

**MOAB CITY COUNCIL MINUTES
REGULAR MEETING
DECEMBER 12, 2017**

Regular Meeting & Attendance: The Moab City Council held its Regular Meeting on the above date in the Council Chambers at the Moab City Center, located at 217 East Center Street, Moab, Utah. A recording of the meeting is archived at <http://www.utah.gov/pmn/index.html>.

Pre-Council Workshop: Mayor David Sakrison called the Workshop to order at 6:30 PM. In attendance were Councilmembers Rani Derasary, Heila Ershadi, Tawny Knuteson-Boyd, Kyle Bailey and Kalen Jones. Also in attendance were City Manager David Everitt, City Recorder/Assistant City Manager Rachel Stenta, City Attorney Chris McAnany, City Engineer Chuck Williams, Public Works Director Pat Dean, City Treasurer Jennie Ross, Special Projects Manager Amy Weiser, Planning Director Jeff Reinhart, Communications Director Lisa Church, Development Services Manager Sommar Johnson, Recorder Assistant Eve Tallman and Parks, Recreation, and Trails Director Tif Miller.

The Workshop began with a discussion of the recently-adopted ordinance regarding idling vehicles and overnight parking. Weiser noted some confusing language. She added Councilmember Jones had pointed out a need for consistent language.

Councilmember Bailey mentioned correspondence received from an unsuccessful bidder for the Supervisory control and data acquisition (SCADA) project.

Councilmember Knuteson-Boyd asked about the pool toy being requested; she requested information about how the staff would track fiscal accountability with increased pool revenues. Terry Lewis, staff member from the Moab Recreation and Aquatics Center, explained the implementation schedule and noted users would pay extra on days the Witbits is in use. Councilmember Jones asked if the staff had been in contact with other facilities using the Witbits and the answer was yes.

Councilmember Derasary reported that she had met the new Code Compliance officer. City Manager Everitt confirmed the City had hired Mona Pompili and citizens with complaints and requests for code enforcement may contact her.

Mayor Sakrison asked if the Entrada landscape plan is in compliance. City Planner Reinhart stated the project is not yet to that stage. He added the developer has a bond, and they won't get their Certificate of Occupancy until the landscaping is completed. Councilmember Derasary added that she had a discussion with neighbors with suggestions. Reinhart stated he passed the feedback along and he can update Council on progress. He added that the Council approved the plan so there would not be a need to remove landscaping already installed.

City Engineer Williams explained the Pack Creek project change order. He mentioned more concrete was needed than originally planned, and the funds are expected to be reimbursed from a Department of Environmental Quality grant.

Councilmember Bailey asked about the Main Street road project. Williams explained the purpose and timeline for the project. Councilmember Knuteson-Boyd asked for updates to be posted on the City's Facebook page. Bailey asked about the cost and Williams said it was \$2 to 4 million, not using City funds.

Regular Meeting Called to Order: Mayor Sakrison called the Regular City Council Meeting to order at 6:57 PM and Councilmember Bailey led the Pledge of Allegiance. Approximately 75 members of the public and media were present.

Citizens to be Heard:

There were no citizens to be heard.

Student of the Month: Mayor Sakrison was presented with the Helen M. Knight School "Mayor of the Century" award by Principal Taryn Kay. She thanked Mayor Sakrison for his many years of leadership. The Mayor spoke about his thirty years in service to the community, and noted retiring Councilmember Bailey's 31 years of service and retiring Councilmember Ershadi's four years of service and presented them with plaques.

Presentation of the Annual Audit: John Haderlie presented Mayor Sakrison with a gift of appreciation. He next submitted the Annual Audit for the City of Moab for Fiscal Year 2016-2017. He noted that the

audit date is based upon June 30, 2017 and that in all required areas, the City was in compliance with state code regarding financial reporting.

Haderlie next presented a report on City financial matters of concern to the auditors, including personal use of government vehicles and fringe benefits. He explained that any type of compensation is considered taxable income and there are procedures to follow to allay concerns with the Internal Revenue Service. Haderlie stated there were 27 vehicles being used and taken home by employees, with only two being considered "on call" vehicles, and the beneficial usage should be considered taxable income by the employees, and may impact individuals' income taxes. He explained clearly marked public safety vehicles are exempt in most cases.

Approval of Minutes:

(:55 on recording)

Councilmember Knuteson-Boyd moved to approve the minutes of the November 14, 2017 meeting with corrections. Councilmember Derasary seconded the motion. Councilmember Derasary abstained because she did not attend the meeting. The motion carried 4-0 aye, with Councilmembers Bailey, Jones, Ershadi and Knuteson-Boyd voting aye.

Public Hearing:

At 7:26 PM, Mayor Sakrison opened a public hearing for Proposed Resolution #01-2018 – A Resolution Establishing Storm Water Utility Rates and Proposed Resolution #02-2018 – A Resolution Revising Miscellaneous Culinary Water Use Fees and Clarifying Rates for Multiple Residential Dwellings that Share a Water Meter.

City Manager Everitt presented the proposed storm water rate changes and reminded the Council that the increase is reflected in the budget. Everitt continued with an explanation of the proposed improvements to the recently-approved culinary water rates, including changing the Bed and Breakfast rate to commercial, removing the special rate for volunteer fire fighters, and how to address shared residential meters. Everitt pointed out that the fire fighter rate was unfair to any other vital community volunteers who do not receive special consideration. Mayor Sakrison asked about the fire line rate, and Everitt acknowledged there is confusion about this rate. Treasurer Ross confirmed no one is being charged this rate.

Councilmember-elect Mike Duncan asked if the increased rates would be used for operational costs and existing infrastructure. Everitt confirmed the funds would be used for maintenance and upgrades for existing infrastructure. Duncan next asked if the City's system were to expand, would rates increase again. Everitt explained there is a current culinary water master plan process underway, and a rate study is a part of the planning process. Everitt also clarified that impact fees cover new services and are distinguished from utility rates for current customers, and both costs are being studied.

Mayor Sakrison asked about the cost of the Stewart Canyon infrastructure project.

Consent Agenda:

(1:10 on recording)

Motion and Vote: Councilmember Jones moved to approve the Consent Agenda. Councilmember Knuteson-Boyd seconded the motion. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi, and Derasary voting aye. The following items were approved:

- 1) Request for Approval of a Sole Source Purchase to Recreonics, Inc. for a Witbits Sports Modular Aquatic Play System in an amount not to exceed \$16,605.
- 2) Request to Set a Public Hearing Date of January 9, 2018 for the Proposed Waste Hauling Commercial Rate Changes.
- 3) Request for Approval of a Sole Source Purchase to Precision Concrete Cutting for a Sidewalk Trip Hazard Repair Bid in an amount not to exceed \$25,000.
- 4) Approval and Award of the Supervisory Control and Data Acquisition (SCADA) Monitoring System for the City of Moab Culinary Water Department to Dorsett Technologies in an amount not to exceed \$150,000.
- 5) Request for Approval of Three Public Utility Easement Agreements for 500 West Utilities.

New Business:

(1:11 on recording)

Annual Audit—Accepted

Motion and Vote: Councilmember Bailey moved to accept the Annual Audit of the City of Moab for Fiscal Year 2016-2017. Councilmember Jones seconded the motion. The motion passed 5-0 aye, with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Storm Water Master Plan—Adopted

Motion and Discussion: City Engineer Williams described the City's storm water system and the proposed plan. He noted that the City's projects represent a \$6 million need with about \$2 million being accounted for with the 100 South project and the Stewart Canyon project. He also mentioned that the adoption of the Plan will enable the City to pursue funding opportunities, such as those offered by the Federal Emergency Management Agency (FEMA). Councilmember Jones asked about reconstruction of streets and lowering the crowns in order to increase flow capacity, and whether that element is included in the Plan, and Williams confirmed that it was. Councilmember Bailey asked about how the storm water is managed, and cited the example of Las Vegas, and asked if that municipality reuses storm water. Williams explained that Las Vegas is able to capture storm water in large box culverts under the streets. He did not know if the water was reused for irrigation. Everitt commented that this Plan represents bringing the City's infrastructure to a baseline level. Councilmember Jones asked questions about flow capacity and also about the ability to remodel fully-developed downtown properties in view of storm water retention requirements. Jones also mentioned that the Water Conservation Board and the Watershed Council would appreciate the opportunity to review this proposed Waste water management plan, and Councilmember Derasary also brought up the possibility of revising the Plan within the next five years, if desired. Williams agreed that the Plan can be amended at any time.

Vote: Councilmember Derasary moved to adopt the Moab Storm Water Master Plan (October 2017). Councilmember Ershadi seconded the motion. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Parked and Idling Vehicles—Tabled

Discussion: Councilmember Jones noted he had communicated with staff about wording and consistency with the rest of the code. City Attorney McAnany explained that the code is being revised and corrected on a chapter-by-chapter basis.

Motion and Vote: Councilmember Jones moved to table until January 9 the motion to approve Proposed Ordinance #2017-39 – An Ordinance Amending the City of Moab Municipal Code, Title 10 Vehicles and Traffic. Councilmember Derasary seconded the motion. The motion to table passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Regional Water Board Vacancies—Discussion

Councilmember Bailey stated he is an appointed member of the Grand County Water Special Service District. Bailey clarified the appointment is at the discretion of Council and he has been on the board for many years. Mayor Sakrison remarked on the importance of this board and invited future Councilmembers to think about this assignment.

2018 City Council Meeting Schedule—Approved

Motion and Vote: Councilmember Jones moved to approve the 2018 Moab City Council Meeting Schedule. Councilmember Knuteson-Boyd seconded the motion. Councilmember Derasary brought up annual conflicts with state-wide meetings and specific Council meeting dates. Councilmember Knuteson-Boyd suggested alterations to the schedule could be adopted by the incoming Council. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

2018 Moab City Holiday Schedule—Approved

Motion and Vote: Councilmember Knuteson-Boyd moved to approve the 2018 Moab City Holiday Schedule. Councilmember Jones seconded the motion. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Interlocal Agreement for County-Wide Recreation Services—Approved

Motion and Vote: Councilmember Jones moved to approve Proposed Resolution #62-2017 – A Resolution Approving an Interlocal Agreement as to the provision of County-wide Recreation Services, by and among the City of Moab, the Grand County Special Services Recreation District and the Grand County School District. Councilmember Knuteson-Boyd seconded the motion. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Old Business:**(1:45 on recording)****Slot Canyon Renovation Project—Approved**

Motion and Vote: Councilmember Jones moved to approve Proposed Resolution #63-2017 – A Resolution Approving the first amendment to the Development Improvements Agreement for the Slot Canyon Renovation Project at 245 Williams Way. Councilmember Derasary seconded the motion. City Planner Reinhart explained the proposed action. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

ROUFA Subdivision Boundary Line Adjustment—Approved

Motion and Vote: Councilmember Jones moved to approve Proposed Resolution #61-2017 – A Resolution Approving a Boundary Line Adjustment for Lots 1 and 2 of the ROUFA Subdivision and the Improvements Agreement for Public Improvements as Submitted by Chad Harris. Councilmember Knuteson-Boyd seconded the motion. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Pack Creek Bank Grading Project Change Order—Approved

Motion and Vote: Councilmember Derasary moved to approve Change Order #1 for the Pack Creek Bank Grading Project. Councilmember Bailey seconded the motion. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Budget Amendment—Approved

Motion and Vote: Councilmember Knuteson-Boyd moved to approve Proposed Resolution #58-2017 – A Resolution Amending the Fiscal Year 2017-2018 Annual Budget. Councilmember Bailey seconded the motion. City Manager Everitt gave a brief overview of updated changes. Councilmember Jones noted his skepticism about the cost of a workplace study proposed in the budget and said he proposed pushing that item to a later budget opening with the hope that staff could articulate the need for the funding. Councilmember Knuteson-Boyd pointed out the line item is a placeholder and Everitt confirmed this step commits funding for the study and that the scope of the study, sometimes referred to as a desk audit, could be worked out at a later date. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi and Derasary voting aye.

Mayor and Council Reports:

Mayor Sakrison reported that he attended the meeting of the Utah League of Cities and Towns (ULCT). Councilmember Jones reported on a reorganization of the Housing Task Force. He also noted he attended a Dark Skies meeting.

Councilmember Knuteson-Boyd mentioned attending the ULCT meeting upstate.

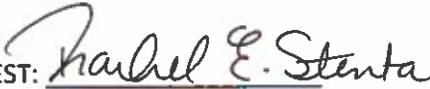
Councilmember Derasary reported on a Trail Mix meeting. She noted there is Community Development Block Grant (CDBG) funding available for 2018. She also noted the ULCT meeting, and said she attended the League of Women Voters' meeting at which Chief Winder spoke.

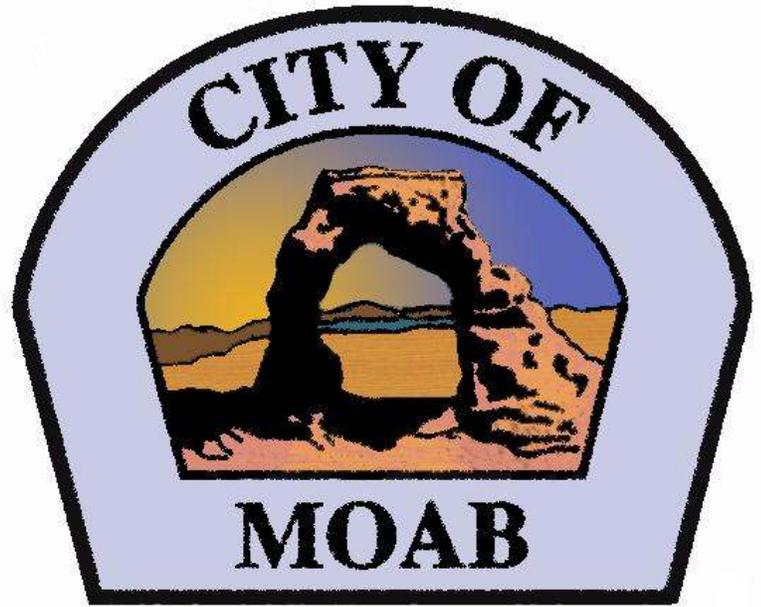
Mayor Sakrison mentioned that the Association of Governments (AOG) will meet on the last Thursday of January in Moab.

Approval of Bills Against the City of Moab: Councilmember Derasary moved to pay the bills against the City of Moab in the amount of \$1,464,979.58. Councilmember Bailey seconded the motion. The motion carried 5-0 aye, with Councilmembers Bailey, Ershadi, Jones, Derasary and Knuteson-Boyd voting aye.

Adjournment: Councilmember Bailey moved to adjourn the meeting. Councilmember Derasary seconded the motion. The motion passed 5-0 with Councilmembers Bailey, Jones, Knuteson-Boyd, Ershadi, and Derasary voting aye. Mayor Sakrison adjourned the meeting at 8:30 PM.

APPROVED: 
Emily Niehaus, Mayor

ATTEST: 
Rachel E. Stenta, City Recorder



CITY OF MOAB

STORM WATER MASTER PLAN

(HAL Project No.: 380.04.100)

October 2017

CITY OF MOAB
STORM WATER MASTER PLAN

(HAL Project No.: 380.04.100)



Joseph Hawkes, P.E.



October 2017

ACKNOWLEDGMENTS

Several individuals contributed to the successful completion of this study. We sincerely appreciate the cooperation, assistance, and expertise provided by members of the project team:

The City of Moab

Patrick Dean – Public Works Director

Jeff Reinhart – City Planner

Chuck Williams – City Engineer

Phillip Bowman – Former City Engineer (Through Feb. 2017)

Eric Johanson – Assistant City Engineer

Mark Jolissaint – Assistant City Engineer

Hansen, Allen & Luce, Inc.

Joseph G. Hawkes

Gordon L. Jones

Benjamin D. Miner

Michael C. Price

Alex Narteh

ABBREVIATIONS AND UNITS

ac	acre
ac-ft	acre-foot
cfs	cubic foot per second (ft ³ /s)
CIP	Capital Improvement Plan
CMP	corrugated metal pipe
E	east
EPA	US Environmental Protection Agency
FF	Farmer–Fletcher (1971) storm distribution
ft	foot
GBEA	Great Basin Experimental Area
GIS	geographic information system
HAL	Hansen, Allen & Luce, Inc.
HEC	Hydrologic Engineering Center (U.S. Army Corps of Engineers)
HMS	Hydrologic Modeling System
ID	identification
in.	inch
irr	irrigation
mi	mile
N	north
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service (formerly SCS)
RR	railroad
s	second
S	south
SCS	Soil Conservation Service (now NRCS)
SWMM	Storm Water Management Model
TR-55	Technical Release 55 (NRCS 1986)
USGS	U.S. Geological Survey
W	west
w/	with
w/o	without
xing	crossing
yr	year

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CHAPTER 1 – INTRODUCTION

PURPOSE

This Storm Water Master Plan (Master Plan) for the City of Moab (City) presents solutions to manage and regulate storm water runoff and to help mitigate flooding and environmental impacts. The master plan will educate developers, private property owners, City staff, and elected officials regarding the capability and needs of the City's storm water system. The master plan examines the existing storm drainage system. Existing deficiencies are identified and the preferred solution alternatives are presented with conceptual cost estimates. A Capital Improvement Plan (CIP) is developed with master plan projects.

Computer models were prepared as part of the master plan to simulate runoff during storm events in the City. The models were also used to determine solutions to system deficiencies.

BACKGROUND

Located along the southern edge of Grand County, Utah, the City of Moab extends from the Colorado River south along the Spanish Valley. The terrain has a vertical relief of approximately 1,000 ft from the surrounding mesas to the Colorado River on the northwest side of the City. Soil types range from permeable desert sands to exposed sandstone formations. Land use varies from urban developments to farmland and desert landscapes.

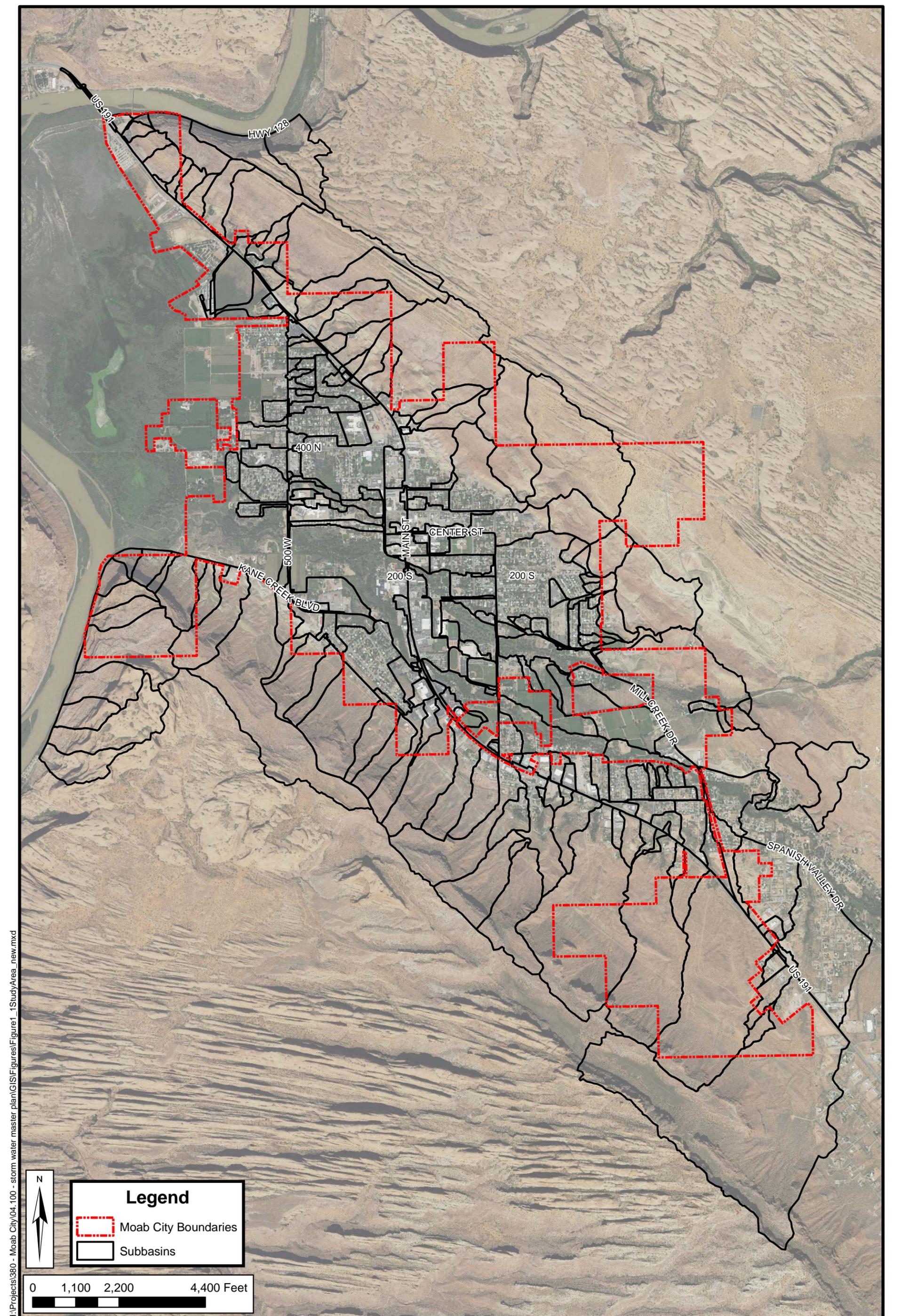
The City was incorporated in 1902 and traditionally relied on mining as the major economic activity. Growth in the City was directly tied to boom and bust cycles of the mining industry. In the 1980s efforts were made to promote Moab as a tourist destination and diversify the economic landscape. Moab had an estimated population of 5,200 in 2014. In an ongoing effort dealing with growth and unique desert watersheds, the City desires to plan an effective drainage system to manage nuisance water and prevent flooding.

AUTHORIZATION

The City of Moab selected Hansen, Allen & Luce, Inc. (HAL) to prepare the Storm Water Master Plan. The master plan has been completed in accordance with the agreement between the City of Moab and HAL from September 2015. The master plan was completed under the direction of, and in cooperation with, City staff.

STUDY AREAS

The study area for the master plan includes the incorporated area of Moab and the surrounding mesas. Approximately 5,620 acres were hydrologically modeled to determine the runoff tributary to the City's storm drainage system. The modeled subbasins representing the study area as well as the City boundaries are shown on Figure 1-1.

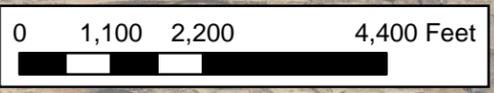


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Legend

- Moab City Boundaries
- Subbasins



**City of Moab
 Storm Water Master Plan**

**Study Area and
 Subbasin Delineation**

**FIGURE
 1-1**

CHAPTER 2 – EXISTING STORM DRAINAGE SYSTEM

This section discusses the features that make up the storm drainage facilities in Moab. Figure 2-1 shows the existing storm drainage system including the natural drainages that act as outfalls for the system.

NATURAL DRAINAGES

The City of Moab discharges storm runoff into three different natural drainages which generally flow from southeast to northwest.

Colorado River

The Colorado River is the largest natural drainage in the study area and is the final outlet for all storm runoff from the City. The Colorado River runs from northeast to southwest on the far west side of the City.

Mill Creek

Mill Creek originates in the La Sal Mountains east of Moab and terminates where it meets the Colorado River.

Pack Creek

Pack Creek originates in the La Sal Mountains east of Moab and terminates where it meets Mill Creek near 100 South and 100 West.

