	0.02	0.694
Developed, High Intensity : NoData	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Developed, High Intensity : Ursine variant very gravelly fine sandy loam, 8 to 15 percent slopes	0.1	0.3	0.1	0.189	0.416	0.041	0.378
Developed, High Intensity : Greenbrae gravelly sandy loam, 4 to 8 percent slopes	4.05	0.48	0.094	0.18	0.415	0.041	0.378
Developed, High Intensity : Hocar-Rock outcrop complex, 15 to 50 percent slopes	11.04	0.16	0.136	0.269	0.438	0.027	0.117
Developed, High Intensity : Carwalker fine sand	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Developed, High Intensity : Hocar-Rock outcrop complex, 15 to 30 percent slopes, eroded	10.99	0.225	0.091	0.225	0.427	0.027	0.117
Developed, High Intensity : Surpass coarse sandy loam, 2 to 4 percent slopes MLRA 26	1.5	0.99	0.066	0.154	0.439	0.041	0.378
Developed, High Intensity : Jubilee coarse sandy loam, 0 to 2 percent slopes	1.21	1.02	0.09	0.191	0.476	0.041	0.378
Developed, High Intensity : Deven-Rock outcrop complex, 4 to 15 percent slopes	17	0.02	0.253	0.385	0.461	0.027	0.117
Developed, High Intensity : Prey gravelly fine sandy loam, gravelly substratum, 8 to 15 percent slopes	3.6	0.79	0.055	0.148	0.419	0.041	0.378
Developed, High Intensity : Tarloc-Glenbrook association	1.72	1.08	0.045	0.125	0.421	0.041	0.378
Developed, High Intensity : Ister-Reywat-Koontz association	5.47	0.43	0.096	0.204	0.43	0.041	0.378
Developed, High Intensity : Glenbrook-Rock outcrop complex, 30 to 50 percent slopes	0.75	0.63	0.081	0.16	0.432	0.035	0.055
Developed, High Intensity : Haybourne sandy loam, 4 to 8 percent slopes	3.34	0.72	0.072	0.161	0.423	0.041	0.378
Developed, High Intensity : Prey fine sandy loam, gravelly substratum, 4 to 8 percent slopes	3.6	0.85	0.055	0.148	0.419	0.041	0.378
Developed, High Intensity : Riverwash-Water complex	0.06	0.57	0.086	0.153	0.455	0.02	0.694
Developed, High Intensity : Glenbrook-Rock outcrop complex, 8 to 30 percent slopes	1.39	0.56	0.085	0.164	0.43	0.035	0.055
Developed, High Intensity : Incy fine sand, 4 to 30 percent slopes	0.01	2	0.014	0.048	0.439	0.02	0.694
Developed, Medium Intensity : NoData	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Developed, Medium Intensity : Ursine variant very gravelly fine sandy loam, 8 to 15 percent slopes	0.1	0.3	0.1	0.189	0.416	0.041	0.378
Developed, Medium Intensity : Greenbrae gravelly sandy loam, 4 to 8 percent slopes	4.05	0.48	0.094	0.18	0.415	0.041	0.378

Land Use: Soil Type	Wetting Front Suction (in)	Saturated Hydraulic Conductivity (in/hr)	Initial Soil Water Content (Wilting)	Initial Soil Water Content (F.Capacity)	Saturated Soil Water Content	Residual Soil Water Content	Pore Size Dist. Index
Developed, Medium Intensity : Hocar-Rock outcrop complex, 15 to 50 percent slopes	11.04	0.16	0.136	0.269	0.438	0.027	0.117
Developed, Medium Intensity : Carwalker fine sand	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Developed, Medium Intensity : Hocar-Rock outcrop complex, 15 to 30 percent slopes, eroded	10.99	0.225	0.091	0.225	0.427	0.027	0.117
Developed, Medium Intensity : Surpass coarse sandy loam, 2 to 4 percent slopes MLRA 26	1.5	0.99	0.066	0.154	0.439	0.041	0.378
Developed, Medium Intensity : Jubilee coarse sandy loam, 0 to 2 percent slopes	1.21	1.02	0.09	0.191	0.476	0.041	0.378
Developed, Medium Intensity : Deven-Rock outcrop complex, 4 to 15 percent slopes	17	0.02	0.253	0.385	0.461	0.027	0.117
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Developed, Low Intensity : NoData	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Developed, Low Intensity : Ursine variant very gravelly fine sandy loam, 8 to 15 percent slopes	0.1	0.3	0.1	0.189	0.416	0.041	0.378
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Open Water : NoData	0.01	1.84	0.023	0.061	0.441	0.02	0.694
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Open Water : Incy fine sand, 4 to 30 percent slopes	0.01	2	0.014	0.048	0.439	0.02	0.694
Emergent Herbaceous Wetlands : NoData	0.01	1.84	0.023	0.061	0.441	0.02	0.694
Emergent Herbaceous Wetlands : Ursine variant very gravelly fine sandy loam, 8 to 15 percent slopes	0.1	0.3	0.1	0.189	0.416	0.041	0.378
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Buildings : NoData	0.01	1.84	0.023	0.061	0.441	0.02	0.694
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Buildings : Surpass coarse sandy loam, 2 to 4 percent slopes MLRA 26	1.5	0.99	0.066	0.154	0.439	0.041	0.378
Buildings : Jubilee coarse sandy loam, 0 to 2 percent slopes	1.21	1.02	0.09	0.191	0.476	0.041	0.378
Buildings : Deven-Rock outcrop complex, 4 to 15 percent slopes	17	0.02	0.253	0.385	0.461	0.027	0.117
Buildings : Prey gravelly fine sandy loam, gravelly substratum, 8 to 15 percent slopes	3.6	0.79	0.055	0.148	0.419	0.041	0.378
Buildings : Tarloc-Glenbrook association	1.72	1.08	0.045	0.125	0.421	0.041	0.378
Buildings : Ister-Reywat-Koontz association	5.47	0.43	0.096	0.204	0.43	0.041	0.378
Buildings : Glenbrook-Rock outcrop complex, 30 to 50 percent slopes	0.75	0.63	0.081	0.16	0.432	0.035	0.055
Buildings : Haybourne sandy loam, 4 to 8 percent slopes	3.34	0.72	0.072	0.161	0.423	0.041	0.378
Buildings : Prey fine sandy loam, gravelly substratum, 4 to 8 percent slopes	3.6	0.85	0.055	0.148	0.419	0.041	0.378
Buildings : Riverwash-Water complex	0.06	0.57	0.086	0.153	0.455	0.02	0.694
Buildings : Glenbrook-Rock outcrop complex, 8 to 30 percent slopes	1.39	0.56	0.085	0.164	0.43	0.035	0.055
Buildings : Incy fine sand, 4 to 30 percent slopes	0.01	2	0.014	0.048	0.439	0.02	0.694

Project: Volume Check
Simulation Run: 10-Year
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 24:00

HMS Version: 4.10
Executed: 08 March 2023, 21:19

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	6.2

Loss Rate: Green and Ampt

Element Name	Percent Impervious Area	Initial Variable	Initial Content	Saturated Content	Wetting Front Suction	Hydraulic Conductivity
Subbasin - 1	3.75	Water Content	0.08	0.43	2.87	0.43

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	30	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	6.2	1943.65	01Jan2000, 12:18	0.43

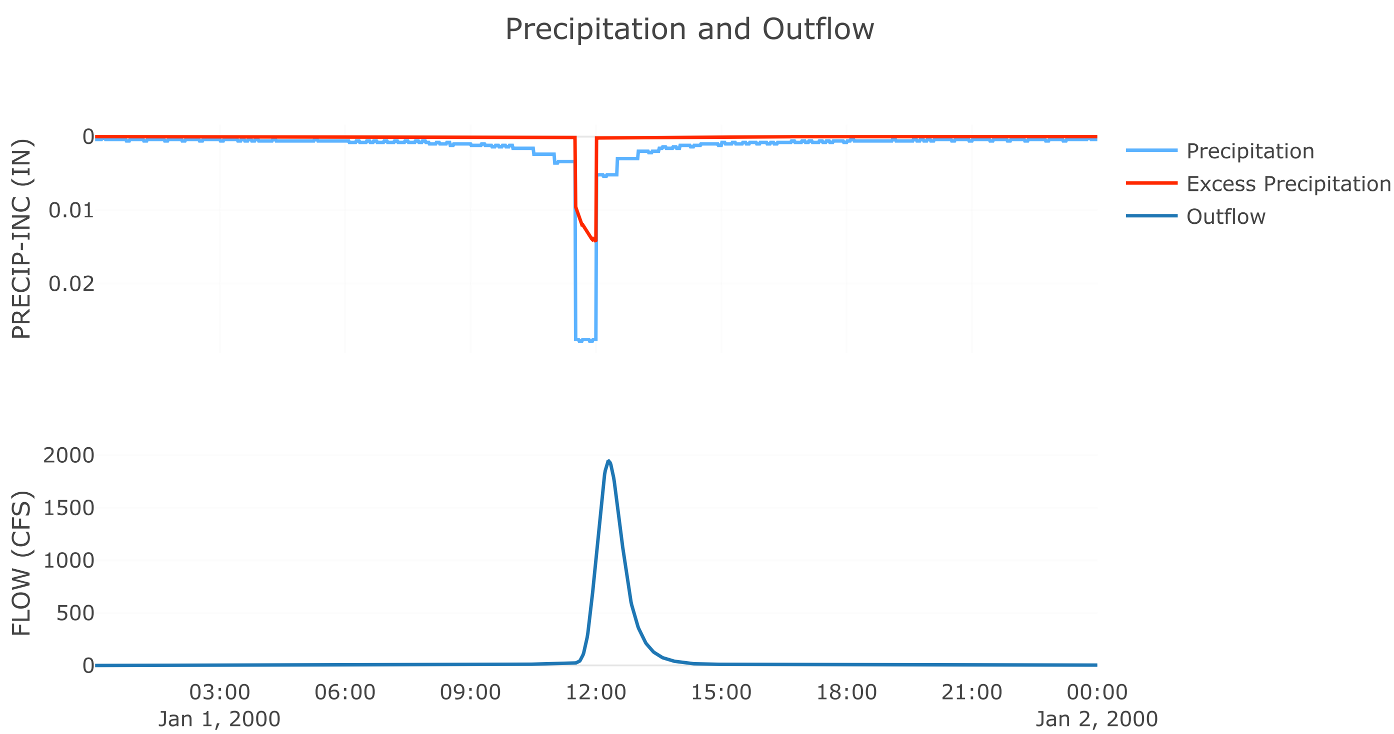
Subbasin: Subbasin-1

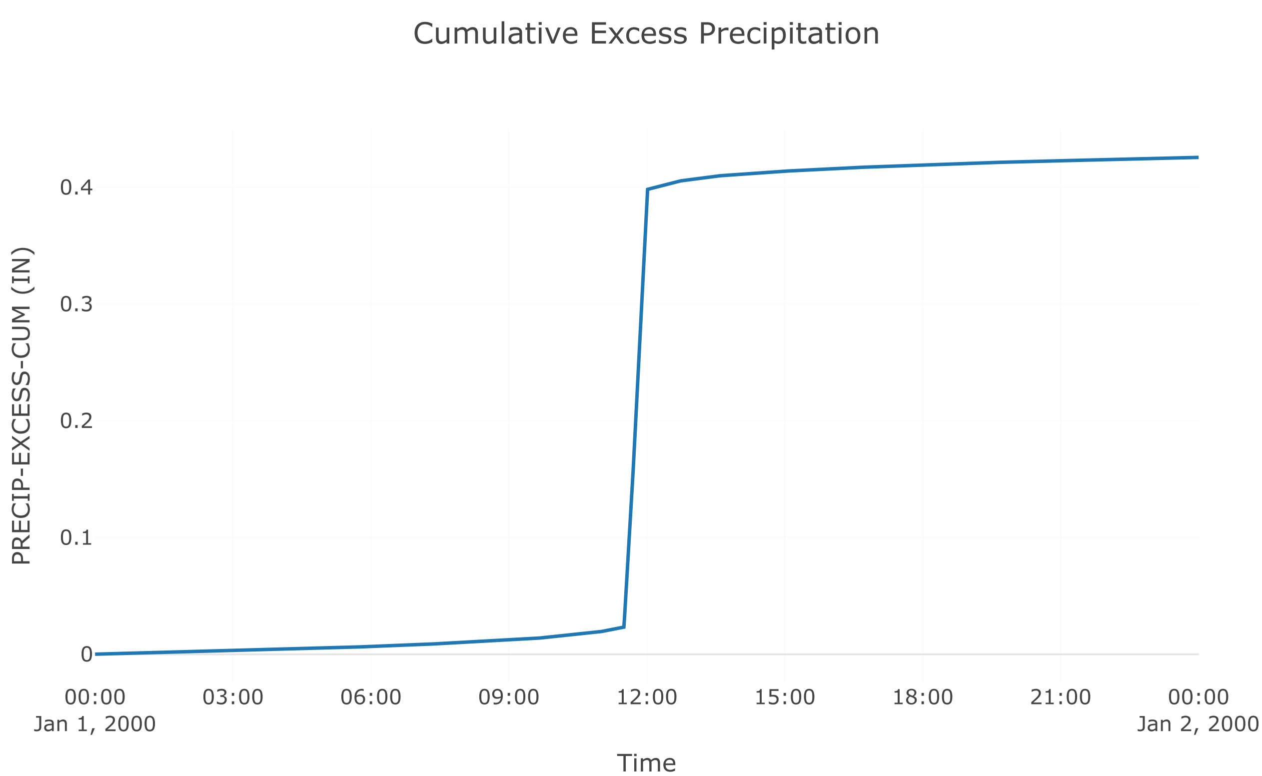
Area (MI2) : 6.2

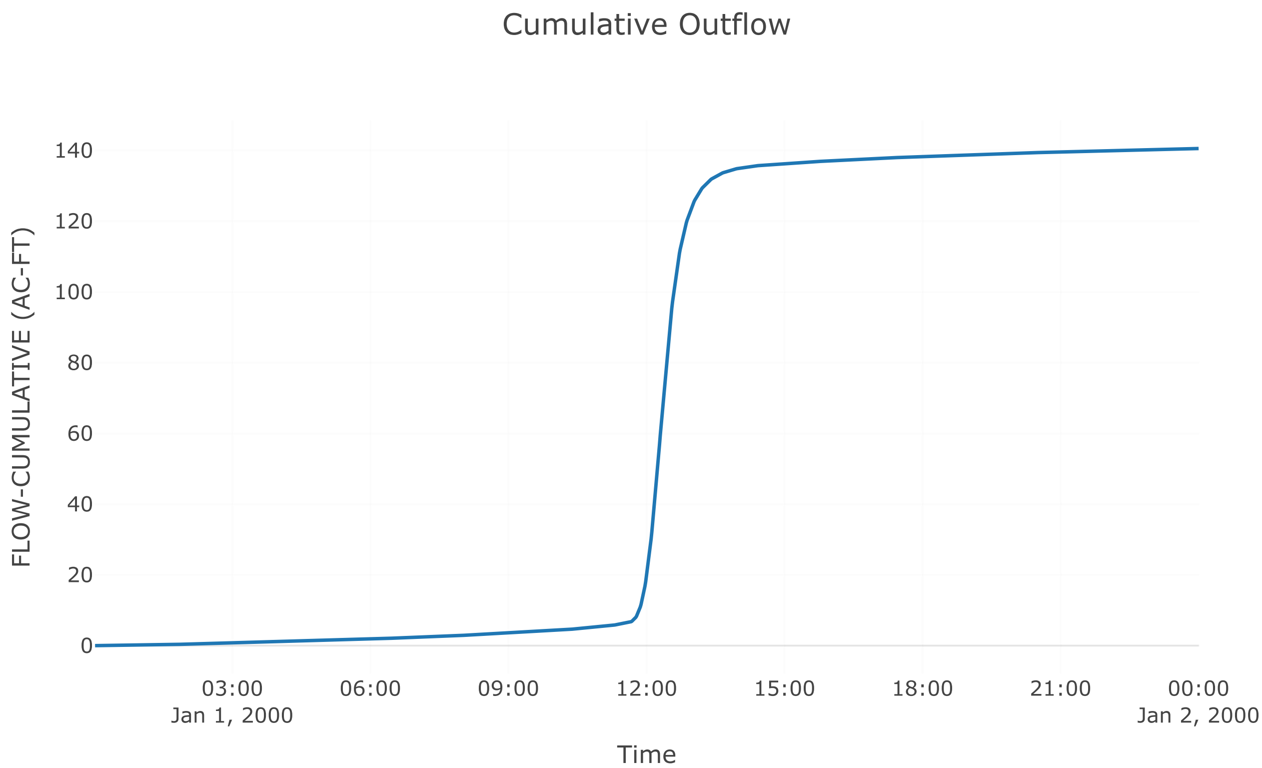
Loss Rate: Green and Ampt	
Percent Impervious Area	3.75
Initial Variable	Water Content
Initial Content	0.08
Saturated Content	0.43
Wetting Front Suction	2.87
Hydraulic Conductivity	0.43

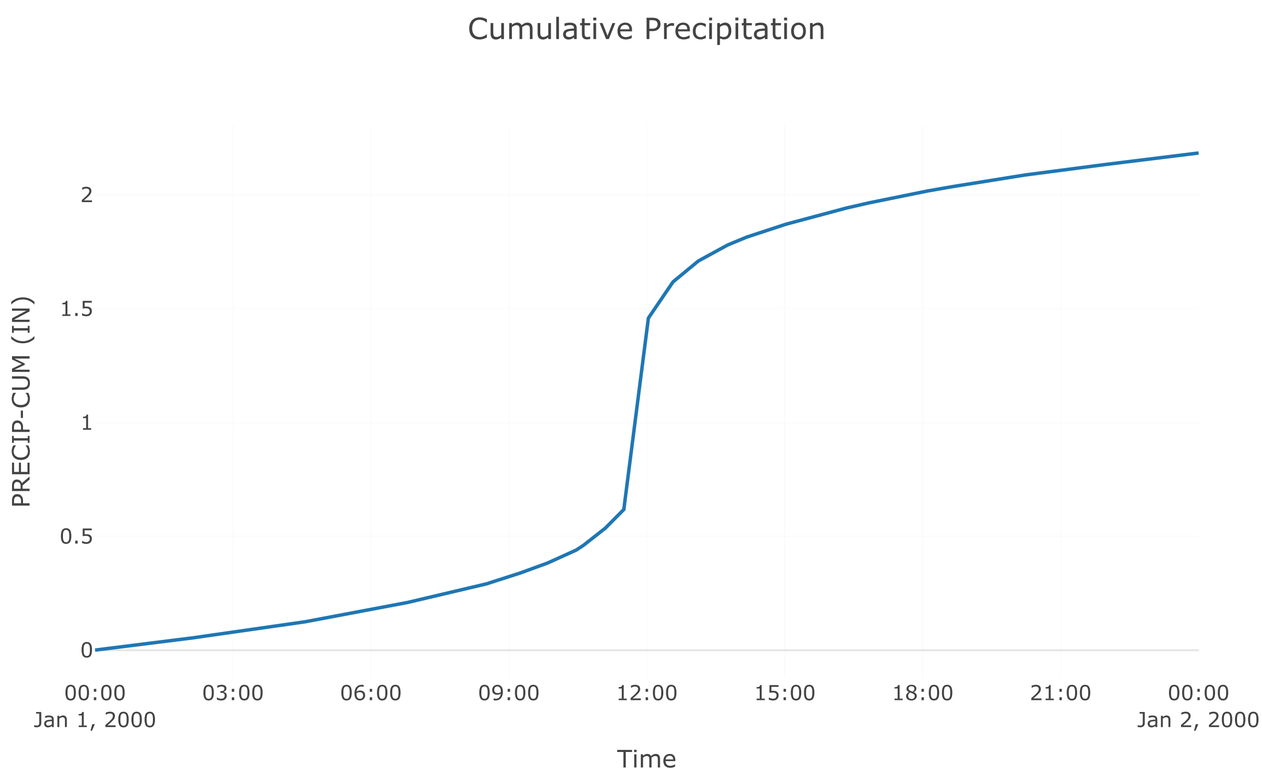
Transform: Scs	
Lag	30
Unitgraph Type	Standard

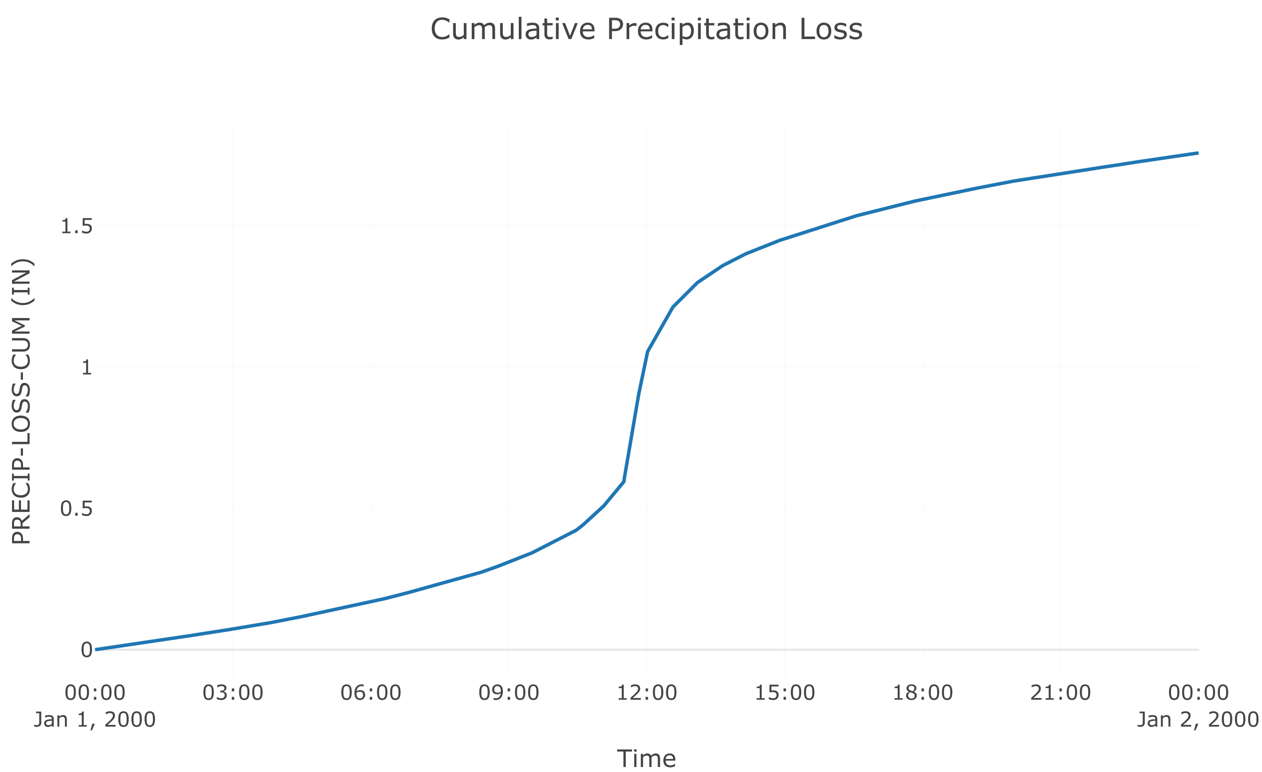
Results: Subbasin-1	
Peak Discharge (CFS)	1943.65
Time of Peak Discharge	01Jan2000, 12:18
Volume (IN)	0.43
Precipitation Volume (AC - FT)	722.18
Loss Volume (AC - FT)	581.45
Excess Volume (AC - FT)	140.72
Direct Runoff Volume (AC - FT)	140.54
Baseflow Volume (AC - FT)	0


Precipitation and Outflow
PRECIP-INC (IN)
0
0.01
0.02
Precipitation
Excess Precipitation
Outflow
FLOW (CFS)
2000
1500
1000
500
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000

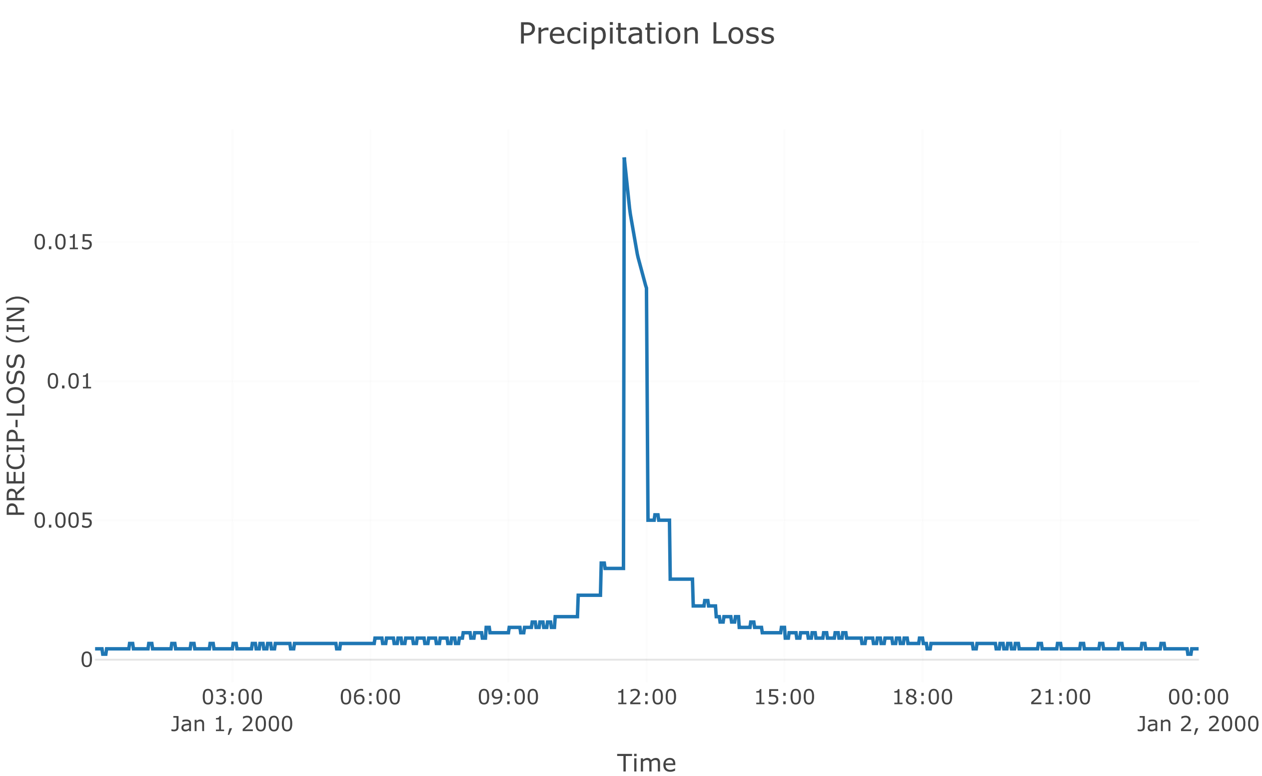

Cumulative Excess Precipitation
PRECIP-EXCESS-CUM (IN)
0.4
0.3
0.2
0.1
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Cumulative Outflow
FLOW-CUMULATIVE (AC-FT)
140
120
100
80
60
40
20
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time

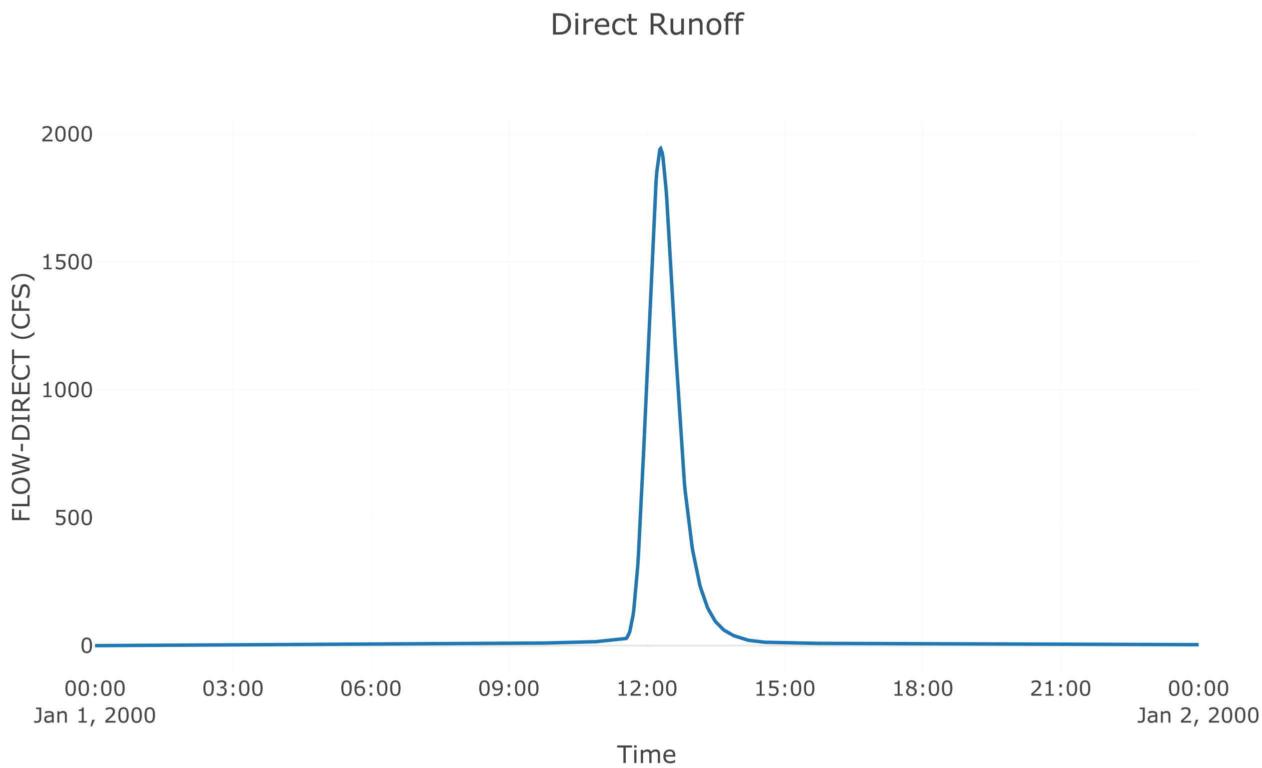

Cumulative Precipitation
PRECIP-CUM (IN)
2
1.5
1
0.5
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time

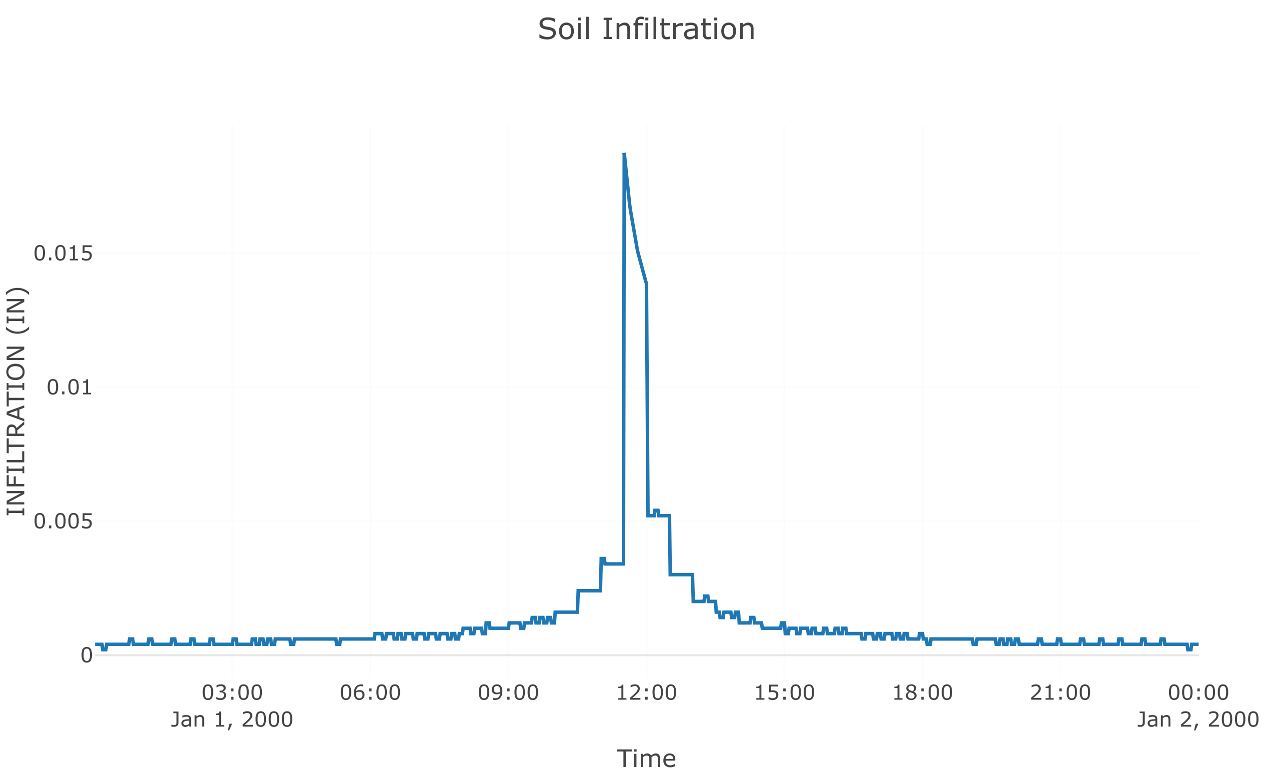


Cumulative Precipitation Loss
PRECIP-LOSS-CUM (IN)
1.5
1
0.5
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time



Precipitation Loss
PRECIP-LOSS (IN)
0.015
0.01
0.005
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Direct Runoff
2000
1500
1000
500
0
FLOW-DIRECT (CFS)
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Soil Infiltration
0.015
0.01
0.005
0
INFILTRATION (IN)
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time