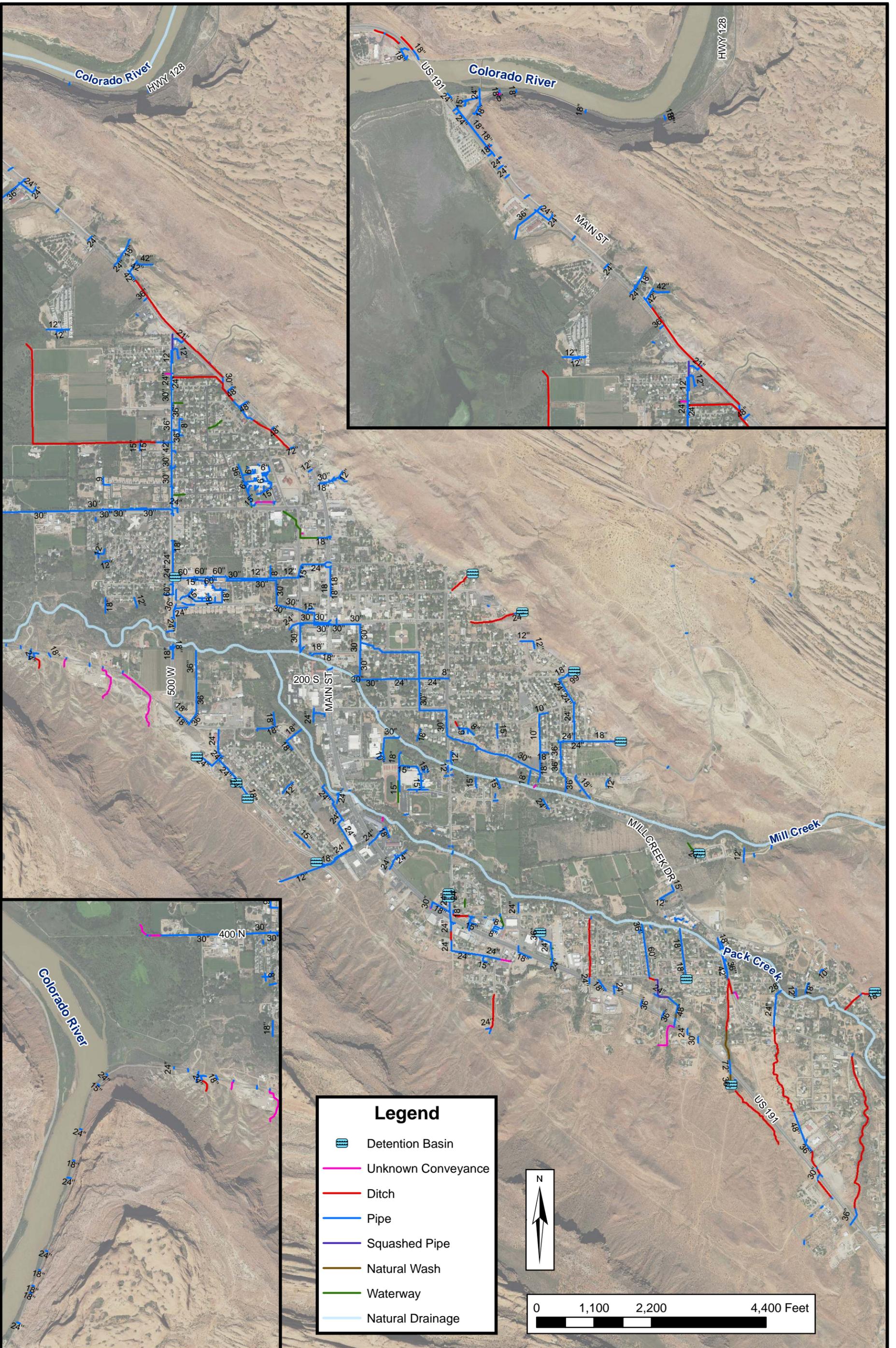
STORM DRAINAGE FACILITIES

As part of this master plan, efforts were made to survey the storm drainage facilities in Moab. HAL staff performed a survey of over 700 points representing inlets, manholes, culverts, detention basins, ditches and select topographical features during October 2015. The survey was linked to an existing GIS database provided by the City of Moab to provide manhole identification numbers and associated information with the points. City staff then performed an inventory on approximately 570 manholes and inlets to collect the depths to the invert elevation of the manhole (measure downs), pipe diameters, and connectivity information. The information gathered from the survey is included electronically in Appendix A.

Some pipe diameters and measure down depths were not able to be determined by City staff due to facility accessibility and some points were not able to be surveyed due to interference from foliage. Therefore, lack of data necessitate that some simplifying assumptions were made to create the model. Junctions and links with estimated values are identified in the GIS inventory. Although the inventory provided in this master plan is mostly complete, ongoing efforts should be made to continue to update and refine the inventory.

Collection and Conveyance

The City of Moab has over 18 miles of buried storm drain conveyances with a wide range of sizes from 72 inches to less than 12 inches. The City has an estimated 724 inlets that introduce runoff into the storm drains. The storm drain system also relies on natural drainages, roadside swales, and curb and gutters to convey runoff to the Colorado River.



Data compiled in the system inventory consist of locations, descriptions, elevations, and measure down depths at each point, as well as location, shape, offset, type, and size for each conveyance. The collection and conveyance system with associated pipe diameters can be seen on Figure 2-1.

Detention

The City maintains several detention facilities. Stage storage curves for the detention basins were estimated using the contour data provided by the City. Invert elevations, maximum elevations, and spill elevations were determined from the survey. Some detention basins were not modeled because basin attributes could not be determined from available information or the small size of the detention basin made it insignificant for master planning purposes. Also, some detention basins lacked information about the orifice size. The modeled detention basins can be seen on Figure 2-1. More information on the detention basins is available in Appendix B.

CHAPTER 3 – METHODOLOGY

The project team adopted a workshop approach with City staff to determine the design criteria, study areas, analysis processes, deficiencies, alternatives, and solutions. This section describes the methodology followed in developing the master plan.

HYDROLOGY

Design Frequencies

The City selected design storm frequencies of 10-year (10% chance of being equaled or exceed in any given year) and 100-year (1% chance of being equaled or exceeded in any given year) for this study. The criteria selected by the City correspond with storm drainage design criteria for Grand County. Criteria include:

- 10-year design capacity for the initial drainage system. The initial drainage system includes inlets, laterals, minor trunk lines, gutters, and roadside ditches.
- 100-year capacity where flooding of homes may occur.
- 100-year capacity on major detention/retention, culverts and major conveyance facilities (limited to storm drain hydraulic capacities of the upstream initial drainage system).

Design Storms

Storm distributions used in this master plan were derived from the SCS Type II distribution for 24-hour storms. The SCS Type II distribution can be seen on Figure 3-1.

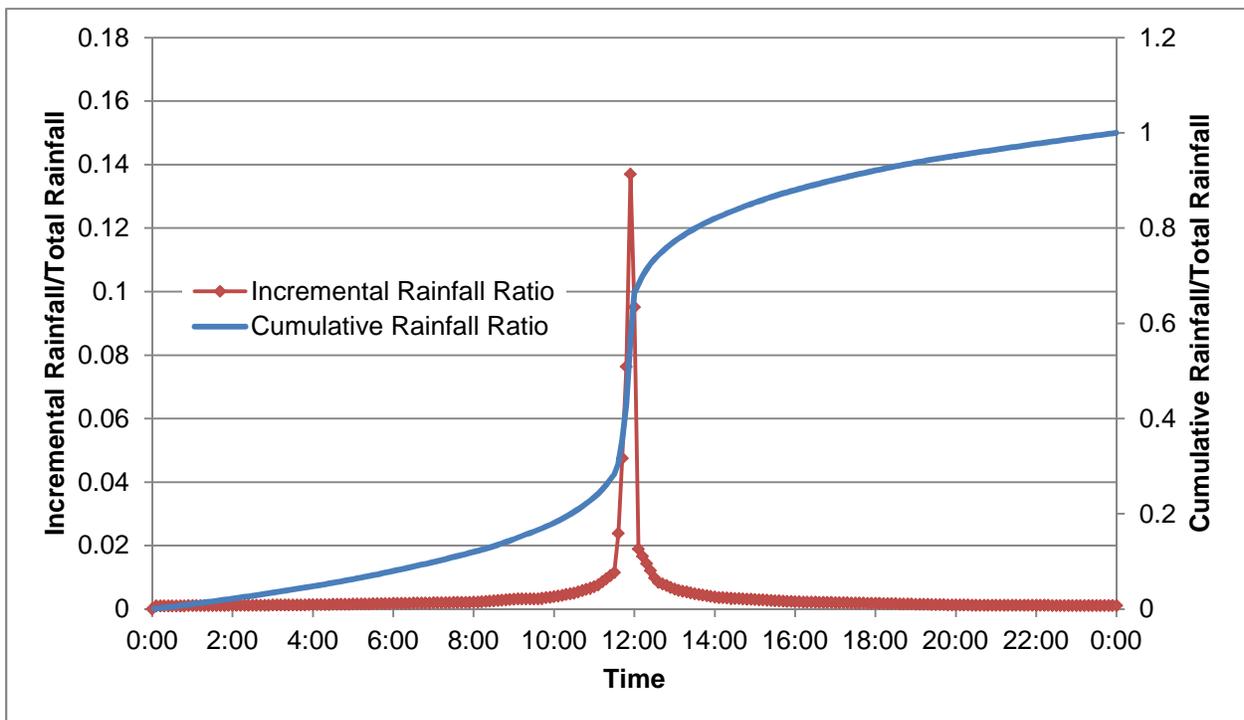


Figure 3-1 SCS Type II 24-hour Distribution

Precipitation depths were obtained from *NOAA Atlas 14 Point Precipitation Frequency Estimates* (NOAA, 2016). The design storm rainfall depths for the City are seen in Table 3-1. Only the 24-hour storms were modeled. Additional rainfall information is in Appendix C.

**Table 3-1
NOAA Atlas 14 Moab Rainfall Depths**

Storm Frequency	1-hr	3-hr	6-hr	12-hr	24-hr
10-year Rainfall Amount (in)*	0.71	0.94	1.11	1.33	1.71
100-year Rainfall Amount (in)*	1.36	1.88	1.97	2.18	2.96

*All rainfall amounts are from NOAA Atlas 14.

DEVELOPMENT OF THE HYDROLOGIC MODELS

As part of the master plan, HAL developed a computer model for the study area to simulate runoff during storm events. Autodesk’s Storm and Sanitary Analysis (SSA) was used to model the storm drainage system. SSA utilizes the EPA’s Storm Water Management Model (SWMM) for hydraulic modeling, while the HEC-1 method was utilized for hydrologic modeling. The model is capable of simulating rainfall, determining runoff, and hydraulically routing the runoff through a gravity driven conveyance network.

A drainage basin, also called a subbasin, watershed or catchment, is an area in which all rainfall or snowmelt runoff will collect to a common point (the lowest point in the basin). Drainage basin boundaries depend upon both the topography and the location of storm drainage facilities. Subbasin characteristics developed for this plan were based on field observation, aerial imagery, soil data, GIS mapping, land use information from the City, and engineering literature. Important subbasin characteristics described below include 1) area, 2) hydrologic soil group, 3) percentage of impervious area, 4) SCS curve number, and 5) Lag time. Much of the methodology is documented in *Technical Release 55: Urban Hydrology for Small Watersheds* (NRCS, 1986), hereafter referred to as TR-55 and also in *Lag Time Characteristics for Small Watersheds in the U.S.* (Simas and Hawkins, 2002).

Subbasin Area

The amount of runoff is proportional to the area of the subbasin. Subbasin boundaries depend upon both topography and location of storm drainage facilities. Subbasin boundaries were delineated using the following data sources: A five meter digital elevation model (DEM) from the Automated Geographic Reference Center (AGRC), contour data provided by the City, survey data collected in October 2015, aerial imagery from the AGRC, USGS Topographic Mapping, and Google Earth.

Hydrologic Soil Group

The hydrologic soil group is a general indication of a soil’s infiltration capacity and is a key determinant of runoff behavior. The Natural Resources Conservation Service (NRCS) has classified soils into four hydrologic groups: A, B, C, and D. Soils of group A have the highest infiltration rate and therefore produce the least amount of runoff. Group A soils include permeable gravels and well-drained sands. Group B soils have moderate infiltration rates and moderately fine or coarse textures. Developed portions of each study area were assumed to have a minimum of nonnative group B soils to represent the desert landscaping common on developed parcels. Group C soils have a lower infiltration rate and finer textures, sometimes

with a layer that impedes infiltration. Soils of group D have the lowest infiltration rate and produce the highest amount of runoff. Group D soils include fine silts, fine clays, and other soils with low infiltration rates. Soil groups are described in TR-55 (NRCS, 1986).

Soil data were retrieved from the Natural Resource Conservation Service's (NRCS) Web Soil Survey. Some map units defined in the soil data required the use of the Soil Survey of Grand County to determine corresponding curve numbers (Soil Conservation Service, 1989).

Group A soils are the most prevalent in the City. A soil map of the City is shown in Figure 3-2. The hydrologic soil group is a factor used to determine the curve number for each subbasin.

Land Use

A GIS shapefile showing the designated land uses for the City was provided by Moab. This shapefile was modified with a parcel shapefile in order to develop a land use designation based on similar hydrologic characteristics. Table 3-2 shows the various land uses implemented in this master plan. The various land uses can also be seen on Figure 3-3.

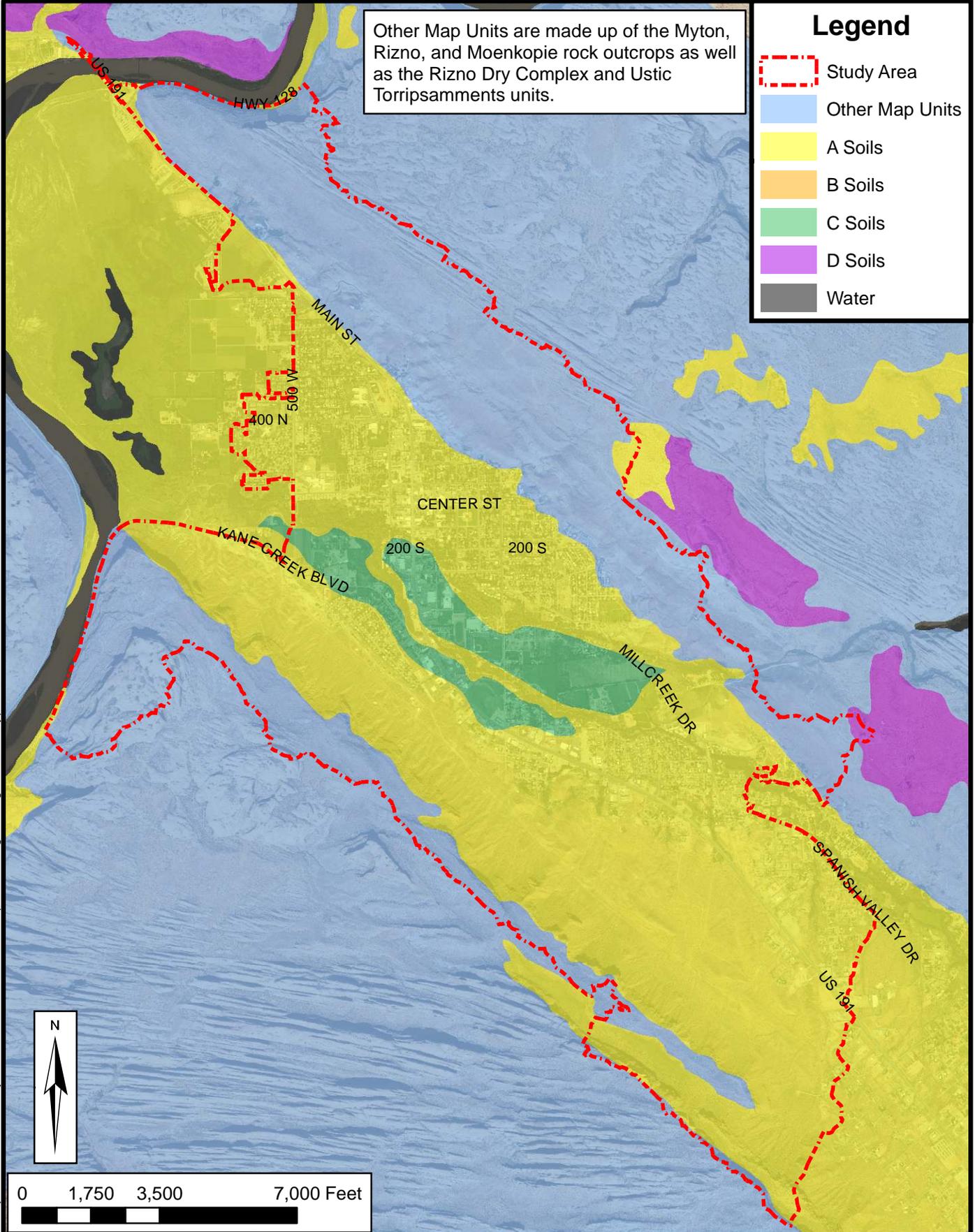
**Table 3-2
Hydrologic Land Uses in Moab**

Land Use Type	Description
Agriculture	Open crop fields, pasture, some outbuildings
Commercial	General commercial lots, parking lots, buildings
Mobile Home	Mobile home parks
Open Space	Undeveloped open space
Parks	Cultivated parks with good cover and irrigated landscaping
Residential (0.25 acres)	Residential lots from 0.08 to 0.5 acres
Residential (0.75 acres)	Residential lots from 0.5 to 1 acres
Residential (1 acre)	Residential lots larger than 1 acre
Residential	Portions of the other residential lots (average attributes of all other residential lots)
Streets	Street, curb and gutter, park strip, sidewalk, and right-of-way space
Vacant Lots	Undeveloped lots in areas likely to be developed
Yards (Storage)	Open storage lots, junk yards, salvage yards

Impervious Area

Impervious areas within each subbasin were estimated using the type of land uses within each subbasin. There are two types of impervious area: directly connected impervious areas and unconnected impervious areas. Directly connected impervious areas provide a direct path for runoff to a conveyance such as a pipe, gutter, or channel. Directly connected impervious areas often include roadways, parking lots, driveways, and roofs. Runoff from unconnected impervious areas must cross a pervious area before reaching the drainage node for the subbasin. Examples of unconnected impervious areas include sidewalks that are not adjacent to the curb, patios, sheds, and usually some portion of house roofs.

It is important to distinguish between directly connected and unconnected impervious areas. Runoff from the directly connected impervious areas reaches the drainage conveyance system



Other Map Units are made up of the Myton, Rizno, and Moenkopie rock outcrops as well as the Rizno Dry Complex and Ustic Torripsammments units.

Legend

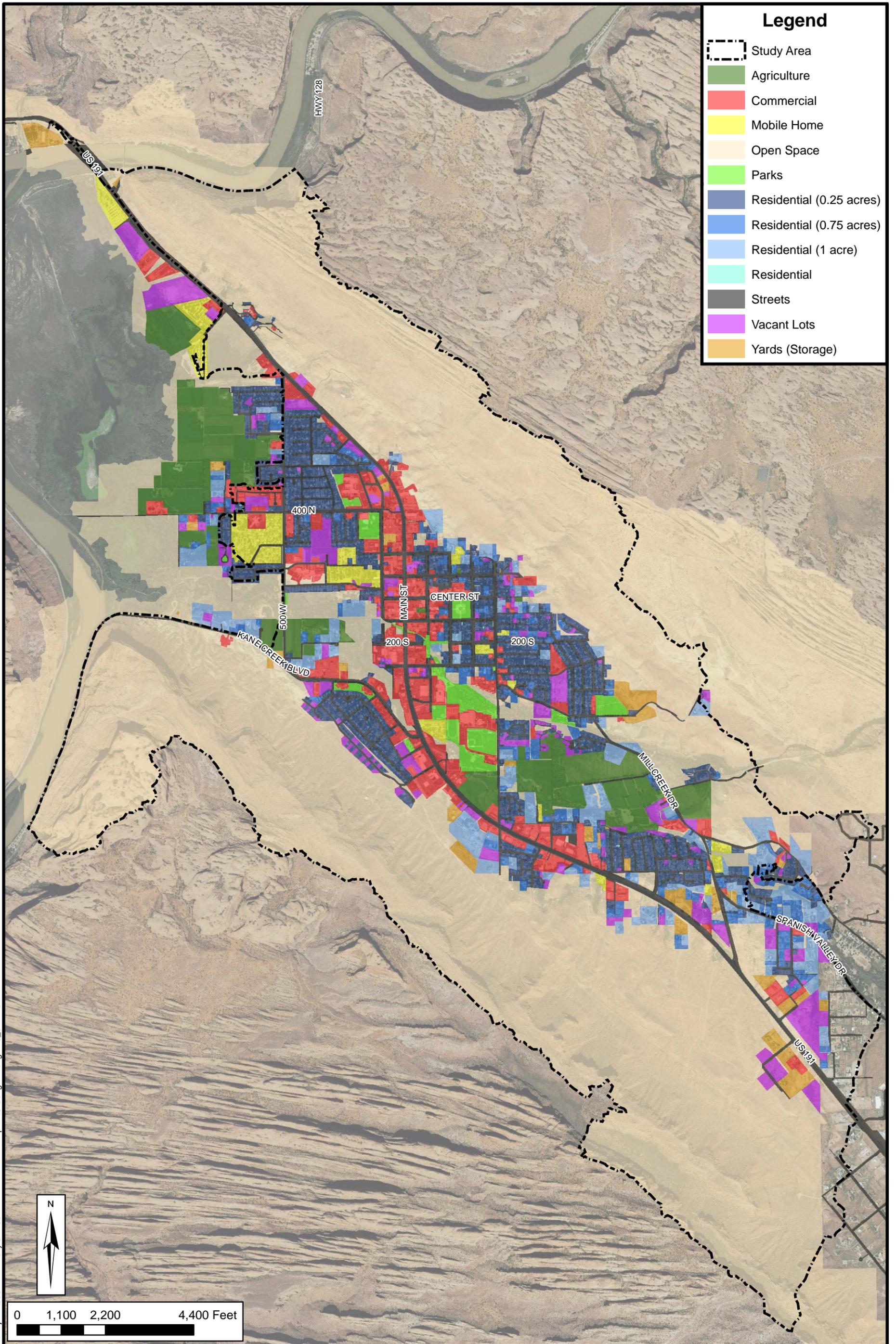
- Study Area
- Other Map Units
- A Soils
- B Soils
- C Soils
- D Soils
- Water

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**City of Moab - Storm Water Master Plan
 Soil Types**

**FIGURE
 3-2**



Legend

- Study Area
- Agriculture
- Commercial
- Mobile Home
- Open Space
- Parks
- Residential (0.25 acres)
- Residential (0.75 acres)
- Residential (1 acre)
- Residential
- Streets
- Vacant Lots
- Yards (Storage)

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**City of Moab
 Storm Water Master Plan**

Land Use

**FIGURE
 3-3**

quickly and usually determines the magnitude of the peak flow rate. Impervious areas such as backyard patios which drain to grassed or landscaped areas have less impact on peak runoff.

Unconnected impervious area for residential land use is included in the modeled pervious area with a composite curve number based on an area-weighted average. Impervious percentages were estimated from a delineation of selected typical lots representing each land use. The directly connected impervious area is included explicitly in the subbasin characteristics as a percentage. See Table 3-4 for the criteria for the impervious percentage assigned to each land use. Attributes for the typical lots can be seen in Appendix D.

SCS Curve Number

Each subbasin was assigned an SCS curve number based on hydrologic soil group, unconnected impervious area, land use, and ground cover type as outlined in Chapter 2 of TR-55 (NRCS, 1986). The curve number describes the relationship between precipitation and runoff from the pervious/unconnected impervious portions of the subbasin. Curve numbers range from 0 to 100. Areas that are more pervious have lower curve numbers. For example, a well vegetated subbasin with sandy soils and little unconnected impervious area would have a lower curve number than a poorly vegetated subbasin with clay soils and a significant amount of unconnected impervious area.

The vegetation condition was determined based on 2014 aerial imagery and the 2011 National Land Cover Database (Homer, et. al., 2015). Vegetative conditions are described in TR-55 as Poor, Fair, or Good for land uses of Open Space, Desert Shrub (reflecting desert landscaping), and Straight Row Crops for agricultural areas. The definitions of the vegetative conditions are included in Table 3-3. Vegetative conditions can be seen on Figure 3-4.

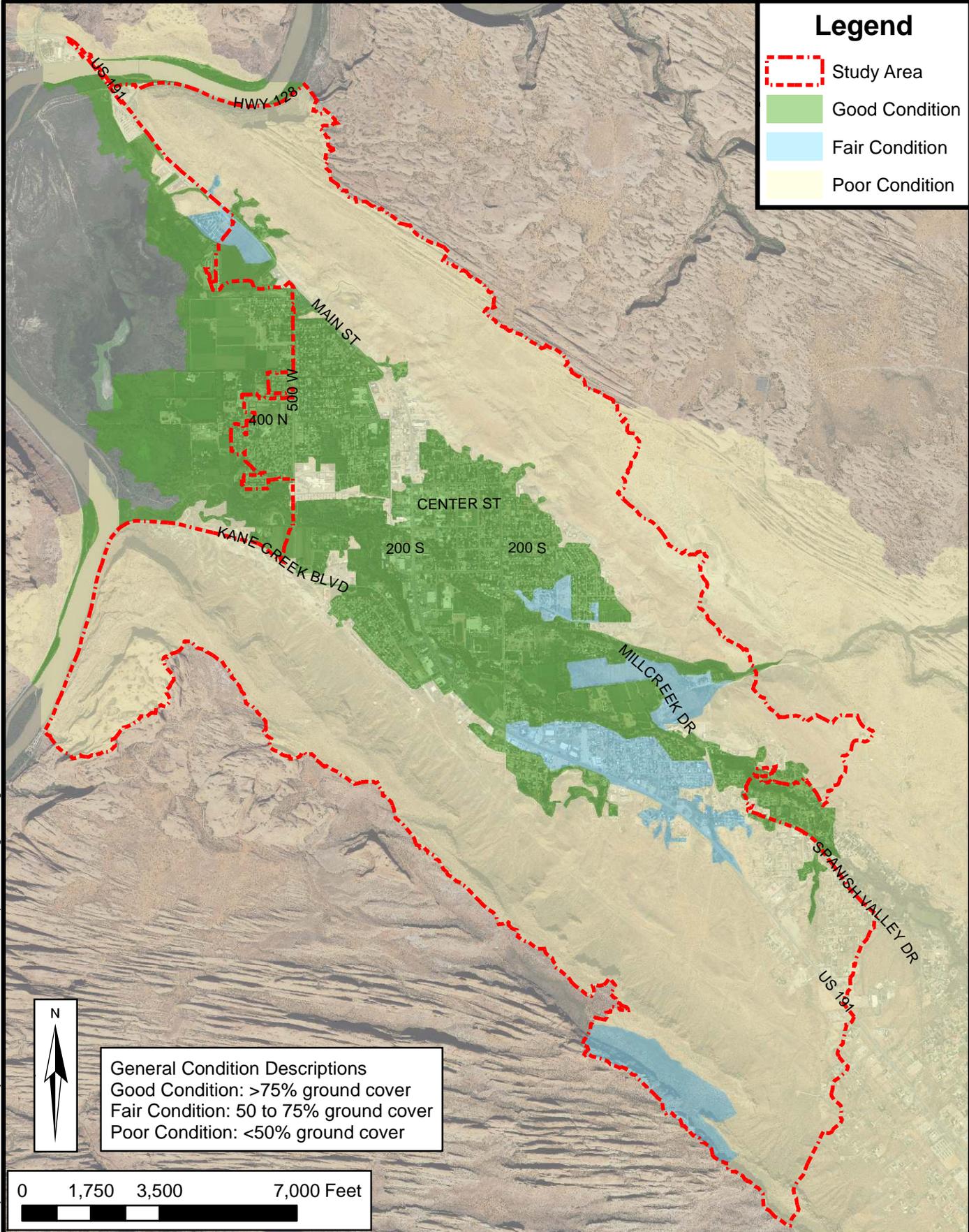
**Table 3-3
Vegetative Condition Definitions**

TR-55 Cover Type	Master Plan Land Use Type	Percent of Area Covered with Vegetation		
		Good Condition	Fair Condition	Poor Condition
Open Space	Open Space, Parks, Residential	<50% Ground Cover	50%-75% Ground Cover	>75% Ground Cover
Desert Shrub	Commercial, Mobile Home, Street, Vacant Lots, Yards	<30% Ground Cover	30%-70% Ground Cover	>70% Ground Cover
Straight Row Crops	Agriculture	<20% Ground Cover	Not Applicable	≥20% Ground Cover

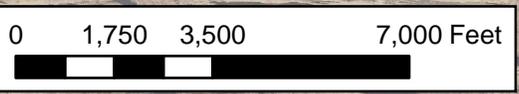
The unconnected impervious areas were determined based on the attributes of typical lots. Curve numbers were taken from TR-55 and then modified based on the unconnected areas delineated in the typical lot survey. See Table 3-4 for the criteria for the curve number assignment and directly connected impervious percentages.

Legend

- Study Area
- Good Condition
- Fair Condition
- Poor Condition



General Condition Descriptions
 Good Condition: >75% ground cover
 Fair Condition: 50 to 75% ground cover
 Poor Condition: <50% ground cover



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**City of Moab - Storm Water Master Plan
 Vegetative Condition**

**FIGURE
 3-4**

**Table 3-4
Land Use Characteristics**

Land Use Type	Directly Connected Impervious	Soil Type with Condition											
		Good				Fair				Poor			
		A*	B*	C	D	A*	B*	C	D	A*	B*	C	D
Agriculture	0%	67	78	85	89	<i>Not in TR-55</i>				72	81	88	91
Commercial	56%	72	82	88	91	<i>Not in TR-55</i>							
Mobile Home	17%	70	81	88	90	<i>Not in TR-55</i>							
Open Space	0%	79	68	79	84	55	72	81	86	63	77	85	88
Parks	1%	44	64	76	82	53	72	81	85	71	81	87	90
Residential (0.25 acres)	13%	56	72	81	85	63	77	85	88	77	85	90	92
Residential (0.75 acres)	6%	46	65	77	82	55	72	81	86	72	81	87	90
Residential (1 acre)	3%	43	63	75	81	52	71	80	85	70	80	87	90
Residential	7%	48	67	78	83	57	74	82	86	73	82	88	90
Streets	78%	63	77	85	88	<i>Not in TR-55</i>							
Vacant Lots	0%	49	68	79	84	55	72	81	86	63	77	85	88
Yards (Storage)	5%	69	80	87	90	<i>Not in TR-55</i>							

*Landuse areas with imported topsoil for desert landscaping use a minimum curve number of the B type soil. Shaded italicized cells were not used in the characteristics calculations.

Lag Time

The lag time is the time between the center of mass of rainfall to the peak of the hydrograph (Linsley and Franzini, 1979). Lag time is often estimated as 0.6 multiplied by the time of concentration (NRCS, 1986). The time of concentration is the time it takes for runoff to travel from the hydraulically most distant point of the subbasin to the outlet of the subbasin.

Lag times for the master plan were calculated using two different methods. A method developed by Simas and Hawkins (1998) was used for undeveloped subbasins that extended up onto the cliffs and mesas surrounding the City of Moab. Approximately 91 subbasins had lag times calculated using this method, with times ranging from 7 minutes to 70 minutes. The calculation is shown below.

$$Lag\ Time = 0.0051 * Width^{0.594} * Slope^{-0.15} * \left(\frac{1,000}{CN} - 10\right)^{0.313}$$

$$Width = \frac{Watershed\ Area}{Watershed\ Length}$$

$$Slope = \frac{Maximum\ Elevation\ Difference}{Watershed\ Length}$$

Watershed Length = Longest flow path from the highest elevation to the outlet

The lag time for the subbasins in the developed portions of the City were determined using the TR-55 method. This method calculates time of concentration by breaking up the watershed length into sections of sheet flow, shallow concentrated flow, and open channels and

subsequently determining the travel times for each section. The method is more time intensive than the Simas and Hawkins method and has several more variables. Due to the large number of subbasins (187) containing developed land and the time required using the TR-55 method, lag times were calculated individually for several subbasins and then applied to subbasins of similar size and land use. Lag times developed by the TR-55 method range between 4 minutes and 33 minutes.

HYDRAULICS

Links

Conveyances (called links in SWMM and SSA) convey runoff between the junctions in the model. Typical conveyances include pipes, box culverts, ditches, canals, natural channels, outlet pipes, orifice plates, weirs, pumps, and in some cases, gutters. Conveyance characteristics for each model were defined using City input, aerial imagery, and data from the system inventory which identified conveyances. This information is used in the model to perform the hydraulic analysis for timing and routing of storm runoff hydrographs.

Some uncertainty is associated with modeled drainage paths. Some of the conveyances had to be added to the model even though the conveyance was not clearly defined. These include cases where flows are conveyed through a culvert but the open ditches downstream of the culvert are heavily vegetated and do not have clearly defined banks.

Unlike HEC-HMS, SWMM and SSA will limit flow through conduits based on the conduit's capacity. For example, if a subbasin has a peak flow of 10 cfs while the conduit only has a capacity of 6 cfs, flooding would occur at the upstream node and the conduit would be limited to its peak capacity under surcharged conditions. The upstream node would experience flooding near 4 cfs. This is helpful when analyzing how the system actually functions, but can hinder efforts to determine the potential peak flows at a point. It is important to remember this model characteristic during the design process and make the proper modifications to accommodate full potential flow.

Nodes

In the model, nodes are points where conveyances or subbasins connect. Nodes generally represent manholes, inlets, outfalls, dividers, detention basins, or points where multiple conveyances combine. Nodes contain elevation data which determine the elevation of attached conveyances. Nodes also have depth data to determine if the point is experiencing flooding due to surcharging conditions.

Flooding at nodes can be handled in the model in several ways. If the surface ponding option is used, the volume of water at a node above the maximum depth is stored at the node and released back into the system once surcharging conditions recede. If the surface ponding option is not used, any flooding is lost from the system. In order to conservatively estimate the volume of water entering storage nodes, the surface ponding option was used in this master plan.

CAPACITY ANALYSIS

The SWMM and SSA models have the ability to determine the water depth, flow rate, and capacity of conveyances during a precipitation event. This detailed analysis includes calculating surcharged conditions and backwater effects if the Dynamic Wave routing method is selected.

This capability makes the SWMM engine a very useful tool in analyzing the hydraulic capability of a storm drainage system.

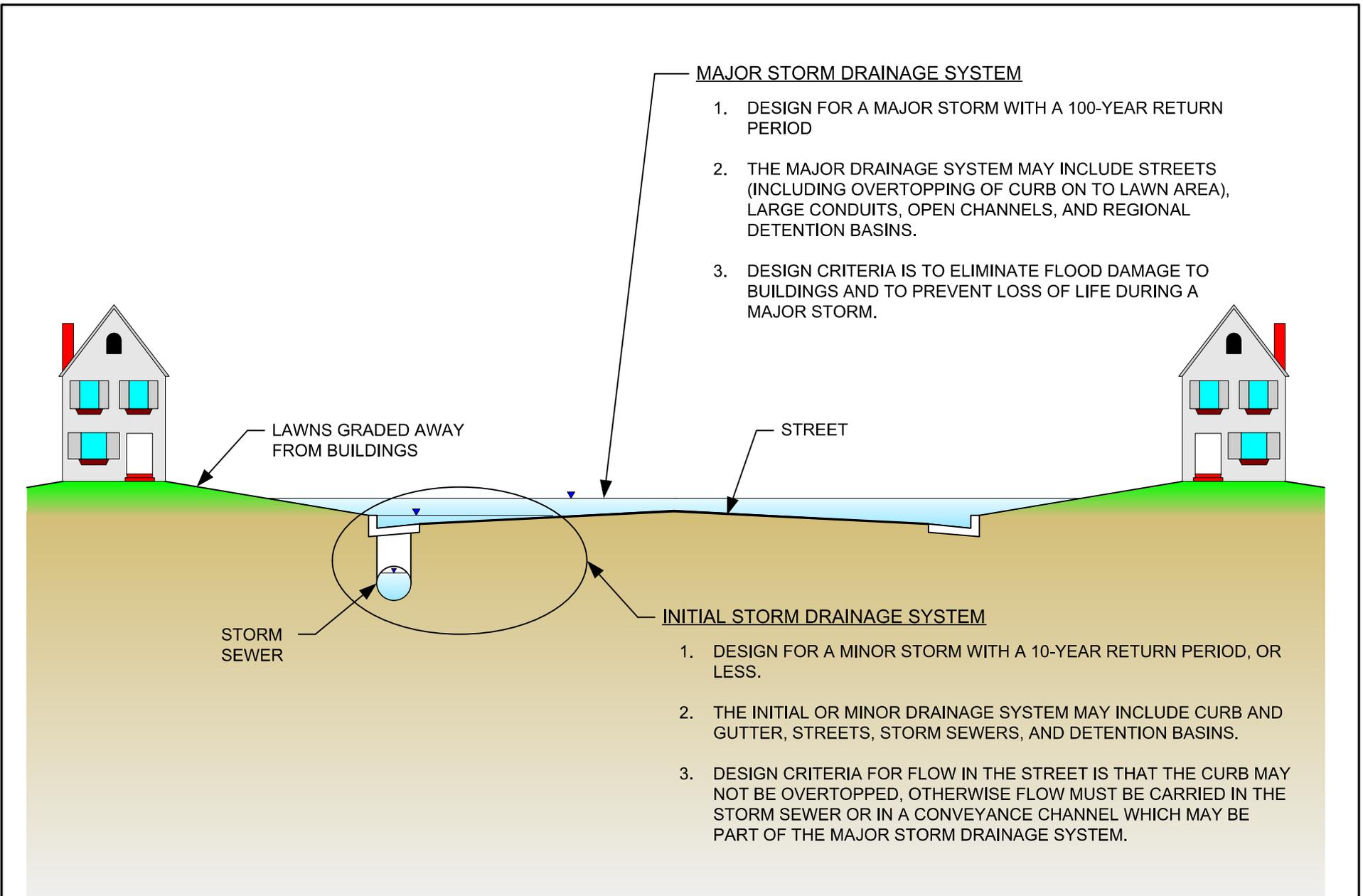
DESIGN FLOW RATES

The model computes hydrographs for each subbasin, conveyance, and junction. The City storm drainage system was analyzed with the 10-year and 100-year 24-hour precipitation events. Select areas requiring the piping network to convey 100-year precipitation events were modeled accordingly.

Because of the way the model handles flooding at nodes, 100-year storms are only modeled for features expected to carry 100-year storm flows, such as storage basins, culverts, and major trunk lines or where significant flooding might occur. Although these features are analyzed based on their ability to convey 100-year flows, some of the minor features tributary to them may provide hydraulic restrictions.

Most storm drain systems anticipate surcharging during 100-year storm events and rely on gutter and surface flow in combination with lateral and minor trunk line capacities to convey excess runoff to the outlet.

A schematic of the urban storm drainage criteria for inlets, laterals, and minor trunk lines is shown on Figure 3-5.



CHAPTER 4 – STORM DRAINAGE ANALYSIS

The Moab Storm Drain System was analyzed using the model, observations from City staff, the Grand County Storm Drainage Criteria, and best management practices for the industry.

CRITERIA

The criteria selected by the City correspond with storm drainage design criteria for Grand County. Criteria include:

- 10-year design capacity for the initial drainage system. The initial drainage system includes inlets, laterals, minor trunk lines, gutters, and roadside ditches.
- 100-year capacity where flooding of homes may occur.
- 100-year capacity on major detention/retention, culverts and major conveyance facilities (limited to storm drain hydraulic capacities of the upstream initial drainage system).

DEFICIENCIES

Deficiencies were identified based on input from City staff, notes during the HAL survey, and results from the model. Locations where the City has experienced flooding were analyzed in the model to determine the cause of the flooding. The model is helpful in determining which hydraulic limitation actually causes the visible flooding.

Table 4-1 and Figure 4-1 summarize the drainage deficiencies identified in this study. Each deficiency has a Deficiency ID (used in this study), a location description, and problem definition.

Not all deficiencies necessitate capital improvements. Because storm drain systems are designed to convey the 10-year event, a 10-year event will produce flows at or near the pipe capacity of the system. Some nodes in the model identified areas of surcharging which were determined to not be a deficiency because the surcharging is contained in the curb and gutter system. A pipe at capacity or a surcharged node in the model was only added to the deficiency list if flooding was significant in the model and/or City staff had identified previous flooding at the location. After identifying the deficiencies in Table 4-1, the project team and City staff met in a workshop to discuss which deficiencies warranted action. Deficiencies identified as not warranting action will be monitored by City staff for flooding.

Deficiencies are shown on Figure 4-1 as sediment issues, in-road conveyances, repair issues, and capacity deficiencies. Sediment issues represent locations where sediment or debris has been deposited in the storm water system or where erosion has impacted the system. In-road conveyances represent areas where significant runoff is conveyed in the curb and gutter or where piped storm drains empty into the curb and gutter before reaching an open channel or enclosed conveyance. Repair issues represent locations where storm water structures are damaged and need repaired. Capacity deficiencies represent areas where the model and/or City have identified flooding.

**Table 4-1
Storm Drainage Deficiencies**

Deficiency ID	Location	Problem Description
1	Williams Way from approximately 150 West to 180 West (Pipe is north of the road)	During survey efforts it was noted that the pipe is damaged and needs to be replaced. Discussions with the City have confirmed the damaged pipe.
2	Private driveway at approximately 420 East and 100 North to the spillway of the detention basin	Conveyance facilities consist of a shallow ditch which gets progressively shallower nearer to 100 North. Any flow from the detention basin results in flows in the driveway. Serious flows and overflows from the detention basin cause significant erosion and flooding problems in the driveway and near 100 North. Efforts have been undertaken by private property owners to protect the driveway and adjacent homes from flooding.
3	Bittle Lane from Main Street to where Bittle Lane turns to the East	Modeling efforts show that adverse grades and small pipe diameters do not provide enough capacity to carry the 10-year flows. The adverse grades also reduce flow velocities to a point that sediments from the south side of main street collect and fill in the storm drain pipes. The City has verified that the area does not have sufficient capacity.
4	Jackson Street from approximately Madison Way to the north side of Main Street	Significant runoff flows onto the southernmost point of Jackson Street. There are no inlet or conveyance facilities to capture the flows. The roadside ditch near Jefferson Street collects sediment from the runoff and the inlets and pipes at the intersection of Jackson Street and Main Street do not have enough capacity to convey the 100-year runoff to Pack Creek. This deficiency was noted by the City, identified during surveying efforts, and identified during modeling efforts. The overflows from this deficiency also contribute to deficiencies 11 and 57. This deficiency may include County facilities.
5	Along the back of the lots on the west side of Tusher Street from Locust Lane to approximately 440 South	Modeling efforts have indicated that the 10-inch pipe experiences full pipe flow. Overflows will be conveyed down Locust Lane in the curb and gutter.
6	The lowest point of Loveridge Drive north to Locust Lane	Modeling efforts have indicated that the 15-inch pipe does not have sufficient capacity to convey the 100-year flows. This is a topographical low point and should have the capacity to convey 100-year flows without flooding any buildings.
7	Culvert across Spanish Valley Drive at approximately 1400 Spanish Valley Drive	Modeling efforts have indicated that the 18-inch pipe does not have sufficient capacity to convey the 100-year flows. This deficiency includes County facilities.
8	Culvert across Murphy Lane at approximately 1320 Murphy Lane	Modeling efforts have indicated that the 18-inch pipe does not have sufficient capacity to convey the 100-year flows. This deficiency includes County facilities.
9	From 123 Arbor Drive to Pack Creek	Modeling efforts have indicated that the 18-inch pipe does not have sufficient capacity to convey the 100-year flows. This is a downstream cul-de-sac and should have the capacity to convey 100-year flows without flooding any buildings. This deficiency includes County facilities.
10	Culvert across US 191 at approximately 1250 Highway 191	Modeling efforts have indicated that the 24-inch pipe does not have sufficient capacity to convey the 100-year flows. This deficiency includes County facilities.
11	The 24-inch pipe along the back of the lots along Main Street from Dogwood Avenue to Birch Avenue and Kane Creek Boulevard	This deficiency is significantly impacted by deficiency 4 but modeling efforts showed it also lacks capacity for local drainage during the 100-year storm. The City has verified this deficiency and sediment issues were also noted during the survey. The sediment likely comes from deficiency 4.

Deficiency ID	Location	Problem Description
12	From Aspen Avenue and Kane Creek Boulevard to Pack Creek	Modeling efforts have shown that the 18-inch pipe does not have sufficient capacity to convey the 10-year flows. The City has also noted that the area experiences inlet clogging issues from autumn leaf falls.
13	Main Street from 100 North to 200 North	The model and City have identified flooding issues along Main Street during 10-year storms. This area experiences flows from the detention basin on the east end of 100 North. Flooding is caused by the lack of capacity in the existing 18-inch pipe, is also impacted by deficiency 14, and is worsened by the placement of storm drain inlets.
14	100 West from 200 North to Walnut Lane, Walnut Lane from 100 West to the hospital property, and from the cul-de-sac at 200 North 209 West to Walnut Lane	The model and City have identified that the existing storm drain reduces to a 12-inch pipe which does not have enough capacity to convey the 10-year storm. Overflows bubble up at 200 North and 100 West and flow north to Swanny Park where they contribute to deficiencies 16 and 18. The storm drainage in the downhill cul-de-sac should have the capacity to convey the 100-year storm.
15	From Nob Hill (300 North) and Main Street to 300 North and 100 West	The model and surveying efforts have identified capacity and sediment issues in this area. The existing 18-inch pipe and small box culvert do not have the capacity to convey the 10-year flows.
16	Swanny City Park from 100 West to 400 North and from Swanny Park and 400 North to 500 West and 400 North	The City and model have identified capacity issues with the trapezoidal channel across the park. The channel does not have capacity to convey the 10-year flows. Significant flows are conveyed in the street and gutter along 400 North to 500 West.
17	Highway 191 at 570 North, Maxine Avenue to 400 North, and along 400 North from Maxine Avenue to 500 West	The City and model have identified capacity issues at the culvert crossing Highway 191. The culvert does not have capacity to convey the 10-year flows and significant flows from Cermak Road sheet flow over the highway, through the private lot, and onto Maxine Avenue. There is no curb or gutter in Maxine Avenue and the runoff surface flows to 400 North where it is conveyed in the street and gutter to the inlets at 500 West. This deficiency may include UDOT facilities.
18	500 West and 400 North	The City and model have identified that the inlets on the east side of the intersection with their adjoining pipes do not have sufficient capacity to convey the 10-year flows. Flows that cannot enter the storm drain network at this point flow around the corner to the inlets on the south side of the intersection.
19	Highway 191 at approximately 600 North, along Highway 191 on the southwest side of the highway to approximately 800 North, then on the northeast side of the Highway to the existing culvert at approximately 1100 North	The City has identified sediment deposits in the large culvert under the highway at 600 North, which are likely deposited due to the lower velocities caused by downstream capacity issues. The culvert flows into a ditch and piping system that lack adequate capacity according to the model and as identified by the City. The minimum pipe diameter in this system is 15 inches. The ditch and piping system along the Highway also lack an adequate outlet. Investigation into the history of the system in this location suggests that the canal was filled in by the irrigation company downstream of 800 North and no efforts were ever made to provide solutions for the storm runoff. During a large enough storm, the canal fills up, spills in some locations, and exceeds the elevation of the drive approach at the bottom of Sunset Grill until it begins to flow northwest on the north side of the Highway. There is no designated conveyance to take the flows along the Highway until they reach the 36-inch culvert at approximately 1100 North. Portions of this deficiency are UDOT facilities.

Deficiency ID	Location	Problem Description
20	Highway 191 at approximately 1100 North	The City and model have identified that the culvert across Highway 191 at approximately 1100 North does not have sufficient capacity to convey the 100-year storm. This is a UDOT facility.
21	Highway 191 at approximately 990 North	Surveying efforts noted sediment deposits in the northern end of the culvert.
22	500 West from Highway 191 to approximately 910 North	The City and model have identified capacity issues with the existing storm drain which does not have enough capacity to convey the 10-year storm. The abnormal pipe shape and small size likely contribute to the capacity issues.
23	Private lots from the west ends of Carlos Court and Juan Court to 500 West and 770 North	The conveyance system from downhill courts does not have sufficient capacity to convey the 100-year storm as identified by the model and by Moab City.
24	Holliday Drive and 400 North	The model has identified that the pipe going from the south side of 400 North to the trunk line does not have sufficient capacity to convey the 10-year storm.
25	Holliday Drive and 230 North	The model has identified that the pipe conveying storm runoff from the Grand Oasis Mobile Home Park does not have sufficient capacity to convey the 10-year storm. This is a private facility.
26	400 North from 500 West to Holliday Drive	The City has identified significant corrosion in portions of the corrugated metal pipe in this area.
27	Kane Creek Road approximately 0.97 miles along the Road from 500 West towards the Colorado River	The model has identified that the 15-inch culvert does not have sufficient capacity to convey the 100-year storm. This may be a County facility.
28	Kane Creek Road approximately 1.15 miles along the Road from 500 West towards the Colorado River	The model has identified that the 24-inch culvert does not have sufficient capacity to convey the 100-year storm. This is a County facility.
29	Kane Creek Road approximately 1.27 miles along the Road from 500 West towards the Colorado River	The model has identified that the 18-inch culvert does not have sufficient capacity to convey the 100-year storm. This may be a County facility.
30	Kane Creek Road approximately 1.33 miles along the Road from 500 West towards the Colorado River	The model has identified that the 24-inch culvert does not have sufficient capacity to convey the 100-year storm.
31	Kane Creek Road approximately 1.61 miles along the Road from 500 West towards the Colorado River	The model has identified that the 24-inch culvert does not have sufficient capacity to convey the 100-year storm. This is a County facility.
32	Kane Creek Road approximately 1.74 miles along the Road from 500 West towards the Colorado River	The model has identified that the 18-inch culvert does not have sufficient capacity to convey the 100-year storm. This is a County facility.
33	Kane Creek Road approximately 1.88 miles along the Road from 500 West towards the Colorado River	The model has identified that the 24-inch culvert does not have sufficient capacity to convey the 100-year storm. This is a County facility.
34	Highway 191 at approximately 1200 North	The model has identified that the 24-inch culvert across the Highway does not have sufficient capacity to convey the 100-year storm. This is a UDOT facility.
35	Highway 191 at approximately 1400 North	The model has identified that the 24-inch culvert across the Highway does not have sufficient capacity to convey the 100-year storm. This is a UDOT facility.
36	Highway 191 at approximately 1500 North	The model has identified that the 24-inch culvert across the Highway does not have sufficient capacity to convey the 100-year storm. This is a UDOT facility.