Project: Volume Check
Simulation Run: 25-Year
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 24:00

HMS Version: 4.10
Executed: 13 December 2022, 05:21

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	6.2

Loss Rate: Green and Ampt

Element Name	Percent Impervious Area	Initial Variable	Initial Content	Saturated Content	Wetting Front Suction	Hydraulic Conductivity
Subbasin - 1	3.75	Water Content	0.08	0.43	2.87	0.43

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	30	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	6.2	2924.73	01Jan2000, 12:17	0.63

Subbasin: Subbasin-1

Area (MI2) : 6.2

Loss Rate: Green and Ampt

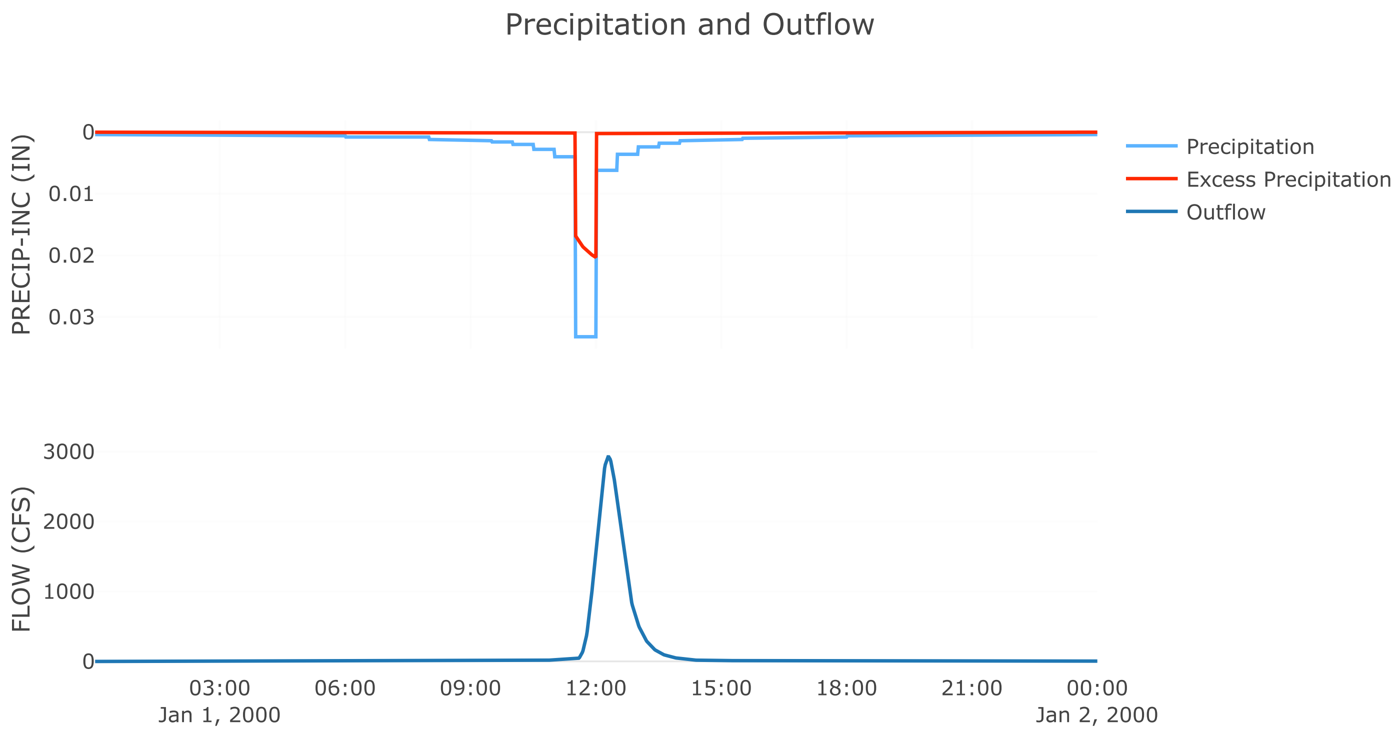
Percent Impervious Area	3.75
Initial Variable	Water Content
Initial Content	0.08
Saturated Content	0.43
Wetting Front Suction	2.87
Hydraulic Conductivity	0.43

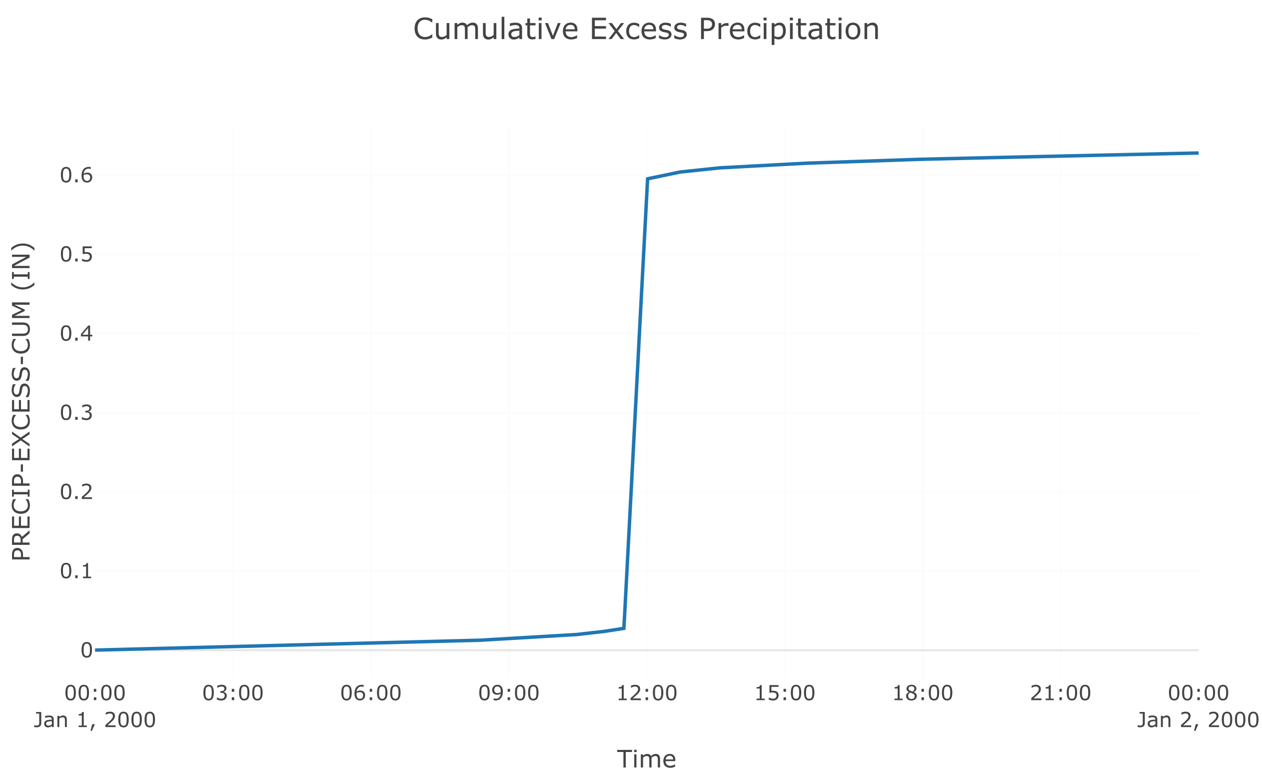
Transform: Scs

Lag	30
Unitgraph Type	Standard

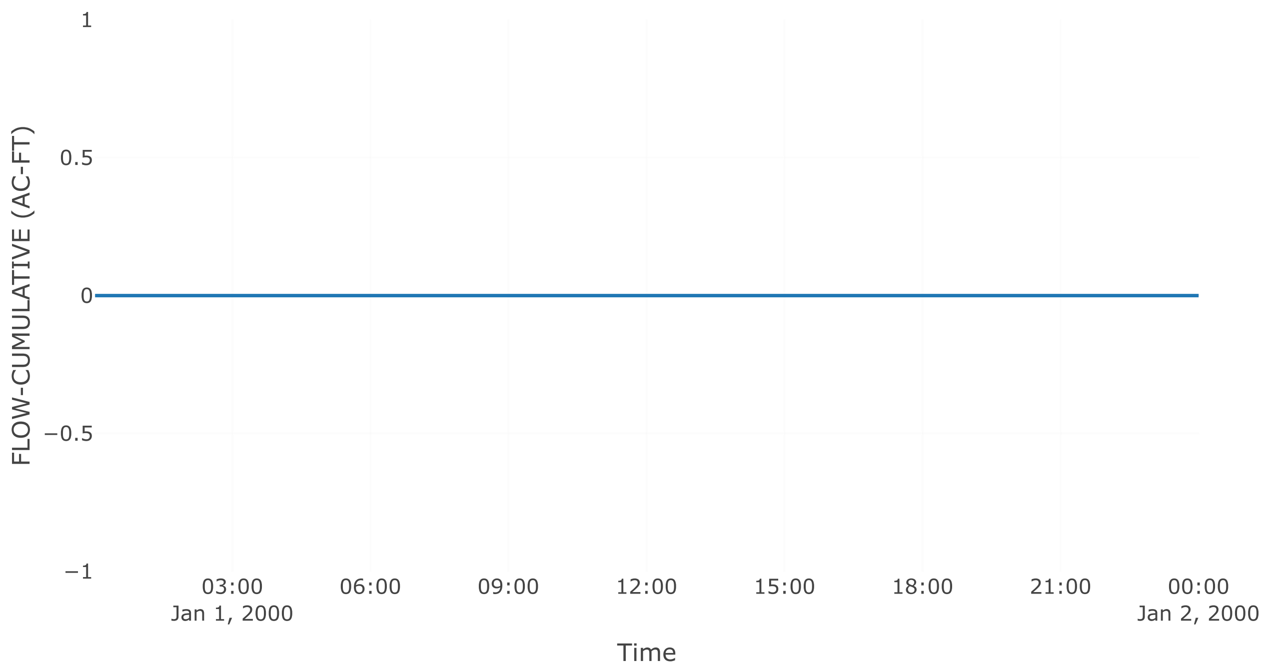
Results: Subbasin-1

Peak Discharge (CFS)	2924.73
Time of Peak Discharge	01Jan2000, 12:17
Volume (IN)	0.63
Precipitation Volume (AC - FT)	861.06
Loss Volume (AC - FT)	653.46
Excess Volume (AC - FT)	207.59
Direct Runoff Volume (AC - FT)	207.37
Baseflow Volume (AC - FT)	0

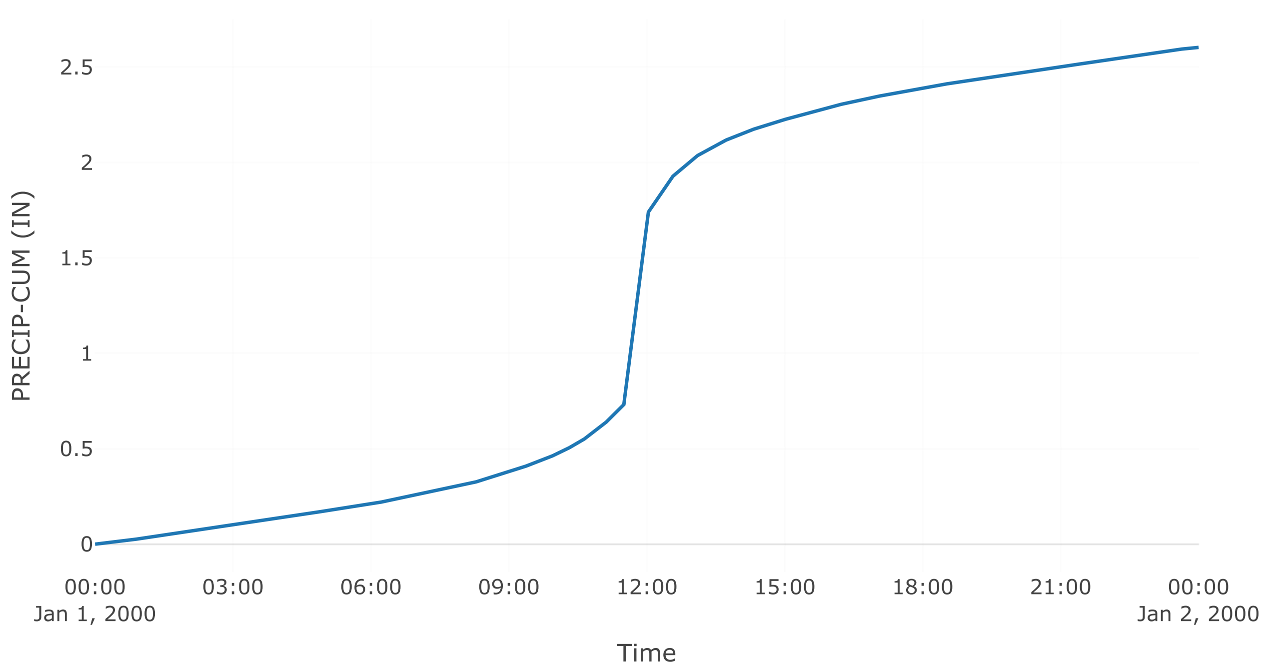

Precipitation and Outflow
PRECIP-INC (IN)
0
0.01
0.02
0.03
Precipitation
Excess Precipitation
Outflow
FLOW (CFS)
3000
2000
1000
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000

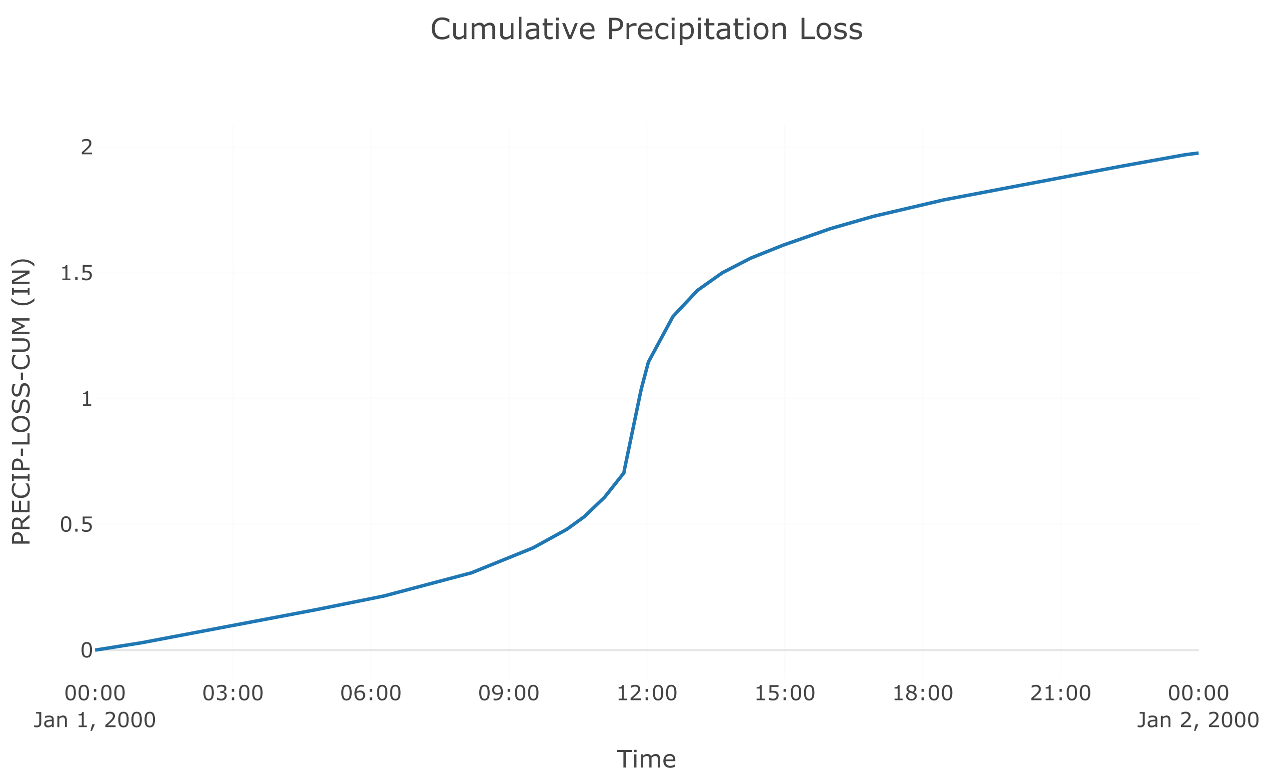

Cumulative Excess Precipitation
PRECIP-EXCESS-CUM (IN)
0.6
0.5
0.4
0.3
0.2
0.1
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time

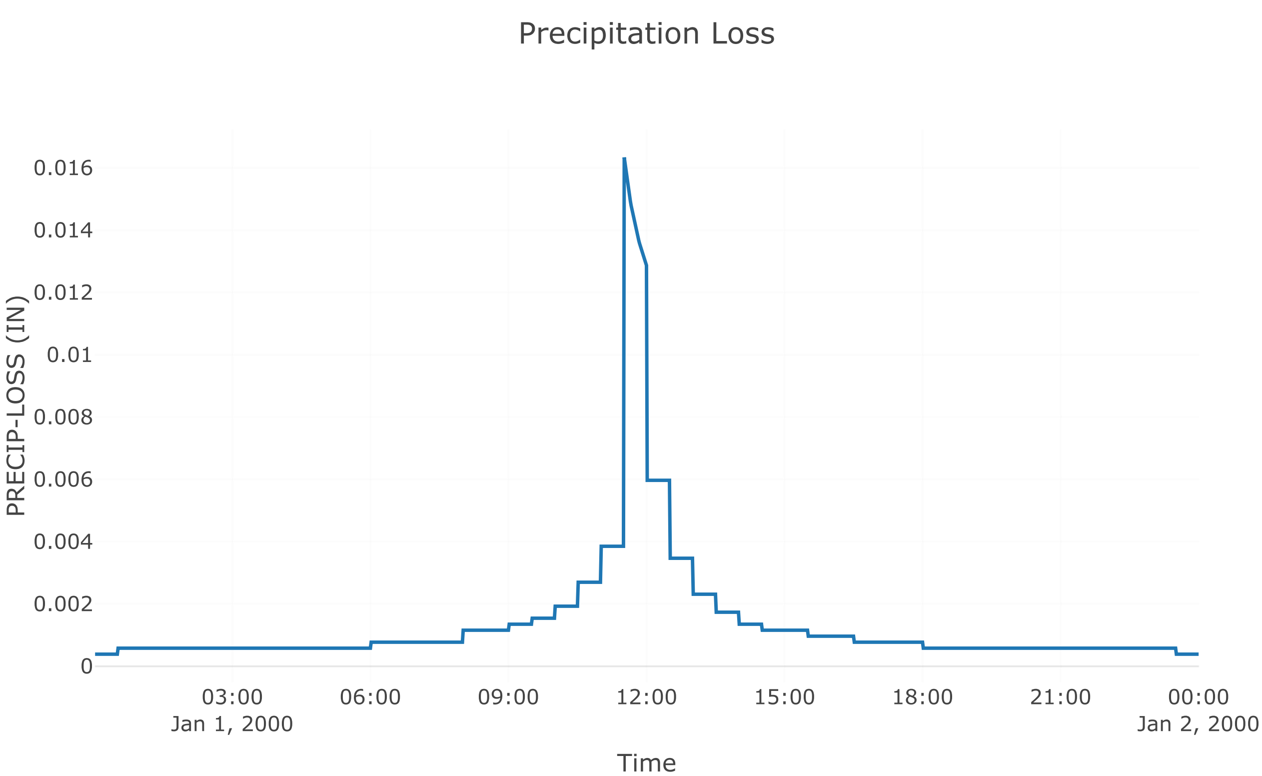
Cumulative Outflow

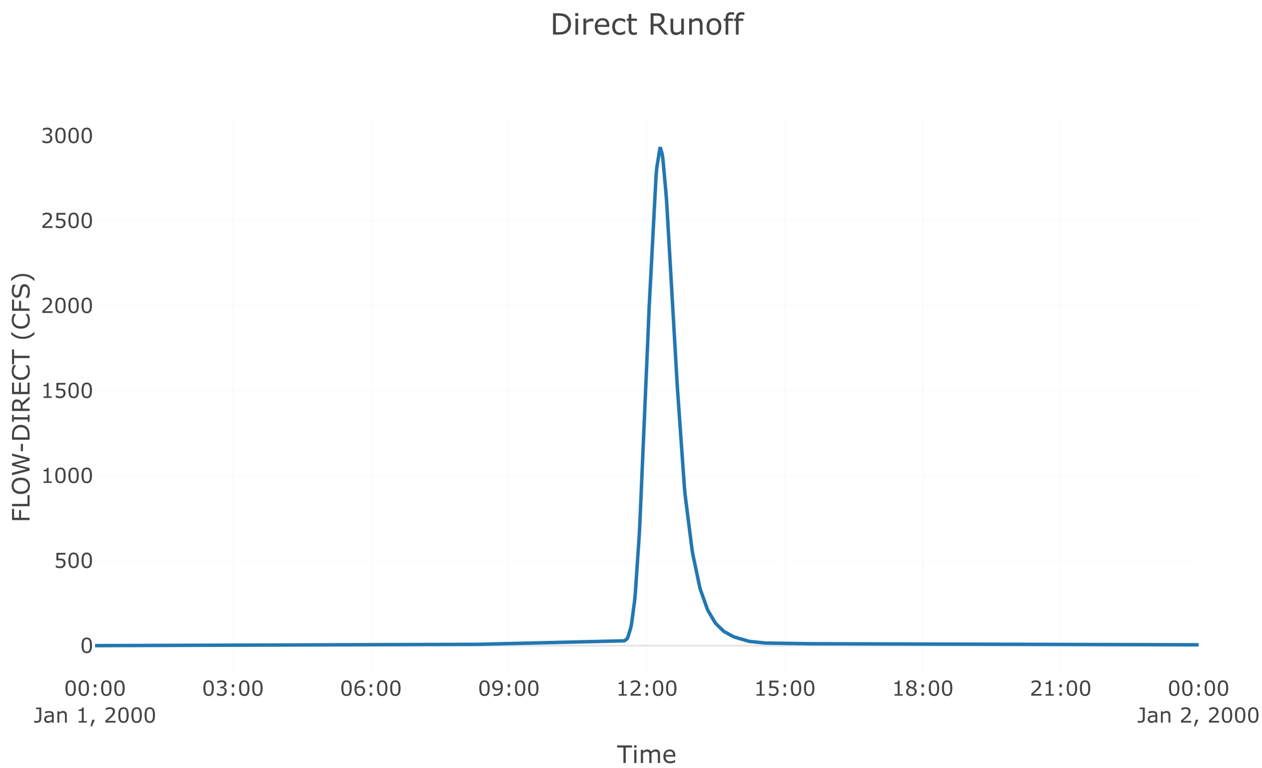


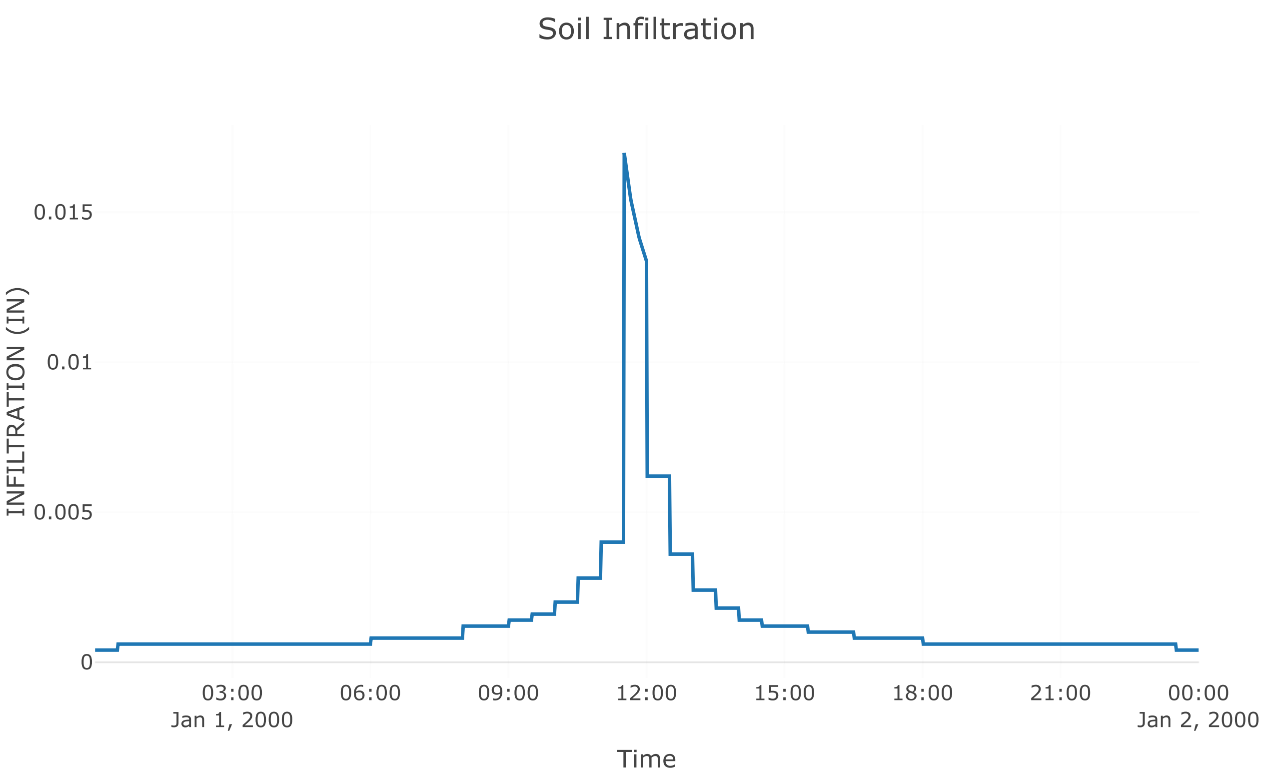
Cumulative Precipitation




Cumulative Precipitation Loss
PRECIP-LOSS-CUM (IN)
2
1.5
1
0.5
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Precipitation Loss
PRECIP-LOSS (IN)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Direct Runoff
FLOW-DIRECT (CFS)
3000
2500
2000
1500
1000
500
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Soil Infiltration
INFILTRATION (IN)
0.015
0.01
0.005
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time

Project: Volume Check
Simulation Run: 100-Year
Simulation Start: 31 December 1999, 24:00
Simulation End: 1 January 2000, 24:00

HMS Version: 4.10
Executed: 08 March 2023, 21:24

Global Parameter Summary - Subbasin

Area (MI2)

Element Name	Area (MI2)
Subbasin - 1	6.2

Loss Rate: Green and Ampt

Element Name	Percent Impervious Area	Initial Variable	Initial Content	Saturated Content	Wetting Front Suction	Hydraulic Conductivity
Subbasin - 1	3.75	Water Content	0.08	0.43	2.87	0.43

Transform: Scs

Element Name	Lag	Unitgraph Type
Subbasin - 1	30	Standard

Global Results Summary

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
Subbasin - 1	6.2	5186.18	01Jan2000, 12:17	1.09

Subbasin: Subbasin-1

Area (MI2) : 6.2

Loss Rate: Green and Ampt

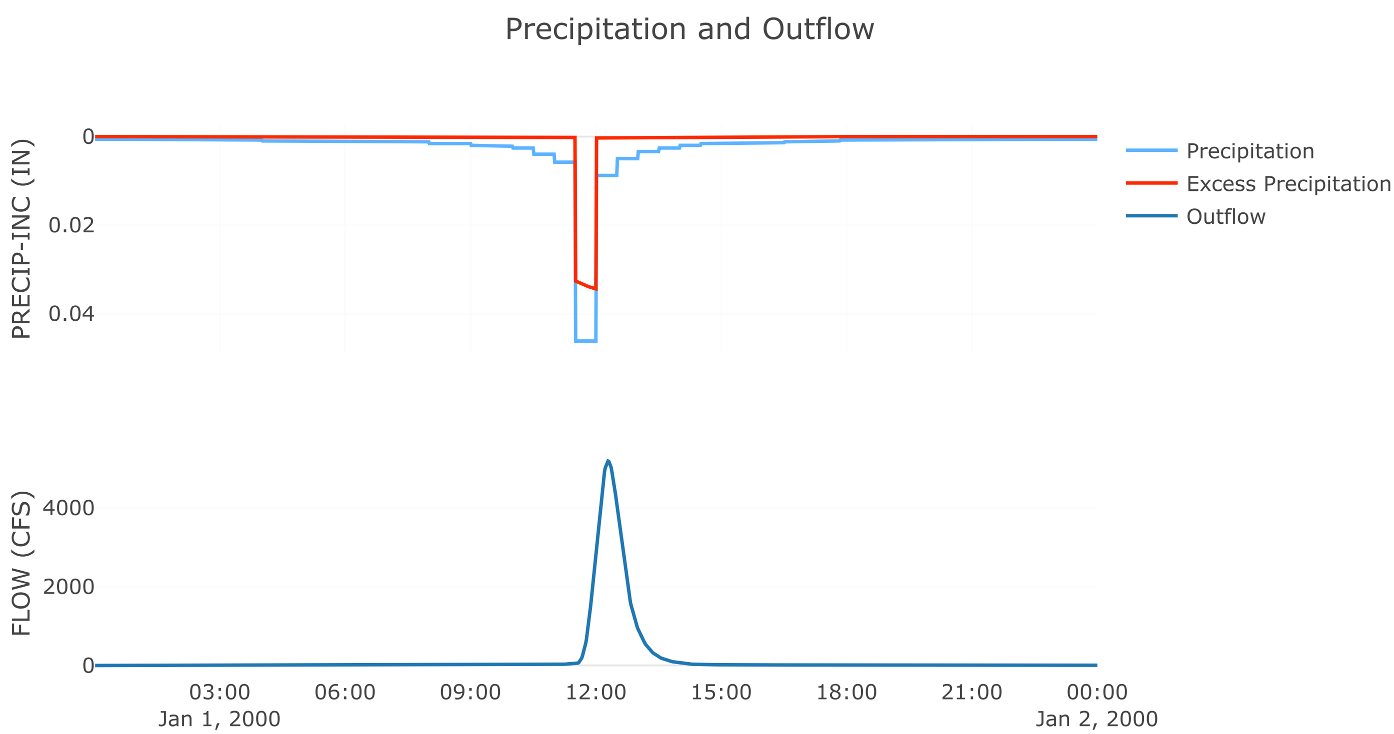
Percent Impervious Area	3.75
Initial Variable	Water Content
Initial Content	0.08
Saturated Content	0.43
Wetting Front Suction	2.87
Hydraulic Conductivity	0.43

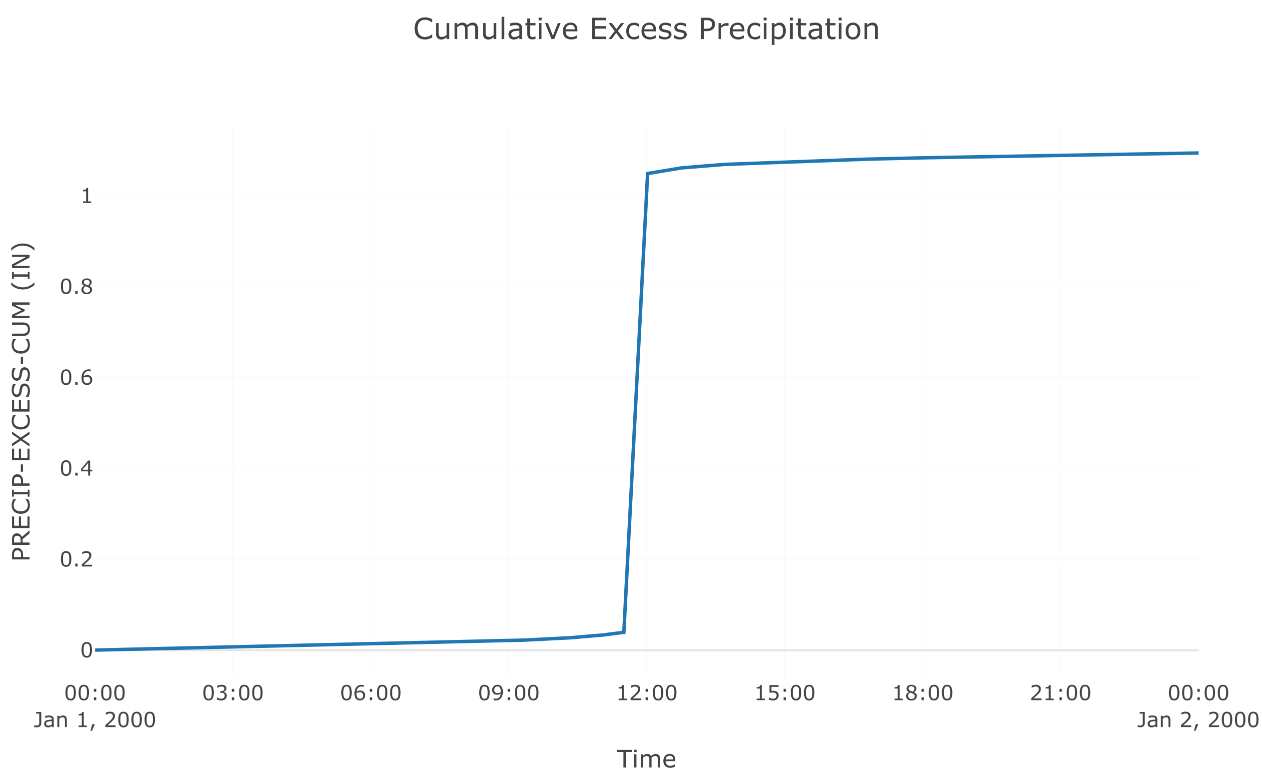
Transform: Scs

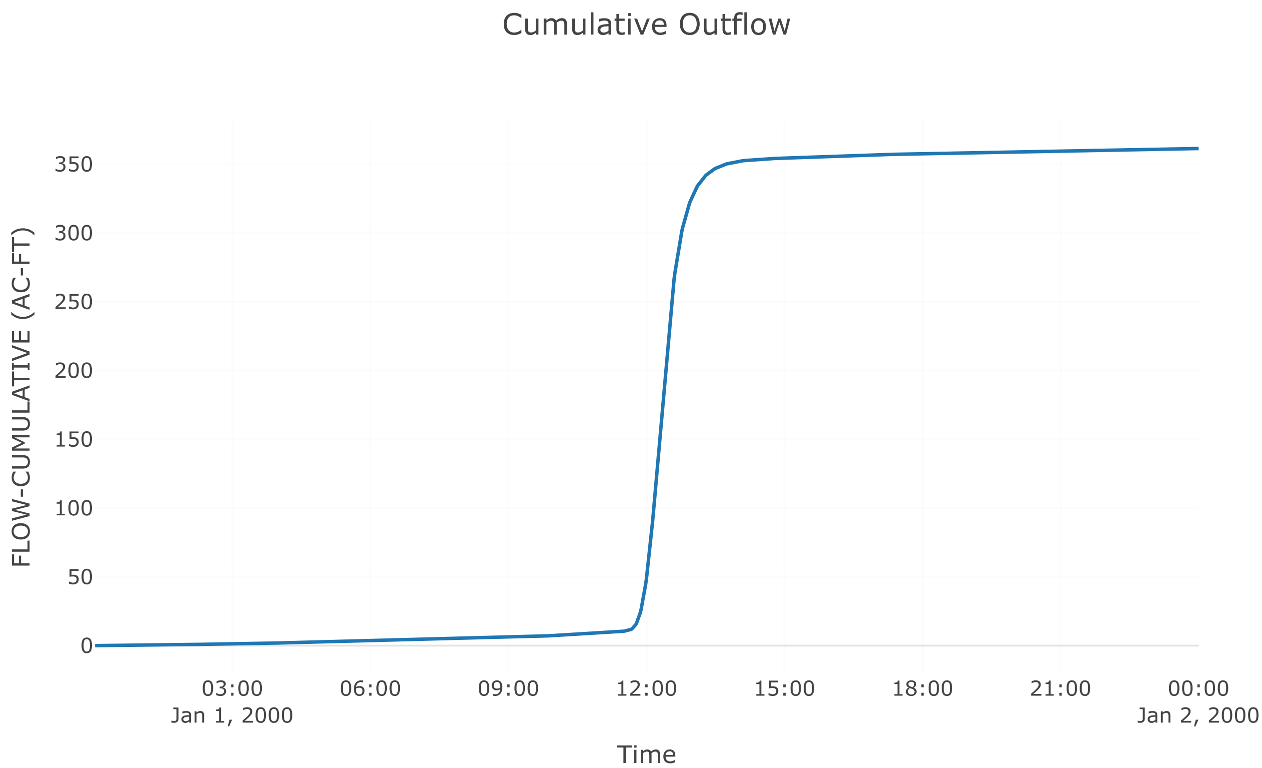
Lag	30
Unitgraph Type	Standard

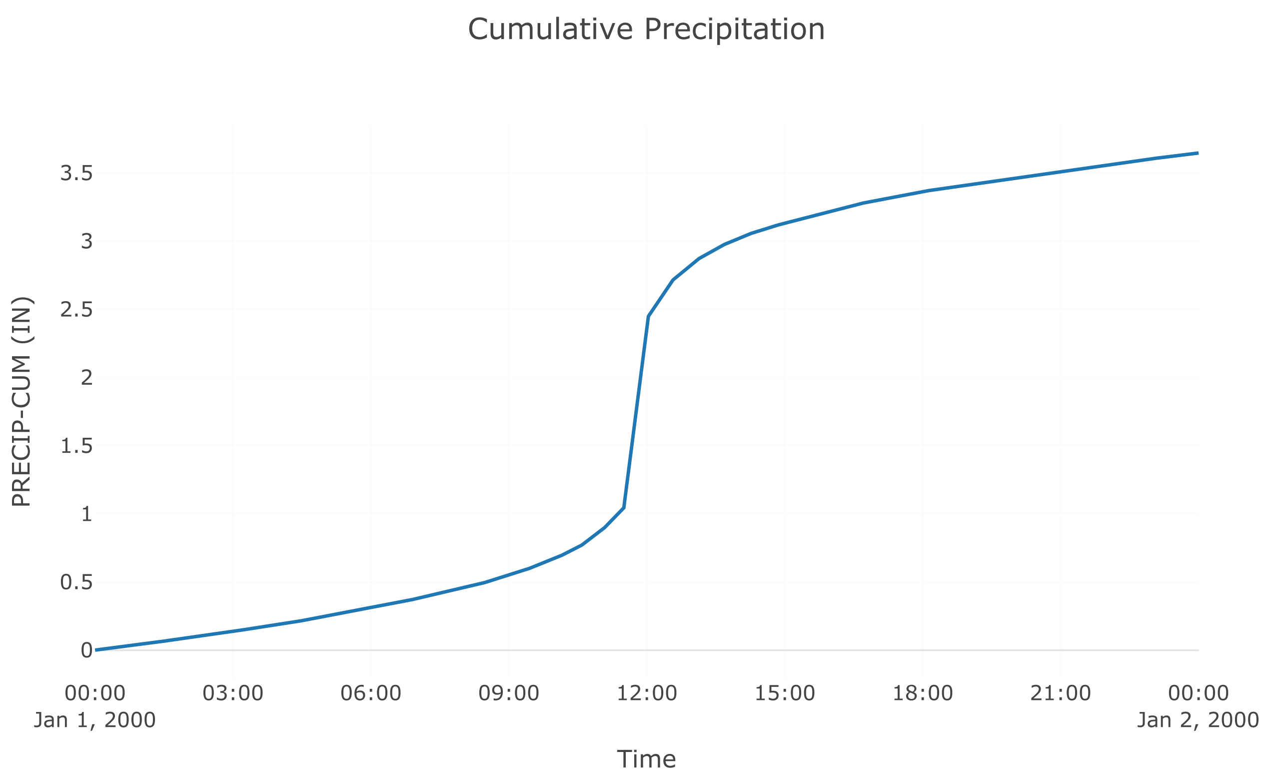
Results: Subbasin-1

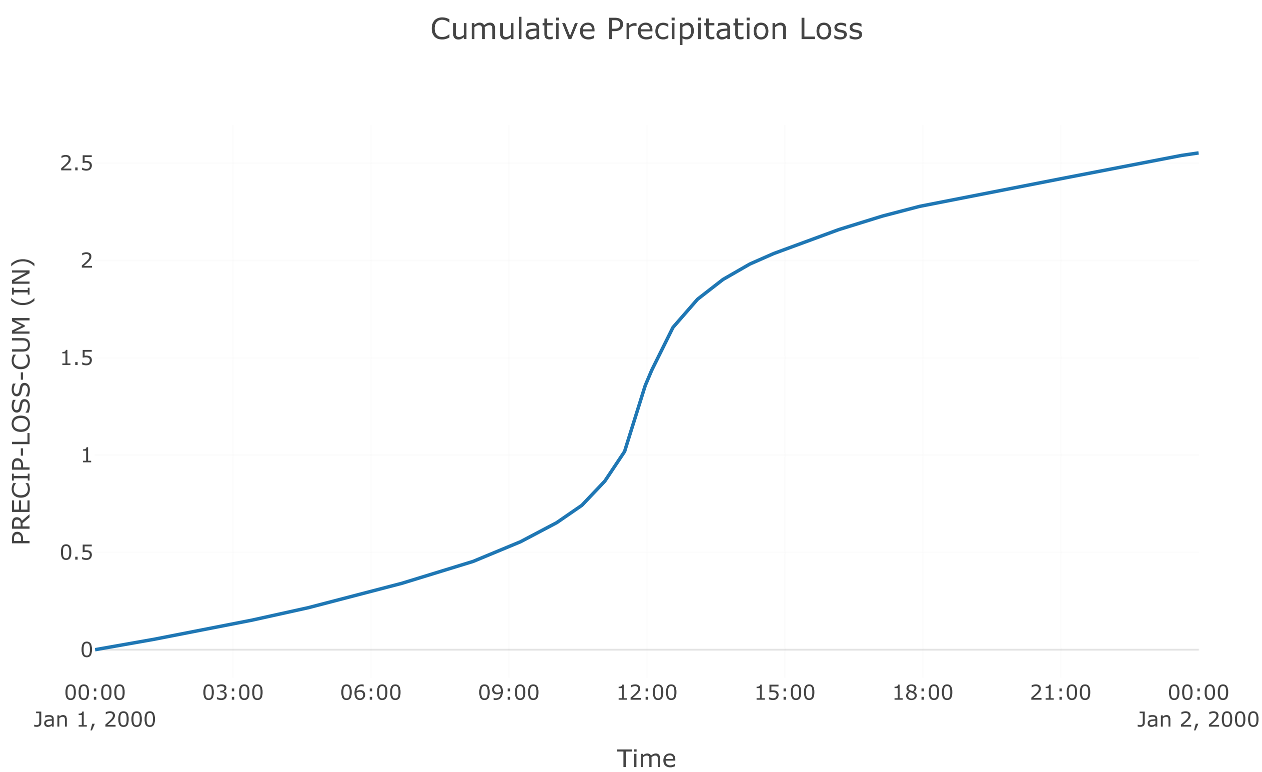
Peak Discharge (CFS)	5186.18
Time of Peak Discharge	01Jan2000, 12:17
Volume (IN)	1.09
Precipitation Volume (AC - FT)	1205.61
Loss Volume (AC - FT)	843.88
Excess Volume (AC - FT)	361.73
Direct Runoff Volume (AC - FT)	361.41
Baseflow Volume (AC - FT)	0

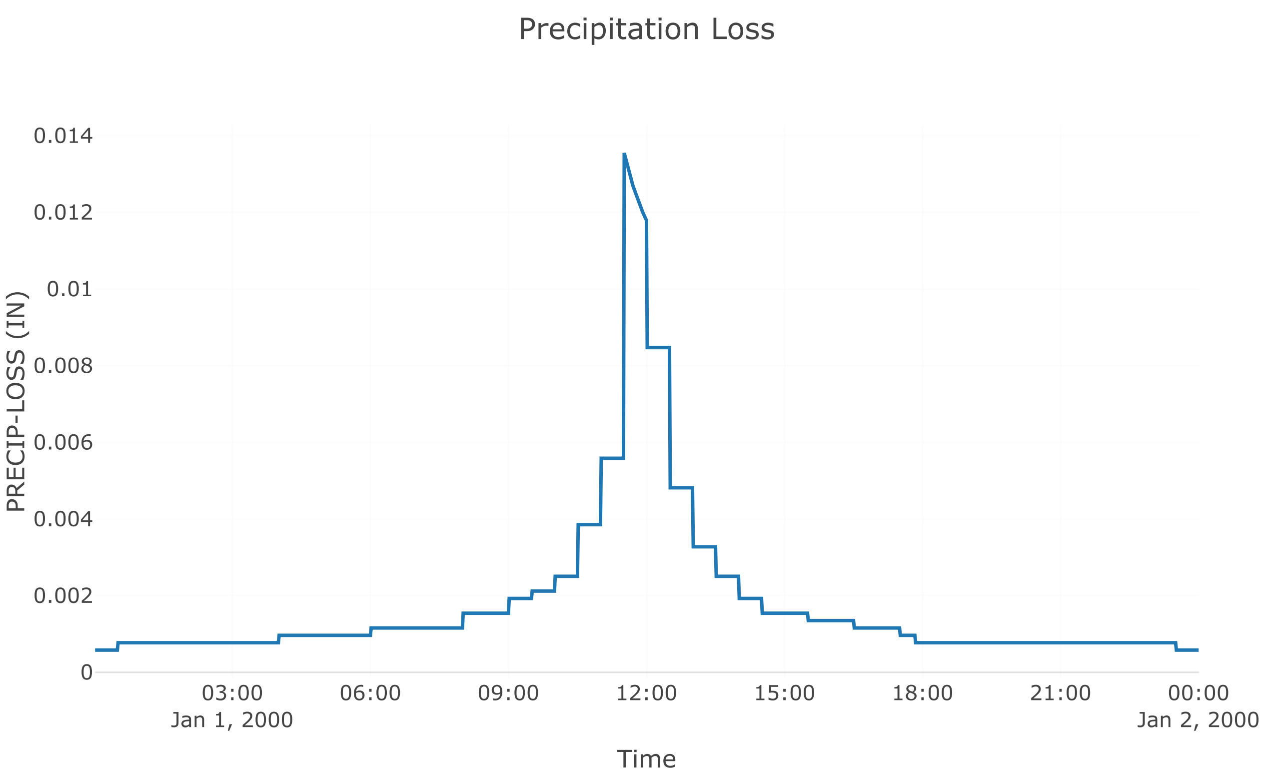

Precipitation and Outflow
PRECIP-INC (IN)
0
0.02
0.04
Precipitation
Excess Precipitation
Outflow
FLOW (CFS)
4000
2000
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000

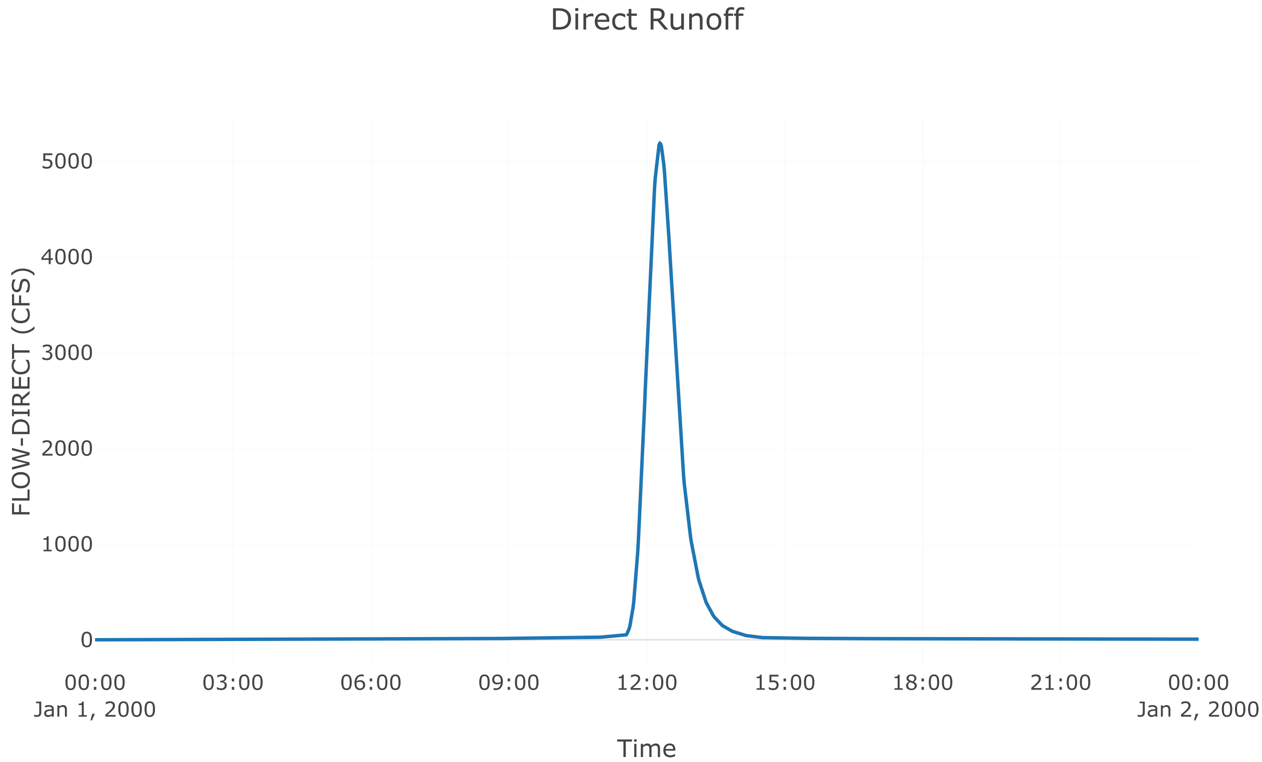

Cumulative Excess Precipitation
PRECIP-EXCESS-CUM (IN)
1
0.8
0.6
0.4
0.2
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time

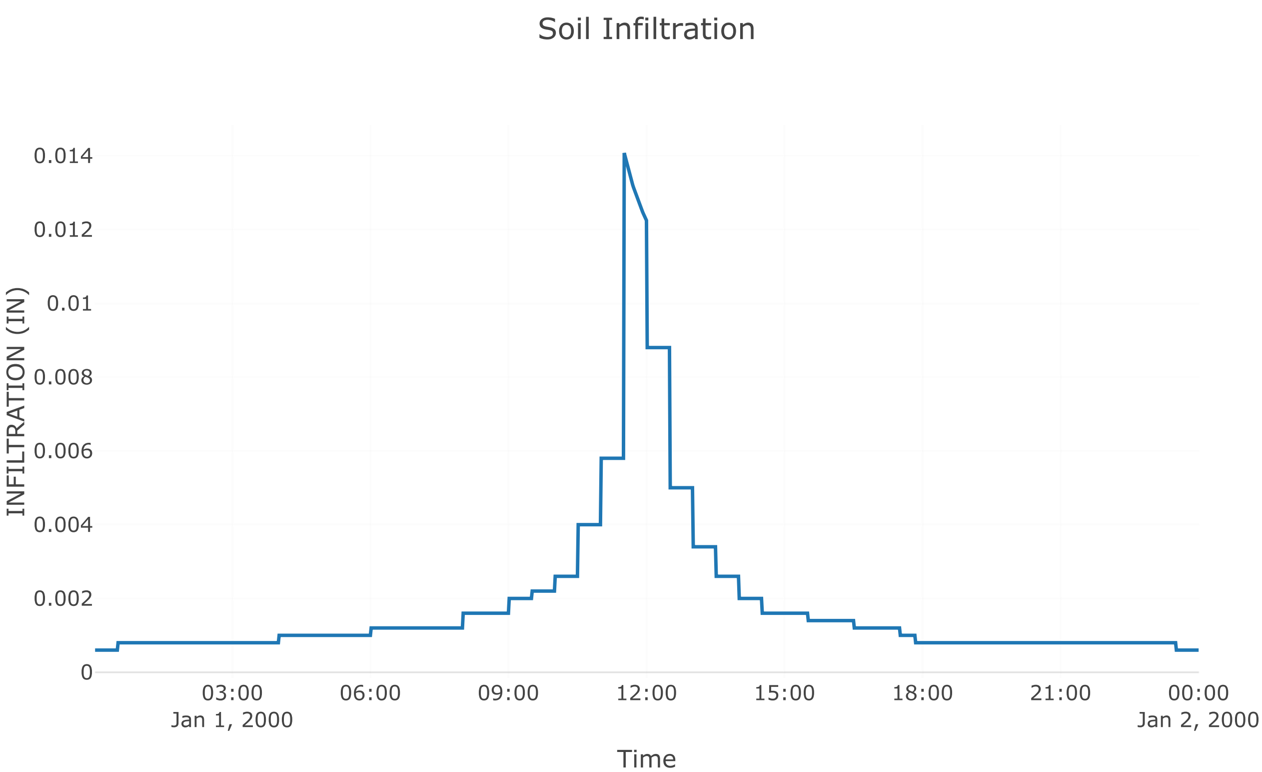

Cumulative Outflow
FLOW-CUMULATIVE (AC-FT)
0
50
100
150
200
250
300
350
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Cumulative Precipitation
PRECIP-CUM (IN)
0
0.5
1
1.5
2
2.5
3
3.5
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Cumulative Precipitation Loss
PRECIP-LOSS-CUM (IN)
0
0.5
1
1.5
2
2.5
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Precipitation Loss
PRECIP-LOSS (IN)
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Direct Runoff
FLOW-DIRECT (CFS)
5000
4000
3000
2000
1000
0
00:00
Jan 1, 2000
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time


Soil Infiltration
INFILTRATION (IN)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
03:00
Jan 1, 2000
06:00
09:00
12:00
15:00
18:00
21:00
00:00
Jan 2, 2000
Time

Appendix B – Outreach

EAST CARSON CITY
AREA DRAINAGE MASTER PLAN

RESIDENT OUTREACH INFORMATION MEETING

Have you experienced flooding or have storm runoff issues on your property?

You are invited to an outreach event to discuss local flooding or drainage concerns in your neighborhood. Meet with Carson City staff and drainage experts to explore options to improve conditions to prevent damage to your home and property.

JOIN US ON
Tuesday, June 21, 2022 | 5:30-6:30 pm

Carson City Sheriff's Office Ormsby Room
911 East Musser Street, Carson City

stormwaterhotline@carson.org
(775) 887-2305

CAN'T MAKE IT? PARTICIPATE VIA ZOOM
Phone: +1 (669) 900-6833
Meeting ID: 857 4998 1141

Share your concerns, comments and identify locations of past flood issues on our interactive map using this QR code on your phone or https://arcg.is/i94b90

Carson City Public Works
3505 Butti Way
Carson City, NV 89701

East Carson City Area Drainage Plan (ADMP): Carson Water Subconservancy Di... Stakeholder Engagement

About

THE GREAT SEAL OF THE MUNICIPALITY OF CARSON CITY, NEVADA
FOUNDED 1858
"Proud of its Past... Confident of its Future"

East Carson City Area Drainage Master Plan (ADMP): Carson Water Subconservancy District (CWSD) Stakeholder Engagement

Project Description: Carson Water Subconservancy District (CWSD) in collaboration with Carson City is conducting a drainage study for the East Carson area. The primary purpose of the East Carson City ADMP is to identify and quantify the flood hazard risk within the Pinion Hills Area. The watershed study will include hydrology and hydraulic analysis to identify existing deficiencies and propose infrastructure to reduce the number of properties and structures located in the flood areas an which may be subject to shallow flooding. The project objective and goals will include:

East Carson Area Drainage Master Plan (ADMP)

Public Outreach – Meeting #1

June 20, 2022

Michael Baker INTERNATIONAL | We Make a Difference

1

Agenda

- Introduction
- Watershed Model – Carlos Rendo
- Project Overview
- Public Outreach

2

Project Partners

Michael Baker INTERNATIONAL

CARSON CITY PUBLIC WORKS

CARSON WATER SUBCONSERVANCY DISTRICT

FEMA

We Make a Difference

3

3

Study Area

- Watershed Area
  - ~8 square miles
  - Pinion Hills Area
  - 13 Canyons
- Not a Mapped FEMA Floodplain
- Approximately 200 addresses/landowners

Project Purpose

Michael Baker INTERNATIONAL

- Identify and Quantify Flood Hazard
  - Pinion Hills – East Carson City
  - Evaluate the needed infrastructure to reduce the number of properties and structures located in flood areas and which may be subject to shallow flooding.

Project Goals

Michael Baker INTERNATIONAL

- Data Collection
- Identify and quantify flood risk within the study area
- Establish guidance for future development
- Establish a flood hazard mitigation strategy
- Public Outreach

Public Outreach

Michael Baker INTERNATIONAL

- Informational Meeting for Residents
- Engage residents and stakeholders
- Solicit feedback throughout the study
- Obtain Information for model validation
- Educate community on flood hazards

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7

Web Portal

Michael Baker INTERNATIONAL

We Make a Difference 8

8

Next Steps

Michael Baker INTERNATIONAL

- Continue the Baseline Modeling
- Alternative Analysis
  - Project Fact Sheet
- Board Presentation
- Schedule
  - 2nd Public Input/Presentation – Late 2022
  - Project Completion – Spring 2023

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Michael Baker INTERNATIONAL | *We Make a Difference*

- For more Information, please contact:
  - Robb Fellows, PE
    rfellows@carson.org
  - Mujahid Chandoo, PE
    mchandoo@mbakerintl.com

10

Nevada Flood Awareness Week

Wednesday, November 16, 2022

Pinion Hills Residents – help us help you prevent flooding in your neighborhood!

Opportunities to meet with us on November 16

Carson City Public Works staff will be visiting your neighborhood to assess road culverts and past flooded areas.

**Please feel free to stop and talk to us, tell us about any drainage or flood problems you have experienced. If you have suggestions on improvements to prevent flooding, let us know!

NEVADA FLOODS .ORG

- **Community Outreach Event** - 11.30-1.30 Richard H. Bryan Building, 901 S. Stewart Street

or

- Carson City – staff field visit:

Look for us on Pinion Hills Drive or S. Deer Run Road

Call us to schedule a site visit: (775) 882-2305

or

- View our interactive map anytime at:

arcg.is/i94b90

Carson City Public Works
3505 Butti Way
Carson City, NV 89701

Carson City Public Works
3505 Butti Way
Carson City, NV 89701

FEMA

Carson City
Stormwater Management
Program

EAST CARSON CITY
AREA DRAINAGE MASTER PLAN

RESIDENT OUTREACH FOR ALTERNATIVE SOLUTIONS

Use this QR code on your phone or go to the link below to provide feedback or tell us about past flooding in your neighborhood.
https://www.surveymonkey.com/r/3RFHXNH

*We will be in your neighborhood on **Monday, February 13th**. Please watch for us as we go door-to-door or call us to schedule a visit with you (775-887-2305).*

Look inside for maps and more information. Your feedback is important.

Carson City Public Works has identified the potential of flooding in the neighborhood of Pinon Hills as a result of runoff in the washes from the hills above. We would like to present alternative solutions that could be constructed to convey the water away from homes and/or access roads to prevent future flooding.

Please see the enclosed map for which we have proposed a solution. We would like your input as it may affect you and your property directly.

CONTACT US

Office: 3505 Butti Way Carson City, NV 89701
Call the Hotline: (775) 887-2305
Email us: stormwaterhotline@carson.org

Carson City Stormwater Management Program

WANT TO LEARN MORE?

Contact your local community officials. Start with the local planning and zoning office or building department, and ask to speak with the designated floodplain administrator.

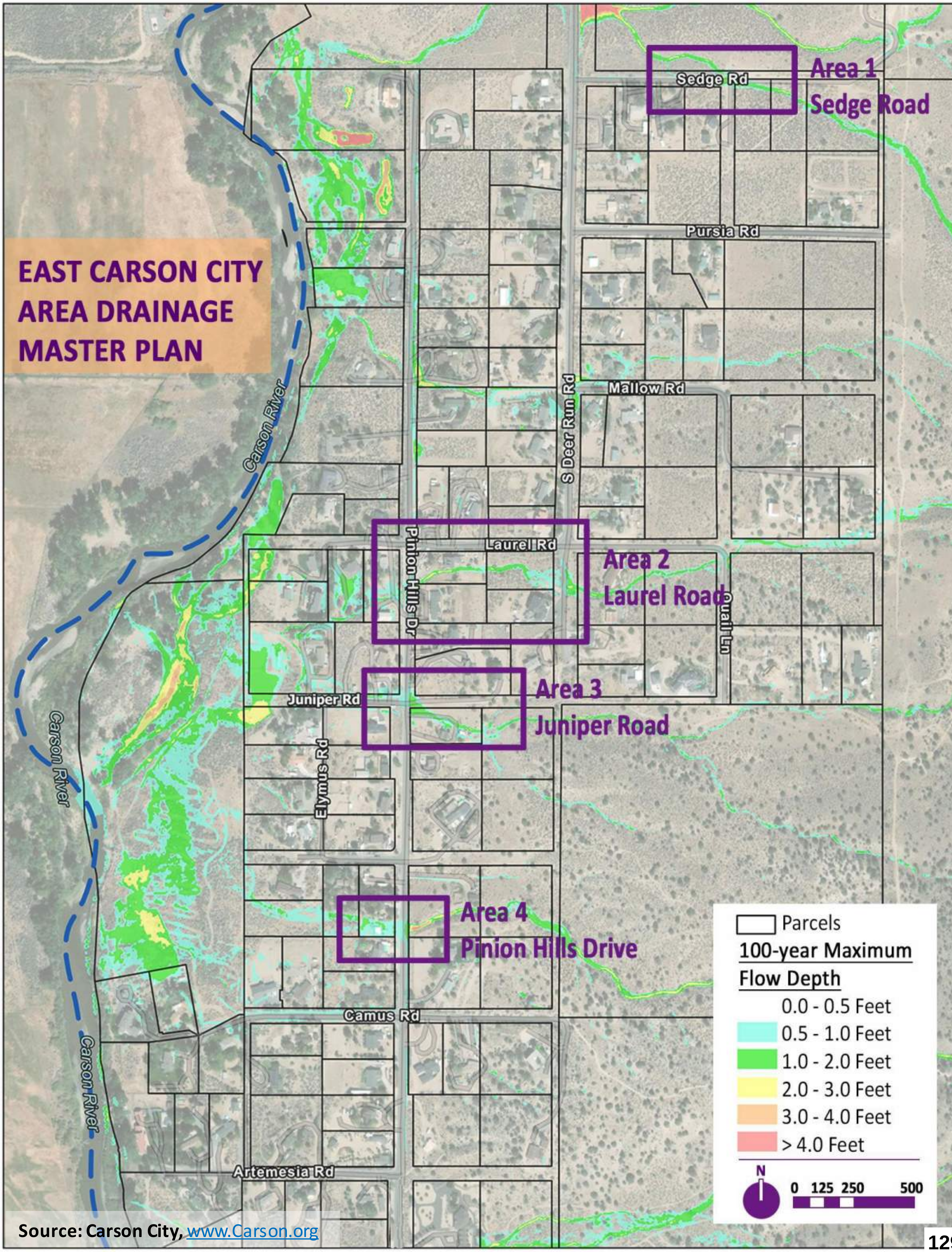
Visit the following websites for more information.

Carson City Stormwater Management Program
http://carsonsw.org/

FEMA Protect Your Property
www.fema.gov/protect-your-property

FloodSmart
www.floodsmart.gov

To purchase flood insurance, please visit
www.floodsmart.gov



Source: Carson City, www.Carson.org

EAST CARSON CITY AREA DRAINAGE MASTER PLAN

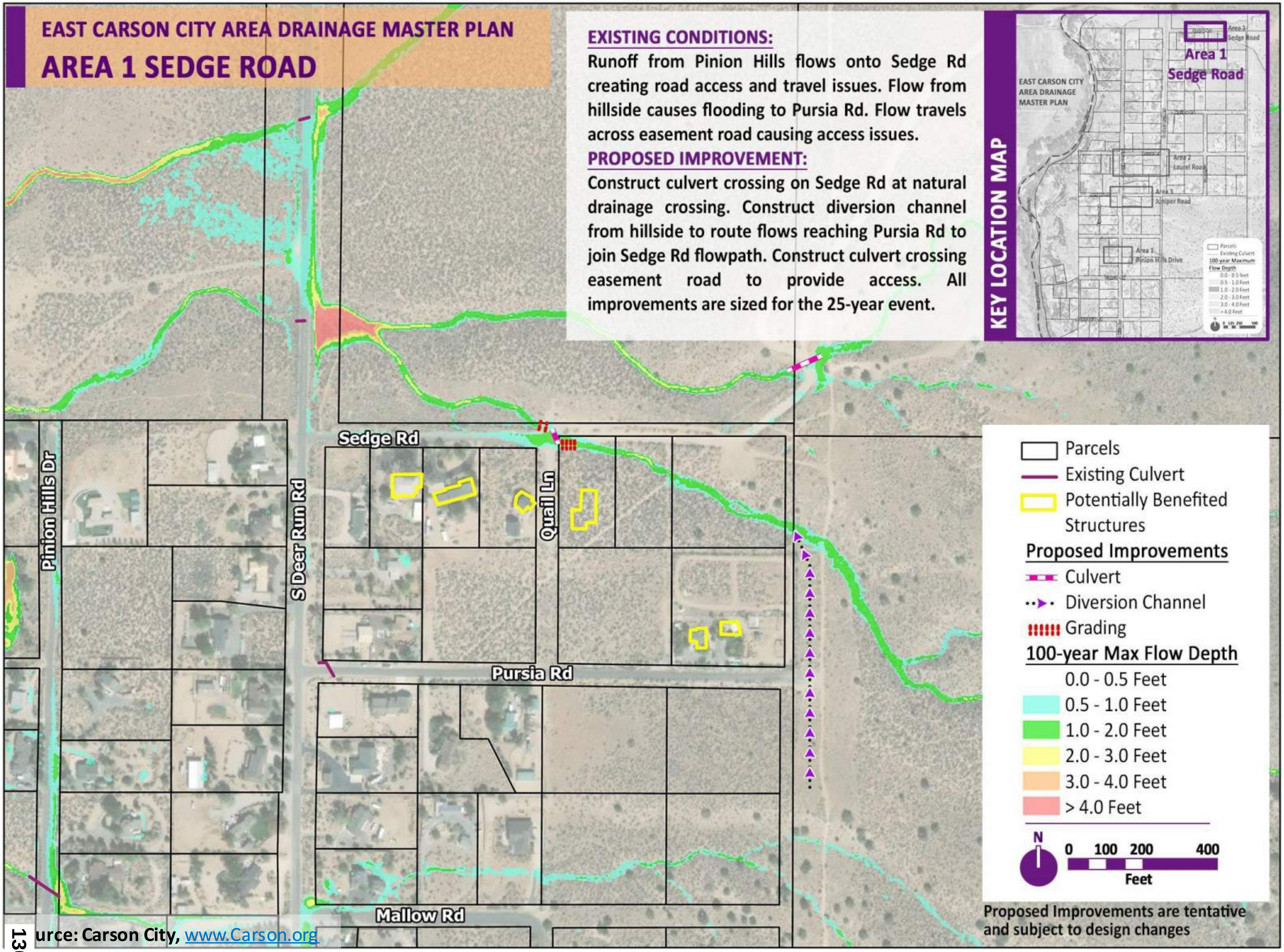
AREA 1 SEDGE ROAD

EXISTING CONDITIONS:

Runoff from Pinion Hills flows onto Sedge Rd creating road access and travel issues. Flow from hillside causes flooding to Pursia Rd. Flow travels across easement road causing access issues.