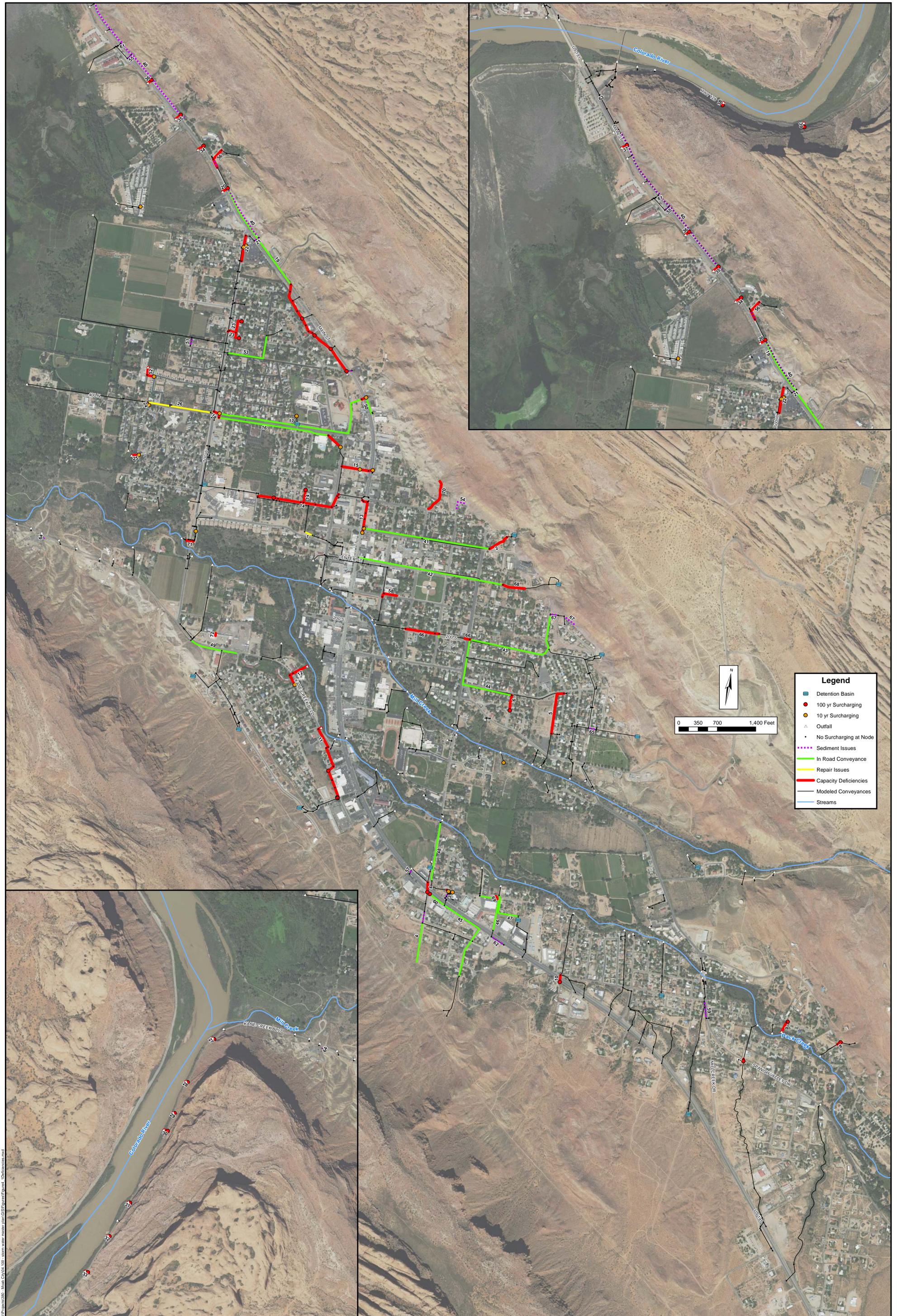
Deficiency ID	Location	Problem Description
37	Highway 191 at approximately 1675 North	The model has identified that the 24-inch culvert across the Highway does not have sufficient capacity to convey the 100-year storm. This is a UDOT facility.
38	Highway 128 approximately 0.49 miles along the Highway from Highway 191	The model has identified that the 18-inch culvert does not have sufficient capacity to convey the 100-year storm. This is a UDOT facility.
39	Highway 128 approximately 0.78 miles along the Highway from Highway 191	The model has identified that the 18-inch culvert does not have sufficient capacity to convey the 100-year storm. This is a UDOT facility.
40	Bike path along Highway 191 from 990 North to 1100 North and from 1400 North to 1700 North	The City has identified that runoff from the uphill side of the bike path overtops the path and causes erosion on the downhill side of the path.
41	100 North from 400 East to Main Street (generally on the north side of the road)	Runoff and flows from the upstream detention basin are conveyed only in the curb and gutter on the north side of the road. The area experiences significant flows and depths during storm events.
42	Center Street from approximately 500 East to Main Street	Runoff is conveyed only in the curb and gutter on the north side of the road. The area experiences significant flows and depths during events.
43	From Rosetree Lane and Hillside Drive to 200 South and along 200 South to 400 East	Runoff is conveyed only in the curb and gutter.
44	Locust Lane from 580 East to 400 East and along 400 East to 200 South	Runoff is conveyed only in the curb and gutter.
45	Boulder Avenue from 1325 South to Highway 191 and along Highway 191 to 1070 South	Significant flows from the drainage south of Boulder Avenue are conveyed in curb and gutter to the nearest inlet on Highway 191. Most of the flow bypasses the inlet due to capacity restrictions. This deficiency may include County facilities.
46	Bowling Alley Lane from Highway 191 to Bittle Lane and along Bittle Lane to Antiquity Lane	Runoff is conveyed only in the curb and gutter. This deficiency may include County facilities.
47	From the detention basin behind the Utah Parks and Recreation Building north of Highway 191 to Bowling Alley Lane and along Bowling Alley Lane to Bittle Lane	Runoff is conveyed only in the curb and gutter.
48	400 East from Minor Court to Pack Creek	Runoff is conveyed only in the curb and gutter.
49	Kane Creek Boulevard from Mountain View Drive to 475 West	Runoff is conveyed only in the curb and gutter. The existing storm drain entering Kane Creek Boulevard in this area acts as a bubble up although the invert of the system is well below the elevation of the curb and gutter. The City has identified flooding in this area.
50	Main Street from 488 North to 570 North	The private storm drain system for the Hampton Inn ends in an inlet that currently acts as a bubble up. Flows are conveyed north in the curb and gutter to the inlet in front of the Inca Inn and south to the inlets at 300 North.
51	Gala Avenue at 585 West to the open channel behind the properties to the north	The City has identified flooding and debris at this location. The deficiencies are likely caused by backwater effects in the open channel which conveys significant flows from 500 West.

Deficiency ID	Location	Problem Description
52	The northwest corner of Hale Avenue to the outlet on the northwest corner of the property	The City and model have identified capacity deficiencies due to the high elevation of the outfall at this location. This is a private facility.
53	McCormick Boulevard from 670 North to McGill Avenue and along McGill Avenue to 500 West	Runoff is conveyed only in the curb and gutter.
54	250 North 300 East	The City has noted sediment and debris in this area.
55	Highway 191 and 1515 North	Surveying efforts revealed that the storm drain has sediment deposits. This is a UDOT facility.
56	Arrowhead Lane for approximately 220 feet from Highway 191	The City and surveying efforts have shown that the storm drain system collects significant sediments in this area. The downstream portion of the system has a very flat slope which may contribute to the deposition of sediments. The buildup of sediment in the pipe also restricts the capacity of the pipe to a point where pressurized pipe flows pop the manhole lid near Highway 191.
57	Highway 191 at 980 South	The City and surveying efforts have identified sediment deposits in the culvert crossing Highway 191. This deficiency may include UDOT facilities.
58	100 South from 150 East to 100 East	The City has identified flooding on the north side of the road. The road is graded so almost all flows collect in the north gutter, the gutter has very flat slopes, and there are capacity issues at the inlet at 100 East and 100 South. Capacity issues at deficiency 66 cause overflows to contribute to this deficiency via 200 East and 100 South.
59	Mill Creek Drive from Holyoak Lane to 1320 South	Surveying efforts identified sediment deposits in the open ditch along Mill Creek Drive.
60	Highway 191 from 1070 South to Jackson Street	Significant flows are conveyed in the curb and gutter between the two inlets.
61	1550 North Highway 191	Surveying efforts identified sediment deposits in the culvert across Highway 191. This may include UDOT facilities.
62	Highway 191 from 1160 South to Bowling Alley Lane	Surveying efforts identified sediment deposits in the 18-inch pipe. This deficiency may include UDOT and County facilities.
63	Southeast corner of the intersection of Highway 128 and Highway 191	Surveying efforts identified sediment deposits in the inlet. This may be a UDOT facility.
64	Parking Lot at approximately 940 East Kane Creek Boulevard	Surveying efforts identified sediment deposits in the private storm drain system from the parking lot.
65	Oak Street from 870 East to Hillside Drive	Surveying efforts identified sediment deposits in the storm drain system.
66	200 South from 400 East to 200 East	The City has identified flooding that flows across 400 East and cannot enter the storm drain systems due to inlet restrictions. The flows pond at 200 East and 200 South and then flow north towards 100 South. There is also a topographical low point with no inlet at the southeast corner of 300 East and 200 South. Modeling efforts show that the pipe should have the capacity to convey the 10-year flows. This deficiency contributes to deficiency 58.

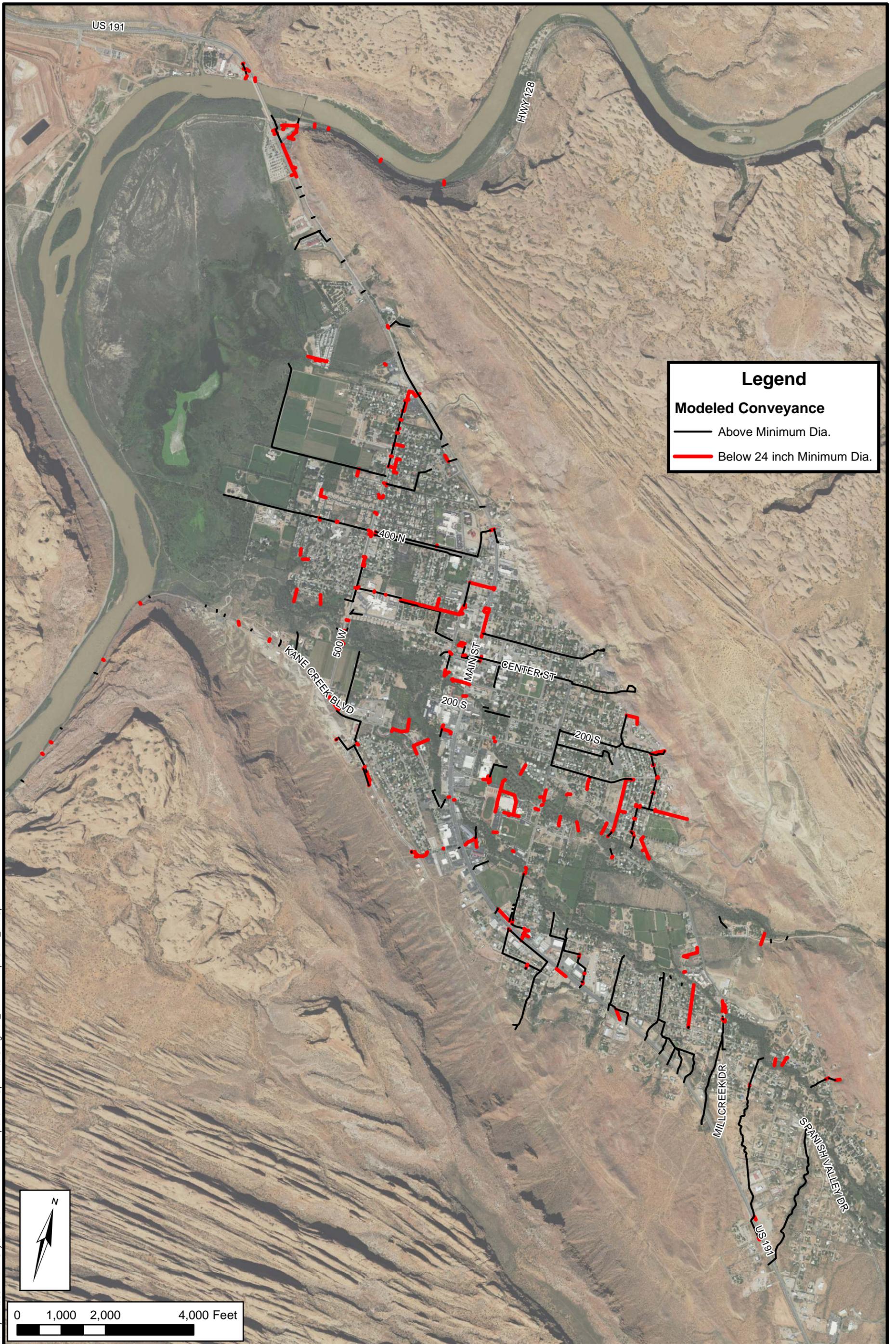
Deficiency ID	Location	Problem Description
67	Dirt road extending from Rosetree Lane east behind the residential lots along the north side of Arches Drive	The City has identified that a ditch and the dirt road experience significant erosion during storms which is then deposited in a bubble up and along the curb and gutter at Rosetree Lane and Hillside Drive.
68	Center Street from 650 East to 500 East	The City has identified that the ditch on the south side of the road experiences flooding and erosion. This may be a private facility.
69	Bowling Alley Lane and Bittle Lane	The City has noted that flows in the curb and gutter on the west side of Bowling Alley Lane overtop Bittle Lane diagonally and flood the driveway west of the storm drain inlet north of Bittle Lane.
70	Kelling Wash to 200 North and 200 East	The previous master plan identified this area as receiving significant flow from Kelling Wash. Current efforts suggest that the impact from runoff is less than previously predicted.
71	Pedestrian walkway under 500 West by Mill Creek	The City has noted that surcharges in the pipeline flood the walkway.
72	Moab City Public Works parking lot and yard	The City has noted that the storm drainage in the Public Works parking lot does not adequately connect to a downstream conveyance and therefore backs up, causing flooding in the yard.

MINIMUM CONVEYANCE SIZE

The criteria selected by the City specifies minimum conveyance dimensions. The City has selected a minimum pipe diameter of 24 inches as the standard for City facilities. Figure 4-2 shows which conveyances do not meet the City's minimum size criteria. Some pipes that do not meet the minimum size are identified as under capacity as seen on Figure 4-1. A pipe not meeting the minimum size does not necessitate an immediate solution unless accompanied by frequent or significant flooding, but should be monitored for surcharging and replaced with the proper size when possible.



Date: 7/21/2017
 Hansen Allen & Luce
 Project: Moab City, UT - storm water master plan (GIS)



Legend

Modeled Conveyance

- Above Minimum Dia.
- Below 24 inch Minimum Dia.

Date: 10/6/2017
 Document Path: H:\Projects\380 - Moab City\04.100 - storm water master plan\Plan Update\GIS\Figure4_2MinimumPipeSizes_newUpdate.mxd



**City of Moab
 Storm Water Master Plan**

Minimum Conveyance Sizes

**FIGURE
 4-2**

CHAPTER 5 – CAPITAL IMPROVEMENT PLAN

This Capital Improvement Plan (CIP) presents the problems, alternatives, and recommendations identified in the study to improve storm drainage in the City of Moab. The CIP was developed from the hydrologic models, deficiency analysis, and workshops with City personnel.

PREFERRED DRAINAGE PLAN DEVELOPMENT

The project team held a workshop with City staff to evaluate the need for drainage improvements based on the deficiencies identified in Chapter 4. Selection of the preferred alternative for each problem was a process of evaluation and refinement rather than a simple choice between alternatives.

The process of selecting a preferred alternative included:

- reviewing the list of storm drainage inadequacies,
- pre-screening drainage inadequacies,
- brainstorming possible solutions,
- screening alternatives based on feasibility and public acceptance,
- developing alternatives,
- comparing cost and function, and
- selecting the preferred alternative.

Design criteria included:

- 10-year design capacity for the initial drainage system. The initial drainage system includes inlets, laterals, minor trunk lines, gutters, and roadside ditches.
- 100-year capacity where flooding of homes may occur.
- 100-year capacity on major detention/retention, culverts and major conveyance facilities (limited to storm drain hydraulic capacities).

PRECISION OF COST ESTIMATES

When considering cost estimates, there are several levels or degrees of precision depending on the purpose of the estimate and the percentage of detailed design that has been completed. The following levels of precision are typical:

<u>Type of Estimate</u>	<u>Precision</u>
Master Planning	±50%
Preliminary Design	±30%
Final Design or Bid	±10%

For example, at the master planning level (or conceptual or feasibility design level), if a project is estimated to cost \$1,000,000, then the precision or reliability of the cost estimate would typically be expected to range between approximately \$500,000 and \$1,500,000. While this may seem very imprecise, the purpose of master planning is to develop general sizing, location, relative cost, and scheduling information on a number of individual projects that may be designed and constructed over a period of many years. Master planning also typically includes the selection of common design criteria to help ensure uniformity and compatibility among future individual projects. Details such as the exact capacity of individual projects, the level of

redundancy, the location of facilities, the alignment and depth of pipelines, the extent of utility conflicts, the cost of land and easements, the construction methodology, the types of equipment and material to be used, the time of construction, interest and inflation rates, permitting requirements, etc., are typically developed during the more detailed levels of design.

At the preliminary or 10% design level, some of the aforementioned information will have been developed. Major design decisions such as the size of facilities, selection of facility sites, pipeline alignments and depths, and the selection of the types of equipment and material to be used during construction will typically have been made. At this level of design the precision of the cost estimate for a \$1,000,000 project would typically be expected to range between approximately \$700,000 and \$1,300,000.

After the project has been completely designed and is ready to bid, all design plans and technical specifications will have been completed and nearly all of the significant details about the project should be known. At this level of design, the precision of the cost estimate for the same \$1,000,000 project would typically be expected to range between approximately \$900,000 and \$1,100,000.

The flows and pipe diameters provided in the following Capital Improvement Plan (CIP) descriptions are approximate and are for planning purposes only. A detailed hydrologic and hydraulic analysis shall be performed during the design process of the projects to identify final design and sizing.

ESTIMATED CONSTRUCTION COSTS

Cost estimates are based on conceptual-level engineering. Unit construction costs were estimated based on construction cost indices (ENR 2016), heavy construction data references (RSMMeans 2016), and HAL's experience with similar construction. Engineering cost estimates given in this study should be regarded as conceptual and appropriate for use as a planning guide. Only during final design can a definitive and more accurate estimate be provided. A detailed cost estimate of each project is provided in Appendix E.

CAPITAL IMPROVEMENT PLAN

Table 5-1 presents the recommended capital improvements which are shown in Figure 5-1.

The projects in the Capital Improvement Plan have been planned at a conceptual level. The projects must go through a preliminary and final design process before construction. The CIP projects are designed to specify the pipe size based on the required capacity as demonstrated in the model. CIP projects do not account for specific utility conflicts or inlet capacity. Utility conflicts and inlet capacity (type and number of inlets) should be determined during preliminary and final designs for each project. The preliminary and final designs should refer to the adopted storm drain criteria for the City. The criteria include guidelines for precipitation, inlet clogging, maximum velocities, sedimentation, erosion, and storage facilities, etc.

The criteria for determining the priority of a project was generally based on existing flooding, flooding history, development plans in the area, and capacity determined by the model. Projects with significant frequent flooding were prioritized higher than other projects. The priority number and low, medium, or high priority status were developed in coordination with Moab City personnel.

**Table 5-1
Capital Improvement Plan**

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
Moab City Facilities						
P1	1	100 West from Williams Way to 100 North	Flows in the pipe crossing 100 West along Williams way need to be diverted to another pipeline to abandon the downstream damaged pipe.	Install 246 feet of 24-in pipe in 100 West from the existing storm drain near Williams Way to the existing storm drain at Center Street and 100 West which outfalls directly south of 100 West to Mill Creek. This project is currently underway in cooperation with development along Walnut Lane.	\$47,000	1 High
P30	49	Kane Creek Boulevard from 450 West to 475 West	Runoff is conveyed only in the curb and gutter. The City has identified flooding in this area.	Install 600 feet of 30-inch pipe from the bubble up in Kane Creek Boulevard to inlet located near 475 West.	\$132,000	2 High
P28A	13, 41, 42, 58	100 North from 425 East to 400 East, 400 East from 100 North to 100 South, 100 South from 400 East to 100 East, 100 East from 100 South to Mill Creek	Flooding occurs along Main Street and is impacted by the lack of conveyance to collect flows from the Johnson Canyon and White Canyon detention basins. Significant flooding occurs near 100 South and 100 East due to insufficient capacity issues as well as due to overflow from the storm drain in 200 South from 400 East to 200 East.	Install 93 feet of 24-in pipe from the detention basin open channel (P2) in 100 North from 425 East to 400 East. Install 1,168 feet of 24-in pipe in 400 East from 100 North to 100 South. Install 635 feet of 24-in pipe in 100 South from 400 East to 300 East. Install 558 feet of 24-in pipe in 100 South from 300 East to 200 East. Install 382 feet of 30-in pipe in 100 South from 200 East to 120 East. Install 112 feet of 36-in pipe in 100 South from 120 East to 100 East. Install 543 feet of 36-in pipe in 100 East from 100 South to the outfall on Mill Creek. To reach new inlets across 100 South install 60 feet of 24-in pipe at 300 East and 200 East, 60 feet of 24-in pipe at 120 East and 70 feet of 24-in pipe at 100 East. This design will convey the 10-year flows from the detention basins and the 100-year flows from the 100 East 100 South area. For the design that conveys the 100-year flows from the detention basins, see 28B.	\$758,000	3 High

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P28B Alternative	13, 41, 42, 58	100 North from 425 East to 400 East, 400 East from 100 North to 100 South, 100 South from 400 East to 100 East, 100 East from 100 South to Mill Creek	Flooding occurs along Main Street and is impacted by the lack of conveyance to collect flows from the Johnson Canyon and White Canyon detention basins. Significant flooding occurs near 100 South and 100 East due to insufficient capacity issues as well as due to overflow from the storm drain in 200 South from 400 East to 200 East.	Install 93 feet of 36-in pipe from detention basin open channel (P2) in 100 North from 425 East to 400 East. Install 565 feet of 36-in pipe in 400 East from 100 North to Center Street. Install 603 feet of 36-in pipe in 400 East from Center Street to 100 South. Install 1,193 feet of 36-in pipe in 100 South from 400 East to 200 East. Install 494 feet of double barreled 30-in pipe in 100 South from 200 East to 100 East. Install 543 feet of 54-in pipe in 100 East from 100 South to the outfall on Mill Creek. To reach new inlets across 100 South install 60 feet of 24-in pipe at 300 East, 60 feet of 24-in pipe at 200 East and 120 East, and 70 feet of 24-in pipe at 100 East. This design will convey the 100-year flows. For a less expensive design that conveys 10-year flows, see 28A.	\$1,287,000	3 High
P35	66	200 South from 400 East to 200 East	Flooding occurs at 200 East after flows east of 400 East cross the road and travel down 200 South.	Replace the existing storm drain in 200 South across 200 East with 70 feet of 30-in pipe with increased inlet capacity. Install 60 feet of 24-in pipe with a new inlet in 300 East across 200 South. Install 55 feet of 24-in pipe in 400 East across 200 South with increased inlet capacities.	\$53,000	4 High