PROPOSED IMPROVEMENT:

Construct culvert crossing on Sedge Rd at natural drainage crossing. Construct diversion channel from hillside to route flows reaching Pursia Rd to join Sedge Rd flowpath. Construct culvert crossing easement road to provide access. All improvements are sized for the 25-year event.



Proposed Improvements are tentative and subject to design changes

urce: Carson City, www.Carson.org

EAST CARSON CITY AREA DRAINAGE MASTER PLAN

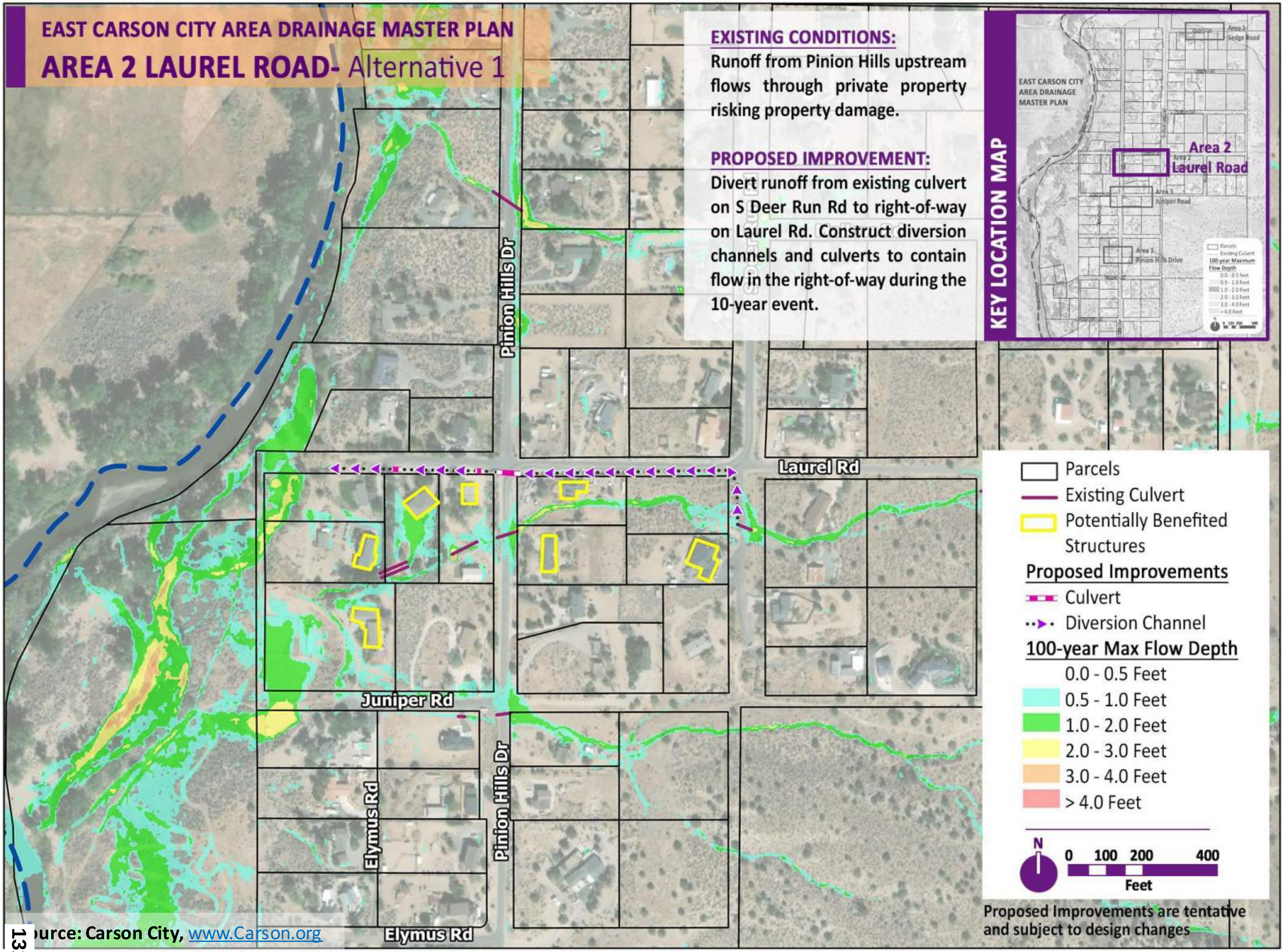
AREA 2 LAUREL ROAD- Alternative 1

EXISTING CONDITIONS:

Runoff from Pinion Hills upstream flows through private property risking property damage.

PROPOSED IMPROVEMENT:

Divert runoff from existing culvert on S Deer Run Rd to right-of-way on Laurel Rd. Construct diversion channels and culverts to contain flow in the right-of-way during the 10-year event.



Proposed Improvements are tentative and subject to design changes

Source: Carson City, www.Carson.org

EAST CARSON CITY AREA DRAINAGE MASTER PLAN

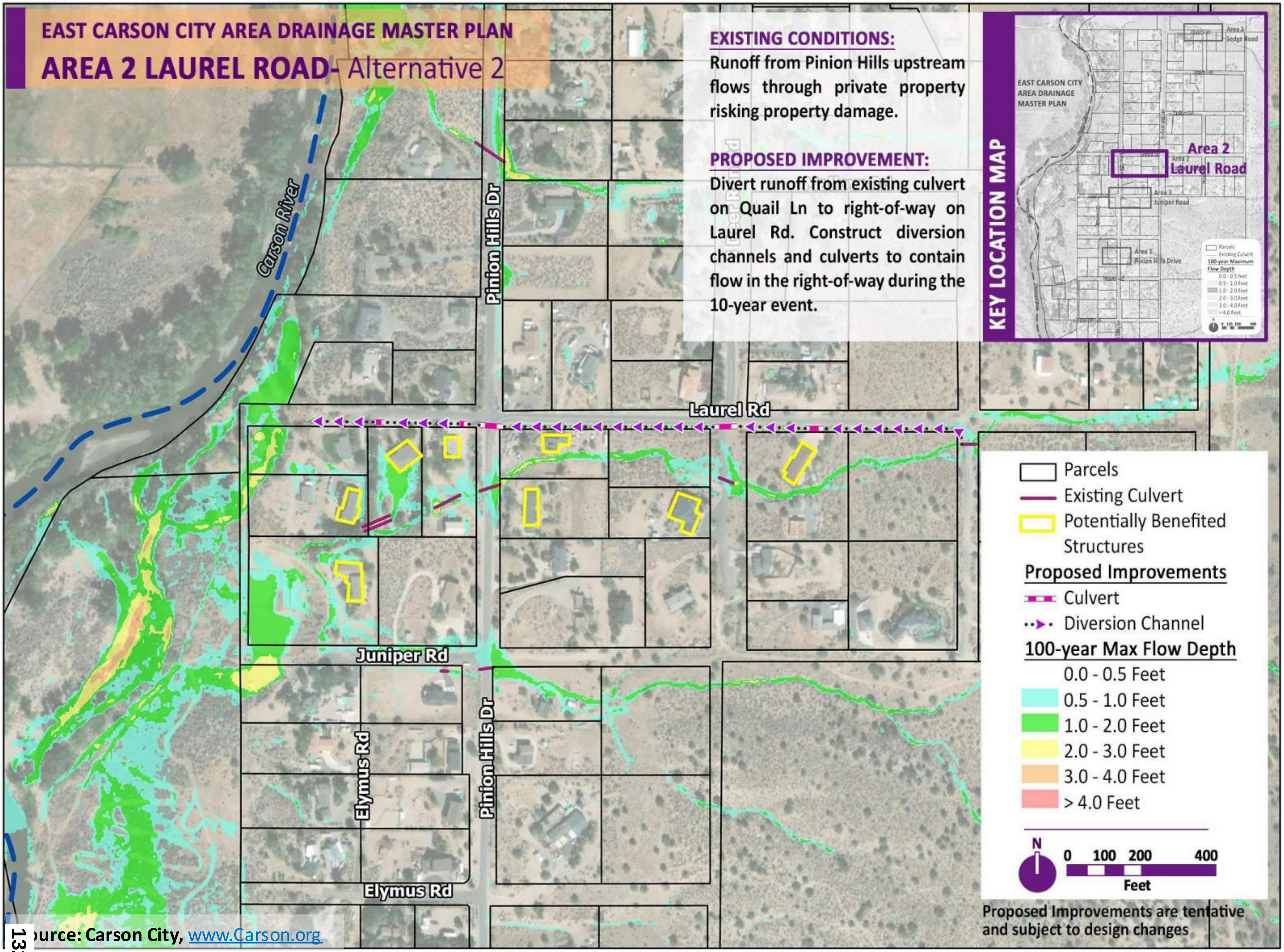
AREA 2 LAUREL ROAD- Alternative 2

EXISTING CONDITIONS:

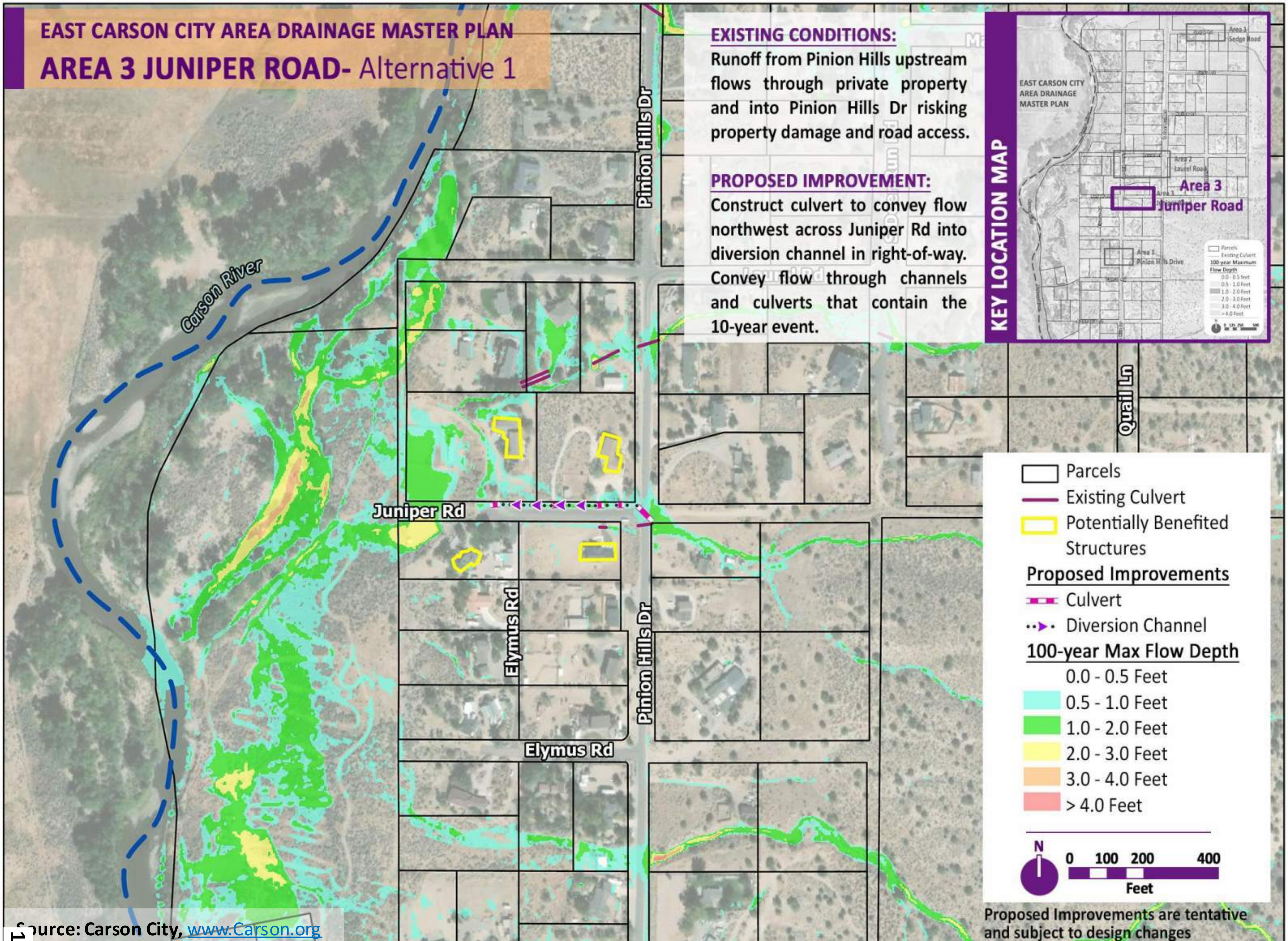
Runoff from Pinion Hills upstream flows through private property risking property damage.

PROPOSED IMPROVEMENT:

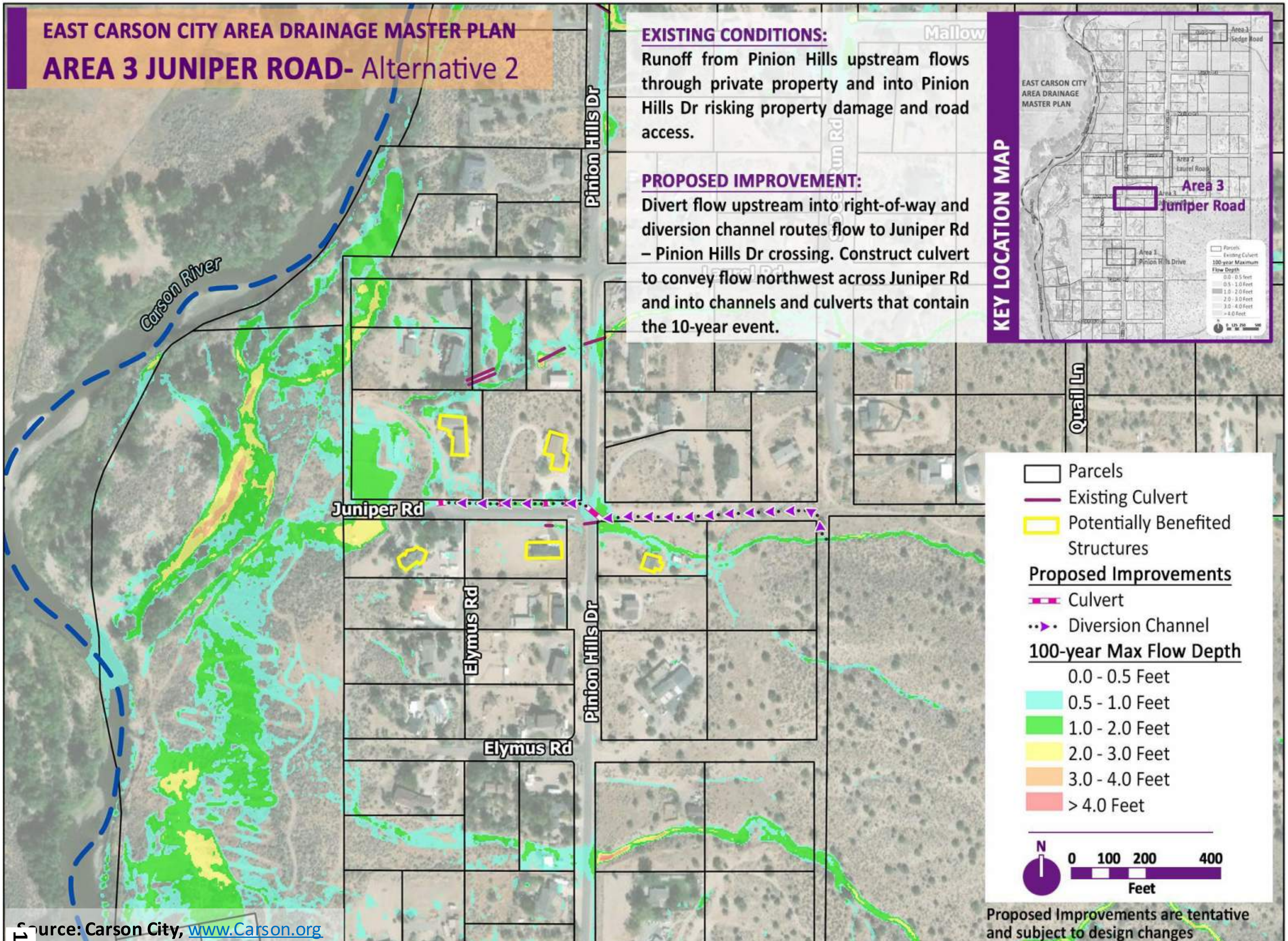
Divert runoff from existing culvert on Quail Ln to right-of-way on Laurel Rd. Construct diversion channels and culverts to contain flow in the right-of-way during the 10-year event.



Source: Carson City, www.Carson.org



Source: Carson City, www.Carson.org


EAST CARSON CITY AREA DRAINAGE MASTER PLAN
AREA 3 JUNIPER ROAD- Alternative 2
EXISTING CONDITIONS:
Runoff from Pinion Hills upstream flows through private property and into Pinion Hills Dr risking property damage and road access.
PROPOSED IMPROVEMENT:
Divert flow upstream into right-of-way and diversion channel routes flow to Juniper Rd – Pinion Hills Dr crossing. Construct culvert to convey flow northwest across Juniper Rd and into channels and culverts that contain the 10-year event.
KEY LOCATION MAP
EAST CARSON CITY AREA DRAINAGE MASTER PLAN
Area 3 Juniper Road
Carson River
Pinion Hills Dr
Juniper Rd
Elymus Rd
Quail Ln
Mallow
Parcels
Existing Culvert
Potentially Benefited Structures
Proposed Improvements
Culvert
Diversion Channel
100-year Max Flow Depth
0.0 - 0.5 Feet
0.5 - 1.0 Feet
1.0 - 2.0 Feet
2.0 - 3.0 Feet
3.0 - 4.0 Feet
> 4.0 Feet
N
0 100 200 400
Feet
Proposed Improvements are tentative and subject to design changes
Source: Carson City, www.Carson.org

EAST CARSON CITY AREA DRAINAGE MASTER PLAN

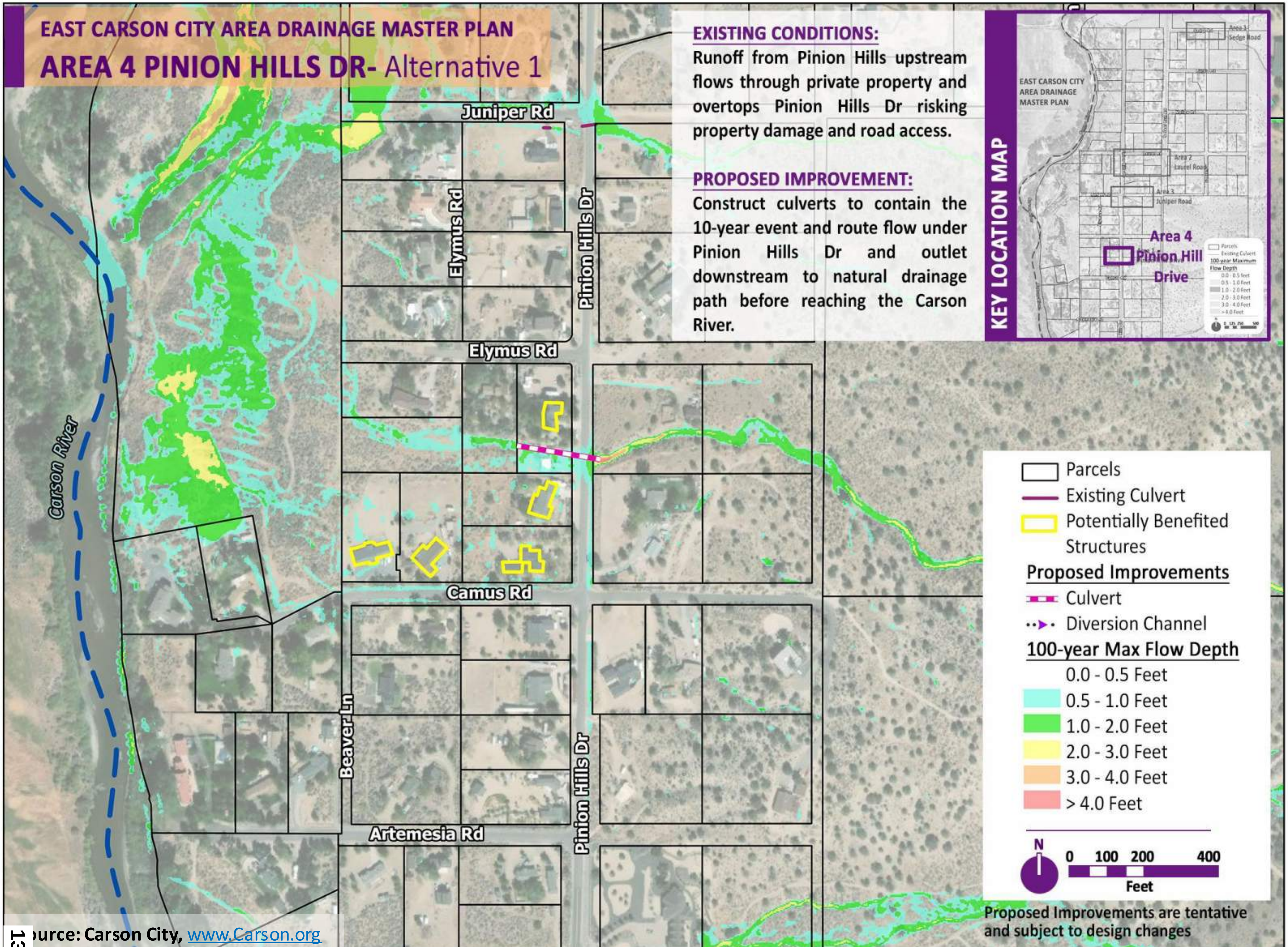
AREA 4 PINION HILLS DR- Alternative 1

EXISTING CONDITIONS:

Runoff from Pinion Hills upstream flows through private property and overtops Pinion Hills Dr risking property damage and road access.

PROPOSED IMPROVEMENT:

Construct culverts to contain the 10-year event and route flow under Pinion Hills Dr and outlet downstream to natural drainage path before reaching the Carson River.



Proposed Improvements are tentative and subject to design changes

Source: Carson City, www.Carson.org

EAST CARSON CITY AREA DRAINAGE MASTER PLAN

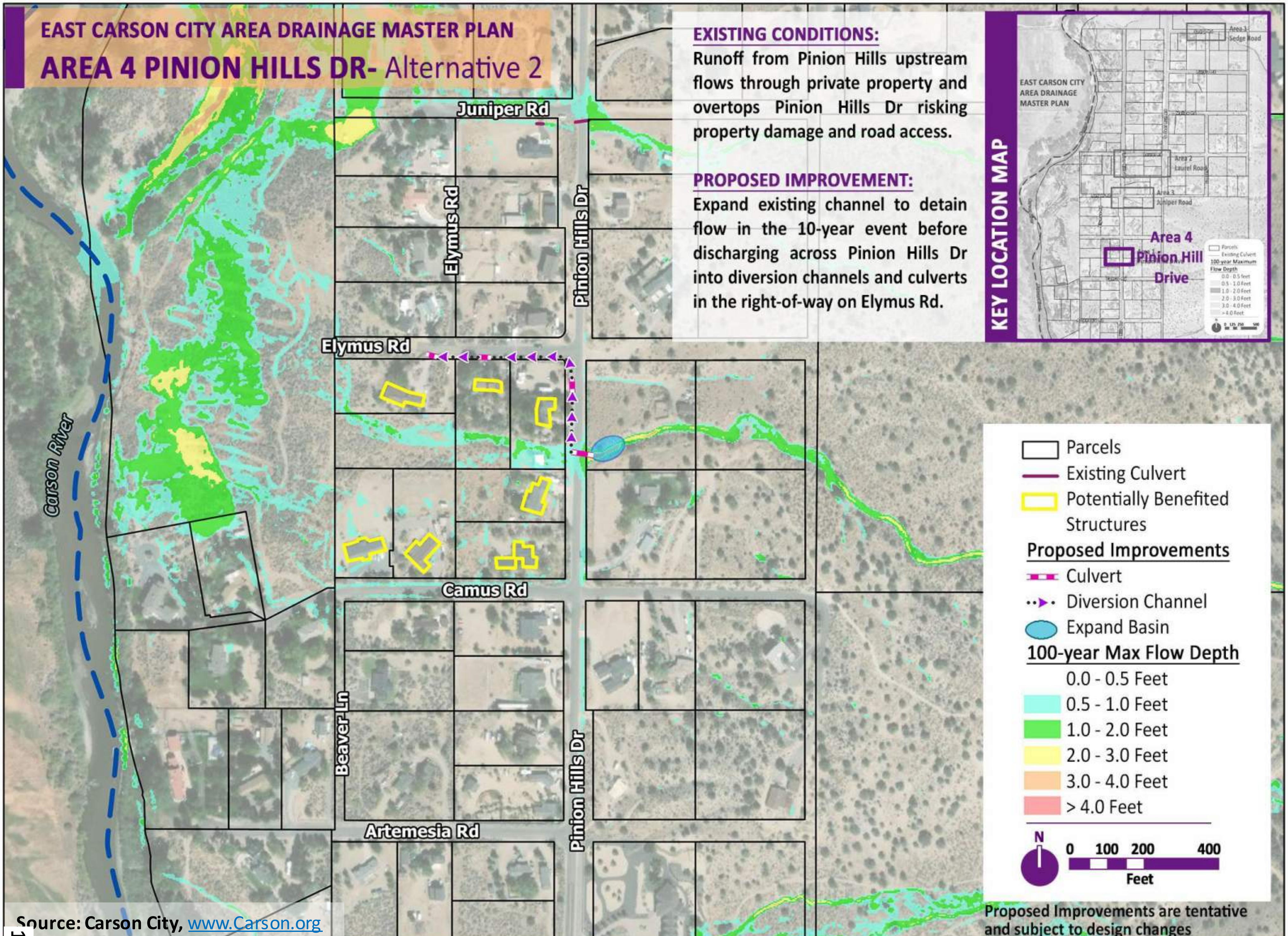
AREA 4 PINION HILLS DR- Alternative 2

EXISTING CONDITIONS:

Runoff from Pinion Hills upstream flows through private property and overtops Pinion Hills Dr risking property damage and road access.

PROPOSED IMPROVEMENT:

Expand existing channel to detain flow in the 10-year event before discharging across Pinion Hills Dr into diversion channels and culverts in the right-of-way on Elymus Rd.



Proposed Improvements are tentative and subject to design changes

Source: Carson City, www.Carson.org

Appendix C – Hazus Report

Hazus: Flood Global Risk Report

Region Name: Carson 4

Flood Scenario: 10

Print Date: Monday, January 30, 2023

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. Theser results can be improved by using enhanced inventory data and flood hazard information.

FEMA

RiskMAP
Increasing Resilience Together

HAZUS
EARTHQUAKE • WIND • FLOOD • TSUNAMI

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

- Nevada

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is approximately 1 square miles and contains 91 census blocks. The region contains over 2 thousand households and has a total population of 3,865 people. The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 1,465 buildings in the region with a total building replacement value (excluding contents) of 739 million dollars. Approximately 88.26% of the buildings (and 60.66% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 1,465 buildings in the region which have an aggregate total replacement value of 739 million dollars. Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	448,263	60.7%
Commercial	115,717	15.7%
Industrial	127,068	17.2%
Agricultural	101	0.0%
Religion	0	0.0%
Government	12,323	1.7%
Education	35,453	4.8%
Total	**738,925**	**100%**

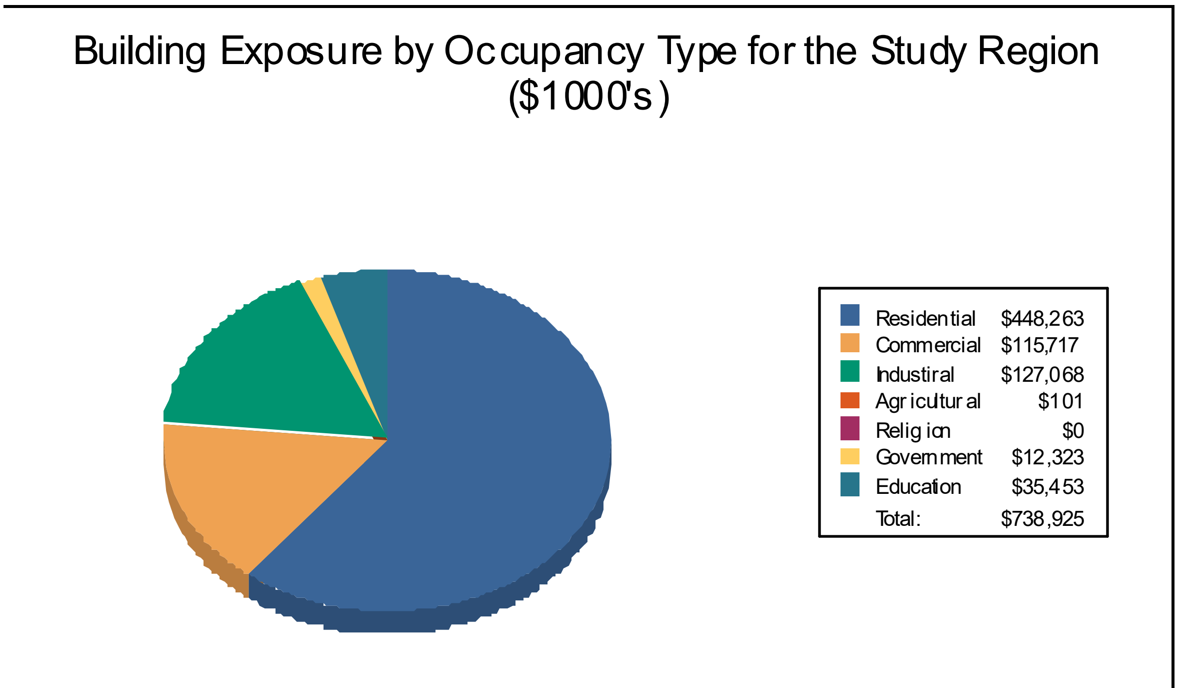


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	448,263	60.7%
Commercial	115,717	15.7%
Industrial	127,068	17.2%
Agricultural	101	0.0%
Religion	0	0.0%
Government	12,323	1.7%
Education	35,453	4.8%
Total	**738,925**	**100%**

Building Exposure by Occupancy Type for the Scenario ($1000's)

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 1 school, no fire stations, no police stations and no emergency operation centers.

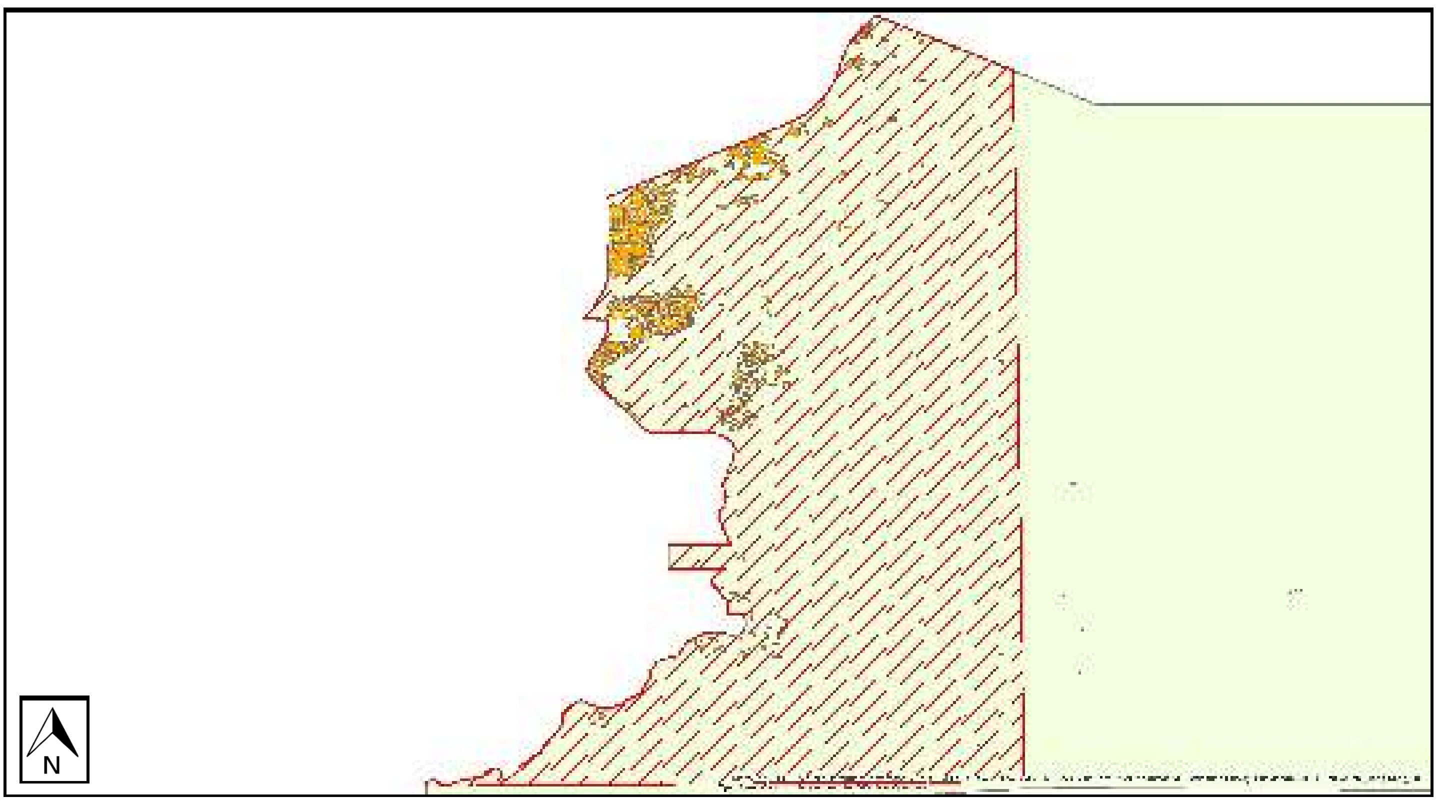
Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Carson4
Scenario Name:	10
Return Period Analyzed:	10
Analysis Options Analyzed:	No What-Ifs

Study Region Overview Map

Illustrating scenario flood extent, as well as exposed essential facilities and total exposure



Building Damage

General Building Stock Damage

Hazus estimates that about 2 buildings will be at least moderately damaged. This is over 50% of the total number of buildings in the scenario. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Flood Technical Manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Total Economic Loss (1 dot = $300K) Overview Map

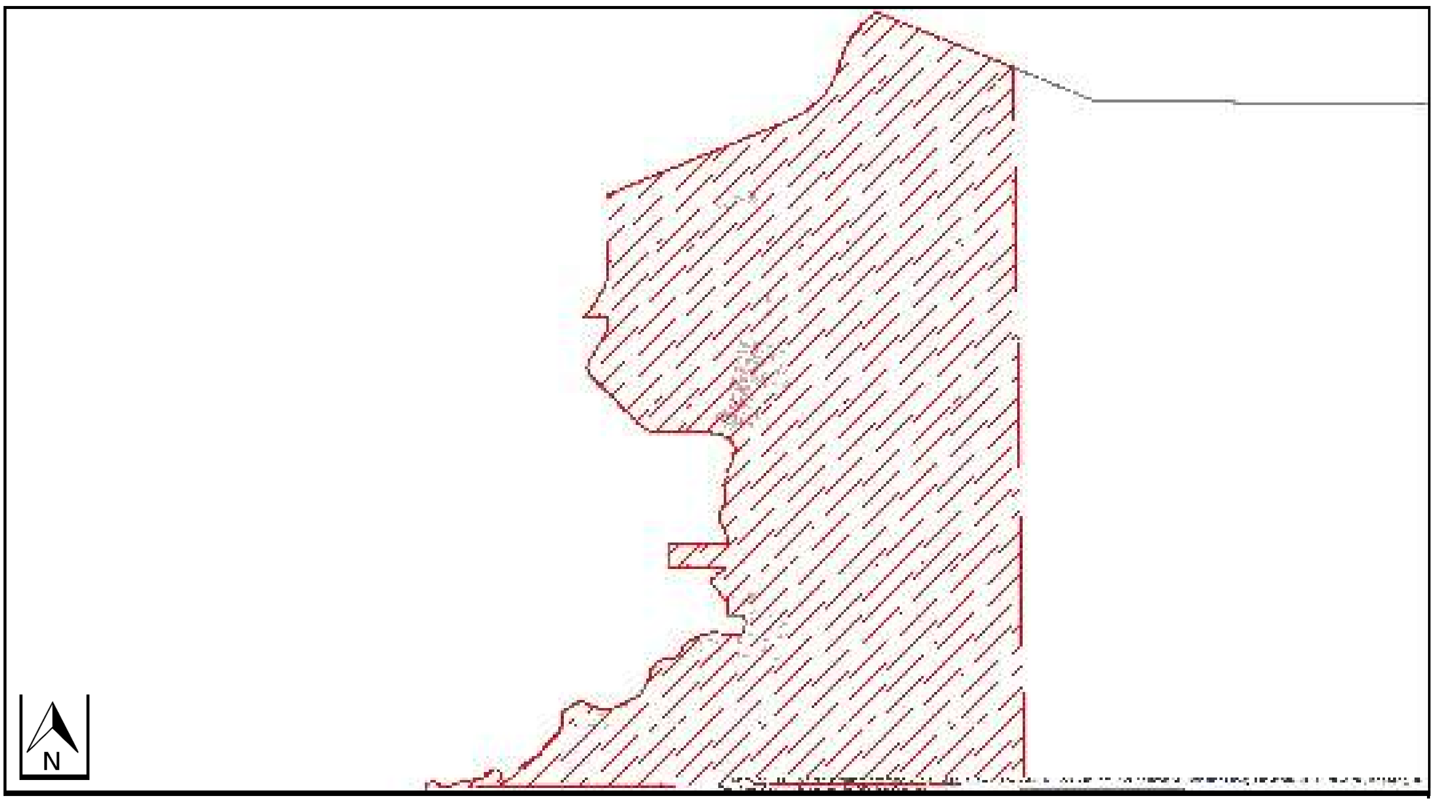


Table 3: Expected Building Damage by Occupancy

Occupancy	1-10 Count	1-10 (%)	11-20 Count	11-20 (%)	21-30 Count	21-30 (%)	31-40 Count	31-40 (%)	41-50 Count	41-50 (%)	>50 Count	>50 (%)
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0	0	0	0	0
Residential	3	60	2	40	0	0	0	0	0	0	0	0
Total	**3**		**2**		**0**		**0**		**0**		**0**	

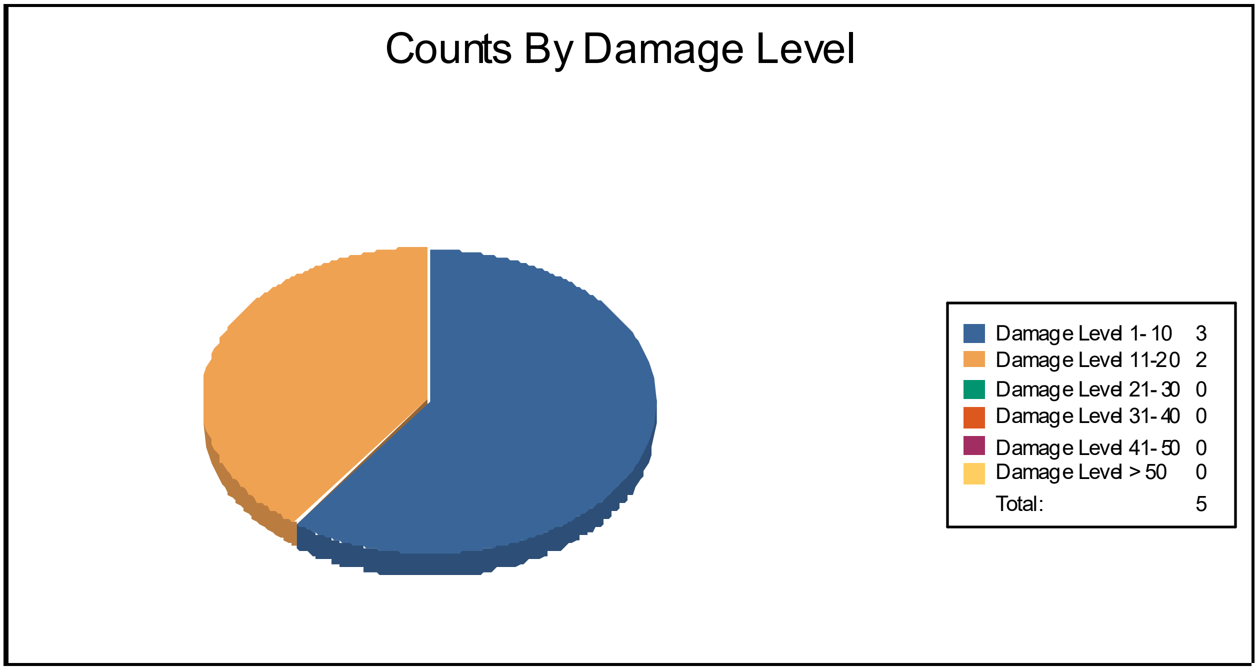


Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		>50	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	0	0	0	0	0	0	0	0	0	0	0	0
Manuf Housing	0	0	0	0	0	0	0	0	0	0	0	0
Masonry	0	0	0	0	0	0	0	0	0	0	0	0
Steel	0	0	0	0	0	0	0	0	0	0	0	0
Wood	3	60	2	40	0	0	0	0	0	0	0	0

Essential Facility Damage

Before the flood analyzed in this scenario, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Emergency Operation Centers	0	0	0	0
Fire Stations	0	0	0	0
Hospitals	0	0	0	0
Police Stations	0	0	0	0
Schools	1	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

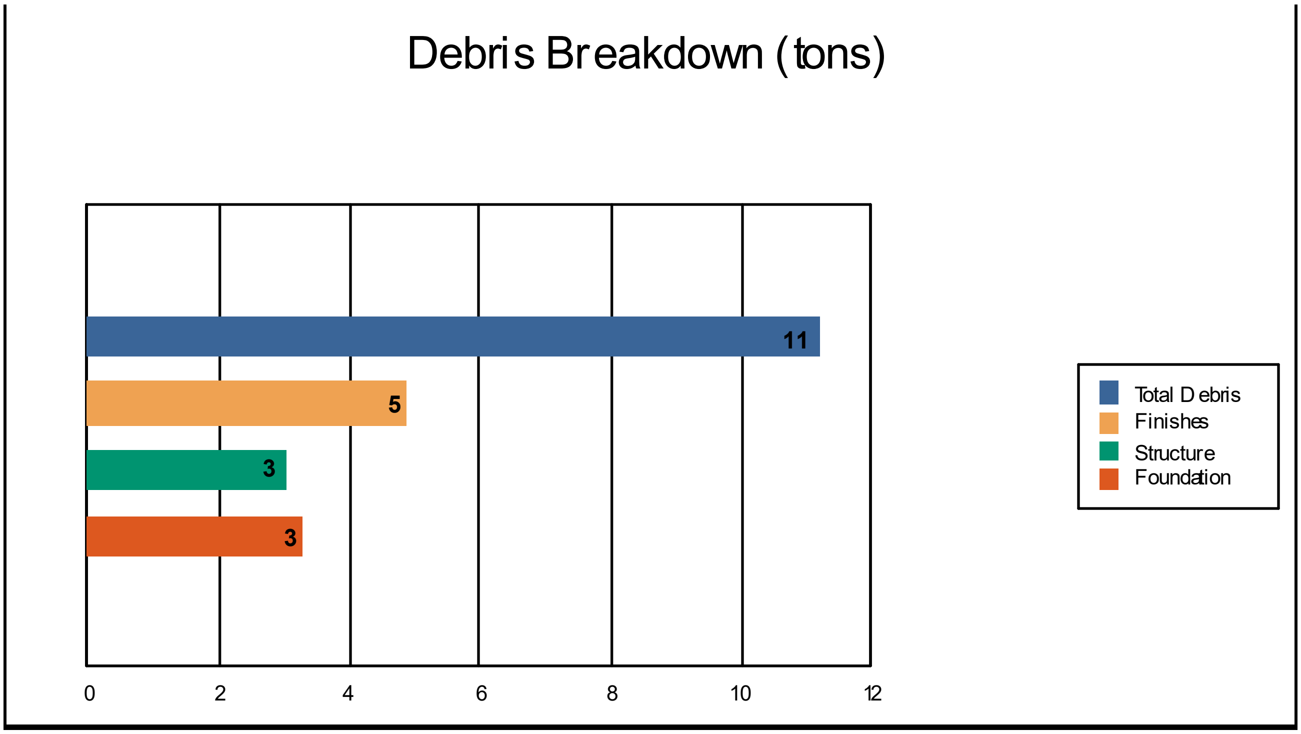
(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.



The model estimates that a total of 11 tons of debris will be generated. Of the total amount, Finishes comprises 44% of the total, Structure comprises 27% of the total, and Foundation comprises 29%. If the debris tonnage is converted into an estimated number of truckloads, it will require 1 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

Analysis has not been performed for this Scenario.

Economic Loss

The total economic loss estimated for the flood is 3.15 million dollars, which represents 0.43 % of the total replacement value of the scenario buildings.

Building-Related Losses

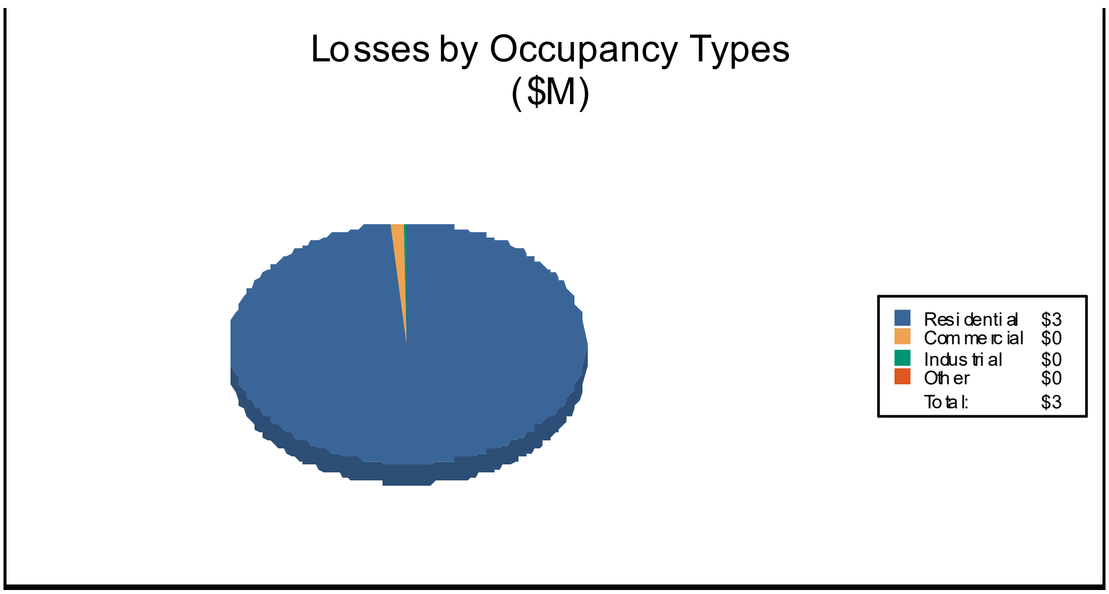
The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the

The total building-related losses were 2.53 million dollars. 20% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 98.73% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	1.63	0.00	0.01	0.00	1.64
	Content	0.88	0.00	0.01	0.00	0.89
	Inventory	0.00	0.00	0.00	0.00	0.00
	Subtotal	**2.51**	**0.01**	**0.02**	**0.00**	**2.53**
Business Interruption						
	Income	0.00	0.01	0.00	0.00	0.01
	Relocation	0.47	0.00	0.00	0.00	0.47
	Rental Income	0.14	0.00	0.00	0.00	0.14
	Wage	0.00	0.00	0.00	0.00	0.00
	Subtotal	**0.60**	**0.02**	**0.00**	**0.00**	**0.62**
ALL	**Total**	**3.11**	**0.02**	**0.02**	**0.00**	**3.15**



Appendix A: County Listing for the Region

Nevada

- Carson City

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Nevada				
Carson City	3,865	448.263	290.662	738,925
Total	**3.865**	**448.263**	**290.662**	**738.925**
Total Study Region	**3,865**	**448,263**	**290,662**	**738,925**

Hazus: Flood Global Risk Report

Region Name: Carson 4

Flood Scenario: 25

Print Date: Monday, January 30, 2023

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. Theser results can be improved by using enhanced inventory data and flood hazard information.

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General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

- Nevada

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is approximately 1 square miles and contains 91 census blocks. The region contains over 2 thousand households and has a total population of 3,865 people. The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 1,465 buildings in the region with a total building replacement value (excluding contents) of 739 million dollars. Approximately 88.26% of the buildings (and 60.66% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 1,465 buildings in the region which have an aggregate total replacement value of 739 million dollars. Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	448,263	60.7%
Commercial	115,717	15.7%
Industrial	127,068	17.2%
Agricultural	101	0.0%
Religion	0	0.0%
Government	12,323	1.7%
Education	35,453	4.8%
Total	**738,925**	**100%**

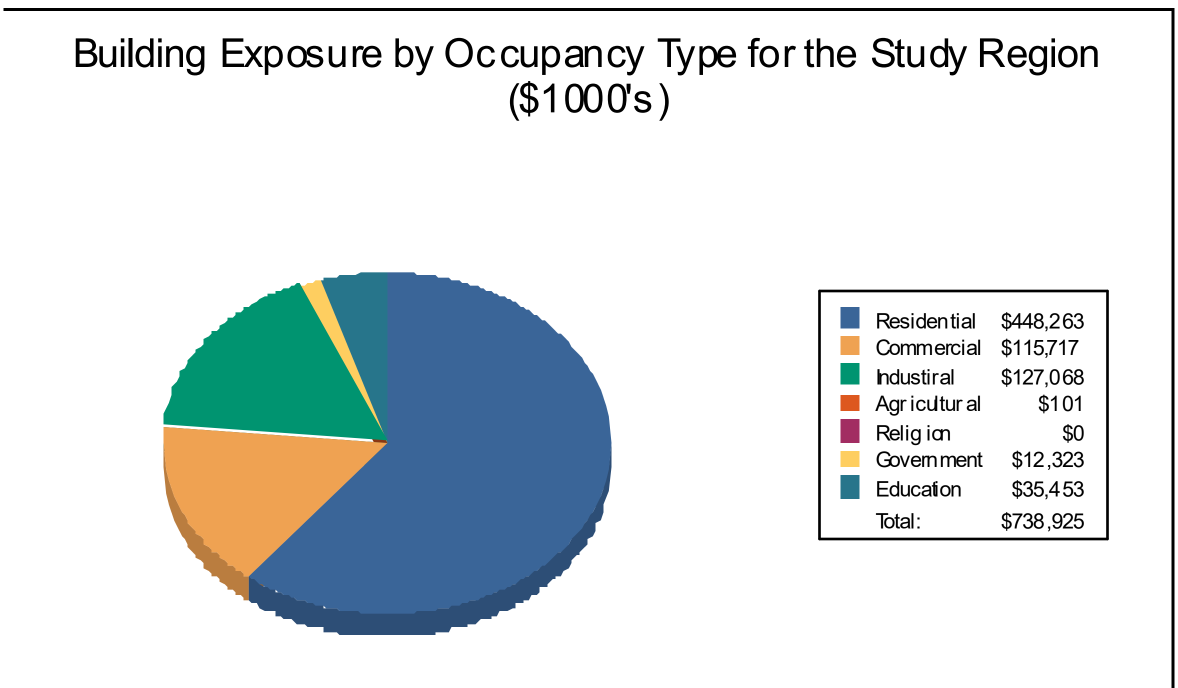


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	448,263	60.7%
Commercial	115,717	15.7%
Industrial	127,068	17.2%
Agricultural	101	0.0%
Religion	0	0.0%
Government	12,323	1.7%
Education	35,453	4.8%
Total	**738,925**	**100%**

Building Exposure by Occupancy Type for the Scenario ($1000's)

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 1 school, no fire stations, no police stations and no emergency operation centers.

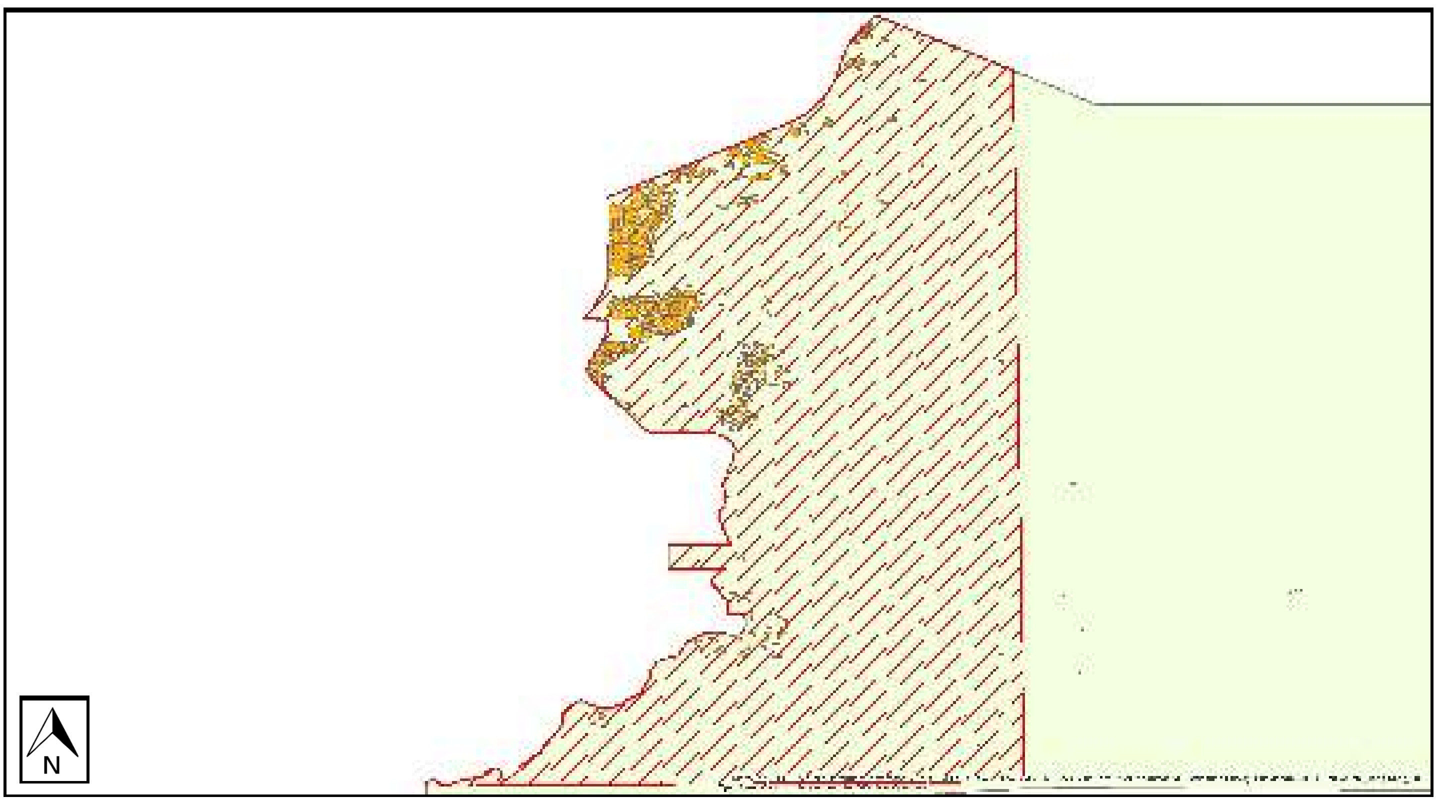
Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Carson4
Scenario Name:	25
Return Period Analyzed:	25
Analysis Options Analyzed:	No What-Ifs

Study Region Overview Map

Illustrating scenario flood extent, as well as exposed essential facilities and total exposure



Building Damage

General Building Stock Damage

Hazus estimates that about 1 building will be at least moderately damaged. This is over 50% of the total number of buildings in the scenario. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Flood Technical Manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Total Economic Loss (1 dot = $300K) Overview Map

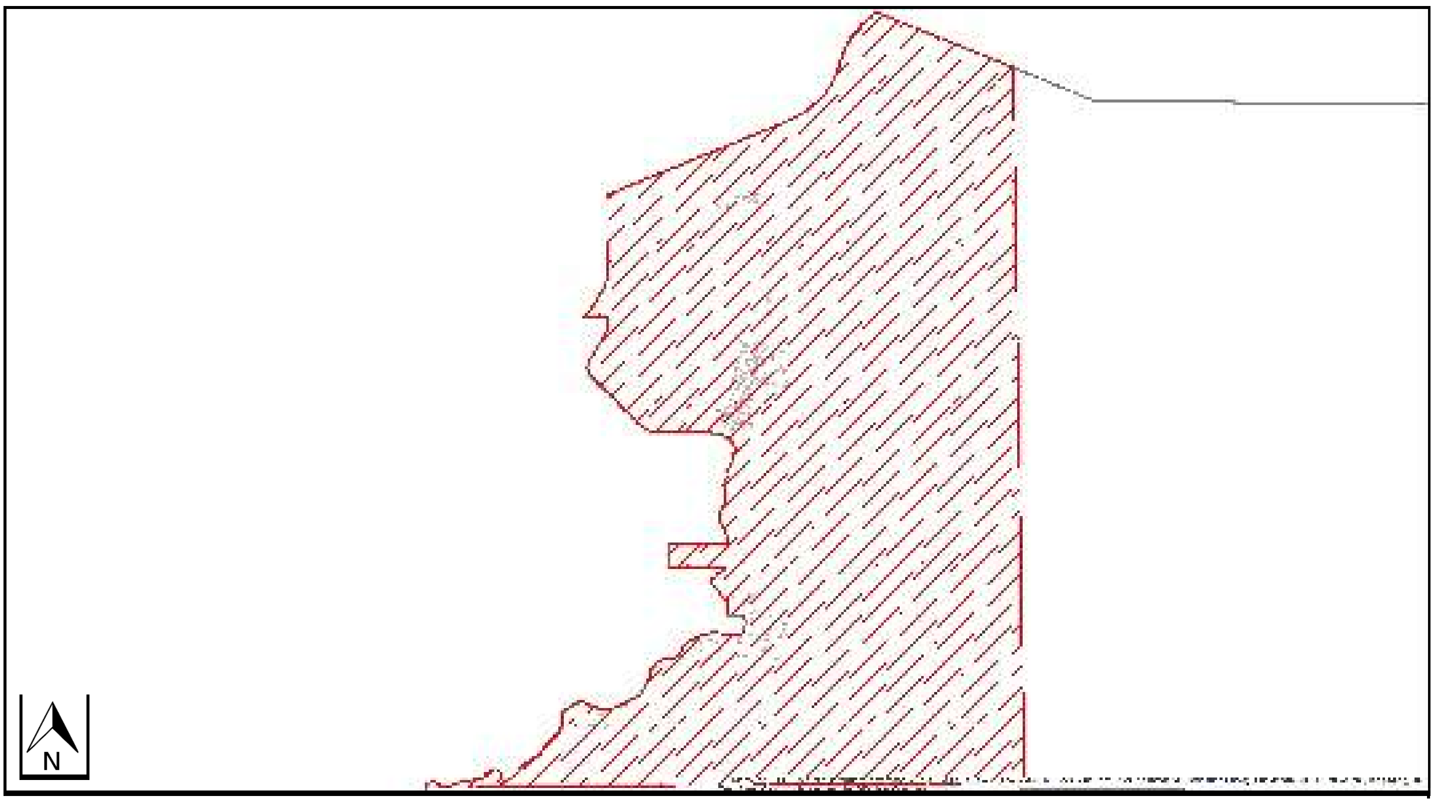


Table 3: Expected Building Damage by Occupancy

Occupancy	1-10		11-20		21-30		31-40		41-50		>50	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0	0	0	0	0
Residential	4	80	1	20	0	0	0	0	0	0	0	0
Total	**4**		**1**		**0**		**0**		**0**		**0**	

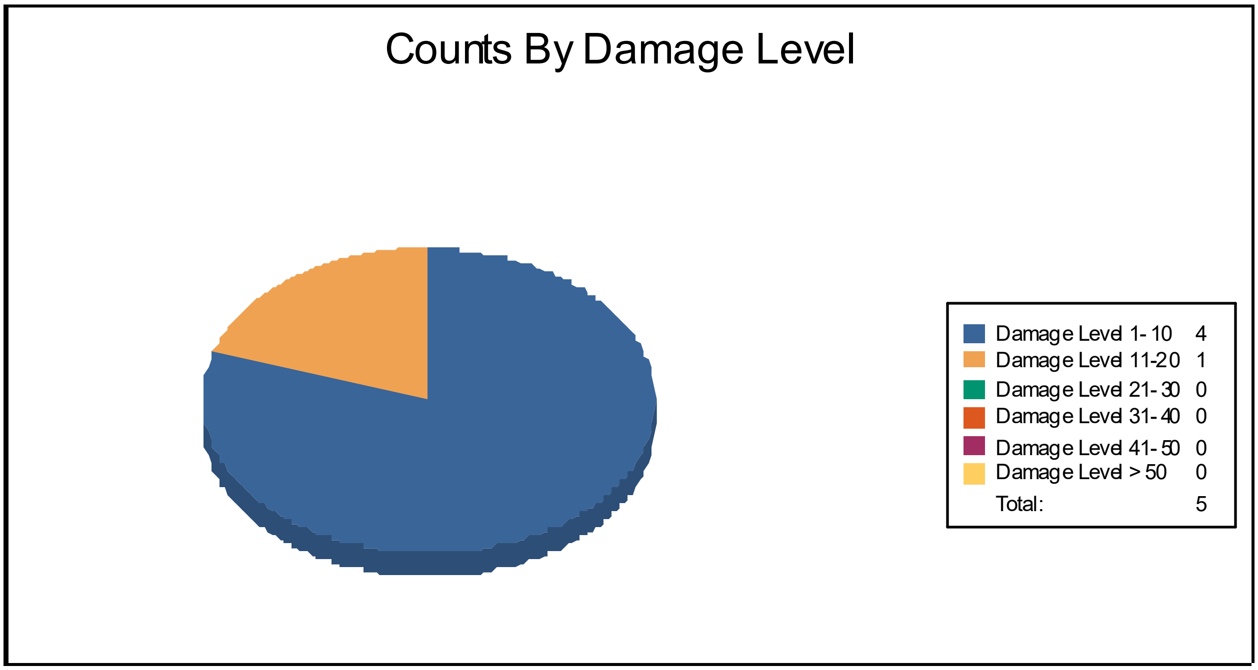


Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		>50	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	0	0	0	0	0	0	0	0	0	0	0	0
Manuf Housing	0	0	0	0	0	0	0	0	0	0	0	0
Masonry	0	0	0	0	0	0	0	0	0	0	0	0
Steel	0	0	0	0	0	0	0	0	0	0	0	0
Wood	4	80	1	20	0	0	0	0	0	0	0	0

Essential Facility Damage

Before the flood analyzed in this scenario, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Emergency Operation Centers	0	0	0	0
Fire Stations	0	0	0	0
Hospitals	0	0	0	0
Police Stations	0	0	0	0
Schools	1	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

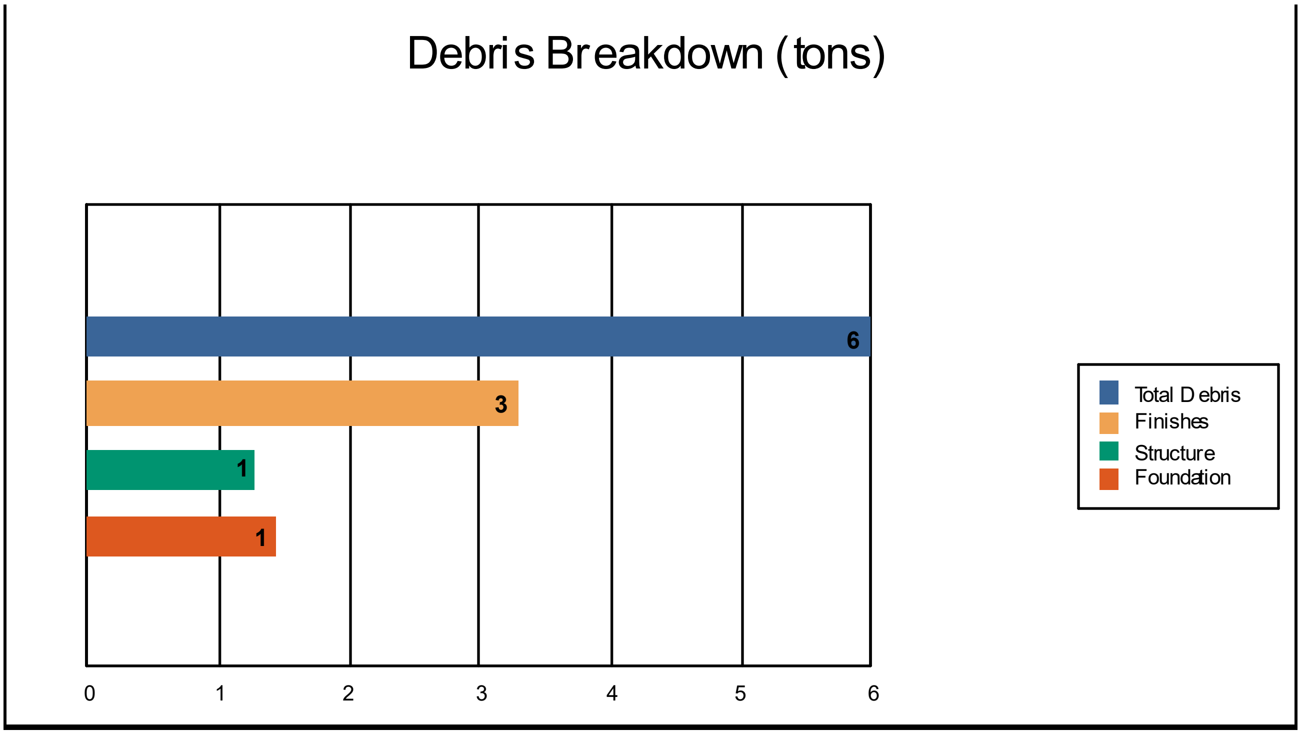
(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.



The model estimates that a total of 6 tons of debris will be generated. Of the total amount, Finishes comprises 55% of the total, Structure comprises 21% of the total, and Foundation comprises 24%. If the debris tonnage is converted into an estimated number of truckloads, it will require 1 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

Analysis has not been performed for this Scenario.

Economic Loss

The total economic loss estimated for the flood is 2.34 million dollars, which represents 0.32 % of the total replacement value of the scenario buildings.