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P12A	14, 15, 16, 18	100 West from 300 North to Walnut Lane, 200 North from 60 West to 100 North, Walnut Lane from 100 West to the existing 60-in storm drain behind the hospital, and from the downhill cul-de-sac on 200 North to Walnut Lane	Walnut Lane lacks adequate capacity to convey flows from Main Street. Flows in excess of the capacity bubble out of the storm drain system and flow north on 100 West, adding to flooding issues at deficiencies 16 and 18. The downhill cul-de-sac on 200 North lacks adequate drainage to convey the 100-year flows.	Install inlets and 550 feet of 24-in pipe in 100 West from 300 North to 200 North. Replace the existing 24-in pipe in 200 North from approximately 60 West to 100 West with 177 feet of new 24-in pipe in order to achieve a steeper slope to gain cover above the pipe. Replace the 18-in pipe at the intersection of 200 North and 100 West with 44 feet of 30-in pipe. Replace the existing 15-in pipe in 100 West from 200 North to Walnut Lane with 223 feet of 36-in pipe. Replace the existing 12-in pipe in Walnut Lane with 522 feet of 42-in pipe from 100 West to approximately 209 West . Replace the existing 12-in pipe in Walnut Lane with 885 feet of 48-in from approximately 209 West to the existing 60-in pipe behind the hospital. Replace the existing pipe from the 200 North cul-de-sac to Walnut Lane with 24-in pipe.	\$770,000	5 High
P12B Alternative	14, 15, 16, 18	100 West from 200 North to 300 North, Park Drive from 100 West to 350 West (future road), 350 West from Park Lane to the existing 60-in pipe behind the hospital.	Walnut Lane lacks adequate capacity to convey flows from Main Street. Flows in excess of the capacity bubble out of the storm drain system and flow north on 100 West, adding to flooding issues at deficiencies 16 and 18.	<i>Connect to existing storm drain and inlets at 200 North and 100 West with approximately 65 feet of 24-in pipe. Install 386 feet of 30-in pipe in 100 West from 200 North to Park Drive. Install 126 feet of 24-in pipe in 100 West from 300 North to Park Drive, install 1,459 feet of 42-in pipe in Park Drive from 100 West to a location in a future road at approximately 350 West. Install 543 feet of 42-in pipe in a future road at 350 West from Park Drive to the existing 60-in storm drain behind the hospital.</i>	\$782,000	5 High

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P14	17, 18, 19, 20, 50	Cermak Road, Highway 191 (Main Street) from 488 North to 500 West, undeveloped area from Stewart Canyon to Highway 191, 500 West and Highway 191 to approximately 1450 West and 1050 North	Flows from Stewart Canyon cause flooding down Cermak Road, and along Highway 191. The existing canal and pipe system along Highway 191 does not have an outlet or designated downstream conveyance. The abandoned canal acts as a retention facility and experiences overflows during large events. The storm drain system from Hampton Inn dead ends in Highway 191. During storm events, runoff sheet flows over the highway and floods 400 North.	Install 311 feet of 30-in pipe in Main Street from 488 North to 570 North (to existing inlets). Install 555 feet of 36-in pipe in Main Street from 570 North to 600 North. Install 524 feet of 30-in pipe in Cermak Road to Main Street. Install 545 feet of 42-in pipe in Highway 191 from 600 North to the existing 48-in storm drain across Highway 191. Install 1,043 feet of 24-in pipe from the Stewart Canyon debris basin southwest to the existing 48-in culvert crossing Highway 191. Install 2,415 feet of 54-in pipe along Highway 191 from the referenced 48-in culvert to 980 North. Install 221 feet of 48-in by 60-in box culvert along Highway 191 from 980 North to 500 West. Install 216 feet of 48-in by 60-in box culvert across Highway 191 to 500 West. Install 1,170 feet of 48-in by 60-in box culvert along the property line at approximately 1010 North from 500 West to 643 West. Install a detention basin with approximately 20 acre-feet of volume with a 24-in outlet approximately 60 feet long. Sizing of the detention basin may vary depending on the outlet structure and capacity. This deficiency includes UDOT facilities. Large conveyances may change in the final design but should retain the capacity of the conveyances listed in the CIP. The design storm is the 50-year storm to match UDOT criteria.	\$1,370,681 ¹ (Moab portion)	6 High

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P3	3	Across Bittle Lane at approximately 1040 South to the open ditch from the west end of Bittle Lane to Minor Court	Adverse grades in the ditch and small pipe diameters do not provide enough capacity to carry the flows. The low capacity also creates slower velocities which promote sediment deposits in the system. The area sees significant sediment laden flows from Boulder Avenue.	Replace the existing 18-in pipe with 53 feet of 24-in pipe, replace the open ditch along the back of the lots on Minor Court with 310 feet of 24-in pipe with a regraded slope, and replace the existing 18-in pipe along 400 East to Minor Court with 83 feet of 24-in pipe. Install 371 feet of 24-in pipe from the bubble up in Minor Court along 400 East to the existing manhole on the west side of the street just north of the Maverick property. Install 830 feet of 30-in pipe in 400 East to a new outfall on Pack Creek, combining flows from 400 East and Bittle Lane as well as accommodating new development in the area.	\$322,000	7 High
P4	4, 11, 57	Jackson Street from the southernmost end to Main Street	City has identified significant flooding issues here. Jackson Street lacks inlet structures to capture flows coming from the cliffside drainages to the south. The ditch along Jackson Street lacks capacity and has experienced sediment deposits. The runoff from the natural drainages is laden with sediments and causes flooding issues at 980 South on Main Street and on Dogwood Avenue.	Install a debris basin with inlet structure to reduce the amount of sediment in the runoff at the southernmost end of Jackson Street. Install 720 feet of 24-in pipe from the debris basin to Jefferson Street. Replace the open ditch along Jackson Street with 146 feet of 24-in pipe. This may include County facilities but it is recommended that Moab pursue the project with or without County financial input.	\$195,000	8 High
P9	11	Existing storm drain alignment along the back of the lots along Main Street from Dogwood Avenue to Birch Avenue and Kane Creek Boulevard	This area sees significant flooding and sediment deposits from Jackson Street as well as lacks capacity to convey the 100-year flows from the area, which is a topographical low point.	Replace the existing 24-in pipe with 1,370 feet of 36-in pipe with a new outfall to Pack Creek being installed across Kane Creek Boulevard approximately 160 feet southeast of the existing outfall.	\$442,000	9 High

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P10	12	Existing storm drain alignment from Aspen Avenue and Kane Creek Boulevard to Pack Creek	Modeling efforts have shown that the 18-in pipe doesn't have sufficient capacity to convey the 10-year flows. The area also experiences debris issues from fallen leaves during autumn.	Replace the existing 18-in pipe with 557 feet of 30-in pipe.	\$112,000	10 High
P31	51	Gala Avenue at 585 West to the open channel behind the properties to the north	The City has identified flooding and debris at this location.	Install a backflow preventer valve in the existing 15-in pipe to prevent debris and flooding from the open channel.	\$9,000	12 Medium
P2	2	Along the private drive at 425 East 100 North	Flows from the upstream detention basin flow onto the dirt road private drive causing significant erosion and flooding problems.	Install 385 feet of a 5-ft wide by 2.5-ft deep rectangular open channel from the spillway structure of the detention basin to 100 North.	\$81,000	13 Medium
P16	22	510 North 500 West	The City and model show capacity issues with the storm drain system, likely impacted by the odd shapes and small sizes of the existing system.	Install 31 feet of 24-in pipe from the existing storm drain on the east side of 500 West to the manhole in the west lane of 500 West.	\$9,000	14 Medium
P18	24, 26, 52	400 North from 500 West to the outfall by the treatment plant	The City has identified storm drain in need of repair from 500 West to Holliday Drive. The model shows the storm drain at Holliday Drive as not having sufficient capacity. Hale Avenue experiences flooding.	Replace the existing 30-in pipe with 3,381 feet of new 30-in pipe with a steeper slope. Replace the inlet near Holliday Drive with 55 feet of 24-in pipe. This project is in coordination with project P32.	\$746,000	15 Medium
P27	40	Bike path along Highway 191 from 990 North to 1100 North and from 1400 North to 1700 North	The City has identified that runoff from the uphill side of the bike path overtops the path and causes erosion on the downhill side of the path.	Install a ditch behind the walking trail with drainage pipe crossing under the trail where needed. This project may be completed by Moab personnel.	\$22,000	16 Medium

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P39	71	Pedestrian walkway under 500 West by Mill Creek	The City has noted that surcharges in the pipeline back up and flood the walkway.	Install 142 feet of 36-in pipe from the existing storm drain at the east side of the pedestrian crossing to Mill Creek. The existing outfall should remain in operation after this project to help alleviate flooding.	\$43,000	17 Medium
P40	72	Moab City Public Works parking lot and yard	The City has noted that the storm drainage in the Public Works parking lot does not adequately connect to a downstream conveyance and therefore backs up, causing flooding in the yard.	Install 294 feet of 24-in pipe from the existing storm drain inlet in the Public Works parking lot to the existing storm drain on the southwest side of the McLaughlin property (200 South 426 West).	\$40,000	18 Medium
P32	52	Hale Avenue from the northwest corner to 400 North	The City and model have identified capacity issues and flooding in this location.	Install 656 feet of 24-in pipe in Hale Ave from the existing inlet to project P18 in 400 North. The existing storm drain in Hale Avenue is a private facility.	\$116,000	19 Medium
P33	54	250 North 300 East	The City has noted sediment deposits in this area.	Install curb and gutter, drive approach, and regrade hillside to reduce rockfall and debris.	\$10,000	20 Medium
P36	67	Dirt road extending from Rosetree Lane east behind the residential lots along the north side of Arches Drive	The ditch and dirt road experience significant erosion during storm which is deposited in the bubble up and curb and gutter in Rosetree Lane.	Regrade the road, install a roadside ditch with erosion control measures (rip-rap), replace the bubble up in Rosetree lane with a higher invert elevation so debris and sediment doesn't fill the outlet.	\$31,000	21 Medium
P37	68	Center Street from 650 East to 500 East	The City has identified that the ditch on the south side of the road experiences flooding and erosion.	In coordination with local property owners, stabilize the ditch with erosion control measures and install a diversion structure to convey excess flows in the curb and gutter without the erosion associated with the higher flows.	\$4,000	22 Medium

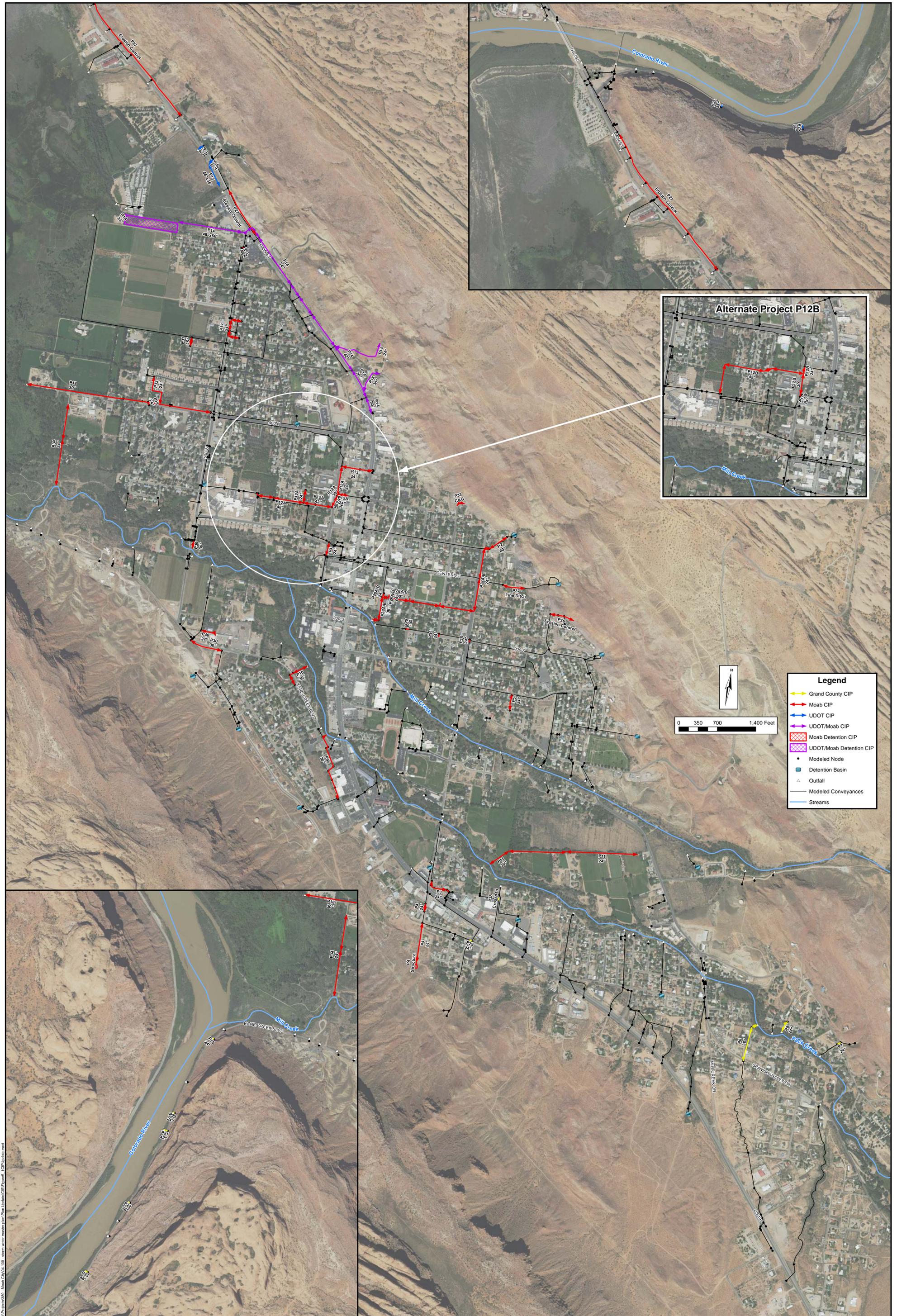
Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P38	69	The intersection of Bowling Alley Lane and Bittle Lane	Flows in the curb and gutter on the west side of Bowling Alley Lane overtop Bittle Lane diagonally and flood the driveway west of the storm drain inlet north of Bittle Lane.	Regrade Bittle lane to provide a crossspan that directs flows to the existing storm drain inlet north of Bowling Alley Lane. Coordination with Grand County may be required.	\$6,000	23 Medium
P17	23	From the westernmost ends of Carlos Court and Juan Court to 500 West then to the inlet on the east side of 500 West	The storm drains from the downhill cul-de-sacs do not have the capacity to convey the 100-year flows.	Install 396 feet of 24-in pipe from Carlos Court to 500 West along the property lines then south to the nearest inlet on 500 West. Install 300 feet of 24-in pipe from Juan Court to 500 West along the property lines then north to the nearest inlet on 500 West.	\$110,000	24 Low
P5	6	Existing storm drain alignment from Loveridge Drive to Locust Lane	Modeling efforts indicate that the existing 15-in pipe does not have capacity to convey the 100-year flows from the downhill drive.	Replace the existing 15-in pipe with 300 feet of 24-in pipe.	\$40,000	25 Low
P13	15	From Nob Hill (300 North) and Main Street to 300 North and 100 West	Modeling efforts have shown capacity issues at this location which likely create velocities that promote sediment deposits.	Replace the existing 18-in pipe and open channel with 571 feet of 24-in pipe from Main Street to 100 West along the existing storm drain alignment.	\$106,000	29 Low
P34	NA	Stewart Lane from 350 North to Mill Creek	This area was identified in the previous master plan as a potential development.	Install 657 feet of 24-in from 350 North to 275 North and 844 feet of 24-in pipe from 275 North to Mill Creek. This project may be completed in coordination with future development.	\$273,000	39 Low
P11	NA	Pear Tree Lane from approximately 1000 East to the western end of the Lane then southwest to Pack Creek	This area was identified in the previous master plan as a potential development.	Install 1,294 feet of 24-in pipe from 1000 East to 840 East. Install 1,053 feet of 24-in pipe from 840 East to the western end of Pear Tree Lane. Install 422 feet of 30-in pipe from the western end of Pear Tree Lane southwest to Pack Creek.	\$382,000	40 Low
Moab City Facilities Projects Subtotal					\$6,229,681²	
Grand County Facilities						

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P6	7	Existing storm drain alignment from 1400 Spanish Valley Drive to the existing outfall on Pack Creek	Modeling efforts have indicated that the existing 18-in pipe does not have sufficient capacity to convey the 100-year flows.	Replace the existing 18-in pipe, 24-in pipe and 28-in pipe with 753 feet of 36-in pipe. This may include County facilities.	\$185,000	26 Low
P7	8	Culvert across Murphy Lane at approximately 1320 Murphy Lane	Modeling efforts have indicated that the 18-in pipe does not have sufficient capacity to convey the 100-year flows.	Replace the existing 18-in pipe with 70 feet of 24-in pipe. This may include County deficiencies.	\$13,000	27 Low
P8	9	From 123 Arbor Drive to Pack Creek	Modeling efforts have indicated that the 18-in pipe doesn't have sufficient capacity to convey the 100-year flows from the downhill cul-de-sac.	Replace the existing 18-in pipe with 218 feet of 24-in pipe. This may include County facilities.	\$35,000	28 Low
P19	27	Kane Creek Road 0.97 miles along the road from 500 West towards the Colorado River	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize the existing culvert to 35 feet of 24-in pipe. This facility may be a County facility.	\$7,000	30 Low
P20	29	Kane Creek Road 1.27 miles along the Road from 500 West towards the Colorado River	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize existing culvert to 32 feet of 24-in pipe. This facility may be a County facility.	\$6,000	31 Low
P21	30	Kane Creek Road 1.33 miles along the Road from 500 West towards the Colorado River	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize existing culvert to 72 feet of 42-in pipe. This facility may be a County facility.	\$26,000	32 Low
P22	31	Kane Creek Road 1.61 miles along the Road from 500 West towards the Colorado River	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize existing culvert to 32 feet of 36-in pipe. This is a County facility.	\$10,000	33 Low
P23	33	Kane Creek Road 1.88 miles along the Road from 500 West towards the Colorado River	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize existing culvert to 59 feet of 48-in pipe. This is a County facility.	\$24,000	34 Low

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P29	3, 45, 60	Jefferson Street and Boulder Avenue	Boulder Avenue does not have inlets or buried storm drain facilities. Storm drains along Main Street and Bittle Lane experience sediment deposits.	Install inlets on the 24-in pipe that crosses Boulder Avenue to intercept curb and gutter flow. May include 53 feet of 24-in pipe. This may be a County facility.	\$16,000	38 Low
Grand County Facilities Projects Subtotal					\$322,000	
UDOT Facilities						
P14 (See also Project P14 in the Moab Facilities Section)	17, 18, 19, 20, 50	Cermak Road, Highway 191 (Main Street) from 488 North to 500 West, undeveloped area from Stewart Canyon to Highway 191, 500 West and Highway 191 to approximately 1450 West and 1050 North	Flows from Stewart Canyon cause flooding down Cermak Road, and along Highway 191. The existing canal and pipe system along Highway 191 does not have an outlet or designated downstream conveyance. The abandoned canal acts as a retention facility and experiences overflows during large events. The storm drain system from Hampton Inn dead ends in Highway 191. During storm events, runoff sheet flows over the highway and floods 400 North.	Install 311 feet of 30-in pipe in Main Street from 488 North to 570 North (to existing inlets). Install 555 feet of 36-in pipe in Main Street from 570 North to 600 North. Install 524 feet of 30-in pipe in Cermak Road to Main Street. Install 545 feet of 42-in pipe in Highway 191 from 600 North to the existing 48-in storm drain across Highway 191. Install 1,043 feet of 24-in pipe from the Stewart Canyon debris basin southwest to the existing 48-in culvert crossing Highway 191. Install 2,415 feet of 54-in pipe along Highway 191 from the referenced 48-in culvert to 980 North. Install 221 feet of 48-in by 60-in box culvert along Highway 191 from 980 North to 500 West. Install 216 feet of 48-in by 60-in box culvert across Highway 191 to 500 West. Install 1,170 feet of 48-in by 60-in box culvert along the property line at approximately 1010 North from 500 West to 643 West. Install a detention basin with approximately 20 acre-feet of volume with a 24-in outlet approximately 60 feet long. Sizing of the detention basin may vary depending on the outlet structure and capacity. This deficiency includes UDOT facilities. Large conveyances may change in the final design but should retain the capacity of the conveyances listed in the CIP. The design storm is the 50-year storm to match UDOT criteria.	\$1,894,319 ³ (UDOT portion)	6 High

Project ID	Deficiency ID	Location	Problem Description	Preferred Solution	Project (\$)	Priority
P15	20, 56	Highway 191 from near Arrowhead Lane to 1100 North	The City and model have identified that the existing culvert across Highway 191 lacks adequate capacity. The elevations at the culvert cause low velocities in the open ditch alongside the highway which promotes sediment deposition.	Install 120 feet of 42-in pipe across Highway 191 along the same trajectory as the existing storm drain along Arrowhead Lane. Lower the existing invert of the bottom manhole along Arrowhead Lane in order to alleviate surcharging conditions due to hydraulic jumps in the existing pipeline. Install a new 4-ft wide by 3-ft deep trapezoidal ditch along Highway 191 from the new 42-inch culvert to the natural drainage near 1100 North. This would be a UDOT facility.	\$97,000	11 Medium
P24	34	Highway 191 at approximately 1200 North	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize existing culvert to 122 feet of 36-in pipe. This is a UDOT facility.	\$38,000	35 Low
P25	38	Highway 128 approximately 0.49 miles along the Highway from Highway 191	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize existing culvert to 52 feet of 36-in pipe. This is a County facility.	\$17,000	36 Low
P26	39	Highway 128 approximately 0.78 miles along the Highway from Highway 191	The existing culvert does not have sufficient capacity to convey the 100-year flows.	Upsize existing culvert to 52 feet of 36-in pipe. This is a County facility.	\$24,000	37 Low
UDOT Facilities Projects Subtotal					\$2,070,319	
Capital Improvements Total Cost					\$8,622,000	

1. Project Cost only includes the Moab portion of the project as discussed below.
2. Moab Facilities Project Subtotal does not include the cost of Project P12B or P28B. Subtotal cost with Project P12B and P28B without project P12A or P28A is equal to \$6,770,681.
3. Project Cost only includes the UDOT portion of the project as discussed below.



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 Hansen Allen & Luce
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FACILITY OWNERSHIP

The CIP is separated into three divisions: Moab facilities, Grand County facilities, and UDOT facilities. Moab facilities were determined to be parts of the storm drain system within the municipal boundaries of Moab that are part of a larger storm drain network. Grand county facilities are those storm drains that are outside of Moab boundaries or appear to just be culverts under county roads. UDOT facilities are culverts under Highway 191 that are not connected to a larger network of storm drains. Storm drains are often not as well maintained as water or sewer facilities and are sometimes “inherited” as Cities expand, incorporate, or irrigation facilities are devoted to storm drainage. Therefore, it is recommended that the ownership of the facilities included in the CIP be verified with the various entities before proceeding with project designs.

STEWART CANYON COST SHARING

Project P14 deals with flows from Stewart Canyon and from the northeast side of Highway 191, on the north end of Moab. UDOT maintains several culverts that cross Highway 191. The outfall for the culverts appears to be an abandoned canal that runs on the south side of Highway 191. The canal has since been partially filled and is no longer used for irrigation or storm water conveyance. Moab facilities do not exist in the area to receive the flow from the UDOT culverts. Flows into the abandoned canal either evaporate, are infiltrated into the ground, or back up to a depth where the runoff overtops the canal at Mivida Drive or flows backwards through the UDOT culverts to the north side of Highway 191 to flow northwest along the highway. Both UDOT and Moab have an interest in managing runoff from the north side of Highway 191 in order to prevent flooding across Highway 191 as well as prevent the flooding of private residences on the south side of Highway 191.

Cost sharing is recommended for the project to represent the interests of both Moab City and UDOT as well as to represent the responsibilities of UDOT to convey natural flows coming to the highway and the responsibility of Moab to manage those flows as they enter Moab facilities. Preliminary estimates of cost sharing use flows and volumes from subbasins tributary to Moab Storm Drain facilities as compared to flows and volumes tributary to UDOT facilities. It is reasonable to expect UDOT facilities to convey the natural runoff flows from undeveloped areas across the highway whether the runoff originated from Grand County land, Moab land, or UDOT properties. When UDOT installs a culvert across a new road that intersects a natural drainage it is sized for the entire flow and UDOT does not normally assess a financial responsibility to landowners based on where undeveloped runoff originated. Tributary areas from Stewart Canyon are difficult to determine due to modifications the private property owner has made to the area. Therefore, the cost sharing recommendations in this master plan are conceptual and the general concepts should be used as a starting point in discussions between Moab City and UDOT on the project's cost sharing.

Pipe size is often determined by the expected peak flow. It is recommended that the cost of conveyances be proportionate to the peak flow to the culverts for UDOT and to the peak flow to Moab facilities for Moab. Moab City asked HAL to generate a cost sharing percentage for the project in studies separate from this master plan. The studies used the methodology described above and show approximately 41% of the cost of the conveyances would be the responsibility of Moab City, while the remaining 59% would be the responsibility of UDOT. Detention basins are sized based on the expected runoff volume. It is therefore recommended that the cost of the detention basin be based on the volume of runoff historically tributary to UDOT culverts and Moab facilities. Using the proportionate volume method, approximately 44% of the cost of the

detention basin would be the responsibility of Moab City while the remaining 56% would be the responsibility of UDOT. Final cost sharing will need to be determined by Moab City and UDOT. Again, the approach discussed above is a preliminary example.

SUMMARY OF CAPITAL IMPROVEMENTS

Costs of the Capital Improvements are summarized in Table 5-2.

**Table 5-2
Capital Improvement Plan Summary**

Project ID Range	Projects	Cost (\$)
P1-5, P9-14, P16-18, P27-28, P30-40	Moab City Facilities	\$6,229,681
P6-8, P19-23, P29	Grand County Facilities	\$322,000
P14-15, P24-26	UDOT Facilities	\$2,070,319
Total Cost		\$8,622,000

OPERATIONAL RECOMMENDATIONS

Minimum Pipe Diameter

Some of the storm drain pipes in Moab are 15 inches in diameter or less. Modeling of the system shows that generally the 15-inch pipes do not have the capacity to convey the 10-year flows. The City has selected a diameter of 24 inches as the standard minimum for City facilities.

Inventory

This master plan included a survey of Moab storm drain facilities. It is recommended that the City maintain and update the GIS inventory of the storm drainage system as the system is replaced or expanded. Updates should occur as information about additional land use, conveyance, capacity, and detention data become available.

Irrigation and Storm Drain Conveyances

Some areas of the Moab Storm Drainage System have conveyances which have historically served as both storm drain facilities and irrigation facilities. Several of the irrigation facilities have been abandoned in favor of a pressurized irrigation system. Therefore, it is recommended that an ongoing effort be made to separate storm drainage conveyances from irrigation conveyances in addition to the recommended projects in the Capital Improvement Plan.

Watch and Maintenance Recommendations

In addition to the existing storm drainage system maintenance, it is recommended that deficiencies 21, 55, 57, 59, 61, 62, 63, 64, 65, and 70 be addressed through more frequent maintenance. A maintenance schedule for these deficiencies could include removing debris, sediment, and clearing weed growth as needed to keep the drainage facilities functioning or until corrective CIP projects can be completed.

Several of the detention/debris basins are on private property. These detention basins significantly impact the Storm Water System and failure or improper function of the basins could cause flooding within the City. Agreements should be made with the property owners to allow City personnel to maintain the detention basins. The basins should be evaluated annually to

determine if sediment deposits are affecting the capacity of the basin, and if so, maintenance efforts should include removing sediment. Key detention basins to be evaluated include the Walker Canyon Detention Basin, White Canyon Detention Basin, Johnson Canyon Detention Basin, Tusher Canyon Detention Basin, McKay Place Detention Basin, the Detention Basin southwest of Highway 191 and Millcreek Drive, and the Doc Allen Drive Detention Basins. Debris basins at Stewart Canyon and northeast of 500 West and Highway 191 should also be periodically evaluated.

Deficiencies identified as not warranting action include 5, 10, 25, 28, 32, 35, 36, 37, 43, 44, 46, 47, 48, and 53. These deficiencies should be monitored for future flooding. If conditions become unacceptable, a project should be added to the CIP to remedy the deficiency.

Storm Water Quality Management Plan

Moab is not listed as an MS4 on the Utah MS4 List (01/01/15), but expansion of the MS4 list, growth of Moab, and expansion of storm water quality regulations are all expected. Therefore, in the future it is likely that Moab will be required to develop a Storm Water Management Plan in accordance with Utah's Utah Pollutant Discharge Elimination System (UPDES) permit. Chapter 6 has been included as a review of requirements included in the UPDES permit. The included chapter does **NOT** constitute a Storm Water Management Plan and is provided to help the City develop the best management practices and ordinances to smoothly transition to a functioning Storm Water Management Plan.

Storm Water Master Plan Updates

The Storm Water Master Plan should be periodically reviewed and updated dependent upon change and new development, at least every 5 years.

CHAPTER 6 – STORM WATER QUALITY

STORM WATER MANAGEMENT PLAN REQUIREMENTS

Moab is not included in the Utah MS4 list and is not required to meet UPDES Permit UTR090000 standards. However, Moab should expect a future inclusion on the MS4 list through population growth and expansion of the program. Therefore, this chapter is included to help Moab begin to implement some of the practices and recommended ordinances required in the UPDES Permit in order to reduce the required time, effort, and resources when the City is required to meet the permit standards. The following sections are compiled based on information from the EPA, UPDES UTS000001 Permit, and the UPDES UTR090000 Permit.

The UPDES permit is intended to reduce discharge of pollutants through the storm drainage system to the maximum extent possible (MEP). The permit helps cities reduce pollutants by requiring a Storm Water Management Plan (SWMP) and offering suggestions of best management practices (BMPs). This Storm Water Master Plan does **NOT** constitute a Storm Water Management Plan.

Public Education and Outreach on Storm Water Impacts

A SWMP must include a “a public education and outreach program to promote behavior change by the public to reduce water quality impacts associated with pollutants in storm water runoff and illicit discharges” (Utah Division of Water Quality, 2013). Educational materials are available from the State and the Environmental Protection Agency (EPA) to assist the City in preparing a public education program. The public education program should inform the following four audiences about the steps they can take to reduce storm water pollution:

1. Residents and households.
2. Businesses, institutions, and commercial facilities.
3. Developers and contractors.
4. Municipal Separate Storm Sewer System (MS4) industrial facilities.

Steps to reduce pollution may include informing the audiences about the proper use and disposal of landscape and garden chemicals, including fertilizers and pesticides, maintenance of septic systems, protecting and restoring riparian vegetation, proper disposal of swimming pool water, proper management of pet waste, benefits of on-site infiltration of storm water, proper use of salt or other deicing materials, proper management of parking lots, proper management of dumpsters, proper storage of materials, and properly disposing of used motor oil or household hazardous wastes.

Effective programs should be evaluated to show evidence that the defined goal of the program was achieved. The City should include written documentation or rationale as to why selected BMPs were chosen for the public education and outreach program.

Some suggestions on how to educate businesses, developers, and City staff are provided below.

1. **Commercial/Industrial.** Provide ongoing education and training to existing and new commercial/industrial entities regarding Best Management Practices they can or are required to implement to minimize pollution of storm water.

2. **In house training of City staff.** This group may include the City's development review committee, plan reviewers, inspectors, regulators, engineers, members of the planning commission and City Council, etc.
3. **Certification programs for developers and contractors who wish to develop within the City.** This would afford the City an opportunity to educate developers and contractors about the regulatory requirements, with which they must comply, in order to develop within the City limits.

The City may also look to State and Federal agencies, professional associations, general contractor associations, and/or conferences and seminars as a means to educate individuals and entities within this category.

Public Involvement/Participation

The City must, at a minimum, comply with State and local public notice requirements when implementing a public involvement/participation program. EPA recommends that the public participation process should make efforts to reach out and engage all economic and ethnic groups. Opportunities for members of the public to participate in program development and implementation include serving as citizen representatives on a local storm water management panel, attending public hearings, working as citizen volunteers to educate other individuals about the program, assisting in program coordination with other pre-existing programs, or participating in volunteer monitoring efforts. Specific time periods for public review of the SWMP are required in the Permit.

Illicit Discharge Detection and Elimination (IDDE)

The City must develop, implement and enforce a program to detect and eliminate illicit discharges into the City's storm drainage system. The City must:

1. Develop, if not already completed, a storm drainage system map, showing the location of all outfalls and the names and location of all waters of the United States that receive discharges from those outfalls. The City's GIS based facilities inventory map meets this requirement.
2. To the extent allowable under State or local law, effectively prohibit, through ordinance, or other regulatory mechanism, non-storm water discharges into the storm drainage system and implement appropriate enforcement procedures and actions, including an escalation of enforcement chart showing steps to enforce City Code in various stages of noncompliance.
3. Have legal authority to carry out the IDDE program.
4. Develop and implement a plan to detect and address non-storm water discharges, including illegal dumping, to the storm drainage system. Include an inspection schedule for priority areas of the city with the IDDE plan and inspect at least 20% of the areas annually.
5. Inform public employees, businesses, and the general public through the public education program of hazards associated with illegal discharges and improper disposal of waste.
6. Promote or provide services for household hazardous waste collection.
7. Publicize a hotline to report spills or illegal dumping.
8. Hold annual staff trainings for those individuals involved in the IDDE plan.

EPA recommends that the plan to detect and address illicit discharges include the following four components: procedures for locating priority areas likely to have illicit discharges; procedures

for tracing the source of an illicit discharge; procedures for removing the source of the discharge; and procedures for program evaluation and assessment.

The City shall document the basis for the prioritization of the IDDE areas. Prioritization may include consideration of the following suggestions:

- Areas with older infrastructure which are more likely to have illicit connections.
- Industrial, commercial, or mixed use areas.
- Areas with a history of past illicit discharges.
- Areas with a history of illegal dumping.
- Areas with onsite sewage disposal systems
- Areas with older sewer lines or with a history of sewer overflows or cross-connections.
- Areas upstream of sensitive waterbodies.

To ensure the effectiveness of this plan, the City should consider implementing additional BMPs which include:

1. The City should maintain a database of all industrial users.
2. Coordinate activities and inspections of City staff responsible for regulating pre-treatment processes for the identification of illicit connections. Particular plans should be developed for monitoring “dry weather” flows for determination of illicit connections. The plans should include procedures for monitoring of both quantity and quality. The City should review the EPA guidance document entitled “Draft Manual of Practice Identification of Illicit Connections” for additional information.
3. Maintain records and database of all illicit connections and action taken.
4. Review all new development plans for compliance with all applicable regulations. Provide training of all plan reviewers.

Enforcement of illicit discharges is most easily controlled through the creation of an ordinance which effectively prohibits illicit discharges into the storm drainage system and implements appropriate enforcement procedures, to the extent allowable under State law.

Illicit discharge education actions may include storm drain stenciling; a program to promote, publicize, and facilitate public reporting of illicit connections or discharges; and distribution of public outreach materials stressing the importance of recycling programs and eliminating sources of potential hazards such as motor oil, antifreeze, pesticides, herbicides, and fertilizers.

Construction Site Storm Water Runoff Control

The City must develop, implement, and enforce a program to reduce pollutants in any storm water runoff to the City’s storm drainage system from construction activities that result in a land disturbance of greater than or equal to one acre. Reduction of storm water discharges from construction activity disturbing less than one acre must be included in the program if that construction activity is part of a larger common plan of development or sale that would disturb one acre or more. This includes projects proposed by the City.

The City’s program must include the development, implementation and enforcement of, at a minimum:

1. An ordinance or other regulator mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance, to the extent allowable

under State or local law. The ordinance shall at a minimum be equivalent to the technical requirements set forth in the UPDES Storm Water General Permit for Construction Activities, UTR300000.

2. Require Storm Water Pollution Prevention Plans (SWPPP), for all construction sites.
3. Develop and implement a written enforcement strategy, including specific processes to obtain compliance from violators and documentation tracking of all enforcement actions.
4. Procedures for pre-construction SWPPP review which incorporate consideration of potential water quality impacts. Incorporate into the review an evaluation of opportunities for use of low impact design (LID) and green infrastructure when possible.
5. Procedures for site inspection and enforcement of control measures. Clearly identify the official responsible for inspection and enforcement of the SWPPP. Inspection forms with their schedules can be found on the Division of Water Quality's webpage.
6. Ensure that staff whose primary job duties are related to storm water pollution prevention are trained annually regarding these job duties.
7. Keep the proper records for all construction activities that disturb more than one acre or are part of a project that disturbs more than one acre of land. Records shall be kept for five years or until the project is complete, whichever is longer.

Additional items which may be considered for inclusion as effective Best Management Practices (BMPs) include, but are not limited to:

1. Ensuring that all storm drains are properly marked to reduce the chance of inadvertent disposal of hazardous products.
2. Providing appropriate educational and training measures for construction site operators;
3. Requiring construction site owners, developers and contractors to attend educational seminars and/or a pre-construction meeting where the previously approved water quality plan is addressed to discuss BMPs which will be used, discuss inspection schedules for verification of compliance, and penalties for failure to comply;
4. Cleaning the storm drainage system within work areas immediately following any construction or repair activities to remove sediments and/or debris;
5. Informing all employees and off-site contractors of the need for good housekeeping. The concentrated effort of a group of individuals can be undone by the careless or unknowing action of a single person.

Long-Term Storm Water Management in New Development and Redevelopment (Post-Construction Storm Water Management)

The objective of this control measure is for the hydrology associated with new development to mirror the hydrology of the undeveloped site or to improve the hydrology of a site to be redeveloped. The City must develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the storm drainage system. The City's program must ensure that controls are in place that would prevent or minimize water quality impacts. The City must:

1. Develop an ordinance that requires long-term post-construction storm water controls at new development and redevelopment sites. The ordinance shall meet the technical requirements set forth in the UPDES Storm Water General Permit for Construction Activities UTR300000.
2. Develop an enforcement strategy for long-term post-construction storm water controls that includes specific processes and sanctions to obtain compliance from violators. Document how BMPs were selected, which pollutant was targeted for the BMP, and the technical basis to support the claims for the selected BMPs.
3. Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs) appropriate for the City. Non-structural BMPs are preventive actions using management and source controls (policies and ordinances that result in protection of natural resources and prevention of runoff). Structural BMPs include storage practices (wet ponds and extended outlet structures), filtration practices (grassed swales, sand filters and filter strips), etc.
4. Develop procedures for site plan review.
5. Develop procedures for site inspection and enforcement of control measures in accordance with the schedule defined in the UPDES Permit Number UTS000001.
6. Provide adequate training for all staff involved in post construction storm water management.
7. Maintain an inventory of all structural post construction storm water control measures installed.
8. By March 1, 2019, require new developments that disturb at least one acre to implement BMPs to prevent the off-site discharge of runoff from all rainfall events less than or equal to the 90th percentile event. The City must develop hydrologic methods for calculating the volume to be retained on-site.

EPA recommends that the BMPs chosen be appropriate for the local community; minimize water quality impacts; and attempt to maintain pre-development runoff conditions. In choosing appropriate BMPs, the EPA encourages the City to participate in locally-based watershed planning efforts which attempt to involve a diverse group of stakeholders including interested citizens. EPA recommends the adoption of a planning process that identifies the municipality's program goals (e.g., minimize water quality impacts resulting from post-construction runoff from new development and redevelopment), implementation strategies (e.g., adopt a combination of structural and/or non-structural BMPs), operation and maintenance policies and procedures, and enforcement procedures. EPA recommends that the City ensure the appropriate implementation of the structural BMPs by considering some or all of the following: pre-construction review of BMP designs; inspections during construction to verify BMPs are built as designed; post-construction inspection and maintenance of BMPs; and penalty provisions for the noncompliance with design, construction or operation and maintenance. Storm water technologies are constantly being improved, and EPA recommends that the City's requirements be responsive to these changes, developments, or improvements in control technologies. Structural storm water controls may include:

- Infiltration
- Evapotranspiration
- Rainwater harvesting
- Rain gardens
- Permeable pavement
- Vegetated swales

Pollution Prevention and Good Housekeeping for Municipal Operations

Operation and maintenance is an integral component of the City's storm water management program. The City must develop and implement an operation and maintenance program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations. Using training materials that are available from the EPA, the State, or other organizations, the program must include employee training to prevent and reduce storm water pollution from activities such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and storm water system maintenance. Properly developed and implemented operation and maintenance programs reduce the risk of water quality problems.

The UPDES requires that, at a minimum, the City include the following in their maintenance program:

1. Maintain a current inventory of municipal owned or operated facilities and storm water controls that may include composting facilities, equipment storage and maintenance facilities, fuel farms, hazardous waste disposal facilities, hazardous waste handling and transfer facilities, incinerators, landfills, landscape maintenance on municipal property, materials storage yards, pesticide storage facilities, public buildings including libraries, police stations, fire stations, etc., public parking lots, public golf courses, public swimming pools, public works yards, recycling facilities, salt storage facilities, solid waste handling and transfer facilities, street repair and maintenance sites, vehicle storage and maintenance yards, and owned or maintained structural storm water controls.
2. Assess the inventory required above for their potential to discharge the following pollutants: sediment, nutrients, metals, hydrocarbons, pesticides, chlorides, and trash. Additional pollutants that could also be found in storm water discharge should be assessed as well.
3. Identify which facilities identified above are "high priority" or have a high potential to generate storm water pollutants.
4. Each "high priority" facility shall develop procedures which include BMPs meant to protect water quality and reduce discharge of pollutants. Further requirements for each facility's procedures can be seen in the UPDES Permit Number UTS000001.
5. Any third party conducting municipal maintenance shall be held to the same standards as the City in regard to storm water controls and good housekeeping practices.
6. An inspection program shall be implemented with "high priority" facilities having a visual inspection for leaks or spills, "high priority" facilities having a quarterly comprehensive inspection, and a quarterly visual inspection of storm water discharges.
7. The City shall develop and implement a process to assess the water quality impacts in the design of all new flood management structural controls that are associated with the City. This process shall include consideration of controls that can be used to minimize the impacts to site water quality and hydrology while still meeting project objectives. Existing flood management structural controls shall be assessed to determine whether changes or additions should be made to improve water quality.
8. Public construction projects shall comply with the same requirements applied to private projects.

9. The City shall provide annual training for all employees who have primary construction, operation, or maintenance job functions that are likely to impact storm water quality.
10. Maintenance activities, maintenance schedules, and log-term inspection procedures for structural and non-structural storm water controls to reduce floatables and other pollutants discharged from the storm drainage system;
11. Controls for reducing or eliminating the discharge of pollutants from streets, roads, highways, municipal parking lots, maintenance and storage yards, fleet or maintenance shops with outdoor storage areas, salt/sand storage locations and snow disposal areas operated by the City, and waste transfer stations;
12. Procedures for properly disposing of waste removed from the separate storm drainage system and areas listed above (such as dredge spoil, accumulated sediments, floatables, and other debris);
13. Ways to ensure that new flood management projects assess the impacts on water quality and examine existing projects for incorporating additional water quality protection devices or practices.

In addition to those elements listed above, the City should work towards implementing the following items:

1. Supporting curb side recycling efforts;
2. Encouraging residential clean-up days;
3. Implementing a program to distribute and collect leaf bags;
4. Continuing street sweeping program for removal of debris and sediment;
5. Reviewing City projects for compliance with BMPs.

Reviewing and Updating SWMPs

In addition to the six minimum control measures referenced above, the City must:

1. Conduct an annual review of the SWMP in conjunction with preparation of the annual report.
2. Make changes to the SWMP with written documentation provided to the Division of Water Quality.
3. Keep records required by the permit at least 5 years.
4. Make records and a description of the storm water management program available to the public upon request.
5. Submit an annual report to the Division of Water Quality using the report form provided on the Division's website.

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APPENDIX A

Electronic GIS Data

APPENDIX B

Detention Basin Data

**Moab Storm Water Master Plan
Modeled Detention Basins**

Detention Basin Attributes

Node ID	1085			Stor-01 (147)			Stor-02 (156)			Stor-3 (171)			254			531			424		
Name	Walker Canyon			McKay Place			Doc Allen Dr			Doc Allen Dr 2			Hospital SW			Holyoak Ln			Maverick 1		
Max Elevation	4193.4 ft			4101.45 ft			4094.98 ft			4114.20 ft			3996.61 ft			4208.51 ft			4125.9 ft		
Max Depth	20.6 ft			7.21 ft			8.83 ft			7.99 ft			2.21 ft			2.94 ft			4.35 ft		
Overflow Elevation	4190.6 ft			4100.27 ft			4093.53 ft			4112.35 ft			3996.61 ft			4208.51 ft			4124.9 ft		
Overflow Offset	17.8 ft			6.02 ft			7.38 ft			6.14 ft			2.21 ft			2.94 ft			3.35 ft		
Bottom Depth	4172.8 ft			4094.24 ft			4086.16 ft			4106.22 ft			3994.40 ft			4206.87 ft			4123.3 ft		
Measure Down	0 ft			0 ft			0 ft			0 ft			0 ft			1.3 ft			1.75 ft		
Invert Depth	4172.8 ft			4094.24 ft			4086.16 ft			4106.22 ft			3994.40 ft			4205.57 ft			4121.55 ft		
Outlet Orifice Size	in			in			in			in			in			7 in			2 in		
Outlet Pipe Size	18 in			15 in			15 in			15 in			12 in			15 in			15 in		
Tributary Acres	21.75			8.27			74.26			27.36			NA			NA			NA		
Max 100 yr Inflow (cfs)	8.10			2.14			16.83			6.54											
Max Inflow cfs/acre	0.37			0.26			0.23			0.24											
	Elevation	Stage	Area	Elevation	Stage	Area	Elevation	Stage	Area	Elevation	Stage	Area	Elevation	Stage	Area	Elevation	Stage	Area	Elevation	Stage	Area
	ft	ft	sq ft	ft	ft	sq ft	ft	ft	sq ft	ft	ft	sq ft	ft	ft	sq ft	ft	ft	sq ft	ft	ft	sq ft
	4172.8	0	0	4094.24	0	0	4086.16	0	0	4106.22	0	0	3994.40	0	0	4205.57	0	0	4121.55	0	0
	4172.8	0	800	4094.24	0	600	4086.16	0	1,100	4106.22	0	1,500	3994.40	0	5,737	4206.87	1.3	456	4123.3	1.75	293
	4190.6	17.8	16,000	4100.27	6.02	2,275	4093.53	7.38	5,800	4112.35	6.14	8,000	3996.61	2.21	15,700	4208.51	2.94	1,600	4124.9	3.35	1,633
	4193.4	20.6	38,000	4101.45	7.21	3,010	4094.98	8.83	9,000	4114.20	7.99	11,000	3996.61	2.21		4208.51	2.94		4125.9	4.35	2,000

APPENDIX C

Precipitation Data

NOAA's National Weather Service
Hydrometeorological Design Studies Center
 Precipitation Frequency Data Server (PFDS)



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General Info

- Homepage
- Current Projects
- FAQ
- Glossary

Precipitation Frequency (PF)

- PF Data Server
- PF in GIS Format
- PF Maps
- Temporal Distr.
- Time Series Data
- PFDS Perform.
- PF Documents

Probable Maximum Precipitation (PMP)

- PMP Documents

Miscellaneous

- Publications
- AEP Storm Analysis
- Record Precipitation

Contact Us

- Inquiries
- List-server



NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: UT

DATA DESCRIPTION

Data type: Units: Time series type:

SELECT LOCATION

1. Manually:

a) Enter location (decimal degrees, use "-" for S and W): latitude: longitude:
 b) Select station (click here for a list of stations used in frequency analysis for UT):

2. Use map:

a) Select location
(move crosshair or double click)

b) Click on station icon
(show stations on map)

LOCATION INFORMATION:
Name: Moab, Utah, US*
Latitude: 38.5731°
Longitude: -109.5507°
Elevation: 4022 ft*

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
 NOAA Atlas 14, Volume 1, Version 5