Building-Related Losses

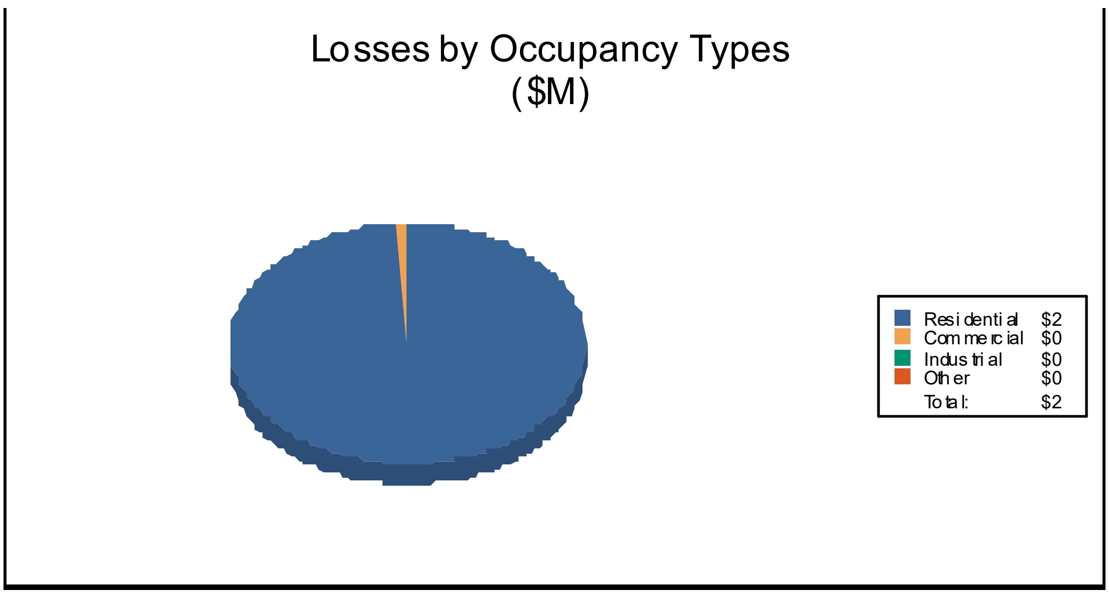
The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the

The total building-related losses were 1.69 million dollars. 28% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 98.80% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	1.09	0.00	0.00	0.00	1.10
	Content	0.59	0.00	0.00	0.00	0.60
	Inventory	0.00	0.00	0.00	0.00	0.00
	Subtotal	**1.68**	**0.00**	**0.01**	**0.00**	**1.69**
Business Interruption						
	Income	0.00	0.01	0.00	0.00	0.01
	Relocation	0.49	0.00	0.00	0.00	0.49
	Rental Income	0.14	0.00	0.00	0.00	0.14
	Wage	0.00	0.00	0.00	0.00	0.00
	Subtotal	**0.63**	**0.02**	**0.00**	**0.00**	**0.65**
ALL	**Total**	**2.31**	**0.02**	**0.01**	**0.00**	**2.34**



Appendix A: County Listing for the Region

Nevada

- Carson City

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Nevada				
Carson City	3,865	448.263	290.662	738,925
Total	**3.865**	**448.263**	**290.662**	**738.925**
Total Study Region	**3,865**	**448,263**	**290,662**	**738,925**

Hazus: Flood Global Risk Report

Region Name: Carson 4

Flood Scenario: 100b

Print Date: Monday, January 30, 2023

Disclaimer:
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

- Nevada

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is approximately 1 square miles and contains 91 census blocks. The region contains over 2 thousand households and has a total population of 3,865 people. The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 1,465 buildings in the region with a total building replacement value (excluding contents) of 739 million dollars. Approximately 88.26% of the buildings (and 60.66% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 1,465 buildings in the region which have an aggregate total replacement value of 739 million dollars. Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	448,263	60.7%
Commercial	115,717	15.7%
Industrial	127,068	17.2%
Agricultural	101	0.0%
Religion	0	0.0%
Government	12,323	1.7%
Education	35,453	4.8%
Total	**738,925**	**100%**

Building Exposure by Occupancy Type for the Study Region ($1000's)

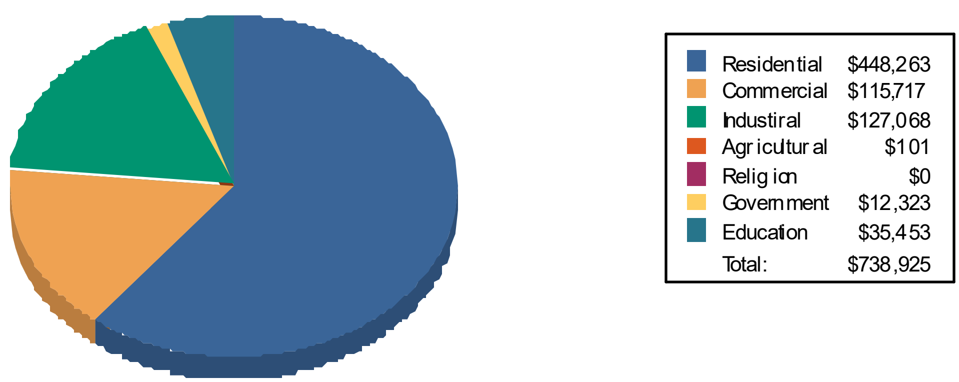


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	448,263	60.7%
Commercial	115,717	15.7%
Industrial	127,068	17.2%
Agricultural	101	0.0%
Religion	0	0.0%
Government	12,323	1.7%
Education	35,453	4.8%
Total	**738,925**	**100%**

Building Exposure by Occupancy Type for the Scenario ($1000's)

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 1 school, no fire stations, no police stations and no emergency operation centers.

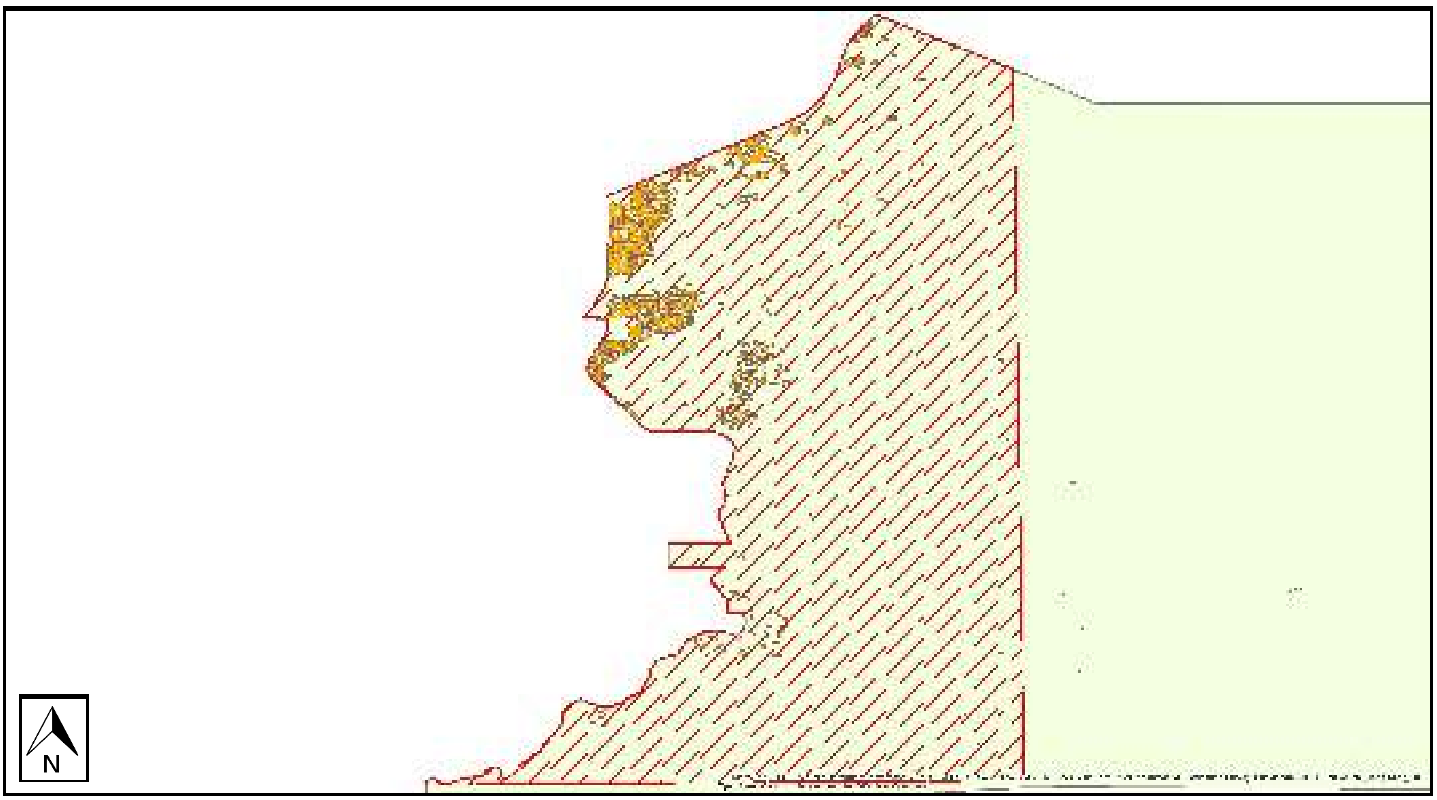
Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Carson4
Scenario Name:	100b
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Study Region Overview Map

Illustrating scenario flood extent, as well as exposed essential facilities and total exposure



Building Damage

General Building Stock Damage

Hazus estimates that about 3 buildings will be at least moderately damaged. This is over 53% of the total number of buildings in the scenario. There are an estimated 0 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Flood Technical Manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Total Economic Loss (1 dot = $300K) Overview Map

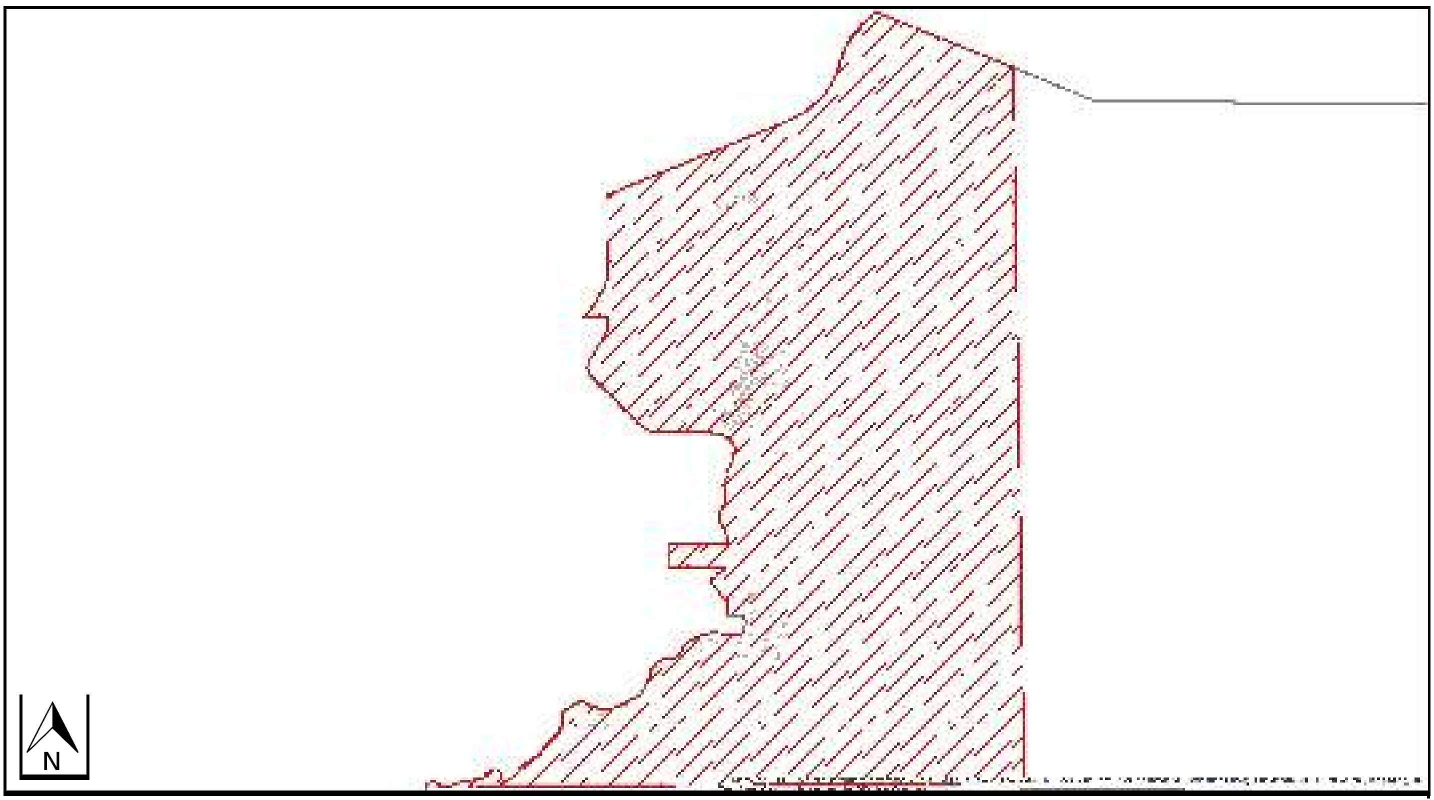


Table 3: Expected Building Damage by Occupancy

Occupancy	1-10 Count	1-10 (%)	11-20 Count	11-20 (%)	21-30 Count	21-30 (%)	31-40 Count	31-40 (%)	41-50 Count	41-50 (%)	>50 Count	>50 (%)
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0	0	0	0	0
Residential	5	63	3	38	0	0	0	0	0	0	0	0
Total	**5**		**3**		**0**		**0**		**0**		**0**	

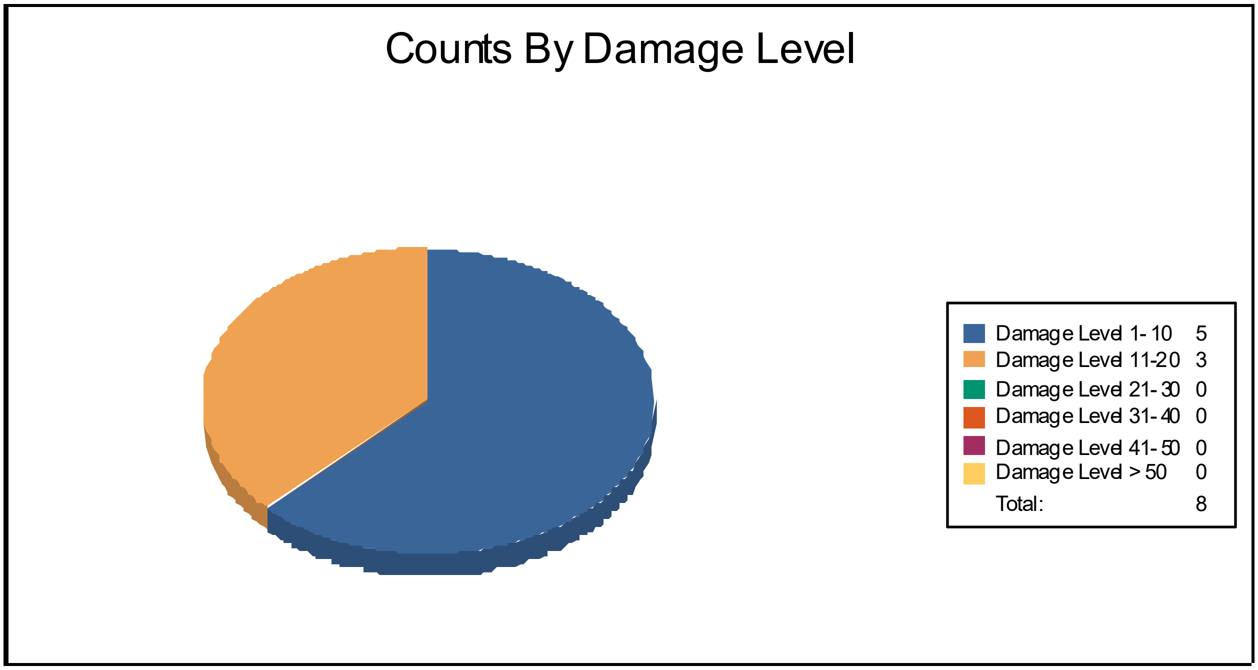


Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		>50	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	0	0	0	0	0	0	0	0	0	0	0	0
Manuf Housing	0	0	0	0	0	0	0	0	0	0	0	0
Masonry	0	0	0	0	0	0	0	0	0	0	0	0
Steel	0	0	0	0	0	0	0	0	0	0	0	0
Wood	5	63	3	38	0	0	0	0	0	0	0	0

Essential Facility Damage

Before the flood analyzed in this scenario, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Emergency Operation Centers	0	0	0	0
Fire Stations	0	0	0	0
Hospitals	0	0	0	0
Police Stations	0	0	0	0
Schools	1	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

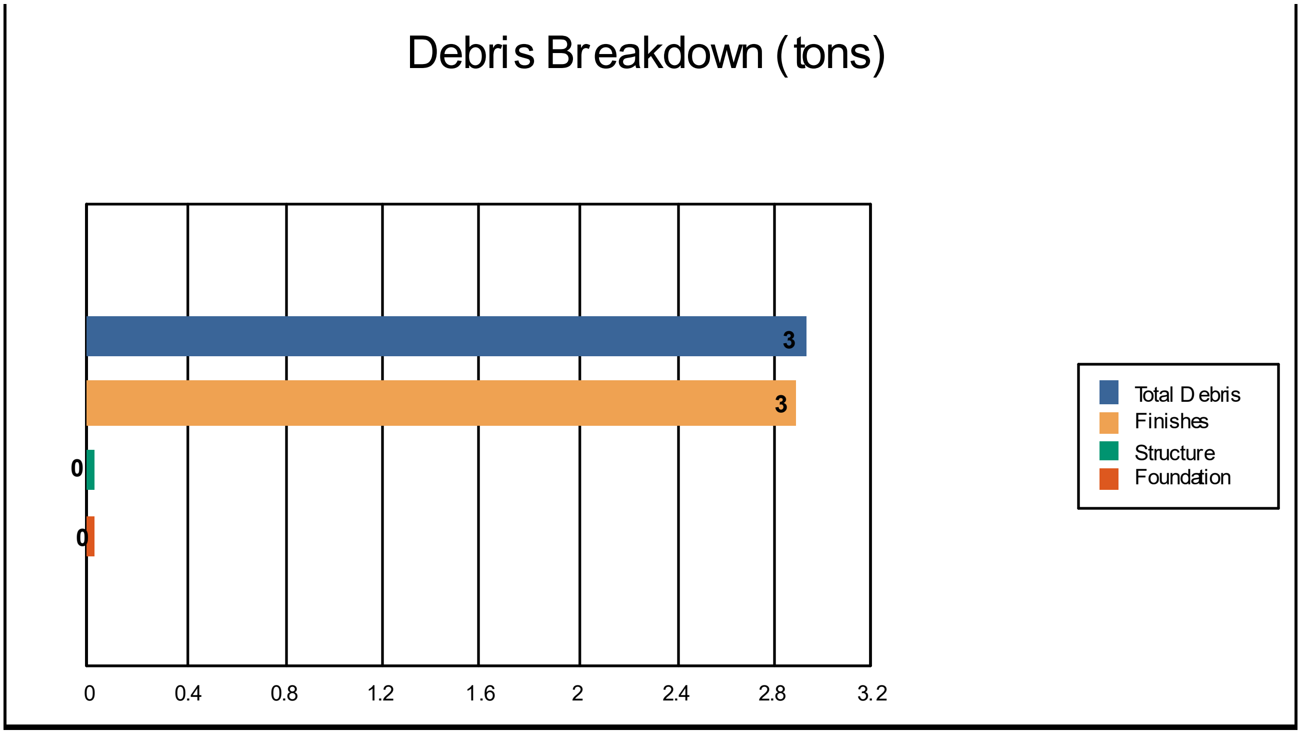
(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.



The model estimates that a total of 3 tons of debris will be generated. Of the total amount, Finishes comprises 98% of the total, Structure comprises 1% of the total, and Foundation comprises 1%. If the debris tonnage is converted into an estimated number of truckloads, it will require 1 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

Analysis has not been performed for this Scenario.

Economic Loss

The total economic loss estimated for the flood is 2.29 million dollars, which represents 0.31 % of the total replacement value of the scenario buildings.

Building-Related Losses

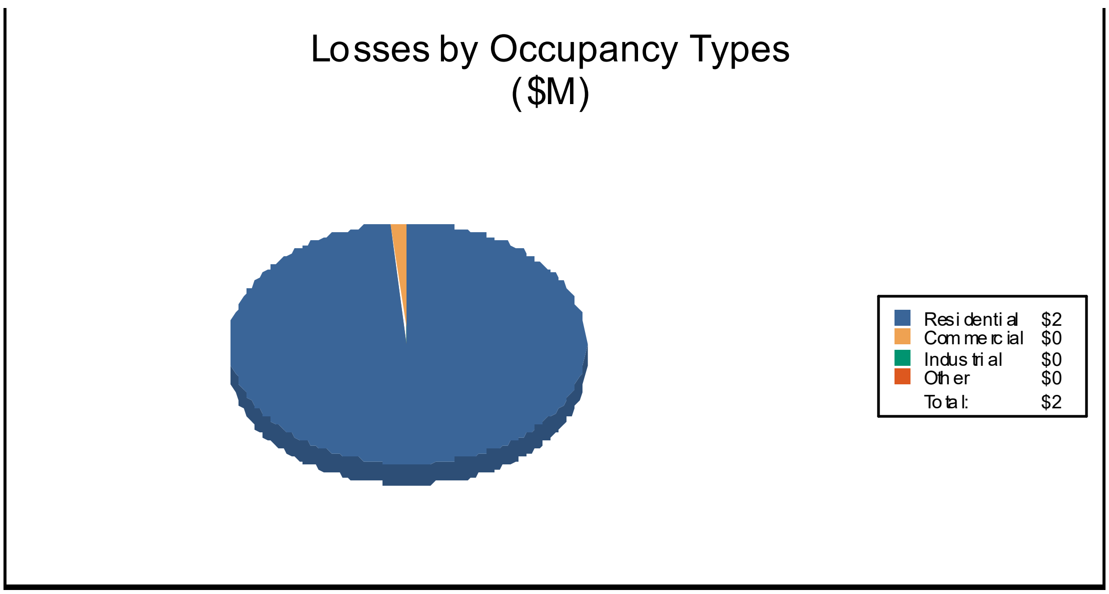
The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the

The total building-related losses were 1.38 million dollars. 40% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 98.25% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
<u>Building Loss</u>						
	Building	0.89	0.00	0.00	0.00	0.89
	Content	0.48	0.00	0.00	0.00	0.49
	Inventory	0.00	0.00	0.00	0.00	0.00
	Subtotal	**1.37**	**0.01**	**0.00**	**0.00**	**1.38**
<u>Business Interruption</u>						
	Income	0.00	0.02	0.00	0.00	0.02
	Relocation	0.67	0.00	0.00	0.00	0.67
	Rental Income	0.21	0.00	0.00	0.00	0.21
	Wage	0.00	0.01	0.00	0.00	0.01
	Subtotal	**0.88**	**0.03**	**0.00**	**0.00**	**0.91**
ALL	**Total**	**2.25**	**0.04**	**0.00**	**0.00**	**2.29**



Appendix A: County Listing for the Region

Nevada

- Carson City

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Nevada				
Carson City	3,865	448.263	290.662	738,925
Total	**3.865**	**448.263**	**290.662**	**738.925**
Total Study Region	**3,865**	**448,263**	**290,662**	**738,925**

Appendix D – Alternatives Development

Culvert Report

Pinion Hills Rd

Invert Elev Dn (ft)	= 4665.11
Pipe Length (ft)	= 27.60
Slope (%)	= 0.07
Invert Elev Up (ft)	= 4665.13
Rise (in)	= 24.0
Shape	= Circular
Span (in)	= 24.0
No. Barrels	= 2
n-Value	= 0.015
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

Embankment

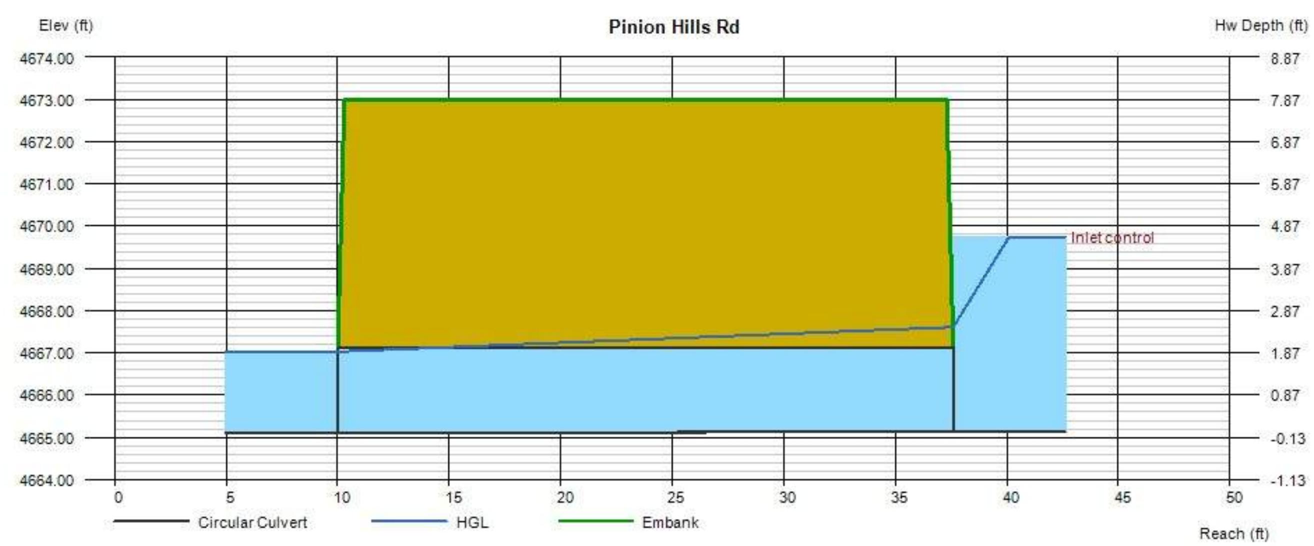
Top Elevation (ft)	= 4673.00
Top Width (ft)	= 27.00
Crest Width (ft)	= 40.00

Calculations

Qmin (cfs)	= 57.00
Qmax (cfs)	= 60.00
Tailwater Elev (ft)	= (dc+D)/2

Highlighted

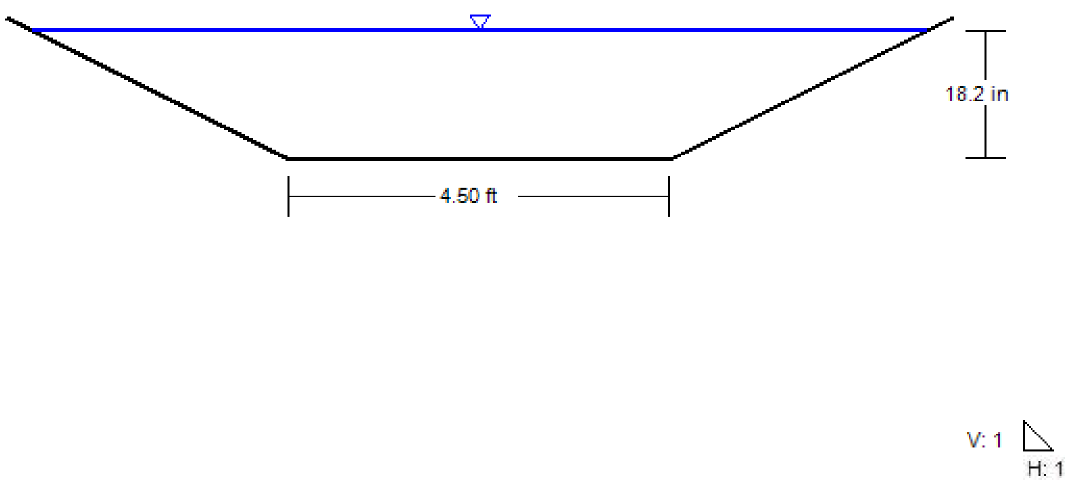
Qtotal (cfs)	= 57.00
Qpipe (cfs)	= 57.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 9.20
Veloc Up (ft/s)	= 9.07
HGL Dn (ft)	= 4667.03
HGL Up (ft)	= 4667.61
Hw Elev (ft)	= 4669.75
Hw/D (ft)	= 2.31
Flow Regime	= Inlet Control



Cross Section for Pinion Hills Diversion Channel

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.030
Channel Slope	0.010 ft/ft
Normal Depth	18.2 in
Left Side Slope	2.000 H:V
Right Side Slope	2.000 H:V
Bottom Width	4.50 ft
Discharge	57.00 cfs



Worksheet for Pinion Hills Diversion Channel

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.010 ft/ft
Left Side Slope	2.000 H:V
Right Side Slope	2.000 H:V
Bottom Width	4.50 ft
Discharge	57.00 cfs

Results

Normal Depth	18.2 in
Flow Area	11.4 ft²
Wetted Perimeter	11.3 ft
Hydraulic Radius	12.1 in
Top Width	10.56 ft
Critical Depth	16.6 in
Critical Slope	0.014 ft/ft
Velocity	4.99 ft/s
Velocity Head	0.39 ft
Specific Energy	1.90 ft
Froude Number	0.847
Flow Type	Subcritical

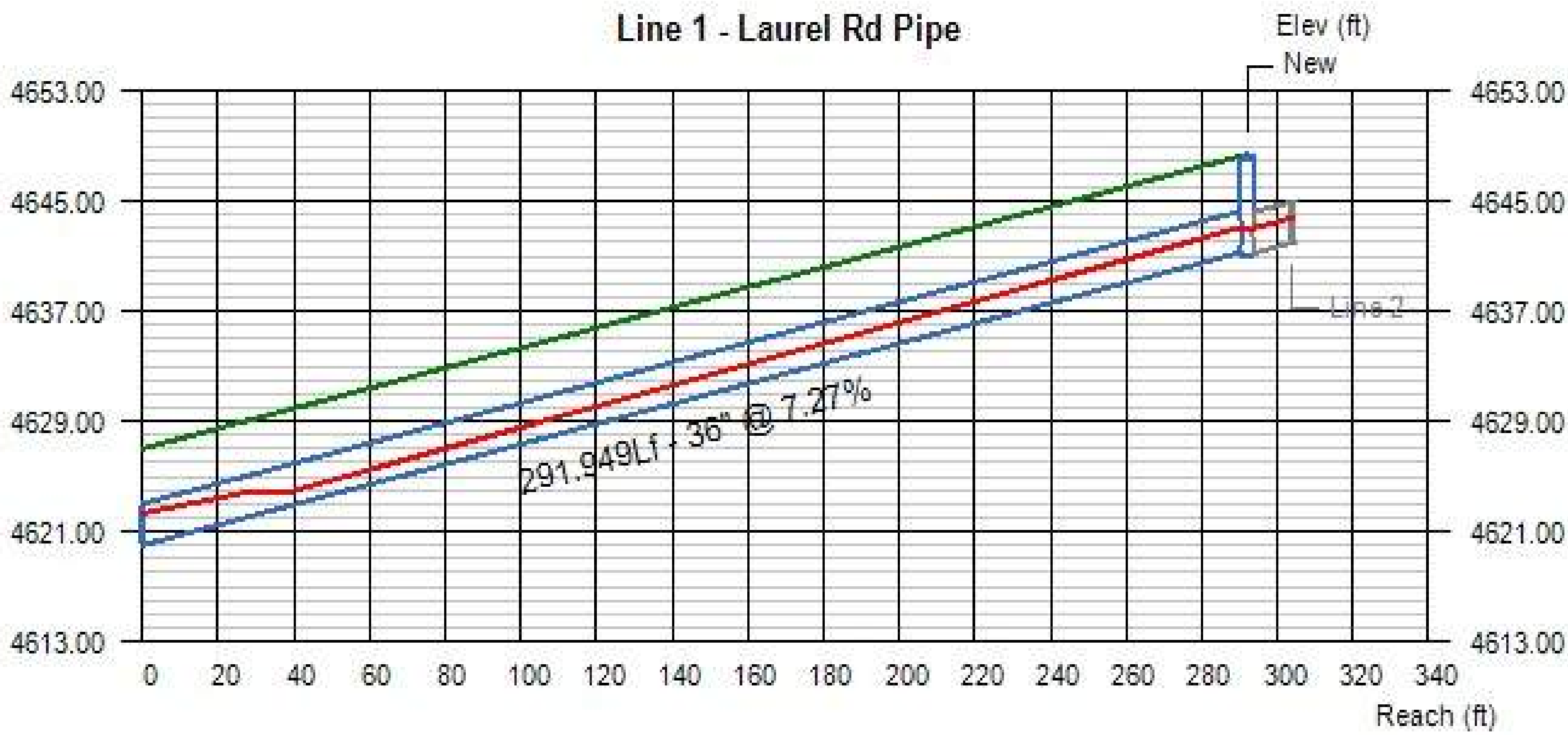
GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	18.2 in
Critical Depth	16.6 in
Channel Slope	0.010 ft/ft
Critical Slope	0.014 ft/ft

Line Profile (Line 1) - Laurel Rd Pipe



Line #	Q	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
	(cfs)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	31.00	4620.00	4641.23	2.30	1.80	1.80	4622.30	4643.03 j	4643.03	5.33	6.99	4.00	4.00

Project File:	No. Lines: 5	Run Date: 5/1/2023

Hydraflow Storm Sewers Extension for Autodesk® Civil 3D® Plan

Project File: Laurel Rd Pipe.stm	Number of lines: 5	Date: 5/1/2023

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Laurel Rd Pipe	31.00	36	Cir	291.949	4620.00	4641.23	7.272	4622.30	4643.03	n/a	4643.03 j	End	Manhole
2	Laurel Rd Pipe(2)	31.00	36	Cir	317.484	4641.23	4664.32	7.273	4643.03	4666.12	n/a	4666.12	1	Manhole
3	Laurel Rd Pipe(2)	31.00	36	Cir	207.043	4664.32	4679.38	7.274	4666.12	4681.18	n/a	4681.18	2	Manhole
4	Laurel Rd Pipe(2)(2)	31.00	36	Cir	130.629	4679.38	4688.88	7.273	4681.18	4690.68	n/a	4690.68	3	Manhole
5	Laurel Rd Pipe(2)(2)(2)	31.00	36	Cir	152.895	4688.88	4700.00	7.273	4690.68	4701.80	n/a	4701.80	4	OpenHeadwall

Project File: Laurel Rd Pipe.stm | Number of lines: 5 | Run Date: 5/1/2023

NOTES: Return period = 10 Yrs. ; j - Line contains hyd. jump.