PF tabular

PF graphical

Supplementary information

Print Page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.105 (0.092-0.124)	0.134 (0.123-0.161)	0.182 (0.167-0.223)	0.227 (0.215-0.285)	0.297 (0.286-0.387)	0.360 (0.349-0.484)	0.434 (0.425-0.612)	0.521 (0.512-0.772)	0.657 (0.646-1.05)	0.780 (0.766-1.32)
10-min	0.160 (0.140-0.189)	0.204 (0.187-0.246)	0.276 (0.254-0.340)	0.346 (0.327-0.434)	0.452 (0.434-0.589)	0.547 (0.531-0.737)	0.661 (0.647-0.932)	0.793 (0.779-1.18)	1.00 (0.983-1.59)	1.19 (1.17-2.02)
15-min	0.198 (0.174-0.234)	0.253 (0.232-0.305)	0.342 (0.315-0.421)	0.428 (0.405-0.538)	0.561 (0.538-0.730)	0.678 (0.658-0.913)	0.819 (0.801-1.16)	0.983 (0.966-1.46)	1.24 (1.22-1.97)	1.47 (1.45-2.50)
30-min	0.267 (0.235-0.315)	0.340 (0.312-0.410)	0.461 (0.424-0.567)	0.577 (0.546-0.725)	0.755 (0.725-0.983)	0.913 (0.886-1.23)	1.10 (1.08-1.56)	1.32 (1.30-1.96)	1.67 (1.64-2.66)	1.98 (1.95-3.37)
60-min	0.331 (0.291-0.390)	0.421 (0.386-0.508)	0.571 (0.525-0.702)	0.714 (0.676-0.898)	0.935 (0.897-1.22)	1.13 (1.10-1.52)	1.36 (1.34-1.93)	1.64 (1.61-2.43)	2.07 (2.03-3.29)	2.45 (2.41-4.17)
2-hr	0.415 (0.373-0.484)	0.526 (0.460-0.606)	0.712 (0.629-0.825)	0.888 (0.779-1.02)	1.20 (1.03-1.37)	1.48 (1.24-1.70)	1.84 (1.50-2.14)	2.28 (1.80-2.68)	3.00 (2.26-3.62)	3.69 (2.69-4.53)
3-hr	0.465 (0.415-0.525)	0.582 (0.515-0.660)	0.767 (0.683-0.859)	0.943 (0.831-1.06)	1.24 (1.08-1.39)	1.53 (1.31-1.73)	1.88 (1.58-2.16)	2.32 (1.90-2.70)	3.05 (2.40-3.65)	3.74 (2.85-4.58)
6-hr	0.576 (0.526-0.637)	0.717 (0.650-0.796)	0.927 (0.844-1.01)	1.11 (1.00-1.22)	1.40 (1.25-1.55)	1.66 (1.47-1.84)	1.97 (1.71-2.21)	2.41 (2.06-2.73)	3.15 (2.60-3.69)	3.84 (3.12-4.63)

PFDS: Contiguous US

12-hr	0.712 (0.649-0.783)	0.888 (0.811-0.979)	1.12 (1.02-1.23)	1.33 (1.21-1.46)	1.63 (1.47-1.80)	1.89 (1.69-2.09)	2.18 (1.94-2.43)	2.52 (2.20-2.83)	3.25 (2.79-3.70)	3.95 (3.33-4.67)
24-hr	0.875 (0.811-0.949)	1.10 (1.01-1.20)	1.42 (1.30-1.55)	1.71 (1.53-1.89)	2.14 (1.86-2.45)	2.52 (2.11-2.98)	2.96 (2.38-3.65)	3.45 (2.66-4.46)	4.20 (3.04-5.80)	4.86 (3.34-7.11)
2-day	0.951 (0.885-1.02)	1.19 (1.10-1.29)	1.52 (1.39-1.66)	1.83 (1.63-2.03)	2.31 (1.99-2.65)	2.73 (2.26-3.25)	3.23 (2.56-4.03)	3.79 (2.87-4.99)	4.69 (3.31-6.66)	5.50 (3.66-8.29)
3-day	1.01 (0.943-1.10)	1.27 (1.18-1.38)	1.63 (1.49-1.78)	1.96 (1.75-2.17)	2.47 (2.13-2.83)	2.92 (2.43-3.47)	3.44 (2.74-4.28)	4.04 (3.07-5.29)	4.97 (3.54-7.00)	5.80 (3.90-8.69)
4-day	1.08 (1.00-1.17)	1.35 (1.25-1.47)	1.74 (1.59-1.90)	2.09 (1.87-2.31)	2.63 (2.28-3.02)	3.11 (2.59-3.69)	3.65 (2.92-4.54)	4.28 (3.27-5.59)	5.25 (3.76-7.34)	6.11 (4.15-9.08)
7-day	1.22 (1.13-1.32)	1.52 (1.41-1.64)	1.94 (1.78-2.12)	2.32 (2.08-2.56)	2.91 (2.52-3.33)	3.42 (2.86-4.05)	4.02 (3.22-4.97)	4.69 (3.60-6.10)	5.74 (4.13-8.01)	6.67 (4.54-9.90)
10-day	1.35 (1.25-1.46)	1.69 (1.56-1.83)	2.17 (1.99-2.37)	2.59 (2.33-2.85)	3.22 (2.81-3.65)	3.75 (3.18-4.37)	4.34 (3.56-5.25)	5.00 (3.94-6.31)	6.08 (4.53-8.23)	7.04 (4.99-10.1)
20-day	1.69 (1.56-1.84)	2.12 (1.96-2.31)	2.71 (2.48-2.95)	3.21 (2.89-3.53)	3.93 (3.44-4.46)	4.53 (3.85-5.28)	5.18 (4.26-6.25)	5.89 (4.65-7.39)	6.92 (5.20-9.14)	7.78 (5.62-10.7)
30-day	2.01 (1.86-2.18)	2.52 (2.33-2.73)	3.20 (2.93-3.47)	3.77 (3.41-4.13)	4.58 (4.03-5.16)	5.24 (4.50-6.06)	5.95 (4.93-7.08)	6.71 (5.37-8.29)	7.80 (5.94-10.1)	8.70 (6.39-11.7)
45-day	2.40 (2.22-2.59)	3.02 (2.78-3.26)	3.83 (3.51-4.14)	4.50 (4.08-4.92)	5.44 (4.81-6.11)	6.20 (5.35-7.13)	7.01 (5.85-8.28)	7.87 (6.36-9.63)	9.09 (7.02-11.7)	10.1 (7.50-13.5)
60-day	2.83 (2.62-3.06)	3.56 (3.29-3.85)	4.46 (4.11-4.84)	5.19 (4.72-5.68)	6.19 (5.50-6.88)	6.97 (6.07-7.92)	7.78 (6.61-9.07)	8.62 (7.12-10.4)	9.77 (7.79-12.3)	10.7 (8.22-13.9)

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

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

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in csv format:

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US Department of Commerce
 National Oceanic and Atmospheric Administration
 National Weather Service
 National Water Center (formerly OHD)
 1325 East West Highway
 Silver Spring, MD 20910
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 Page last modified: August 27, 2014

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APPENDIX D

Typical Lots Data



Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary 0.25 Acre
 380.04.100
 1/4/2016

D1

1	2	3		17	18	19	20	Lot Length					
Parcel ID	Lot Area ft ²	Frontage Width ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft	Area ac
01B180001	19,515	295	Good	4,808	7,320	7,387	12,128	38%	62%	25%	38%	115	0.448
01MNI0027	19,898	118	Good	3,631	3,931	12,336	7,562	62%	38%	18%	20%	179	0.457
01MUT0042	11,148	95	Good	75	2,495	8,578	2,570	77%	23%	1%	22%	117	0.256
02SGV0003	11,082	104	Good	615	1,565	8,902	2,180	80%	20%	6%	14%	105	0.254
02SSH0009	10,929	243	Good	592	2,794	7,543	3,386	69%	31%	5%	26%	88	0.251
01POR0016	3,931	94	Good	980	1,282	1,669	2,262	42%	58%	25%	33%	63	0.090
AVERAGE	12,751	158					5,015	61.4%	38.6%	13.2%	25%	111	0.29
AVERAGE	0.29 ac												

TR 55 Open Space Condition			CN			Weighted CN Ave	Weighted CN with Condition		
Good CN	Fair CN	Poor CN	Unconn	Imp	98		Good	Fair	Poor
39	49	68	A Soil CN Weighted Ave			56.2	63.3	76.8	
61	69	79	B Soil CN Weighted Ave			71.8	77.5	84.5	
74	79	86	C Soil CN Weighted Ave			81.0	84.5	89.5	
80	84	89	D Soil CN Weighted Ave			85.3	88.1	91.6	

Other Lots

01MNI0059	4219.6	128	Poor	0	640	3579.57008	640		0.15167422	0	0.15167422	64.000
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Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary 0.75 Acre
 380.04.100
 1/4/2016

1	2	3					17	18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft
010350007	43,500	132	Fair	1,553	3,793	38,154	5,346	88%	12%	4%	9%	325
020080145	35,345	0	Poor	0	1,771	33,574	1,771	95%	5%	0%	5%	253
20080082	33,735	124	Fair	3,585	2,355	27,795	5,940	82%	18%	11%	7%	270
02IVY0001	32,826	279	Fair	2,231	4,147	26,448	6,378	81%	19%	7%	13%	207
01MUT0086	28,267	397	Good	3,494	6,279	18,494	9,773	65%	35%	12%	22%	153
02SHE0021	22,015	64	Good	851	2,367	18,797	3,218	85%	15%	4%	11%	246
AVERAGE	32,615	166					5,404	82.7%	17.3%	6.2%	11%	242
AVERAGE	0.75 ac											

TR 55 Open Space Condition			CN		Weighted CN with Condition			
Good	Fair	Poor	Unconn Imp	98	Weighted CN Ave	Good	Fair	Poor
39	49	68			A Soil CN Weighted Ave	46.0	54.8	71.5
61	69	79			B Soil CN Weighted Ave	65.4	72.4	81.2
74	79	86			C Soil CN Weighted Ave	76.8	81.2	87.4
80	84	89			D Soil CN Weighted Ave	82.1	85.6	90.1

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary 1 Acre
 380.04.100
 1/4/2016

1	2	3					17	18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage Width ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft
020120002	348,961	400	Fair	7,006	24,410	317,545	31,416	91%	9%	2%	7%	610
030020086	157,801	232	Good	0	3,672	154,129	3,672	98%	2%	0%	2%	675
010010052	229,802	113	Poor	5,225	2,730	221,847	7,955	97%	3%	2%	1%	360
020070055	206,865	581	Good	4,199	3,985	198,681	8,184	96%	4%	2%	2%	417
020120042	187,909	288	Poor	0	6,136	181,773	6,136	97%	3%	0%	3%	332
01B090004	44,944	410	Good	4,597	9,120	31,227	13,717	69%	31%	10%	20%	230
AVERAGE	196,047	337					11,847	91.2%	8.8%	2.8%	6%	437
AVERAGE	4.50 ac											

TR 55 Open Space Condition			CN				
Good CN	Fair CN	Poor CN	Unconn Imp	Weighted CN with Condition			
			98	Weighted CN Ave	Good	Fair	Poor
39	49	68		A Soil CN Weighted Ave	42.6	52.0	69.9
61	69	79		B Soil CN Weighted Ave	63.3	70.8	80.2
74	79	86		C Soil CN Weighted Ave	75.5	80.2	86.7
80	84	89		D Soil CN Weighted Ave	81.1	84.9	89.6

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary Agriculture
 380.04.100
 1/4/2016

1	2	3					17		18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft	Description
030350156	136,580	0	Good	0	0	136,580	0	100%	0%	0%	0%	350	Row crops
010350041	559,298	0	Good	0	0	559,298	0	100%	0%	0%	0%	360	Row crops
010350004	43,530	0	Good	0	0	43,530	0	100%	0%	0%	0%	130	Row crops, orchard, and trees by ditch
010010257	297,914	168	Fair	0	5,956	291,958	5,956	98%	2%	0%	2%	600	Worn pasture and outbuildings
020070065	907,924	100	Good	0	9,562	898,362	9,562	99%	1%	0%	1%	796	Row crops, creek, and outbuildings
01MPT0002	32,645	220	Good	0	0	32,645	0	100%	0%	0%	0%	155	Orchard
AVERAGE	329,649	81					2,586	99.5%	0.5%	0.0%	1%	399	
AVERAGE	7.57 ac												

TR 55 Row Crops (SR)
Condition

Good CN	Poor CN
67	72
78	81
85	88
89	91

CN
Unconn Imp 98

Weighted CN Ave	Weighted CN with Condition	
	Good	Poor
A Soil CN Weighted Ave	67.2	72.1
B Soil CN Weighted Ave	78.1	81.1
C Soil CN Weighted Ave	85.1	88.1
D Soil CN Weighted Ave	89.0	91.0

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary Commercial
 380.04.100
 1/4/2016

1	2	3					17	18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft
011260002	43,523	125	Fair	445	10,172	32,906	10,617	76%	24%	1%	23%	270
010350030	80,795	330	Fair	60,514	7,016	13,265	67,530	16%	84%	75%	9%	240
01MUV0018	9,747	60	Fair	9,747	0	0	9,747	0%	100%	100%	0%	162
01MUV0019	9,909	64	Fair	9,909	0	0	9,909	0%	100%	100%	0%	160
010360005	101,215	180	Poor	18,170	5,364	77,681	23,534	77%	23%	18%	5%	300
020120019	11,105	108	Poor	11,043	0	62	11,043	1%	99%	99%	0%	99
010120005	21,023	226	Good	5,167	6,580	9,276	11,747	44%	56%	25%	31%	132
010010189	66,384	350	Good	21,005	13,612	31,767	34,617	48%	52%	32%	21%	190
AVERAGE	42,963	180					22,343	32.7%	67.3%	56.2%	11%	194
AVERAGE	0.99 ac											

TR 55 Western Desert Urban (natural)
 Condition

CN
 Unconn Imp 98

Weighted CN with Condition

CN
63
77
85
88

Weighted CN Ave	Good
A Soil CN Weighted Ave	71.9
B Soil CN Weighted Ave	82.3
C Soil CN Weighted Ave	88.3
D Soil CN Weighted Ave	90.5

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary Mobile Home
 380.04.100
 1/4/2016

1	2	3					17	18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage Width ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft
011350003	304,532	78	Poor	34,047	33,648	236,837	67,695	78%	22%	11%	11%	525
010020010	250,034	2,067	Poor	72,922	67,359	109,753	140,281	44%	56%	29%	27%	300
010010158	125,870	300	Poor	28,834	20,900	76,136	49,734	60%	40%	23%	17%	190
020080062	105,472	332	Poor	19,968	7,217	78,287	27,185	74%	26%	19%	7%	245
010070039	30,976	311	Poor	915	6,464	23,597	7,379	76%	24%	3%	21%	100
AVERAGE	163,377	618					58,455	66.5%	33.5%	17.0%	16%	272
AVERAGE	3.75 ac											

TR 55 Western Desert Urban (natural)
 Condition

CN
 Unconn Imp 98

Weighted CN with Condition

CN
63
77
85
88

Weighted CN Ave	CN
A Soil CN Weighted Ave	69.9
B Soil CN Weighted Ave	81.2
C Soil CN Weighted Ave	87.6
D Soil CN Weighted Ave	90.0

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary Park
 380.04.100
 1/4/2016

1	2	3					17	18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage Width ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft
010010108	290,772	1,911	Good	18,873	16,645	255,254	35,518	88%	12%	6%	6%	260
01B120001	213,261	1,850	Fair	0	21,906	191,355	21,906	90%	10%	0%	10%	230
010010016	177,814	294	Good	0	5,007	172,807	5,007	97%	3%	0%	3%	532
010010200	182,392	930	Good	0	2,436	179,956	2,436	99%	1%	0%	1%	200
010070035	84,973	380	Good	0	20,525	64,448	20,525	76%	24%	0%	24%	260
AVERAGE	189,843	1,073					17,078	89.8%	10.2%	1.3%	9%	296
AVERAGE	4.36 ac											

TR 55 Open Space			CN			
Condition			Unconn Imp 98			
Good	Fair	Poor	Weighted CN with Condition			
CN	CN	CN	Weighted CN Ave	Good	Fair	Poor
39	49	68	A Soil CN Weighted Ave	44.3	53.4	70.7
61	69	79	B Soil CN Weighted Ave	64.3	71.6	80.7
74	79	86	C Soil CN Weighted Ave	76.2	80.7	87.1
80	84	89	D Soil CN Weighted Ave	81.6	85.3	89.8

*Use C soil minimum

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary Street
 380.04.100
 1/4/2016

1	2	3					17	18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft
01PRV0000	70,117		Poor	41,841	0	28,276	41,841	40%	60%	60%	0%	12
010010128	9,712		Fair	7,345	0	2,367	7,345	24%	76%	76%	0%	13
vy191 Donnas	69,629		Fair	55,522	0	14,107	55,522	20%	80%	80%	0%	45
02SAL0000	21,548		Fair	17,802	0	3,746	17,802	17%	83%	83%	0%	16
N of bridge	268,326		Poor	241,618	0	26,708	241,618	10%	90%	90%	0%	40
AVERAGE	87,866						72,826	22.5%	77.5%	77.5%	0%	25
AVERAGE	2.02 ac											

TR 55 Western Desert Urban (natural)
 Condition

CN
 Unconn Imp 98

Weighted CN with Condition

CN
63
77
85
88

Weighted CN Ave	CN
A Soil CN Weighted Ave	63.0
B Soil CN Weighted Ave	77.0
C Soil CN Weighted Ave	85.0
D Soil CN Weighted Ave	88.0

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary Yard
 380.04.100
 1/4/2016

1	2	3					17	18	19	20	Lot Length	
Parcel ID	Lot Area ft ²	Frontage ft	Cover Assessment	Directly Connected Impervious ft ²	Unconnected Impervious Area ft ²	Pervious Area ft ²	TOTAL LOT Impervious ft ²	Percent Lot Pervious %	Percent Lot Impervious %	Percent Directly Conn Impervious %	Percent Unconnected Impervious %	Overland Flow Length ft
21XST0015	74,495	289	Poor	5,070	15,362	54,063	20,432	73%	27%	7%	21%	310
010020025	57,579	0	Poor	0	9,908	47,671	9,908	83%	17%	0%	17%	200
30060125	123,944	300	Poor	550	5,258	118,136	5,808	95%	5%	0%	4%	200
020120037	114,939	320	Poor	19,385	19,945	75,609	39,330	66%	34%	17%	17%	380
020070008	43,510	420	Poor	0	7,554	35,956	7,554	83%	17%	0%	17%	140
AVERAGE	82,893	266					16,606	79.8%	20.2%	4.8%	15%	246
AVERAGE	1.90 ac											

TR 55 Western Desert Urban (natural)
 Condition

CN
 Unconn Imp 98

Weighted CN with Condition

CN
63
77
85
88

Weighted CN Ave	CN
A Soil CN Weighted Ave	68.6
B Soil CN Weighted Ave	80.4
C Soil CN Weighted Ave	87.1
D Soil CN Weighted Ave	89.6

Moab City Storm Water Master Plan
 Typical Lot Characteristics Summary
 380.04.100
 1/4/2016

Notes	Soil	Condition			Directly Connected Impervious %	Typical Overland Flow ft	HAL suggested Overland Flow ft
		Good	Fair	Poor			
		CN	CN	CN			
Residential lots between 0.08 ac and <0.5 ac	Residential A	56	63	77	13%	111	100
	B	72	77	85			
	C	81	85	90			
	D	85	88	92			
Residential lots between 0.5 ac and <1 ac	Residential A	46	55	72	6%	242	200
	B	65	72	81			
	C	77	81	87			
	D	82	86	90			
Residential lots >=1 ac	Residential A	43	52	70	3%	437	300
	B	63	71	80			
	C	75	80	87			
	D	81	85	90			
Average of residential lots above, usually parts of larger lots (<0.08 ac)	Residential A	48	57	73	7%	264	150
	B	67	74	82			
	C	78	82	88			
	D	83	86	90			
Agriculture	A	67		72	0%	399	250
	B	78		81			
	C	85		88			
	D	89		91			
Commercial	A	72			56%	194	50
	B	82					
	C	88					
	D	91					
Mobile Home	A	70			17%	272	70
	B	81					
	C	88					
	D	90					
Open	A	49	55	63	0%		300
	B	68	72	77			
	C	79	81	85			
	D	84	86	88			
Park	A	44	53	71	1%	296	300
	B	64	72	81			
	C	76	81	87			
	D	82	85	90			
Street	A	63			78%	25	25
	B	77					
	C	85					
	D	88					
Vacant lots are parcels not developed, but are in developable areas and platted accordingly	Vacant A	49	55	63	0%		150
	B	68	72	77			
	C	79	81	85			
	D	84	86	88			
Yard	A	69			5%	246	200
	B	80					
	C	87					
	D	90					
Myton Family Rock Outcrop	MUSYM 39	39	74	77	81	NA	
Rock Outcrop	MUSYM 53	53	82	84	87	NA	
Rizno Dry Rock Outcrop	MUSYM 71	71	63	67	73	NA	
Rock Outcrop	MUSYM 72	72	86	87	89	NA	
Moenkopie Rock Outcrop	MUSYM 73	73	59	64	70	NA	
Rizno Dry Complex	MUSYM 75	75	63	67	73	NA	
Ustic Torripsamments	MUSYM 76	76	83	85	88	NA	
	MUSYM 117	117	94	95	95	NA	

APPENDIX E

Cost Information

2016 AVERAGE STORM DRAIN SYSTEM COST PER FOOT

Diameter (in)	Diameter (ft)	Outside Diameter (ft)	Material	Pipe Material & Installation (1)	Excavation	Imported Bedding Installed	Hauling Excess Native Mat'l	Trench Backfill Installed (3)	Trench Box per Day (2)	Average Daily Output	Trench Box Cost	Top Trench Width (ft)	Road Repair Width (ft)	Asphalt Cost	Manhole Cost	Inlet Cost	Curb & Gutter Cost	Utility Relocation	Trench Dewatering (4)	Total Cost per Foot of Pipe	Adjusted Cost per foot	Cost Out of Street (3)	Cost Out of Street w/ NO inlets	Adjusted Total Cost per Foot	Adjusted Cost Out of Street	Adjusted Cost Out of Street No Inlets
15	1.3	1.46	RCP	\$39.50	5.13	26.44	5.02	0.94	210.00	150	1.40	4.86	8.86	35.40	6.25	13.75	14.65	0	0.00	148	138	100	86	\$137.94	\$92.55	\$79.78
18	1.5	1.75	RCP	\$47.50	5.77	29.92	5.88	1.00	210.00	132	1.59	5.15	9.15	36.39	6.25	13.75	14.65	0	0.00	163	151	113	99	\$151.15	\$104.90	\$92.13
21	1.8	2.04	RCP	\$51.00	6.46	33.48	6.80	1.06	210.00	120	1.75	5.44	9.44	37.39	6.25	13.75	14.65	0	0.00	173	160	122	108	\$160.33	\$113.22	\$100.45
24	2.0	2.33	RCP	\$57.50	7.18	37.12	7.79	1.13	210.00	100	2.10	5.73	9.73	38.38	6.25	13.75	14.65	0	0.00	186	173	134	120	\$172.64	\$124.68	\$111.90
27	2.3	2.63	RCP	\$83.00	7.94	40.84	8.84	1.19	210.00	92	2.28	6.03	10.03	39.37	6.25	13.75	14.65	0	0.00	218	203	166	152	\$202.62	\$153.80	\$141.03
30	2.5	2.92	RCP	\$91.50	8.74	44.65	9.96	1.25	210.00	88	2.39	6.32	10.32	40.36	6.25	13.75	14.65	0	0.00	233	217	180	166	\$216.91	\$167.24	\$154.46
33	2.8	3.21	RCP	\$108.75	9.58	48.55	11.14	1.31	210.00	80	2.63	6.61	10.61	41.35	6.25	13.75	14.65	0	0.00	258	240	204	190	\$239.62	\$189.10	\$176.32
36	3.0	3.50	RCP	\$126.00	10.46	52.52	12.38	1.37	210.00	72	2.92	6.90	10.90	42.34	8.50	13.75	14.65	34	0.00	319	296	230	216	\$296.46	\$213.27	\$200.50
42	3.5	4.08	RCP	\$155.00	12.33	60.73	15.07	1.49	210.00	72	2.92	7.48	11.48	44.32	8.50	13.75	14.65	34	0.00	363	337	272	258	\$337.21	\$252.32	\$239.54
48	4.0	4.67	RCP	\$183.00	14.35	69.27	18.01	1.61	210.00	64	3.28	8.07	12.07	46.31	11.35	13.75	14.65	34	0.00	410	381	317	303	\$380.71	\$294.11	\$281.34
54	4.5	5.25	RCP	\$222.50	16.53	78.15	21.21	1.73	210.00	56	3.75	8.65	12.65	48.29	11.35	13.75	14.65	103	0.00	535	497	371	357	\$496.65	\$344.73	\$331.96
60	5.0	5.83	RCP	\$262.00	18.87	87.36	24.68	1.85	210.00	48	4.38	9.23	13.23	50.27	16.54	13.75	14.65	103	0.00	597	555	432	418	\$554.65	\$401.02	\$388.25
66	5.5	6.42	RCP	\$313.50	21.36	96.90	28.40	1.97	210.00	44	4.77	9.82	13.82	52.25	16.54	13.75	14.65	103	0.00	667	619	500	486	\$619.45	\$464.12	\$451.35
72	6.0	7.00	RCP	\$365.00	24.01	106.79	32.38	2.09	210.00	40	5.25	10.40	14.40	54.24	16.54	13.75	14.65	103	0.00	737	685	568	555	\$685.03	\$527.99	\$515.21
78	6.5	7.58	RCP	\$425.00	26.81	117.00	36.62	2.21	210.00	36	5.83	10.98	14.98	56.22	16.54	13.75	14.65	103	0.00	817	759	646	633	\$759.30	\$600.55	\$587.77
84	7.0	8.17	RCP	\$485.00	29.77	127.56	41.12	2.34	210.00	32	6.56	11.57	15.57	58.20	16.54	13.75	14.65	103	0.00	898	874	725	712	\$834.41	\$673.94	\$661.17
6' x 3' box	6.0	6.00	RCP	\$310.00	19.57	72.31	25.72	1.89	210.00	140	1.50	9.40	13.40	50.84	6.25	13.75	14.65	103	0.00	619	575	453	440	\$575.20	\$421.09	\$408.32
6' x 7' box	6.0	6.00	RCP	\$385.00	19.57	72.31	25.72	1.89	210.00	125	1.68	9.40	13.40	50.84	6.25	13.75	14.65	103	0.00	694	645	528	515	\$645.05	\$490.93	\$478.16
8' x 3' box	8.0	8.00	RCP	\$390.00	28.91	92.98	39.81	2.30	210.00	113	1.86	11.40	15.40	57.63	6.25	13.75	14.65	103	0.00	751	698	579	565	\$697.52	\$537.54	\$524.77
8' x 8' box	8.0	8.00	RCP	\$470.00	28.91	92.98	39.81	2.30	210.00	100	2.10	11.40	15.40	57.63	6.25	13.75	14.65	103	0.00	831	772	659	645	\$772.07	\$612.09	\$599.32