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf		Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf	Ave Sf	Enrgy loss		
	(in)	(cfs)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(%)	(ft)	(K)	(ft)
1	36	31.00	4620.00	4622.30	2.30	4.44	5.33	0.76	4623.06	0.000	291.949	4641.23	4643.03 j	1.80**	4.44	6.99	0.76	4643.79	0.000	0.000	n/a	0.15	n/a
2	36	31.00	4641.23	4643.03	1.80*	4.44	6.99	0.76	4643.79	0.000	317.484	4664.32	4666.12	1.80**	4.44	6.99	0.76	4666.88	0.000	0.000	n/a	0.15	n/a
3	36	31.00	4664.32	4666.12	1.80*	4.44	6.99	0.76	4666.88	0.000	207.043	4679.38	4681.18	1.80**	4.44	6.99	0.76	4681.94	0.000	0.000	n/a	0.15	n/a
4	36	31.00	4679.38	4681.18	1.80*	4.44	6.99	0.76	4681.94	0.000	130.629	4688.88	4690.68	1.80**	4.44	6.99	0.76	4691.44	0.000	0.000	n/a	0.15	n/a
5	36	31.00	4688.88	4690.68	1.80*	4.44	6.99	0.76	4691.44	0.000	152.895	4700.00	4701.80	1.80**	4.44	6.99	0.76	4702.56	0.000	0.000	n/a	1.00	n/a

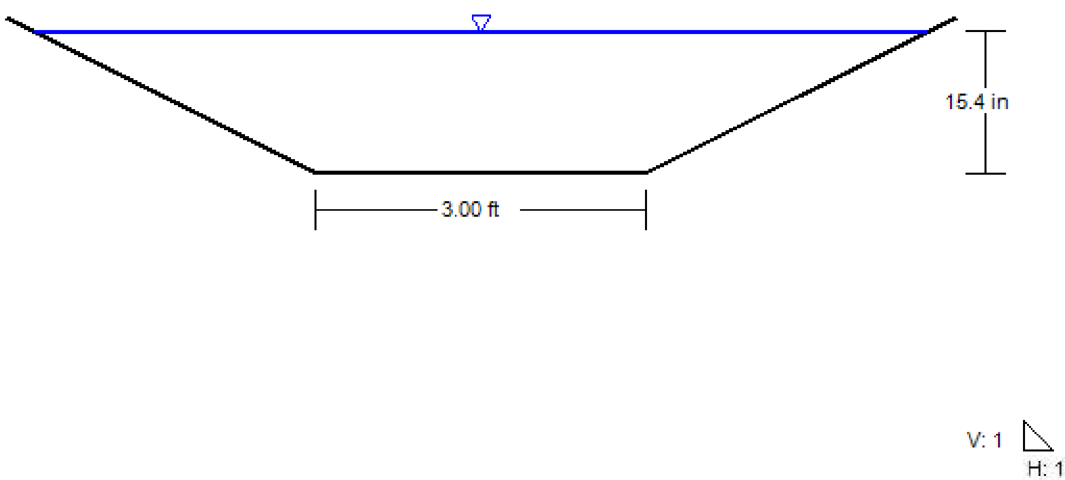
Project File: Laurel Rd Pipe.stm | Number of lines: 5 | Run Date: 5/1/2023

Notes: * Normal depth assumed; ** Critical depth.; j-Line contains hyd. jump ; c = cir e = ellip b = box

Cross Section for Pinion Hills Diversion Channel

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.030
Channel Slope	0.010 ft/ft
Normal Depth	15.4 in
Left Side Slope	2.000 H:V
Right Side Slope	2.000 H:V
Bottom Width	3.00 ft
Discharge	31.00 cfs



Worksheet for Laurel Rd Drainage Ditch

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.010 ft/ft
Left Side Slope	2.000 H:V
Right Side Slope	2.000 H:V
Bottom Width	3.00 ft
Discharge	31.00 cfs

Results

Normal Depth	15.4 in
Flow Area	7.2 ft²
Wetted Perimeter	8.7 ft
Hydraulic Radius	9.8 in
Top Width	8.14 ft
Critical Depth	13.8 in
Critical Slope	0.015 ft/ft
Velocity	4.33 ft/s
Velocity Head	0.29 ft
Specific Energy	1.58 ft
Froude Number	0.815
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	15.4 in
Critical Depth	13.8 in
Channel Slope	0.010 ft/ft
Critical Slope	0.015 ft/ft

Culvert Report

Laurel Rd

Invert Elev Dn (ft)	= 4709.00
Pipe Length (ft)	= 45.00
Slope (%)	= 1.00
Invert Elev Up (ft)	= 4709.45
Rise (in)	= 36.0
Shape	= Circular
Span (in)	= 36.0
No. Barrels	= 1
n-Value	= 0.015
Culvert Type	= Circular Concrete
Culvert Entrance	= Square edge w/headwall (C)
Coeff. K,M,c,Y,k	= 0.0098, 2, 0.0398, 0.67, 0.5

Embankment

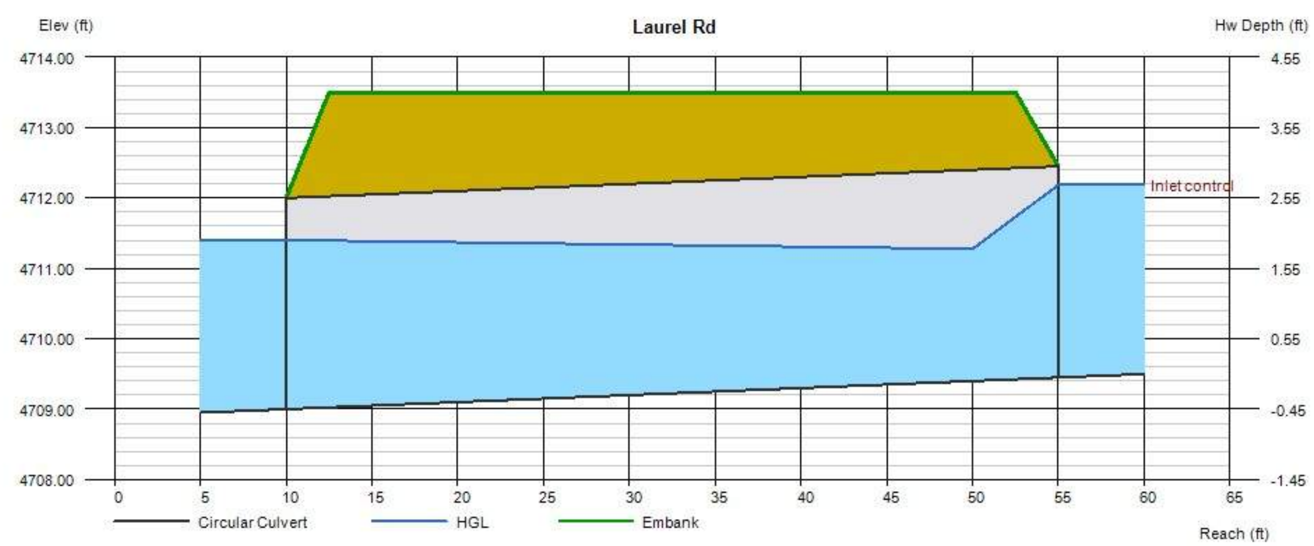
Top Elevation (ft)	= 4713.50
Top Width (ft)	= 40.00
Crest Width (ft)	= 40.00

Calculations

Qmin (cfs)	= 31.00
Qmax (cfs)	= 50.00
Tailwater Elev (ft)	= (dc+D)/2

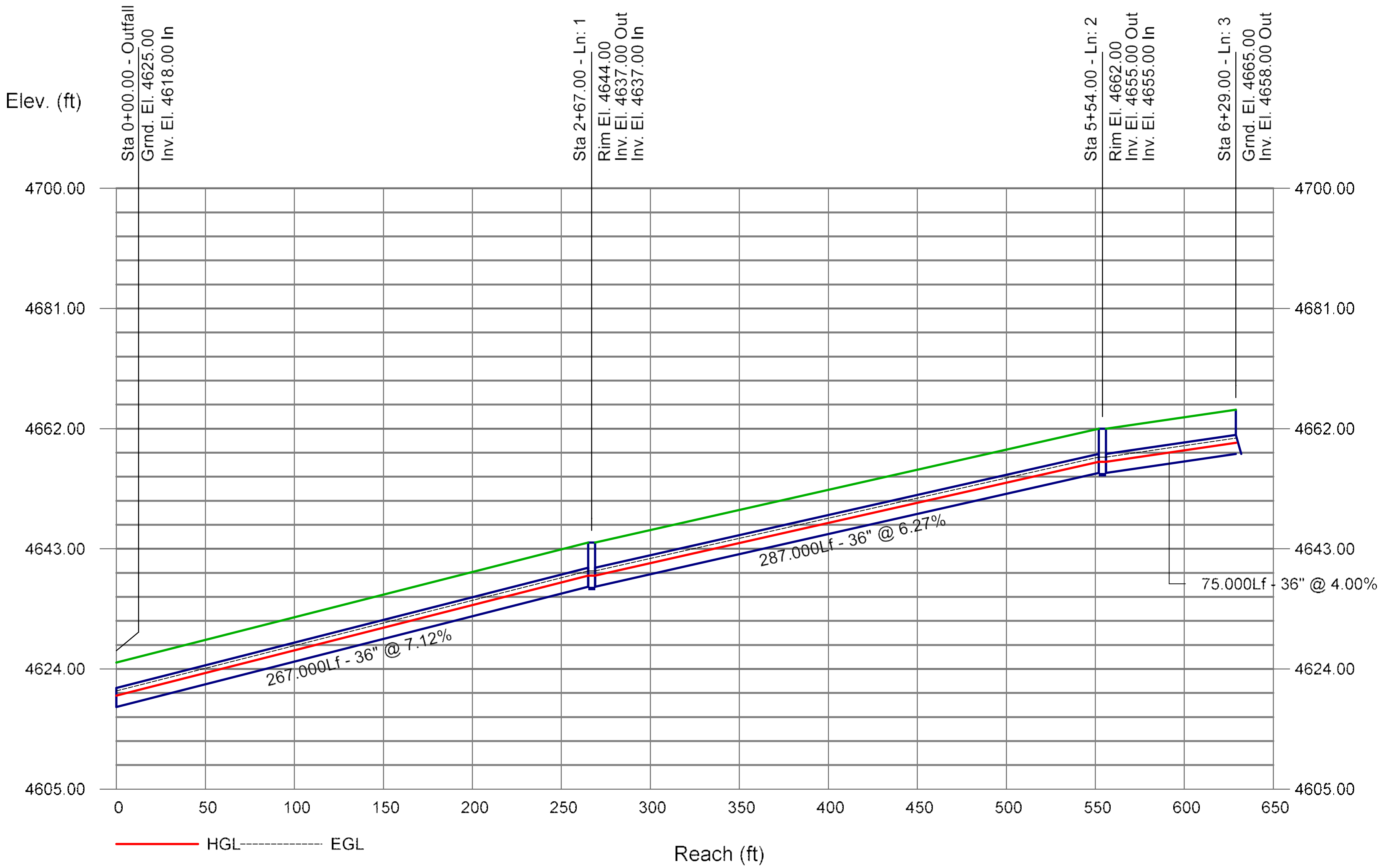
Highlighted

Qtotal (cfs)	= 31.00
Qpipe (cfs)	= 31.00
Qovertop (cfs)	= 0.00
Veloc Dn (ft/s)	= 5.11
Veloc Up (ft/s)	= 6.95
HGL Dn (ft)	= 4711.40
HGL Up (ft)	= 4711.26
Hw Elev (ft)	= 4712.19
Hw/D (ft)	= 0.91
Flow Regime	= Inlet Control

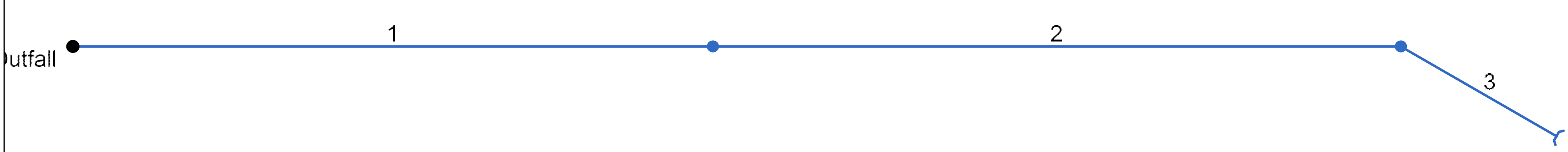


Storm Sewer Profile

Proj. file: Juniper Rd Pipe.stm



Juniper Rd



Project File: Juniper Rd Pipe.stm	Number of lines: 3	Date: 5/2/2023

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	DS	30.00	36	Cir	267.000	4618.00	4637.00	7.116	4619.77	4638.77	n/a	4638.77	End	Manhole
2	Mid	30.00	36	Cir	287.000	4637.00	4655.00	6.272	4638.77	4656.77	n/a	4656.77	1	Manhole
3	Up	30.00	36	Cir	75.000	4655.00	4658.00	4.000	4656.77	4659.77	n/a	4659.77	2	OpenHeadwall

Juniper Rd	Number of lines: 3	Run Date: 5/2/2023

NOTES: Return period = 10 Yrs.

Hydraulic Grade Line Computations

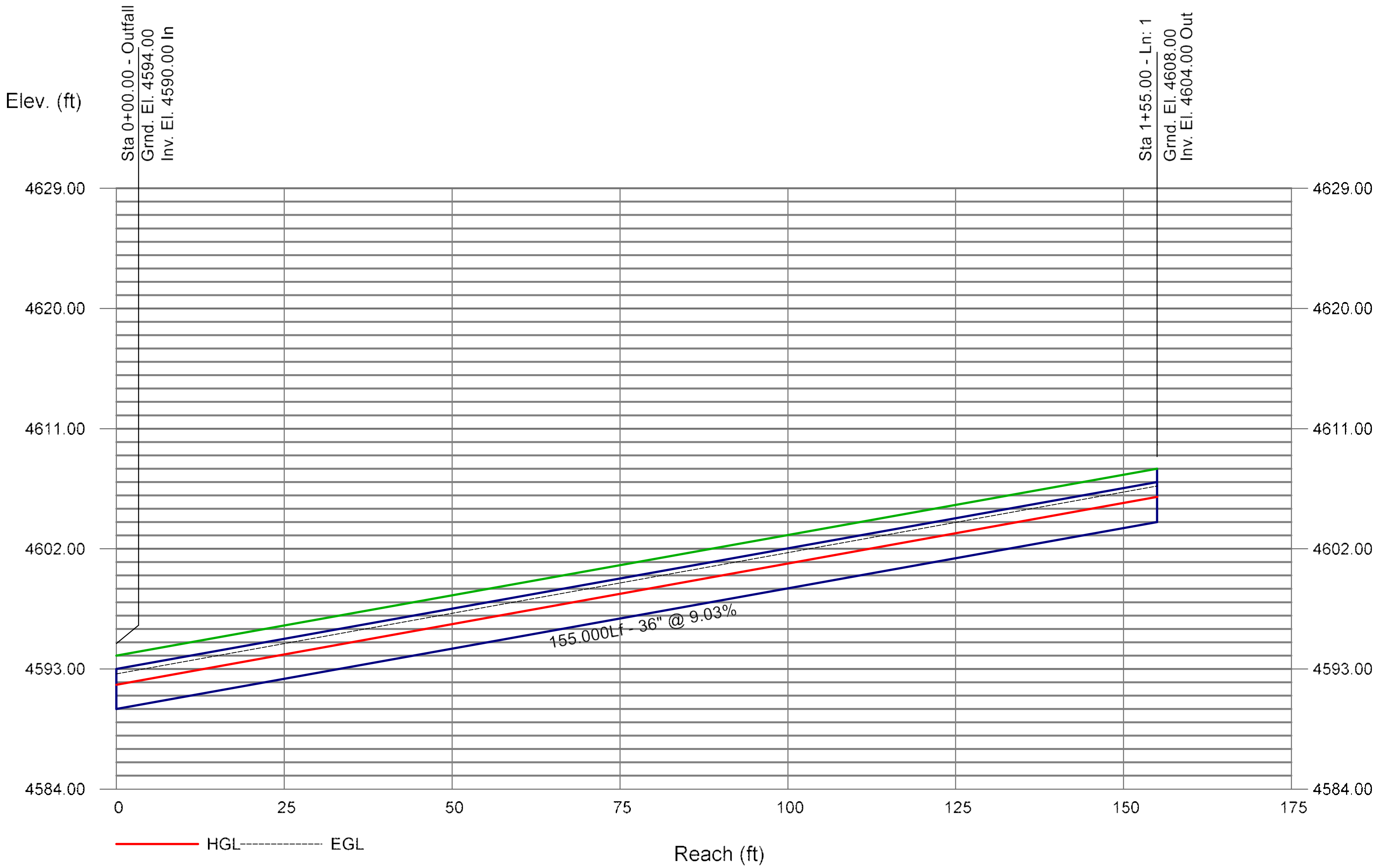
Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
			Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf		Invert elev	HGL elev	Depth	Area	Vel	Vel head	EGL elev	Sf	Ave Sf	Enrgy loss		
	(in)	(cfs)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(sqft)	(ft/s)	(ft)	(ft)	(%)	(%)	(ft)	(K)	(ft)
1	36	30.00	4618.00	4619.77	1.77	4.35	6.90	0.74	4620.51	0.000	267.000	4637.00	4638.77	1.77**	4.35	6.90	0.74	4639.51	0.000	0.000	n/a	0.15	n/a
2	36	30.00	4637.00	4638.77	1.77*	4.35	6.90	0.74	4639.51	0.000	287.000	4655.00	4656.77	1.77**	4.35	6.90	0.74	4657.51	0.000	0.000	n/a	0.56	n/a
3	36	30.00	4655.00	4656.77	1.77*	4.35	6.90	0.74	4657.51	0.000	75.000	4658.00	4659.77	1.77**	4.35	6.90	0.74	4660.51	0.000	0.000	n/a	1.00	n/a

Juniper Rd	Number of lines: 3	Run Date: 5/2/2023

Notes: * Normal depth assumed; ** Critical depth. ; c = cir e = ellip b = box

Storm Sewer Profile

Proj. file: Juniper Rd Pipe2.stm



Juniper Rd 2

Project File: Juniper Rd Pipe2.stm	Number of lines: 1	Date: 5/2/2023

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Juniper DS	34.00	36	Cir	155.000	4590.00	4604.00	9.032	4591.81	4605.89	0.81	4605.89	End	OpenHeadwall

Juniper Rd 2	Number of lines: 1	Run Date: 5/2/2023

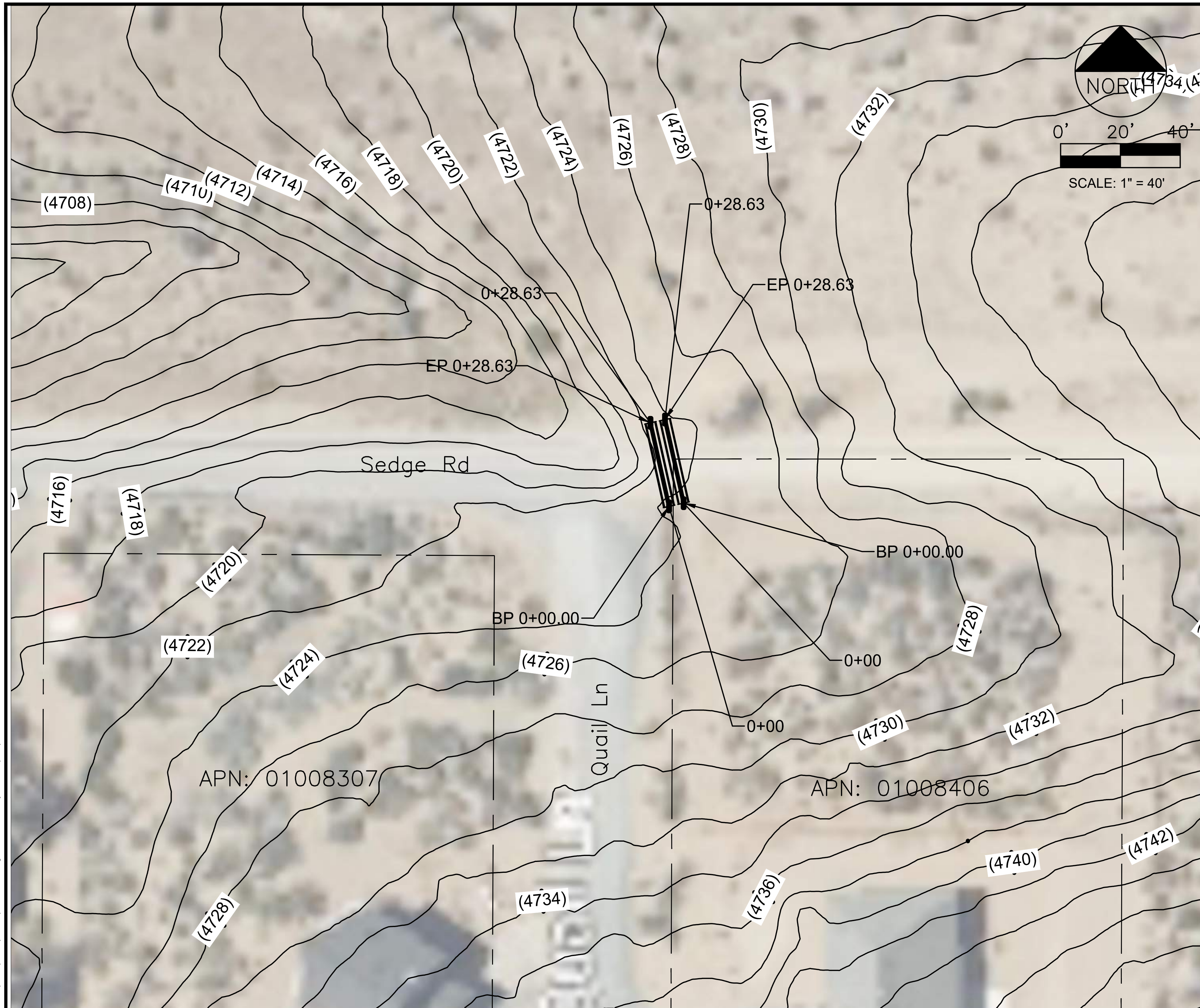
NOTES: Return period = 10 Yrs.

Hydraulic Grade Line Computations

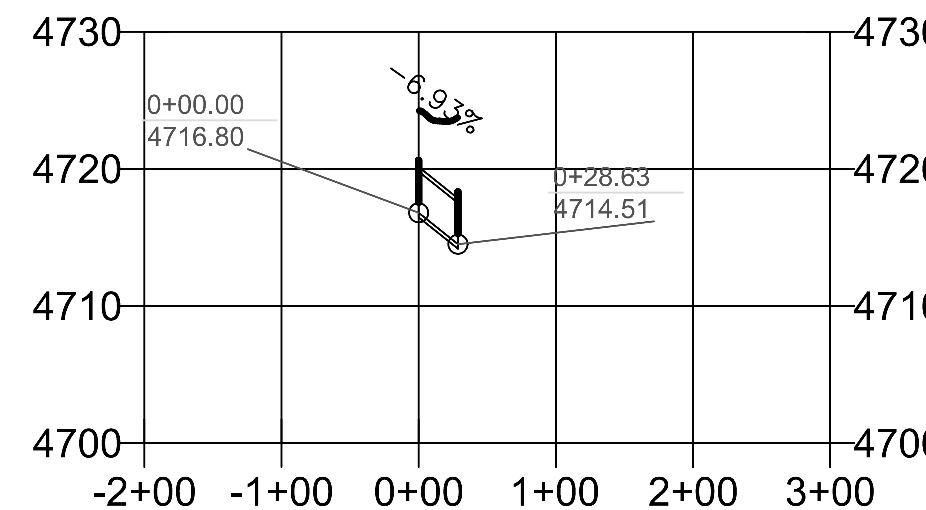
Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
1	36	34.00	4590.00	4591.81	1.81	4.46	7.63	0.81	4592.62	0.000	155.000	4604.00	4605.89	1.89**	4.70	7.24	0.81	4606.71	0.000	0.000	n/a	1.00	0.81

Juniper Rd 2 | Number of lines: 1 | Run Date: 5/2/2023

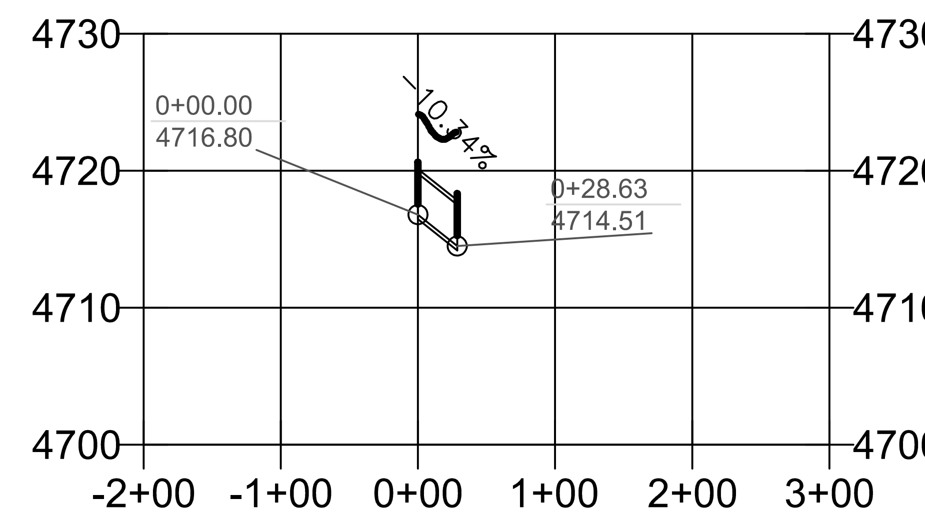
Notes: ; ** Critical depth. ; c = cir e = ellip b = box



(E) 36-Inch RCP Culvert w/ Headwalls



(W) 36-Inch RCP Culvert w/ Headwalls



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PHOENIX, AZ 85012-2794
602.279.1234 FAX 602.279.1411 www.MBAKERINTL.com

LEGEND

EG	Existing Grade
— — —	Parcel Boundary

NOT FOR CONSTRUCTION

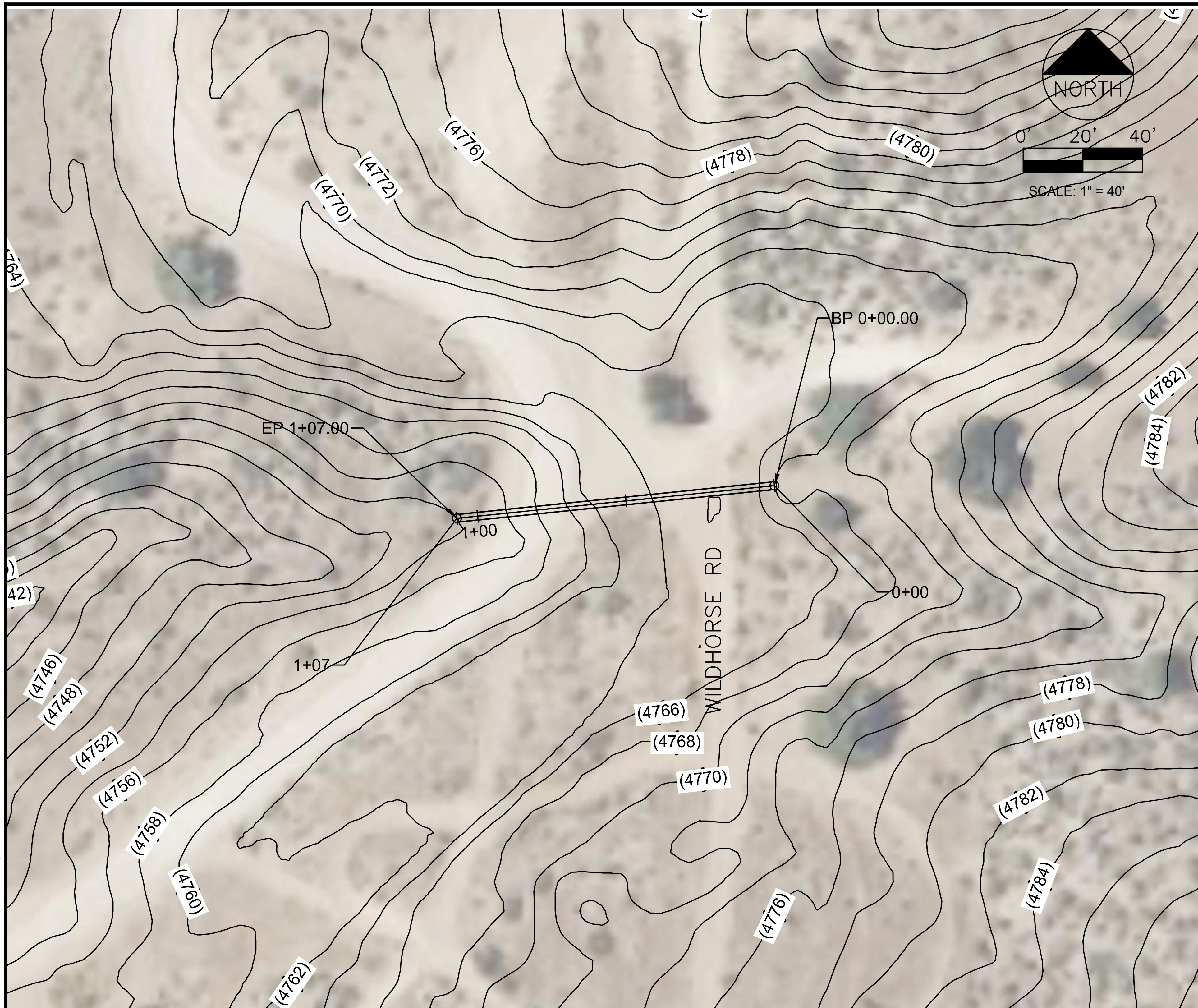
PROJECT NAME **EAST CARSON CITY - 10% CONCEPT PLANS**

EXHIBIT NAME **CULVERTS AT SEDGE RD AND QUAIL LN**

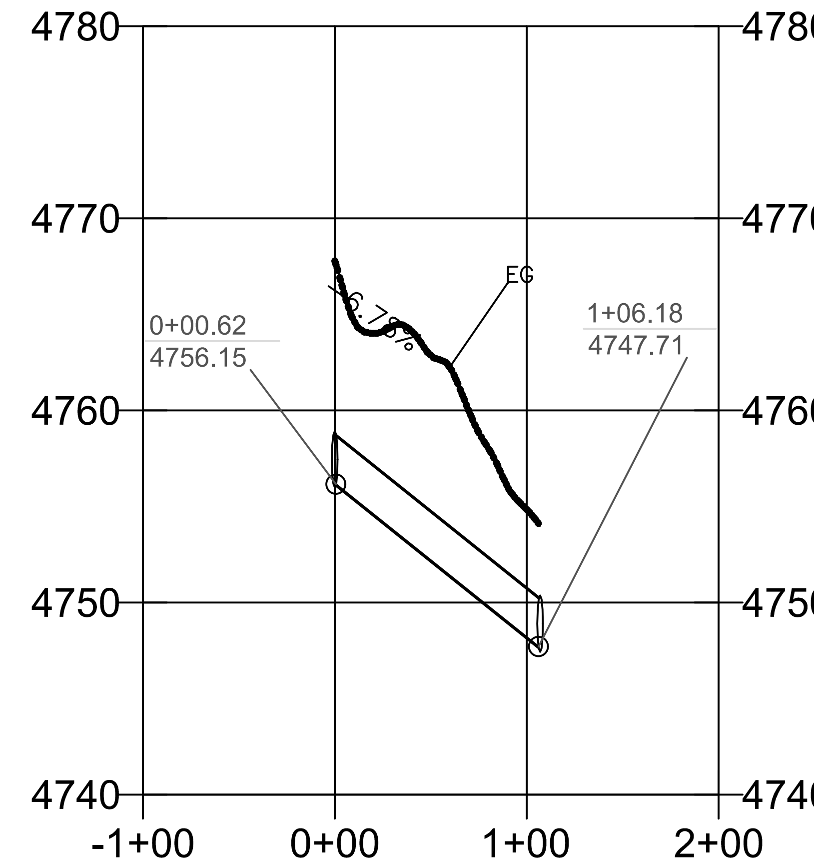
DATE FEB/2023

PROJECT NUMBER 189353

EXHIBIT 1



30-Inch HDPE Culvert



LEGEND

EG–Existing Grade

APNs?

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602.279.1234 FAX 602.279.1411 www.MBAKERINTL.com

PROJECT NAME: EAST CARSON CITY - 10% CONCEPT PLANS

EXHIBIT NAME: CULVERTS AT WILDHORSE RD

DATE: FEB/2023

PROJECT NUMBER: 189353

EXHIBIT 2

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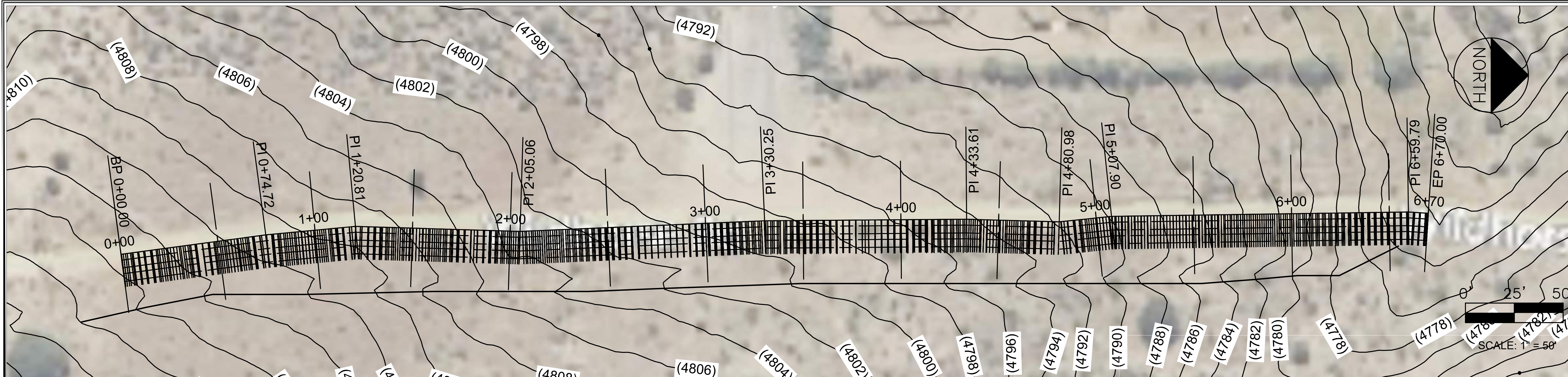
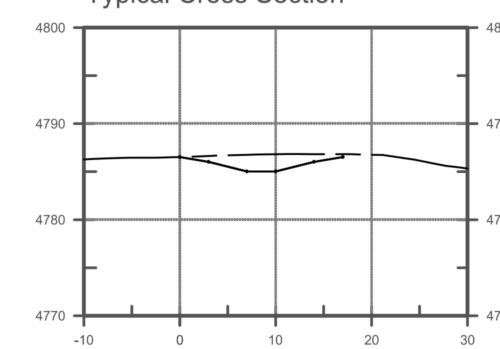
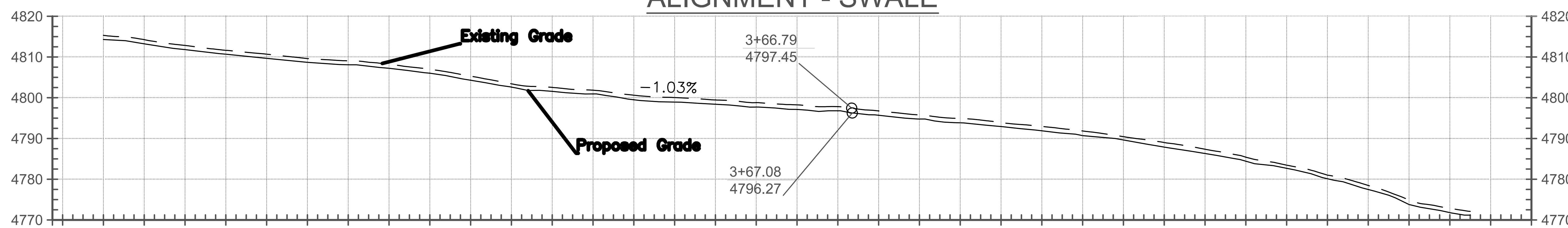


Typical Cross Section



ALIGNMENT - SWALE



Michael Baker INTERNATIONAL 2929 NORTH CENTRAL AVE, SUITE 800 PHOENIX, AZ 85012-2794 602.279.1234 FAX 602.279.1411 www.MBAKERINTL.com	LEGEND	NOT FOR CONSTRUCTION	PROJECT NAME: EAST CARSON CITY - 10% CONCEPT PLANS EXHIBIT NAME: SWALE AT WILDHORSE ROAD	DATE: FEB/2023 PROJECT NUMBER: 189353 EXHIBIT 3

C:\Projects\189353_East Carson\CAD\DWG\ConceptPlan_1.dwg Perez, Royce 2/21/23 3:48:54 PM

East Carson City

Area Drainage Master Plan

Carson Water Subconservancy District

Carson City Stormwater Management Program

FEMA

Michael Baker INTERNATIO

Project Partners

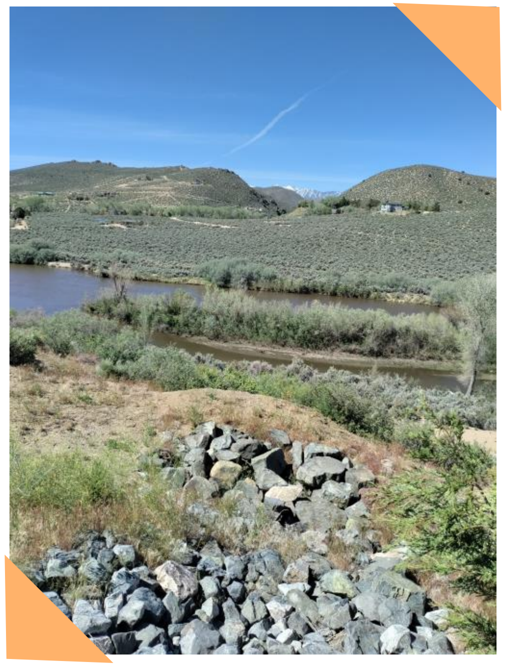
Carson City Public Works

Carson Water Subconservancy District

FEMA

Project Purpose

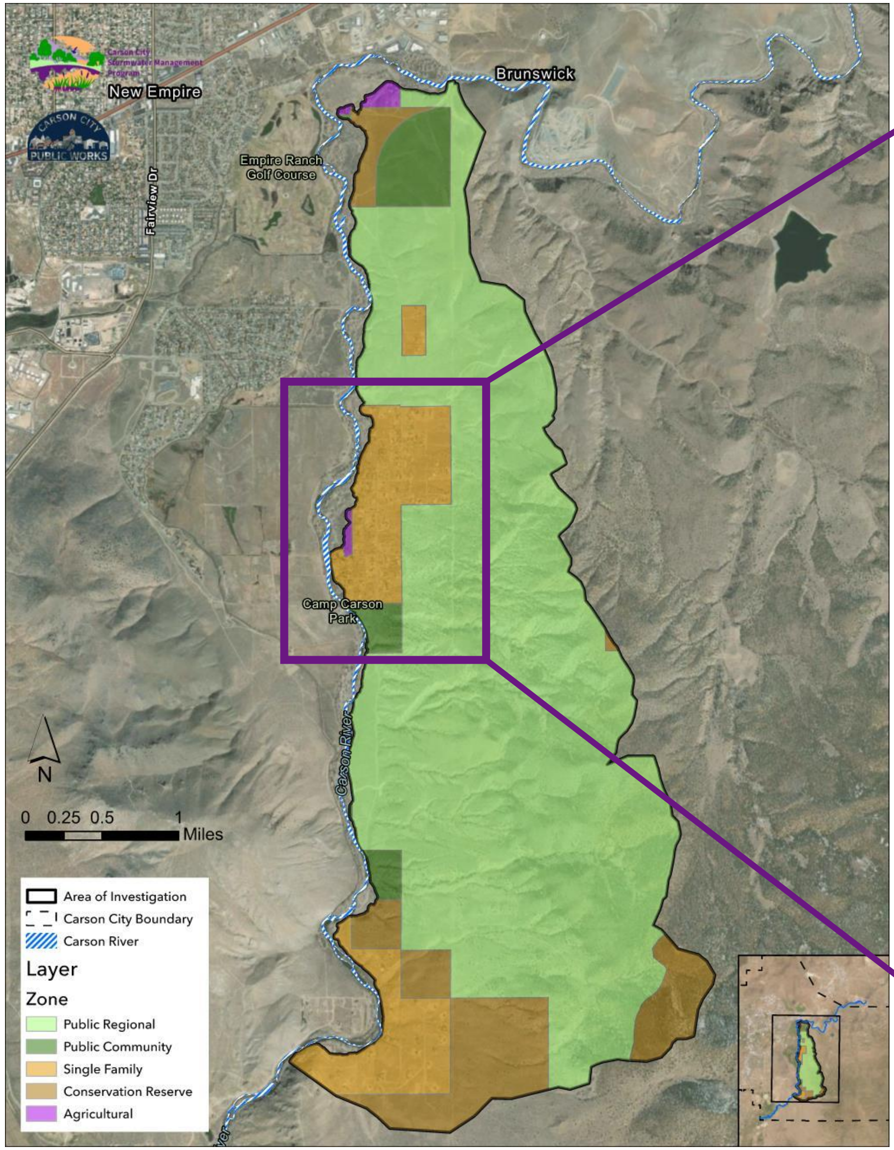
Evaluate the Pinion Hills area of Carson City for flooding risk and propose solutions to mitigate that risk.

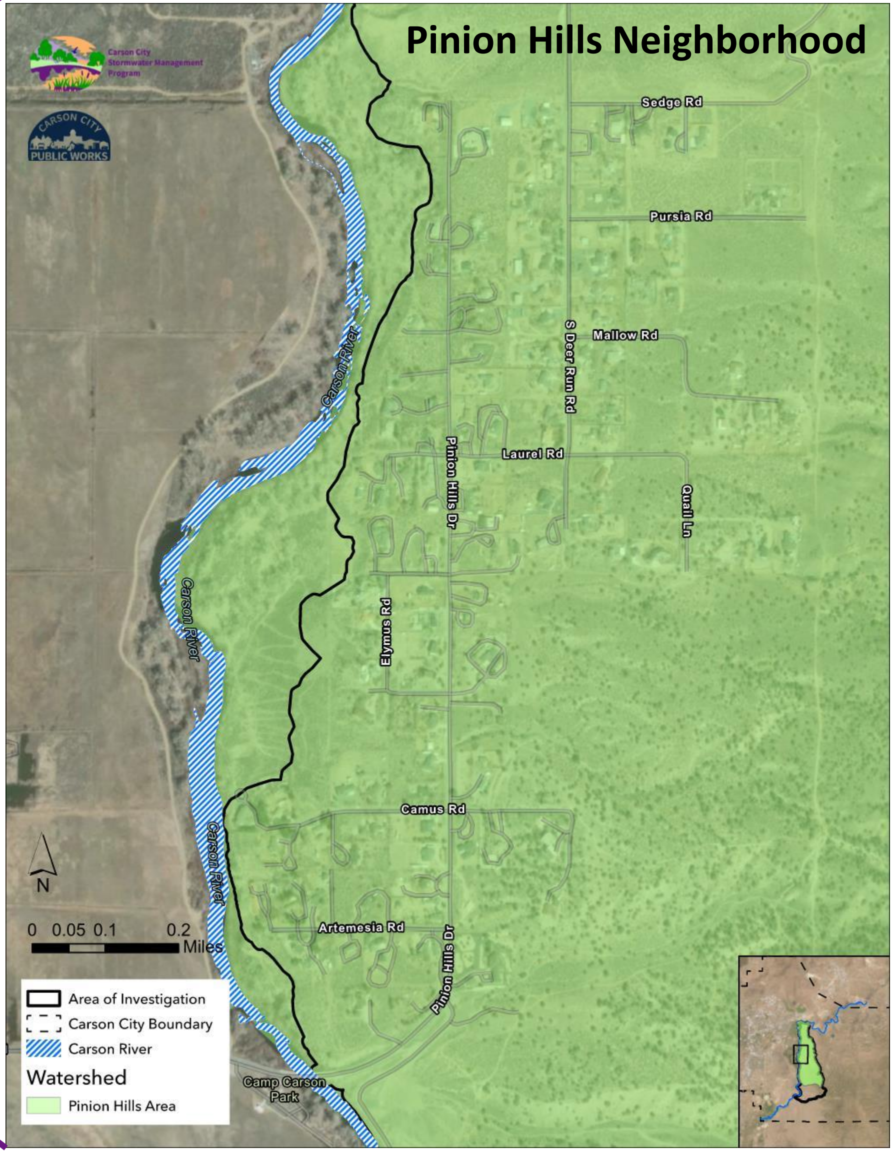


Project Goals

- Collect Data
  - Existing drainage information, through topographic survey and public sources
- Identify and quantify flood risk
  - within the study area through engineering software models
- Collect information from residents through public outreach
- Prepare a flood hazard strategy
  - Develop cost-effective project alternatives
  - Establish public support for future flood mitigation projects

Project Study Area





EAST CARSON CITY
AREA DRAINAGE MASTER PLAN

RESIDENT OUTREACH INFORMATION MEETING

Have you experienced flooding or have storm runoff issues on your property?

You are invited to an outreach event to discuss local flooding or drainage concerns in your neighborhood. Meet with Carson City staff and drainage experts to explore options to improve conditions to prevent damage to your home and property.

JOIN US ON

Tuesday, June 21, 2022 | 5:30-6:30 pm

Carson City Sheriff's Office Ormsby Room
911 East Musser Street, Carson City

stormw[redacted]otline@carson.org
(775) 88[redacted]05

CAN'T MAKE IT? PARTICIPATE VIA ZOOM
Phone: +1 (669) 900-6833
Meeting ID: 857 4998 1141

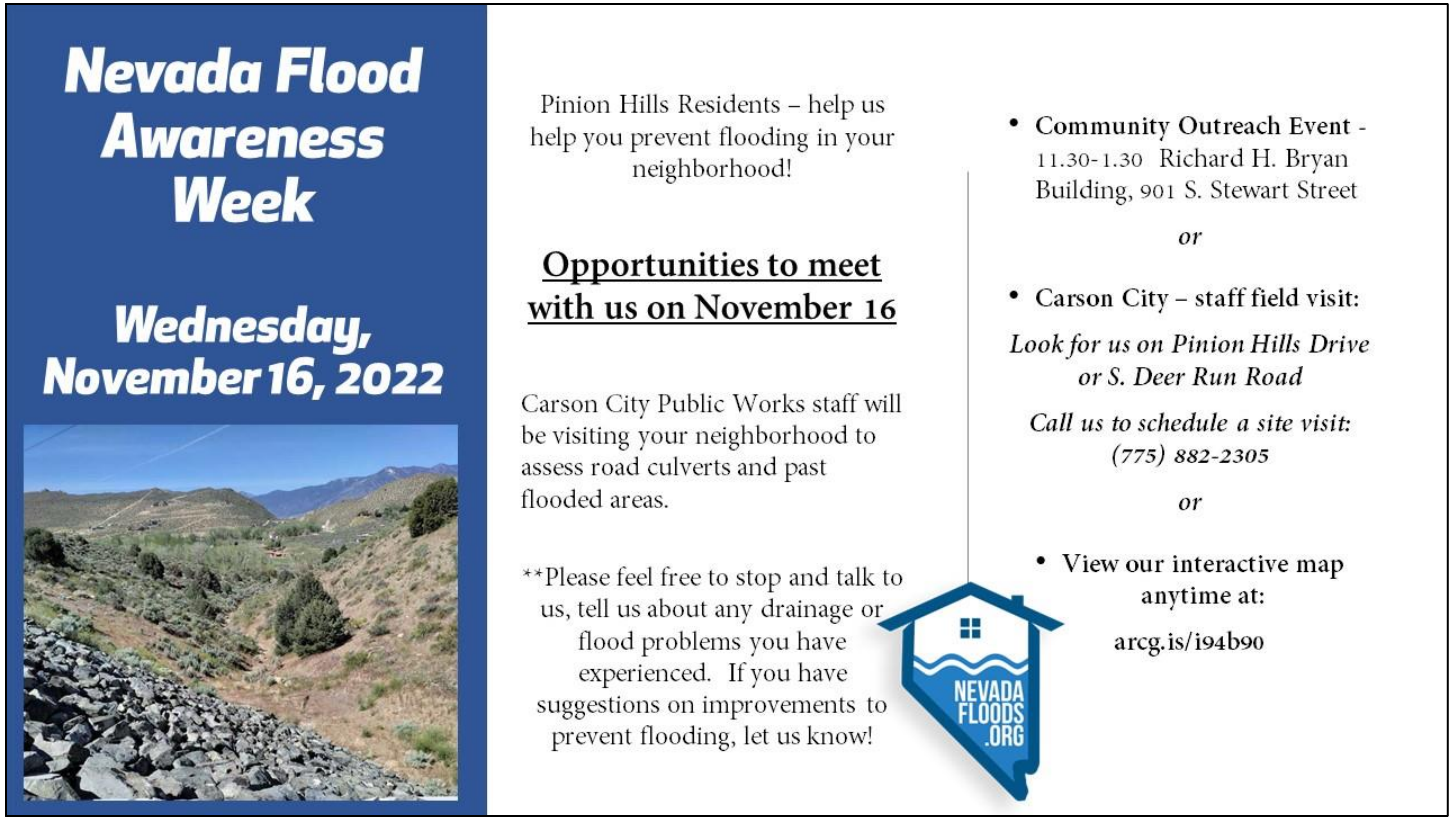
Share your concerns, comments and identify locations of past flood issues on our interactive map using this QR code on your phone or https://arcg.is/i94b90

VIRTUAL

IN PERSON

Outreach #2

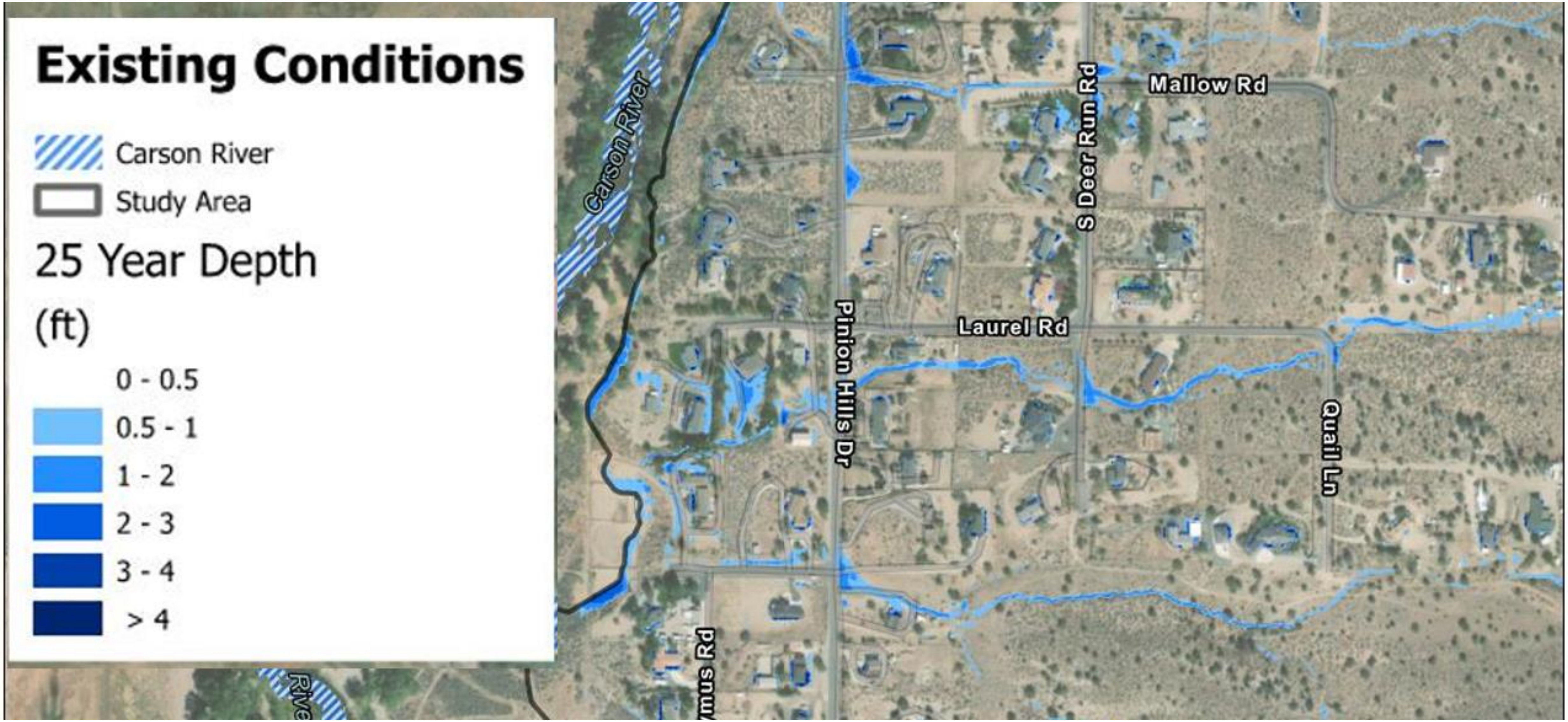
Coordinated with FAW



Two options to meet with residents:

- Meet City staff at Nevada's Flood Awareness Week activities at NDEP
- Meet us out in the field while walking around

Existing Conditions



Outreach #3

Community Walk

Carson City
Stormwater Management
Program

EAST CARSON CITY AREA DRAINAGE MASTER PLAN

Use this QR code on your phone or go to the link below to provide feedback or tell us about past flooding in your neighborhood.
https://www.surveymonkey.com/r/3RFHXNH

RESIDENT OUTREACH FOR ALTERNATIVE SOLUTIONS

*We will be in your neighborhood on **Monday, February 13th**. Please watch for us as we go door-to-door or call us to schedule a visit with you (775-283-7083).*

Carson City Public Works has identified the potential of flooding in your neighborhood Quail Lane & Sedge Road as a result of runoff in the washes from the hills above. We would like to present alternative solutions that could be constructed to convey the water away from homes and/or access roads to prevent future flooding.

Please see the enclosed map for which we have proposed a solution. We would like your input as it may affect you and your property directly.

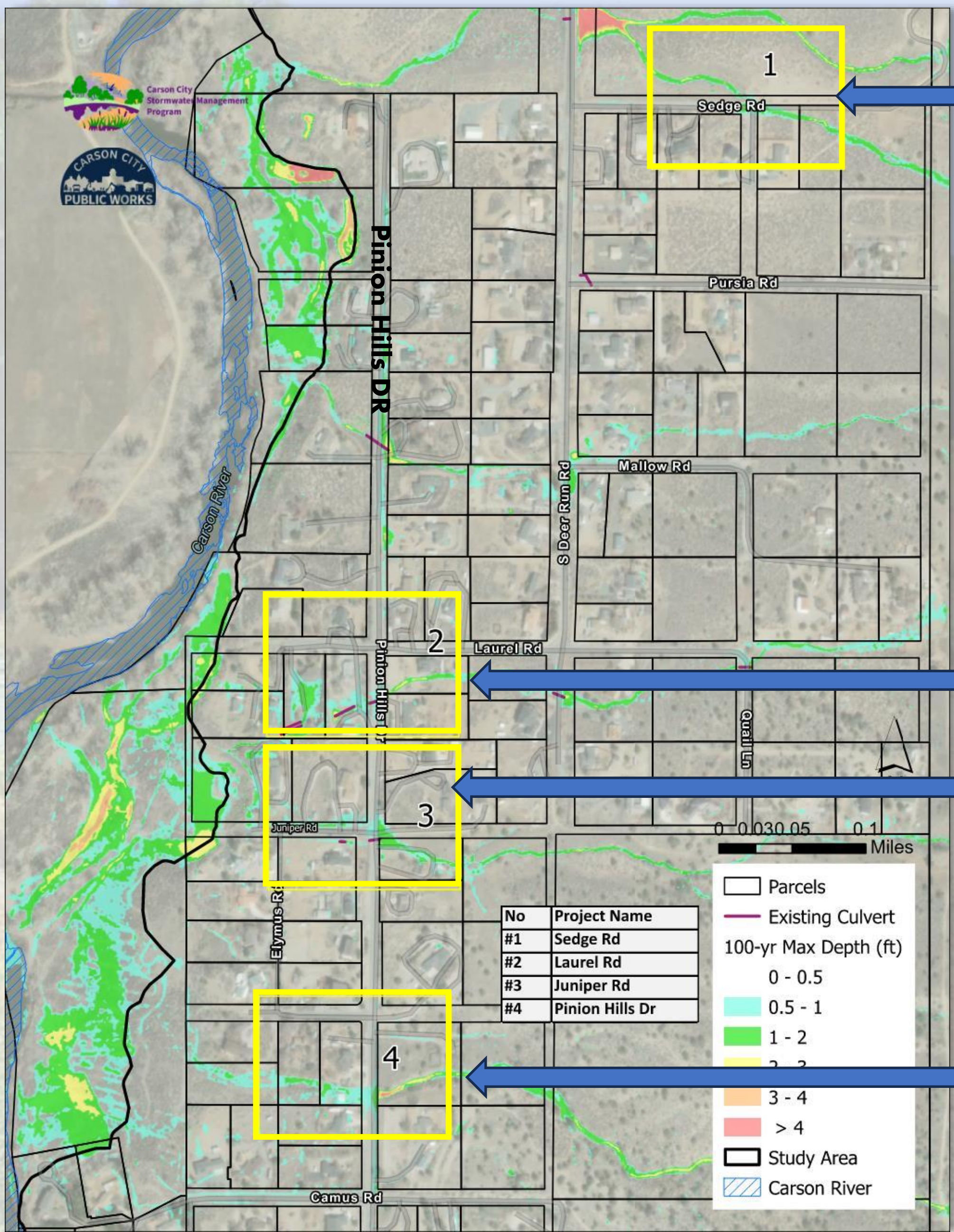
Look inside for maps and more information
Your feedback is important

CONTACT US

Office: 3505 Butti Way Carson City, NV 89701
Call the Hotline: (775) 887-2305
Email us: stormwaterhotline@carson.org

CARSON CITY PUBLIC WORKS

Areas of Interest



Sedge Road

Laurel Road

Juniper Road

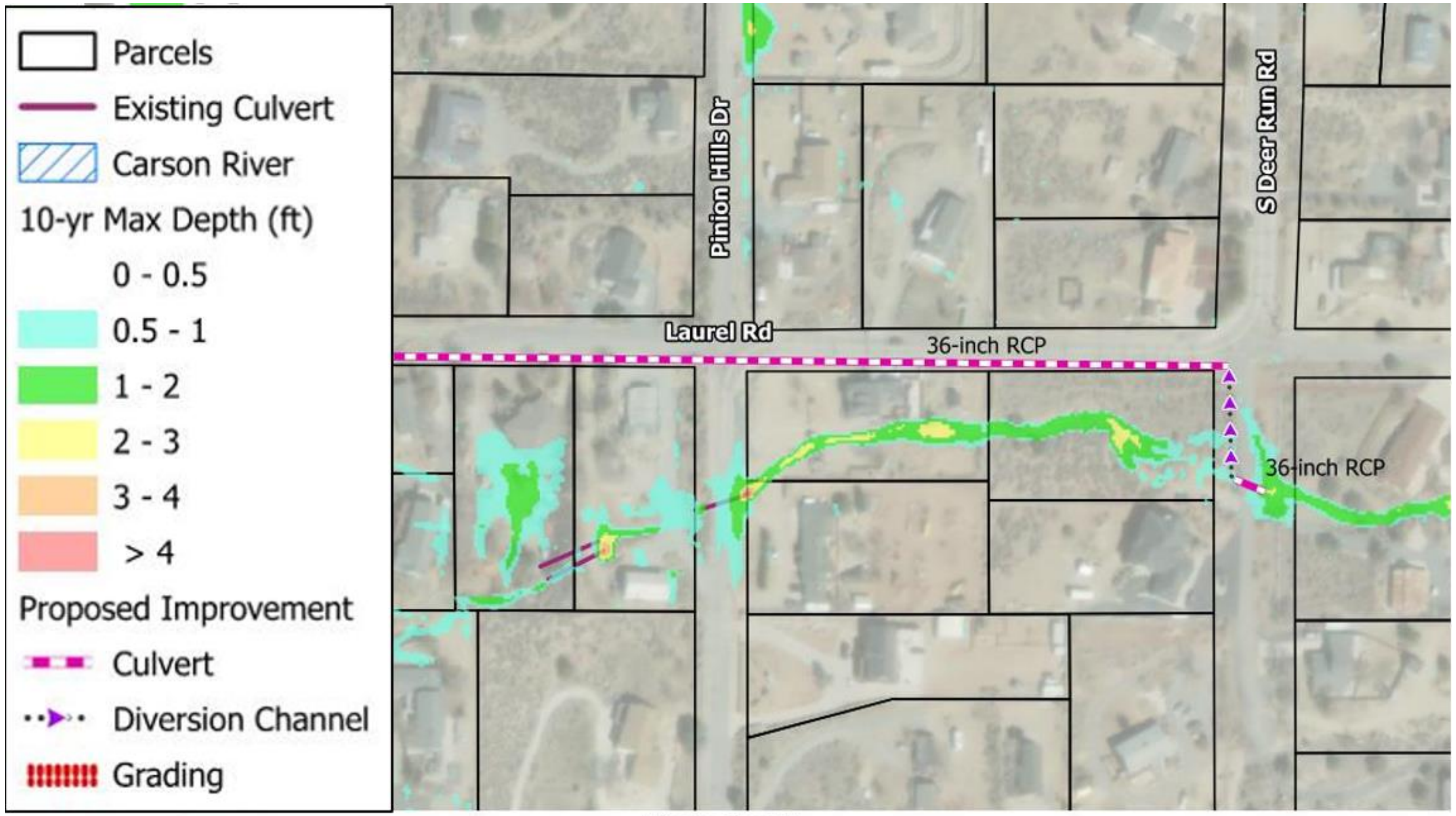
Pinion Hills Drive

Design Goals

1. **Up to 25-year protection**
2. **Utilize City right-of-way**
3. **Mitigate downstream conditions to match existing (pre-flood)**

Development Alternatives

Design Results

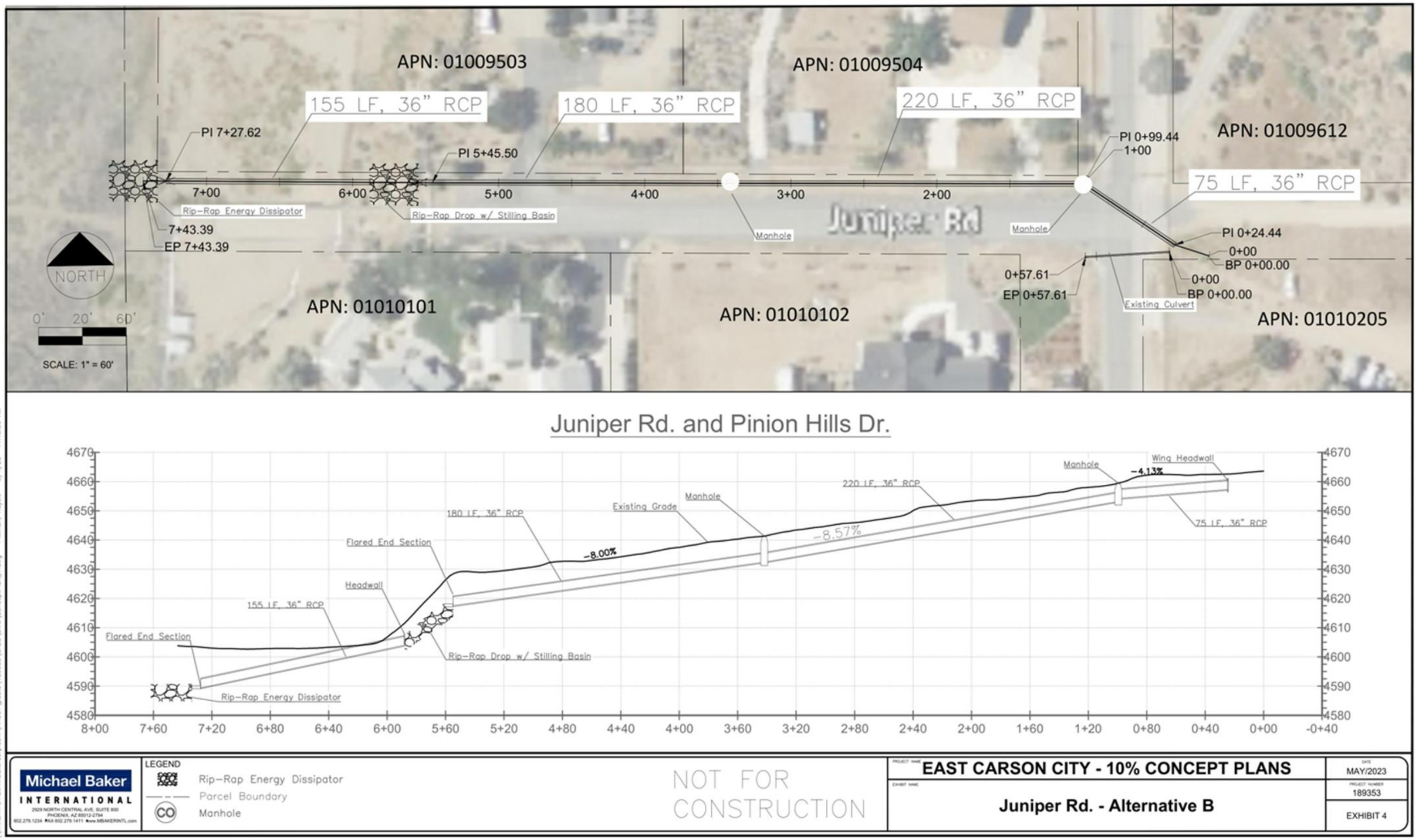


Alternative B

- 10- year protection
- Matches downstream storm drain capacity
- Significantly mitigated 100-year flood depths

Concept Plans

Project Name	Level of Service	Cost	Benefit-Cost Ratio
Pinion Hills	25	$647,000	1.9
Laurel Rd	10	$924,000	1.1
Juniper Rd	25	$589,000	2.1



Next Steps

- Board of Supervisors
  - Approve the plan
- Public Works
  - Pursue funding opportunities