Reference: 2016 RSMMeans Heavy Construction Cost Data
Updated: 2/2016 JGH

Assumptions:	Costs:
N Total Import Trench Backfill? (Y/N)	1.07 \$ 6.09 /CY Native Trench backfill - 31 23 16.13: 3020 \$2.95 plus compaction 31 23 23.23: 6020 \$1.43; convert from loose to compacted volume. (\$2.95+\$1.43)/LCY * 1.39 LCY/ECY
N Dewatering? (Y/N)	1.74 \$ 61.98 /CY Imported Select Fill - sec 31 23 23.16 (0200, 0500) 31 23 23.20 (4022): Sand, dead or bank w/ hauling (20 CY, 6 mi) and compaction. (\$35/LCY + \$5.60/LCY)*1.39 LCY/ECY + \$5.55/ECY
y Catch Basins & Inlets? (Y/N)	1.02 \$ 6.15 /CY Excavation - 31 23 16.13 1375: 10-14 ft deep, 1 CY excavator, Trench Box.
One side of street C&G is regraded (30' street).	1.00 \$ 30.58 /SY 4" Asphalt Pavement -32 11 23.23 (0390), 32 12 16.13 (0120, 0380), 31 23 23.20 (4022): 9" Bank run gravel base course (\$7.55/SY), 2" Binder (\$9.55/SY), 2" Wear (\$10.70/SY [4"=\$20.50/SY]) and Hauling (\$5.55/LCY * 1.39LCY/ECY * 0.361CY/SY)
10 v:1h trench side slope (use trench boxes)	1.02 \$ 2.65 /LF 4" Asphalt cutting - 02 41 19.25 (0015, 0020): Saw cutting asphalt up to 3" deep (\$1.70/LF), each additional inch of depth (\$0.95/LF)
3' average depth to top of pipe	1.34 \$ 3,125.00 /EA 4' Manhole (for pipes <= 2.5' diameter) - 33 49 13.10 (1130, 1140): Precast 8' deep (\$3,125/ea), each add'l foot of depth (\$320/VLF)
0.33' thick asphalt road covering	1.10 \$ 4,250.00 /EA 5' Manhole (for pipes > 2.5' and <= 3.5') -33 49 13.10 (1170, 1180): Precast 8' deep (\$4,250/ea), each add'l foot of depth (\$550/VLF)
0.75' thick untreated base course	1.07 \$ 5,675.00 /EA 6' Manhole (for pipes > 3.5' and <= 4.5') - 33 49 13.10 (1210, 1220): Precast 8' deep (\$5,675/ea), each add'l foot of depth (\$755/VLF)
500' Average distance between manholes	1.03 \$ 8,269 /EA Manholes (for pipes > 4.5') ENR cost index adjustment from 2014 to January 2016
3' + Outside Diameter = Bottom trench width	1.02 \$ 1,375.00 /EA Catch basins -33 44 13.13 1582: Curb inlet frame, grate, and curb box, Large 24" x 36" heavy duty \$1,375
1' bedding over pipe	1.06 \$ 14.65 /LF Curb & Gutter - 32 16 13.13 (0440, 0441) 32 11 23.23 (0390) : Steel forms, 24" wide, straight (\$12.40/LF) and radius (\$13.95/LF). Plus 9" bank run gravel (\$8/sy or \$1.78/lf) Calculated based on percentage of C&G on radius.
0.5' bedding under pipe	1.03 \$ 10.29 /CY Hauling - 31 23 23.20 4622: 20 CY dump truck and conversion from loose to compacted volume. \$7.4/LCY * 1.39 LCY/ECY
1 Inlets per 100 ft of pipe	1.00 \$ 210.00 /day Trench Box (7' deep, 16' x 8', 31 52 16.10 4500)
30% of curb & gutter is on radius	2.39 \$ 66.83 /CY Stabilization Gravel - sec 31 23 23.16 (0050, 0500) 31 23 23.20 (4022): Bank Run Gravel (\$38.50/LCY * 1.39 LCY/ECY) plus compaction (\$5.60/ECY) and hauling (\$5.55/LCY * 1.39 LCY/ECY)
	1.03 \$ 1,117.00 /day Dewatering - 31 23 19.20 (1000, 1020): 4" diaphragm pump, 8 hrs attended (\$990/day). Second pump (\$127/day)

1.71	Construction Cost Index ratio since 1998. See ENR Construction Cost Index.xlsx at H:\Standards\Calculations\Cost Estimating
5920	ENR Construction Cost Index 1998
10133	ENR Construction Cost Index January 2016
92.9%	RSMMeans City Cost Index for Grand Junction, CO

NOTES:

- (1) Assumes Class 3 RCP (33 41 13.60). 33", 54", 66", & 78" costs were estimated by linear interpolation between sizes. Costs for these sizes may be much higher because they are odd sizes.
- (2) 7' deep trench box (16' x 8') 31 52 16.10 4500
- (3) Backfill Material & Installation assumes in street. For out of street unit costs, the backfill material cost has been added in place of base course and asphalt.
- (4) Dewatering assumes 1' stabilization gravel at the bottom of the trench plus dewatering pumps
- (5) Conversion from loose to compacted volumes assumes 125 PCF for compacted density and 90 PCF for loose density. Or (125 PCF/ECY)/(90 PCF/LCY) = 1.39 LCY/ECY
- (6) Conversion from cubic yards to square yards for hauling of asphalt paving assumed a total thickness of 13". 3 ft x 3 ft x (13 in)/(12 in/ft) = 0.361 CY/SY

Abbreviations:

VLF	vertical lineal foot
PCF	pounds per cubic foot
LCY	loose cubic yard
ECY	embankment cubic yard

City of Moab
Storm Water Master Plan
Unit Costs

Catch Basins 500 ft between manholes				No Catch Basins No manholes		
D (inches)	Adjusted Total Cost per Foot	Adjusted Cost Out of Street	Adjusted Cost Out of Street No Inlets	Adjusted Total Cost per Foot	Adjusted Cost Out of Street	Adjusted Cost Out of Street No Inlets
15	\$137.94	\$92.55	\$79.78	\$119.37	\$73.97	\$73.97
18	\$151.15	\$104.90	\$92.13	\$132.58	\$86.33	\$86.33
21	\$160.33	\$113.22	\$100.45	\$141.75	\$94.64	\$94.64
24	\$172.64	\$124.68	\$111.90	\$154.06	\$106.10	\$106.10
27	\$202.62	\$153.80	\$141.03	\$184.04	\$135.23	\$135.23
30	\$216.91	\$167.24	\$154.46	\$198.33	\$148.66	\$148.66
33	\$239.62	\$189.10	\$176.32	\$221.05	\$170.52	\$170.52
36	\$296.46	\$213.27	\$200.50	\$275.79	\$192.61	\$192.61
42	\$337.21	\$252.32	\$239.54	\$316.54	\$231.65	\$231.65
48	\$380.71	\$294.11	\$281.34	\$357.40	\$270.80	\$270.80
54	\$496.65	\$344.73	\$331.96	\$473.34	\$321.42	\$321.42
60	\$554.65	\$401.02	\$388.25	\$526.52	\$372.89	\$372.89
66	\$619.45	\$464.12	\$451.35	\$591.32	\$435.99	\$435.99
72	\$685.03	\$527.99	\$515.21	\$656.90	\$499.86	\$499.86
78	\$759.30	\$600.55	\$587.77	\$731.17	\$572.42	\$572.42
84	\$834.41	\$673.94	\$661.17	\$806.27	\$645.81	\$645.81
6' x 3' box	\$575.20	\$421.09	\$408.32	\$556.63	\$402.51	\$402.51
6' x 7' box	\$645.05	\$490.93	\$478.16	\$626.47	\$472.35	\$472.35
8' x 3' box	\$697.52	\$537.54	\$524.77	\$678.94	\$518.97	\$518.97
8' x 8' box	\$772.07	\$612.09	\$599.32	\$753.49	\$593.51	\$593.51

Manholes	
4 ft	\$3,125.00 for 30" and smaller
5 ft	\$4,250.00 for 36"-42"
6 ft	\$5,675.00 for 48"-54"
Cast in Place	\$8,269.00 for larger than 54"

City of Moab
Storm Water Master Plan
Project Cost Estimates

ENR Construction Index	10692.17	Jun-17
	10181.92	Feb-16

Project ID	Length ft	Diameter in	Project ID	In or Out of Street	Size Label	Number of Manholes	Unit Pipe Cost/ft	Pipe Cost	Per Manhole Cost	Manhole Cost	Total Conveyance Cost	2016 Project Total Conveyance	2017 Project Total Conveyance
1	246	24	1	In	24"	2	\$154.06	\$37,899	\$3,125.00	\$6,250.00	\$44,149	\$44,149	\$47,000
10	284	30	10	Out	30"	1	\$148.66	\$42,219	\$3,125.00	\$3,125.00	\$45,344	\$105,738	\$112,000
	197	30	10	In	30"	1	\$198.33	\$39,071	\$3,125.00	\$3,125.00	\$42,196		
	76	30	10	In	30"	1	\$198.33	\$15,073	\$3,125.00	\$3,125.00	\$18,198		
11	1294	24	11	Out	24"	0	\$124.68	\$161,332	\$3,125.00	\$0.00	\$161,332	\$363,191	\$382,000
	1053	24	11	Out	24"	0	\$124.68	\$131,285	\$3,125.00	\$0.00	\$131,285		
	422	30	11	Out	30"	0	\$167.24	\$70,574	\$3,125.00	\$0.00	\$70,574		
12	177	24	12	In	24"	1	\$154.06	\$27,269	\$3,125.00	\$3,125.00	\$30,394	\$732,454	\$770,000
	47	48	12	In	48"	2	\$357.40	\$16,798	\$5,675.00	\$11,350.00	\$28,148		
	290	48	12	In	48"	1	\$357.40	\$103,646	\$5,675.00	\$5,675.00	\$109,321		
	548	48	12	In	48"	1	\$357.40	\$195,855	\$5,675.00	\$5,675.00	\$201,530		
	522	42	12	In	42"	1	\$316.54	\$165,234	\$4,250.00	\$4,250.00	\$169,484		
	223	36	12	In	36"	1	\$275.79	\$61,501	\$4,250.00	\$4,250.00	\$65,751		
	44	30	12	In	30"	1	\$198.33	\$8,727	\$3,125.00	\$3,125.00	\$11,852		
	549	24	12	In	24"	1	\$154.06	\$84,579	\$3,125.00	\$3,125.00	\$87,704		
237	24	12	Out	24"	1	\$106.10	\$25,146	\$3,125.00	\$3,125.00	\$28,271			
13	571	24	13	In	24"	4	\$154.06	\$87,968	\$3,125.00	\$12,500.00	\$100,468	\$100,468	\$106,000
14	555	36	14	In	36"	2	\$275.79	\$153,063	\$4,250.00	\$8,500.00	\$161,563	\$3,108,594	\$3,265,000
	545	42	14	Out	42"	1	\$231.65	\$126,249	\$4,250.00	\$4,250.00	\$130,499		
	709	54	14	Out	54"	1	\$321.42	\$227,888	\$5,675.00	\$5,675.00	\$233,563		
	221	60	14	Out	48"x60"	1	\$372.89	\$82,409	\$8,269.00	\$8,269.00	\$90,678		
	1043	24	14	Out	24"	4	\$106.10	\$110,662	\$3,125.00	\$12,500.00	\$123,162		
	55	24	14	Out	24"	2	\$106.10	\$5,835	\$3,125.00	\$6,250.00	\$12,085		
	311	30	14	In	30"	1	\$198.33	\$61,681	\$3,125.00	\$3,125.00	\$64,806		
	1032	54	14	Out	54"	2	\$321.42	\$331,708	\$5,675.00	\$11,350.00	\$343,058		
	396	54	14	Out	54"	1	\$321.42	\$127,283	\$5,675.00	\$5,675.00	\$132,958		
	278	54	14	Out	54"	1	\$321.42	\$89,355	\$5,675.00	\$5,675.00	\$95,030		
	524	30	14	In	30"	3	\$198.33	\$103,925	\$3,125.00	\$9,375.00	\$113,300		
	1170	60	14	Out	48"x60"	3	\$372.89	\$436,281	\$8,269.00	\$24,807.00	\$461,088		
216	60	14	In	48"x60"	2	\$526.52	\$113,727	\$8,269.00	\$16,538.00	\$130,265			

Project ID	Length ft	Diameter in	Project ID	In or Out of Street	Size Label	Number of Manholes	Unit Pipe Cost/ft	Pipe Cost	Per Manhole Cost	Manhole Cost	Total Conveyance Cost	2016 Project Total Conveyance	2017 Project Total Conveyance
15	120	42	15	In	42"	2	\$316.54	\$37,985	\$4,250.00	\$8,500.00	\$46,485	\$91,757	\$97,000
	451	48	15	Out	48"	1	\$87.80	\$39,597	\$5,675.00	\$5,675.00	\$45,272		
16	31	24	16	In	24"	1	\$154.06	\$4,776	\$3,125.00	\$3,125.00	\$7,901	\$7,901	\$9,000
17	203	24	17	In	24"	2	\$154.06	\$31,274	\$3,125.00	\$6,250.00	\$37,524	\$104,280	\$110,000
	191	24	17	Out	24"	1	\$106.10	\$20,265	\$3,125.00	\$3,125.00	\$23,390		
	193	24	17	Out	24"	1	\$106.10	\$20,477	\$3,125.00	\$3,125.00	\$23,602		
	108	24	17	In	24"	1	\$154.06	\$16,639	\$3,125.00	\$3,125.00	\$19,764		
18	3381	30	18	In	30"	8	\$198.33	\$670,553	\$3,125.00	\$25,000.00	\$695,553	\$710,276	\$746,000
	55	24	18	In	24"	2	\$154.06	\$8,473	\$3,125.00	\$6,250.00	\$14,723		
19	35	24	19	In	24"	0	\$172.64	\$6,042	\$3,125.00	\$0.00	\$6,042	\$6,042	\$7,000
2	383	60	2	Out	60"	99	\$201.26	\$77,081	\$0.00	\$0.00	\$77,081	\$77,081	\$81,000
20	32	24	20	In	24"	0	\$172.64	\$5,524	\$3,125.00	\$0.00	\$5,524	\$5,524	\$6,000
21	72	42	21	In	42"	0	\$337.21	\$24,279	\$4,250.00	\$0.00	\$24,279	\$24,279	\$26,000
22	32	36	22	In	36"	0	\$296.46	\$9,487	\$4,250.00	\$0.00	\$9,487	\$9,487	\$10,000
23	59	48	23	In	48"	0	\$380.71	\$22,462	\$5,675.00	\$0.00	\$22,462	\$22,462	\$24,000
24	122	36	24	In	36"	0	\$296.46	\$36,168	\$4,250.00	\$0.00	\$36,168	\$36,168	\$38,000
25	52	36	25	In	36"	0	\$296.46	\$15,416	\$4,250.00	\$0.00	\$15,416	\$15,416	\$17,000
26	77	36	26	In	36"	0	\$296.46	\$22,827	\$4,250.00	\$0.00	\$22,827	\$22,827	\$24,000
27	3081	0	27	Out	Erosion Control	0	\$0.00	\$0	\$3,125.00	\$0.00	\$10,000	\$20,000	\$22,000
	952	0	27	Out	Erosion Control	0	\$0.00	\$0	\$3,125.00	\$0.00	\$10,000		
28A	543	36	28A	In	36"	3	\$275.79	\$149,754	\$4,250.00	\$12,750.00	\$162,504	\$721,080	\$758,000
	70	24	28A	In	24"	1	\$154.06	\$10,784	\$3,125.00	\$3,125.00	\$13,909		
	93	24	28A	In	24"	1	\$154.06	\$14,328	\$3,125.00	\$3,125.00	\$17,453		
	565	24	28A	In	24"	1	\$154.06	\$87,044	\$3,125.00	\$3,125.00	\$90,169		
	635	24	28A	In	24"	1	\$154.06	\$97,828	\$3,125.00	\$3,125.00	\$100,953		
	382	30	28A	In	30"	1	\$198.33	\$75,762	\$3,125.00	\$3,125.00	\$78,887		
	603	24	28A	In	24"	1	\$154.06	\$92,898	\$3,125.00	\$3,125.00	\$96,023		
	558	24	28A	In	24"	1	\$154.06	\$85,966	\$3,125.00	\$3,125.00	\$89,091		
	112	36	28A	In	36"	1	\$275.79	\$30,888	\$4,250.00	\$4,250.00	\$35,138		
	61	24	28A	In	24"	1	\$154.06	\$9,398	\$3,125.00	\$3,125.00	\$12,523		
	57	24	28A	In	24"	1	\$154.06	\$8,781	\$3,125.00	\$3,125.00	\$11,906		
	61	24	28A	In	24"	1	\$154.06	\$9,398	\$3,125.00	\$3,125.00	\$12,523		

Project ID	Length ft	Diameter in	Project ID	In or Out of Street	Size Label	Number of Manholes	Unit Pipe Cost/ft	Pipe Cost	Per Manhole Cost	Manhole Cost	Total Conveyance Cost	2016 Project Total Conveyance	2017 Project Total Conveyance
28B	565	36	28B	In	36"	1	\$275.79	\$155,821	\$4,250.00	\$4,250.00	\$160,071	\$1,225,147	\$1,287,000
	635	36	28B	In	36"	1	\$275.79	\$175,127	\$4,250.00	\$4,250.00	\$179,377		
	112	30	28B	In	30"x2	1	\$396.66	\$44,426	\$3,125.00	\$3,125.00	\$47,551		
	70	24	28B	In	24"	1	\$154.06	\$10,784	\$3,125.00	\$3,125.00	\$13,909		
	430	54	28B	In	54"	2	\$473.34	\$203,535	\$5,675.00	\$11,350.00	\$214,885		
	382	30	28B	In	30"x2	1	\$396.66	\$151,524	\$3,125.00	\$3,125.00	\$154,649		
	61	24	28B	In	24"	1	\$154.06	\$9,398	\$3,125.00	\$3,125.00	\$12,523		
	57	24	28B	In	24"	1	\$154.06	\$8,781	\$3,125.00	\$3,125.00	\$11,906		
	558	36	28B	In	36"	1	\$275.79	\$153,891	\$4,250.00	\$4,250.00	\$158,141		
	61	24	28B	In	24"	1	\$154.06	\$9,398	\$3,125.00	\$3,125.00	\$12,523		
	603	36	28B	In	36"	1	\$275.79	\$166,301	\$4,250.00	\$4,250.00	\$170,551		
	93	36	28B	In	36"	1	\$275.79	\$25,648	\$4,250.00	\$4,250.00	\$29,898		
113	54	28B	In	54"	1	\$473.34	\$53,487	\$5,675.00	\$5,675.00	\$59,162			
28C	994	24	28C	In	24"	3	\$154.06	\$153,136	\$3,125.00	\$9,375.00	\$162,511	\$162,511	\$171,000
29	53	24	29	In	24"	2	\$154.06	\$8,165	\$3,125.00	\$6,250.00	\$14,415	\$14,415	\$16,000
3	392	24	3	Out	24"	3	\$106.10	\$41,591	\$3,125.00	\$9,375.00	\$50,966	\$305,904	\$322,000
	53	24	3	In	24"	1	\$154.06	\$8,165	\$3,125.00	\$3,125.00	\$11,290		
	371	24	3	In	24"	0	\$172.64	\$64,048	\$3,125.00	\$0.00	\$64,048		
	828	30	3	In	30"	0	\$216.91	\$179,599	\$3,125.00	\$0.00	\$179,599		
30	599	30	30	In	30"	2	\$198.33	\$118,799	\$3,125.00	\$6,250.00	\$125,049	\$125,049	\$132,000
31	155	15	31	Out	15"	0	\$0.00	\$0	\$3,125.00	\$0.00	\$8,000	\$8,000	\$9,000
32	656	24	32	In	24"	3	\$154.06	\$101,064	\$3,125.00	\$9,375.00	\$110,439	\$110,439	\$116,000
33	162	0	33	In	C&G	0	\$54.65	\$8,853	\$3,125.00	\$0.00	\$8,853	\$8,853	\$10,000
34	657	24	34	In	24"	0	\$172.64	\$113,423	\$3,125.00	\$0.00	\$113,423	\$259,129	\$273,000
	844	24	34	In	24"	0	\$172.64	\$145,706	\$3,125.00	\$0.00	\$145,706		
35	69	30	35	In	30"	2	\$198.33	\$13,685	\$3,125.00	\$6,250.00	\$19,935	\$49,690	\$53,000
	60	24	35	In	24"	2	\$154.06	\$9,244	\$3,125.00	\$6,250.00	\$15,494		
	52	24	35	In	24"	2	\$154.06	\$8,011	\$3,125.00	\$6,250.00	\$14,261		
36	446	0	36	Out	Erosion Control	1	\$59.00	\$26,314	\$3,125.00	\$3,125.00	\$29,439	\$29,439	\$31,000
37	408	0	37	Out	Line Ditch	1	\$0.00	\$0	\$3,125.00	\$3,125.00	\$3,125	\$3,125	\$4,000
38	49	0	38	In	Crosspan	0	\$109.30	\$5,356	\$3,125.00	\$0.00	\$5,356	\$5,356	\$6,000
4	35	24	4	Out	Structure	1	\$106.10	\$3,713	\$3,125.00	\$3,125.00	\$6,838	\$185,009	\$195,000
	719	24	4	Out	24"	3	\$106.10	\$76,286	\$3,125.00	\$9,375.00	\$85,661		

Project ID	Length ft	Diameter in	Project ID	In or Out of Street	Size Label	Number of Manholes	Unit Pipe Cost/ft	Pipe Cost	Per Manhole Cost	Manhole Cost	Total Conveyance Cost	2016 Project Total Conveyance	2017 Project Total Conveyance
	146	24	4	Out	24"	2	\$106.10	\$15,491	\$3,125.00	\$6,250.00	\$21,741		
5	299	24	5	Out	24"	2	\$106.10	\$31,724	\$3,125.00	\$6,250.00	\$37,974	\$37,974	\$40,000
6	638	36	6	Out	36"	4	\$192.61	\$122,884	\$4,250.00	\$17,000.00	\$139,884	\$175,850	\$185,000
	115	36	6	In	36"	1	\$275.79	\$31,716	\$4,250.00	\$4,250.00	\$35,966		
7	70	24	7	In	24"	0	\$172.64	\$12,085	\$3,125.00	\$0.00	\$12,085	\$12,085	\$13,000
8	218	24	8	Out	24"	3	\$106.10	\$23,130	\$3,125.00	\$9,375.00	\$32,505	\$32,505	\$35,000
9	1370	36	9	In	36"	10	\$275.79	\$377,832	\$4,250.00	\$42,500.00	\$420,332	\$420,332	\$442,000
39	142	36	39	Out	36"	3	\$192.61	\$27,350	\$4,250.00	\$12,750.00	\$40,100	\$40,100	\$43,000
40	294	24	40	Out	24"	2	\$106.10	\$31,193	\$3,125.00	\$6,250.00	\$37,443	\$37,443	\$40,000